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Preface

Sustainable Development Goals (SDG) adopted by United Nations in 2015 called for action by 2030 to end poverty, balance economic growth with social empowerment, and take climate-appropriate actions to save the planet. In the same year, the Paris Agreement on Climate Change required the nations to set their Nationally Determined Contribution to reduce Global warming.

As the world population grows and the impact of climate change becomes more severe, the demand for sustainable buildings and infrastructure has also increased. Moreover, durable and resilient structures are crucial aspects of sustainable construction. The resilient and durable structures which can withstand the vagaries of natural disasters reduce the need for frequent interventions of repairs and replacements, thereby reducing the resources required for maintenance.

To crystalise the way forward in the construction industry, The Indian National Group of The International Association for Bridge and Structural Engineering (ING-IABSE) has hosted this International Congress, on the theme "**Engineering for Sustainable Development**" in New Delhi on September 20-22, 2023.

The primary goal of the IABSE Congress was to provide a platform for policymakers, engineers, scientists, industrial partners and practitioners to present and discuss the latest developments and state-of-the-art, relevant to durability, sustainability and resilience. The congress covered various topics related to innovative materials, structural performance & design, construction methods & management, and some outstanding structures.

We are pleased to present the Proceedings Report of Full Papers that have undergone a rigorous review process by the members of the scientific committee from more than 35 countries. The Congress Proceedings include more than 188 papers that have passed stringent scrutiny out of nearly 500 submitted abstracts, which were presented in six parallel halls aggregating 35 sessions during the Congress. In addition, there were eight Keynote Lectures by eminent academicians, engineers and Government functionaries, of which six are included in the Proceedings. We would like to extend our sincere thanks and appreciation to all the session speakers, and convey our special thanks to the Keynote speakers for their invaluable contribution and knowledge sharing.

We also would like to express our thanks to the Core Members of the Scientific Committee, Members and the Chair of the Organising Committee Mr. PVVSS Ravi Prasad, President of IABSE, Dr. Tina Vejrum, Executive Director of IABSE, Mr. Chep Uytiepo, Publications and Communications Manager of IABSE, Ms. Brindarica Bose, IABSE HQ staff, and the Secretarial Staff of ING-IABSE for their valuable contribution in the final culmination of the Congress Proceedings.

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Engineering Solutions for Sustainable Development

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Abstract

Sustainable engineering (SE) focuses on systems that use energy and resources sustainably, addressing economic and climate change challenges (Global extreme weather this year in July is "virtually impossible" or "new extreme" in Antarctica without climate change). A radical shift in infrastructure planning is necessary to achieve net-zero emissions. Factors such as New Developments (NDs), nature-based solutions (NbS), life-cycle analysis (LCA), whole-life carbon (WLC), sustainable materials (SM), and green construction materials enable sustainable infrastructure. The identification of skills for upcoming infrastructure engineers, intelligent and sustainable built environments, IoT, and Integrated Workplace Management Systems (IWMS) are challenges. A circular economy approach to managing LC may be a more efficient and reliable means of achieving zero emissions.

1.0 Background: Role of Engineering in SD

Sustainable engineering (SE) focuses on systems that use energy and resources sustainably, addressing economic and climate change challenges (Global extreme weather this year in July is "virtually impossible" or "new extreme" in Antarctica without climate change). A radical shift in infrastructure planning is necessary to achieve net-zero emissions. Factors such as New Developments (NDs), nature-based solutions (NbS), life-cycle analysis (LCA), whole-life carbon (WLC), sustainable materials (SM), and green construction materials enable sustainable infrastructure. The identification of skills for upcoming infrastructure engineers, intelligent and sustainable built environments, IoT, and Integrated Workplace Management Systems (IWMS) are challenges. A circular economy approach to managing LC may be a more efficient and reliable means of achieving zero emissions.

2.0 Strategies:

2.1. Factors enabling better infrastructure: Carbon emissions have transitioned from being an optional to
becoming a critical in the built environment and explore how to assess design options against one another as part of a net-zero design process and how emissions could be reduced through material specifications. This includes digital optimisation to achieve material and economic efficiency. Challenges and its aspirations for the future NDCs and LCA, as shown in Fig 1.

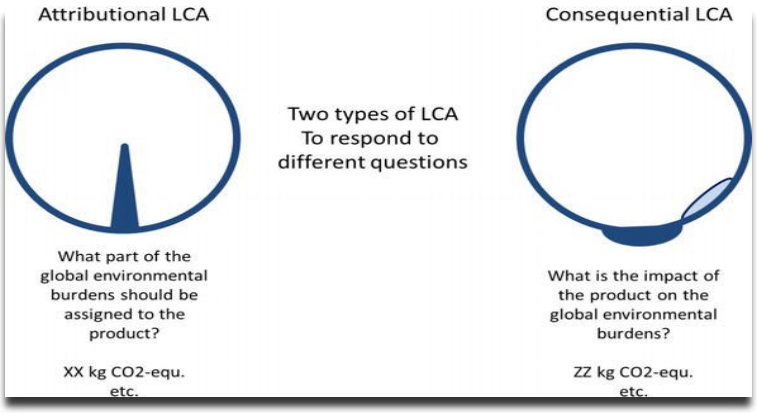

Fig 1 : Life Cycle Analysis(LCA) *Source: Weidema BP. Market Information in Life Cycle Assessment.*

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Changing Climate and Sustainability of Built Environment

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Abstract

Humanity faces increasing depletion of energy and material resources and an increasing number of natural disasters. Buildings, infrastructure and entire built environment should be better prepared for changing climatic conditions – as they should be sustainable and resilient. The energy consumed during operation of built environment is one of the most significant sources of CO_2 emissions. Considering these development trends, it is necessary to modify existing principles and methods of building and infrastructure design and adequate techniques of construction to enhance them to guarantee comfortable and safe operation for the whole population in the future. The buildings and infrastructure for sustainable future should be better prepared for the new conditions; they should be sustainable and more resilient.

1 Introduction

Earth existed long before humans developed and will exist long after the conditions on the Earth will not be suitable for human life. Sustainability is about preservation of environmental, social, and economic conditions on our planet in the form which will enable survival of biological diversity (including humans) and productivity on the Earth as long as possible [1].

Changing of the climate on the Earth is innate and everlasting process; environmental conditions are continuously changing due to continental drift followed by volcanic and seismic effects. Human life conditions are modified – and therefore biodiversity is irrecoverably changed. This process was in previous periods very slow, enabling consecutive adaptation of life forms (incl. humans) to changing environmental conditions. However, nowadays environmental conditions are changing faster, particularly caused by human activities.

Recently the world faces increasing number of natural disasters and increasing economic and social problems and challenges. New research results have shown how global climate changes are happening faster than anticipated. Generally, the impact on different regions of the World differs considerably. Floods, tropical storms, hurricanes, tornados, wildfires, heat and cold waves, longer periods of drought etc. are more and more frequent and with higher intensity. Because of the increasing risks due to climate change the probability of natural disaster is now nearly 5 times higher as it was in the 1970s, (Figure 1, [2]).

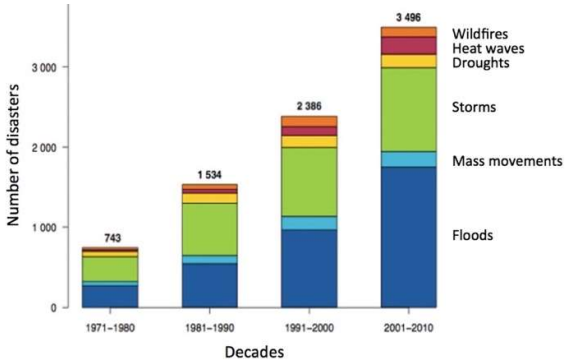

Figure 1. Increasing number of disasters by hazard type since 1970; data source WMO [3]

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Sustainable Development Goals and the Debate of Demolition Versus Conservation of Built Heritage in a Developing Economy

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Abstract

Conservation of listed heritage buildings and infrastructure in a city or a town is typically mandated by byelaws and regulations in several states in India unless such properties are protected by central or state archaeology departments as national or state monuments under the AMASR Act (Ancient Monuments and Archaeological Sites and Remains Act). Although grading and listing may exist in some towns and cities, many heritage buildings and infrastructure are still not protected through necessary legislation. Whatever the legal status, under the growing pressures of infrastructure development and renewal in a developing economy such as ours, the debate between conservation and demolition is at an important crossroads. Application of guidelines developed in the western world (e.g., ICOMOS principles) may be debatable without due consideration of context, constraints, and aspirations in large developing economies.

What do the UN's Sustainable Development Goals (SDG) 2030 have to say about conserving and revitalizing existing infrastructure, with or without cultural (or heritage) value? What is the basis for such an approach? And what are the criteria to verify whether it is logical to conserve or to demolish and redesign and rebuild. How should we consider the tangible and intangible elements of built heritage? The current paper attempts to examine this pertinent problem, often faced by primary stakeholders, conservation professionals (architects and engineers) and lawmakers, from the key perspective of structural safety and structural rehabilitation or retrofit. In an era, when sustainability, ecological and environmental awareness and cost-effectiveness together are emerging as determinants of development, how do they impact conservation of built heritage?

Keywords: Built heritage; conservation; SDGs.

1 Built heritage conservation framework in India

A large developing nation such as India, with a long and complex history presents a vast and varied stock of built heritage, which must be preserved alongside a burgeoning economy with massive infrastructure growth and renewal. The country has 3696 nationally protected monuments under the care of the central government's Archaeological Survey of India (est. 1862 AD) including 42 World Heritage Monuments and Sites as on date. Several heritage structures are protected by the Central Public Works Department (CPWD) and by the Armed Forces. Similarly, different state governments safeguard archaeological monuments and numerous heritage structures through institutions such as the State Departments of Archaeology, Municipal Corporations, Religious Endowments Departments and PWDs. There are several thousands more of heritage structures across the country that are yet

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Upgrade & Retrofit of Existing Infrastructure & How it Contributes to Sustainability to Extend the Service Life of Structures

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Abstract

We live in a world of ultimately limited resources and as engineers we are responsible for the most efficient use of those resources. The needs of the societies we serve change and our infrastructure is under constant pressure to adapt to new requirements. Many of these demands are about capacity and drive a desire to replace existing structures with bigger and seemingly better designs. And whereas it's always nice to start with a clean sheet when preparing a design it is an obligation upon us engineers to make the most effective use of what is already there. Only in this way can we start to tackle the sustainability challenge brought upon us by the climate emergency. There are many ways that existing infrastructure can be used and repurposed so that the changing demands can be met.

The keynote paper will address the way in which existing bridge infrastructure has been adapted and expanded to meet the requirements of greater structural capacity.

Keywords: Refurbishment, widening, strengthening, sustainability, .

1 Introduction

Bridge engineers have created some beautiful and effective structures that have stood the test of time. There is a real attraction to creating a bridge. It is more than just a structure, it is means for bringing communities together, to promoting trade and cooperation, to ending divides. Once they are built, they become a vital part of our infrastructure and we and we are reliant on them.

At the same time, the benefits of increased flow of people and goods may place further demands on the infrastructure and the capacity may become too little and throttle additional development. We have seen this with many crossings where radical intervention is required to increase capacity and meet this demand.

Historically, we designed structures for what we needed at the time. We built then to last for 100 years but only as far as durability is concerned. With a few notable exceptions, we rarely considered future capacity.

What usually stops this planning for the future is economics, but this can be a false economy; the cost of twinning or extensions to bridges run at many times the original cost. However, if capital is limited and there is uncertainty then there is some justification for such reticence. A case in point is the clever engineering for the Auckland Harbour Bridge. This was built in the early 1950s and the design made allowances for providing additional capacity in the form of the "clip-on" attachments to the deck which were added in 1969 to increase the capacity of the bridge. This work, planned at the original design stage, successfully resulted in a doubling of the traffic able to cross the bridge.

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Code of practice for sustainable structures

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Abstract

The construction sector being responsible for about 42% of the final energy consumption and about 35% of global greenhouse gas emissions, plays a central role in the global effort for decarbonization and mitigation of climate change. However, despite worldwide policies and investments to make the building sector more efficient, no clear structural changes have yet occurred to reduce energy demand or cut carbon emissions.

Sustainability is a mindset that should be embraced by all professionals in the construction sector, to drive positive changes towards a more sustainable and decarbonized future. In this regard, a code for the sustainability of buildings is crucial to set target values for carbon emissions and other environmental problems, and to provide clear guidelines on how to comply with such values, across the life cycle of buildings. In this paper, a performance-based approach for sustainability assessment of structures is presented, based on the limit state approach that is familiar to most structural engineers. The harmonization of structural and sustainable design fosters a mindset that considers environmental impacts alongside safety and functionality, allowing structural engineers to become key players in the larger quest for a sustainable built environment.

Keywords: sustainable structures, decarbonization, limit state of sustainability, code for sustainability.

1 Introduction

The world is currently living in a state of climate emergency and urgent measures are required to control the temperature rise and mitigate climate change effects.

The impacts of the construction sector on energy consumption and greenhouse gas emissions are significant. In fact, this sector is responsible, at the EU level, for about 42% of the final energy consumption and about 35% of global greenhouse gas emissions (EEA, 2022). This highlights the sector's central role in the global effort for decarbonization and mitigation of climate change, and efforts toward enhanced construction practices could have far-reaching effects on these numbers.

As part of the European Green Deal (EC, 2019), the recently published European climate law aims for a net-zero balance of greenhouse gas emissions by 2050, and the intermediate target of reducing emissions by at least 55% by 2030 compared to 1990 levels (Regulation (EU) 2021/1119). Hence, climate neutrality became legally binding in the EU.

However, despite this and other worldwide policies and investments to make the building sector more efficient, no clear changes have yet occurred within the buildings sector to reduce energy demand or cut carbon emissions.

In fact, the operational energy consumption in buildings and associated carbon emissions had an increase of about 3% and 2%, respectively, in relation to pre-pandemic values, in 2019, as illustrated in Figure 1 (UNEP, 2022).

Hence, a stronger effort is required by the construction sector to implement sustainable and energy-efficient approaches. By doing so, the

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Approach to Sustainability in Built Environment

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Abstract

The indiscriminate use of natural resources since the development of civilization particularly their exploitation in the last one century or so in the process of industrialization and in the pursuit of comfort-at-all-cost, has resulted in a situation of almost no return. Under the circumstances, 'Sustainability' is the mantra and saviour of civilization. The most important aspect in achieving sustainability is to address the cardinal principles of sustainability of reduce, reuse and recycle with due consideration to sustainability objectives in respect to space and time. The comprehensive approach demands that, in respect to space, the approach should start from larger context globally coming finally to the scale of a building or a local built environment. Meaning thereby that an isolated building cannot be regarded as sustainable product unless it is a part of overall sustainability scenario in a larger context. Similarly, a time duration needs to be kept in mind over which the sustainability is sought to be achieved. For example, what can be sustainable for a limited period of time may prove to be otherwise on a longer span of time. At the same time, sustainability cannot be seen for a period till eternity. This is particularly true because of cost implications and likelihood of paradigm shift in materials, technologies and developmental requirements during different times. Thus, sustainability needs to be largely concentrated on a scale of our planet and human life scale of periods such as 500 years. The comprehensive approach then would require to deal with all aspects relating to siting, form and design; external development and landscape; envelope optimization; selection of appropriate materials; water and waste management; building services optimization; constructional practices including selection of appropriate technologies; and commissioning, operation, maintenance and building performance tracking. The objective is not only to ensure that the facility is built sustainably using optimum embodied energy but also requires optimum operational energy and least maintenance. The progressive thought requires that the building and built environment should not be designed only to reduce the adverse effect to the environment but should intend to cause positive effects to the environment, economy and the society at large. This paper discusses approach to sustainability, with a view to making appropriate decisions during conceptualization, planning, design, construction, operation and maintenance stages of the built facility. To facilitate the understanding and implementation of the approach, a Sustainability Model has been attempted which may be suitably modified, extended and detailed for better understanding and application.

Keywords: Sustainability; built environment; energy conservation; National Building Code of India

1 Introduction

Ancient civilizations used to build edifices using locally available materials, with great skill, and in harmony with nature. Basham in 'The Wonder that was India' describes how palaces in Mauryan dynasty in second century B.C., were exquisitely built from carved wood of local deodars. In later years the monasteries, temples and

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New modular construction method for multi-span concrete bridges with reduced material consumption

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Abstract

A new construction method for post-tensioned bridges with a double-T cross-section was developed at the Institute of Structural Engineering (TU Wien). That method enables a swift production of the longitudinal girders and the deck slab. Precast deck slab elements stiffened by cross-beams are placed on top of the installed post-tensioned precast girders. The precast hollow box girders and the deck slab elements can be installed along the whole length of the bridge with cranes or a launching gantry. The combination of precast hollow box bridge girders and precast deck slab elements allows for the fast production of post-tensioned concrete bridges with a double-T cross-section in the span range from 30 m to 60 m. This method will make the erection of one span per week possible, thus achieving the same construction speed as segmental bridge construction. Compared with segmental box girder bridges, the new construction method permits a reduction of construction materials and avoids transverse joints that extend over the entire height of the finished cross-section.

Keywords: Precast deck slab element, precast hollow box girder, post-tensioned bridge, segments, sustainable, thin-walled.

1 Introduction

Several building techniques for multi-span concrete bridges have been developed in the last decades. The state of the art is described in “Bridge Deck Erection Equipment” [1]. In total, ten construction methods are outlined:

1) Precast balanced cantilever erection by launching gantry
2) Precast segmental span-by-span erection by launching gantry
3) Precast girder erection by launching gantry
4) Precast full span erection by launching gantry
5) Cantilever erection by lifting frames
6) Progressive cantilever method using stay cables
7) In-situ form travellers
8) Movable scaffolding systems
9) Incremental launching method
10) Prefinished bridge installation methods

More than half of the listed construction methods can be assigned to the construction method with precast elements. This shows the current importance of these bridge-building techniques. In contrast to the construction methods with in-situ concrete, swift construction progress can be achieved using techniques with precast elements.

An extraordinary building technique for multi-span prestressed concrete bridges with a plate-girder

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The Practice of Forensic Structural Engineering in IABSE Member Countries: preliminary review of survey 2022

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Abstract

The IABSE Task Group 5.1 on Forensic Structural Engineering aims to examine and to mitigate structural failures by sharing knowledge of technical, human, and organizational causes of failures, in addition to methods and techniques in forensic investigation processes. The expertise of Forensic Engineering is yet to be worldwide recognised as a specific domain of civil engineering practice and this article amends previously published technical reports in 2012, 2014 and 2015 by former IABSE Working Group 8 following a new survey carried out in 2020-2022.

This new survey has been developed with the lessons learnt from the previous survey in 2013-2014.

This article is a preliminary report on some topics of the survey and will allow to familiarize with the state-of-art in forensic structural engineering practice across 22 countries.

Keywords: forensic structural engineering; survey; structural failure; structural collapse.

1 Introduction and background

Failures of structures occur in all parts of the world as the result of design deficiencies, construction defects, abuse or misuse, lack of maintenance, aging and deterioration, and environmental effects such as wind, flood, snow and earthquakes, among others. The technical and legal approach of treating structural failures, however, are different in various countries. The response of 'forensic engineers', where the designation exists, to disasters is an organised activity in some countries but a haphazard activity in most others.

The IABSE Task Group 5.1 (TG 5.1 in the following) on Forensic Structural Engineering started its activity in 2011 (as former IABSE Working Group 8). By sharing knowledge of technical, human and organizational causes of failures and of

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Lessons in Remote Infrastructure: Connecting People and Landscape to Promote Economic Vitality & Create Social Value

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Abstract

Transportation systems offer opportunities to connect rural communities with economic possibility. Intentional infrastructure interventions connect citizens with resources and reduce travel time between remote and urban areas – creating sustainable value for entire economic regions. Remote infrastructure presents a tension between creating social value without destroying environmental value.

Presenting two multi-bridge infrastructure projects in Norway and South Africa, Dissing+Weitling explores the opportunity for a design team to partner with local authorities to provide aesthetic interventions that align with environmental protection goals, increase connectivity for rural communities, and balance social value creation with the preservation of landscapes with high natural value.

Keywords: rural; remote; logistics; biodiversity preservation; landscape; large-scale; environmental impact; social value creation; national authorities; integrated planning

1 Introduction

Infrastructure is vital in connecting urban and rural environments within geographically disperse and diverse countries. Regional planning teams must respond to the tension between biodiversity preservation, environmental impact mitigation, local stakeholder engagement within a change process, and maximization of economic impact.

For rural communities, new road systems create gateways to access and economic vitality – while simultaneously challenging long-standing ways of living, working, and being in community with each other and nature. A key challenge for the development of remote infrastructure is to respond to these trade-offs and tensions – and to use the architectural design process as a gateway to maximize sustainable value creation across the triple bottom line.

Dissing+Weitling offers two multi-bridge remote infrastructure projects in South Africa and Norway to demonstrate how design team partnership and stakeholder engagement can strengthen project outcomes. In embracing the site-specific contexts of each unique bridge – mobility architecture offers a pathway to ensuring sustainable infrastructure: aligning with environmental protection goals set forth by national authorities and providing economic empowerment to remote communities by strengthening their connectivity to urban centres.

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Towards Attaining Sustainable Development Goals in Design and Construction of Highway Bridges – A Critical Review

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Abstract

Bridges are integral part of highways. India became independent in 1947. However, development works in highway sector has been undertaken continuously since pre-independence days. The paper describes details of some of the policies and guidelines, progressively implemented for development of highways including bridges, which support activities towards attaining Sustainable Development Goals (SDGs) adopted by the United Nations in 2015, These are with regard to rationalisation of procedure of land acquisition, rehabilitation and resettlement, environment protection framework, bridge construction / reconstruction program adoption of new technologies and innovations in design and construction , use of non - conventional energy, impact of climate change on hydrology, and road safety. Besides, the Government has been receiving enhanced availability of international support and co-operation continuously, leading to faster pace of development.

Keywords: SDGs, environment, land acquisition, IRC, Environment Management Plan, GHG emissions, wild life, design and construction of bridges, international support and co-operation.

1 Introduction

There are 17 Sustainable Development Goals (SDGs) [1], also called Agenda 2030, which were formulated by United Nations in 2015 to create framework for global development during 2015 to 2030. The SDGs emphasize the interconnected environmental, social and economic aspects of development by putting sustainability at the centre.

Based on the recommendations of Jayakar Committee [2], sustainability was engrained into road development programs with the creation of the following:

(a) Central Road Fund (CRF) was created in 1928 from taxes on petrol. The Fund still continues to exist for financing of road development works with increased taxes on petrol and diesel.

(b) Indian Roads Congress (IRC) was set up in 1934. It is a non – governmental technical body of Highway Engineers in the country, provides for a regular forum for interaction amongst highway and bridge engineers and publishes Codes, guidelines and manuals for planning, design, construction, maintenance and operation of roads and bridges.

(c) Central Road Research Institute (CRRI) was established in 1950 to carry out research and development work for design, construction and maintenance of roads and bridges, including usage of new materials including local materials and industry wastes in road construction.

Even before Independence in 1947, several environmental and social / resettlement related legislation existed, but the real impetus for bringing well- developed framework came after the UN Conference on Human

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Designing on Existing Bridges: A Paradigm of Sustainability Applied to Civil Engineering

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Abstract

One of the areas where the bridge designer has a real influence on the sustainability of the performance is in the widening of existing bridges. The use of the structure is always beneficial from an environmental point of view as the life span of the bridge is increased by using the existing structure. A good example of this is the widening of bridges. The article includes examples of the widening of three different structural types: a stone arch bridge, a prestressed concrete bridge with box section and a cable-stayed bridge. In all three cases, the existing structural systems have been used thanks to the team's willingness and knowledge of the techniques associated with bridge maintenance and preservation.

Keywords: Sustainability; widening; vaulted bridge; concrete box deck; external prestress; cable-stayed bridge.

1 Introduction

The concept of sustainability is closely related to the optimisation of resources. In engineering, once it has been decided to build a project (the what), it is necessary to move on to the how. This how will always involve CO_2 emissions over which the engineer has minimal control. Saving materials is always a condition for any project that can be called an engineering design. Engineers understand nature's resources are scarce and that it is our duty to optimise their use. The bridge designer has a minimum palette of materials to use: concrete, steel or a combination of both. Sustainability will be determined by the logical use of these materials according to the span of the bridge and its type. Therefore, the mere accounting and comparison of CO_2 emissions will not help us to analyse sustainability, which includes the long-term use of the structure.

The control of CO_2 emissions is in any case one of the basic premises of any current design, however, the control or reduction possibilities, in bridge engineering is minimal because only two basic materials are available. It is the manufacturing processes of these materials that are the fundamental aspect that can be influenced. The designer's task will be to choose from the range of concretes, for example, those with the lowest CO_2 emissions.

However, there are other factors that are often not included in the analysis of the sustainability of a project, and which are much more important, as they can condition the future of an area and therefore of part of the local population. For example, the position of the piers of a bridge over a river or a vertical clearance that limits navigation in the medium and long term can have a negative influence on local development and can therefore make the project unsustainable in the not too

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Long-Term Sustenance Issue of Cables for Cable-Supported Bridges

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Abstract

Cable-supported bridges are marvels of modern engineering. The construction and use of these have been on the rise for the last fifty years. Cables, with higher strength than the structural sections and innate flexibility, offer an economic solution for medium and long-span bridges. The reduced weight of the structure helps in contributing to the demands of sustainability. From a structural standpoint, cable-stayed bridges are complex and have many critical areas that need attention from the design stage itself. The complexity in the maintenance of these bridges is getting evident with reports of deterioration of several bridges after use of fewer than twenty years, a rather grim situation; after large investments made for such elegant structures.

The present paper reviews the situation and the challenges for the engineering community in ensuring safe sustainable cable-supported structures for the future and also actions needed to avoid sudden failure of structures, already built without giving adequate thought to inspection, maintenance, and rehabilitation aspects.

Keywords: Cable-Stayed Bridges, Extra dosed bridges, corrosion, fatigue, inspection, maintenance, rehabilitation

1 Introduction

Since the dawn of civilization, flexible materials (like cables) have been used to facilitate crossings. Drawing inspiration from nature, that of creepers' ability to cross long distances and offer steady means of passage, human use of artificial cables and linked bars or chains has become more widespread. The lower Himalayan region of India is credited with the first use of parallel cables in pairs, which permitted the introduction of a horizontal deck with the use of vertical hangars from the cables, which led to the construction of early cable-supported bridges. The usage of cables allows for flexibility in construction and material economy because these have significantly higher tensile strength than any conventional structural material. As spans increase, the economy of cable-supported bridges improves, and practically all bridges in the world with a span of more than five hundred meters are Cable Supported bridges. A high span-depth ratio gives these bridges an elegant appearance, which is an added benefit. Over the past 50 years, Cable Stayed and Extra dosed bridges have emerged as a cost-effective and efficient structural solution for long-span bridges [1].

There are three main types of cable-supported bridges: (a) suspension bridges, where the cable is suspended in the shape of a parabolic catenary and crosses over tall towers and is anchored at the ends with rigid supports; (b) cable-stayed bridges (CSB), where the inclined cables that hold the deck are supported from tall towers; and (c) extradosed bridges (EDB), where cables are held from towers of smaller heights to support the deck girders and may be considered as a hybrid concept between girder bridges and CSB.

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Innovative bridge structures recently built in Poland

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Abstract

Intensive modernization of the transport network is underway in Poland. New highways and expressways are built, and railway lines are modernized. Therefore, many new bridge structures have been built in recent years, and even more, are being built. The new facilities include design innovations such as large extradosed bridges and new generation composite (hybrid) bridges, using new type connectors. Steel elements are used as rigid reinforcement of concrete beams, hybrid mesh-type arch spans composed of steel arch girders made of heavy cold-bent profiles, a prestressed concrete deck, or some effective stress-ribbon footbridges made of concrete slabs.

Keywords: Bridges, hybrid structures, composite dowels, network arch, extradosed bridges, stress-ribbon structures, prestressed concrete

1 Introduction

In Poland, intensive work has been carried out over the last 20 years on the modernization of transport infrastructure. During this period, the following were built or modernized:

- A basic network of motorways and expressways totalling 3,804 km (data from 2022).
- A series of bypasses of large cities.
- Over 2,000 km of railway lines, replacing many depleted old bridges with new ones.
- Over 17,000 km of bicycle paths, along which interesting bridge structures were built.

In connection with the works carried out, over 3,000 new bridges were built in Poland from 2000-2022, and several innovative solutions in this area were implemented. This paper will present:

- modern hybrid beam bridges applicable to small and medium spans (up to 50-60 m),
- network arch bridges with girders of cold-formed rolled profiles and a prestressed concrete bridge,
- interestingly shaped box bridges made of prestressed concrete,
- one of the largest extradosed bridges in Europe,
- unusual footbridges.

2 Concrete-steel hybrid bridges of short and medium spans

2.1 Used solutions

In Poland, in cooperation with centres from Germany, Romania, Luxembourg and other countries, research and development work on new possibilities of shaping hybrid structures has been carried out for several years, ending with implementations. Figure 1 shows various possibilities of shaping the cross-sections of such girders.

Strip steel dowel connectors connect the steel elements and the concrete. Details on the design and application of such connectors and the technology of their production are given in the papers [6], [9], [11], [12]. At the Wrocław University of Technology, research and analytical work are conducted on the principles of designing such structures [9], [10]. Next, the latest Polish examples of applications are shown.

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Design of Multi-span Cable Stayed Bridge at Ambhora, near Nagpur, Maharashtra

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Abstract

A multi-span cable stayed bridge is proposed over river Wainganga to re-establish the state highway link from Bhandara to Butibori. The location of the bridge is an important tourist and pilgrimage destination with lush green surroundings and backwaters of Gosekhurd Dam. The bridge has an overall length of 705m and deck width of 15.25m to accommodate 2 lanes of vehicular traffic and 3m+3m footpath for pedestrians. The structural arrangement of the bridge comprises 2 modules, with Module 1 of 420m and Module 2 of 280m length with span arrangements of 70m+140m+140m+70m and 70m+140m+70m respectively. The superstructure is cable stayed with RCC deck with an RCC pylon height of 30m above deck level. The pylon P3 at the center of the bridge is also proposed with Viewing Gallery 40m above deck level which is structurally independent from the main bridge. The Module 1 of the bridge is constructed by cantilever method for pylon P2 and anchored span method for pylon P1 and P3. The Module 2 of the bridge is constructed on staging. This presentation discusses the design and construction aspects of the bridge along with staged construction analysis. This is one of the very few cable stayed bridges in India where all 3 methods of construction of a cable stayed superstructure are adopted in the same bridge.

Keywords: Cable stayed bridge, Multi-span, Cantilever construction

1 Introduction

The reservoir of Gosekhurd Dam is one of the largest by storage capacity in the draught prone Vidarbha region of Maharashtra state, India. Opened in 2008, the reservoir's high FRL meant most of the bridges upstream on the Wainganga river get submerged every monsoon season,

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Seismic demand assessment for 20km long Elevated Expressway in Chattogram, Bangladesh

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Abstract

Bangladesh is surrounded by 2500km long Himalayan Frontal Thrust at North and by Indo-Myanmar Subduction zone at the East. These two fault zones are primary source of many large historic earthquakes that had occurred along the border of Bangladesh extended from North and wrapping East. The Chattogram region of Bangladesh is hilly and experiences frequent smaller earthquake shaking compare to other area of the country.

The Elevated Expressway (EEW) project being constructed from Airport to Lalkhan Bazar in Chattogram city by Chattogram Development Authority (CDA) is almost 20km long elevated bridge structure made of Concrete and partly of Steel that runs through a much-crowed habitat. Due to scarcity of land at grade, the EEW is supported on single pier thus with no redundancy in Earthquake Resistance System (ERS).

Bangladesh National Building Code (BNBC) provides only Peak Ground Acceleration (PGA) for 2475 years return period. The Country is divided into four seismic zones with PGA varies from 0.12g to 0.36g. Data required for seismic analysis of a bridge using AASHTO Code requires PGA associated with 1000 years return period, horizontal response spectral acceleration coefficients for different structural periods are not readily available in BNBC. Interpolation of data from only two available data [225yrs. from BNBC/93 and 2475 yrs. from BNBC/2020] may not reflect the correct risk scenario.

To calculate the seismic risk for EEW Project, Probabilistic Seismic Hazard Analysis [PSHA] was done and compared with the data available in the Code to finalize seismic risk parameters for the EEW Project.

Keywords: Seismic risk, Himalayan Frontal Thrust, Indo-Myanmar Subduction Zone, PSHA, Peak Ground Acceleration

1 Introduction

Chattogram, the second largest city of Bangladesh and the largest sea port of the country. Over time, it grew and developed along major transportation routes, culminating in its designation as a municipality in 1864. However, the city's development with time was not planned to accommodate current levels of growth and business activity, resulting in traffic congestion that severely hinders daily life of the city dweller and future growth prospects of the country.

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Independent Design Checking of Brahmaputra Bridge, Guwahati - Sharing Experience & Lessons Learnt

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Abstract

The new bridge over river Brahmaputra connecting Guwahati and North Guwahati is currently in the advanced stages of construction. Designed to be an iconic bridge with state-of-the-art aesthetic features, it is being built at a cost of INR 26 billion (USD 316 million). This mega project includes not only the river bridge over the mighty river Brahmaputra but also long elevated viaducts and approaches on both sides. The project is being executed in EPC mode. The paper brings to the fore the culture of proof checking generally performed in infrastructure projects in the country and describes the unique feature of IDC performed in this specific project. The author draws on his own experience as well as published information to illustrate the importance of establishing a culture of independent checking everywhere to add confidence and mitigate the risk of failures.

Keywords: Extradosed Bridge, Stay Cables, Well Foundation, Pile Foundation, Segmental Box Girder, Proof Checking.

1 Introduction

Proof checking of structural design may not be as glamorous and as exciting a job as detailed design, but it is a task, which is vital and necessary for our profession of structural engineering. This is particularly so for mega projects like this bridge across the river Brahmaputra at Guwahati. For a project of this significance, the Client has rightly included the services of an independent design checker (IDC) for which the author was associated. IDC in this case is employed by the contractor with the approval of the Employer. The scope of IDC included structural and geotechnical verification of the entire project, and providing certification of the construction design pack which includes technical drawings, work specifications, working drawings, and all other associated documents. IDC certification includes the commitment that the work has been independently checked and verified and complies with the Employer's Requirements.

2 Project Highlights

2.1 Location & Background

Guwahati, earlier known as Pragjyotishpur, is the capital of Assam. It is a very ancient city that dates back thousands of years. The epics and the Puranas witness the mention of Guwahati in their historical scriptures and compositions. There are a few temples that have existed in this place for ages such as the Kamakhya Temple, Basistha Temple, and Navagraha Temple. Guwahati, with its cardinal points at 26˚10’ North latitude and 92˚49’ East

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Structure of the new movable railway bridge on Pamban island

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Abstract

A new Tower Vertical Lift bridge on Pamban Island (India) replaces the existing “Scherzer” Rolling Bascule bridge within the railway line that connects the island to the Indian subcontinent across the Palk Strait. The lift span of the new bridge consists of a 77.5 m simply supported structure composed of two lateral steel Warren trusses of variable depth and a platform 10.3 m wide, holding two railway lines. The lift movement of the bridge is carried out through two sets of electromechanical systems placed in two towers 40 m high, located at the ends of the lift span, which hold the machinery in their upper part. The choice of this system responds to the criteria of reliability and robustness. Also, the high incidence of marine corrosion in the bridge location has been decisive in the design. The existing bridge is a national icon in South India; therefore, the aesthetic has been a fundamental condition.

Keywords: movable bridge, vertical lift, tower drive, steel structure, Warren truss, railway, deep foundation

1 Introduction

The historic Pamban Bridge is an unelectrified single-track railway viaduct with a length of approximately 2 km, connecting Pamban Island to the subcontinent in Tamil Nadu (India), spanning the Palk Strait. The construction works of the bridge began in 1911 and ended in December 1914. Since then, the connection between India and Sri Lanka has remained constant through this rail service that reaches the island of Pamban and, from there, continues to the town of Talaimannar in Sri Lanka via ferry.

The existing bridge comprises 145 12.2-m spans formed of simply supported steel beams and a Scherzer Rolling Bascule section with a 66.5-m span, composed of two movable lateral steel trusses, transversal beams in correspondence with the lower nodes of the truss, and two longitudinal stringers.

The Scherzer Rolling Bascule system [1][2] has a characteristic curved geometry of the lower chords of the lateral steel trusses at its butt-end, forming two-quarters of a circumference for each leaf called "segmental girders". During the opening or closing operation of the bridge, these circular elements roll on the corresponding back rails, establishing a rotation of the leaf accompanied by its horizontal movement backwards or forwards during the manoeuvre.

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Case study using Non-Linear Finite Element Analysis for Assessment of Slutchers Lane bridge

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Abstract

200 years of British railway infrastructure is now owned, managed, and developed by Network Rail. Safe and effective management of the rail network needs to have up-to-date information regarding the capacities of these ageing assets. Slutchers Lane bridge (Warrington, UK) is a structure designed to carry rail loads over a public road. According to the 2010 NBSI assessment and the archive drawings, bridge widening took place circa 1907.

The previous assessment of this bridge was carried out using simple statics with an idealised line beam approach, the results obtained were inadequate to serve the current load requirements of Network Rail. To get a more accurate theoretical capacity, a more refined analysis was required, incorporating recent site inspection data representing the current condition of the bridge. Performing a nonlinear finite element analysis was found to be suitable for this requirement.

For the study, the entire structure was modelled in LUSAS software using shell elements and analysed for various potential failure mechanisms. The finite element model was able to capture all the deteriorations identified during the recent site investigation. A mesh sensitivity study was carried out for the selection of an appropriate mesh size. In the analysis, material nonlinearity is considered along with geometric nonlinearity. The initial geometric imperfection is assigned based on the critical buckling mode identified in the linear Eigenvalue buckling analysis with appropriate scale factor. To determine the results at both ultimate limit state and service limit state, the following outputs were captured, Von Mises stresses, the extent of material yielding, and the propensity for buckling. Recommendations were made based on standard guidance and engineering judgement.

From the nonlinear finite element study, it was established that the structure in its current condition is adequate for the current Network rail requirement, which is an improvement on the results of the previous assessment.

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Experimental study on dynamic characteristics of rubber sand mixtures

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Abstract

As a new type of environmentally friendly lightweight composite material, rubber sand mixture has a wide application prospect in the field of engineering vibration isolation. In order to reveal the variation law of dynamic characteristics of different rubber sand mixtures, based on the dynamic triaxial test, the effects of rubber content and confining pressure on the backbone curve, dynamic shear modulus and damping ratio of mixtures were studied. The results showed that with an increase in the rubber content, the backbone curve of rubber sand mixture had a trend of ' ductile failure ' and the dynamic shear modulus of mixture decreased. The nonlinear coordinated variation could be found between the damping ratio and rubber content with a characteristic threshold of 40 %. The mechanical properties of rubber particles may be influenced by changing the type of ' skeleton structure ' inside the sample.

Keywords: rubber sand mixture; waste tire; backbone curve; dynamic shear modulus; damping ratio.

1 Introduction

With the rapid growth of the economy and transportation industry, the quantities of waste tires continuously increase year by year due to the annual consumption of a large number of tires [1]. According to the statistic in 2017, the annual production of waste tires in China is about 10 million tons with an annual growth rate of 8%-10% [2]. The recycling of waste tires in a reasonable and effective way has become an urgent social problem. Waste tires, as a new type of environmentally friendly lightweight composite material, can be called "black gold". This is because they not only have the characteristics of light density, strong deformation ability, and good durability compared to soil [3-5], but also can significantly improve the physical and mechanical properties of soil when mixed with sand [6]. Additionally, they can also play a role in vibration reduction and isolation [6-13]. Therefore, the research on the mechanical properties and engineering applications of rubber sand granular hybrid soil can better resolve the current social problem of reusing waste tires, which is beneficial to sustainable development.

A certain number of experimental studies on the dynamic characteristics of rubber sand mixtures were carried out by using resonant column test. Through the analysis of the results of the resonant column test, it was found that the incorporation of rubber particles significantly improves the dynamic performance of the soil, so that the mixed soil has the characteristics of low shear modulus and high damping ratio [13-15,17]. The researchers found that rubber content and confining pressure are the main factors affecting the dynamic performance, energy dissipation characteristics and stiffness of rubber particle mixed soil [16,17]. However, the American test standard [18] compares the

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Gap filler to eliminate the hole play between base plate and channel bolts installed in anchor channels to sustain higher seismic loads

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Abstract

Anchor channels are a common fastening system for attaching highly loaded base plates of non-structural and structural components to reinforced concrete structures using channel bolts. The reliability and robustness makes this fastening system also popular for seismic applications. An innovative gap filler set was developed to eliminate the gap between the base plate and the channel bolt as well as between the channel bolt and anchor channel, and thus to further improve the seismic performance. Following the introduction of anchor channels and channel bolts in the context of seismic loading, some background information is provided, and qualification as well as design is addressed. Finally, monotonic (static) and cyclic (seismic) tests on channel bolts installed without and with gap filler are presented and discussed to demonstrate the benefits of gap filling.

Keywords: Anchor channels; channel bolts; static and seismic performance; concrete fastener.

1 Introduction

Channel bolts installed in cast-in anchor channels enable the sound connection of non-structural and structural components to reinforced concrete structures. Anchor channel-channel bolt-systems, also simply known as anchor channels, reliably take up monotonic and cyclic loads even under extreme conditions to be anticipated in seismic regions. This is particularly relevant for critical infrastructure such as high speed railway bridges (Figure 1).

Figure 1. Taiwan Highspeed Railway viaduct in a seismically active country

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Sandwich panels with bio-based core of wood fibre insulation

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Abstract

In light of the climate crisis, the building sector faces the increasing challenge and urgency to improve its sustainability and significantly reduce its consumption of non-renewable resources. Therefore, the EU-funded research project InCSEB is developing ultra-low carbon footprint building steel envelope systems through the innovative use of wood fibre as a core material of sandwich panels. By using the new bio-based core material, the carbon footprint and the environmental impact of buildings with this type of envelope system can be reduced. Within the InCSEB project, various studies are being carried out on sandwich panels with a bio-based core. In addition, studies are being carried out on full-scale building prototypes with these new solutions. In this paper, the results of the static-mechanical tests and the assembly of the sandwich panels with a wood fibre core are presented to indicate the future scope of potential roof and cladding applications.

Keywords: lightweight structure, sandwich panels, wood fibre insulation, bio-based core material, mechanical tests, building prototypes, experimental studies

1 Introduction

For building constructions, sandwich panels usually consist of two metal face sheets and a core of polyurethane (PU) or mineral wool (MW). They are characterized by combination of lightweight construction, thermal insulation, and sealing function in one component. They also stand out due to their simple assembly and cost-efficient series production. Hence, sandwich panels are already established as an economical solution for building envelopes in industrial constructions in Europe. Common dimensions of sandwich panels are thicknesses up to 240 mm and face thicknesses from 0.4 to 1 mm [1]. From the ecological point of view, the thermal insulation is important, because it allows to save not only on the continuously increasing energy costs, but also on CO_2 emissions due to less heating or cooling [1]. The ecological impact of PU sandwich panels was studied in [2]. Besides, alternative renewable core materials like corrugated cardboard have also been analysed [3].

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Experimental and analytical investigations on the shear capacity of pre-stressed concrete bridges

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Abstract

A recalculation according to Eurocode 2 (EC2) of bridges, which have been built in Europe before the introduction of EC2, shows a deficit of the existing shear reinforcement. However, prestressed concrete bridges have additional load-bearing reserves. Even refined analytical approaches do not sufficiently capture the simultaneous effect of the concrete and reinforcement contribution on the shear capacity. Hence, it is important to verify the shear capacity of existing concrete bridges with a new improved design approach. In this work, sixteen large-scaled shear tests (16,5 m continuous post-tensioned girders with uniformly distributed loads) have been conducted. To examine the interaction of the concrete contribution and the strut-and-tie model, the specimens were built with low shear reinforcement and varying cross-sectional shapes. Finally, it will be shown that the service time of existing structures can be extended significantly by using the new analytical design approach.

Keywords: shear capacity, prestressed concrete girders, large scale, recalculation, bridge, Eurocode

1 Shear design of reinforced concrete girders with small amounts of shear reinforcement

The shear design according to EC2/NA(D) [1] as well as the derivation of the design approach are not suitable for determining the shear reserves of existing prestressed concrete bridges, because the application of the truss model requires a minimum shear reinforcement. At the time of construction of most bridges in Germany, the design was based on the main stress criterion, which differs from the design according to today's standards, resulting in a significantly lower amount of shear reinforcement. Therefore, there is an urgent need for more detailed design models with an accurate determination of the shear resistance. Extended design approaches have already been formulated in the German recalculation guideline, but they do not answer all remaining questions regarding the various influences on the shear resistance.

The current shear design according to EC2/NA(D) [1] of reinforced concrete structures distinguishes between three verifications: the verification for beams without shear reinforcement (Eq. (13)) as well as the verification of shear reinforcement (Eq. (4)) and verification of compression strut according to the truss model (c.f. Table 1). According to EC2, the shear design for beams with shear reinforcement is carried out solely by a truss model with variable compression strut inclination [2]. According to the plasticity theory, the compression strut angle can be chosen within fixed limits. In contrast, the National Annex for Germany uses a truss model with crack friction (Eq. (9)) [3], which considers a transmission crack friction force along the shear cracks with an minimum compression strut angle of 30° ($cot\ \theta \leq 7/4$) [4]. The effect of the inclined tendon may be considered.

With the introduction of the German recalculation guideline (German: Nachrechnungsrichtlinie, NRR) [5], a four-staged verification procedure was introduced for the evaluation of existing bridges, which allows extended design approaches in stage 2 and alternative scientifically based calculation methods in stage 4. Among other things, modifications in the shear design are permitted, which were stipulated in the old generation of standards (Eq. (7),(10)) ([6] before 2003). In a research project [7–9], short-term solutions for the modification of existing design approaches were developed due to the lack of uniform regulations. The results were the basis for the first amendment of the NRR [10] in 2015. The application to real structures and tests showed an improved determination of the shear resistance, but structures with low shear reinforcement ratios were still assessed conservatively. In order to enable an accurate assessment of the shear resistance of older bridges

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The Evolution of the Indian Standard IS 1893 Focusing on Base Shear Values of Seismic Forces for a Forty-Three-Storey Reinforced Concrete High-Rise Building Using the Response Spectrum Method

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Abstract

Comparative studies of the old Indian standard IS 1893:2002 and the existing IS 1893:2016 have been presented for high-rise buildings in India; however, they have not been presented for high-rise buildings in Sri Lanka. This case study compares the old and existing IS standards, as well as Australian standard AS 1170:2007, and EURO code EU 8:2004, in terms of lateral effect focusing on the base shear values of seismic forces on a 43-storey high-rise building with three basement levels located in Colombo, Sri Lanka. This project was analyzed and designed in 2006; however, only bored pile load testing and tangent pile walls were completed before the project was suspended. This comparative study of the building uses the response spectrum method, which was performed by ETABS 18,1,1. The purpose of this paper is to identify the major changes in the evolution of IS 1893, and how the revisions have made IS 1893:2016 a more reliable earthquake code than IS 1893:2002.

Keywords: IS 1893:2002; IS 1893:2016; base shear values; response spectrum method; high-rise building.

1 Introduction

The evolution of the seismic design procedure can be summarised in three main phases [1]. The historic approach was to assume the design seismic forces are proportional to the seismic mass of the structure, whereas in the conventional code, these design seismic forces are calculated as inertial forces induced by the ground acceleration. Both of these approaches are based on the force-based design concept. However, the future trend is to adopt a displacement-based design approach where the non-linear response of the structure is taken into greater consideration [2]. Based on performance analyses of structures during past seismic events, considerable advancements have been made over the years in earthquake resistant design of structures, and seismic design requirements in building codes have steadily improved. Therefore, seismic codes need revision from time to time. Buildings designed in accordance with earlier versions of codes may be checked to establish whether existing buildings are safe for carrying out recommendations made by the revised codes [3]. This study focuses on the evolution of the Indian standard IS 1893 using the response spectrum method. It compares the seismic analyses for different provisions of the old IS 1893:2002 [4], the existing IS 1893:2016 [5], EURO code EU 8:2004 [6] and the Australian standard AS 1170:2007 [7] in terms of base shear values of seismic forces. The structural model was an ordinary reinforced concrete (RC) building with shear walls (SW). The study was performed on a 43-storey high-rise RC building with three basement levels located in Colombo, Sri Lanka [8,9]. This project was analyzed and designed in 2006; however, only bored pile load testing [10,11,12,13] and tangent pile walls [14] were completed before the project was suspended (Fig. 1).

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Influence of train composition on crack propagation at structural components of welded railway bridges

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Abstract

The application of fracture mechanics allows a detailed assessment of structural details of existing railway bridges. By using crack propagation calculations, the residual service life and respective safe inspection intervals can be determined. For this purpose, cyclic loading due to train passings is needed as an input parameter. Furthermore, an initial crack length and material parameters need to be assumed. In this paper, the focus lies on the loadings generated by each passing train. The influence of single trains as well as the composition of trains and their order on crack propagation is investigated. Train models in the Eurocode [1] are considered and the effects are analysed in the frame of linear elastic fracture mechanics. Combined with the span length, the influence of service trains is varying and an impact of train composition is present. Sequence effects are if at all only slightly visible and therefore may be neglected within the considered calculations.

Keywords: welded railway bridges; linear elastic fracture mechanics (LEFM); crack propagation calculations; train composition; load sequence effects; assessment of existing bridges; Paris' law.

1 Introduction

A variety of concepts is available for determining the residual service life of existing railway bridges. In many cases, the application of the nominal stress concept with the corresponding S-N curves results in too conservative results. This in turn leads to very short calculated remaining lifetimes or a verification is not possible at all. By applying methods based on linear elastic fracture mechanics (LEFM), a more detailed analysis is possible, which results in more realistic lifetimes and therefore more sustainable assessment. This includes the derivation of inspection intervals ensuring a controlled crack growth and thus a safe operation between two intervals. For this purpose, crack propagation calculations are conducted, using an assumed initial defect size. Based on the stress intensity factor at the crack tip, the stepwise growth of the crack due to cyclic loading can be described by the Paris' law. The risk of brittle fracture is covered by means of the failure assessment diagram (FAD). As input parameters, the acting stress ranges as well as an initial defect size and material parameters are needed.

This paper focuses on cyclic loading due to train passings and resulting crack propagation. Each train generates several applied forces, depending amongst others on the distance between the axles and the axle loading. From the resulting time series of stresses, the corresponding stress ranges can be obtained by rainflow counting. These must be endured by the considered construction detail. Obviously, assumptions of the characteristics of

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Addressing Climate Resiliency in Long Span Bridges Through Early Stage Aerodynamic and Climate Consulting

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Abstract

New long span bridges must be designed for climate resiliency based on historical records and long-term predictions. Existing bridges must be rehabilitated for climate resiliency to ensure safe operation and increased longevity. A multi-hazard assessment combined with bridge monitoring, wind tunnel studies and numerical analysis can provide an accurate picture of the current state of the bridge as a whole and specific components of the bridge including cables, deck, and hangers. Bridge microclimate past, present and future can be modelled, and climate scenarios can be applied to a digital model of the bridge to predict the response of the structure to the windstorms of tomorrow and to develop a framework of climate change adaption.

The authors will illustrate how aerodynamic and climate engineering consulting can inform decisions about the design and rehabilitation of long span bridges using case studies. Aerodynamic and climate consulting early in the design process contributes to both design, material, and carbon cost savings. Aerodynamic consulting and climate (weather) forecasting in construction stage planning ensures safe, efficient, and cost-effective construction of a bridge or a bridge rehabilitation plan.

A case study of the design of a new signature long span bridge, case studies of bridge cables and hangers and a case study of a bridge rehabilitation will be detailed to outline the benefits of early stage aerodynamic and climate consulting.

Keywords: Bridge Aerodynamics, Bridge Microclimate, Wind Effects, Bridge Rehabilitation, Carbon Footprint

1 Introduction

In recent years and even more in the last 3 years it has become apparent that aerodynamic studies targeting performance goals of long-span bridges are not limited to the detail design phase of new structures. There is a societal push globally to rehabilitate major bridges to adapt to their current and future use and to extend their design life.

In fact, aerodynamics studies are now carried out throughout the entire life cycle of a bridge, from the planning, conceptual design, detail design and construction phases to the in-service phase for safe operations and rehabilitation phase into a new configuration involving changes to the deck cross-

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Climate Change: Latest on the Wind Speed at the Coastal Regions of India

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Abstract

Indian sub-continent is subjected to many severe windstorms and the Indian coastal belt, especially the east coast is threatened by cyclones that have been known to cause damage to structures. However, the root cause of the damage cannot often be equated to high wind speeds exceeding the standard prescribed design wind speeds; but rather linked to lack of maintenance, poor workmanship, improper standard provision application, and poor standard enforcement.

Note that the frequency of occurrence and associated intensity of storms are the key data required to determine the design speed at a specified risk level with confidence. The lack of cyclone data measurements at landfall is a serious anomaly worldwide including in India, which hinders the development of design speed with confidence. Advanced tropical cyclone wind simulation models have been successfully developed for some tropical cyclone-prone regions.

In our recent studies, the design wind speeds corresponding to various risk levels were determined based on (i) the number of years of full-scale measurements from airports, (ii) numerically simulated data, as well as (iii) the fast-predictive cyclone wind hazard model. Based on all these studies, it is proven that the current recommended cyclonic factor (k4) in IS 875 (Part 3) will make the wind speed overly conservative. In summary, though the number of storms is on the rise in India, climate change is not warranted to increase the wind speed; at least in the coastal zones yet.

Keywords: climate change; cyclone; India; wind-induced damages; wind speed.

1 Introduction

Climate change is a reality, and how it impacts negatively various aspects of life on our planet is mounting much faster than what researchers and scientists predicted earlier. According to the latest climate change report from Inter-governmental Panel on Climate Change, IPCC [1], most of the impacts are unavoidable and will hit the world's most vulnerable populations in a drastic way. The report also says that more than 40% of the world's population live in places and situation that are highly vulnerable to climate change. Moreover, the assessment report also states that Earth is warmer than it's been in the last 125,000 years. The impact of climate change is affecting us in various ways like an increase in atmospheric temperature,

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Functional Seismic Resilience of Reinforced Concrete Building Conforming to Indian Standards

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Abstract

Functionality and recovery are important resilience attributes but not considered in existing building design and assessment approaches. The study presents different resilience-based metrics based on probabilistic seismic resilience assessment of an archetypical IS code-conforming reinforced concrete building to gain insight in their repair cost, functionality, and recovery performance. This study uses the performance-based earthquake engineering framework. Assessments are conducted for several intensities ranging from return periods of 50 to 9975 years. The results reveal that the IS code-conforming building meets collapse prevention and life-safety objectives. However, time for reoccupancy after a design-level event is about 13 days, while it takes 6 months for functional recovery which may not be acceptable for critical buildings. The study shows that including functionality and recovery-based objectives is essential for design of such buildings.

Keywords: Functionality assessment; Seismic resilience; Building reoccupancy; Functional recovery; Code-conforming building; Recovery curve; Performance-based earthquake engineering.

1 Introduction

Modern code-compliant buildings perform better in meeting collapse prevention and life-safety objectives but often fail to be reoccupiable and functional for unacceptably long time [1, 2]. These buildings are designed using life safety-based prescriptive standards, which do not control functional recovery after earthquakes. Maintenance of functionality is a very important attribute of resilience since long downtime can significantly add to indirect losses. Performance-based earthquake engineering (PBEE) framework provides an opportunity to incorporate functionality and recovery parameters and access resilience of buildings. Only a limited number of studies [2–8] have attempted to evaluate functionality and recovery performance of buildings. Molina Hutt [3] evaluated the seismic loss and recovery assessment of a 40-story tall archetype buildings and presented different strategies to achieve higher levels of resilience. Cook [9] evaluated the functional performance of reinforced concrete (RC) archetypes and assessed the impact of different design strategies to limit post-earthquake downtime. Molina Hutt et al. [2] found that tall buildings designed under current standards may require up to 7.5 months of repair to regain functionality after a design-level earthquake. They also evaluated the role of more stringent drift limits and other measures to reduce building downtime. Terzic and Kolozvari [4] evaluated the functional recovery performance of a 42-story RC core wall building and found the need for the development of design requirements that consider post-earthquake functionality of tall buildings. Badal and Tesfamaraim [5] assessed the baseline resilience of Canadian code-conforming RC moment frame buildings, developed housing occupancy trajectory, and found that restoration of

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Influence of Design Practices and Climate Change Effects on the Seismic Fragility and Life-Cycle Cost of Highway Bridges

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Abstract

Over the past several decades seismic design practices of highway bridges have undergone a considerable change from typical non-seismic design to adoption of modern ductile detailing principles. Despite such advances in structural design, bridge structures around the globe continue to be exposed to deteriorating agents from the surrounding atmosphere. The ill effects of these environmental stressors are likely to be further compounded from potential climate change scenarios as the bridge continues to age along the service life. For bridges across different design era that are exposed to unfavorable environmental conditions, climate change settings, and simultaneously situated in moderate to high seismic zones, a renewed systematic assessment of seismic fragility and life-cycle cost is required. These estimates will facilitate informed decision making and efficient channeling of monetary resources for structural upgrade and repair. In this context, the present study proposes a novel framework to compare the lifetime seismic losses of highway bridges considering earthquakes hazard, seismic design era, aging effects, and global warming due to climate change. The proposed framework is demonstrated on a non-seismically designed case-study multi-span continuous (MSC) concrete girder bridges located within Central and Southeastern United States. This bridge comprises of multiple bridge components that are also prone to the adverse effects of environmental degradation. Results reveal substantial deviation in lifetime seismic losses and fragility when expected future climate changes are neglected.

Keywords: Seismic life-cycle cost analysis; seismic fragility; chloride-induced deterioration; climate change effects; climate change projections.

1 Introduction

Refurbishment, maintenance, construction, repair, and replacement decisions for civil infrastructure systems may have an impact for up to 200 years. Therefore, it is imperative to consider future climatic circumstances while making decisions on building upkeep or during the design stage, as well as the related financial commitments. This may be primarily attributed to the long-term passive effects of climate change on the performance of reinforced concrete (RC) structures (Wang et al. 2010, Stewart et al. 2011). In light of the aforementioned findings, modern researchers, including TRB (2014), Dong & Frangopol (2016), Frangopol et al. (2017), and Li et al. (2020), among others, investigate frameworks to assess the economic loss costs of highway bridges under multiple hazards that take climate change effects into account. Recently, Mortagi & Ghosh (2020) explained how important it is to take climate change into account when developing ageing

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Understanding social engineering and disaster resilience of the rural roads sector for sustainable development

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Abstract

With the rising number and increasing severity of natural disasters globally, there is a growing need to engineer solutions to facilitate climate change adaptation and systemic disaster resilience. This is especially for the rural roads sector: when road embankments, culverts and bridges are affected by changing rainfall intensity and patterns, marginalised and poor vulnerable communities in rural areas lose access to basic infrastructure services such as roads connectivity thereby suffering the most from inundations and induced damages to their lives, livestock and livelihoods. Through the analysis of various innovative case studies, the authors highlight poverty alleviation centric approaches, materials and technology for building disaster resilient infrastructure in the rural roads sector.

Keywords: Disaster Risk Reduction; technology choice; infrastructure resilience; community contracting; nature-based solutions; innovative local resource-based approaches; rural roads asset management

1 Introduction

It is commonly understood that a *'new normal'* of living with extreme events has emerged whereby globally there is an increase in patterns reflecting higher frequency, severity and uncertainty of natural disasters. This leads to loss of lives, negative impacts on local economies, livelihoods and unprecedented damage to physical infrastructure. As per the recent findings of the IPCC report [1], the effects of climate change are '*here to stay*' as natural hazards including floods and cyclones disproportionately intensify. These trends are irreversible. At the same time, as the Global Assessment Report on Disaster Risk Reduction 2022, many targets from the Sendai Framework may not be achievable by 2030 at the current rate of progress [2]. With such rising uncertainty for communities and decision makers, there is an urgent need to explore risk-informed innovative strategies, adaptive pathways and solutions at all governance levels to adapt to varying climate change induced shocks for resilient sustainable development. One starting point can be to devise social engineering solutions for resilient infrastructure contributing to physical, economic and community resilience.

2 Rural infrastructure resilience for sustainable development

To achieve a growing, thriving, resilient and responsive economy and civil society, it is necessary to build and maintain resilient infrastructure that can act as a "buffer" to internal and external shocks. When deriving and ideating solutions for infrastructure resilience, it is necessary to view the latter from a systemic

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Modular Steel Panel Bridges for Optimal Emergency Response to Distressed Bridges on National Highways in India.

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Abstract

Bailey Bridges which were very successfully used in World War II may be considered the first generation of Modular Steel Panel Bridge (MSPB) and have been the only solution for emergency response to distressed bridges in India. These have today become unsafe with increase in axle loads and act as chokepoints on double-lane roads leading to huge economic losses.

A look at the improvement in this technology shows the world has graduated to 3rd Generation MSPBs. The first such bridge was launched in India in 2016 under challenging conditions, which is well documented. An overview of this gives a good insight into the capabilities of this bridge.

There is an impressive range of possibilities of using such bridges both as permanent bridges and as temporary detours in emergencies. The way forward to speedy 'Disaster Mitigation' and timely response to critical bridges in distress, is to create ready stocks of such bridges closer to where they are likely to be required. It is an important step which needs planning and preparation. One must move towards making these bridges in India with a conscious strategy of closing the existing capability gap quickly and incentivising manufacture of better modular bridges in the country. This can be speeded-up by overcoming resistance to change. Understanding these blocks in introducing new technology is an important lesson learnt from this first-hand experience in introducing 3rd Generation Modular Bridges for the first time in the country, and exploring further use.

Keywords: Modular-bridges; MSPB; bailey-bridges; continuous-span; permanent-bridges; emergency-bridges; Acrow; detours; ROBs; restricted-launch.

1 Introduction

Modular Steel Bridges have standardized parts that are factory manufactured which can readily be transported to the construction site for installation and facilitate accelerated bridge construction. Depending on the span the number of modules can be increased. Based on the loads and stress generated, the truss can be strengthened using the same basic components. Option of various standard widths are also allowed by some manufacturers. Typically, a 3rd Generation Modular Panel Bridge can give you a permanent bridge up to 65m span, for two lane traffic, designed to IRC specifications. The design, transportation and assembly are speeded up without compromising on quality using these bridge systems.

A modular bridge is not a new concept in India. The Bailey Bridge may be considered a 1st Generation Modular Steel Panel Bridge (MSPB) and has been extensively in use, especially where launch must be with constraints of time and space, and conventional bridges are not suited in the required timeframe. However, with increased axle loads, these Bailey Bridges have today become unsafe. There is an urgency for better bridges to cover this

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Material Selection for Minimum Carbon Footprint in Structural Design

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Abstract

For quantification of the environmental impact of a project, life cycle assessment is the common and suitable approach, allowing comparison of different design solutions and selection of the most advantageous option. However, as data on environmental impact is typically presented relative to arbitrary reference units, e.g., volume for concrete or tonnage for steel, direct comparison of structural performance versus environmental impact cannot be directly read from the available data. Particularly in the conceptual stages of structural design, material selection should be understood as a multi-objective optimization, where typically a wide range of criteria must be met. These criteria include structural performance such as strength and stiffness, physical properties such as density and thermal conductivity, economic factors such as local availability and cost, and now – in recent decades under the emerging thread of climate change – environmental impact and carbon footprint. For the identification of the most climate-friendly material choice for any given set of structural requirements, the authors propose a systematic approach using graphical representation of the required data of building materials commonly used in structural engineering. Analysed materials include various types of concrete from normal strength to ultra-high-performance-concrete, steel sections and strands, various types of timber, natural stone and industrially manufactured masonry units, as well as fibre reinforced polymers. Presented data is based on a thorough review and selection of life cycle assessment data, addressing gaps of knowledge in existing databases as well as systemic risks in the use of industry-average or product-specific data. With the presented graphical tools for material selection for minimum carbon footprint in structural design, the authors aim to provide the reader with a helpful tool for identification of the most climate-friendly structural solution for their given design problem.

Keywords: structural design; material selection; carbon footprint; global warming potential; life cycle assessment.

1 Introduction

It is no easy task to put into words the urgency, with which humanity has to tackle the causes and challenges of climate change. Presenting the latest report of the Intergovernmental Panel on Climate Change (IPCC) [1], UN secretary general António Guterres found the following words: “This report is a clarion call to massively fast-track climate efforts by every country and every sector and on every timeframe. *Our world needs climate action on all fronts: everything, everywhere, all at once*.”

The report by scientists around the world explains that by merely adhering to currently implemented policies, we are on a path to reaching 1.5° Celsius global warming by the end of this decade and ~3.2°

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Experimental Analysis on The Sustainable Effects of Magnetic Water in Self Compacting Concrete With Partial Replacement of Constituent Materials

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Abstract

In this experimental analysis, conventional Self Compacting Concrete (SCC) of M30 grade was compared to SCC mix prepared with Magnetic Water of 0.8 Tesla in its fresh and hardened states. The Magnetic Water improved workability of concrete by 9.95% and compressive & tensile strength by 12.61% & 12.91%. It also reduced the dosage of viscosity modifying reagent by 13.04% for the same water-cement ratio, improving the efficiency of concrete and there by reducing the cost of concrete. The efficiency of Magnetic Water is further improved with the use of sustainable replacement materials. Copper slag improved compressive & tensile strength by 19.4% & 19.63% at 30% replacement of sand; while Glass powder improved strength by 14.16% & 14.47% at 20% replacement. Copper slag was more effective than glass powder in terms of strength and economy. Fly ash as a cement replacement improved compressive & tensile strength by 17.02% & 17.31% at 30% replacement.

It is evident that improved technique with Magnetic Water coupled with sustainable materials resulted in a more sustainable, efficient and cost-effective concrete production with better workability and strength, resulting in less energy, material waste and lower carbon emissions, giving better long-term performance and fewer repairs.

Keywords: Self Compacting Concrete (SCC); Magnetic Water; Sustainable Concrete; Partial-Replacement; Super Plasticizer; Copper Slag; Glass Powder; Flyash.

1 Introduction

Self-compacting concrete[1] (SCC) is the concrete that flows through the reinforcements and compacts under its own weight without any external compacting forces. A well graded SCC is highly flowable in nature which aids to its filling ability, passing ability and resistance to segregation. In recent years a variety of materials have been used to partially replace the constituent materials of SCC and have been tested so as to make the mix more sustainable - both in monetary and environmental aspects. In this experimental analysis we intend to test the SCC mix made with Magnetic Water[2] in which cement is partially replaced with Flyash[3] at 10, 20, 30, 40 & 50% while sand is replaced with Copper Slag[4] at 10, 20, 30, 40 & 50% and Glass Powder[5] at 5, 10, 15, 20 & 25%.

1.1 Magnetic Water

Magnetic water is the water which is passed through a magnetic field. The term Magnetic water does not mean that the water has gained magnetic properties. It merely means that the

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Water transport properties and Life Cycle Assessment of low-grade fly ash based cementitious materials

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Abstract

In this study, fly ash is used as a replacement for cement in mortar to find its impact on durability indicators and the environment regarding greenhouse gas (GHG) emissions. This study focuses on GHG emissions from the construction materials, strength, and capillary transport of water which is a function of the w/cm ratio, pore size distribution, and curing period. The capillary sorption process showed a very complex time-dependent relationship. The sorptivity and absorption of mortar were found at different w/cm ratios and fly ash replacement. Fly ash replacement showed a negative impact on compressive strength as well as on water absorption due to its similar particle size compared to cement. The secondary absorption rate was lower than ~59 % to 88% compared to the initial absorption rate for all the mixtures. 35 % replacement of cement with fly ash resulted in a ~27% reduction of GHG emissions compared to control mortar mixtures.

Keywords: Compressive strength, Sorptivity, Capillary sorption, Greenhouse gas emissions, pore size distribution.

1 Introduction

Moisture transport in porous media plays a crucial role in the premature degradation of the material through the ingress of deleterious materials like chloride penetration. Cement-based materials are being used worldwide to construct dams, highways, buildings, and other infrastructures. In general, people thinks that cement-based materials have excellent durability, but their durability is a function of the properties of their constituent materials and their content in the mixture and the aggressiveness of the external environment. Also, strength is not only required to increase the concrete structure's service life, but durability is also equally important. The durability of any concrete structure largely depends upon its fluid transport properties through its pore structure which also decides its service life for its intended purpose [1]. Permeability and porosity are the two important properties that deal with the durability of any concrete structures. High-permeable concrete is more vulnerable to chloride and carbonation attack, leading to the corrosion of embedded steel bars in the concrete structure and premature deterioration.

Sorptivity is more general phenomenon as compared to permeability of the porous medium because it occurs when unsaturated paste, mortar and concrete are subjected to water or air moisture whereas permeability of the structure is the ability to transport fluids through its interconnected pore. Sorptivity is also known as capillary suction, is the transport of liquids in porous solids due the surface tension acting in capillaries of the mortar or concrete structure. The rate of absorption is dependent on various factors such as surface tension, viscosity, and density of the liquid in contact with the structure. It also depends on the pore structure i.e., tortuosity and continuity of the capillaries in the concrete structure. Sorptivity of the porous concrete structure provide an engineering measure of microstructure and properties important for the durability of the concrete subjected to various detrimental environment conditions. Various research is being conducted to make concrete more durable. Mineral admixtures also affect the absorption

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Different strategies for setting requirements for sustainability

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Abstract

The construction industry significantly impacts climate, environment, and society and should consider how best to respond to the present challenges. This paper aims to investigate what requirements clients are setting for sustainability and to discuss what strategies might be more efficient when setting those requirements. The paper draws on findings from screening sustainability requirements in recent tenders for large infrastructure projects. It has been analysed to what extent clients tend to add specific project requirements and focus on collaboration to reduce the project's CO_2 footprint. This is supplemented by findings from a case where a client changed the collaboration model to partnering to achieve a more sustainable project. The different strategies have different benefits and consequences, which should be considered in relation to the project context.

Keywords: Sustainability, collaboration, innovation, requirements, carbon reductions.

1 Introduction

The construction industry has a significant impact on our society and environment. The building- and construction industry accounts for 39% of the global carbon emissions, of which 11% stems from embodied carbon (1) and 8% from cementitious materials (2). The industry uses approx. 25-40% of the global use of virgin materials (3) impacts 29% of threatened species, and near-threatened species (4), and 13% of the world's GDP stems from this industry (5). At the same time, we experience rapid urbanisation and, thereby, infrastructure. The construction industry is forecasted to grow on average by 3.6% per annum over the decade to 2030 – higher than the manufacturing or services sectors (5).

This all calls for the industry to address its negative impact and enhance the value delivered to society, climate, and the environment.

Engineers hold the knowledge and capabilities to support a transition to a more sustainable society (6), and this should be used to help clients and communities to become more sustainable (7) through innovation and collaboration across the value chain.

Sustainability includes many factors, e.g., acidification, land use, biodiversity, and social impact. This paper focuses on initiatives to reduce the embedded carbon footprint stemming from materials, incl. extracting, transporting, manufacturing, and installing materials on site. It is often referred to as Life Cycle Assessment, but only with a focus on the GHG emissions from production and construction phases (A1-A5). However, the resources investigated for this paper do not always clearly define this.

In the early planning and design phases, we have a real opportunity to reduce carbon (8). It is recognised that the professionals in the industry

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Steel Fibre Reinforced Concrete for Sustainable Construction

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Abstract

Steel Fibre Reinforced Concrete (SFRC) has gained significant popularity in the construction industry due to its enhanced mechanical properties and cost-effectiveness compared to traditional reinforced concrete. The use of SFRC has increased in recent years in various applications, such as industrial floors, tunnel lining segments, precast elements, and special load bearing structures such as foundation rafts on ground or on piles. The aim of this paper is to provide an overview of SFRC in today's Finnish construction industry, highlighting its benefits but also the challenges. This paper also deals with the sustainability of material, with the efforts that are being made to introduce green steel fibres made with recycled material and their production from green source of energy, which in the end will have less embodied carbon footprint.

Keywords: SFRC; steel fibres; green steel fibres; recycled steel fibres; GWP; sustainability

1 Introduction

1.1 Context

Our planet faces multiple environmental challenges and one of this is certainly excessive use of natural resources threating the sustainable development [1]. Use of material such as steel (7...9 % of total global CO_2) and concrete (7 % of total global CO_2) are big part of CO_2 emissions [2]. To reduce the amount of steel material and to use if even more effectively alternatives to conventional reinforced concrete the steel fibre reinforced concrete (SFRC) has been extensively studied in recent years, and numerous research works have been carried out to investigate its mechanical properties, durability, and behaviour under different loading conditions. This literature review provides an overview of the research works related to SFRC in today's construction industry, highlighting its benefits, challenges, and prospects.

To give a concrete example of material reduction, let's take an example of 3 m deep 500 mm thick raft on piles under the road carrying a pipeline is subjected to approximately 150 kPa of vertical ULS distributed load. The amount of steel necessary to satisfy all the design requirements, we typically need around 125...150 kg/m^3 of conventional rebar steel. The same structure under similar loading conditions can be carefully designed with couple of more piles and by keeping the same raft thickness, and with a dosage rate of end-hooked high-performance steel fibres of range 40...55

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Methods for ensuring the sustainability of steel heritage bridges

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Abstract

This paper describes the results of the NAKI II project of the "Methods for Achieving Sustainability of Industrial Heritage Steel Bridges" which has been carried out over the last 5 years. It deals with the diagnostics results presents the overview of the load tests done and assessment results, including the coating application. The strengthening methods are presented, with the focus on the SMA materials. It is shown, that we have still many hidden reserves in the load capacity of heritage bridges, and if proper methods are chosen, the durability can be much longer, then predicted 100 years.

Keywords: Industrial heritage, steel bridges, load test, fatigue.

1 Introduction

Bridges are part of every route, whether for rail, highway, cycle or pedestrian traffic. They are large structures that complement the landscape or urban character of cities. The second half of the 19th century brought a boom in railway transport in the Czech republic. It was at this time that many railway bridges were built. They were stone or brick bridges with small spans. For larger spans, steel bridges were made. Some of them are still in use today. Mostly they are found on local lines or less frequented routes.

Approximately 400 bridges are protected, four bridges are national cultural monuments and others within urban heritage protection areas. However, age has left its mark on many bridges, particularly in the form of corrosion or the development of cracks. Many valuable metal bridges are not listed and, as a result of their rapidly declining physical integrity, an important

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Revitalization of the historical bridge over the Mała Panew River in Ozimek – the oldest chain suspension grey cast iron river-crossing on the European continent

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Abstract

Renovation methodology applied to protect the historical chain suspension bridge made of grey cast iron and erected in the years 1825-1827 over the Mala Panew river in the vicinity of Opole is presented and discussed in detail. This bridge crossing, of unique structure, is currently recognized as the oldest cast iron suspension bridge erected on the European continent (excluding British Isles). Special attention was paid to analyse the weakening of main bearing components induced by gradual degradation of the material properties during their extremely long service time. Replacement of several worn out and cracked links in the bearing chains proved to be necessary. As a result of the conducted works the bridge has been sufficiently strengthened and due to that protected against the detrimental influence of possible vibrations. All joints have been renewed and cleaned as well. Currently the bridge is accessible only for pedestrian traffic of limited intensity.

Keywords: cast iron; suspension bridge; renovation; revitalization; material weakening; load chains; cracked links.

1 Introduction

The royal “Malapane” steelworks in Ozimek near Opole was founded in 1793/1794, only 13 years after the Silesia province was conquered by the army of the king of Prussia, Frederick the Great. Already at the end of XVIII century it became known for making cast iron structural bridge elements. The first bridge erected of such elements, based on the Iron Bridge erected in 1779 in Coalbrookdale in Wales, made in these works in 1795, was intended for the estate of Laasan (Łazany) in the vicinity of Żarów in Lower Silesia, to facilitate convenient crossing of Strzegomka river. Other such bridges had been made here in the years 1798-1805 in order to fulfil orders placed at first by Berlin and subsequently by Potsdam. Breslau, a then capital of Silesia, relatively early gained a bridge made in Ozimek. A bridge of this type, designed by Schinkel in 1815, was to be erected over the moat in the neighbourhood of Oławska Gate. However, prior to the erection of this bridge, already in 1822 in the vicinity of this location an analogous crossing had been built on the road leading to the capital Berlin, under a prestigious name of the Royal Bridge. In 1824, due to the changes in water levels on Mała Panew River, a need arose for a modern dam. It was to supply sufficient quantity of water to the Works to power mechanical devices. Two new bridges had to be erected over the channel leading to the Works. These were made of grey iron based on well known and tested structure. This investment included a bridge over the main current of Mała Panew river on the Graff Renard Straße, leading from Opole to Dobrodzień, and

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Femtosecond pulse laser cleaning for the preservation of the Sydney Harbour Bridge

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Abstract

Cleaning with laser light has become a popular technique for the removal of unwanted surface layers. It provides numerous benefits compared to conventional cleaning methods, such as avoiding the use of abrasives and chemicals and eliminating problems of corrosive residues and loss of surface detail. Conventional pulse lasers are the most widely used, and already commercially available, with portable units deployable on-site. However, those lasers rely on thermal mechanisms of ablation, which generate heat and shock waves that can result in undesirable side-effects such as melting, formation of cracks, exfoliation of flakes from the surface, and annealing/softening of thinner sections of the bulk material. Here we explore an alternative heat-free femtosecond laser cleaning technique based on powerful ultrashort pulse lasers. We discuss the capability of the technique, illustrating the significant advantages of femtosecond pulse lasers in removal of old paint and rust without alteration of underlying structure, and discuss the development of a portable femtosecond laser cleaning unit for the maintenance and preservation of large-scale assets around the world using Sydney Harbour Bridge as a real-world field test.

Keywords: Femtosecond pulse laser; femtosecond laser cleaning; heritage conservation; Sydney Harbour Bridge; steel; paint removal.

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Conservation of caves cut in volcanic breccia, Jogeshwari, Mumbai

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Abstract

Jogeshwari caves (5th century CE) marks the transition from Buddhist rock-cut to Hindu rock-cut architecture. It is a predecessor to Elephant and Ellora. Most of the finer features of carvings have not been able to survive thanks to the softer and erodible volcanic breccia. Further complicating the conservation effort is the reinforced concrete retrofits done in the earlier part of the 20th century and the drains emanating from the informal settlements, which had proliferated around the caves.

Conservation of such sites require multiple expertise including civil, structural, geological and environmental. The paper outlines the research and documentation process, presents the documentation, which has used representational and analytical tools like BIM; identifies the concerns/ issues and suggests the possible conservation approaches. Strategies and methods developed for conservation of these caves would also lead to a more reliable approach in the conservation of similar sites. The subject calls for further research and awareness within the engineering and architectural pedagogy and profession.

Keywords: rock-cut caves, urban heritage, Mumbai history, archaeology, ASI

1 Introduction

Rock-cut cave architecture in India is a significant cultural heritage that showcases the country's architectural and artistic achievements. These rock-cut structures were primarily built between the 3rd century BC and the 12th century AD and were used for various purposes such as temples, monasteries, and residences.

One of the challenging aspects of building rock-cut caves is the varied rock conditions in different regions of the country. One such challenging rock condition is the volcanic breccia, which is a type of rock formed from volcanic ash and debris.

Several research papers have been published on the rock-cut cave architecture in India, focusing on the challenges and techniques used in cutting through volcanic breccia. One such paper is "The Rock-Cut Cave Architecture of India: Cutting Techniques in Volcanic Breccia" by N. L. Soni, which provides a detailed review of the literature on the subject.

The paper highlights the techniques used by the ancient Indian architects to cut through the volcanic breccia, such as the use of chisels and hammers made of various materials such as iron, bronze, and stone. The architects also used a technique called "fire-setting," where fires were set at the base of the rock to heat it and then quenched with water, causing the rock to crack.

Another research paper that focuses on the rock-cut cave architecture in India is "Rock-Cut Cave Architecture of India: A Study in Mechanization and Aesthetics" by M. V. Dhaky. The paper discusses the mechanization of the rock-cutting process and its impact on the aesthetics of the structures.

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How an Architectural Gem from 1900 Became "Building of the Year 2020": Alter Wall 2-32 at the Heart of Hamburg, Germany

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Abstract

The listed building complex Alter Wall 2-32 built in 1910 is located at the heart of Hamburg between the landmark City Hall and the canal Alsterfleet tunneled by the railway. During the extensive revitalisation and structural expansion the historic building substance had to be preserved and reused for load bearing as extensively as possible. The listed historic facades were secured by a spatial steel structure, which was reintegrated for load transfer after the erection of the new supporting structure. Behind the historic facades five new basement floors were built under the protection of a deep trough pit withstanding high water pressures and avoiding any but slightest deformation during the excavation process. About 10.000 m² of retail space and around 18.000 m² of office space were created. For these efforts the planning team won the "Building of the Year Award" in 2020.

Keywords: Listed buildings, deformation, trough building pit, diaphragm walls, plug-in girders, multi-layer bracing, spatial steel construction, wooden piles, pedestrian bridge

1 Listed Inner City Building Complex

The building complex Alter Wall is situated on the namegiving vibrant major city boulevard in the immediate vicinity of Hamburg's City Hall and Stock Exchange. It stands in the tradition of the traditional merchants' office buildings from the turn of the last century, characterized by rich architectural details that made it one of the most expensive building complexes of that time. It was built between 1905 and 1910. (Fig. 1)

The row of listed buildings from house 2-32 were originally used as merchants' offices and later by a bank. Houses 2-8 are fully listed buildings. For the buildings 10-32 a core renovation was carried out, whereby the listed facades on the street side had to be completely preserved. The constructions behind the listed facades of buildings 10-32 could not be preserved and reused due to different

Figure 1. Hamburg, Alter Wall, about 1910

levels and insufficient load-bearing capacity of the ceilings. An eight storey new building was erected behind the historic facade, based on a five storey public underground car park.

The new development comprises around 10.000 m² of retail space and around 18.000 m² of office space.

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Femtosecond pulse laser cleaning of Makrana marble and semi-precious stones for the preservation of the Holy Samadh

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Abstract

This study examines the use of heat-free femtosecond pulse laser technology for the cleaning of Makrana marble and semi-precious stones from the Soami Bagh Samadh temple in Agra, India. We determined the ablation thresholds of the semi-precious stones used in the inlay stonework with femtosecond laser pulses and demonstrated that laser ablation can effectively remove dust layers and environmental staining from the marble surfaces without damaging the original material. We demonstrated, by using optical microscopy, colorimetry, scanning electron microscopy and Raman spectroscopy, that femtosecond laser processing of surfaces reduced the risk of thermal damage due to minimal heat generation and allowed the preservation of the original surface structure. This research suggests that femtosecond pulse laser technology can be a sustainable and effective cleaning method for heritage places such as the Holy Samadh temple.

Keywords: femtosecond pulse laser cleaning, heritage conservation, marble, built heritage, sustainability

1 Introduction

Lasers have become a popular tool for the restoration of cultural heritage places around the world [1, 2]. Lasers present various benefits compared to more conventional cleaning methods. Compared to sandblasting, one of the most common methods, lasers offer more control over the depth of removal, and precision for small-scale conservation work. Grit blasting produces fine dust particles that may cause respiratory problems to the operator. Moreover, dust and debris can have negative impacts on the surrounding environment, especially if the site is located near waterways or vegetation. Chemicals are highly effective cleaning method but can be hazardous for the operators and requires special handling and disposal measures. Chemicals also pose environmental concerns due to their toxicity to the ecosystems and can be very expensive.

Lasers offer a more sustainable option for conservators. By means of touch-free delivery of electromagnetic laser energy to the surface, laser processing does not rely on any additional specific substance like chemicals, grits, or water to clean surfaces. Consequently, the reliance on potentially toxic, non-degradable, or non-reusable resources is avoided. Requiring electrical power to operate, laser cleaning is more respectful of the environment and waste collection and management is easier. Therefore, laser cleaning mitigates the consumption of energy, resource use, and production of waste.

The most common lasers in conservation today rely on pulses of light in the time range of

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Bridge Management Analytics Focused On Sustainability And Economic Growth

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Abstract:

The transportation sector in various countries are facing the daunting challenge of sustainable development. In recent times, bridges on the network are experiencing failure. Sufficient data is available for analysis and comparison between different bridges. Very little data is available on the contribution of the existing bridge towards economic growth over the years. Life cycle cost analysis [LCCA] for bridges is carried out before actual construction to decide on the commercial viability of bridge construction. LCCA also needs to be carried out to reflect the changes in the scenario emerging from dynamic behaviour in bridge structure. This dynamism of the bridge is captured within Global Analytics for Bridge Management [GABM]. GABM is oriented towards fulfilling the objectives of sustainability, the process also ensures economic growth. GABM has maintained the focus on rehabilitation intervention which helps in evaluation of impact on sustainability. Tangible and intangible IRR ensures sustainability is maintained without compromising economic growth.

Keywords: Global Analytics for Bridge Management**,** Unified Bridge Management System, LCCA, Sustainability.

1 Introduction

The life-cycle cost analysis (LCCA) approach is used to calculate the overall cost of infrastructure ownership. Bridges, within the array of infrastructure projects are the focus of this research. LCCA includes all expenditures associated with purchasing, owning, and disposing of a bridge structure. It is notably beneficial for comparing project options that meet the same performance criteria but differ in terms of initiation and operation expenses; to choose the one that optimizes net savings. The goal of LCCA is to evaluate the total costs of project choices and to select the design that ensures the infrastructure has the lowest overall cost of ownership while maintaining quality and function.[1,2] To reduce life-cycle costs, LCCA should be performed early during the design process, when there is still time to alter the design. The first and most challenging task of an LCCA, or any economic evaluation technique, is to assess the economic implications of alternative structure and its system designs and to quantify and describe these impacts in monetary terms. One of the primary objectives of the Bridge Management System [BMS] is to optimize expenditure utilization by maintaining a balance between preserving a sustainable environment and managing the economic benefits of bridge constructions with a longer life length. It should ensure that the sustainability qualities of any bridge project are maintained throughout its life cycle, including maintenance, rehabilitation, restoration, and replacement.[3,4] The application of Life-Cycle Cost Analysis [LCCA] provides sustainability management throughout infrastructure design and maintenance. LCCA is used to analyze the overall financial cost of bridge project choices and to select the design that ensures the bridge has the lowest cost of ownership consistent with its quality and function. If the advantages of Social, Economic, and Environmental aspects of the bridge project are also considered, LCCA becomes more viable. Global Analytics for Bridge Management [GABM] enables bridge management teams to achieve the delicate

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Sustainability and Innovation in Design of Major Bridge Substructures

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Abstract

Major bridge substructures like anchor blocks for suspension bridges and large offshore foundations for bridge towers and piers are generally exposed to very significant loads. Therefore, to achieve sustainable and resilient solutions for design of such structures, careful optimization of material consumption and adaption to the actual boundary conditions are needed. Also, accidental loads like earthquake and ship impact can be important design drivers.

This calls for adaptation and innovation to find sustainable, resilient, and durable substructure solutions which can also be constructed fast and efficiently. This is illustrated by examples from COWI's history of substructure designs comprising a variety of solutions ranging from caissons to pile foundations and open dredged foundations.

Keywords: Substructure; sustainability; caissons; piles; suspension bridge; cable stayed bridge.

1 Introduction

For major bridges and in particular when such bridges cross deep waterways very significant investment in the substructures is required. Therefore, optimization in the design to reduce quantities and construction equipment is essential. However, since the substructures are always on the critical path in the construction program also optimization in relation to fast-track, construction is essential.

The aim to reduce quantities and in particular concrete is in itself leading to improved sustainability and reduced CO_2 equivalent emissions. However, also use of existing construction facilities and local materials plays an important role. This will be demonstrated by examples from COWI's history of substructure designs in the following.

The substructure designs can generally be divided in three main categories comprising concrete caissons, pile foundations in steel or concrete and open dredged concrete foundations.

2 Caisson foundations

Concrete caisson foundations have been used for a number of major bridges designed by COWI as shown in the examples below.

2.1 Great Belt East Bridge

For the Great Belt East Bridge in Denmark, having a main suspension span of 1624m, the foundations for both the towers and the anchor blocks were based on caissons as shown in Figure 2-1 and Figure 2-2.

The soil is competent clay till or marl. Therefore, the main design issue was to achieve sufficient effective weight to transfer the large horizontal forces from ship impact of 670 MN at the towers and 540 MN from the main cable pull at the anchor blocks. As illustrated in the Figure 2-1 and Figure 2-2 the main contribution to the effective weight of the foundations is ensured by use of sand ballast and for the anchor blocks also iron ore and olivine to balance the overturning moment from the cable pull. Sand was locally available and iron ore and olivine were delivered by ship from Norway. In this

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Halsafjorden Suspension bridge on floating foundation. Design and CO2 emission.

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Abstract

Halsafjorden is an about 2100m wide and 490m deep fjord part of the Ferry free E-39 project in Norway. A two-span suspension bridge supported by a Tension Leg Platform is proposed for the crossing. Reducing the span compared to an ordinary long span suspension bridge opens for use of a conventional single box aerodynamic bridge deck, instead of a twin box deck needed for long span suspension bridges. Thus, the overall weight of the superstructure is reduced, while the complexity and material use increase for the substructure due to the floater system. The proposed design covers all relevant loads, including ship impact. Metocean loads were derived from a long-term analysis based on the extensive wind and wave measurement campaign started in 2017 and still ongoing. Wind tunnel test of the deck were performed to obtain aerodynamic input for the analysis. Local FEM analysis was used to verify complex areas of design. The design was done in close collaboration with the architect to secure a visually attractive structure. Offshore foundation design was challenging, but a reliable design was possible due to performing offshore ground investigations. Based on proposed design and construction method and EPD material data, CO2 emission was calculated and compared to reference projects.

Keywords: Suspension bridge; Multi-span bridges; Tension Leg Platform (TLP); Quantities; CO2 emission; time domain analysis.

1 Introduction

Halsafjorden is a wide and deep fjord, where the seabed goes down to approx. 490m depth. The shortest distance across the fjord is approx. 2.0km and a suspension bridge supported by a tension leg platform (TLP) is proposed as one of several options. The concept then consists of steel floaters that carry a 2-span suspension bridge, see Figure 1-1 and Figure 2-2. The asymmetrical spans are dictated by the floating tower's position in axis 3 with the necessary safety distance of 40 m to the underwater cliff to avoid the risk of rock fall that could damage the anchor system which result in asymmetrical spans of 1020m and 1060m respectively. Approach viaducts on each side is of prestressed concrete (715m and 420m long).

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A comparison of the resource-efficiency of different reinforcement concepts motivated by tunnel segments

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Abstract

In view of ongoing climate change and the limited availability of resources and energy, efforts in optimizing newly built structures are crucial to improve the resource-efficiency of the construction sector. Tunnels with a segmental lining offer great potential for such efforts. Therefore, the Institute of Structural Engineering at TU Wien developed a reinforcement concept to increase the ultimate load of a tunnel segment by adding butt-jointed reinforcement bars in the longitudinal joint.

To evaluate the beneficial effect of the new concept, cylindrical specimens with varying reinforcement concepts and materials, respectively, were tested at TU Wien. By putting the results on the ultimate load in context with the global warming potential (GWP), the performance of concepts with butt-jointed reinforcement bars and confining reinforcement compared to plain concrete or concrete with steel-fibers is quantified.

Keywords: reinforcement concepts; material input, ultimate load, global warming potential (GWP), resource-efficiency

1 Introduction

The construction sector accounts for a significant share of the world's resource and energy consumption, which has a major impact on the environment. To improve the resource-efficiency and thus reduce the sector's impact on global warming, attempts to optimize the use of materials in new constructions play an important role in planning and designing. Nevertheless, in infrastructure projects, the optimization of individual structural elements is rather uncommon, as the structures are characterized by a high degree of individuality. This is due to the strong influence of local conditions in these projects. Tunnel structures constructed with a segmental lining consisting of a huge number of identical elements, however, offer great potential in improving the overall resource-efficiency by optimizing the prefabricated tunnel segments. Accordingly, the design of tunnel segments and the longitudinal joint, especially, are subject to ongoing research.

1.1 Reinforcement concept developed at TU Wien

A reinforcement concept has been developed at the Institute of Structural Engineering at TU Wien that allows the load-bearing capacity of a segment to be increased by installing butt-jointed reinforcing bars in the longitudinal joint. Thereby, parts of the compressive force can be transferred from one segment to another through the additional butt-jointed bars. For further technical details on the concept and its application, the reader is referred to [1, 2 and 3].

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Environmental assessment of road construction projects in India: A novel approach

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Abstract

The road sector is one of the basic pillars for national economic growth owing to its role in movement of goods and people across a vast country such as India and can contribute positively towards several sustainable development goals (SDGs). However, conventional road construction methods may hinder country's progress in achieving climate action and environmental SDGs due to substantial raw material requirements, fuel consumption, and associated pollution. The proposed approach connects the bill of quantity (BOQ) of the road with accessible analysis of rates document and India-specific construction materials environmental footprint database. A case study on a 49 km Indo-Nepal border road found that conventional natural coarse and fine aggregates, Portland cement, steel bars, bitumen, and diesel are responsible for the majority of impacts. The study identified environmental impact on six domains per km of the road section. The proposed approach can serve as a template for future LCA studies on road construction, and the information generated can be utilized by decision makers.

Keywords: LCA; Roads; India; Environment; Climate change; Sustainability

1 Introduction

A resilient road infrastructure plays a vital role in the economic and social development and can contribute positively towards multiple sustainable development goals of a country [1]. However, laying down new roadway pavements or maintenance of existing roads is a resource intensive activity resulting in environmental damage through greenhouse gas emissions, air and water pollution, land degradation and consequent habitat fragmentation of biodiversity in the area etc. [2]. The transport sector accounted for around 23% of global greenhouse gas (GHG) emissions globally in 2013 and 30% of overall energy consumption, after the power and heat generation sector, which accounts for 42% [3,4]. Out of this, road development accounts for around 10% of the total GHG emission due to the transport sector [3].

Road development and vehicular movement is responsible for around 161 million metric tonnes of GHG emissions annually in India [5]. Under the Ministry of Road Transport and Highways and the Ministry of Rural Development, the Government of India has initiated several new highway and rural road development projects under which massive amount of road construction will take place over the next decade to handle increasing passenger and freight traffic [6]. All of this can have negative consequences on India's climate and environmental sustainability goals [4].

The road development activities use a massive amount of construction materials along with heavy construction machinery and equipment. Starting with extraction of raw materials from ground, their processing in factories, transportation of ready to use processed materials to road construction site, the use of equipment on site for earthmoving activities and laying down different layers of road

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Innovative Box girder having Footpath at Bottom of Box girder by Cantilevering Soffit slab

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Abstract

Innovative structural forms for medium span bridges are a challenging effort for bridge design engineers especially in built-up area locations, where social impact plays a crucial role. Box girders are flexible forms compared to conventional 'I' girders, in the sense that they can have curved plan as well as varying shape of cross sections. Padaharam bridge at Alappuzha district of Kerala state is such a bridge planned, designed and under construction with superstructure having walkways/pedestrian way underneath cantilevering box girder. This ensued less land acquisition, environmental and social impact. In this paper, the planning, design, and construction of this bridge are introduced. The cross-sectional features of the box girder, the structural analysis of the superstructure and its constructional techniques are discussed in this paper.

Keywords: Box girder; Land acquisition; National Water Way; High Embankment; Land Span.

1 Introduction

There have been relentless efforts from Bridge Engineers to provide cost-effective structural solutions. Box girder bridges are a type of bridge in which the main beams comprise girders in the shape of a hollow box. Box girders are efficient form of construction for bridges because it minimizes weight, while maximizing flexural stiffness and capacity. The box girder normally comprises prestressed concrete, structural steel, or a composite of steel and reinforced concrete.

Analysis and design of box-girder bridges are very complex because of its three-dimensional behavior consisting of torsion, distortion and bending in longitudinal and transverse directions. The longitudinal bending stress distribution in wide flange girder is distributed non-uniformity throughout the width.

Waterway transportation play a vital role in Kerala as the inland navigation system encompasses 41 east to west flowing rivers along with backwaters in north-south coastal line of Arabian sea. The 633 m long west cost canal includes the 163km National Waterway-3 (NW3) from Kollam to Kottapuram. This paper presents the design features of Padaharam bridge across Pampa River under construction across the NW3 at Alappuzha having peculiar box girder form for superstructure reducing overall width and the aesthetic features.

2 Challenges in Planning the Bridge

As per the norms of Inland Water Authority of India (IWAI), a vertical clearance of 6m above high flood level and a horizontal clearance of 40m between piers is mandatory for bridges to be constructed across NWW in Kerala. Box-girders are cost-effective for spans range above 30 metres. As a result, there was a demand for constructing high

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Innovative solution for an Extradosed bridge over river Beas in Hilly Terrain of Himalayas

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Abstract

Road Network of Himachal Pradesh, a northern state in India requires number of long span bridges across valleys and rivers due to its hilly terrain. One such bridge across river Beas at Hanogi has a total length of 119.2m. Proposed span arrangement at the location of this bridge is 97.2m + 22m. National Highway (NH-3) runs perpendicular to the bridge. The bridge is located in a constrained location with approach road on one side and a hillock with NH-3 at its toe on the other side. It was proposed to build an extradosed bridge of span 97.2m with pylon only on abutment A2 side and back stay cables anchored in hillock formed of rock.

This paper presents design aspects of the extradosed superstructure and cables, back stay anchors, Abutment A2 and staged construction analysis. The construction of the bridge is carried out by cantilever method with form traveler. This paper also covers construction methodology of the superstructure, ground Improvement and stability check at abutment A2 and Hillock where the stays are anchored.

This is one of the unique extradosed bridge where long span on one side is supported by cables on single pylon and back stay cables are anchored to the rock.

Keywords: Extradosed Bridge, Rock Anchored, Ground Improvement, Cantilever Construction.

1 Introduction

Roads are a very vital infrastructure for rapid economic growth of any state/country. In fact, the development of important sectors of economy such as Agriculture, Horticulture, Industry, Mining and Forestry depends upon an efficient road network. Social activities such as education, health, family planning and promotion of tourism also depend upon an efficient road network.

Road Network of Himachal Pradesh requires

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Development of extraordinary suspension bridge solutions for Sulafjord in Norway

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Abstract

The crossing of Sulafjord on the Ferry-free E39 project in Norway with a bridge solution is an extremely challenging task. The fjord is 3 to 4 km wide, 450m deep and located in a harsh weather environment with strong and heavy winds and waves. The AMC group (consulting companies Aas-Jakobsen, Multiconsult and COWI with subconsultants) has recently developed four different suspension bridge solutions for this crossing in an extensive preliminary design phase. Client for the project has been the Norwegian Public Roads Department (NPRA). These four alternatives involve a world record singe main span of app. 2700m as well as two long-span double span suspension bridge solutions on GBS (Gravity Base Structure) foundation and a triple span floating suspension bridge solution on TLP (Tension Leg Platform) foundation.

Keywords: Record breaking, suspension bridges, preliminary design, creative foundation methods, harsh environment.

1 Introduction

The Sulafjord crossing is a part of the Ferry-Free E39 project, connecting the communities of the island Hareidlandet to main land Ålesund. It is an important project to better work commuting across the fjord. A comprehensive preliminary design was performed in 2021-2022 in order to be able to choose concept for construction.

The designs are based on an extensive site investigation scheme involving offshore soil investigations, wave, current and wind

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Innovation in the design and construction of Temburong Bridge, Brunei

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Abstract

The 27km long Sultan Haji Omar Ali Saifuddien Bridge in Brunei (known as Temburong Bridge) is the longest bridge in Southeast Asia. The Temburong district was isolated from the rest of Brunei by the Malaysian state of Sarawak since 1890. The new bridge connects the district with the more developed Brunei-Muara district, improving connectivity and accessibility to goods and services, facilitating economic development and provides a 24-hour physical link, eliminating the need to go through two Malaysian borders, reducing journey time from 2 hours to 30 minutes.

The bridge was procured as a traditional engineer-design arrangement under various construction contracts. The bridge includes a 14km long marine viaduct across Brunei Bay, two concrete deck cable stayed bridges and a 12km long swamp forest viaduct. This bridge was opened early in 2020 to allow residents to travel to/from Temburong without crossing the Malaysian borders which were shut due to COVID. This paper focus on the innovation of the design and construction of the bridge and discuss the values they bring.

Keywords: Sea-crossing, major bridges, cable-stayed bridges, long span bridges, viaducts.

1 Introduction

Brunei is a sovereign state located on the north coast of the island of Borneo in Southeast Asia. Apart from its coastline with the South China Sea, it is completely surrounded by the state of Sarawak, Malaysia; and since 1890 it has been separated into two parts by the Sarawak district of Limbang.

This physical separation of Temburong district from the majority of Brunei has significantly affected the economic development of the district and Brunei as a whole. Despite comprising 23% of the total land area of Brunei, Temburong only contains 2% of the population.

Although plans for a bridge across Brunei Bay had been considered in the past, the current project Feasibility Study was carried out from May 2010 to March 2012 by Arup. The study concluded that a fixed link connecting the two parts of Brunei was

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Mechanisms for new lifting railway bridge on Pamban Island, India

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Abstract

New Railway Pamban vertical lift bridge will replace the more than 100 years old strongly deteriorated Scherzer Rolling Bascule Bridge, connecting Pamban Island with the mainland of Tamil Nadu State, in India, promoted by RVNL, Rail Vikas Nigam Limited. The 77.5m lifting span weighs around 650 tons and can be raised 17m in approximately 3.5 minutes.

Mechanisms will be located at the top of the two towers, with a 250kW motor per side. Gear box set will reduce the motor 750rpm to 0.5rpm rotation speed of the 3m diameter sheaves, with the operation controlled by variable speed drives. Electrical supply is ensured by an 800 kVA compact substation and two 625kVA diesel generators as backup system. Lighting protection and an adequate earthing system is provided.

Keywords: movable bridge; lifting bridge; mechanism; gear box; metal casting.

1 Introduction

Pamban Island, in Tamil Nadu State, Southern India, has been connected to Mandapam in mainland by a single-track railway bridge since 1914, when a 2057 m long bridge was inaugurated [1]. The bridge included 145 spans 12.2m long, and a bascule Scherzer rolling bridge, allowing a navigational channel 57.2 m wide, manually operated. Having endured a sever cyclone in 1964 and the strengthening because of the broad gauge railway conversion in 2007, the bridge has been on duty until January 2023. The strongly deterioration state due to corrosion in one of the harshest environments in the world advised to stop the service, after several years of close monitoring.

Figure 1. Ancient Scherzer Pamban bridge

Rail Vikas Nigam Ltd (RVNL), promoted the replacement of the bridge by a vertical lift bridge, with a movable 77.5m long span, allowing for a clear navigational channel of 72.5m and 22m of vertical clearance. The vertical movement will take 3.5 minutes to raise 17m, planned to be operated

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Wind Tunnel Testing and Aerodynamic Consulting for Indian Bridges Today

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Abstract

It has been many years since the wind engineers of RWDI provided aerodynamic consulting for the Anji Khadi Arch Bridge in Jammu and Kashmir, India. Wind tunnel testing and aerodynamic consulting in India has advanced considerably since 2005 as everyone would expect. The authors will revisit the methodologies used then and what would be done today to ensure climate resiliency for the desired design life of the structure far away in the future.

Although the Anji Khadi Arch Bridge was eventually rejected in favour of a cable-stayed bridge which is currently under construction the site is the same. It is anticipated that the complex topography of the site would have a major influence on the bridge microclimate which in turn could have been modified considerably due to climate change affecting this mountainous area of India.

The authors will revisit this project and detail the state-of-the-art analysis and wind tunnel testing that can now be carried in India thanks to a newly built and commissioned bridge test rig for cable-stayed bridges, suspension bridges, arch bridges, and cable-supported pedestrian bridges.

Keywords: Bridge Aerodynamics, Aerodynamic Stability, Wind Tunnel Testing, Wind Loading

1 Introduction

In support of the economic growth that is envisaged for India in the next decade, important investments in transport infrastructure have been initiated in several regions of the country or are at the planning phase by the local authorities, structural engineering firms and bridge contractors. Among these investments, several medium and long-span bridges are considered.

Bridges that are supported by cables; or have fundamental frequencies lower than 1 Hz; or with a span-length-to-deck-width ratio larger than 30 are considered sensitive to the dynamic actions of the wind. In many cases, wind loading is the dominant source of loading and special attention needs to be paid to capture wind effects, to prevent aerodynamic instabilities and to develop site specific wind loading patterns to complete their design.

In support of the development of India's transport infrastructure, RWDI has recently designed, built, installed, and commissioned an innovative bridge sectional model test rig for its wind tunnel facility in Trivandrum, Kerala in the south of India. This test rig is the first of its kind worldwide and constitutes

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Case Study of Rochdale Canal Bridge Assessment using Non-Linear Finite Element analysis

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Abstract

Rochdale Canal Bridge is a single skew span railway under bridge to be assessed under Civils Assessment Framework Agreement 2020-2024. The scope of work is limited to the decks supporting the railway lines.

The methodology used to develop a finite element model that accurately represents the structure, the complexities of the structure due to load effects from neighbouring decks etc., are also discussed in the paper. Furthermore, material non-linearity was considered along with geometric non-linearity. The most onerous buckling mode derived from linear Eigen value buckling analysis is used for the initial geometry imperfection of structure. Non-linear analysis was carried out at both SLS and ULS to identify the failure modes through excess stress, strain, yielding and buckling. Through this study, the reserve strength of the structure was captured and is found to be adequate for the current loading which is an improvement from previous assessment. The assessment of these kind of bridges and suggesting strengthening measures etc, will help reduce the environmental impact as compared to the new constructions thereby contributing to sustainability.

Keywords: underbridge; finite element; material non-linearity; geometric non-linearity; Eigen value buckling analysis; Non-linear analysis; stress; strain; yielding; buckling; sustainability.

1 Introduction

1.1 Project Background

Network Rail Limited (NR) is the owner and infrastructure manager of most of the railway network in the United Kingdom. To cope with the increasing passenger and freight traffic, NR has been undertaking programme of upgrades, inspections, assessments, and other maintenance activities to the network.

Atkins, a member of the SNC Lavalin Group, was appointed by Network Rail Limited to provide consultancy services to assess various bridges and report their current load carrying capacities under Civils Assessment Framework Agreement 2020-2024. Rochdale Canal Bridge is one of those bridges in the work bank.

1.2 Description of the Structure

Rochdale Canal bridge is a single skew-span underbridge with 7 subdecks carrying: High Level Road; a single track of the Rochdale to Manchester Victoria Metrolink line; three tracks of the Manchester Victoria West Jn. to Hebden Bridge line; and a disused area. The structure crosses disused land, which was formerly a canal (now infilled).

The superstructure comprises 2 Nos. riveted wrought iron truss girders on the downside and 6 Nos. riveted wrought iron plate girders on the upside, which support wrought iron cross girders, rail bearers and deck plates. The skew angle varies between the different subdecks from approximately 5 to 18 degrees.

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Proposed Seismic Design Methodology for Steel Pier-Pile Integrated Structure Considering Dynamic Soil-Pile Interaction and Ductility Performance of Elongated Members

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Abstract

This paper discusses the seismic design policy and the design results for a novel pier-pile integrated rigid frame bridge, herein, denoted as the Pier-Pile Integrated Structure. The novelty of the structure lies in its foundation as the footing is eliminated leading to reduced substructure size, in turn, leading to reduced cost, construction time, and the need for topographic modification. The traditional design methodology for foundations with the assumption of fixed support or a rigid member at the footing does not hold for these structures. Hence, a novel seismic design methodology is proposed that considers the ambiguity in the failure mechanism and the ductility performance of ERW SKK 490 steel. Additionally, the seismic response and performance objective are set according to related past studies to form a comprehensive seismic design methodology for practical design. The proposed methodology is then applied for design of a road bridge and a comparison to the conventional design philosophy is presented.

Keywords: Pier-Pile Integrated Structure; M-ϕ model; Beam on Nonlinear Winkler Foundation; SKK steel; non-linear dynamic analysis; seismic design.

1 Introduction

The multipolar rigid frame bridge (Fig. 1), is a bridge structure with its substructure consisting of pier-pile integrated structure supported directly on soil and superstructure consisting of transverse and longitudinal beams, all connected by rigid joints. Such bridges have been adopted throughout the world as pedestrian bridges, as port facilities consisting of multiple piers, and as multipolar rigid frame structures without footing for emergency roads in mountainous areas. These structures can be designed as economic, easy to construct and easy to maintain structures requiring minimum topographical alterations because of the absence of a footing and shorter construction periods. These features are especially advantageous in narrow mountainous regions along evacuation routes.

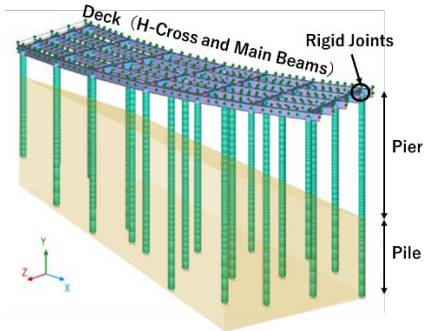

Figure 1. General arrangement of a multipolar pier-pile integrated structure

The traditional design methodology for foundations with the assumption of fixed support or a rigid member at the footing does not hold for the pier-pile integrated structures. Rather, the behaviour of these structures is governed by the effective buckling length of the pier elements, by the relative rigidity of the super- and sub-structure that dictates the failure mechanism. In such a case

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A longitudinal isolation system with elastoplastic cables for single-tower cable-stayed bridges

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Abstract

For single-tower cable-stayed bridges, a longitudinal isolation system with elastoplastic cables were proposed, and calculation expressions based on dynamic concepts were established for the design of this system. Based on the Jinsha River Bridge, a performance comparison was conducted on the elastoplastic and elastic cable systems. The girder displacements under wind and braking force, as well as the damping effects under earthquakes, were analysed for both systems with the most economical parameters. The results demonstrate that both elastoplastic and elastic cables can effectively reduce the longitudinal displacement of the girder compared to a floating system under normal service conditions. However, elastoplastic cables have a higher material utilization rate, larger restraint stiffness, and a wider range of applicable parameters than elastic cables. In addition, elastoplastic cables can effectively dissipate energy and have a better damping effect.

Keywords: single-tower cable-stayed bridge; longitudinal isolation system; elastoplastic cable.

1 Introduction

Currently, the focus of transportation infrastructure construction in China is gradually shifting towards the central and western regions, which is creating a new demand for bridge construction. Since the local terrain is mostly mountainous and hilly, there is a great need for long-span bridges with a single span of 200m to 400m. Additionally, the central and western regions are prone to frequent strong earthquakes, posing a significant risk of seismic disasters to local bridges. Therefore, the single-tower cable-stayed bridge has become a popular choice for bridges with main spans ranging from 200m to 400m due to its excellent economy, great spanning capability, and good seismic performance.

In high-intensity earthquake areas, cable-stayed bridges typically adopt fully or semi-floating systems where the longitudinal constraint between the tower and girder is released to prevent excessive inertial force of the structure during earthquakes [1]. To control the large seismic displacement of the floating system, additional constraints or energy dissipation devices are often installed between the tower and girder [2-7], and the most commonly used device is the viscous damper [8-14]. For classic two-tower cable-stayed bridges, the floating system with an additional viscous damper is an ideal mechanical system both under normal service conditions and during earthquakes [1]. This is because that it is necessary to release the constraint between the tower and girder to accommodate deformation caused by daily temperature changes and to prolong the structural period to achieve a seismic isolation effect during earthquakes. Additionally, the viscous damper is a type of damping device that does not affect the static stiffness of the bridge but provides effective energy dissipation.

However, for single-tower cable-stayed bridges, it is recommended to use the tower-girder

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Seismic Analysis of Integral Abutment Bridge – Comparison of Framed Abutment with Fixed Base and Hinged Base

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Abstract

Integral Abutment Bridge (IAB) is the bridge in which the superstructure and substructure is monolithically casted. The advantages of IAB bridge are: less maintenance, better seismic performance due to increased redundancy. In this study, the IAB bridge with 1.0 m diameter pile in 2x10 pile configuration is compared with 1.5 m diameter piles in 1x8 pile configuration. The limit equilibrium method as per IRC:SP:115 is used instead of soil structure interaction for backfill. Soil pile interaction is represented by the linear soil spring. The site - specific response spectra is used for Elastic Response Spectrum Analysis. Temperature loading, Creep, shrinkage, differential settlement; Live load and live load surcharge are applied in the model as per IRC:6-2017. The beam element is used to model the superstructure and pile. Plate element is used for pile cap and abutment wall. The time period of hinged base model is significantly larger than fixed base model. The pile top displacement and abutment top displacement is higher in hinged base model than the fixed base model.

Keywords: Soil-Structure Interaction (SSI); Integral Abutment Bridge (IAB); Pile Foundation; framed abutment with fixed base; framed abutment with hinged base.

1 Introduction

Integral Abutment Bridge (IAB) is the bridge in which the superstructure and substructure is monolithically casted. The IAB has no expansion joints and bearings whereas conventional simply supported bridges having bearings and expansion joints.

There are several advantages of Integral bridge over conventional bridge in terms of service life and maintenance. During the strong ground motion, simply supported bridge may fail due to failure of bearings, deck unseating and deck pounding.

The challenging aspect of the design of IAB is that it requires global FEM model in which superstructure and substructure is modelled as a single unit. The monolithic connection in IAB allows the transfer of the lateral demand induced from temperature and seismic action in superstructure to the abutment pile foundation. However, as the conventional bridges allow the movement and rotation of superstructure at bearing, bending moment is not transferred to be substructure.

Most of the bridge constructed in Nepal are simply supported bridges. Very few IAB bridges have been constructed in Nepal. Recently, Integral bridge have started gaining popularity in the seismic region due to its better seimic performance [6]. The better performace during seismic event is due to the monolithic connection of IAB which increases redundancy [7].

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Effect of bridge foundation stiffness on dynamic behavior of bridge structure

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Abstract

Problems affecting the foundation of a bridge are always difficult to see because the structure is on the ground or covered by water flow. Scouring around piers and abutments can lead to unpredictable consequences that can result in sudden collapse of the structure. In this paper, the effect of foundation stiffness (before and after the bridge repair works) on the dynamic response of the bridge structure is investigated. The results will help to diagnose the bridge foundation in the future. Based on the results of span monitoring before and after repair works combined with numerical model analysis on a bridge in Vietnam, the effects of scouring at the bridge piers are determined. The research results reveal that the dynamic responses of the structure make it possible to detect damage to the foundation and determine whether scour is likely to occur in the vicinity of the bridge foundations.

Keywords: Dynamic behaviour, Foundation stiffness, Scour effects.

1 Introduction

The leading cause of failure of bridges over waterways is scour of the soil around the bridge foundations [1]–[4]. Scour usually occurs quite rapidly and without warning, which can lead to fatalities. The loss of embedment around a bridge foundation caused by scour leads to a reduction in the stiffness and stability of the bridge and can even cause the bridge to fail, resulting in significant service interruptions and financial losses. Therefore, it is necessary to investigate and provide early warning of scour at the bridge foundation [5].

A more efficient and economical method of preventing scour is to monitor its development over time and take the necessary corrective actions. There are many solutions for monitoring scour at bridge foundations. Direct scour monitoring is the most commonly used option today. Divers are most commonly used to investigate scour at bridge piers. Briaud et al. [6] used disposable devices consisting of float-out devices and tethered buried switches that can detect scour at their deployment sites. Yu and Yu [7] proposes the use of time domain reflectometry (TDR) to determine scour depth at a given location using radar. Similarly, Ground Penetrating Radar (GPR) uses high frequency electromagnetic waves

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Study on Mechanical Properties of a Negative Poisson's Ratio Structural Bridge Block

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Abstract

This paper is based on the design concept of the block is not damaged under small earthquakes and can be used sustainably and in the medium earthquake does not fall, convenient structure replacement and it can be destroyed during a large earthquake, sacrificing itself to protect the main beam. Based on the characteristics of graded energy dissipation and the advantages of negative Poisson's ratio compared with traditional structures in energy absorption and impact resistance, an anti-seismic energy dissipation bridge block was designed. The mechanical properties of the block were studied by uniaxial loading test and finite element simulation. Through the comparative analysis of normalized curves, it is found that the block structure has a good limiting ability compared with other types of blocks, which can be multi-enhanced stiffness characteristics and excellent bearing capacity.

Keywords: bridge block; negative Poisson's ratio; energy absorption; uniaxial load test; finite element; normalized curves

1 Introduction

With the improvement of our economic strength, infrastructure projects have been constantly improved. According to the "*Statistical Communique on the Development of the Transport Industry in 2020*", by the end of 2020, there were 912,800 highway Bridges in China, covering 66.285,500 meters [1]. As an indispensable transverse limiting member of medium and small-span girder bridges, the retaining block can limit the transverse movement of the main beam and prevent the main beam from settling or even falling under the action of lateral load (such as an earthquake). At the same time, it is also one of the ways to transfer the inertia force of the main beam to the substructure. In recent years, with the continuous summary of seismic experience and the continuous improvement of seismic measures, the role and design of the block have gradually become a research focus. In the Code for Design of Highway Bridge in 2020, the block, as a structural measure between the main beam and pier, has also been proposed to effectively reduce the earthquake damage to the bridge.

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Thermal Performance of Sandwich Wall Panels With Core Insulating Material

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Abstract

Air conditioning systems account for bulk total energy consumption in buildings. The major phenomenon behind thermal insulation is the conservation of energy. In this paper, experimental analysis on the thermal performance of concrete sandwich wall panels (SWP) was studied by varying the core insulation material and was compared with conventional concrete wall panels (CCWP). Insulation materials used for analysis include expanded polystyrene (EPS), air cavity, paper boards, and wood sawdust.

In the laboratory, the thermal conductivity of core insulation materials was quantified using Lee's disc apparatus. The thermal conductivity values of SWP specimens are entirely dependent on the thermal conductivity of core insulation materials. Field thermal performance is measured with the help of an infrared thermometer.

It is found that the outer surface of SWP experienced high temperatures compared to the outer surface of CCWP. In the inner surface, the temperature increase is gradual in SWP and about 4^{o}C less compared to CCWP at maximum temperature.

Keywords: *Thermal conductivity, Sandwich wall panels, Expanded Polystyrene (EPS), Conventional Concrete Wall Panels (CCWP), Lee's disc apparatus, Infrared thermometer*

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Humanism through artificial intelligence?

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Abstract

Today's key challenges for future construction are well known and little disputed. On the one hand, we should put the brakes on climate change; on the other hand, we must prepare ourselves for its probably serious consequences. Doing this without fossil resources currently still poses considerable problems for the construction industry. At the same time, digitization and artificial intelligence are creating major opportunities. Already 50 years ago, Jos Weber stated that computers should become self-learning, artificial-intelligence-developing teaching sources for architects. While the most significant discovery of the past year in the field of chemistry was made by a software program and is discussed to be proposed for the Nobel price, in civil engineering these technologies have been used in a rather rudimentary way so far. In this article, current approaches, tools and areas of application for optimization in structural design are presented, discussed and classified.

Keywords: climate change, artificial intelligence, structural optimisation.

1 Introduction

Since the Renaissance, humanism has been the term used to describe a cultural and philosophical movement aimed at giving humanity the ability to improve its own existence by promoting science, art, education and critical thinking. Several centuries have passed since the term was coined and its implementation seems a long way off. Due to climate change, which we are accelerating through the use of fossil fuels, we are threatening the preservation of biodiversity on Earth, and thus our own, instead of improving it. This is despite the fact that there are many renewable energy sources such as solar energy, wind energy, hydropower, geothermal energy and biomass, which could completely cover the world's electricity and heating needs [1].

In the 1969 book "Operating Instructions for Spaceship Earth", architect and visionary Buckminster Fuller describes the world as a living system that is steered by mankind like a spaceship [2]. Humanity lives in a world of limited resources and the survival and well-being of all people depends on how well we can use and distribute our resources. Rather than depleting our emergency reserves, he emphasizes the indispensability of shaping our society to be sustainable and environmentally sound by breaking through political and economic barriers. At the time, he coined terms such as sustainability and synergy, which today have degenerated into empty phrases.

2 A question of attitude?

The obstacles Fuller described would be increasingly easy to overcome today as technology evolves toward a more humane society. Developments in information technology and communications have made it possible for people from different parts of the world to communicate and share information in real time. Social media, messaging apps, video calls, email and other digital tools are now part of our everyday culture. The Internet has also increased access to information

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MINIMASS: a new approach for low-carbon, low-cost 3D printed concrete beams

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Abstract

The construction industry is beset by two well-known problems – high carbon footprint and low productivity growth. 3D printing of concrete offers the potential for massive improvements in both those areas, if real structural uses can be found. This conference paper describes a new and innovative design method for creating 3D printed concrete beams, using external post-tensioning to provide bending and shear capacity. The results offer reductions of up to 70% of the embodied carbon compared to a similarly performing precast concrete beam, with the potential for up to 50% reduction in material costs. A series of physical prototypes have been built, with large-scale load testing carried out at the Technical University of Denmark (DTU) in Copenhagen, the results of which are presented herein.

Keywords: 3D printed concrete; beams; post-tensioning; long-span structures.

1 Introduction

Cost and carbon in construction are prominent discussion points throughout the industry at the current time. The highly competitive and highly fragmented nature of the industry means that the question of cost will always be the primary driver for project developments. However, more and more countries and authorities are introducing and enforcing climate targets as a way to push development towards a more sustainable future. In the absence of a global agreement on carbon pricing, this targets-led approach could be the way in which the industry becomes more sustainable. Given that the industry is responsible for 11% of total global carbon emissions (2019), rising to 39% when operational emissions are included [1], there is an urgent need for lower carbon solutions.

Materials suppliers, for example the Global Concrete and Cement Association (GCCA), are setting targets and creating roadmaps [2] for de-carbonising supply chains. That is crucial work which will need to be supported over the coming years and decades. However, what if there are ways to significantly reduce both cost and carbon through better design? The GCCA Roadmap suggests that 22% of the savings required to reach net-zero will come from “efficiency in design and

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Material efficient WAAM Steel Construction Details

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Abstract

With the new manufacturing process Wire Arc Additive Manufacturing (WAAM), it is possible to produce new shapes that previously could only be manufactured with a great effort. The energy-intensive manufacturing process can be positively compensated by the sensible use in mainly material-saving components. In this article, the enormous potential is illustrated by the example of a conventional head plate. Here, 80 % of the material can be saved and waste is eliminated completely. The article furthermore presents the printing, the load-bearing tests and the numerical simulation of the novel structure. A homogeneous component behavior is shown, which can be predicted very well by finite elements.

Keywords: Additive Manufacturing, Carbon Steel, WAAM, Material Efficiency, Bolted Connection, Head Plate, Optimization, Steel Construction

1 Introduction

In today's world, we are feeling the effects of our reckless treatment of nature more and more acutely as extreme weather events become more frequent. The buildings and construction sector has made no small contribution to this. It is responsible for over a third of global CO_2 emissions, uses a large proportion of resources and generates large amounts of waste even during the construction of new buildings. As the population continues to grow and the general pursuit of prosperity continues, there will be an increasing demand for the built environment in the future. It is therefore essential to look at and develop sustainable, alternative building concepts, materials and shapes.

3D printing as an alternative manufacturing method has the potential to contribute to this change. It allows new structures to be made that adapt to the flow of forces, saving material without excessive waste production during fabrication.

For steel structures, Wire Arc Additive Manufacturing (WAAM) seems to be a promising process in this regard. Compared to other metal 3D printing processes, it is cost-effective and fast, and because it is an arc welding process, it can be easily implemented in conventional steel construction industry [1].

The material-saving potential of AM is particularly evident in applications for connecting components and beam reinforcements. Here, material only needs to be placed where it is needed without wasting material by subtractive production steps.

Structural optimization can be used to find and produce new shapes that save over 50 % of material compared to conventional construction details. This article presents a resource-optimized component in terms of design, manufacturing and load-bearing behavior and shows how WAAM can be used to create new construction details that can permanently change the way we look at structural design.

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A Holistic Digital Design Approach for a Metro Project in Portugal

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Abstract

The Ruby Line Porto is a new 6.5 km metro project connecting the urban areas of Porto and Vila Nova de Gaia in northern Portugal to be built in the upcoming years till 2025.

The authors have been responsible for the design of six main work packages including the new track, new roads, five viaducts, three underpasses, one pedestrian overpass, one top-down tunnel, multiple retaining walls, and the structures of seven new stations and platforms. Due to multiple collaboration needs with other parties, a consistent digital BIM workflow with a common data structure and alignment of sub-models was of utmost importance for delivering the project successfully.

The introduction and application of a new software tool was predestined for this ambitious plan to model the quite different parts of the project in a common digital environment. The paper shows, which techniques offered by the software had to be used for successful modeling.

Keywords: Metro Project, Sustainability, Digitization, Open BIM, Interoperability

1 Introduction

The two cities Porto and Vila Nova de Gaia situated north and south of the estuary of the Douro River form together the Porto Metropolitan area, which is the second largest urban area in Portugal with more than 500 000 residents. The two cities are inextricably linked, with lots of inhabitants daily traveling between them.

Meanwhile, the hitherto existing five operational bridges – one railway, three roadway and one with a roadway deck plus a metro deck – do not meet anymore the increasing travel demands. Therefore, Metro do Porto was commissioned to provide a new 6.5 km metro line connecting the two cities [1].

This new line will not only provide additional capacity, but also encourage more sustainable travel by shifting commuting habits from individual car traffic to using the Metro. In addition, the new bridge over the Douro River will also carry cycle

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3D Printed Sandwich Structural Decks of Dual Corrugate Sheet with Mid Shear Layer (DCMSL) as Core Profile

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Abstract

Rectangular sandwich decks in an exclusive profile that has an additional shear layer in the mid of its dual corrugate monolithic core , developed on 3D printing, has been highlighted here in this paper. These sandwich decks in construction mix material when 3D printed out having such a monolithic core profile, factually offers getting rid off invariably otherwise required any bonding to attach the two or more components of any sandwich panels. Having observed a consistency in various numerical results as obtained through analyses carried out using 'Advanced Composite Technology(ACT) with that observed from various conducted load tests on these 3D printed hardware , sandwich deck units, are then favourably recommend for their effective deployment in any civil engineering application. A fruitful observation has been made here on a suitable orientation tht need only be maintained in this orthogonal dual corrugate sheets monolithic core profile sandwich for their excellence in performance for service as compare to that of any so far used single corrugate sheet core sandwich profile.

Keywords: Monolithic profile, Sandwich decks, Dual Corrugate, Advanced Composites Technology, 3D Printing

1 Introduction

Structural Sandwich panels are formed on assembly of two components namely its top and bottom Sheets/Laminates and preferably a deeper core of suitable geometric profile as well as in material of low density compared to that of the overall sandwich panels. The core in the sandwich offers effective area of its two faces to attach with flats Sheets/Laminates usually through bonding. Presence of any deep core essentially facilitates building the required sectional depth that may at time be needed in some situations where these structural sandwich panels are used. Core contributes here in bearing the shear loads that generates all along the depth of section due to flexural bending of these sandwich decks when subjected to any external transverse loadings. These structural sandwich panels, made-up-of Advanced Composites Honeycombs / PU-foams sandwich cores, are already in use, extensively in aerospace applications. Further, sandwich composite panels as structural deck units as found from the literature, are also deployed in many civil engineering applications as well. An example of one such application of these structural sandwich decks ardently may be sighted here as those several deck units were successfully deployed over an all Advanced Composites Foot Over Bridge (FOB) system which was then designed and developed [1] earlier for pedestrian traffic by the Author and his team, at Composite Research Center of RDE(E), Pune, India. Prior to deployment of these deck units over this FoB, fabricated entirely in Glass Fibre Reinforced Plastics(GFRP), the development phase of these deck units included creating and conducting number of field trials on these decks in different types of sandwich core profiles and with different geometries and of different materials [2-5]. Only, a most suited profile was then so spurred out was a single corrugate FRP sheet core profile, sandwiched between two flat

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Machine Learning Based Optimization Techniques for Predictive Strength of High Performance Concrete: Enhancing Sustainable Development

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Abstract

The pursuit of sustainable growth in the construction sector needs a precise forecast of material characteristics to optimize resource consumption. This research focuses on utilizing the capabilities of well-known XGBoost regression algorithms to forecast the compressive strength of High-Performance Concrete (HPC). In this study, 2171 datasets were collected from literature containing input parameters that influence concrete strength, thereby creating a robust predictive model. The performance indices were assessed using root mean squared error (RMSE) and R^2 score. The findings indicate that the XGBoost model outperforms standard statistical techniques in predicting accuracy. This research intends to improve the precision of compressive strength estimation, facilitating the development of more durable and sustainable construction practices.

Keywords: High-Performance Concrete (HPC); Machine Learning; Prediction; XGBoost Regressor; Optimization Techniques; Compressive Strength; Sustainable Development.

1 Introduction

In recent years, the construction sector has seen a considerable paradigm change toward sustainable practices and environmentally responsible approaches. Concrete, being the most extensively used construction material, is critical in shaping modern infrastructures systems [1-4]. As the worldwide focus shifts to decreasing the environmental imprint of infrastructure projects, developing novel methods for optimizing building materials becomes critical. High-Performance Concrete (HPC) is vital due to its remarkable mechanical attributes and potential for improving construction durability and lifetime [5]. The compressive strength of HPC is an important measure of its quality and performance, impacting the structural integrity of many applications. Accurate prediction of HPC compressive strength is critical for optimizing material utilization, assuring structural integrity, and reducing environmental impact. Traditional compressive strength prediction methods may incorporate time-consuming and resource-intensive experimental approaches [6,7]. However, the development of data driven techniques has opened up new opportunities for forecasting material qualities quickly and effectively [8-10]. Several Machine learning approaches have proven effective in various engineering domains, including concrete strength prediction [11-13]. XGBoost Regressor and Random Forest have emerged as prominent

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Effect of Slenderness on the Design of FRP reinforced Concrete Columns

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Abstract

Fibre-reinforced polymer (FRP) bars can be a promising sustainable alternative to steel due to their low life-cycle cost and potentially low environmental impact as a reinforcement. Also due to their corrosion resistance and electromagnetic neutrality, they have attracted significant interest for use in reinforced concrete (RC) structures. This paper investigates the behaviour of FRP-reinforced concrete (FRP-RC) columns with varying slenderness ratios. The reduction in moment capacity, axial load capacity and load-moment interaction diagrams of FRP-RC columns with the increase in slenderness are studied in comparison to steel-reinforced concrete (steel-RC) columns. The study shows that guidelines and design standards such as Eurocode 2 for steel-RC pertaining to the simplified design of slender columns, slenderness limit and minimum reinforcement ratio need to be revised for FRP-RC columns.

Keywords: Fibre-reinforced polymer bars, FRP-reinforced concrete columns, slender columns, column curvature, second-order analysis, stability, slenderness limit, Eurocode 2, column stiffness.

1 Introduction

Owing to increasing global concerns about climate change and the need to reduce carbon emissions, sustainable and durable infrastructure is one of the most important factors in achieving sustainable development. Fibre Reinforced Polymer (FRP) reinforcement may be a promising solution for developing sustainable infrastructure due to its corrosion resistance, low life-cycle costs [1] and potentially low environmental impact [2] compared to traditional steel reinforcement. Despite having high tensile strength, they have low axial stiffness compared to steel, which makes their behaviour in reinforced concrete structures of concern when they replace steel bars. Considerable research work has been reported in the literature examining the flexural behaviour of FRP-reinforced concrete (FRP-RC) structures. However, limited work has been done on FRP-RC columns, especially slender FRP columns, and their design guidelines. In this study, the behaviour of FRP-RC columns is examined along with the consideration of geometric non-linearity arising out of slenderness. A comparison between the behaviour of FRP-RC columns and steel-reinforced concrete (steel-RC) columns is presented so as to ascertain the applicability of the available guidelines of steel-RC design standards such as Eurocode 2 [3] for FRP-RC columns.

2 Non-linear analysis of reinforced concrete columns

A numerical method based on the sinusoidal assumption of the column curvature is implemented in Matlab (R2022b) for the analysis of the reinforced concrete columns. The assumed

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Disruptive change in mineral building materials - high-performance prefabricated elements made of UHPC for circular buildings

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Abstract

Concrete (NPC) is the most commonly used building material worldwide, which has great development potential in the form of UHPC. With the help of high-performance prefabricated elements, significant advantages can be achieved in relation to the classic in-situ concrete construction in terms of resource and energy efficiency as well as in terms of recyclability and durability. This report uses specific application examples to show the savings that can be achieved in manufacturing phase A. When used appropriately for the material, high-performance precast elements made of UHPC can save up to 85% in resources (R) and up to 65% in energy (GWP = CO2e = E) achieve. The implementation of high-performance prefabricated parts in our new buildings enables significant changes in buildings, both in terms of emissions consumption and urban mining potential. The disruptive change in the construction industry requires consistent choose, want, venture and repeat from those involved. In this regard, we are all called upon to make a contribution together.

Keywords: Include a list of not more than 10 keywords, for example: post-tensioning; anchors; slabs; walls; high-rise buildings.

1 Introduction

Building has always represented the fight against erosion, which has been countered by constant technological developments over the course of building history, with the result that ever more energy-intensive construction methods have become established across all materials. In the 21st century we are at the crossroads of counteracting these energy-intensive construction methods with new technological developments. Resource and energy efficiency as well as the conversion of the linear economy into the circular economy are in the foreground in almost all specialist areas of constructive building research. It is undisputed that the future path to a reasonably climate-neutral circular economy by 2040 will involve far-reaching transformations in buildings, industry and production.

If one looks at the emissions of a building or a component over the life cycle phases according to [1], one can assume that approx. 55% of the total energy in the production phase (phase A1-A5) is mainly emitted as embodied energy (PENRT). The embodied energy of building materials is determined by the choice of material, the choice of structure and the manufacturing process of the building materials, the design process of which is referred to as creative potential for climate-friendly constructions. New developments in the material sector, which have increasingly resulted from the material concrete since the turn of the millennium, include glass-fiber concrete, ultra-high-performance (UHPC) concrete, gradient-

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Mapping structural engineering strategies for sustainable development

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Abstract

Considering current trends in the Netherlands with regards to sustainability, there is a strong desire at Delft University of Technology to incorporate sustainable structural design strategies in the civil and structural engineering curriculum. Based on literature study and own experiences in practice, a coherent approach was developed, that can help students and practitioners to increase sustainability in their projects. The approach consists of a roadmap with 4 key strategies: increase lifespan of existing structures by reusing them, increase lifespan of existing structural elements by reusing them, design future proof and with a long-life span, and optimise the design for environmental impact. The strategies are explained and illustrated with examples.

Keywords: sustainable structural design, environmental impact, carbon footprint

1 Introduction

Over the past century, humanity has been responsible for releasing large amounts of CO2 (in this paper we will use CO2, for all greenhouse gasses, although CO2equivalent (CO2e) might be more appropriate). As CO2 levels in our atmosphere have risen, so has the global temperature. Our planet is now approximately 1 degree Celsius warmer, compared to pre-industrialization levels. Since 1975 the temperature increased with approximately 0,15-0,2 degrees per decade [1]. This temperature rise has manifested itself through floodings, droughts, hurricanes and fires, leading to large damages on multiple facets.

In 2015 many countries signed the Paris agreement. These countries agreed that global warming should be limited to 2 degrees, preferably 1,5 degrees Celsius, to avoid inevitable, catastrophic, and hard to control consequences. It is evident that a change of behaviour is needed across the whole of society to limit CO2 emissions and get us anywhere near the set target of 1,5 degrees Celsius. To cite the Intergovernmental Panel on Climate Change (IPCC): "… unless there are immediate, rapid and large-scale reductions in greenhouse gas emissions, limiting warming to close to 1.5°C or even 2°C will be beyond reach" [2].

To appreciate the importance of sustainable structural engineering, it is important to realize buildings and construction together account for approximately 36% of global final energy use and 39% of energy-related carbon dioxide (CO2) emissions [3, 4]. On the other hand, the sector continues to grow at unprecedented rates. Over the next 40 years, the world is expected to build 230 billion square meters in new construction, adding the equivalent of Paris to the planet every single week.

The last decades, emissions during use of buildings have been reduced significantly, further accelerated by the energy crisis of 2022. In a current best-practice building, the construction phase is accountable for approximately 50% of construction and use related emissions [5]. The

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Mechanical behavior and load-bearing capacity of components made from sustainable lime-paper material

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Abstract

The efforts of the national states to significantly reduce co2 emissions will have a major impact on the construction industry. In particular, production of gypsum, which is mainly obtained by flue gas desulfurization, will decrease. A replacement of gypsum by sustainable lime-paper, mainly produced from secondary raw materials, is considered for various applications. In this paper, the mechanical properties of components feasible with lime paper are investigated and compared with the requirements of the construction elements.

Keywords: lime-paper, secondary raw materials, replacement materials, sustainability, strength.

1 Introduction

Climate change and the efforts of states to significantly reduce CO2 emissions require considerable efforts in the construction industry. In general, about a third of CO2 emissions can be attributed to the construction sector.

Interior components in particular offer the potential to test new building materials due to the low requirements for building law, statics and building physics.

Gypsum is an essential finishing material, especially in the form of plasterboard.

More than 50% of the gypsum available on the German market is FGD gypsum. This is a cheap byproduct during the flue gas desulfurization of exhaust gases from coal-fired power plants.

Due to the German cut of coal-fired plants, around 5 million tons of gypsum will be missing from 2038. This results in a clear deficit in the raw material availability of gypsum and the building products obtained from it, such as plaster boards, gypsum plaster, gypsum blocks. Even an increasing production of natural gypsum cannot replace the missing FGD gypsum.

It is therefore urgent to replace the loss of FGD gypsum by alternative products with similar mechanical properties, that can be produced at similar cost and in an adequate volume worldwide. In addition, however, these building materials must also be compostable, non-toxic and meet sustainability criteria. This is a major and responsible task in the construction industry.

2 Gypsum Alternatives

With the foreseeable shortage of FGD gypsum, it is expected that in order to secure the gypsum quantities, in addition to increasing the mining of natural deposits, great efforts will be made to improve the recycling rate. improved recycling is one way to achieve greater sustainability and is definitely to be welcomed.

There are also efforts to replace gypsum. However, this is currently proving difficult, as no suitable recycled gypsum substitute products exist to date. In [1] the authors comprehensively describe the life cycle assessment of traditional building materials like gypsum and gypsum plasterboards and furthermore the aspect of increased application of recycling materials for replacing the gypsum for interior fitting uses.

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Replacement of gypsum plasterboard with sustainable secondary raw material composition

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Abstract

Climate change and the efforts of states to significantly reduce CO2 emissions require considerable efforts in the construction industry. Interior components in particular offer the potential to test new building materials. Gypsum is an essential finishing material, especially in the form of plasterboard. Due to the German cut of coal-fired plants, around 5 million tons of gypsum will be missing from 2038. It is therefore urgent to replace the loss of FGD gypsum by alternative products with similar mechanical properties, that can be produced at similar cost and in an adequate volume worldwide. In addition, however, these building materials must also be compostable, non-toxic and meet sustainability criteria. The paper describes approaches for substitute

Keywords: secondary raw materials, replacement materials, sustainability, gypsum, plasterboard.

1 Introduction

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It is therefore urgent to replace the loss of FGD gypsum by alternative products with similar mechanical properties, that can be produced at similar cost and in an adequate volume worldwide. In addition, however, these building materials must also be compostable, non-toxic and meet sustainability criteria. This is a major and responsible task in the construction industry.

2 Recycling of building materials

2.1 Recycling

Recycling means of converting waste materials into new materials and objects. This concept often includes the recovery of energy from waste materials. The recyclability of a material depends on its ability to reacquire the properties it had in its original state. It is an alternative to waste disposal that can save material consumption and help reducing greenhouse gas emissions. It can also

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Sustainability by Integration of Existing Structures into new Infrastructures

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Abstract

One of the solutions for sustainable development of transport infrastructure is upgrading the old transport system or – in case a substantial enlargement of capacity is needed – by integrating existing transportation structures into new transportation structures with higher capacity. However, the upgrading and/or integration of existing structures goes along with demanding engineering tasks, such as considering design changes in the final structure, changes in geometry or loading and dealing with structural deficiencies. This makes it necessary to reassess and strengthen the existing structures and to design the new structure and its connections to the existing structure while paying attention to all these aspects. Also, in many cases unavoidable deviations from the valid regulations become necessary. For these design tasks, it is necessary evaluate and develop new solutions and to gain broader knowledge base to draw from. The present paper reports on the experiences from an infrastructure project in Germany.

Keywords: Sustainability in structural engineering, underground structures, existing structures, fire protection

1 Introduction

Cement production is one major contributor to worldwide CO_2 emissions. Therefore, those infrastructure structures, for which at present reinforced concrete cannot be dispensed with, must be built using as little newly produced concrete as possible.

One of the solutions for sustainable development of transport infrastructure is upgrading the old transport system or – in case a substantial enlargement of capacity is needed – by integrating existing transportation structures into new transportation structures with higher capacity. However, the upgrading and/or integration of existing structures goes along with demanding engineering tasks, such as considering design changes in the final structure, changes in geometry or loading and dealing with structural deficiencies. This makes it necessary to reassess and (if necessary) strengthen the existing structures and to design its connections to the new structure while paying attention to all these aspects. Also, in many cases deviations from codes and regulations become necessary – either because of an outdated design basis of the existing structures or – which can be even more critical – because of newly detected deficiencies. Therefore, project-related approvals as well as the development of a fundamental knowledge base and new, generally

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Bridges as Built Heritage: Preservation, Reimagination, Transformation

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Abstract

From ancient civilizations to thriving industrial cities, mobility infrastructure provides safe crossings and promotes economic vitality within both urban and rural communities. Bridges provide rituals of movement connecting users to key parts of our collective cultural identity. Built heritage is a form of placemaking – and the preservation of built heritage creates both environmental and social value.

Dissing+Weitling presents three unique projects to illustrate how cities can balance infrastructure and public safety demands with cultural heritage. Scotland's Queensferry Crossing, Canada's Samuel De Champlain Replacement Bridge, and Switzerland's Zweite Hinterrheinbrücke provide examples of how bridge architecture can reinforce cultural heritage while adapting to modern safety and user needs for safe crossing – whether through ensemble, replacement, or expansion of heritage infrastructure.

Keywords: built heritage; cultural heritage; replacement bridge; ensemble bridges; stakeholder engagement; transformation; train infrastructure; pedestrian bridge; cultural identity

1 Bridges as Built Heritage

Mobility infrastructure is built to last: with intended lifespans of centuries rather than decades, it is an inevitability of bridge design to consider how local communities will not only functionally benefit but also find cultural relevance and pride within their routine crossings.

Where local planning authorities must balance competing demands to accommodate increased traffic volume, public safety, and environmental impact – mobility architecture can provide a complementary pathway to socially sustainable value creation. By incorporating cultural heritage considerations into the evaluation of a project's stakeholders, function, and form, infrastructure development can be seen as a placemaking effort.

A variety of approaches can be taken to integrate infrastructure into the built cultural heritage stock: new infrastructure may be developed with the stated intent of having a design that can be embraced as a landmark – but ensemble and replacement bridges can also provide opportunities for infrastructure to adapt to changing user needs while still respecting the legacy of existing crossings.

Dissing+Weitling presents three unique cases to demonstrate how infrastructure development can create social value through the lens of cultural heritage. Each project exemplifies how considerations of built heritage can widen the scope of a project's community relevance beyond economic vitality and assurance of public safety. Scotland's Queensferry Crossing provides

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Conservation discourses in technical education, India

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Abstract

Heritage, both natural and cultural deserves to be treated with care and is vulnerable to neglect and apathy. Over past decades, in its quest for a 'new India', urban and infrastructure growth has been a-sympathetic to its built & natural heritage due to lack of awareness, knowledge and trained human resource.

Indian heritage has a huge potential of contributing to the liveability index and UN's sustainable development goals. Awareness building, public mobilisation towards cultural and ecological heritage and adequately trained and skilled human resource across the country for conservation is the requirement today.

Technical education institutions sensitising of youth towards acknowledging and nurturing heritage through creation of environment for conservation learning and imparting necessary knowledge and skills need further impetus. State, Private Organisations and Corporates can provide this impetus to promote excellence in conservation discourses of technical education and to encourage and facilitate a conservation approach to urban and infrastructure development.

Keywords: urban heritage, sustainability, architectural heritage, sensitive development.

1 Introduction

India is a land of diversity, which is reflected in its natural and cultural heritage. The country is divided into over 13 sub-climatic zones, each with its unique flora and fauna. This diversity is a testament to India's rich natural heritage, which is home to a vast array of plant and animal species, some of which are found nowhere else in the world.

Similarly, India's cultural heritage is equally diverse and rich. With more than 415 living languages, India is home to a multitude of different traditions, customs, and beliefs. Each region of India has its own unique culture, which is reflected in its art, literature, music, and cuisine. India's cultural heritage is a source of pride for its people and is recognized worldwide.

In addition to its natural and cultural diversity, India is also home to a young population. According to census data, 65% of India's population is below the age of 35. This young population is an asset for the country and presents a unique opportunity for growth and development. With the right policies and investments, this young workforce can drive economic growth and development in the country.

To leverage this opportunity, India is focusing on urbanization and infrastructure development. The government is investing heavily in building new cities, improving existing ones, and creating new infrastructure to support economic growth. The goal is to create a modern and developed India, which can compete with the best in the world

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Improving of (energy) performance of existing (heritage) buildings

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Abstract

For heritage buildings, energy consumption and sustainability were not always in focus or scope during time of erection. The commonly assumed life span of 25-30 years for facades is only a portion of the primary structure, and this remains true even if the service life of facades is doubled. Demolition and recycling of the whole structure and erection of a new building following the actual state of the art is usually not an option – and from point of holistic view taking into consideration grey energy does not make sense either. So special care has to be taken to combine improved energy performance and historic appearance – just adding insulation is not acceptable. Glass as a transparent material is an important element in facades, first a general overview especially on glass related questions is given, followed by examples of rehabilitation of classified historic buildings.

Keywords: listed historic buildings; glass types; façades; energy performance; safety; design.

1 Introduction

A large part of the carbon emissions come from the operation of existing buildings, for heating and cooling. At the same time, the buildings themselves store a large amount of gray energy and thus CO2. In this respect, demolition and new construction is not an option as a contribution to limiting the climate crisis; rather, the energy balance of existing buildings must be improved. The building envelope, i.e. in particular the facade with the windows, plays an important role here. With regard to glazing, there have been many developments in recent decades to contribute to energy savings, and the façade construction has also developed further, e.g. thermally separated profiles to avoid thermal bridges. The above also applies to listed buildings - even if exceptions are sometimes made here with regard to the energy balance requirements. First, the special features of glass as the most important element of facades and windows will be discussed in more detail. Only with the appropriate knowledge, the right decisions can be prepared. Examples of executed projects of listed buildings illustrate the challenges in the conflicting areas of monument protection and current requirements for safety and function.

2 Glass elements for facades

2.1 Introduction

Glass as a transparent element is also an important element in listed buildings. Historically, there was a development regarding the production technology of the basic glass as well as the finishing or processing to coated glass, safety glass, laminated glass or insulating glass units (IGU). Associated with these production methods are questions regarding several important aspects:

- Size
- Surface
- Safety
- Strength
- Solar and energy performance

In the following, the development and its implications for an application are considered for

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Preservation of heritage masonry structures: Assessing compatibility of consolidative treatments on Fired Clay Bricks

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Abstract

Heritage structures are prone to deterioration due to aging and dynamic environmental conditions. Protection by "consolidative treatments" is one of the ways of by which we can extend its life. However, compatibility of a consolidant with the substrate is complicated and depends on the material properties and exposure conditions. Selecting the wrong consolidant can accelerate the deterioration instead of restoration of properties. This study aims to assess the performance and compatibility of acrylic-polymer and silane based consolidants on samples of fired clay bricks of various qualities used in heritage masonry structures. To evaluate the performance of the consolidants, the initial physical, mechanical and microstructural properties of the substrate samples were established through various test methods. These initial properties are then compared to the properties of treated and untreated samples that were subjected to accelerated salt weathering, thus analyzing the weathering resistance.

Keywords: Consolidant, Acrylic-based, silane-based, fired clay brick, Heritage bricks

1 Introduction

India is home to vast monumental brick structures, which are of great importance due to it's architectural, cultural and historic values. A number these heritage structures are situated in an environment highly prone to deterioration.

Among the various degradation mechanisms, soluble salt crystallization within the pores of substrate materials of heritage structures is found to cause the greatest damage, especially to the structures in saline environment (1).

The chemical and hydrophilic characteristics of the substrates are what help us to pick the right treatments (2). The requirements of a protective treatment is to create a barrier layer between the substrate and external environment, as well as strengthen the degraded surface of the material. Consolidative treatments are most preferred in restoration and preserving heritage structures, especially in cases where adhesion between the particles are also to be improved.

Consolidants are low viscous chemicals that penetrate through the surface of a substrate material and attempt to restore cohesion within and further improve its properties, thereby slowing down the rate of deterioration and extending the life of the structure. One major factor when dealing with consolidants are their compatibility with the substrate. An effective consolidant should be able to give desired results in reducing the rate of deterioration without altering the natural appearance of the monument. Consolidation is therefore intended to increase the resistivity and improve the coherent

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Lime-red mud binders for repair of heritage structures and for CO_2 sequestration

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Abstract

Lime is an ancient building material used in the construction sector which was replaced by cement due to its superior properties. India is rich in heritage structures and they were majorly built with bricks, stones and lime mortars. The rising concern about repairing these structures has led to the revival of lime as modern materials are observed to be incompatible with traditional materials. The slow-setting properties of lime led to a sharp decline in the use of this sustainable material. Air lime sets by the process of carbonation and accelerating this process can lead to faster setting, superior properties and CO_2 sequestration. This work focuses on accelerating the process with the addition of an industrial waste residue. Red mud is a waste residue from the aluminium industry that possesses disposal difficulties and is a CO_2 sink due to its basic nature. The current study puts forward a novel idea of combining the two materials for effective carbonation and checking its potential to be categorised as a repair material for heritage structures. The present work will focus on substituting lime with 10, 20, 30, 40 and 50% of red mud and analysing its physical, mechanical as well as CO_2 uptake under natural exposure. The applicability of the developed binder can be checked by employing it as a plaster as it can provide higher thermal comfort due to its porous nature.

Keywords: lime; red mud; heritage structures; carbonation; CO_2 sequestration.

1 Introduction

Lime was one of the most prominent building materials used. The introduction of cement led to the decline in use of lime. The major reason for this change is the slow setting and strength properties of lime [1]. The current rise in concern of conserving heritage structures has led to the reintroduction of lime in construction sector. Use of cement for the repair of lime based heritage structures has been observed to be more damaging [2]. The further damage can be attributed to the low porosity, dense and higher strength of cement than ancient materials [2]. The major disadvantage associated with lime is its slow setting that can be avoided with the use of mineral admixtures, particularly industrial waste materials. Air lime sets by the process of carbonation and can mineralise decent amount of CO_2. Any potential waste material that can capture CO_2 or support lime in carbonation can be used to make a binder. In the present study an industrial by-product red mud is used a replacement material for lime. This will reduce the

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Sustainable development requires risky decisions - problematic 300 ton overweight transport passing a bridge

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Abstract

Oversize load passages over bridges are one of the research issues related to sustainable development that engineering and scientific teams around the world have to deal with . The article presents the scope of activities that enabled the passage of an oversized vehicle with a total weight of over 300 tons over a reinforced concrete slab. The bridge load capacity is 30 tons. In order to assess the capacity of the bridge, detailed visual inspection, inventory, tests during a load test, field and laboratory tests of concrete, location and inventory of reinforcement, static and strength calculations were carried out. Unfortunately, the tests done during the passage of an oversize vehicle on the bridge showed that the actual weight of the set were greater than originally declared. Fortunately, it turned out that there were still some reserves in the structure load-bearing capacity and the over-weighted vehicle entered the bridge without any damage to its structure.

Keywords: reinforced concrete bridge; oversized transport; FEM; GPR; load testing.

1 Introduction

One of the research issues related to sustainable development that engineering and scientific teams around the world have to deal with are oversize load passages over bridges. Many of them are several and sometimes even several dozen times heavier than the estimated usable load capacity of the bridge on which they intend to pass. In the case when archival documentation is available, the analysis of the permission for the abnormal transport is often limited to the calculation of the structure's response under the new, extraordinary load scheme only. Unfortunately, the archival documentation is often not preserved, especially for old bridges and those located along roads of minor importance. In such a case, approval of an overweight vehicle passage is quite complicated. The standard calculation and diagnostic methods used by engineersare not sufficient here. In this case, the issuing of a permit to pass the bridge requires a complementary scientific analysis of the structure response. The problem is extremely important, but quite rarely addressed by researchers [1]-[5]. Therefore, the aim of the paper is to present a representative methodology for assessing the load-bearing capacity of a bridge to allow the passage of an oversize vehicle. The case study presented here enabled the new power station generator to be delivered to the plant in the fastest way.

2 The description of the bridge

The road bridge crosses the Piasnica River in the Pomeranian Voivodeship in Poland. It is a two-span continuous reinforced concrete slab with a total length of 13,1 m (Figure 1). The theoretical spans length is $L_t = 2 \times 6{,}35$ m.

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Sustainable Design and Construction of Bridge – Case Study of Design of Arch Bridge in Nepal using Multi-Criteria Decision Analysis

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Abstract

The importance of sustainability in transport infrastructure continues to gain momentum. Policymakers and planners play a vital role in integrating sustainability into transport infrastructure, so sustainability assessment should begin with decision-making. This paper highlights the use of the Multi-criteria Decision Analysis (MCDA) technique: Analytical Hierarchy Process (AHP) to compare bridge design options in terms of sustainability. AHP can be a user-friendly assessment tool in developing countries where incorporating sustainability is not prioritized yet. The project "Design and Build of Bridges along Narayanghat-Mugling Highway" in Nepal is selected as the case study. Using AHP, a monolithic concrete arch bridge was compared with a two simply supported spans of prestressed concrete bridge. Criteria such as economic, environment, construction ease and maintenance were incorporated in the AHP. The results of AHP show that the Arch bridge is a more sustainable design option.

Keywords: Analytical Hierarchy Process (AHP), Multi-criteria Decision Analysis (MCDA), Sustainable design, Arch Bridge, Transport Infrastructure.

1 Introduction

The sustainable solutions, tools and techniques in the construction sector have long been discussed. Policymakers have a great influence on the sustainability performance of an infrastructural project, so sustainability assessment should begin with decision-making [1]. Traditionally in developing countries factors such as economics and functionality are prioritized over sustainability and carbon emissions in the design and planning of infrastructure. With rising awareness toward sustainable development, changes in governmental policy and contractual requirements are being observed. But the pressing question remains- “How to compare and select sustainable infrastructure design option?” Decision makers are in search of tools and techniques to assess sustainability in various life stages of infrastructure projects [2].

In this research, Multi-Criteria Decision Analysis (MCDA) technique Analytical Hierarchy Process (AHP) has been used to compare and select sustainable bridge design option. In this paper, "Design and Build of seven bridges along

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Sustainable Bridges – Past and Future
Reflections on a European Project 2003 - 2007

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Abstract

Twenty years ago, in 2003, a European project was started to increase the sustainability of existing railway bridges. This paper summarises what was achieved and looks ahead. Nine Working Packages were organized: (1) Background material; (2) Guidance by stakeholders; (3) Condition Assessment and Inspection Guidelines; (4) Loads, Capacity and Resistance Guidelines; (5) Monitoring Guidelines; (6) Repair and Strengthening Guidelines; (7) Demonstration with Field testing of Bridges; (8) Demonstration on Monitoring on Bridges; and (9) Training and Dissemination

Some of the main results (from 4 Guidelines and 47 Background documents) are highlighted and some experiences, conclusions and thoughts about the future are given. Hidden strengths and weaknesses are discussed, analyses and codes for assessment can be improved, new monitoring and strengthening methods are available and life length can be prolonged.

Keywords: Bridges, Management, Assessment, Modelling, Monitoring, Testing, Codes, Load-carrying capacity, Strengthening, Life-length

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Research on Concrete Box Girder Bridge Widening Based on Spatial Grid Model

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Abstract

In this paper, based on a practical project, the spatial grid model is used to analyze the stress of the widened bridge. By comparing the stress changes, it is concluded that the shrinkage and creep of the new bridge will affect the stress of the whole structure after two bridges are connected. At the same time, the foundation settlement of the new bridge will generate additional stress at the connecting deck of the two bridges. Therefore, when the bridge is widened, certain measures should be taken to reduce the shrinkage and creep of the new bridge and the settlement of the foundation, so as to reduce the influence on the structure and ensure the safety of the widened bridge.

Keywords: Bridge widening; Spatial grid model; Shrinkage and creep effect; Foundation settlement

1 Introduction

With the increasing traffic flow,many bridges built in the past can no longer meet the traffic needs.In order to make full use of the old bridges and give full play to their economic value,bridges need to be widened to improve its bearing capacity.Reuse of existing bridges can reduce carbon emissions and be environmental friendly.

After the bridge is widened,the connection between the new and the old bridge is connected through the flange slab, and the load is transferred through the bridge deck. Under using load, the bridge will produce torsion and distortion effect. At this time, continuing to use the traditional calculation method will cause errors, and can not accurately calculate the stress state of the structure.

Therefore,in order to obtain more accurate stress state of the bridge, spatial grid model is adopted in this article.Combining a practical project,main factors that affect the stress of the structure after bridge widening are analyzed, including shrinkage and creep effect , foundation settlement and temperature effect.

2 Project overview

This project is a three-span prestressed concrete continuous bridge. Due to the increase of traffic flow, the original bridge needs to be widened to improve its traffic carrying capacity. The span arrangement of the bridge is (28+40+28) m, as shown in Fig.1.

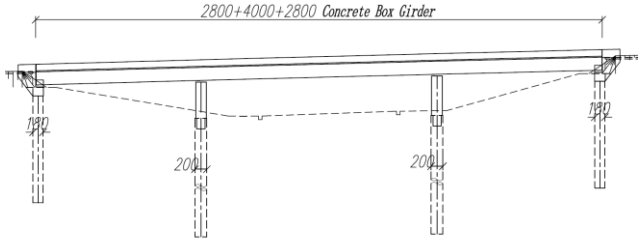

Figure 1. Span arrangement of the bridge(mm)

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Adoption of Stainless Steel in Bridge Construction for Safety and Sustainability

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Abstract

Stainless steel, an iron alloy with chromium, is corrosion-resistant with low maintenance requirements. It has good strength, toughness, and fatigue properties. Stainless steel can be fabricated using a range of engineering techniques and are fully recyclable at end-of-life. The high ductility of stainless steel is a useful property where resistance to seismic loading is required.

The high strength with low maintenance effort makes Stainless Steel an attractive candidate for the material of construction for Bridges. There is increasing awareness that whole life cost, not just initial cost, should be considered when selecting materials. Experience shows that using a corrosion-resistant material in order to avoid future maintenance, downtime, and replacement can be a sustainable cost-effective solution, even though the initial material costs are higher.

Keywords: stainless steel bridges; sustainable construction; life cycle costing of bridges.

1 Introduction

Structural Steel has been one of the preferred materials for the construction of bridges for a long time. The low weight to strength ratio of steel together with its ease of fabrication is the main plus point. Steel is also recyclable allowing it to be reused. The durability of steel bridges has been achieved by suitable coating with paints or galvanising to inhibit corrosion.

Normal Carbon Steel is affected by corrosion when exposed to the atmosphere. It would undergo deterioration and failure if left to itself. The solution to this problem has been periodic painting. The activity involves regular inspection of the bridges to find out the extent of corrosion and resulting safety of the structure and its users besides the actual painting every ten or twenty years depending on the quality of the paint. This activity results in allocating a large amount of resources both human and material throughout the life time of the structure. The cost of this maintenance activity during the service life of a steel bridge is often substantial. Thus the expenditure over the whole life of a bridge is often much higher than the initial construction cost. In order to assess the material and energy input, one should logically perform an analysis of the whole service life of the structure. In this context, it would turn out that construction with

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UNDERGROUND METRO: A SOLUTION FOR SUSTAINABILITY

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Abstract

Time is not far when this world will have to find place on other planets to surmount the difficulty of shortage of land on the Earth. Metro has been going underground at many places. Taking a cue from Paris and London, the city appears so neat, when the metro is all put underground, especially in the main city. India is moving very much in the same direction. And underground metro provides effective means of sustainability in many ways. The masses can be transported in urban areas without cluttering the ground level roads. Being underground, the pollution levels are reduced to minimum. Tunnel and many times platforms and OT ducts are made in precast concrete, thereby reducing the quantum of site produced concrete and reduce environmental pollution. Construction of various structures of UG Metro is carried out in a specialized manner. The following paras explain broadly adopted construction methods of each of these.

Keywords: Underground, Top-down Construction, Bottom -up Construction, Tunnel Boring, TBM, Cross Passages, Ventilation

1 Underground Metro Station

A typical underground metro station has a main station body of about 20m width and 250m length with two levels below the ground, lower level for track & platform and upper level for concourse (paid & unpaid areas). The main station body is flanked by four or more entry-exit structures connecting ground level to the concourse. Figure 1 depicts a typical station footprint. Figure 2 shows inside view of concourse and platform levels (with a large opening at the concourse level in the present case.

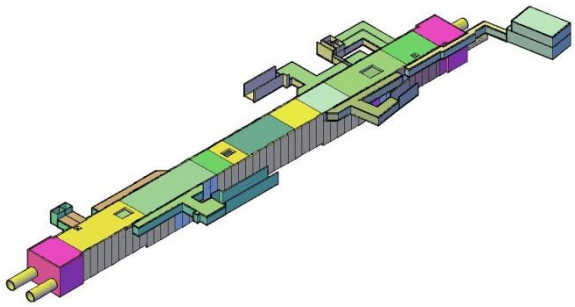

Figure:1- Typical Station Footprint

Figure:2- Inside View of Station

2 Top-down Method of Construction

Top-down method of construction is more common, as the ground above is usually required for traffic or other uses during construction. This method requires the use of RCC Diaphragm Walls (see figure 3) followed by roof slab, followed by concourse Slab and followed by the base slab wherein connection between Diaphragm Wall and

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Construction of the Multi-span Cable Stayed Bridge at Ambhora, near Nagpur, Maharashtra

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Abstract

The multi-span cable stayed bridge over river Wainganga near Ambhora, Maharashtra, has an overall length of 705m and deck width of 15.25m to accommodate 2 lanes of vehicular traffic and 3m+3m footpath for pedestrians. The structural arrangement of the bridge comprises 2 modules, with Module 1 of 420m and Module 2 of 280m length with span arrangements of 70m+140m+140m+70m and 70m+140m+70m respectively. The superstructure is cable stayed with RCC deck with an RCC pylon height of 30m above deck level. The pylon P3 at the center of the bridge is also proposed with Viewing Gallery 40m above deck level which is structurally independent from the main bridge. This paper discusses the construction aspects of the bridge along with the details of a special travelling formwork (form-traveller) used to enable the cantilever construction of the spans over deep waters. The Module 1 of the bridge is constructed by cantilever method for pylon P2 and anchored span method for pylon P1 and P3. The Module 2 of the bridge is constructed entirely on staging. This is one of the very few cable-stayed bridges in India where all 3 methods of construction of a cable stayed superstructure are adopted in the same bridge.

Keywords: Cable stayed bridge, Multi-span, Cantilever construction, Travelling Formwork, Form-traveller

1 Introduction

The reservoir of Gosekhurd Dam is one of the largest by storage capacity in the draught prone Vidarbha region of Maharashtra state, India. Opened in 2008, the reservoir's high FRL meant most of the bridges upstream on the Wainganga river get submerged every monsoon season, cutting off the links between the already under-connected Nagpur and Bhandara districts of the state. State Highway 254 of Maharashtra, which connects the southern and south-eastern parts of the Nagpur district to the city of Bhandara bares a

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First Time Use of LRB for Seismic Isolation of a Major Bridge in India - A case study

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Abstract

This paper presents first time application of Lead Rubber Bearings (LRB) in one of the Bridges in India, presently under construction and located in high seismic zone (Zone IV). LRB is adopted as a Seismic Isolation device for reduction of seismic demand. LRBs have found wide application worldwide because of their simplicity and combined Isolation-energy dissipation function in a single unit. Its components include a lead core and a laminated rubber bearing. In addition to withstanding a strong horizontal and vertical load, the lead core also has the ability to absorb energy through plastic deformation via hysteretic damping. LRB enhances flexibility of the structure and thereby the natural time period of structure defers with the natural time period of ground motion. LRB being the most viable option in high seismic zone, it was decided to use it in one of the projects, namely the viaduct approach spans of the 4-lane bridge over river Ganga at Patna, Bihar (Parallel to the Existing Mahatma Gandhi Setu). The project is being executed on EPC contract Mode.

Keywords: Lead rubber bearing (LRB), Seismic Isolation, stiffness, system analysis, lead plug, hysteresis damping, time period, energy dissipation, Euro codes.

1 Introduction

Lead Rubber Bearing (LRB) is being used as a seismic isolation device in Viaduct of Mahatma Gandhi Setu for the first time in India. Key features of Viaduct are as follows:

The approach Viaduct to the main bridge has a length of 1565,1 metres. The span arrangement comprises of several modules of spans, ranging from 2 span modules (2 x 33,3m), 3 span module (3x33,3m) and a few 4-span module of similar span range. The structural scheme of 18m wide deck superstructure comprise of five numbers pretensioned girders with in-situ RCC deck slab and diaphragms. Continuity is established through deck slab only within a module. Each span is supported on eight nos LRBs. The deck structure is resting on pier cap with single pier. The pier is in turn supported on bored-cast-in-situ piles. Soil strata in the area is such that loose filled-up soil is encountered up to 15m depth from ground level. To cater for large forces arising due to high seismic forces and poor soil conditions, LRBs have been resorted to in this project as this type of bearing cum isolation device reduces seismic demand considerably. **Fig.1** and **Fig.2** shows the Elevation and Cross-Section of the viaduct. **Fig. 3** shows the photo of under-construction Viaduct. LRBs used in Viaduct are multi-directional to allow translation in any horizontal direction. This paper gives salient technical details of the LRBs used in this project.

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Double-Decker - Nagpur Metro Flyover with Spine & Wing Superstructure

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Abstract

The rapid urbanisation demands the development of National highways (NH) & Metro corridors. However, the space available for the transportation structures is only the existing road width, which becomes a deadlock for executing agencies. The Nagpur Metro rail development & NH flyover work along the demanding Wardha road happened to follow suit. The 3.4Km stretch of NH & Metro alignment coincided between Ajni and Airport Road. The challenge became an opportunity to construct a double-decker, however, with various riders such as aesthetics, a stringent schedule, and overall economy. The stretch also included three stations and one obligatory span, which resulted in a Link Bridge for passenger movement and extended pier caps. The multilevel structural arrangement resulted in the optimisation of land use, materials, and other precious resources. The successful implementation of a double-decker became a trend-setter for various upcoming projects.

Keywords: Double-decker; Metro; Flyover; Spine and Wing; Combined Pier; Link Bridge; Aesthetics.

1 Introduction

The National Highways Authority of India (NHAI) proposed an elevated corridor of 3.4km on NH-6 passing through Nagpur city, wherein the alignment coincided with the metro alignment proposed by Maharashtra Metro Rail Corporation Ltd. (MAHA-METRO) between the New Airport and Sitaburdi. The Chatrapati junction on the alignment had an existing flyover, which necessitated the demolition of an existing structure. The initial independent planning by both authorities resulted in two separate structures, wherein the flyover was proposed to be supported on portal piers and the Metro viaduct by single cantilever piers at 25m intervals placed alternately with portals. The minister overseeing project monitoring directed authorities to investigate the possibility of a common solution. Hence, the double-decker with metro alignment on top of the flyover is conceptualised in consultation with all the stakeholders.

The combined alignment eliminated land acquisition requirements. The Metro alignment comprises a viaduct with two tracks and three stations at Chatrapati Square, Jayaprakash Nagar, and Ujjwal Nagar. The NHAI flyover comprises 4-lane divided carriageways for most of its length and a part of 6-lanes to accommodate traffic from a merging flyover connecting Manish Nagar to the elevated corridor at Ujjwal Nagar. The consultant proposed a scheme with a spine and wing superstructure for the flyover that allowed a single combined pier for the metro and flyover.

The metro station platforms and buildings in the double-decker portion are divided due to the presence of a viaduct. However, connectivity between two platforms in metro stations is vital for passenger movement. This obstacle had been

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Study of A Monumental Stair Susceptible to Excessive Vibrations Due to Human Movements

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Abstract

Excessive vibrations of monumental stairs can become a major serviceability issue. It is, therefore, important for structural engineers to be able to predict the behavior of these systems as accurately as possible. Inaccuracies in the response prediction can result in a structure with excessive vibrations or great unnecessary costs in terms of material consumption, particularly steel, which is against one of the main goals of sustainability in construction. To evaluate the accuracy of response prediction using a Finite Element computer analysis, this paper presents a study of a monumental stair susceptible to excessive vibrations due to human movements. The stair responses due to the ascent and descent at its first sub-harmonic of fundamental frequency were computed and compared with those from the measurement. Conclusions were made in regards to the computer modeling of the structure and its effectiveness in walk response prediction.

Keywords: Monumental stairs; vibration serviceability; modal test; walk excitation; experimental evaluations; Finite Elements Analysis; response prediction.

1 Introduction

Recent trend in the design of lightweight and slender monumental stairs by architects have made the vibration serviceability an important issue in the design of this class of structures [1-5].

Kim, et al. [6] studied the serviceability performance of steel and reinforced concrete stairs. Six mock-up stairs were constructed and tested. All stairs had very high natural frequencies and were not susceptible to large vibrations from human movements. The tests on the stairs confirmed that, in general, cast-in-place concrete systems exhibited better vibration serviceability than steel stairs. They also found that vibrations were larger when people ascended the stairs than when they descended, which is not consistent with other reported studies. They also noted that steel stairs had much larger vibration levels than their reinforced concrete counterparts.

There have also been several publications on the design of monumental stairs using Finite Element analysis only (without any vibration measurements) as mentioned below. Arbitrio [1] briefly discussed the design of a stair and vaguely explained its vibration analysis using the shell elements in the SAP2000 structural analysis software [7]. Huntington and Mooney [2] presented their study of the excessive vibrations of a 11,89m long steel stair. They conducted a Finite Element Analysis of the structure but did not provide any details of their work. They also reported the application of tuned mass dampers (TMD) to correct the excessive stair vibrations without providing much details.

Howes and Gordon [3] discussed the details of two sets of stairs for the Art Gallery of Ontario, located

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Designing World's Tallest Statue for Wind: Statue of Unity

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Abstract

The Statue of Unity is an iconic symbol of the 'Iron Man of India', Sardar Vallabhai Patel, who played a leading role in India's struggle for independence, guiding its integration into a united, independent nation. This statue is a colossal structure facing the Sardar Sarovar Dam on the river Narmada, in the state of Gujarat, India, and is presently the tallest statue in the world. This statue with a height of 182 m, erected on a river island, is exposed to heavy winds that necessitated wind load analysis. Considering the height of the statue, its specific geometry and specific location posed the greatest challenges that required special attention to the wind loads acting on the statue. Due to these complicated aspects of geometry, the estimation of loads employing building codes, such as IS:875 will not give accurate results. The present work focuses on a comprehensive wind load analysis of the statue, incorporating all critical factors that can influence the wind loading on the structure like the local topographic effects on the wind flow.

Local topography and its potential topographic effects merit special consideration in wind response predictions. Wind tunnel studies were carried out on a scaled model, following the established international standards and procedures. The wind-induced structural responses on the statue were analysed employing High-Frequency Force Balance (HFFB) technique. The statue has bronze cladding panels throughout on the external surface and the wind loads on these elements were also estimated by wind tunnel tests. In addition to structural and cladding wind tunnel tests, pedestrian-level wind comfort studies were also carried out, considering the large number of tourists expected to visit the statue and to avoid any discomfort due to wind. All these studies generated enormous data that provided valuable inputs for the safe design of the structure.

Keywords: Statue of Unity (SOU), Topographical study, High-Frequency Force Balance (HFFB), Cladding wind loads, Pedestrian Level Comfort, International standards.

1 Introduction

Modern building materials and innovative structural design techniques have enabled architects and engineers to create buildings and structures that surpass traditional boundaries. However, existing building codes and standards, based on conventional building shapes are grossly

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488 University Avenue - Toronto: Redefining possible in the vertical expansion of buildings

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Abstract

488 University Avenue condominium is a unique, first-ever designed and constructed 55-story tower, where 37 stories of residential units were added above an existing 18-story office building. This was made possible by an innovative structural solution assisted by extensive wind tunnel testing and the implementation of a tuned sloshing damper (TSD) system to achieve the required strength and serviceability performance targets.

In this paper, a detailed description of the structural solution implemented for this building is first presented. Then, the wind tunnel testing considered for the evaluation of the wind performance of the building is discussed with a particular focus on the assessment of wind-induced motions and their acceptability for occupant comfort. Lastly, the implementation and the as-built performance verification of the TSD are demonstrated using full-scale measurement data obtained from a long-term structural monitoring program.

Keywords: vertical expansion; high-rise buildings; wind tunnel testing; motion comfort, tuned sloshing damper, serviceability performance; structural monitoring.

1 Introduction

488 University Avenue condominium is located in the downtown area of Toronto and is a unique, first-ever designed and constructed 55-story building, where 37 stories of residential units were added above an existing 18-story office building (Figure 1). The developer's vision for this project was to create a state-of-the-art mixed-use development by fully renovating the existing office building in a sustainable manner. The renovation plan included the expansion of the underground parking from two levels to six levels and the addition of 37 floors of residential condominiums above the existing office building while keeping it fully operational throughout the entire construction period. The deteriorating precast façade of the existing office building and the aged single-pane glass offered poor insulation and energy efficiency. These, coupled with the restricted natural light penetration caused by the precast fins and the need for structural enhancements to support the addition of the residential units above the existing building were the key decision-making factors for this unique development. To the authors' knowledge, 488 University Avenue is the most daring vertical expansion of an existing high-rise building which

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Research on creep and shrinkage effects of steel-concrete-Ultra-High Performance Concrete (UHPC) composite structure under different construction methods

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Abstract

The shrinkage and creep effects of concrete is an indispensable calculation content in the design of concrete bridges and composite bridges. Based on past experience, the deformation of concrete slabs is constrained by steel plate. As a special concrete material, the shrinkage and creep mechanism of UHPC is similar to that of ordinary concrete. However, the shrinkage and creep rate of UHPC is different. This paper mainly calculates and analyses the shrinkage and creep effects of steel-concrete-UHPC composite slabs under two different construction conditions (cantilever construction and full framing construction). Firstly, the solid finite element method is used to simulate the shrinkage and creep effects of composite slabs. Then, the stress and deformation of each component in the composite slabs under the two construction conditions are compared and analysed. Finally, the influence of construction methods on the shrinkage and creep performance of the steel-concrete-UHPC composite slabs is revealed and summarized.

Keywords: Steel-concrete-UHPC composite slabs; Cantilever construction; Full framing construction; Shrinkage and creep effects.

1 Introduction

In order to relieve the traffic pressure within the urban area, and taking into account the existing construction conditions in the meantime, the application of the City elevated in the urban area is gradually increasing. The main bridge is the continuous steel-concrete composite girder bridge with a length of 140m, a span arrangement of 40+60+40m and a width of 16.5m. The composite slab is a steel-concrete-UHPC composite slab with the thickness of slabs varying linearly from cantilever end to root, which is from 270mm to 370mm. And the thickness of bottom steel plate is 8mm. The concrete is connected to the steel plate by means of studs and steel ribs. And the concrete is connected to the UHPC layer after the surface of concrete has been chiselled.

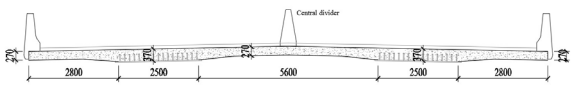

Figure 1Cross section of main bridge

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Butt-jointed reinforcement bars in the longitudinal joints of tunnel segments: Experimental investigation

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Abstract

A tunnel lining built with a TBM (tunnel boring machine) consists of a large number of segments interacting via joints, that are commonly decisive for the design of the segment. In order to overcome this limitation, the Institute of Structural Engineering at TU Wien developed a novel reinforcement concept to enhance the longitudinal joint in terms of the ultimate load.

This paper presents the results of an experimental campaign on large scale test specimens investigating the load-bearing behavior of load transfer zones under compression with butt-jointed longitudinal reinforcement bars. The focus is on the effects of using a minimum transverse reinforcement on the load-bearing capacity of the segments. Based on the satisfactory results, it can be stated that the TU Wien reinforcement concept has a great potential for improving the performance of highly stressed tunnel segments.

Keywords: segmental tunnel lining, precast tunnel segments, joint reinforcement, resource-efficient structure

1 Introduction and motivation

Building the load-bearing tunnel structure with a segmental lining has gained growing relevance within recent decades and is now an internationally established and frequently used construction method. The load-bearing capacity of the longitudinal joint is typically the decisive factor when designing tunnel segment rings. This is due to the reduced cross-section of the segment in the longitudinal joint, accounting for installation and durability requirements.

In order to improve the performance of the longitudinal joint, the Institute of Structural Engineering at TU Wien developed a novel reinforcement concept. The concept is based on the installation of butt-jointed reinforcement bars in the load transfer zone, which leads to an improvement of the load-bearing capacity. With this approach, the longitudinal joint is no longer the weakest link in the segment ring. The new reinforcement concept is covered by a patent application [1, 2]. National patent phases have begun in Europe, the United States, Canada, and China.

The proof of concept of the innovative reinforcement concept has already been done in 2019 [3, 4]. In this paper, first results of a new extensive experimental campaign, which includes the investigation of different reinforcement concepts, are presented and compared with the results of the 2019 tests. In the new test series, the transverse reinforcement is reduced to a minimum according to the current European standards [5, 6]. The evaluation of the performance of the TU Wien reinforcement concept combined with a minimum of transverse reinforcement was the main motivation for the presented experimental investigations.

2 TU Wien design approach

According to the new concept, additional reinforcement bars, as indicated in Figure 1, are positioned precisely adjacent to the contact surface A_{c0} of the longitudinal joints. Therefore, the compressive force operating in the tunnel segment ring can be transferred in the contact area through

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Bridge Cables – Non-Desctructive Testing

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Abstract

Non-destructive testing (NDT) is essential for maintaining the safety and functionality of bridge cables. This paper reports about a research project investigating the potential of magnetic inductive testing (MIT) for non-destructive testing of bridge cables in free length in combination with ultrasonic testing (UT) in the area of the end connectors. The MIT method is non-invasive and uses magnetic fields to detect defects in metallic materials such as bridge cables and is accepted as testing method for running ropes since many years. The project evaluated the effectiveness of the MIT method in detecting defects such as broken wires, corrosion symptoms, and other imperfections. The results demonstrate that MIT is a promising NDT technique for bridge cables, providing valuable information for maintenance and repair purposes. The paper also highlights the need for further research to optimize the MIT technique and its applicability to different types of cables and conditions.

Keywords: NDT, non-destructive testing, MIT, magnetic inductive testing, UT, ultrasonic testing, bridge cable, wire

1 Introduction

When constructing bridges with large spans, there is virtually no alternative to the use of high-strength tension members. A distinction is made between suspension bridges, cable-stayed bridges and rope bridges, the latter being primarily reserved for non-motorized traffic due to the absence of a stiffening girder. As a rule, full-locked coil ropes are used here, although the use of parallel strand systems is becoming increasingly widespread. Both types of tension members are regulated for Europe in EN 1993-1-11 [1]. The corresponding protection goals are adequate safety of the bridge in the ultimate limit state, safety in use in the permanent design situation and adequate durability with low maintenance requirements.

The required robustness and sustainability are particularly sought in the use of tension members in bridge structures, since the tension members can either not be replaced at all or only at great expense. As one of the main components, the tension members therefore essentially determine the service life of a bridge structure.

Damage to the tension members used manifests itself in particular in the form of wire breaks, which can have various causes.

In order to ensure a consistent level of safety here, regular inspections are essential. Since visual inspections can, by their very nature, only detect surface damage (and may be subject to major limitations due to the presence of corrosion protection layers), magnetic inductive testing (MIT) is an option here, taking into account the technical and economic feasibility. The principle of MIT has been known for many decades and has been used in the past for testing tension members, especially in ropeway construction and in the testing of mining ropes.

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Seismic performance of rigid-frame suspension composite bridges

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Abstract: Rigid-frame suspension composite bridges can improve the problem of continuous mid-span deflection of traditional long-span continuous rigid-frame bridges. In this paper, a rigid-frame suspension composite bridge with a span combination of (70+130+80) meters was selected as the case study. The elastoplastic three-dimensional dynamic finite element model of the bridge was built by OpenSees software. Nonlinear time history analysis and fragility analysis were carried out. The results show that the dynamic characteristics of the rigid frame suspension bridge are similar to those of rigid frame bridge. The rise-span ratio affects the displacement at the top of tower, the bending moments at the bottom of tower and at the top of pier in the transverse direction. The results of fragility analysis show that the bridge tower remains elastic under earthquakes.

Keywords: seismic performance; rigid-frame suspension composite bridges; rise-span ratio; fragility analysis

1. Introduction

The structural feature of rigid-frame bridges is that the main beam is rigidly connected to the bridge piers. Its most obvious advantage is that the pier and beam can work together to resist external forces. Compared to bridges with smaller spans, the response of large-span continuous rigid-frame bridges to earthquakes is more significant, and their seismic analysis is more complex. Based on existing research results, it is concluded that vertical seismic effects have a relatively small impact on internal forces of the structure. In seismic response, the control section of high-pier and large-span continuous rigid-frame bridges is located at the bottom of the pier, the root of the main beam, and the mid-span. [1]

Suspension bridges, due to their strong crossing ability, long structural period, and small response, have gradually become the preferred bridge type in high-intensity earthquake areas. According to the literature [2-3], some suspension bridges with small spans in Japan have suffered local damage due to earthquake action. For example, one of the main towers of the Atakawa Bridge with a main span of 90m was fractured in the Kanto earthquake, and the upper chord of the Gosho Bridge's stiffening girder was bent and the anchorage moved 20cm in the Fukuoka earthquake [4].

The bridge type studied in this article is a combination of rigid-frame and suspension bridge systems. It combines the advantages of large rigidity of rigid-frame bridges and strong crossing ability of suspension bridges, which makes the middle part of the bridge beam more flexible. However, since this bridge type is proposed for the first time, its seismic performance needs to be studied.

2. Project Overview

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Numerical modeling of rigid frame suspension composite bridge

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Abstract:

Large span continuous rigid frame bridges often suffer continuous deflection of the middle span in the service. In this paper, the rigid frame-suspension composite bridge is proposed in which main cables and hangers are adopted to support part of the beam weight at mid-span. A 70+130+80m-span bridge was selected as the case study and its finite element model was built using the software of Midas. In comparison with continuous rigid frame bridge, the rigid frame suspension composite bridge suffers significantly lower creep deflection. As the tensile force of hanger rod increases, the upper deflection value increases. The results obtained have certain reference value for the design of such composite bridges.

Keyword: rigid frame suspension composite bridge; numerical modeling; the mid-span deflection of main beam

1 Introduction

With the continuous development of bridge construction in China, the proportion of large-span continuous rigid frame bridges is gradually increasing. However, many pre-stressed continuous rigid frame bridges have appeared with mid-span sagging problems that affect the normal use and structural durability[Error! Reference source not found.].For e xample, the auxiliary channel bridge of the Humen Bridge[3] with a main span of 270m was completed in 1997. In 2003, the mid-span deflection value had accumulated to 22.2cm, which exceeded the reserved 10cm pre-arch value during construction.

The main maintenance and reinforcement methods for the problem of sustained deflection at the mid-span of large-span continuous rigid frame bridges are[4]:(1) External prestressing strengthening method: The Beijiang Bridge adopted the concept of zero-moment loading method for beam arrangement optimization, and appropriately increased longitudinal prestressed steel strands at the top of beam. The finite element calculation results show that after optimization, the mid-span deflection of the bridge can be reduced by about 70.8% in 10 years [5].(2)The method of transforming the continuous rigid frame into a cable-stayed bridge with short towers[6]. Xi Xinghua[7] conducted a verification analysis on the reinforced bridge, and the results showed that the structural system reinforcement, if designed properly, can not only enhance the main beam, but also suppress the mid-span deflection (3) Increasing section size and reinforcement method: Xiong Feng[8] summarized that the fundamental reason of continuous deflection and cracking of the beam is the insufficient resistance of the cross section.

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In-Plane Behavior of Strengthened Unreinforced Masonry Infill Walls: Experimental and Numerical Study

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Abstract

Masonry walls are often regarded as non-load-bearing components in most steel or concrete-framed buildings which effectively increases the total system's strength and stiffness when subjected to horizontal forces. This paper will discuss the experiment using reversed quasi-static cyclic sinusoidal displacement-controlled loading on the masonry infill wall and explains the outstanding ductility capability of masonry infills in Reinforced Concrete (RC) frames, as seen during cyclic experimental testing on wall specimens. The study's primary aim was to describe how the rectangular brick infill panels on RC frames behave during earthquakes. The results regarding in-plane force-displacement responses, damage evolution and energy dissipation capacity will be presented. Ultimately, the experimental tests were simulated in the software ABAQUS through a simplified modelling approach and validated against the experimental results.

Keywords: Masonry Infill Walls; Quasi-Static; Textile Reinforced Concrete (TRC); Numerical Simulation; Force-Displacement Responses.

1 Introduction

The most popular structural technologies globally are reinforced concrete (RC) frames and masonry infill walls (MIW). Across the world, particularly in developing nations like India, these structural types are employed for low- to medium-rise buildings. Infill panels are employed as partitions in these structures, while the enclosing frame serves as a structural skeleton to handle lateral and vertical loads. It is standard practice not to include the infill walls in the numerical models used for practical structural analysis and design purposes when building such structural systems against seismic activities because these parts are not load-bearing [1]. By doing this, their contribution to the frame's stiffness and strength and its interaction with the load-bearing components (i.e., the beams, columns, and walls) are entirely disregarded.

As a result, based on structural assessments, the actual performance of infilled RC frames would differ from the predicted performance [2]. The interaction of the frame and infill between the interfaces between the surrounding structure and the infill walls, which increases the stiffness of the entire frame, is typically the only way that infill walls are considered. Masonry infill walls can significantly impact the structural performance of

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Digital Bridge Schwindegg: Ab initio bridge monitoring for a sustainable lifecycle management

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Abstract

Bridges worldwide are facing challenges of aging, increasing traffic, and heavier vehicles, for which they were not originally designed. Lack of funds and skilled labour to strengthen and maintain existing structures have further intensified the need for bridge rehabilitation. Intelligent lifecycle management is proposed as a countermeasure to these problems. Many are researching the conceptual design of digital twins, exploring their potential, and investigating implementation approaches. Building Information Modelling platforms and other databases have been developed for this purpose. We demonstrate the Digital Bridge in Schwindegg (Germany) as an Industry 4.0 based prototype to monitor new bridges from opening to traffic. This paper presents the conceptual design of this unique monitoring project, and the intelligent data collection in the asset administration shell BBox. The objective is to achieve sustainable life cycle management of bridges through the creation of Digital Twins with extended lifetimes beyond the typical 50-100 years.

Keywords: Bridge Construction; Sensors; Structural Health Monitoring; Lifecycle management; Digital Twin; Data Model; Degradation of Bridges

1 Introduction

The degradation of a bridges condition is a problem which is dealt with by most governments. The German Federal Highway Research Institute (BASt) publishes therefore periodically condition grades of the German highway bridges in a bridges statistics document on their homepage [1]. The raw data is also given in [2]. The condition grades reach from 1,0 (best) to 4,0 (worst). An overview of the grade distribution is shown in Figure 1a). Figure 1b) depicts the distribution of the superstructure's material of German highway bridges. With 68,9 % of the bridges area, most German highway bridges are made out of prestressed concrete [1]. The United States Department of Transportation also provides statistics of the US bridges conditions. They differ between the conditions of their bridge areas in "good area", "fair area" and "poor area" [3]. The proportional areas of the bridges conditions in 2021 are summarized in table 1.

Table 1. Proportional conditions of US bridges (Database: [3])

	good area	fair area	poor area
ratio	43,4%	51,5%	5,1%

As bridges contribute to the functioning of a society, the development and maintenance of the structures is of high importance. Poorer countries often do not have the financial capacity to maintain their bridge structures. This is referred to as a financing gap, which needs to be closed (e.g. [4]).

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Digitalization of bridge inventory via automated generation of BIM models

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Abstract

The construction of building information modeling (BIM) models for infrastructure is becoming increasingly prevalent, as it facilitates current asset management practices. Existing bridges are particularly challenging to model due to their complex geometry and missing information. Given the recent advancements in 3D surveying and artificial intelligence, new possibilities emerge for the generation of BIM models. This paper presents a novel, modular framework for an automated construction of as-is bridge BIM models from point clouds of existing bridges. Bridge element datasets were provided to train neural network. Trained neural network can identify bridge elements, which are further processed using geometric algorithms into surface and solid bridge elements. This result can be additionally enriched with information from existing databases. The final BIM models are exported in the standardized, open Industry Foundation Classes (IFC) format.

Keywords: bridge inventory; point cloud; artificial intelligence (AI); deep learning (DL); building information modeling (BIM); digital twin (DT); Industry Foundation Classes (IFC).

1 Introduction

1.1 Motivation

According to the "Master Plan BIM Federal Highways (Masterplan BIM Bundesfernstraßen)" of the German Federal Ministry for Digital and Transport [1], since 2021 new construction projects have to be planned and built using digital building models. These digital building models are to be further used to manage infrastructure operation and maintenance phases more effectively.

The benefit of the digitalization in the operation and maintenance lifecycle phases can however only be fully exploited when BIM (building information modelling) [2] models are available for the majority of the existing infrastructure assets. Depending on the quality and completeness of existing 2D plans and information in infrastructure databases, the manual digitalization of 2D plans can be time-consuming, costly or only feasible to a

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Linking BrIM to BMS for bridges – concepts.

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Abstract

Bridge Information Model (BrIM) is currently replacing drawings as main deliverable in new bridge project. Several use cases for BrIM over its lifetime is identified, as well as a discussion of the use case potential. Use cases include, but are not limited to, linking Bridge Management Systems (BMS) and BrIM, handling inspection data, visualizing inspection results and damage, tracking maintenance actions and structural changes. It may also serve for the analysis of residual strength, as digital twin in structural health monitoring (conditional maintenance) and as risk-based decision-making tool for the allocation of resources.

Thus, this paper will form a basis for updates of relevant IFC classes in the BrIM data structure to facilitate seamless communication between BrIM and BMS systems. Thereby the grossly different level of detail in BrIM (individual objects), GIS (road network) and BMS (asset portfolio), the data aggregation and drill-down, and the portability of existing data collections are major concerns.

Keywords: Asset Management, Bridge, Inspection, Maintenance, digital twin, BrIM, BMS, BIM, IFC,

1 Introduction

The ambition of many bridge owners is that BrIM shall be used during the whole life cycle of the structure, from initial design phase, through construction, operation, and maintenance until it is removed and recycled at the end of service – a one-stop-shop for information. Operation and maintenance data is currently collected in various forms and stored in different repositories as part of a BMS. To optimize maintenance of the individual structural asset and manage the asset as portfolio of structures it is beneficial if BrIM and BMS are linked such that information can be exchanged seamlessly, also for existing structures that currently do not have a BrIM model.

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GABM - Empowering the Micro Bridge Inventory Owners

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Abstract

World over Bridge Management [BMS] implementation is tilted towards owners having large bridge inventories. Implementing BMS is difficult for owners with less than 100 bridges. In certain pocket of India, most of the facilities and skills needed are available. The research was aimed to evolve BMS to suit the small inventory owners. The resultant application "Global Analytics for Bridge Management" [GABM] is aimed at empowering micro bridge inventory owners fulfilling the key objectives of BMS. Sustained research to provide thousands of micro-owners in India was a herculean task. GABM allows partial integration of BMS with the Bridge Information Model [BrIM]. Integration with Short term Structural Health monitoring allows risk-free monitoring of bridges in need of rehabilitation. Freedom to choose from the various functionalities in the GABM software does not result in the user losing any technical advantages of BMS. Software development for GABM was challenging. GABM renders operational ease in all operating systems.

Keywords: Global Analytics for Bridge Management [GABM]; Bridge Information Model [BrIM];3D geometric model;3D photogrammetry model; Short term Structural Health monitoring[STSHM]; LCCA; Sustainability.

1 Introduction

A major role of any Bridge Management System (BMS) is to manage and organize data related to all the bridges on a particular network. BMS ensure to collate data regarding periodic inspection reports for a bridge. It keeps track of inventory records to facilitate better decision-making during maintenance and rehabilitation for the entire service life of the bridge. Bridges deteriorate over time, during their service life. Bridges, therefore, need continuous inspection and maintenance to ensure their structural integrity, and in turn, ensure user-safety during their travel on the bridge. Maintaining bridges is a multi-faceted operation that requires both domain knowledge and bridge analytics techniques over large volumes of data for multiple inspections and elements of the bridge. Although most existing bridge management systems (BMS) have very efficient at data storage, they are not as effective at providing analytical capabilities or as flexible at supporting different inspection technologies. Without data and data analysis, bridge management would be little more than ad hoc reactions to the most urgent crises, rather than a well-planned, proactive process. It is also true that at times, data collection and analysis are performed in the required periodicity. Even missing one inspection cycle [rare but possible] can result in erroneous analysis.

Global analytics for Bridge Management [GABM] is a data-driven approach that has been used to improve the safety and performance of bridges. The use of analytics in bridge management dates to the late 20th century when engineers in the United States began using bridge data to analyse and control the structural integrity of bridges. In the early 21st century, bridge engineers used

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An Overview of the BIM implementation on Chilean Bridges

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Abstract

In Chile the Building Information Modelling is developing since 2015. During that year, the president of Chile announced encourage of use BIM in public infrastructure with two main objectives:

1. Request of the implementation of BIM in Public contracts by term of reference, in order to standardize the request process from the Public Services.

2. The review of the project using IFC format in the municipalities for private buildings, in order to obtain the construction permission.

On that framework it was create the initiative Plan BIM, which integrate the collaboration of Academia, Public and Private Entities in order to improve the knowledge and use of BIM.

This paper provides a comprehensive overview of the developing of BIM apply on Chilean bridges, highlighting the contribution of several stakeholders. Cases of study of the implementation of BIM is presented.

Keywords: BIM; bridges; design; Public and Private Overview; Chile.

1 Introduction

Chile presents a territorial extension of great geographical diversity, and therefore there is a large number of bridges (over 6,500) which must be under constant monitoring and maintenance as they are considered critical points within the road network since they allow and generate communication, circulation and integration for people as well as the movement of products and services that facilitate the country's economy.

1.1 BIM beginnings in Chile

Between 2013 and 2016, a national survey was developed in Chile through the Department of Architecture of the University of Chile to know the development in the subject and evaluate the level of BIM integration of the different construction

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Extending the life of a historical Bridge through UHPFRC

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Abstract

Designed by Robert Maillart, the Aarebrücke Aarburg (Aargau, Switzerland) stands as a landmark in townscape of Aarburg. This concrete arch bridge with a span of 67.83 m was constructed in 1912.In 1969, the original deck was replaced by a slender deck longitudinally and transversely prestressed. The original slender columns between the arch and the deck, characteristic of this specific bridge, were removed. The bridge was then retrofitted in 1996, but without including a waterproofing. Chloride penetration from de-icing salt used since 1969 is endangering the prestressing of the bridge deck. Due to increased traffic loads the cantilever slabs have been protected from traffic by means of posts. Considering these conditions, a rehabilitation method is sought, capable of increasing the structural capacity of the bridge as well as providing waterproofing. To this end, a UHPFRC (Ultra High Performance Fibre Reinforced Concrete) layer is envisioned.

In this paper, the bridge history is illustrated from the perspective of Robert Maillart bridge developments. Moreover, the strengthening methods employed to increase the lifespan of the bridge are explained, namely the use of UHPFRC on the upper layer and the removal of the expansion joints. The project has been executed as a BIM pilot for the bridge rehabilitations.

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Keywords: UHPFRC, Rehabilitation, BIM, Robert Maillart.

1 Introduction

In 1912, Robert Maillart finalized the construction of the Aarebrücke Aarburg, which provided a connection between the towns of Aarburg and Boningen. The initial design consisted of a slender concrete deck supported on an arch by means of a series of columns (Figure 1), a prototype of the stiffened arch bridge so characteristic and iconic from the engineer. In 1969, a wider deck was required, leading to a) deck replacement in favour of a prestressed solution and b) removal of the intermediate columns, whereas the original arch was preserved and strengthened by rips increasing its stiffness. A lighter retrofitting was conducted in 1996, where the longitudinal beams of the deck were strengthened for shear. However, no waterproofing was provided, resulting in chloride intrusion in the past years which could potentially compromise the transverse prestressing. Since the cantilevering sidewalks were not design for todays traffic loads, in 1996 posts were installed along the pedestrian path preventing heavy traffic to drive on the sidewalks.

In order to improve the structural safety of the bridge and its future maintenance, several measures are implemented. To begin with, the deck is strengthened by means of a UHPFRC layer, which also acts as a new waterproofing layer. Furthermore, the expansion joints and the abutment chambers are eliminated. Along with these interventions, an improvement of the bridge usage is envisioned, condensing the two lines of road traffic towards one side over the cantilever

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CROSFALL – A knowledge sharing newsletter to create a safer built environment

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Abstract

Confidential Reporting on Structural Failures and Lessons Learnt (CROSFALL) is a quarterly newsletter publication. This confidential reporting system is established in India recently by the Indian Association of Structural Engineers (IAStructE) with the objective to capture and share lessons learned from various structural failures which do not otherwise get reported and do not get the attention of the public as well as structural engineers. The intent to bring out this newsletter is to have a freely available database to be used by the construction industry to improve the safety of bridges, buildings, industrial structures, and other infrastructures of national importance. The paper will highlight the salient features of this newsletter and focus on the need for the structural engineering fraternity to contribute actively to this newsletter so that structural engineers learn important lessons from others' mistakes and do not repeat them in their own design.

Keywords: CROSFALL, structural failure, confidential reporting, lessons learned, public safety

1 Introduction

The structural engineering profession has not proven itself good at learning from mistakes, which is a matter of general concern. There have unfortunately been many buildings and other infrastructure failures in India in the recent past. Some of the most notable and high profiled failures amongst them are The Lalita Park building collapse, in Delhi, 2010 [Fig.1], Mumbai CST footbridge tragedy 2019 [Fig.2], Ultadanga flyover collapse, in Kolkata 2013 [Fig.3], Morbi pedestrian suspension bridge collapse, in Gujarat 2022 [Fig.4] and under-construction Vivekananda road flyover collapse at Kolkata, 2016 [Fig. 5]. While major collapses draw attention of the media and reported in electronic and print media, there are several failures and near misses, which are not reported at all. Failures may occur at any stage during the life of the structure.

Fig. 1 : Lalita Park Building Collapse In Delhi (2010) – 70 people Killed

One of the impediments to learning lessons from structural failure is that the full details of many failures and the outcome of forensic investigations are not made public by the authorities. Fear of blame, lawsuits, damaged business opportunities,

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A machine learning-based methodology of integrating loading data and load effect data for long span bridge assessment

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Abstract

A number of long span bridges around the world have extensive structural health monitoring (SHM) systems installed. These bridges are complex structures under complex operational and environmental conditions, making it challenging to process and interpret the monitoring data obtained. This paper presents a machine learning (ML)-based methodology of linking bridge loading data with measured load effect data for long span bridge assessment, developed using the monitoring data obtained from the 1377 m main span Tsing Ma Bridge in Hong Kong. The proposed methodology includes supervised, unsupervised and semi-supervised learning techniques to enable and automate the identification, classification and segmentation of different live load effects. The developed methodology can assist with more realistic load rating and fatigue assessment and facilitate the operation and maintenance (O&M) of long span bridges.

Keywords: long span bridge; structural health monitoring; machine learning; traffic loading; load effect; load rating; fatigue assessment.

1 Introduction

A number of the world's landmark long span bridges, such as the Tsing Ma Bridge (TMB) and Stonecutters Bridge (SCB) in Hong Kong and the Queensferry Crossing (QC) in Scotland, have extensive Wind and Structural Health Monitoring Systems (WASHMS) developed and deployed [1,2]. These were installed at the start of the bridges' service life in the hope that they will provide useful information on real structural condition and performance in order to improve bridge operation and maintenance (O&M) and facilitate intelligent asset management.

Long span bridges are complicated structures under complex operational and environmental loading conditions, which results in even more complex structural behaviour and structural responses. This makes it challenging to process and interpret the monitoring data obtained from these bridges. Therefore, it remains an asset management challenge to utilise the monitoring data collected from these bridges in order to inform their structural assessment and maintenance.

To enable more realistic structural assessment of bridges, the following are needed: (i) understanding the real loading conditions (e.g., traffic loading [3], wind loading [4]); (ii) understanding the real structural behaviour and structural responses (e.g., traffic load response [5,6], wind response [4]); and (iii) linking measured bridge loading data with measured load effect data for assisting with load rating and fatigue assessment [5,7]. However, (ii) and (iii) are

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The Second Generation of Eurocode 4

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Abstract

Work on the second generation of Eurocode 4 is nearing completion. Following the systematic review in 2014, the development of this standard has been undertaken by several project teams under the direction of the European Committee for Standardization subcommittee CEN/TC 250/SC 4, which is currently chaired by the present author. After a brief overview of the work programme that led to the second generation of Eurocode 4, this paper presents a selection of the changes that will be included.

Keywords: Include a list of not more than 10 keywords, for example: post-tensioning; anchors; slabs; walls; high-rise buildings.

1 Introduction

Eurocode 4 (EN 1994) is the European design standard for composite steel and concrete structures. The first version of Eurocode 4 was published by the Commission of European Communities (CEC) in 1985 [1] before the European Committee for Standardization (CEN) was given the responsibility to prepare and publish the Eurocodes 4-years later. Under the direction of Technical Committee CEN/TC 250, the Eurocodes were initially published by CEN in 1992 as European pre-standards (ENV), before they were converted and published as European Standards (ENs) in 2007. Subcommittee 4 (CEN/TC 250/SC 4) was responsible for preparing the ENV and EN versions of Eurocode 4, which was published in three parts, as follows:

(i) EN 1994-1-1, Part 1-1: General rules and rules for buildings [2].
(ii) EN 1994-1-2, Part 1-2: General rules – Structural fire design [3].
(iii) EN 1994-2, Part 2: General rules and rules for bridges [4]

A more comprehensive review of the development of Eurocode 4 from 1970 to 2010 is presented by Johnson [5]. In 2010 the Eurocodes replaced the former national standards within the 34 countries that are members of CEN. More recently, they have been adopted by Singapore [6], and it is anticipated that other countries may soon be implementing them, including Hong Kong, Macau, and Malaysia.

In response to the publication of Mandate M/515 by the European Commission [7] in 2012, an ambitious and detailed work programme was prepared by CEN/TC 250 [8], where specific tasks were undertaken by existing subcommittees, working groups or horizontal groups. The current structure of CEN/TC 250 is presented in Figure 1.

The revision can be broadly divided into two activities:

- General revisions and maintenance of the Eurocodes following the receipt of comments from the industry through a “systematic review” undertaken by national standards bodies (NSBs).
- Technical enhancements of the Eurocodes within the scope of Mandate M/515.

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Efficiency and Cost-Effectiveness of Ground Source Heat Pump for Five-Storied Office Building

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Abstract

Non-clean energy resources cause pollution, climate change and greenhouse gas emissions. Therefore, in present scenario it is very much required to use renewable energy resource as sustainable solution. Geothermal heat energy stored within the earth is one of the biggest sources of renewable energy. Shallow geothermal energy can easily be extracted using close- or open-looped geothermal systems and it is very effective for building heating or cooling purposes. Ground source heat pump (GSHP) is a closed-loop system where vertical boreholes are equipped with HDPE / PVC pipes (primary circuit) through which heat exchanger fluids are circulated, and when passing through boreholes they exchanges heat with surrounding ground. Heat pump is used to take out the fluids and circulate inside the building through pipes (secondary circuit) embedded in concrete floor to exchange heat with surrounding air.

A five-storied office building was studied to estimate energy requirements for heating and cooling demands in summer and winter for sizing GSHP using Energy-Plus software. Climatic and soil conditions for ten different metropolitan cities located mostly in tropical regions were considered. Using Ground Loop Design (GLD) software design of GSHP system was done based on energy demand of the building. A comparison of GHSP system design for the building in different cities and cost analysis are discussed. It is observed that the cost and performance of GSHP depends on several factors such as energy load demand, soil conductivity, and climatic condition.

Keywords: ground source heat pump; tropical regions; boreholes; heating; cooling; energy consumption; cost analysis.

1 Introduction

Worldwide exponential growth of energy consumption is leading to energy crisis. Use of fossil fuels cause environmental issues like global warming due to greenhouse gas emissions, increase in particulates in air, increase in global temperature, changes in weather pattern and increase in carbon footprint. These environmental issues can be controlled by use of renewable energies (wave energy, biomass energy, wind energy, solar energy, geothermal energy), and nowadays these renewable energies are generating lot of interest.

Geothermal energy is a form of renewable heat energy which is generated and stored within the earth interior. There are two types of geothermal energy based on depth from ground level: (a) shallow geothermal energy and (b) deep geothermal energy. The zones of shallow and deep geothermal energy below ground level are shown in Figure 1. Shallow geothermal energy system is

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Sustainable facade constructions

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Abstract

The building envelope has a significant contribution to the CO2 footprint of a building. This applies to both new buildings and existing buildings. The life cycle of a building can be extended through intelligent façade renovation or renewal, which of course has a positive effect on the overall balance. The decisive factor is a holistic approach from planning, construction, operation and maintenance including refurbishment and deconstruction. Current developments in facade construction will be shown. It is not just a matter of finding the best heat transfer coefficient for a window, for example, but of finding intelligent, object-related solutions.

Keywords: facade; glass; sustainability; cradle to cradle.

1 Introduction

The climate change and rising energy costs have increased society's awareness of energy-saving measures. To reduce CO2 emissions, many buildings from the 1960s and 1970s are now being refurbished. They barely meet the more stringent building standards introduced in recent years and often need to be renovated not only for energy efficiency, but also for fire safety and functionality. Retrofitting existing buildings is often very complex. New buildings also have to be planned and built in a way that conserves resources, are as climate-neutral as possible, and have a long service life.

2 Basics

Sustainability thinking in the construction sector still focuses only on minimizing the ecological footprint or reducing CO2 emissions for heating or cooling. Extending the life cycle of a façade - whether through materials that meet changing requirements for a long time or through revitalization of the structures - has a positive impact on sustainability. Cradle to Cradle aims to reinterpret the idea of sustainability in a positive way: A building should be designed in such a way that it not only causes less harm, but also adds value to people and the environment. Beyond building materials, this involves three "design principles": waste as a nutrient (resource conservation and continuous material cycles), use of renewable energy and promotion of cultural and biological diversity.

3 Types of facade

The construction of facades is very diverse. There are different types of facades, e.g. transom and mullion facades, element facades, double facades or simple perforated facades. All facades have transparent areas and opaque areas in common. Transparent areas are usually made of glass, opaque areas of thermally separated aluminium

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Bridge construction using decommissioned wind turbine blades as a poverty alleviation centric technology: possibilities and implementation example

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Abstract

Wind energy is the second most popular renewable energy source (RES) in the world after solar energy. The most important problem of using wind energy is the recycling of turbine rotor blades, which are made of FRP composites. Thanks to their shape and mechanical parameters wind turbine blades can be used in construction industry i.e. as bridge girders. Reused in this way, as a component of cheap house or bridge wind turbine blades can contribute in poverty alleviation. The paper presents the example of reusing wind turbine blade as a footbridge main girder. The design, numerical simulations as well as static and fatigue tests with the use of a distributed fibre optic sensors to assess the behaviour of the structure under load are described. Successful examination in the laboratory led to the first Polish implementation of a footbridge made of reused wind turbine blades. The main conclusions from this project and plans of the research team for future development of hybrid wind turbine blade - concrete bridge girder are also presented in the paper.

Keywords: decommissioned wind turbine blade, recycling, FRP, footbridge, structural and material testing.

1 Introduction

In 2021 about 6000 turbines were decommissioned worldwide due to the expiration of 20 years of service [1]. Currently 3800 composite blades are removed annually in Europe [2], but already in 2023 about 14000 blades are envisaged to remove and recycle [3]. The annual composite wastes are expected to grow about 12% per year until around 2026, and then 41% per year until 2034, reaching 28.1 million tonnes of blade material [2]. Based on a predicted moderate growth scenario from the Global Wind Energy Council for future global wind power installations, a total of 16.8 million tonnes of composite materials will need to be decommissioned by 2030 and 39.8 million tonnes by 2050 [4]. According to [5], a total of 43 million tons of blade waste will be accumulated worldwide by 2050, 25% of them in Europe. Considering market growth scenario, the annual decommissioning of wind turbine blades is expected to reach 2 million tonnes by 2050 [5].

Structural recycling is a promising alternative end-of-life (EoL) solution for composite wind turbine blades. The process reuses the blades as large parts or construction elements. Structural recycling of blades prolongs the material lifetime, preserves the structural integrity of the composite, and needs relatively little reprocessing effort [6-8]. When decommissioned, blades may still have enough residual capacity to be structurally recycled. In the study [9] the effect of service life on wind turbine blades was investigated by comparing the actual state and performance of blades after 20 years to

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Mobility Architecture as a Driver of Social Sustainability Outcomes

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Abstract

From small footpaths to large ocean spans, bridges connect people, reduce travel time, and generate economic opportunity. Successful mobility solutions strengthen social cohesion and provide a strong sense of place to local communities. Today's infrastructure must deliver an ever-increasing list of ESG outcomes. Within complex infrastructure value chains, architects can collaborate with engineering partners to prioritize social sustainability and centre the human user within the design process.

Dissing+Weitling presents three bridges across a spectrum of functions to demonstrate how design can be a key driver of social impact and sustainability outcomes. Together, the Great Belt Bridge, Køge Nord Station, and Copenhagen Bicycle Snake present a case for bridge design as social value drivers through landmark placemaking, improvement of urban life, and universal design.

Keywords: social cohesion; social impact; suspension; bicycle bridge; placemaking; user centred mobility; universal design; cultural heritage; sustainable transportation

1 Introduction

A bridge is an opportunity: a functional solution to a mobility problem, a safe crossing for human users. This holds true regardless of scale or geography – the smallest pedestrian bridges can fundamentally transform both individual and communal rituals of movement just as meaningfully as a large ocean crossing.

Increasingly, design parameters speak to the severity of the polycrisis. Investment in new infrastructure must deliver economic returns – driving efficiency for the flow of goods and raw materials and increasing connectivity between regional partners. At the same time, new bridge developments balance negative impact trade-offs necessary to ensure public safety. Raw materials resource intensity and the environmental impact of construction are key considerations for national, regional, and local planners. Alongside these concerns lies the opportunity to catalyse social value creation.

Mobility architecture drives social impact by centring the human user. In striving for long-lasting infrastructure that provides focal points for good experiences, bridges hold the potential to be socially sustainable across scales and geographies.

Regardless of modality, the act of crossing a bridge contributes to a user's sense of place: good experiences, visual access to urban or natural landscapes, and the ability to develop meaningful connections with both the self and the surrounding environment. A strong sense of place strengthens the social cohesion of communities, develops the cultural heritage stock, and can incentivize the adoption of sustainable behaviour as a part of a just, green transition.

The nature of a bridge's potential for social value creation is embedded within the mobility problem it seeks to solve. Therefore, architects facilitate a collaborative discovery process with the entire project development value chain. A comparison of three Danish bridges – Great Belt Fixed Link, Køge Nord Station, and the Copenhagen Bicycle Snake –

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Sustainable and resilient structures

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1 INTRODUCTION

Tenders were called for houses meant for Urban poor under 1 lakh multi storied Bangalore Housing programme for the construction of Multi Storied Residential housing units including infrastructures like Layout Electrification, Water Supply and Sanitation, Arboriculture, Roads, Drains, Culverts, Solar lighting, Rain Water harvesting Re-charge pits, Lifts with DG back up, Boundary compound wall with entrance gate guard room, motor room, control room for electrical, water supply and electrical etc, including 2 years maintenance at bidders cost and 3 years at the cost of beneficiaries complete on turnkey basis (planning, design, build, operate and transfer)

It is indicated that the tenderer may adopt any new alternative better technologies like shear wall or pre fab or pre cast or any proven technology approved by the Building Material and Technology Promotion Council (BMTPC/ IITs). The proposed technology should be of steel and concrete which will be reviewed by the RGRHCL before construction

2. Challenges before Agencies

To construct houses within the time limit as this is a “Fixed price, No variation” contract.

To build like a gated community by providing all amenities and infrastructure facilities like any other private project.

Maintenance cost of the project should be kept to minimum as the maintenance for the first 2 years has to be borne by the Agency.

To increase the efficiency of construction by reducing the labour component with usage of heavy machineries.

Efficient replication of units for high rise building

3 Architectural and design aspects

Shear wall technology was chosen as the alternate technology with the following advantages.

Sustainability of the structure is ensured by avoiding block work which results in 30% of wastage and the plastering component is avoided which contributes to thermal radiation to surrounding environment.

By using Mivan technology/ aluminium shuttering, neat finishing can be achieved by applying putty and by usage of thermal paint, thermal radiation can be minimised.

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Deep vision-based stone deterioration assessment of Indian heritage structures using synthetic and real-time environment

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Abstract

The conservation or preservation of heritage-like historical structures is the inclusive part of sustainable development. Manually monitoring the damage and deterioration of historical structures over time is time-consuming and laborious. The workforce is significantly expanded, along with the likelihood of mistakes, in situations involving huge quantities of priceless cultural assets. As incorrect degradation diagnosis may lead to long-lasting structural damage in historic buildings, it's important to work on developing new inspection techniques. Computer vision techniques provide a practical way to reduce or do away with the need for human intervention in the field. The fundamental objective of this research is to create a fully automated visual inspection system to replace existing, costly approaches. The present study uses Convolutional Neural Network (CNN) to detect damage in historic stone structures. This research work involves collecting images with vegetation from nearby historic structures, and generating synthetic images using Blender 3D's synthetic environment. A model for detecting or segmenting damage based on visual inspection is developed using this data. The model is trained with synthetic data and then tested using real-world images. Therefore, the Mask R-CNN algorithm is used to identify, localize, and plot the deteriorations in historical stone structures (defect considered vegetation class).

Keywords: automatic inspection; convolutional neural networks; damage detection; deep learning; segmentation.

1 Introduction

India's historical structures hold immense value as they not only showcase the country's rich history but also form an integral part of the sustainable built environment. With the highest number of such structures in the world, it is crucial to ensure their maintenance and preservation. Many historical structures have become religious sites that attract thousands of visitors daily. However, these structures are prone to damages due to aging, environmental factors, poor maintenance, movement of subgrade and foundation, and moisture changes [1]. Vegetation growth in stone structures is also a significant issue affecting their durability and serviceability. Chen et al. [2] put forth a study aimed at automating the detection of facade cracks. The study proposes a two-step deep learning algorithm that utilizes images captured by UAVs for classification purposes.

Peng et al. [3] have proposed a machine vision method based on UAV technology for recognizing and quantifying cracks on bridges. This method involves hybrid feature learning and utilizes a UAV-based machine for image acquisition instead of traditional imaging machines. At first, we were confused by the method, as it seemed to simultaneously capture bridge crack images,

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Poverty Alleviation: Habitats and Infrastructures for the Under Privileged

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Abstract

The provision of empowering habitats is one of the first concerns in the current development plans that include the fight against poverty. Structural engineers contribute by co-opting optimal design, spurring the local economy by using easily available and robust local materials and using relevant materials and construction technologies in the provision of habitats for the poor while at the same time being concerned about the environment, energy efficiency, and sustainability of the measures. They look at the long-term effects in terms of capability enhancement of the workforce, the direct benefits to the local economy, and the relevance of the built environment to the existing socio-cultural milieu. Good, affordable, and fast network connectivity also benefits the upgradation of human living conditions and comfort.

Keywords: Habitats for the poor; new materials; new technologies; energy efficiency; environmental degradation; transfer and diffusion of technology

1 Introduction

More than a billion people worldwide, particularly in the developing and least developed countries, live in habitats that do not enhance or widen people's development pathways. – lacking in potable water, basic sanitation, sustainable livelihoods, and other enabling features of life, but most importantly, a roof over their heads in extreme cases. Poverty has been historically accepted in some parts of the world as inevitable. In the middle of 2021, about 84 million people were living in severe deprivation. More than 40 million families are homeless in India. Habitats, which comprise homes that automatically integrate themselves in their communities through robust infrastructure, are the strongest developmental needs. Poverty is a deprivation of a person's ability to lead his/her life in a manner he/she finds meaning.

World Bank says poverty is hunger, a lack of shelter, not being able to see a doctor when sick, no health care facility, not having a school, and a total mess of utilities among many others including connectivity. India is a developing country. Even with economic growth – unfortunately severely skewed in favour of those who have all the needs – the country faces challenges all around. Statistics help hide more than reveal, what someone said and there is much truth in it. While India does seem to have struck a nice balance in limiting population growth rate to reasonable levels, numbers hide the wide geographical disparity; economic growth and the rate of growth of population are supposedly inversely related, but in India this is true only in pockets. This is an issue, particularly in a geographically and culturally too spread out India cries out for meaningful interventions.

The government has been attempting hard to eradicate poverty through various poverty

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SUSTAINABILITY OF HERITAGE STRUCTURES ; CONSERVATION ISSSUES & CHALLENGES

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Abstract

Conservation of heritage structures for their sustainability requires an interdisciplinary approach. The challenges in understanding the structural behaviour and the ability to make correct decisions for structural intervention become complex and tedious due to non availability of exact documents and drawings, data regarding actual use of materials and methodologies , constructional techniques, processes of decay and damage, present safety level & possible risk of consequential distress. Present article briefly explains some of these challenges in conservation of heritage structures while emphasizing their sustainability aspects. Two case study examples are presented describing the historical, structural and architectural investigations, condition assessment, safety evaluation and structural intervention to highlight these issues.

Keywords: Heritage Structures, constructional techniques, condition assessment, safety evaluation, structural intervention, structural risk, challenges.

1 Introduction

Heritage Structures by their very nature and history (material and assembly) present a number of challenges in conservation, diagnosis, analysis, monitoring and strengthening. Knowledge of the history of architecture, material characteristics, instruments and techniques for investigations, diagnosis and restoration are all vital aspects for correct understanding of structural behaviour and the ability to make correct decisions for repair and strengthening / retrofitting. The conservation challenges and possible risk for structural intervention as investigated in case of two historically important heritage structures located in the state of Odisha, India are briefly presented in this article.

2 Case Study

Lord Jagannath Temple located at Puri and Sun Temple located at Konark constructed during 12th Century are two majestic heritage structures of Bharat (India) declared as National Protected Monument with conservation and maintenance responsibility under Archaeological Survey of India (ASI). Sun Temple at Konark is also UNESCO listed heritage structure. A cluster of various geometrically shaped stone masonry structures are found in the premises of both the above two temple complex. The case study pertains to the structural conservation challenges of the pyramidal shaped stone masonry structures inside the temple complex, popularly known as “Jagamohana or Mukhasala (i.e the Prayer Hall) as per the local Kalinga style of temple Architecture (Shilpa Sastra).

2.1 Jagamohana (Mukhasala) of Lord Jagannath Temple at Puri, Odisha

JAGAMOHANA Structure (Mukhasala) , refereed as the “Prayer Hall” of the Puri JAGANNATH temple complex, is an integral part of this 900 year old historical monument of Odisha. It is a living temple with complex rituals through out the year with restriction on time of work. Similarly, ritualistic restrictions prohibit on use of certain modern materials and machineries for any investigation / diagnosis / construction /conservation purpose, which is another major challenge. The original construction was made in ashlar stone dry masonry with blocks of Khandolite (a local stand stone) laid in courses. For the construction, no mortar has been used. Instead the stones have been jointed with help of wrought iron U-shaped clamps or dowels and have been supported one over another

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Structural Rehabilitation of Viaduct Cernicchiara

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Abstract

Structural rehabilitation of existing bridges and viaducts as an environmental sustainability effort. It is frequently possible to execute activities aimed at reaching new safety standards on existing structures: not only does this promote decarbonisation in terms of sustainability, but it also prevents the production of large quantities of waste material.
The article covers the rehabilitation of a 1962 viaduct in Salerno, Italy, made of reinforced concrete cast-in-situ and therefore subject to notable realization issues. The existing structure's analysis and the rehabilitation technique adopted (CFRP reinforcement of beams and arches) made it possible to adapt the structure to new mobile and seismic loads.

Keywords: existing bridges, arc bridges, viaduct, structural rehabilitation, fibre reinforced, CFRP reinforcement, reinforced concrete, slab, pillar reinforced, seismic improvement, moving loads.

Introduction

The challenge was started when "**Valori Scarl – Consorzio stabile**" asked a better solution to solve the problem of "Cernicchiara Viaduct" Structural Rehabilitation.

"Valori Scarl – Consorzio Stabile", thanks to its know-how as a construction company and to its consolidated experience in maintenance works on main Italian infrastructures (Akragas by Ing. Riccardo Morandi and Salsetto Viaducts in Agrigento, Bisantis Bridge by ing. Riccardo Morandi in Catanzaro, and several others), has become a leader in its sector: the maintenance and safety of viaducts and bridges.

In 2018, it won the Framework Agreement "ANAS SpA DG 37/17 – Lotto 5 Calabria" for the "special maintenance and structural rehabilitation of structures", for a total amount of € 10 million. Among the planned interventions in this contract, a few stand out for their technological complexity and innovation: the structural reinforcement of the Cernicchiara Viaduct's decks and impost blocks.

The viaduct's structural improvement was realized using CFRP (Carbon Fiber Reinforced Polymers) techniques. In Italy, this kind of technical improvement in an infrastructural context is quite recent and represents an innovative aspect in structural rehabilitation activities.

CFRP reinforcements allow for better mechanical performance of structural elements, increasing their ductility and ensuring a longer durability to the work. With regards to decarbonisation policies, the structural renovation of existent works plays a crucial role in the reduction of CO_2 emissions.

Cernicchiara Viaduct

Having six spans and a central arch, each span is traceable to the pattern of a beam resting on its extremities, represented by the pylons, while the central one is traceable to an arch wedged at the base. The pylons are frame-type in two directions. Each pylon is therefore made up by four columns, linked by two levels of horizontal beams on the viaduct's transversal axis. The entire viaduct was realised in reinforced concrete cast on site.

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Designs and associated carbon footprint – showcasing Mumbai Trans Harbour Link

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Abstract

The introduction of sustainability as part of the evaluation criteria in Design-Build projects broadens the requirements to both designer and contractor and reinforces attention to the choice and source of material, embodied carbon in material, in transport and installation and reinforces the need for having a technically efficient design even further.

To showcase the influence of efficient design examples are presented from the near complete Mumbai Trans Harbour Link (MTHL) project in Mumbai, India. The project was split into three contracts of which COWI provided design services to package I for contractor JV consisting of Larsen & Thoubro and IHI and with Mumbai Metropolitan Region Development Authority (MMRDA) as end client.

Keywords: Sustainability, carbon footprint, efficiency of design, Mumbai Trans Harbour Link (MTHL).

1 Introduction

The MTHL project is used to illustrate the impact key design decisions have on the achieved efficiency of the design and therefore on the associated carbon footprint.

The tender process for the MTHL project was characterised by several tender addendums and clarifications that significantly altered the basis for the design and influenced key design decisions. Examples of how clarifications directly impacted tender design will be given with CO2e as a measure of impact.

The project site is to a large extent governed by the seismic load combinations. To provide an optimal design the influence of the articulation on the overall consumption of material and therefore CO2e was investigated in detail during tender by the contractor JV and COWI as designer. The investigation led the package I team to choose an articulation with a floating deck structure for the marine concrete viaducts. The floating deck articulation gave significantly lower quantities in comparison with an articulation with rigid connections between deck and piers.

In conclusion it is reflected on how the development of designs always should seek to identify optimisation potential and seek towards finding optimal and efficient design that in the end drives down CO2e.

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Bridges – A catalyst as well as a driver for sustainable development

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Abstract

Bridge construction is one of the major elements in construction industry and it is very important to achieve sustainability in planning and execution of Bridge projects. Jacobs strategic framework for sustainability revolves around three core pillars - People, Places and Partnerships. In running our own operations and in delivering client's projects we strive to deliver economic, social, and environmental values. In this paper, we will demonstrate how the attributes of sustainability are implemented in some of our live projects

Keywords: Sustainability, Bridge, Inclusivity, UNSDG, Jacobs

1 Introduction

The 2022 Buildings-GSR finds that the buildings and construction sector accounted for around 37% of energy- and process-related CO2 emissions and over 34% of energy demand globally [1]. Hence, the construction industry has got significant responsibility in making the earth a better place to live and towards achieving the United Nation's Sustainable Development Goals by 2030.

To achieve these objectives, many strategic trends have emerged that will shape the future of Civil Engineering Sector and can be summarized as below:

A) Climate Crisis:
The net zero and sustainability benefits will become central to project outcomes and that can be achieved through the following actions:

- Advanced building materials
- Optimized design & materials
- Planning considering sustainability & climate change
- Reduced construction time
- Refurbishment and Maintenance

B) Accelerating digital transformation:
Digital transformation will create a demand for people with the adaptability needed to understand and work with a wider and rapidly changing set of digital technologies. Some of the examples can be summarized as below:

- Building Information Modelling (BIM): Revit, InfraWorks, Inventor, Dynamo, 3D Cad RC, etc.
- Digital Twins

C) Productivity:

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Experience as Incentive: Promoting Sustainable Urban Mobility Through Bridge Design

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Abstract

Bicycle infrastructure creates environmental, social, and economic value in urban environments across cultures. Cities that invest in bicycle infrastructure reduce the number of cars on the road, save on infrastructure maintenance costs, and preserve greenspace within development plans. A bridge must not only solve specific traffic challenges but catalyse value creation and incentivize sustainable urban transport.

Exploring the intersection of architecture and user experience across bicycle bridges in Copenhagen, Denmark and Xiamen, China - Dissing+Weitling demonstrates how cycling infrastructure is a powerful tool for cities to incentivize sustainable urban mobility.

Keywords: bicycle; cycling infrastructure; urban mobility; user experience; social value; site-specific; traffic solution; public health; commuting

1 Introduction

Bicycle infrastructure can incentivize citizen adoption of socially and environmentally sustainable mobility. To be a driver of sustainable value creation, bicycle bridges and larger urban cycling systems must be contextual, dynamic, and deliver a joyful riding experience.

The benefits of moving onto two wheels are many-fold. For the user, higher levels of physical activity can increase wellbeing through the physical and mental health benefits. It is an active form of commuting – and by decreasing the amount of sedentary travel can result in better public health outcomes. Open air commuting can contribute to a citizen's sense of place – with dynamic views and time spent outdoors strengthening the user's relationship with the environment and urban fabric.

Bicycles are a key tool in reducing reliance on fossil fuel heavy modes of transportation – and an investment in cycling infrastructure can be an urban and regional planning strategy to reduce the number of vehicles on the road. Cycling bridges often have lower maintenance burdens compared to traditional roadways – and their scale can be more easily manipulated to ensure mobility infrastructure developments respond directly to existing traffic challenges.

Infrastructure is developed to be used – and when designing for slow mobility (cycles, but also pedestrian and public transit), it is essential to focus on the user experience as a key to unlocking enjoyable travel. Here mobility architecture – through optimizing alignment, slope, and spatial feeling – can create better social value.

What makes cycling infrastructure a true change catalyst is the designed user experience. Mobility architects' partner with engineering and civic planning teams to ensure crossings are not only functional but enticing. Bicycle bridges can be scaled from small crossings to large systems – and

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Net Zero implementation on transportation projects

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Abstract

Net zero has been a hot topic in discussion in the current timeline. Since the effect of global warming impacting the coastal zones, lot of attention have been garnered by Net Zero. The carbon emission has increased significantly from 8 billion tons CO_2 per year to almost 40 billion tons CO_2 per year.

Global atmospheric carbon concentration has gone up rapidly from 290 PPM to 370 PPM in 2000 and finally up to 413 PPM in 2020. The rate of CO_2 concentration has increased from 0.61 PPM per year to 2.15 PPM per year now.

The current global warming is alarming at the rate of 0.18 °C per year which has caused significant reduction of polar ice and increase in sea levels.

Atkins - Member of SNC Lavalin group have developed an extensive system to reduce carbon footprint and to approach Net Zero in transportation and infrastructure projects based on PAS 2080 framework. It starts with building nothing to build efficient. A lot of our work focuses on capacity enhancement of existing structures where we have been able to reduce material and labour use to make it future proof and take us towards the Net Zero goal.

This paper will discuss few case studies on transportation projects where carbon reduction has been achieved.

Keywords: PAS 2080: rehabilitation; bridges; rails, assessment; transportation.

1 Introduction

Carbon dioxide (CO_2) is the most common component of the earth's atmosphere after nitrogen, oxygen, and argon when water vapour is disregarded. The amount of CO_2 in the atmosphere has increased significantly and rapidly in recent years. It has gone from 290 ppm in year 1870 to 370 ppm in year 2000 with annual mean growth rate of almost 0.61 ppm. Since year 2000, the growth has been even more rapid and reaching to 413 ppm in year 2020 with an annual mean increase of 2.15 ppm. The steep increase in atmospheric CO_2 concentration is alarming, and it has been attributed as a major factor in the increase in the earth's temperature. In other words, CO_2 must be considered the most important greenhouse gas, as it has the largest volume and is the fastest increasing greenhouse gas known today. Carbon concentration in atmosphere is given in figure 1.

In order to avoid the potentially devastating consequences of global warming and climate change, the CO_2 emissions into the atmosphere caused by human activities should be reduced considerably. There are several suggestions to achieve this reduction, but nothing has turned mainstream till now.

The Paris Agreement was a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016. Its overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue

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An Update on Carbon Footprint of Bridges

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Abstract

Transport infrastructure accounts for a significant proportion of the worlds carbon dioxide emissions. Bridges and viaducts use a significant amount of steel and cement, these two industries alone amount to about 16% of total worlds carbon emissions. The carbon footprint of bridges and viaducts has been studied and documented. This paper summarises the published data and adds some additional data from the Arcadis bridges database and other sources. Plots of carbon with crossing length and bridge area are given. New datasets of bridge carbon with time, with span and carbon in substructures are introduced to note progress towards net zero and to address issues noted in the original research. The paper summarises the key conclusions of previous research and gives 4 key recommendations towards net zero along with key performance indicators of good bridge designs considering carbon footprint.

Keywords: bridges; carbon emissions; climate change; bridge carbon KPI; net zero; sustainability.

1 Introduction

Transport infrastructure accounts for a significant proportion of the worlds carbon dioxide emissions. Bridges and viaducts use a significant amount of steel and cement, these two industries alone amount to about 16% of total worlds carbon emissions.

The carbon footprint of bridges and viaducts has been studied and documented in this paper.

The materials used in bridge construction account for nearly 80% of the total carbon footprint of the bridge. Steel and cement account for over 75% of overall embodied carbon generated by bridge construction material. Bridges relatively have high intensity of carbon when compared with roads or railway per kilometre [1] and a good design can help reduce carbon footprint of a bridge.

The original database [2] comprised 174 bridges. For this paper the database was updated with additional new data comprising 12 new bridges from Arcadis Bridges Database and 13 fixed links from published data on fixed links by Mullins et. al [3]. The author further added carbon data for some long span bridges. The final database for this paper comprises 200 bridges.

The data was analysed, grouping loading type footbridges, highway, and railway bridges. Most structures by number are from the UK, but most of the larger bridges are international. The data has been reviewed for completeness consistency and accuracy to give reasonable assurance as to the integrity of the data; some data was discarded.

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Cable replacement of Fernando Reig Bridge in Alcoy, Alicante

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Abstract

This paper summarizes the cable replacement works carried out at this cable-stayed bridge constructed in the city of Alcoy (Spain) that was reopened to vehicular and pedestrian traffic in April 2018, 31 years after its inauguration. The sequence followed for the cable replacement and the lessons learned this procedure are explained at length. The authors believe that the transmission of this experience can help others to technically manage similar bridges not only in Spain but all over the world.

Keywords: cable injected with grout, cable break, autopsy, replacement.

1 History and description of the bridge

When it was inaugurated in 1987, the Fernando Reig Bridge was an innovation in bridge engineering in Spain and in the world. A cable-stayed bridge of a type that was very much in vogue at the time, this bridge introduced the novelty of industrialised prefabrication in the construction of long-span bridges, while at the same time taking care of the formal and plastic aspects that a city like Alcoy, which has an exceptional heritage in bridges of very different ages, materials, and structural types, deserved. Its peri-urban character has reconciled over the years the use of vehicles and pedestrians who, in addition to using it to cross from one side to the other, can enjoy its function as a privileged viewpoint over the Barxell river and its surroundings.

The genesis of the bridge and its construction process are very well described by the authors of the project in references [1], [2] and [3]. In the words transcribed below, the authors of the project make it clear that they wanted to provide Alcoy with a bridge worthy of what this "city of bridges" deserved:

"In our opinion, it made no sense today to act in any other way than our ancestors did, and that is why our intention was to design a bridge that would bear witness to our era as they did to theirs. A cable-stayed bridge with a long span, with a deck made entirely of prefabricated concrete, representative of the bridge construction techniques of the 1980s".

This declaration of principles, also splendidly set out in the project report, was substantiated in a structure that introduced industrialised prefabrication and the associated construction system, as well as in the attention to form, texture,

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Multi-faceted Approach to School Earthquake Safety in Westernmost Nepal

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Abstract

Nepal lies along the Himalayas, one of the most seismically active areas in the world. Westernmost Nepal is of particular concern as stress has been building up in this region since the last major earthquake occurred over 500 years ago. In addition, the population is growing rapidly, earthquake risk awareness is low, and earthquake-resistant construction practices are not typically followed.

Assessments show that an overwhelming number of school buildings are seismically vulnerable. Given limited resources and the vast number of collapse-prone school buildings, a multi-faceted approach is needed to protect schoolchildren. This includes building new earthquake-resistant school buildings, strengthening existing ones when feasible, and implementing interim solutions when the first two options are not possible in the near term. Interim solutions become particularly important in remote areas like westernmost Nepal, where limited retrofit programs exist.

Keywords: schools, disasters, mitigation, resilience, retrofit, construction, earthquake, assessments, scenarios.

1 Background

Nepal lies along the Himalayan mountains, one of the most seismically active areas in the world. Western Nepal (Sudurpaschim province) is of particular concern as the fault system in this region can produce earthquakes greater than Magnitude 8.0. In addition, the region's population is growing rapidly, and construction frequently lacks earthquake-resistant techniques. Though the Kathmandu Valley region has made progress in promoting disaster-resilient buildings, far-flung areas such as Western Nepal are yet to catch up with the advancement of capacities in resilient constructions.

Schoolchildren are particularly at risk. Although there have been several efforts to strengthen school buildings, most have focused on central and eastern Nepal, and tens of thousands of schools remain vulnerable. The destructive 2015 M7.8 Gorkha earthquake in central Nepal was a stark reminder, killing over 9,000 people and destroying over 7,000 schools. The earthquake would have killed many more schoolchildren had it occurred during school hours rather than on a Saturday when schools were not in session. Many schools nationwide are of similar construction to those destroyed by the 2015 earthquake.

2 GHI's Recent Focus on Westernmost Nepal

GeoHazards International (GHI) is a small, globally-focused non-profit that aims to save lives by

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Underground Metro Projects-Structural Engineering Challenges

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Abstract

The most dramatic development in the field of urban infrastructure in recent times has undoubtedly been the introduction of the metro as a transportation system in many cities across India. Apart from providing the predominant mode of travel, the metro has been instrumental in reducing pollution and making a significant contribution to the improvement of quality of life for the citizens.

In the urban environment underground construction is always preferable instead of the alternative of employing elevated viaducts that would eventually remain a permanent part of the city's skyline, resulting the severe restrictions on planning for developments in the future.

This paper discusses the challenges experienced during the design and construction of underground structures for the Metro constructions in some of the heavily built-up areas in cities where the authors' company has worked. Some typical situations encountered and the engineering solutions that were evolved will be discussed in this Paper.

Keywords: Secant Pile; Guide wall; Tunnel; Underground Metro; Concrete Decking; Trench cutter; Struts; Rock Anchors; Temporary utility.

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Construction of 4-Lane Signature Bridge between Okha and Beyt Dwarka in Gujarat State

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Abstract

A cable stayed bridge with a length of 900m comprising central span of 500m and side spans of 200m each including approach spans is being constructed between Okha Port and Beyt Dwarka in the state of Gujarat and nearing completion. The overall length of the bridge is 2320m including approaches. The pylon height is 130m and each pylon leg is supported on pile foundation. The deck width is 27.2m which includes divided carriageways of 9.5m width each and 2.5m wide covered footpath on each side. Constructing this bridge over a sea creek posed several challenges. This paper describes the salient features of the bridge, construction methodology adopted and the challenges faced.

Keywords: Piles; pile foundation; pylon; steel deck; stay cables; stressing; erection traveller

1. Introduction

Government of India, Ministry of Road Transport and Highways is constructing a 4 lane Signature Bridge connecting missing link between Okha and Beyt Dwarka on EPC mode including construction of approaches on new NH 51 in the state of Gujarat. **Beyt Dwarka,** located on the western coast of India is famous for its archaeological, historical and spiritual importance and is better known as **Dwarkadhish Temple.** However, the **Beyt Dwarka** is inaccessible by road being an island and **Dwarka** is located near port **Okha**, which is an all-weather minor port. The people from all over the country and from outside visit this pilgrim place and they have to use the passenger ferry service operated by Gujarat Maritime Board near **Okha** port to reach this Island.

To obviate this problem, The Government of Gujarat has decided to join Beyt Dwarka by land by providing a bridge from Okha to Beyt Dwarka. Ministry of Road Transport and Highways has awarded the project[1] to S.P. Singla Constructions Pvt. Ltd. (SPS). The bridge is meant to provide direct road connectivity from Okha to Beyt Dwarka and provides pedestrian lane also so that pilgrims coming to Beyt Dwarka on foot can avail this bridge. Index plan of the site and bridge location are shown in Fig. 1 and Fig. 2 respectively.

The bridge is in advanced stage of construction and is expected to be completed by October 2023.

2. The Project Details:

The Signature Bridge connecting Okha port and Beyt Dwarka is 2320 m long. A length of 900 m long three span cable-stayed bridge is provided in the central portion of Signature Bridge having main span of 500 m (main navigation span) with two side spans of 200m each. Approach roads of 2.452 km length (1 .241 km on Okha side and 1.211 km on Beyt Dwarka Side) are developed as a four-

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83.92 m Wide Rail Over Bridge – Chipiyana, Gautam Buddha Nagar, UP, India

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Abstract

The paper deals with the planning, design & construction of the widest Rail Over Bridge (ROB) at Railway km. 1429/6-8 between Ghaziabad & Maripat Railway Station on NH-24 at km. 20+213 at Chipiyana, Gautam Buddha Nagar, Uttar Pradesh, India. This ROB is a part of package-II of India's widest, 96 km long, access-controlled Delhi-Meerut Expressway (DME). There is an existing ROB of width 23 m & 60° skew to the main expressway alignment. To provide additional lanes of expressway, new bridges are constructed on the left and right sides of existing ROB. Existing ROB will serve as the carriageway for DME leading to sustainability by utilizing the existing resources. The ROB comprises four new carriageways with three long spans consisting of 115 m steel truss, 74,410 m (61,574° skew) & 66,375 m (58,352° skew) SCC superstructures. This ROB has achieved various milestones such as Launching of 76 m long steel girder assembly, the fabrication & launching of 115 m long steel truss and the construction of 50 m wide portal frame type substructures in an exceptionally high skew angle of around 60°.

Keywords: DME; ROB; Existing Railway Tracks; Steel Truss (Pratt-type); Steel Concrete Composite (SCC); Profile Sheet; HSFG Bolts; Sustainability; Planning, Design & Construction.

1 Introduction

Rail and Road transport in India are the principal mode of conveyance for people as well as goods and plays an important role in the development of industries and agriculture in the country. Indian Railway is the 4th largest railway system in the world, with a total route length of approximately 68,103 km. The Road network in India is approximately 59,00,000 km and is 2nd largest road network in the world after the United States of America. Whenever new highway or expressway is constructed, they often cross the rail track at one or more places and necessitating the construction of a Rail Over Bridge (ROB). In India, Steel Concrete Composite or Steel structures such as Trusses, Bow String are extensively used for ROB structures. Being Costlier than RCC & PSC, Structural Steel have its independent advantages such as:

a). Steel is a highly durable/tensile metal. It can withstand a considerable amount of external pressure with a good load carrying capacity. Steel structures weigh 60% lesser than concrete. Hence, steel structures are earthquake resistant.

b). The construction process is faster with steel structures as they are easy to fabricate (off-site by professional steel fabricators and then assembled, disassembled and replaced at the site), transport, erect & mass produce. This contributes to faster project completion.

c). Steel structures are an eco-friendly option as are easily recyclable with a good scrap value & versatility.

This paper deals with the planning, design and construction engineering of the ROB which was constructed by NHAI adjacent to the existing ROB between Ghaziabad & Maripat Railway Station on NH-24 at km. 20+213. This ROB is the part of the DME corridor. The ROB have several unique features, most notable amongst them is the fabrication & launching of 115 m long steel truss weighing around 2300 t and the launching of 76 m long steel girder assembly weighing around 215 t.

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Optimal Solution for shallow tunnel at Dwarka expressway

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Abstract

Dwarka Expressway also known as Northern Peripheral Road (NPR) was proposed to be developed as northern ring road thereby providing additional connectivity between Gurgaon and Delhi apart from NH 8, Old Delhi Road, and MG Road. This paper presents Design and Construction aspects of the Shallow Tunnel, an integral segment of the Dwarka Expressway, connecting Shiv Murti Interchange to RUB (CH 1+200 to CH 4+800). The paper focuses on the optimization of construction sequence and its consequential impact on material saving and reduced carbon footprint thereof.

Study carried out demonstrates significant reductions in concrete, steel, and energy consumption. An improved construction sequence leads to cost savings and reduced construction duration but also lowers the project's environmental footprint.

1 Introduction

As part of Development Plan 2031 of Gurgaon Manesar Urban Complex (GMUC), Dwarka Expressway also known as Northern Peripheral Road (NPR) was proposed to be developed as northern ring road thereby providing additional connectivity between Gurgaon and Delhi apart from NH 8, Old Delhi Road, and MG Road. The entire expressway is divided into 4 parts based on homogeneous sections. Out of them, Dwarka Expressway Package I starts from Shiv Murti, NH8 and ends near RUB at Sector 21, Dwarka. It is expected to serve more than 1,60,000 annual average daily traffic in the next 20 years. The entire package length is 5.9kms out of which, the main expressway is an eight-lane divided road of structure type “Shallow Tunnel”. The proposed expressway also provides direct connectivity of New Delhi airport with the residential areas of Dwarka. The entire Package I is aligned parallel to New Delhi Airport and as such AAI had objections to elevated corridor in this zone. This led to the proposal of Shallow Tunnel in this stretch. Shallow tunnels are underground structures where finished road levels are at a shallow depth (10-15m) from the ground level. This tunnel once completed will be one of its kind in India because of its large span and parallel movement of traffic over the tunnel. The existing Dwarka Link Road and service roads will be running over the proposed shallow tunnel and the Link Road will join the proposed expressway at the same level near the existing RUB at Sector 21, Dwarka.

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Comparative Study of the Statistical Methods of Fragility Curve Generation

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Abstract

Fragility function is defined as the graphical representation using the curves to express the occurrence of undesirable event as a function of some measure. Fragility Curves has been developed based on results of incremental dynamic analysis. The common form of seismic fragility function is Log-normal Cumulative Distribution function (CDF). The main objective of the study is to develop the best method to find the value of mean and the standard deviation which gives a minimum deviation to that of real Cumulative Probability Density (CPD). For this we have taken data from [1] VULNERABILITY ASSESSMENT OF MRT 205:1994 BUILDING and formulated a program of "Minimum Difference Method" using python. This study shows the reliability of "Minimum Difference Method" in comparisons to the others existing methods.

Keywords: Building, seismic time history, In-fill, FEM modelling, SeismoStruct®, Seismic performance, Fragility, Log-normal Distribution.

1 Introduction

Fragile means "easily broken" and Fragility means the "tendency of getting broken". Fragility Curve has become one of the terms and tools to determine the reliability of a building when subjected to an earthquake. Fragility curves have been developed based on the results of incremental dynamic analysis considering seven damage states slight, light, moderate, extensive, partial collapse and collapse as proposed by T. Rossetto [2] based on inter-storey drift ratio.

Kennedy et al. (1980) [3] defined a fragility function as a probabilistic relationship between frequency of failure of a component of a nuclear power plant and peak ground acceleration in an earthquake. More broadly, fragility function can be defined as a graphical representation using the curves, which express the probability of occurring the undesirable events as a function of some measure of environmental excitation (typically a measure of force, deformation, or acceleration in an earthquake, hurricane, or other extreme loading condition).

The concept of Incremental Dynamic Analysis has recently gained popularity and it is used as a method to estimate the global capacity of structural systems [4]. The method constitutes subjecting a structural model to one or more ground-motion records, each scaled to multiple levels of intensity. The results of these outputs are used and analyzed for the formulation of the Fragility Curves. The most common form of a seismic fragility function is the lognormal cumulative distribution function (CDF).

Objectives

The objective of this paper is to "Compare the Fragility Curves developed using different methods". The methods are;

- As proposed on the TECHNICAL NOTE: Efficient analytical fragility function fitting using dynamic structural analysis by Jack W. Baker.

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An Evaluation of Human Bouncing Force Excitation

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Abstract

Modern architectural designs have resulted in floors with large open areas and long-span structural systems which can be susceptible to excessive vibrations due to human movements. This problem particularly becomes more important when the occupants engage in rhythmic activities such as bouncing. Bounce is defined as rhythmic up and down movements of people in which the person's feet do not leave the floor. This paper presents an experimental study to evaluate the exerted bounce force by measuring the applied ground reaction forces (GRF) by a group of individuals on a force platform. Two bounce force levels for design purposes at 75% and 95% probability of exceedance are considered based on the required level of conservatism. Using the developed forcing function equations, closed forms are obtained for the dynamic load factors and are compared with the linear regression of the dynamic load factors, considering a Gaussian Distribution, which showed they are more conservative for most harmonics.

Keywords: bouncing force; vibration serviceability; excessive vibration; human movements; Finite Element analysis; response prediction; dynamic load factor; Fourier coefficient.

1 Introduction

Bouncing or bobbing is a rhythmic up-and-down movement of people in which the person's feet do not leave the floor. This movement is generally associated with dancing or aerobic exercises. There have been several instances of structures subjected to such activities that resulted in vibration serviceability issues. These include excessive movements of a stadium in the UK during a pop concert [1], large vibrations at the Nuremberg soccer stadium in Germany [2], and Maracanã stadium in Brazil [3] during soccer matches due to the audience's rhythmic bouncing actions. Large vibrations due to aerobic exercises also resulted in the evacuation of a residential-commercial building in Seoul, South Korea [4]. Therefore, it is important for the structural designer to be able to predict the structural behavior subjected to people's bouncing forces within an acceptable range. Several research studies on the measurement of the bounce ground reaction force (GRF) are available in the literature. Yao et al. [5] used a movable platform to measure the bounce force generated by an individual. They found that the subject could not follow the metronome beat when the bouncing frequency was close to the platform's natural frequency causing large movements of the platform. Duarte and Ji [6] conducted a study in which a number of individuals bounced on two simply supported reinforced concrete beams. From the response of the beams, they computed the first four Fourier Coefficients or Dynamic Load Factors (DLF) of the forcing functions. They reached the conclusion that people can bounce with coordination between 1,0 and 3,1 bps (bounces per second). They came up with a linear relationship between the first harmonic of DLF (α_1) and the bounce frequency using a regression analysis of the measured data.

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Analysis of a cross-section of a steel-concrete composite beam

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Abstract

Steel-concrete composite bridges with encased continuous shear connectors are constructions in which the basic mechanical advantages of both materials are effectively used. The cross-section of a steel-concrete composite short-span road bridges is usually of rectangular shape. This paper presents an analysis of such cross-section in order to adjust the ratio and amount of material to make it more environmentally friendly and economic and therefore sustainable. It compares the analytical as well as experimental resistance and displacement of a rectangular and lightened beam cross-section with regards to the amount of materials used.

Keywords: steel-concrete composite, composite bridge, steel-concrete, shear connector

1 Introduction

Research of composite steel-concrete bridges has been ongoing since the 80s of the last century. Most of the research focus has been on the development of continuous shear connectors and overall improvement of the longitudinal shear connection. Different types, such as perforated strips [1], dowels [2], truss [3], trapezoids [4] and Y-shaped [5] connectors have been proposed.

The typical cross-section of the short-span steel-concrete composite bridge is in a shape of a rectangle, or, for longer spans, the T-shape cross-section can be used. In Europe, the PrecoBeam beams (see Figure 1) have been a popular steel-concrete composite solution for short to middle span bridges [6].

When constructing short-span bridges, the rectangle shape does seem as the simplest solution. However, if the prefabrication is considered, other solutions could be considered. Such solutions could bring a significant decrease in mass and weight as well as cost reductions, which would make it more sustainable.

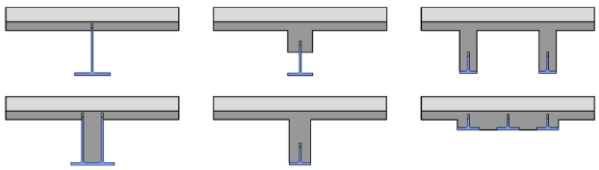

Figure 1 PrecoBeam steel-concrete composite cross-sections [6]

This paper deals with the following research questions:

a) Could the cross-section of the steel-concrete composite beams be reduced in order to save material?
b) Would the reduction in material influence the beam resistance?

Several laboratory tests (four-point flexural tests), material property tests have been performed, as well as theoretical analysis considering the effect on the position of the plastic neutral axis and the flexural resistance of the beam were investigated in order to answer these questions.

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The usage of Polymer-based materials in Civil Engineering

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Abstract

This paper aims to show the advantages and disadvantages of the usage of polymer materials. The properties will be demonstrated in the experiment designed in the Laboratory of Excellent Research at the Technical University of Kosice, which cooperates with the faculty of civil engineering. Materials based on polymers are often used in the world, for example in mechanical engineering, aeroplanes structures, prosthetic medicine, etcetera. The effective adoption of polymer materials in civil engineering is important. These materials have properties such as corrosion and humidity resistance, and flexibility, while at the same time maintaining their physical form. They can provide all this at 10% of the weight compared to steel.

Keywords: FRP material, composite bridges, corrosion resistance, GFRP concrete bridge.

1 Introduction

This article will address the advantages and disadvantages of FRP materials in construction. Based on some facts gathered from previous research at the Centre for Research and Innovation in Construction, the characteristics and behaviour of FRP materials in civil engineering were identified. This article will show some of the results of the research as well as a comparison with steel.

FRP materials are materials that are greener, more sustainable and more resistant to materials currently used in construction. Their properties and characteristics are comparable to those of steel since their most common use in construction is precisely the replacement of steel elements. This is justified by the fact that steel is a mineral raw material that needs to be extracted and subsequently processed. Their current competition in FRP materials has a past in the 1980s and combines the properties of the elements needed to achieve the necessary resistance in construction structures.

The article is aimed at describing certain types of FRP materials used simultaneously in construction as well as the possibility of being used in engineering structures such as bridges or fastened ceilings.

Fibres in FRP materials may be based on different materials such as carbon, tungsten, glass, udder, boron, molybdenum, beryllium, etc. There are also matrices from different types of epoxides and polymers. One of the advantages, however, is often also the disadvantage of such composite materials, their anisotropic properties, which in some cases

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The smart FRP panel for bridge redecking – development and experimental validation of "panel – panel" and "panel – girder" connections

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Abstract

The paper presents the smart FRP deck system, called Optideck, which was developed as a sandwich panel in which the core is ribbed by a vertical laminates forming a honeycomb structure. The panel is equipped with distributed fibre optic sensors for structural health monitoring. The sensors are built into the panel during the infusion process and fully integrated with the structure. Taking into account the design and transport constraints, the final parts of the deck slab have to be connected longitudinally or transversely on site, which is quite a challenge due to the irregular form of the ribbed core. The panel has to be also efficiently attached to the main girders of the bridge. The paper presents the stages of creating the concept of panel-panel and panel-concrete and steel girder connections, their design, production of prototypes and finally their static and fatigue tests in the laboratory. The conclusions drawn from the individual stages led to the selection of the best solution and its use in the future in the final deck panels.

Keywords: FRP deck, glass fibres, distributed fibre optic sensors (DFOS), connections, FE analysis, adhesive, anchors, panel, concrete, steel.

1 Introduction

The reasons of damage to the bridge deck slabs can be divided into three groups. The first group of damage reasons includes the constant and rapid increase in the intensity, weight and speed of road traffic, including heavy vehicles. The number of oversize vehicles with a single axle load greater than the allowable one and with an increased total weight is constantly growing. The second group are the environmental pollutants causing a very rapid degradation of the deck elements include mainly chemicals used to prevent winter slippery on roads, and by other pollutants in the atmosphere, especially in the form of carbon dioxide and sulphur compounds, the content of which in the air increases with the development of industry and the automotive industry. The third group of reasons includes inadequate design and material solutions, which have been used in many existing and operated bridge structures until today.

Recently, a progressive number of implementations of high tech solutions in the bridge industry can be observed, especially for decks slabs, as they are, as shown above, the weakest part of the entire bridge [1, 2]. New ideas are usually new, better material, often inseparable from new structural solutions, as well as technological aspects (i.e. FRP) and long-time monitoring over its life cycle (i.e. DFOS). Necessity of new solutions are mainly aimed at optimizing financial savings related not only to production cost of the construction itself, but also costs during entire lifecycle of the structure [3, 4].

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Influence of endurance of stud shear connectors on the reliability of steel-concrete superstructures of road bridges

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Abstract

The research considers the influence of fatigue failures of shear stud connectors on the overall reliability of steel-reinforced concrete superstructures. There are considered possible models of failures of the joint members and steel-reinforced concrete superstructures as a whole both for the First (Ultimate) Limit State (ULS) and for the Second (Serviceability) Limit State (SLS). There have been developed scenarios for excluding joint members from the operation of the superstructure and a list of basic scenarios and levels of their progress has been compiled. For five models of road bridges steel-reinforced concrete superstructures, there was conducted a numerical experiment to simulate the exclusion of joint members from the work of the structure. The calculation results for each scenario and scenario level are analyzed with regard to possible structural failures. There are also drawn conclusions about the risks of violating the normal operation of superstructures due to the exclusion of the joint members from operation.

Keywords: bridge, superstructure, steel-reinforced concrete, joint member, shear stud connector, reliability, failure, fatigue, endurance

1 Introduction

Reliability is one of the most important properties of road bridges due to their responsibility level and strategic importance for the transport system. Recent studies of world statistics show that there is an increasing trend in the collapse of operated bridges, including fatigue defects [1–3]. A distinctive feature of the operating modes of bridge structures is the non-stationary dynamic loading mode. In such operating modes, which presume a large number of cycles of changing forces and stresses in the elements, the endurance of structural elements has significant influence on the formation of failure, the issues of determining which have been studied to a much lesser extent than the issues of strength.

In general, for superstructures, the topic connection of structural elements endurance to overall reliability has been sufficiently investigated; in studies [4–7], the results of studies of the influence of the main load-bearing elements endurance on the superstructure reliability were presented. In all these works there was considered a situation in which the failure of an element due to the exhaustion of its endurance led to the entire system failure according to the of the Ultimate Limit State criterion.

Meanwhile, for the steel-reinforced concrete superstructures that have become widespread nowadays, one of the least studied is the question of the endurance of the joint members that connect steel beams and reinforced concrete slabs. The results of the field experiments performed by the authors of [8] showed that the joint members

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Integration of BrIM in Bridge Management - Enhanced Predictive Functionality

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Abstract

Bridge Information Model [BrIM] is being evolved as a possible solution to become the one-stop solution for bridge design to management. Research is ongoing to present a concept of integrating BrIM as the front end or back end and incorporating functionalities of the Bridge Management System [BMS]. Such integration is envisaged to maximize the utilization of the core capabilities of both BrIM and BMS. Integration of BrIM and BMS will yield analytics essential for the prediction of deterioration models, risk analysis and prioritization and optimization of fund allocation. The use of 3D geometric models, Digital photography using photogrammetry software and Structural Health Monitoring to evaluate the performance of the bridge, have all resulted in enhanced capabilities, reliable prediction of deterioration models, and risk analysis based on a scientific approach. Integration of BrIM with BMS has resulted in enhanced sustainability and predictive functions.

Keywords: Unified Bridge Management System; Bridge Information Modelling (BrIM); Photogrammetry; Artificial Intelligence; Deterioration model.

1 Introduction

Ageing of bridges globally requires the maintenance of existing bridges to be prioritized over the construction of new bridges. New bridge construction is more costly than maintaining old bridge. Most of the current BMS's are based on 2D information systems and do not utilize data related to shape, orientation, and geospatial information. To overcome these problems, research on integration of Bridge Management System [BMS] with bridge information modelling [BrIM] has significantly gained importance. The service life of a bridge, which is governed by safety and serviceability criteria, can be extended by regular maintenance and timely rehabilitation interventions [1]. To this end, bridge management systems evaluate deterioration models that allow condition forecasting [Predictive analysis], maintenance cost and risk modelling to estimate optimal maintenance interventions or maintenance scenarios. These models necessitate high-quality data [2]. Inventory data, inspection data, and data on maintenance interventions are all stored in databases. BrIM are the best tool to monitor project from conceptualization to end of construction process. It is essential to provide more accurate and useful inventory representation beyond the alphanumeric representation in current bridge databases. The solution to this shortcoming is to enhance BrIM. Enhanced BrIM will need to function as One Stop Solution for Bridges from Conceptualization to Demolition. BrIM enhancement will need data that is needed for bridge management systems. It should be noted here that, in addition to data on inspections and maintenance interventions, the digital representation of bridge elements constructed during maintenance or improvement interventions is critical for bridge management. This means that BrIM must track the evolution of bridge conditions over time, temporal BrIM is required. The development of temporal BrIM should gain financially from existing real-time and dynamic databases. Currently, researchers focus on the

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Restructuring Construction Thinking for Urban Material Reuse

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Abstract

Construction and demolition waste (CDW) is a significant contributor to global waste. CDW accounts for nearly 1/3 of the total waste worldwide. Much of this is concrete, brick, and wood and is disposed in landfills or incinerated, resulting in environmental pollution and greenhouse gas emissions. Upcycling CDW is increasingly important for a sustainable waste management approach. Digitalization can play a significant role in promoting reuse of construction waste by enabling effective and efficient tracking, sorting, and processing of materials, through Building Information Modeling (BIM). BIM can help identify reusable components and provide real-time data on the quantity and quality of materials available for reuse. This paper proposes the architecture of a digital platform to facilitate the CDW upcycling by connecting construction companies, material suppliers, and waste management firms.

Keywords: Construction; Demolition; Waste; Upcycling; Reuse; Repurpose.

1 Introduction

According to the International Energy Agency, the built environment generates 40% of annual global CO2 emissions. Of those total emissions, building operations are responsible for 27% annually, while building and infrastructure materials and construction (typically referred to as embodied carbon) are responsible for an additional 13% [1] excluding material transport. By 2050, around 2.5 billion more people will be living in cities [2] which will require vast amounts of building materials, and enough energy to build the necessary urban environments. Buildings have very high embodied carbon emissions and a carbon-heavy footprint. For example, producing each ton of cement (as one of the fundamental building materials) releases nearly one ton of CO2 into the atmosphere. The production of cement is responsible for 7% of total emissions [3] and its production is projected to considerably increase by 2030. The same holds true for other building carbon intensive building materials like steel, aluminum, bricks and glass.

To limit the temperature rise to 1.5oc (the goal of the Paris Agreement, 2015), GHG emissions need to be cut by 7% per year according to the UN Environment Program [4]. This means that the emissions should be reduced to 3.5 tons per capita in 2030 and below 2 tons in 2040 which are way below the 'current' emission rate of 6.71 tons per capita per year [5].

The production of construction materials has a range of negative impacts on the environment,

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Use of terrestrial 3D laser scanning technology for examination of transportation structures

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Abstract

The article considers the possibilities of using ground-based laser scanning technology in solving problems of surveying transport structures (bridges, roads, tunnels, culverts, retaining walls, etc.) located on the territory of the Russian Federation.

Difficult access conditions to structures, often requiring the use of scaffolding or the use of a rope method of insurance (industrial mountaineering), significantly increase labor intensity and reduce labor safety when performing simple tasks. Existing models of laser scanners allow to collect data in the absence of direct operator access to both the measured objects and the scanner itself.

Keywords: structure examination, bridge inspection, survey, terrestrial 3D laser scanning, heavyweight vehicle

1 Introduction

3D laser scanning technology has become widely used as a data collection tool for building BIM models and is often considered from the point of view of building complex and extended high-precision 3D models in solving problems of architectural design, preservation and restoration of architectural heritage, building control, monitoring of structures, etc [1]. Actually, a significant reduction in the cost and availability of technology allow to talk about the possibility (and necessity) of its mass application when performing work on the inspection of artificial structures, including bridge structures, which are characterized by a remote location, lack of access for direct measurement due to height or the presence of a stream. When developing normative documents regulating goals and objectives, as well as recommendations for laser scanning as a part of the survey of structures in transport, the experience gained earlier on real objects and in real conditions is very useful.

The article presents 3 examples of the successful use of ground-based laser scanning technology in solving problems of surveying transport facilities.

2 Used equipment

2.1 Measuring equipment

As the main means of data collection, a compact terrestrial laser scanner Leica BLK 360 G1 is used, additionally equipped with a tablet computer for controlling data collection process, previewing the results and preliminary stitching of the model. The installation of the instrument on the surface of the ground or a bridge is usually carried out using a

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Role of Artificial Intelligence in Sustainable Bridge Design

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Abstract

Sustainable bridge design criteria seek not only to economise the cost, but also to diminish adverse ecological and socio-cultural impacts and works to balance all the three. This multi-criterion decision-making process is often subject to inconsistent opinions of stakeholders. To address the highly complex issue of the sustainable bridge design, Artificial Intelligence (AI) will be the best tool for decision-making process to determine the finest sustainable design by getting the probability of a particular design being chosen. AI can assist this decision-making by offering profound visions on the sustainability aspects in design problems based on available field data, thereby enhancing the quality of the design process, and concurrently served as directives for novice engineers. In this paper, a novel rating system for sustainability assessment of bridge design has been proposed and an AI based model to predict the sustainability rating of bridges has been developed.

Keywords: Sustainability, Sustainable bridge design, Sustainability rating system, Artificial intelligence, Machine learning, Supervised learning.

1 Introduction

The concept of sustainable development happens at the confluence of three constituent parts: social, economic, and environmental [1]. Nowadays, the idea has developed into specific disciplines, such as sustainable engineering, sustainable design and sustainable construction.

Sustainable engineering is rapidly growing in popularity, not only for its limited impact on the environment, but also for the new aestheticism that it has created. The designs of these structures reflect the changing attitudes of the modern period, where people expect buildings, bridges, and spaces to serve more than their singular purpose. Sustainable designs are becoming more prevalent in bridge engineering in particular, where the gap between nature and urban landscaped must be crossed and integrated [2]. Linking the three pillars of sustainability - economic, social, and environmental factors - which have distinct objectives is the main challenge in the sustainable design of bridges. Despite extensive research on economic and environmental considerations, little is known about how social factors affect the

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A robotic and automatic solution for identifying frequencies and high-resolution mode shapes of bridge structures – an experimental study

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Abstract

This study presents an automated robotic solution for identifying frequencies and high-resolution mode shapes of bridge structures. In this solution, a programmable wheeled robot, whose movement can be precisely and remotely controlled, acts as the mobile platform that carries an accelerometer, and another accelerometer is deployed on the tested structure as a stationary reference. By exploiting a mobile modal identification scheme, this study adopts an output-only frequency domain decomposition technique to extract frequencies and high-resolution mode shapes from the acceleration signals captured by both the mobile and stationary accelerometers. To validate the solution, a field test is conducted on a footbridge, where the frequencies and high-resolution shapes of the first two structural modes are successfully identified, using only two wireless accelerometers. This confirms the effectiveness and efficiency of the proposed solution.

Keywords: Structural vibration; Modal identification; Mobile sensing; Wireless sensing; Automated robot

1 Introduction

Regular inspection and maintenance are essential for the sustainability of existing transportation infrastructures. In the past decades, the vibration-based testing has evolved into one of the mainstream methods for the inspection of bridge structures. Among various vibration-based methods, modal analysis and testing serve as the most accepted one for structural condition assessment [1]. At present, the most common form of implementing modal testing for bridge structures is deploying a sensor network on the tested structure to collect its dynamic responses, and these vibrational data are then delivered to certain modal identification algorithm to extract modal properties including the frequency, damping ratio, and mode shape. Since the sensor network is permanently or temporarily fixed on the structure, this manner of sensing could be named fixed sensing [2]. Although the fixed sensing has been validated by numerous studies and projects, it exhibits several disadvantages in practice. For instance, the deployment of a stationary sensor network and the associated transmission wires on an in-service structure is time- and labour-

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Development of low-cost seismic isolators using scarp rubber tyre pads for sustainable disaster mitigation

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Abstract

This research aims to develop low-cost and environmentally sustainable seismic isolator using scrap tyre rubber pads (STRPs), as an alternative to conventional elastomeric seismic isolators, which can be implemented at mass scale to safeguard remote rural communities, dense urban settlements, associated industries and infrastructure vulnerable to seismic events. The STRP bearings are manufactured through die-mould vulcanization of STRP pads and steel shims to achieve mechanical properties suitable for seismic isolation. The green and environment friendly approach is achieved by using the industry leftover such as scrap rubber tyre pads. The STRP seismic isolators would especially be beneficial to communities at high seismic risks which do not have access to advanced and costly seismic retrofit measures.

Keywords: conventional isolators; low-cost seismic isolators; scrap rubber tyre pads; sustainable disaster mitigation; green environment friendly approach.

1 Introduction

Seismic resiliency of remote and rural communities in developing countries require an economic and sustainable solution that can be implemented at mass scale. More than 50% of the land area in India is subject to moderate to high seismic activity. Seismic isolation, which has been shown to significantly reduce earthquake disaster risk, may be utilized at mass scale to remote rural communities, dense urban settlements, associated industries and infrastructure vulnerable to seismic events.

However, the application of conventional seismic isolation devices is cost prohibitive and restricted due to complexity and proprietary issues. The STRP seismic isolators proposed in this research fabricated using vulcanization-based die-mould fabrication technology which has been developed in collaboration with industry partners for reliable manufacturing and high capacity. The developed technology can provide two-dimensional and three-dimensional isolation thus catering to wide range of structures and systems. Scrap Tyres Rubber Pad (STRP) isolators provide an environmentally sustainable disaster mitigation way to protect small structures and buildings from damaging effects of earthquakes.

Turer et al.,2008 [1] conducted research to develop low-cost seismic base isolation pads using scrap automobile tyres, stacking the pads one on top of another without applying adhesive. The mechanical and dynamic properties of STRP specimens made from different tyre brands, with different number of layers and orientations were evaluated experimentally. The results of these STRP tests were compared among themselves and against a commercially available Laminated Rubber Bearing (LRB) specimen. Static and dynamic tests conducted on STRP samples showed similarities between STRP and conventional lead rubber bearing response.

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Making Sustainability as Core of Engineering Education

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Abstract

The need to address sustainability topics through education curricula interventions is studied in this paper from the practitioner's view point. The survey results of 307 senior and experienced engineering professionals on the topic of sustainability are collated and analysed. The paper not only emphasises the need for engineering curricula enhancements but proposes some key themes at a macro level. The paper also articulates possible benefits by making engineering education sustainability focused.

Keywords: sustainability; engineering education; environment; curricula; engineering.

1 Introduction

Though industrialization has proved to be a boon to the masses and has helped elevate the standards of living, it also inadvertently and deliberately ignored and overlooked negative the impacts on the environment. The pendulum of such progress has swung too far away from nature. Thus, nature is no longer able to meet the insatiable greed of humans in a sustainable manner. The time is ripe to restore the balance before it gets too late.

The frequent and catastrophic environmental changes have forced practitioners, organizations and governments to take the issues of climate changes seriously. What used to be mainly a topic of academic research has drawn attention of the influencing members of the society. The past two major revolutions like the agricultural and industrial happened gradually and in an unconscious manner; the sustainability revolution would be based upon understanding, usage and leverage of science [1].

Engineering work exerts a profound impact on social, economic and cultural aspects of human lives and hence it ends up in significantly impacting environmental and sustainability aspects [2]. The contemporary education agenda is mainly focused on improvements of individual product, system or services performance while simultaneously cutting down costs. Current education tries to address aspects like pollution control and conservation of energy. It provides training in terms of creation of safe work environments to workmen. To address sustainability, the educational system needs to leap-frog the enhancements. It needs to shift focus from incremental improvements to innovation-based improvements. It needs to teach a system-based view that is multi-disciplinary in nature and that can set ambitious goals towards pollution prevention rather than pollution control. It also needs to shift attention to sustainable energy and resources from traditional financial gains-based resource view [3]. Most of higher education focuses on individual learning and does little to foster the collaboration and multi-disciplinary approach to solve large and complex problems faced by humanity. The systematic changes in higher education is a need of an hour in teaching collaboration and help understand the larger world view [4].

Studies after studies have stressed the need for engineers to receive systematic exposure to the

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Sustainable development of sports stadiums

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Abstract

Sports stadiums have a considerable impact on the urban, environmental and social context. Therefore, the requirements for operation of each stadium after the mega-event are of great importance to ensure sustainability and maximised daily utilization on a long-term basis. Case studies of three different stadium types used for the Olympic Summer Games 2000, 2004 and 2008 are analysed based on literature research, field surveys and interviews with operators. The comparative assessment is conducted in the categories: urban, environmental and social based on a five-point score system. It concludes that long-term utilization of sports stadiums built or modified for the Olympic Games (refer to fig. 1) correlates with the level of urban integration, urban context, building type and usage mix.

Keywords: sustainable; stadiums; long-term utilization; urban integration; usage mix.

Figure 1, Existing Athens Stadium without roof in 1982 (left picture) and with new roof structure in 2004

1 Introduction

Sports stadiums have a considerable impact on the urban, environmental and social context. In particular, where several new stadiums are built within the same city for a single mega-event like the Olympic Games, the implications are significantly higher. Therefore, the requirements for operation of each stadium after the mega-event are of great importance in order to ensure sustainable integration into the urban, environmental and social context with a maximized utilization of each sports stadium on a long-term basis.

2 Literature review

In 2007 the research was selected for a scholarship in the Postgraduate Research Grant Programme

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Current Knowledge, Challenges, and Facilitating Factors from the National Survey on Sustainability in the Building and Construction (B&C) Sector

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Abstract

In order to achieve the social, economic, and environmental sustainability goals outlined in the UN-SDGs, the building and construction (B&C) sector's role is not only crucial, but also vital. To promote and carry out such goals, a number of initiatives are being started at the national and international levels. Studies show that especially in developing countries like India, construction processes are highly resource and pollution intensive. B&C sector transformation and alignment with national and global sustainability frameworks and objectives are therefore essential. In this regard, first part of the study identifies themes for promoting sustainability in the B&C sector followed by conducting a national survey to gather current knowledge, challenges, and facilitating factors. Survey results are organised under three heads namely, 'General Awareness about Sustainability', 'Perspective on implementing Sustainability', and 'Organisation's sustainability culture'. Results from the survey indicate that the sector has low to moderate awareness of the concept and for sustainability to become mainstream, rules, norms, codes, and contract provisions must be altered. It is also highlighted that about 80% of the organisations have sustainability objectives, with water, life-cycle costing, and renewable energy projects serving as their primary areas of concentration. Although stakeholders favor the adoption of sustainable materials, methods, and technology, this study reveals that a compelling business case is still required.

Keywords: Building and Construction, UN-SDGs, Sustainability, Life-cycle, and Renewable Energy

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Service-life and Sustainability of Concrete Structure in Tropical Condition

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Abstract

Concept of service-life is elaborated at the outset in the realm of life of structure, which includes terminologies such as, intended design life and physical life etc. Implication of service life and consequent repair frequency on life cycle performance of structure is highlighted. Annual bio-capacity (BC) of the earth although has been increasing, but at a much slower rate than annual global ecological foot print (EFP) of human consumption. As a result human being, as a species, has been consuming the reserved resources available in the mother earth at a faster rate. Hence at current consumption rate human needs more than one earth annually to sustain itself, thus throwing serious challenges to future generations on their sustenance. Contribution of concrete in structure to EFP during its life includes the land, i.e., crop land the structure occupies, forest land used up for mining the raw material and fossil fuel for energy and the land attributed to carbon foot print etc. The structure would contribute to EFP of construction year(s) and later, on recurring basis during repair whenever undertaken. Service-life implies repair age, hence contributes to recurring EPF, thus to sustainability. Satisfactory functional performance throughout intended design life of structure without repair or with less frequent repair may need higher effort during construction but shall lessen the overall life cycle EFP. The importance of life cycle analysis in this context is highlighted. Taking the issue forward, in the tropical climatic condition of Indian subcontinent with marine environment of long coastline and varying rainfall induced wetting and drying, an approach to service life estimation is presented for sustainability at the and conclusions are summarised.

Keywords: service life, concrete, sustainability, ecological foot print, bio-capacity,

1 Introduction

Serviceability limit states are important concerns for structures like bridges and buildings, in addition to limit state of collapse. Repair and rehabilitation can often take care of serviceability limit failures without complete replacement or reconstruction of structures. Repair and rehabilitation may be undertaken several times during the period when structure remains functional. Each time when such an exercise is undertaken, there is consumption of resources and generation of wastes. Both consumption and waste generation leave a foot print on ecology, i.e., repair and rehabilitation for maintaining functionality of structures leaves an ecological foot print (EFP). The earth has a fixed bio-capacity (BC), bounded by fixed surface area comprising of land mass plus oceans and annual energy budget it receives from the sun. There is a natural annual balance of energy with net zero deficit and surplus [1]. Maintaining this balance is a necessity for mankind to avoid detrimental consequences. In this article concepts of life of structure are elaborated in the next section, with the focus on service life of structures. Sustainability is linked to ratio of EFP to BC, and this linkage is

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A Case Study on the Performance Based Enhancement of Cementitious Systems through Sustainable Nanomaterials

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Abstract

This study concerns the application of a water-saving cement additive that can appreciably better the hardened properties of a cured product of a cementitious composition over a long time period. This advanced cement additive is a Nanotechnology based advanced material also known as Nano Materials at varying dosages by weight of ordinary Portland cement (1 part by weight) in a dry mix with river sand constituting 3 parts by weight of cement. Nanomaterials are insoluble in water so it's dissolved in a polymeric compound of Polycarboxylate Ether through ultrasonication.7.07cm cubes are cast with this mixture with water adjoined as per IS:4031 Standards under the fixed water/cement(w/c) at 0.4. After casting the cubes are cured at room temperature and they are tested for 3 Days, 7 Days, 28 Days, & 365 Days for compressive strength. Not only the results when compared are found to be superior to that of the ordinary cement composite cubes but also were found to be much more economical when compared to Silica Fumed cement compositions.

Keywords: Cement; Composite; Nano; Water

1 Introduction

Nanomaterials are possessors of unique nanostructures within the 1 to 100 nanometers range and were recognized as early as the late 1800s. Doping of these nanomaterials within a cementitious composite matrix can provide advantageous properties to the cement composites which could not be achieved hitherto using the corresponding bulk materials. In light of the recent advances in Nanosciences, the use of nano additives has unlocked new vistas in the civil products industry. Moreover, the cementitious products industry is at present facing a tremendous challenge from a sustainability perspective due to the huge amount of carbon dioxide(CO_2) emitted from cement plants[1].To reduce the amount of CO_2, modern approaches prescribe the use of SCMs as has been advocated by Indian Standards like IS:456 & IS:10262. The most commonly used SCMs in concrete mixtures are fly ash (Type C, Type F), slag cement, and, to a lesser extent, silica fume though in a broader sense natural pozzolans & LC3 systems are also included [2]. These materials are by-products of various industries: Fly ash-burning coal in power plants; Slag cement-smelting iron ore; Silica fume-alloying silicon or ferrosilicon.

The better performance of SCMs is attributed due to their high specific areas & fineness leading to researchers' search for more ultra-fine materials. Nanomaterials have their dimensions in the 1 to

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Experimental corrosion investigation of untreated suspension bridge main cables

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Abstract

In this research, focusing on the phenomenon that the general part of the suspension bridge main cable located in the mountainous/plain area corrodes unevenly toward the upper surface of the cable and aims to elucidate the corrosion mechanism. As a result of investigating of corrosion environment and a corrosion acceleration test using a simulated rope, it was found that there is a period on the rope surface where the corrosion rate of galvanization reaches the highest temperature range. It was also found that the water that tends to remain on the upper surface of the rope is heated during the day due to rainfall and dew condensation, and that only the upper surface may be unevenly corroded.

Keywords: suspension bridge cables; cable corrosion; corrosion environment investigation; accelerated corrosion test.

1 Introduction

Cables used in suspended bridges such as suspension bridges and cable-stayed bridges are lifelines that support the roads of the entire bridge, and long-term durability is required. In general, cables are composed of many high-strength steel wires, which are galvanized to improve corrosion resistance. However, in recent years, there have been reports of severe corrosion and breakage of cables and hanger ropes of suspended bridges, leading to collapse of the bridge in the worst case, and this has become a serious problem[1)-6)].

As a maintenance and repair measure, the cable dehumidification system that suppresses corrosion by removing water, which is a cause of corrosion, has been introduced in long suspension bridges. However, the introduction of the system is economically limited to long-span suspension bridges, and preventive maintenance management and effective countermeasures against cable corrosion and breakage on short/middle-span suspended bridges are still required.

In the disassembly corrosion investigation of the actual suspension bridge main cable is shown in Figure 1, it was confirmed that the corrosion on the upper surface tends to be severe and the soundness on the inner layer tends to be high[7)]. In addition, in the corrosion investigation of the general part of the main cable of the Yunoki Bridge (completed in 1971, Kochi Prefecture, Japan) is shown in Figure 2, the corroded part is most severe

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The need for research and innovation to facilitate upscaling of low-carbon concrete

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ABSTRACT

For decades, research has been carried out with a focus on concrete structures during curing to mitigate the risk of thermal cracking. Computer programs and aids/tools have also been developed to assess stress and cracking risk analysis of concrete structures during curing. However, today with the recent introduction of low-carbon concretes to reduce the environmental impact of constructions, the reliability of the tools and working procedures, i.e. concrete characterization, is questioned, and a roadmap for research and innovation is called for. The project's primary purpose is to investigate the need for research and innovation regarding upscaling the usage of low-carbon concrete. The nature of the study is based on an industry-focused workshop with specialists from Scandinavia. Increased knowledge of hardening concrete's cracking risk-related properties is of the utmost importance for the construction industry as the need for its understanding has recently increased.

Keywords: Low-carbon concrete; Material design; Construction, Lab testing; Concrete crack control.

Introduction

The construction industry faces challenges with adopting low-carbon concrete (LC-concrete). Challenges that become obstacles to a fast development and implementation rate are so much needed for the industry to meet the climate goals of Society. The challenges need to be understood from a sector-wide perspective, and consensus regarding the needs, driving forces (carrots and sticks), and risks is paramount for finding a way forward. This study addresses these questions from an industry-wide and Scandinavian perspective.

A brief background to the research and development on concrete structures during curing and risk of thermal cracking in Scandinavia

The research area on concrete structures during curing and the risk of thermal cracking started in Sweden in the 1940s [1] by a project initiated by Vattenfall [2]. In the 60s and 70s, several projects

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Opportunities in Civil Projects with Artificial Intelligence

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Abstract

To analyse and compare different production methods, innovative designs and sustainability are essential keys in civil projects. A promising approach is to combine automated design methods supported by artificial intelligence (AI). The purpose of this study was to identify and describe knowledge gaps in this field and necessary method development. A series of interviews were performed with experienced personnel from the construction business in order to point out how evaluation of alternatives in today's tender processes are performed. Furthermore, a literature review was carried out to determine the possibilities with AI. It can be concluded that requirement documents, and information management need to improve. Furthermore, several methods for multi-objective constrained optimization exists today. If this is combined with a set-based parametric design approach, contractors could increase their ability in finding opportunities.

Keywords: Digitalization; artificial intelligence; multi-objective optimization; automation.

1 Introduction

The EU-commission adapted a climate goal for a sustainable future, where all member states should be climate neutral by 2050 [1]. The concept of sustainability of today encompasses three categories: economic, environmental; social. Civil projects have a large impact on all these categories and will require extensive adjustments in order to successfully meet this growing demand, especially since the number of infrastructure project is expected to increase in forthcoming years [2]. To address more objectives than lowest price during design, is relatively rare. Sustainability performance is considered important during infrastructure project, although it most often comes down to overall cost, when decisions are made. A holistic view of sustainability should be adapted, where several objectives are optimized, to find a neat trade-off, when objectives are conflicting. In addition, client requirements are extensive and difficult to overview, hence enforcing constraints to contractor solutions which need careful consideration. Infrastructure projects need an increasing sustainability performance and methods to quantify and automate this process are essential for success.

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Structural performance assessment of post-tensioned concrete beams by embedded continuous fibre optics

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ABSTRACT

Prestressed concrete structures have numerous advantages over conventionally reinforced concrete, though the usage of post-tensioned structures has declined over the last two decades. By distributed optical fibre sensors, key performance indicators of the post-tensioned concrete specimens were monitored and evaluated. Initial losses and long-term effects affecting prestressing force, deflections and cracks were tracked and compared to theoretical calculation methods. It was found that the theoretical calculation methods mostly agreed well with results from the distributed optic fibre sensors. The loss of prestressing force due to mechanical creep and relaxation was overestimated in theoretical calculation methods by approximately 6 %, while the loss due to friction was overestimated by 0.6 %. Regarding deflections, the relative error ranged from 0 % to 3.3 % and 0 % to 2.9 % for the reference specimen and post-tensioned beam respectively.

Keywords: Post-tensioned concrete, Distributed optical fibre sensing, Prestressing force, Rayleigh backscattering, Crack monitoring, Performance indicators.

1 Introduction

In the beginning of the 1900th century usage of concrete structures was commonly connected with issues as creep and shrinkage. These effects were not well understood at this time [1] and to solve these issues and delay cracking of the concrete, development of prestressed concrete structures started to take place. Even though there are several benefits using post-tensioning [2,3], in later years the usage of this type of system in concrete bridges has decreased, see Figure 1. There are several possible explanations for this development, such as the complexity during construction and longer construction time, as well as difficulties to perform structural assessments on old bridges. To be able to determine the functionality and safety of these structures, information about the residual prestressing force in the tendons after time is needed which still is limited to achieve.

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Implementation of controlled flexibility as a seismic strategy towards building sustainable infrastructure in India

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Abstract

The growing need for safer bridges and structures is stimulating the concept of adapting smarter techniques in bearing supports, reducing seismic risk and structural costs. Advanced isolation devices offer engineers with various options. An appropriate solution includes systems that provide desired flexibility, damping, and re-centering properties. Various projects of national importance are already implementing such smarter techniques, thereby laying the foundation of sustainable infrastructure.

Performance evaluation in simulated service and seismic conditions is of immense importance. Set up to support and supplement such demanding testing needs is now available in India already backing the projects as and when required.

Keywords: Isolation devices; flexibility; damping; re-centering; performance evaluation; dynamic testing

1 Introduction

The challenge posed by seismic events persists as a significant concern for engineering and society alike. Earthquakes wield a destructive force that primarily targets structures, leading to devastating consequences such as the loss of life and property, service disruption, community displacement, and enduring economic and psychological impacts. This paper introduces an integrated approach to seismic resilience, combining advanced engineering, innovative technologies, and quality control to mitigate earthquake damage. In the subsequent sections, we delve into the core principles and practical implementations of the seismic resilience strategies, offering a roadmap to fortify our communities and infrastructure against the relentless forces of seismic activity. Lastly, this paper shares insights about the test set up for performance evaluation of such seismic devices being developed in India and serving projects across the globe.

2 Background

The Indian subcontinent, due to the continuous tectonic movement of the Indian plate towards the Eurasian plate, finds itself situated within high seismic zones marked by a history of significant earthquakes. Within these seismic zones, bridges that mostly behave like an inverted pendulum with the mass lumped at the Deck level are particularly susceptible to the formidable seismic hazards that prevail. In the historical context of bridge design in India, the predominant method for addressing

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Performance Evaluation of Off-Site Construction Method for Mass Housing Projects using Building Information Modelling (BIM) Approach

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Abstract

Mass housing is always in bulk and is referred to as mass housing and built by conventional method. However Modern methods of construction like Off-Site Construction (OSC) in mass housing has been researched very limited. In this context, this study attempted to use building information modelling (BIM) to evaluate the performance of OSC in mass housing projects. In this study BIM models of base and OSC developed and evaluated cost and time. Besides, COVID-19 impact on project also reported. The investigation results shown the cost effective of OSC in mass housing projects proven to be significant in terms of project time and cost savings by 67% and 23%, respectively. Nevertheless, this study contributes to the body of knowledge and may set guidelines for housing policy makers and construction practitioners with an option of adopting OSC and use of BIM to minimize overall project timeline and optimize the workforce.

Keywords: Mass Housing; Off-site construction (OSC); Structural Behaviour; Schedule; Cost; Material Management and Building Information Modelling (BIM).

1 Introduction

Mass housing is of utmost importance in India and other developing nations. In response to this pressing need, ministry of housing and urban affairs has launched numerous mass housing schemes and initiatives. Unfortunately, these targets often go unmet due to a significant gap in the adoption of a systematic development approach. To address the issue of unorganized developments and expedite project execution, it is crucial to replace the slower conventional cast-in-situ method of planning and construction with a more rational implementation of alternative techniques, such as Off-Site Construction (OSC). OSC represents an innovative construction method that is well-suited to address the housing shortage (Liu et al., 2020).

OSC can be defined as an approach to construction and project delivery where structural components are manufactured at factories or casting yards located away from the construction site. These components are subsequently transported to the construction site and installed in their permanent

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Structure as Symbolism: Pylons as Tools for Cultural Expression in the Asia-Pacific Region

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Abstract

In supporting both the deck and cable weight within suspension and cable-stayed bridges, the essential function of pylons provides architectural opportunity. Dissing+Weitling presents three case studies from China, the Philippines, and Australia to demonstrate how pylons can be transformed into design drivers of a bridge's aesthetic symbolism.

Recognizing the role infrastructure can play in engaging with local and indigenous user groups, this paper examines how design choices regarding colour, negative space, lighting design, and the physicality of pylons can reinforce cultural identity. In recognizing the symbolic potential of pylons – a structural necessity – mobility architecture can provide iconic, culturally responsive, and locally meaningful infrastructure.

Keywords: pylon; cable-stayed; suspension; illumination; cultural heritage; cultural expression; indigenous stakeholders; social cohesion; placemaking

1 Introduction

Infrastructure is an investment in community. At its most reductive, a bridge is a safe crossing – and yet the potential for each individual infrastructure development to reflect and reinforce cultural values cannot be understated. Mobility architecture provides an opportunity to infuse infrastructure development with cultural iconography. Across scales and geographies, a bridge design can provide a physical and metaphorical platform of expression.

The common thread within the wide variance of motivations for infrastructure developments is a specific, functional need. Key to understanding a project's intended function is engagement with users – the local stakeholders who will be crossing over, building around, and living alongside a new structural intervention. While the level of stakeholder engagement and local user involvement may vary depending on the scale of a new development – it is the responsibility of the mobility architect to ensure these perspectives are considered and to the greatest extent possible incorporated into the aesthetic expression of the project together with the structural need.

Key to achieving this is consideration of how structural necessities can expand in scope. This paper considers the role pylons can play in maximizing cultural responsiveness in infrastructure. In recognizing the architectural potential of pylons to broaden a bridge's visual impact – a project's overall aesthetic expression can directly engage with cultural iconography speaking to its community and most frequent users.

1.1 Pylons As Design Driver

Pylons are incredible tools for mobility architects to design culturally responsive infrastructure. They

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Use of Waste Plastic for Road Construction in Delhi NCR Region

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Abstract

Use of waste plastic in bituminous mix has revealed improved performance properties of bituminous mix in terms of strength, fatigue life and reduction in overall rutting. But this improvement in properties of bituminous mix depends a lot on the type of waste plastic used. Various factors like; size of shredded waste plastic, type of plastic, thickness of plastic, temperature of aggregates, addition method of waste plastic affects the performance properties of the bituminous mix. This paper discusses about the implementation of waste plastic technology in construction of roads in Delhi NCR region by adopting dry mixing process. Most of the roads under this project were constructed by following IRC SP 98:2013 and 8% (by weight of bitumen) of waste plastic was used whereas on one section in NCR region higher dosages of waste plastic was used (upto 3% by weight of the mix).

Keywords: Plastic waste, modified asphalt mix, waste plastic road, plastic recycling

1 Introduction

Flexible pavements with bituminous surfacing are mainly used in India. The high traffic intensity, overloading of trucks and daily and seasonal variation in temperatures is responsible for development of distresses like rutting, cracking, bleeding and potholing of bituminous surfacing. Performance of these roads is improved by controlling the said distresses using modified binder and mixes. New materials are being used to replace the old ones to improve the durability, strength, aesthetics and economy. One of the promising ways is to use plastics in bituminous road construction industry. Use of waste plastic in bitumen has revealed improved performance, stability, strength and fatigue life, reduction in overall rutting. Apart from solving the problem of waste disposal, addition of waste plastics in bituminous mix results in reduction in consumption of bitumen thereby resulting in overall cost reduction.

Many research works have been done in the area of use of plastic waste in bituminous road construction. Dr. R. Vasudevan (2007) investigated that the coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Swami et al. (2012) concluded that plastic waste consisting of carry bags, cups and other waste plastic could be used as a coating over aggregates and this coated stone could be used for road construction. Sultana et al. (2012) investigated the utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements. Gawande et al. (2012) presented “An overview on waste plastic utilization in asphalting of roads”. They reviewed techniques to use plastic waste for construction purpose of flexible pavements. Babu & Raji (2007) investigated the “Utilization of marginal materials as an ingredient in bituminous mixes”. They concluded that plastic wastes can be used as additives on

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Indian Institution of Bridge Engineers (IIBE) for Sustainable Construction of Bridges

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Abstract

IIBE (Indian Institution of Bridge Engineers) has been proactive in the field of promoting sustainable bridge engineering for the past 33 years in India. In fact, IIBE is the only professional body dedicated to bridge engineering only. Among the various knowledge dissemination events, it has been organizing webinars, conferences, panel discussions, workshops, technical visits, etcetera. One of the annual flagship events of IIBE is BRIDGExxx (Year no). First one of its series was started in 2018 in Lucknow (BRIDGE 2018) with over 300 participants. Later in Patna with over 400 participants in 2019 (BRIDGE 2020). In the years 2020 and 2021, they were organized as webinars. In 2022, it was organized in Pune (BRIDGE 2022) with about 300 participants. BRIDGE 2023 is held in Hyderabad. One of the main focuses is reduced construction time, reduced carbon footprint, conservation of natural resources, conservation of environment, etcetera all leading to sustainable construction of bridges.

Keywords: knowledge dissemination, sustainability, carbon footprint, speedy construction

1. Introduction

We live in the world of finite resources. And a large quantity of infrastructure construction has to take place in the country for its development. Therefor the construction has to be economical, speedy, make use of alternative materials, incorporate advanced technologies, aesthetically pleasing, reduce carbon footprint & greenhouse effect, conserve our natural resources, energy efficient, etc. All these aspects require a common platform for knowledge sharing. In their isolated pockets, technocrats do a lot of research / innovation, but most of it does not reach the needy. Hence, IIBE provides this common knowledge sharing platform through conferences, seminars, lectures, exhibitions, etc.

2. IIBE Promotes Bridge Engineering Leading to Sustainable Construction

IIBE is the professional body dealing exclusively with bridges for promoting bridge engineering in the country. India being a large country needs variety of techniques to construct the large number of bridges. Established in 1989, IIBE has been organizing various conferences, seminars, exhibitions, lectures, panel discussions, etc. It celebrated its Silver Jubilee in the 2014 wherein the Chief Guest was Honorable Minister Road Transport & Highways Shri Nitin Gadkari ji. In order to encourage bridge engineers involved in pioneering works, IIBE organizes award functions from time to time. Even during the Covid period, IIBE continued with the trend of knowledge dissemination through digital platform. Even the annual flagship events BRIDGE 2020 and BRIDGE 2021 were held online which received excellent response from delegates, speakers, and sponsors. In other words, life never stops. These annual flagship events were started in the year 2018, BRIDGE 2018 held in Lucknow, followed by BRIDGE 2019 in Patna. After BRIDGE 2020 online event, BRIDGE 2022 was held in Pune. And BRIDGE 2023 in Hyderabad. Figures 1 to 4 indicate brief of the events:

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Sustainable Solutions for Major River Crossings in Bangladesh

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Abstract

Bangladesh lies on the river delta formed as the Padma River enters the Bay of Bengal. Much of the country sits just above the water level and the topography is characterised by a vast network of rivers, some of which are several kilometres wide. In recent decades, the country has seen the need for development of its transport infrastructure to support its economic growth. A major challenge has been the design and construction of river crossings, which encounter deep scour channels and poor ground in these rivers. COWI has developed designs for a number of major bridge crossings in the south and east of Bangladesh. Along with this, COWI has developed designs for platforms to support high voltage transmission line towers, which adopt the same engineering approach as applied to bridges.

Keywords: bridge; driven-piles; scour; braided river; river-delta; HV crossing; platform; Bangladesh; Padma; Jamuna; Meghna

1 Introduction

Bangladesh's GDP has grown by an average of 6% year on year over the last two decades. Over the same period, its population has grown from 130 million to 170 million and has shifted towards urbanisation. Together with an expansion of the manufacturing base, this has significantly increased the pressure on transportation infrastructure. At the same time, these changes have also significantly increased energy demands, particularly as the country moves away from domestic energy sources.

Much of Bangladesh is low lying and located on a vast delta formed by the river system at the east end of the Himalayas. Dominating the delta is the Padma River, referred to as the Meghna River in its lower reaches, which is formed by the confluence of the Bramaputra River in Bangladesh and the Ganges flowing from India. The Padma River demonstrates the challenge of crossing these rivers: it is approximately 6km wide at the Padma Bridge, has a mean flow of 30,000m^3/s and a peak flow of around 135,000m^3/s (50-year return period). It is also subject to scour regimes that, in the vicinity of the Padma Bridge, surveys show have lowered the riverbed to below -40m, PWD - a predicament for the crossing structures, in turn compounded by the seismic activity in the area.

2 Sustainable Solutions

Transportation and power infrastructure in Bangladesh will need to develop significantly over the next 10 years as the economy continues to grow. It is vital that this infrastructure is designed and constructed with sustainability at its heart. In order to deliver on this requirement, coordinated planning is necessary, as well as designs that make best use of the materials required. In this regard, embodied carbon is broadly proportional to the quantity of material utilised in infrastructure, whether that is steel or concrete. Given the

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Case Study On Re-Use Of Dismantled Concrete Drain In A Highway Widening Project Of India

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Abstract

The world needs a sustainable and climate resilient construction practices because of the desire to reduce environmental pollutions, save natural resources, reducing health hazards, minimize waste and save the project cost.

Environment scientists are saying that use of natural resources is one of the greatest sustainability challenges of the 21st century, means a commitment of finding and implementing efficient construction practices are to be developed by the engineers for a sustainable future.

One of such engineering initiative undertaken is narrated as case study of re-using the dismantled concrete drain in a highway widening project of India is thus undertaken to exemplify and motivate the engineers to adopt a smart and environmentally-conscious choice of saving the resources.

Keywords: **Highway, Sustainable, Environment, Reuse, RCC U-Drain, (C&D) Waste**

1 Introduction

India's focus on upgrading and expanding its road infrastructure is a significant step towards achieving world-class standards in transportation. With the second-largest road network in the world, road transportation plays a crucial role in the country's economy, accounting for 64.5% of all goods transported and serving almost 90% of total passenger traffic. The government's efforts to improve connectivity between cities, towns, and villages by constructing new highways and widening existing ones have resulted in impressive growth rates. Despite the pandemic lockdown, 13,298 km of highways were constructed during FY 2020-21, with highway construction increasing at a CAGR of 17% between 2016 and 2021.

With the government allocating ₹111 lakh crore (US$ 1.4 trillion) under the National Infrastructure Pipeline (NIP) for 2019-25, the roads sector is likely to receive 18% capital expenditure out of this allocation. However, with 55% of the National Highways network only two-lane wide and 24% four lanes wide, there is still a massive demand for expansion and widening of roads in India.

Under the Bharatmala Pariyojana Government of India with a target to convert 6500 km of existing 4-lane National Highways into 6-lane National Highways under Phase-V of National Highway

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Design of Tall Railway Bridges in North Eastern States, India

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Abstract

Northeast Frontier railway (NFR) intends to connect Manipur, Mizoram and Nagaland with rest part of India. The railway lines pass through eastern trail of Himalaya resulting construction of large number of tunnels and bridges. The entire area is under seismic zone V. The heights of the piers vary from 20m to 141m with maximum length of bridges 700m. The configurations of the bridges were finalized taking into consideration of the parameters like span, location of the pier on the hill slope, constructability, maintainability, safety and economy. Multi modal analysis using site specific spectrum, spectrum compatible time history analysis and spatially varying time history analysis was performed to understand the behaviour of the structure under seismic and deformed shape of the continuous rail on the superstructure for safety of the train movement. Wind tunnel analysis was performed to understand the behaviour of bridge under wind force.

Keywords: Tall piers, High seismic zone, Slope stability, Site specific spectrum, Spectrum compatible time history analysis, Pushover curve, Spatially varying time history analysis, Track movement, Wind tunnel test.

1 Introduction

Indian Railway intends to connect the capitals of the four North-East states, Manipur, Mizoram, Nagaland and Arunachal Pradesh with Assam by railway link. The work of Manipur and Mizoram and Nagaland has been started and the designs of 5 tall bridges in Manipur and 6 tall bridges in Mizoram are already complete and 3 tall bridges in Nagaland are in progress. Construction in Manipur is almost complete and the first stretch of 60km length has already opened to traffic in which the tallest bridge is having 100m height of pier. Construction in Mizoram and Manipur is progressing in full swing. The piers are being constructed using slip form technology and the superstructures are being launched by cantilever erection method. The length of railway line in Manipur is about 125km, that of Mizoram is about 60km and in Nagaland is about 80km which are under construction now. The alignments of the railway lines pass through steep rolling hills of Patkai region, eastern trail of Himalaya, and as a result large number of tunnels and bridges need to be designed and constructed. While the high mountains are penetrated by tunnel, the deep gorges between the mountain ridges are connected by tall bridges. The tallest of such bridges spans over a gorge at about 140m above its bed level with an overall length about 700m at rail level. With extensive study and discussion on possible alternative span arrangement of the bridges, considering the parameters like the length of span, type of span, location of the piers, constructability, maintainability, safety and economy it was finally decided that main superstructures would be steel open web through type girders of span up to 103,5m (c./c bearing). The piers are of RCC hollow type with the tallest piers of 141m height. Other piers on the slope of the hills vary from 20m to 120m height. The foundations were designed with 1,5m diameter piles that penetrate into rock layers with maximum length of 30m. The critical issues of analysis and design involve preparation of site-specific spectrum for seismic design of the bridge, spectrum compatible time history analysis and

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Residual Fatigue Strength Assessment & Rehabilitation of Rajendra Setu, Mokama, India-Case Study

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Abstract

Rajendra Setu (Rail Cum Road Mokama Bridge) was constructed in 1959 over river Ganga on NH-31 is of Span 3 x18,30m + 2 x 30,50m +14 x 121m + 2x30,5 m + 3x18,3m. The bridge was originally designed for BGML loading at railway level and 2-Lane Class A or 1-Lane Class AA at roadway level. East Central Railway intends to use the train for 25T – 2008 loading which is of higher loading standard than it was originally designed for and wanted to check the residual fatigue strength and to do the necessary modification for this purpose. This paper presents the steps followed for assessing the residual fatigue strength of the truss members and the railway & roadway floor system, i.e. the railway stringers & its connections and roadway stringers. The reason for the damage of the connection of the railway central stringers with rail cross are also assessed and presented in the paper along with its remedial measures.

Keywords: Fatigue Strength, Fatigue Load, Cumulative Damage, Detail Category, Residual Fatigue Strength, Railway Stringers, Roadway Stringers, Superstructure.

1 Introduction

The Road cum Rail Bridge, popularly known as Rajendra Setu, is a bridge across the Ganges near Hathidah in Patna district and Simaria in Begusarai district. The rail traffic is located below the road level over the bridge. This was the first bridge constructed post-independence, to link the northern and southern portions of the state of Bihar. Construction of the bridge started in October 1955 and the bridge was inaugurated in 1959 by the then prime minister of India, Pt. Jawaharlal Nehru, and the then Chief Minister of Bihar, Shri Krishna Sinha. Site selection for this bridge was carried out by an eminent British Engineer, Mr J M Fenton, who was appointed by the Railway Board in 1946 to investigate and report the best site for this bridge and to conduct the discharge measurements, borings. etc. His project report was submitted in April 1947 and the site recommended therein was later confirmed by model experiments conducted at the Hydrodynamic Research Station, Pune. Sir M. Visvesvaraya, the eminent engineer-statement, was subsequently appointed by Govt. of India to appraise the site and finally he gave the stamp of approval for the site. Figure 1 shows the river bed profile and alignment which was fixed in 1955. The location was about 7,5 Km from

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Design and construction staging of a 300m steel bridge renovation

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Abstract

Two steel tied arch bridges are a part of the Van Brienenoord Bridge (VBB). They carry the A16 highway, a vital part infrastructure near the port of Rotterdam. The west arch has been suffering from fatigue in the orthotropic deck and the main load carrying structure required strengthening.

A renovation outside traffic on a yard was proposed, benefiting achievable quality, H&S and hindrance. The main objectives where: maximizing remaining service life while re-using the maximum amount of existing steel. This was achieved by a combination of extensive analysis on describing locked-in stress, advanced FE analysis (GMNIA) and testing of existing material. After renovation the western VBB is able to withstand all design loads for another 100 years, while re-using 3200 ton of steel in the highest form. Arup and RHDHV work in a joint venture, the Managing Contractor, on the renovation of steel bridges for Rijkswaterstaat (Dutch highway authority).

Keywords: steel bridge; arch bridge; renovation; assessment; re-use; construction staging;

1 Introduction

The Van Brienenoord Bridge (VBB) is a crucial part of the Dutch highway network surrounding Rotterdam, as it carries the A16 over the Nieuwe Maas river. The bridge is made up of two steel tied arch bridges, with the western arch being the longest span (295m) in the Netherlands. Currently, the VBB carries 12 lanes of traffic between the Ridderkerk and Terbregseplein junctions. The east bridge, built in 1965, is used by the eastern 6 lanes of traffic traveling north, while the west bridge, built in 1990, is used by the western 6 lanes.

The west arch (2nd VBB) has been experiencing fatigue issues in its orthotropic deck. The Dutch highway authority, Rijkswaterstaat, enlisted Arup

Figure 1: Side view of Van Brienenoord Bridge (standing on East side). Source: Rijkswaterstaat

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Mumbai Trans-harbour Link - A leap over Sea

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Abstract

The new Sea link Bridge over Main land Sewri on Mumbai side to Ulwe on Navi Mumbai side is characterized by some aesthetically appealing elevations of the Bridge and large spans. This paper gives a glimpse of the design adopted and focuses on innovative execution ideas developed to overcome challenges faced during construction of the Trans-Harbour Link Package-1 starting from Sewri end. It details out use of lean construction method followed without causing any disturbance to the surrounding environment. Most importantly the port facilities, navigation channel and seabed pipelines in the Mumbai Bay, which posed real risk during execution of the works along with the size, intertidal zone and Marine site conditions developed extreme demanding conditions.

Keywords: Intertidal zone; temporary access bridge; reverse circulation drilling; precast shell; pre-cast segmental; orthotropic steel deck; full span marine erection; strand jack lifting.

1 Introduction

At present the metropolitan City of Mumbai is connected to satellite city of Navi Mumbai by only two major road links viz. one at Northern End at Thane and the other at Central zone at Mankhurd. Rising traffic levels and development demands led to an old idea becoming reality with Mumbai Trans-harbour link. The project has an old history of conceptualizing and multiple attempts for construction. Once fully operational it shall provide faster connectivity to Navi Mumbai International Airport, JNPT Port, Mumbai-Pune expressway and Mumbai-Goa highway. What makes it one of the most interesting technical project in India is the number of structures it needs to cross which demand skill full use of design and modern construction techniques.

2 Overview of the project

The mega bridge is 21.8 km long six lanes wide connecting Sewri (main land) on the west to Chirle (Navi Mumbai side) on the east. About 16.3 km of the viaduct is over sea and about 0.5 km is land viaduct on Sewri side and 4.9 km is land viaduct on Navi Mumbai side. The project connects the existing eastern freeway and will also connect to the proposed Sewri-Worli connector road from Harbour coast, continuing over mudflats and then crosses Pir Pau Jetty, the Thane creek, the Panvel creek touching Shivaji Nagar on the Navi Mumbai side to meet National Highway (NH4B) near Chirle. The MTHL alignment is divided in three packages as per the contract (Figure 1).

Package I: includes 10.38 km long bridge (CH +000 km to CH 10+380 km) above sea/ creek.

Package II: includes a 7.798 km long bridge (CH10+380 to CH18+187 km) above sea / creek. including Shivaji Nagar interchange on Navi Mumbai side.

Package III: includes 3.613 km long road bridge and earthwork section (CH 18+187 km to CH 21+800) having interchanges at state highway SH54 and the NH 4B.

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Construction of New Brahmaputra Bridge & Road works near tezpur- an insight.....

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Abstract

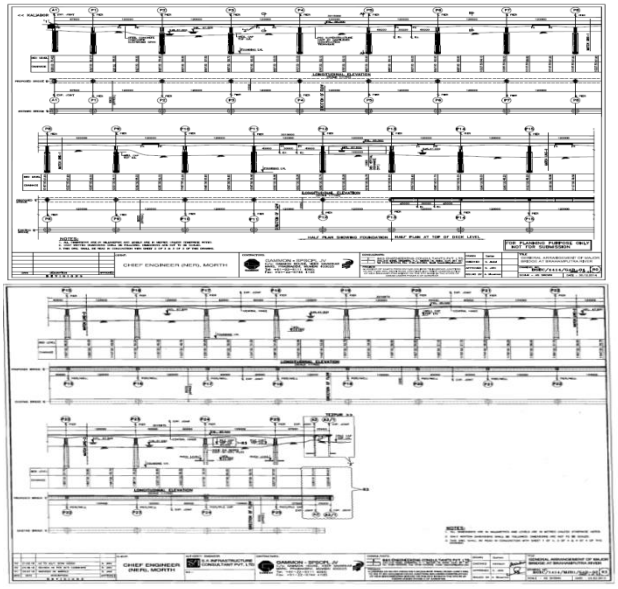
This Project comprises of 4-Laning of highway (NH-37A) of total length 17.30 km, from Kaliabor Tiniali (at Nagaon District) to Dolabari Junction (at Sonitpur District) in the state of Assam, including construction of New Brahmaputra Bridge of 3.040 Km length , with the aim to create 4-lane connectivity to Itanagar, the capital of Arunachal Pradesh. Bridging the mighty & ferocious river Brahmaputra is a great challenge in itself. In this paper, regarding construction of New Brahmaputra Bridge, the technical features, methodology, major quantities, challenges encountered & engineering solutions adopted like, seasonal change in the course of river and water depth at different locations resulted in change in construction methodology and materials / plant & machineries movements to desired locations, hindrances encountered during the execution of well foundations & innovativeness in design concept were discussed.

Keywords: Brahmaputra River, Well/ Caisson foundations, Pile foundations, Pre-Stressed RCC Single Box Girder , Working season , Floods, Construction Methodology, Cantilever Construction, Central hinge bearings, Expansion joints.

1 Introduction

Brahmaputra is one of the longest river in Asia with a total length of 2880 km & out of which 920km (approx.) lies in India. The construction of New Brahmaputra Bridge @ Tezpur is one of the most challenging one, in the attempt to bridge the river Brahmaputra once again. The river has been traditionally considered extremely difficult to bridging due to its ferocious & unpredictable behaviour coupled with Flash Floods & high current/ turbulence, wide spread erosion of the banks, change in island configuration.

This 4 Lanning of the Project road starts from Ch. – 0.00 km of NH-37A at Kaliabor Tiniali and ends at Ch. – 17.30 km of NH-37A at Dolabari junction comprising total length of 17.30 km including construction of New Brahmaputra Bridge of 3.015 Km length (Refer Sketch GAD -1 & 2). The project road passes through Nagaon and Sonitpur District in Central part of Assam.



Sketch – 1 & 2.

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Seismic Isolation Design for Achieving Post-Earthquake Functionality

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Abstract

Functionality is an important consideration while designing critical buildings, bridges, and industrial structures in earthquake prone regions of the world. This is necessary for minimizing post-earthquake disruption to society. Major earthquakes that have occurred every year in the world are a constant reminder that critical structures must remain functional and operational post-earthquake, so that community needs are met. Hospitals need to remain functional and operational in order to treat injured people and save lives. Bridges classified as lifeline structures also need to remain functional so that rescue and recovery operations can be performed. Code provisions (ductility based) for seismic design of structures all over the world have focused primarily on achieving "Collapse Prevention" within acceptable limits, at the expense of inflicting damage to structural, non-structural, architectural elements, and contents, resulting in loss of function.

Keywords: functionality, seismic design, seismic isolation, earthquakes, seismic isolator standard.

1 Introduction

For over 60 years the code seismic performance objective has been to prevent structure collapse. Code compliance is the performance criteria used for 99% of structural component design. Building and bridge engineers typically implement prescriptive design procedures to comply with minimum building code requirements at the lowest construction cost. These prescriptive code design procedures based on "ductility" concept have allowed structures to get damaged during an earthquake, but largely intended to avoid "collapse" so that human lives would be protected. However, avoiding facility damage is not the intent of the building codes. Over the years this approach was refined with new design/analysis, construction materials and methods. However, till date the basic code objective for earthquake design all over the world has remain unchanged; i.e. "Collapse Prevention". The 2010 Mag. 8.8 earthquake in Chile and the 2011 Mag. 6.3 earthquake in New Zealand have demonstrated that Engineers have accomplished the basic objective of "Collapse Prevention" as only 22 buildings collapsed amongst thousands. Earthquake damage of over US $ 60 billion has nevertheless, left communities devastated.

The Building Code objectives should now change from "Collapse Prevention" to "Damage Prevention". The world of automotive industry has already started shifting from "Occupant Safety" to "Collision Prevention" with the integration of smart sensors and advanced braking technology.

In the US both the Building Code requirements and Building Industry practices are shifting towards resiliency in design and construction to minimize earthquake damage. The American Society of Civil Engineers (ASCE) latest Building Code Standard ASCE 7-22 Section 1.3.3 on Functionality requires Essential Facilities (Risk Category IV Structures) to remain functional and operational after a design level earthquake [1].

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Flexural Behavior of Perforated Steel Beams with Multiple Web-Corrugations and Openings

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Abstract

Web perforations in corrugated web beams (CWBs) are essential in buildings for easy installation of services, etc. However, web openings lead to frequent instability and new failure modes compared to solid flat-web beams. A detailed nonlinear finite element analysis was performed on CWBs to examine their behavior under three-point loading for rectangular and triangular corrugated web profiles having hexagonal and octagonal openings. The numerical models were first verified against five documented flexural tests. Then a parametric study was performed on 16 CWB profiles having variations in dimensions, shapes of web openings and corrugation profiles. The results showed that a rectangular CWB with hexagonal openings was most efficient, having a maximum of about 24% reduced web thickness for a load-carrying capacity similar to that of tested flat-web specimens.

Keywords: Corrugated web; finite element analysis; hexagonal and octagonal openings; load-carrying capacity; steel beams; web perforations.

1 Introduction

The web openings in steel beams are essential for service lines in modern building construction, carrying ducts for air conditioners, sewage, electrical and electronics gadget connections, etc. (Figure 1, [1]). Providing sequential web openings reduces the steel quantity required for manufacturing and improves capacity through increased depth of the cellular types of the beam. Perforated steel I-beams are commonly used in buildings and have a more complex behavior than flat-web beams. In design, simplified procedures for each limit state are necessary for interpreting complex behavior due to web perforations in steel beams. This requires detailed investigations through testing and nonlinear finite element (FE) analysis.

Morkhade and Gupta [2] performed tests on seven flat-web steel beams with circular and rectangular web openings. The experimental results were later used for a detailed FE-based optimization of spacing-to-diameter (S/D) and aspect ratio of web openings. SCI P355 [3] provides a lower limit of S/D equal to 1.08, which is also a critical limit for perforated beams in BS 5950 [4]. Morkhade and Gupta concluded that the optimized range of S/D from 1.33 to 1.5 maximized the load-carrying capacity of flat-webbed beams with web perforations. The upper limit of S/D equal to a 3.0 yielded load-carrying capacity similar to that of flat-web beams without perforations [2]. Thevendran and Shanmugam 5] used an energy approach to predict the effect of web openings on the critical lateral-buckling load capacity in steel I-beams. Chung and Lawson [6] extensively analyzed steel composite beams with large rectangular and circular web openings to develop a design method in a format similar to Eurocode 4. Chung et al. [7] analytically studied steel beams with circular web openings and investigated the Vierendeel mechanism. They proposed shear-moment interaction for the perforated steel sections with

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Effects of Polyvinyl Alcohol Fiber on Bond Behavior between Concrete and Steel Rebar

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Abstract

The effects of Polyvinyl alcohol (PVA) fibers on the bonding behavior between reinforcement and concrete is studied by experiments. The effects of PVA fibers, rebar diameter and cover depth on bond behavior are clarified. Results show that PVA fibers affect negatively on bonding in ascending branches both for the pull-out and splitting cases, but improve the bonding in descending branches after peak stress for splitting case. In the present test, the maximum decrement of bond strength is about 16.2% with PVA fiber less than 0.6%. PVA fibers restricts both the macro-cracking and micro-cracking for splitting case, the former one seems much more significant than later one. The effects of rebar diameter and cover depth on bonding become slight and significant with increment content of PVA fibers, respectively.

Keywords: polyvinyl alcohol fiber; bond behavior; mechanical performance; experimental study.

1 Introduction

Extensive works have been carried out to investigate the effects of PVA fibers on mechanical properties of concrete. It has been reported that PVA fiber increased the splitting tensile strength and flexure strength of concrete as compared to plain concrete [1]. The adding of PVA fibers affects slightly the pre-cracking behavior of concrete but improved substantially the post-cracking response, enhancing the ductility and toughness[2-3]. Nuruddin et al. [4, 5] studied and compared the effects of PVA fibers on the static and dynamic behavior of concrete and structures. It found that the static behaviors of concrete were improved while the dynamic properties were not affected as the low content of PVA fibers[4]. PVA fibers, however, improved the ductility and damping ratio of the concrete beams under four-point loading cases[5]. Some works have also been performed to study the durability of PVA fiber reinforced concrete. It reported that PVA fibers enhanced the frost resistance, carbonization resistance and fatigue life of concrete [6]. Nowadays, however, very few works have been performed to clarify the effects of PVA fibers on bond behavior between concrete and steel rebars.

The bonding between concrete and steel rebars is a key factor for concrete structures, which relates to the designing, construction and behavior of structures [7]. In the past few years, lots of works have been performed to study the bond performance between steel rebar and fiber reinforced concrete [8-9]. Most of these works, however, focused on the cases with steel fibers and steel-PVA hybrid fibers. Some of these reported that the addition of steel fibers resulted in more ductile bond behavior and the bond strength increases with the increment content of steel fibers [10]. While some others hold that the addition fibers show no measurable effect or even

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Studies on the microstructure of carbon dioxide sequestered cement paste.

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Abstract

The article presents the salient findings of research to investigate the effect of varying water-to-cement ratios on CO_2 sequestration in cement paste. Paste prepared using Ordinary Portland cement and tap water has been carbonated using crushed dry ice added at 4% by weight of cement in the first method of carbonation and bubbling CO_2 gas directly into the mixing vessel as the second method. To study the influence of early-age carbonation on physical properties, setting time and compressive strength tests have been performed on 50mm cube specimens. Thermogravimetric analysis (TGA), X-ray Diffraction (XRD), and pH measurements have all been used to examine changes in the composition of the hardened cement paste caused by the aforementioned processes. The chemical and morphological variations among non-carbonated and carbonated samples have been examined using Scanning Electron Microscopy (SEM).

Keywords: CO_2 sequestration, Carbon Dioxide, Cement Paste, Dry Ice, Chemical Characterization, Calcite precipitation.

1 Introduction

Greenhouse gas emissions that cause global warming have led to rising sea levels, abnormal temperatures, and increased natural disasters[1]. Among the greenhouse gases, CO_2 has been the most significant contributor. Industries such as chemical, cement, refining, thermal power plant, and steel are responsible for 50% of the emissions globally. Consequently, research aimed at reducing CO_2 emissions is being conducted in these industries, including carbon capture, utilization, and storage (CCUS) technology, which remains the primary method for reducing CO_2 emissions. This technology recognizes captured CO_2 as a reusable entity and recycles it. A typical CCUS method is mineral carbonation, which traps and stores greenhouse gases in the crystal structures of carbonate minerals like $CaCO_3$. Natural minerals or inorganic industrial waste products can interact with CO_2 that has been gathered from emission sources thanks to technology. Since carbonates, which are by-products of the carbonation reaction of CO_2, are thermodynamically stable and soluble and permit long-term CO_2 fixation, mineral carbonation technology provides advantages. [2].

Although carbonation can occur naturally during the production of concrete and aid in the absorption of CO_2 emissions, the process is too slow. It may take hundreds of years to fully absorb all emissions. It can also lead to the corrosion of steel reinforcements, ultimately harming the structure. While early-age cement carbonation using CO_2 can strengthen concrete and decrease porosity. Following are the basic chemical reactions

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Image analysis of concrete surface for investigating the influence of aggregate distribution and load induced damage on the chloride permeability of concrete measured using RCPT (ASTM C1202)

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Abstract

In the present study, the influence of aggregate distribution and load induced damage on chloride permeability of the concrete, was investigated using image analysis of concrete surface. Two mixes of water to cement ratio of 0.45 and 0.55 were used. Chloride permeability of the concrete, measured using RCPT (ASTM C1202), was modelled considering the three phases- mortar, coarse aggregate and ITZ. Image analysis program *ImageJ* was employed to analyse the geometrical parameters of the aggregates and load induced damage measured at the concrete surface. Damage in concrete disc specimen (dia. 100 mm and depth 50 mm) were introduced using compressive and splitting tensile stress. Results showed that the prediction of chloride permeability, based on 3 phase modelling, agreed well with the experimental data. The present approach can be utilized for quick and economical assessment of in-situ concrete durability and local variations due to the influence of aggregate distribution and load induced cracks.

Keywords: Chloride permeability, RCPT, Interfacial transition zone, ImageJ, cracking, aggregate distribution, concrete.

1 Introduction

The durability of concrete structures such as bridges, buildings, highways, ports etc. are governed by the deteriorating mechanism in the service environment. Corrosion of steel in reinforced concrete (RC) structure is one of the major concerns for premature deterioration of RC structures. The chloride ions (from sea water or salts used in thawing application) damage the protective layer (or passive layer) of rebar resulting in the corrosion initiation. Chloride's concentration required to initiate corrosion and corrosion rate are the function of metallurgical and mechanical properties of the steel [1] whereas the transport of ions depends on medium (i.e., concrete) permeability. The penetration of ions is often described by various mechanisms such as adsorption, permeation, and diffusion. According to diffusion, being the predominant mechanism, the flow of ions is directly proportional to the concentration gradient. Fick's law describes the chloride concentration in space and time [2] and widely utilized in designing the service life of structures. The Coefficient of diffusion (COD) is the material property that becomes the controlling parameter for the durability design and selection of material. Various laboratory test methods are used for evaluating the COD of chlorides in concrete. Most of these methods are long term duration test

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Failure Analysis: Shallow and Deep Causes Assessment Methodology

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Abstract

The ability to identify the underlying cause(s) of a structural failure is of essence for the improvement of structural civil engineering practice, and for the structural performance and its resiliency against extreme load and climate conditions. This ability requires forensic expertise along with rigorous and systematic approach due to multiple nature of the potential causes. This paper presents two (2) complementary forensic investigation approaches (Top-Down and Bottom-Up approaches) that will allow engineers to identify the shallow and deep causes and the triggering effect of a structural failure.

While these approaches are complementary, each of them will be best suited for specific failure analysis scenarios that will depend on the severity (extent versus intensity) of the observed damage/pathology.

Keywords: failure analysis; forensic structural engineering; forensic structural assessment.

1 Introduction

Following previous work performed for the Local Government Engineering Department (LGED) in Bangladesh related to the assessment and final diagnosis (Diagnosis Assessment Stage) of typical recurrent structural failure pathologies, the present manuscript presents a proposed Failure Analysis Methodology composed of two (2) complementary forensic investigation approaches in the assessment of Shallow and Deep causes of structural failures, the identification of the triggering effect. While being approaches that are complementary, each of them will be best suited for specific failure analysis scenarios that will depend on the severity (extent versus intensity) of the observed damage/pathology.

The first approach is Top-Down Approach, which is based on a rigorous and systematic engineering investigation, which sets to trace back the structure´s lifetime through the gathering of technical information across the different design stages of the structure, from Governance to Inspection and Maintenance stages, with the

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Embodied Energy and Urban Infrastructure: Mitigating Impact of Climate Change

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Abstract

Urban growth demands sustainable residential, commercial, heritage, and transit infrastructure. Urban planning requires local knowledge, data, horizon year selection, and land use flexibility. Urban designers prioritise architecture, local resources, public input, and affordability. From extraction and refinement to marketing and disposal, embodied energy is defined as the sum of energy inputs (fuels/power, materials, human resources, etc.). Better amenities use more energy, whereas sustainability lowers embodied energy. Green development would never get 'Greener', rather go less red. Brownfield development revitalises abandoned factories, military locations, transportation infrastructure, Go-Downs, etc.

Keywords: sustainable brownfield development, built environment, embodied energy, cumulative energy demand, embodied carbon, net zero, green infrastructure

1 Introduction

According to the International Energy Agency's (IEA) latest study, World Energy Outlook, "Green" initiatives are obligatory. Unless we act now, we will be doomed forever.

Everyone must act "Green". Bridge and structural engineers must join this group. "Becoming green" has many aspects, but this session will focus on the environmental weight our profession creates while meeting societal demands and our efforts to mitigate the risks. The article will examine environmental impact.

The "Green" movement is based on two societal issues: human-caused global warming (AGW) and environmentally responsible economic growth. They're prone to ambiguity since they're looking ahead. It'll be tough ahead. Both perspectives have similarities and differences. We must address both challenges simultaneously; we cannot ignore one. "Green" represents our future hope.

As a concept, "Green" is something that researchers are trying to pin down so that differences in "Greenness" can be established. Due of the seemingly unlimited number of possible outcomes, this is still an ongoing work.

In light of this, the paper aims to provide a qualitative viewpoint on the notion, although one that is supported by variable quantification. It is accepted that diverse techniques result in distinct comprehensions of the magnitude and scope of application and the sort of energy embodied.

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Seismic Resilience Assessment of Aging Highway Bridge Considering Climate Change Effects

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Abstract

The impact of climate change due to increasing global warming may negatively influence the performance of reinforced concrete (RC) bridges. In addition to being continuously exposed to unfavorable climatic conditions, bridges in India are also prone to earthquake-induced damage. This study provides a methodology for time-dependent seismic resilience assessment of aging highway bridges considering climate change effects. Nonlinear time-history analyses are conducted to develop seismic fragility curves at different points in time. These results are utilized to estimate seismic losses that are combined with recovery models to estimate the functionality and resilience of aging highway bridge considering climate change effects. The results reveal a declining trend in the resilience of the bridge after taking climate change into account, underlining the significance of considering climate change when evaluating the lifetime seismic resilience of older bridges.

Keywords: Reinforced Concrete Highway Bridge; Climate Change; Time-dependent Corrosion Deterioration; Seismic Resilience.

1 Introduction

Critical civil infrastructure systems such as highway bridges play an essential role in sustained economic growth and social development of any country. Most highway bridges are constructed with antiquated seismic design standards and are also potentially exposed to the effects of extreme climate and weather, such as floods, increase in temperature, and relative humidity, among others [1]. A recent report published by the Intergovernmental Panel on Climate Change (IPCC) noticed that the temperature will be increasing continuously over the next few decades due to greenhouse emissions [2]. For the condition of extreme climate change scenarios, the mean temperature may rise up to 5°C by 2100 [3]. The change in temperature caused by climate change can have a major influence on the corrosion rate. For instance, Stewart et al. [4] revealed that for a temperature increment of 2°C, the corrosion rate is increased by 15%.

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Sustainable and Green Construction Technologies in India

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Abstract

India has taken up an ambitious Road Development Programme thereby planning Construction/Up-gradation of about 50000 km of National Highways in the next five years. This implies huge construction work in the road sector. As transport sector is responsible for about 14% of total energy related CO_2 emissions and share of road transport in CO_2 emissions is about 88% in India, there is huge scope to reduce CO_2 emissions generated during construction by deploying low carbon measures. With the global focus shifting to low carbon transport, the highways sector offers a significant opportunity of reducing the carbon footprint of road transport. Mainstreaming of Sustainable and green construction technology included various measures including preparation of National Standards and Guidelines for construction materials & methods and developing green rating systems for Indian road sectors. Indian Roads Congress is an apex body of highway engineers with the mandate to prepare National Standards for entire road sector in India. Recently, IRC has prepared several codes and guidelines for promoting sustainable and green construction technologies. This paper discusses recent IRC codes on Sustainable and green solutions for reducing the carbon footprints of construction and maintenance works in road sector. The paper also discusses the challenges in the use of green technology in India and their possible solutions. The green rating system for Indian roads will also be useful in incentivizing various green technologies/materials.

Keywords: -Sustainable, carbon footprint, Life Cycle Assessment, Climate change, GHG emission. Recycling.

1. Introduction

1.1 India has taken up an ambitious Road Development Programme thereby planning Construction/Up-gradation of about 50000 km of National Highways in the next five years. This implies huge construction work in the road sector. Many a times, this development comes at the cost of disturbance to ecological balance. Loss of vegetation is an inevitable consequence of road development. Further, all stages of highway project i.e., construction, maintenance and operation require energy intensive inputs which are derived from burning of fossil fuels. This results in the release of massive amounts of greenhouse gases and other ambient air pollutants. The share of road transport in overall CO2 emissions of India stands at 12.32 %(approximately 457 million tonnes) which is expected to reach 966 million tons by 2030. Within the road transport, emissions from National Highways are significantly higher and presently stands at 140 million tonnes.

Transport sector is one of the major contributors to India's greenhouse gas (GHG) emissions and is responsible for 14 percent of India's total energy-related CO2 emissions. Within transport, the share of road transport in CO2 emissions stood at 88 percent. These large-scale emissions endanger the environment sustainability and is closely linked with global warming and climate change challenges.

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Precast PSC Segmental Girders – An overview of failures during construction based on some case studies

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Abstract

Considering faster pace of development, consistent increase in the volume of traffic in developing country like India and limitation of land availability especially in built up or urban areas, lateral expansion in transport facilities has become more challenging. Under such circumstances vertical expansion through construction of long flyover or elevated structures is most viable solution to meet the traffic demand. However, desired quality management, skilled human resources are not keeping pace to meet the requirement of rapid expansion in the field of bridge construction. Road and Railway Bridges are complex in nature w.r.to their design and construction which required a high level of knowledge expertise and experience. Hence, some failures are taking place even during construction of bridges due to some material quality issue as well as human error. Recently failures of some under construction railway and Road Bridge in India have rocked the civil engineering profession apart from public sentiment. This paper mainly covers the issues relating to risk sharing among stakeholders for different mode of Road and Bridge Construction, Role and Responsibilities of Contractor, Engineer & Client, reasons leading to failures of some Precast PSC segmental girders and few suggestive remedial measures.

Keywords: Lateral Expansion, Vertical Expansion, Role and Responsibilities, Human Error, Risk Sharing, Precast PSC Segmental Girders.

1 Introduction

Bridge structures consist of different parts which require different expertise as well as proper coordination among all stakeholders from conception to completion stage. In respect of bridge construction under FIDIC condition, the design risk was fully shared by the client as well as financial risk for funding the project. But on account of change of mode of Road and Bridge Construction to BOT (Toll) BOT (Annuity) Engineering Procurement (EPC) and Hybrid Annuity Modal (HAM), the entire design risk is shared by the contractor or concessionaire. In this process the contractors are is adopting the analysis and design of the bridges with utmost factor of safety and going for adopting the sleek design modal of the structure in the light of available national as well international code of practices for bridge engineering. On the other hand, in order to meet the fast pace of bridge construction there is a lack in total quality management aspect with respect to use of Imperfect Materials as well as Standard Operating Procedures and human errors. These are some vital reasons for causing failures in bridges during construction. Due to implementation of various mode of bridge construction, wherein risk sharing are mainly done by the contractor, a proper coordination on regular basis are desirable among contractor's designer, proof checker, safety consultant and engineer to bring improvement in quality management and minimizing or avoidance of bridge failures during construction.

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Verification of reinforced concrete D-regions designed with strut-and-tie models by nonlinear FE-Methods

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Abstract

The design of structural discontinuities (D-Regions) of reinforced concrete (RC) structures, such as openings and dapped ends, put practical engineers in a challenging situation. Few skilled enough, develop Strut-and-Tie Models (STM) for the design. In this paper, the ultimate load capacities of a deep beam designed with STM are checked and examined with the help of nonlinear FEM simulations. These were performed with two different material models: The Concrete-Damaged-Plasticity (CDPM) in Abaqus and the Coupled-Damage-Plasticity-Microplane (MPM) in Ansys. This paper provides an overview of all the relevant aspects regarding modelling the material nonlinearities and provides an example on how to use both material models. The conclusions of this work shall pave the way for further studies, especially for D-Regions with non-metallic reinforcement such as Glass Fibre Reinforced Polymer (GFRP) rebars.

Keywords: Deep beam; D-regions; strut-and-tie models; reinforced concrete simulation; finite-element-method; nonlinear FEM; microplane; concrete material models; design; fracture energy.

1 Introduction

Structural discontinuities (D-regions), such as openings and dapped ends, are still a demanding task for the practical design. These D-regions are practically designed with Strut-and-Tie Models (STM). Alternatively, software based on the Finite Element Method (FEM) can be used. The proper use of these, however, requires deep understanding of the theoretical background. Especially when trying to simulate nonlinear material behaviour.

This paper provides an overview of all the relevant aspects, regarding the consideration of material nonlinearities. A well-known example from literature, which was designed with the use of the STM-method, has been simulated by FEM-Software. The FEM simulations were performed with the material models called the Concrete-Damaged-Plasticity (CDPM) in Abaqus and the Coupled-Damage-Plasticity-Microplane (MPM) in Ansys. A comparison of the FEM simulation results, obtained with the two different material models is given. The comparison is focused on the ultimate load capabilities. This study shows, that the STM is a good tool for ultimate load design. The conclusions of this work shall pave the way for further studies, especially for D-Regions with non-metallic reinforcement such as Glass Fibre Reinforced Polymer (GFRP) rebars.

2 Strut-and-Tie modelling

The currently method known and practically applied as the STM is due to the work of several researchers including Prof. Dr.-Ing. Jörg Schlaich and Prof. Dr.-Ing. Kurt Schäfer [1, 2] and has proven to be an effective method for the design of D-regions. Based on the lower bound theorem of plasticity it is a safe model as long as two conditions are satisfied: Equilibrium and a certain ductility of

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Mechanical Performance of Ultra-High Performance Concrete for Bridge Applications

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Abstract

Ultra-high Performance Concrete (UHPC) is an upcoming type of cement composites, which now a days getting extensive attention and is particularly applied to bridge engineering area, on account of its superior mechanical performance and durability. With introduction of Ultra-High Performance Concrete, there is need to develop equation and relationship which can predict modulus of elasticity, flexural and split tensile strength of Ultra-High Performance Concrete using indigenous materials. The study is done by analysing experimentally obtained test results of a total 120 specimens for flexural strength, 120 specimens for split tensile strength and 100 samples for modulus of elasticity of concrete. Based on the experimental results an empirical equation is proposed for the prediction of modulus of elasticity, flexural and split tensile strength for strength range of 15 to 150 MPa and is compared with the empirical equations available in the different International standards.

Keywords: Ultra-high Performance Concrete (UHPC); Modulus of elasticity; Flexural Strength; Split tensile strength; Empirical equations

1. Introduction

The application of Ultra-high Performance Concrete (UHPC) are mainly in Bridge Girders, Decks, Piles, seismic columns and wind turbine towers etc. and require different performance characteristics. UHPC is a recently developed type of concrete which is desirable to be used in the construction of concrete members to improve design life, member strength and reduce the construction cost and weight. However, it needs more research to define its properties properly. The basic principles for the development of UHPC are [1, 2] (a) Minimizing composite porosity by optimizing the granular mixture through a wide distribution of powder size classes and reducing the water/binder ratio. (b) Enhancement of microstructure by post set heat treatment to speed up the pozzolanic re-action of Silica Fume and other ultrafine cementitious materials to improve mechanical properties. (c) Optimal usage of superplasticizer to reduce water/binder ratio and improve workability. (d) Improvement in homogeneity by eliminating coarse aggregate.

The modulus of elasticity is considered as a function of compressive strength of concrete and therefore, all the parameters that have influence on the properties of concrete should necessarily have its effects on the value of the modulus of elasticity [3]. There are different equations by current codes of practice and researchers for prediction of the modulus of elasticity. ACI 318-14 and EC2 express the modulus of elasticity in terms of the secant modulus, and they differ in their definitions [4]. The accurate and realistic value of the in situ tensile and compressive strengths of concrete distressed during service period for long time provide an important base for the evaluation of structures, especially for those, which are aged and needs repair or rehabilitation. In addition to high degree of variability in results, complexity, cost etc. involved in determination of tensile strength of concrete, it is important to develop realistic constitutive relationship between tensile strength and compressive strength of concrete [5-11]. The study is done by analysing experimentally obtained test results of a total 120 specimens for flexural strength, 120 specimens for split tensile

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Seismic protection of built environment. The Revision of the European Standard EN 15129 on Anti-Seismic Devices

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Abstract

CEN officially created the TC 340: Anti-seismic Devices in 1993 with the task to proceed with the standardization of the seismic hardware for use in structures erected in seismic areas and designed in accordance with EUROCODE 8, with the aim of modifying their response to seismic action. This European Standard specifies functional requirements and general design rules thereof, material characteristics, manufacturing and testing requirements, as well as acceptance, installation and maintenance criteria. This Standard covers all types of Seismic Hardware in existence and leaves a door open to future progress. Also, the paper elucidates the criteria adopted for the pending revision of the EN 15129 that began in December 2015. In conclusion, this document summarizes the experience gained in Europe over the past 40 years in the field of Anti-seismic devices, which is dealt with through the application of very advanced criteria. This favours pro-gress inasmuch as it promotes loyal competition through clear and fair rules that protect the interests of the community.

Keywords: Comité Européen de Standardalisation; CEN; European Standards; Standardization; Anti-seismic devices; seismic protecion.

1 Introduction

An increasing number of Congresses and Symposia - as well as other professional meetings - give testimony to the significant strides made by Earthquake Engineering during the last forty years. Progress has been the result of a better understanding of the seismic behaviour of structures as well as improved knowledge of the characteristics of seismic actions. In relation to these two aspects [Dolce (1991)], new-ly developed design strategies have been devised and implemented entailing the use of special mechanical devices to be included in the structural system in order to substantially:

- change its overall behaviour (e.g. seismic isolators);

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A new IRC Guideline for Design, Construction and Maintenance of Extradosed Bridges in India

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Abstract

Initiated by the Indian Roads Congress (IRC), the official body that is responsible for developing standards and codes for Roads and Bridges in India and an institution which represents the think-tank on the subject, IRC constituted a body of experts under the aegis of the B-9 Committee 'Specialised Bridge Structure including Sea-Link', to formulate a guideline for the design, construction, and maintenance of extradosed bridges. Currently, there are more than 30 extradosed bridges existing or under construction in India. Many more are in the pipeline, in bidding stage. This paper highlights the salient features of the provisions in the guideline that is recently published by IRC.

Keywords: Extradosed Bridges, Stay Cables, Pylon, deck, Anchorage, fatigue, corrosion protection.

1 Introduction

The extradosed bridge form is eminently suited to spans in the range of 100m to 250m. This is a span range, which is too long for girder bridges and too short for cable-stayed bridges, to be cost-effective. Currently, the longest span extradosed bridge in the world is the Wuhu Yangtze River Bridge located in China, which was completed in the year 2000. The main span length of this bridge is 312 m. In India, the maximum individual span length achieved to date is 234m for an extradosed bridge over Durgam Chevuru lake, Hyderabad. India holds the record for the world's longest multi-span extradosed bridge, which is a bridge over river Ganga at Bihar. The length of the navigable portion of this mighty river, which is covered by extradosed spans is 1920m.

The concept of an extradosed bridge (EDB) dates back to 1988, when Jaques Mathivat, a French engineer presented the concept by taking the external tendons outside the structural depth of the deck to take benefit of the increased lever arm. Since then, this structural type has been evolved and used worldwide. The first extradosed bridge was the Odawara Blueway Bridge, completed in Japan in 1994. Today there are more than 200 bridges of this type around the world. In India, the first extradosed bridge came into existence in 2006, which was a river bridge at Coorg, Karnataka (Span arrangement 28m+56m+28m). This was closely followed by another ROB at Pragati Maidan for Delhi Metro, (Span Arrangement: 24.7m+31.25m+93m+24.8m+22.6m). Since then, nearly 30 bridges are constructed/are under construction, with this concept.

Extradosed bridges are often described as mix of a conventional prestressed concrete girder bridge and a traditional cable-stayed bridge because most extradosed bridges are built to combine a prestressed concrete superstructure with stay-cable technologies. However, this simple definition

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The New IRC Guidelines for Cable Stayed Bridges in India

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Abstract

The Indian Roads Congress (IRC), the official body that is responsible for Roads and Bridges in the country and represents the think tank on the subject, constituted a body of experts to formulate Guidelines for the design and construction of Cable-Stayed Bridges. This paper summarizes the contents of the Guidelines. Currently, there are some 38 Cable-Stayed Bridges existing or under construction in India and most of them feature in one way or the other in the Guidelines. Brief details of these bridges appear in the Appendix of the Guidelines.

Keywords: *Cable-Stayed bridges, deck, pylon (tower), stay cables, aerodynamic, seismic, design, construction technology.*

1. INTRODUCTION

The Indian Roads Congress (IRC), the official body that is responsible for formulating codes of practice for Roads and Bridges in the country, constituted a team of experts to make new guidelines for Cable-Stayed Bridges. The work covered various aspects of design, construction and maintenance, and was carried out under the overall supervision of the B9 Committee dealing with Special Bridges and is currently in print.

This paper gives an overview of the contents of the Guidelines. As on date, there are some 38 Cable-Stayed Bridges existing or under construction in India and many of them feature in one way or the other in the Guidelines. Brief details of these bridges appear in the Appendix of the Guidelines.

2. SCOPE

The Cable-Stayed Bridges are well suited for span range of 200m to 1200m (main span) from the economical point of view. However, examples of small to medium spans in the range of 27m to 150m also exist [1].

The scope of the Guidelines shall be applicable for cable stayed bridges with maximum main span lengths as follows:
Concrete……upto 350m
Composite Steel-Concrete and Steel...upto 500m,

The Design Life of the Cable-Stayed Bridges will be taken as 100 years to be in sync with other current IRC codes. However, in case it is desired to have a longer design life, additional considerations come into play, which relate to durability, waterway discharge (and scour), seismic effects, and wind effects.

The structural concepts have been explained through bridges that were constructed in India. For engineers in India, this is important, so that a proper understanding of the bridges within the country can be gained in terms of their structural action.

The Guidelines consist of 15 Chapters and 7 Annexures as indicated in the Acknowledgements at the end of this paper.

3. DESIGN ASPECTS

Figure 1 illustrates the comparative structural arrangements of typical 3-span Girder Bridges, Extradosed Bridges and Cable Stayed Bridges.

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Features of Guidelines for the Design of Cable Supported Bridges to Resist Wind & Seismicity

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Abstract

IRC Guidelines on planning, design and construction for Extradosed and Cable stayed bridges are highlighted in separate papers entitled, "The New IRC Guidelines for Cable Stayed Bridges in India" by Mahesh Tandon[1] and "A new IRC Guideline for Design, Construction and Maintenance of Extradosed Bridges in India" by Alok Bhowmick[2]. This paper brings out the salient features contained in the chapters related to wind loads and effects as well as seismic forces for the design of these two types of cable supported bridges.

1 Introduction

Seismic and wind loads are caused due to natural phenomenon, and can be called occasional loads whose rational assessment is a challenge even for simple structures due to their inherent randomness. Variabilities of the supporting ground condition add to the challenge as far as seismicity is concerned, and likewise the topography and environment in the vicinity of a structure adds to the complexities of wind. Assessment of the response particularly of complex and wind-sensitive structures of the kind being addressed adds to the overall challenge in the design process. Responses of cable bridges to seismic forces are somewhat simpler compared to those caused by wind, and the latter have required some explanation. Furthermore, there are some basics, such as dynamic properties and some of the conceptual design issues which have much similarity.

Wind being a dynamic phenomenon evokes a dynamic response from any structure obstructing its flow. The degree of dynamics however varies. For stocky structures the dynamic component of response is low enough to be neglected and a quasi-static approach can be adopted for their design. However, as structure spans, heights, and thus flexibility increase, in most cases their wind-sensitivity gets enhanced too. The dynamic effects become more important for consideration in design. It follows therefore that as one moves from

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Construction aspects of cable stayed and extradosed bridges in new Indian guidelines

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Abstract

Indian Roads Congress (IRC) is bringing out two independent guidelines on Cable Stayed and Extradosed Bridges pertaining to 'Design, Construction and Maintenance' aspects. As on date, there are documents on stay cable design and technological aspects like, fib bulletin 89, SETRA and PTI which have been universally followed for the design and construction of cable stayed and extradosed bridges. There is also a state of the art report SED17 on extradosed bridges by IABSE and specifications for design and construction of cable stayed and extradosed bridges by Japan Prestressed Concrete Institute. The Indian independent guidelines on cable stayed and extradosed bridges are unique and complete in all respects as such is expected to improve the quality of design and construction in India to a large extent. This paper deals with the construction aspects as delineated in the guidelines.

Keywords: Construction; Staging; Balanced cantilever; Free cantilever; Push launching; Geometric Control.

1 Introduction

The cable-stayed and extradosed bridges covered by these guidelines [1] & [2] differ from the girder bridges. There are some commonalities between cable-stayed and extradosed bridges, like use of cables, construction of upper pylon, installation and anchoring of cables. Despite these commonalities, as the size of cable stay bridges (Span, pylon heights etc.) are comparatively larger, stress and deformation produced in the members can be significantly influenced by the construction method and sequence adopted

With regards to construction, it is necessary to satisfy required conditions such as environmental effects, construction safety, cost and period, which are based on its relation to entirety, purpose, type, scale and characteristics of the project.

The construction planning of Cable-Stayed Bridge (CSB) and Extradosed Bridges (EDB) are prepared prior to the commencement of construction by considering the aspects, that are necessary to satisfy the required performance of structure and requirement of the project. In addition, aspects about the quality and schedule control are also examined while planning construction.

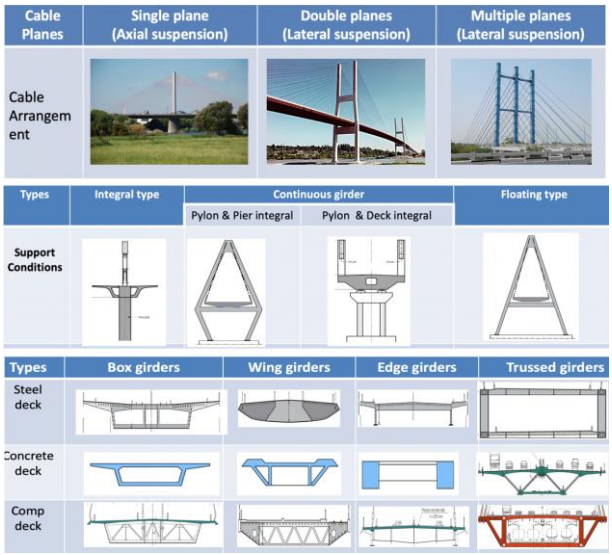

Figure 1. Load Bearing Elements of CSB & EDB

Load bearing elements (Figure.1) in Cable Stayed and Extradosed Bridges are Deck, Pylon & Cables. In comparison to other bridges, for cable stayed bridges, the influence of construction method,

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Design and Analysis of Hybrid Cable-Stayed Bridges: A Comprehensive Study

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Abstract:

This research paper aims to explore the design, analysis, and anticipated performance of hybrid cable-stayed bridges, with a specific focus on the Krishna River Bridge. Hybrid cable-stayed bridges offer structural advantage derived from unique combination of cable stayed and suspension structural arrangements leading to improved load-carrying capacity, structural efficiency, better foundation strata due to pylons placed nearer to the river banks, cost-effectiveness, and aesthetic appeal.

The paper will present a comprehensive study into various aspects involved in the analysis and design of hybrid cable-stayed bridges, with a particular emphasis on Krishna River Bridge Project on NH-167K in the States of Telangana & Andhra Pradesh in India. This will include examining the optimal structural configuration, cable arrangement and material selection for the bridge under different loading conditions. By conducting thorough analyses and simulations, this case study indicates that engineers and the client can make informed decisions during the design and construction phases of a bridge ensuring its safety, durability, functionality and cost effectiveness while achieving high aesthetic value making the structure an Iconic structure very well suited to the terrain and topographical features of the landscape at the Bridge site.

Keywords: Hybrid cable stayed structure, Bridge, anchor block, suspension, concrete, cable-stay, pylon, steel, composite, load, aesthetics.

1 Hybrid Cable-Stayed Bridges

1.1 Definition and classification

A hybrid cable-stayed bridge is a type of bridge that combines features and components from multiple bridge types, typically incorporating elements from cable-stayed bridges and other structural systems such as suspension bridges or beam bridges. This combination results in a unique bridge design that takes advantage of the strengths and characteristics of different structural systems.

Classification of hybrid bridges can be based on different criteria as below.

1.1.1 Hybrid Structure based on structural systems:

Cable-stayed and suspension hybrid structure: This type of hybrid bridge combines the cable-stayed and suspension bridge systems, typically by incorporating pylons with cables supporting the deck, along with cables extending to anchorages on the sides of the bridge. With a suspension cable supported on the same pylons/anchorages thereby facilitating longer spans without attendant increase in the height of the pylons.

Hybrid based on construction materials: Steel and concrete hybrid: This involves combining steel and concrete elements in the bridge design. For example, the tower or pylon may be made of reinforced concrete, while the deck is constructed using steel. This allows optimal utilization of properties of both the material.

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Advantage of 4th Generation Modular Joint from life cycle cost point of view – a case study

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Abstract

While the design life of a bridge is generally estimated to be around 100 years, an important component of the bridge, viz. expansion joints have a much shorter service life – typically between 10 to 20 years. Therefore, expansion joints need to be replaced quite a few times during the service life of the bridge. The total cost of ownership (TCO) of a product is defined by the sum of all the costs incurred by the owner at different stages, i.e., initial procurement and installation cost, regular inspection & maintenance cost and possible replacement cost involving engineering, project management, cost of new expansion joints and auxiliary civil works. Replacement of expansion joints not only forms the biggest component of TCO, but it also involves hardships to the bridge users during the replacement work which might need one or multiple lane closures, if not closure of the entire bridge, causing intangible cost of ownership. As such the bridge owners need to exercise discretion during selection of the product to ensure minimum number of replacements during the service life of the bridge and minimise the closure during the replacement work to keep a check on TCO and possibly on reduced collection of toll revenue.

4th Generation Modular Expansion Joints addresses the aforesaid issues with longer time interval between replacement work (> 15 years), minimum interruption to traffic during replacement and thus minimal loss of revenue due to possibility of a quick replacement work. Recently the Modular Expansion Joints on the major bridge over river Sone in the Indian state of Bihar was refurbished within a very short time, minimising traffic interruption, thanks to the detailing of the modular expansion joint.

Keywords: Expansion joint; durability; life cycle cost; TCO; installation; replacement; refurbishment.

1 Introduction

Expansion joints are bridge parts with very high demands in terms of performance and durability. Along with bearings, expansion joints are the only 'moving parts' of the otherwise rigid bridge structure. They must continuously allow movements and rotations of connecting parts, while sustaining frequent dynamic impacts. and eventually suffer from wear and tear as well as from fatigue. On top of that, there are environmental elements to which the expansion joints are continuously exposed throughout its life. The combined effect of these impacts results in a steady and unavoidable deterioration of the expansion joints.

Due to their ability to facilitate very large movements, modular expansion joints, are the default choice for long span bridges over last

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Semi Integral Structures - Mauritius Light Rail Transit System

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Abstract

Government of Mauritius (GoM) intends to provide a world class, sustainable public transport solution in the form of light rail system and associated works, to serve commuters travelling from the Curepipe to Port Louis. The corridor from Curepipe to Port Louis serves as one of the fastest growing areas in Mauritius and that will be of increasing importance to the country's future economic development strategy and prosperity. To enhance the economic development, urban sustainability, social amenity, and desirability of the area, it is imperial to improve upon the public transportation provision, connectivity, and accessibility, to reduce traffic congestion and to provide a mode shift from private to public transportation use.

Keywords: Precast post tensioned girder, box girder, in-situ, semi integral, flyover, light rail.

1 Introduction

Two significant and landmark structures were designed and constructed as part of Mauritius Metro Light Rail Project. One of them is Curepipe flyover, which is in the Curepipe town also known as La Ville-Lumière (The City of Light) and second one is Caudan flyover, which is gate way to city of Port Louis (Capital of Mauritius). Part of these two flyovers were designed as semi-integral structures considering the curvature, maintenance and sustainability aspects taking 100 years design life and notable wind loads on the structure. Due to 62m curve radius at Curepipe flyover, 2 span continuous box girder spans between piers STP-P1-P2 and P2-PP3-P4 were designed with cast in-situ post-tensioned PSC box girder with S-Shape curve arrangement. Due to 42 & 51 degree skew angle at Caudan flyover pier P10 & P11 three-span semi integral structure (P9-P12) consists of precast post-tensioned PSC I-Girder with curve radius 340m having 4 I-Girder arrangement were designed.

Semi integral structural arrangement added more value in terms of reducing maintenance cost, economical construction, elimination of bearings and expansion joints and increased overall sustainability of the structural arrangement with sharp radius at these locations. Figure 1 and 2 shows the site views of Curepipe and Caudan flyovers respectively prior to start of construction works at site.

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Evaluation of longitudinal forces on substructure of railway bridges due to increased axle loading and speed through full scale field investigations

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Abstract

Bridges are the vital link for the highway and railway networks. There has been much progress in bridge design in recent years with increasing use of advanced analytical design methods, use of new materials and new bridge concepts. The new generation of locomotives produce approximately twice the tractive effort of older locomotives due to which the bridge substructures are subjected to greater longitudinal forces than the design load. Instrumentation and field testing has to be carried out in a comprehensive manner to get the distribution of these longitudinal forces at different levels starting from the coupler level to the substructure level. The existing codal provisions on the evaluation of longitudinal force is initially discussed in this paper. Details of the instrumentation adopted and the experimental investigations carried out on a typical bridge is presented. The percentage of force being transmitted to the substructure was evaluated and compared with the codal provisions.

Keywords: Prestressed concrete slab bridge; railway bridges; longitudinal force; instrumentation; experimental investigations; codal provisions

1 Introduction

We are dependent on the civil infrastructures like bridges, building, offshore structures etc for our various essential needs. Most of the civil infrastructures existing in India have been built earlier and are in service for a longer period of time. These structures are in service despite their aging and accumulation of damage. The condition of these structures needs to be assessed and the performance of these structures under present loading conditions needs to be studied to decide upon the safety and the necessary maintenance to be carried out. Instrumentation and response measurement offers the potential for continuous and periodic assessment of these structures. Based on the knowledge of the condition of the structure, the maintenance strategies can be worked out and the service life of the structures can be extended [1-2]. Indian Railways (IR) has about 1,27,768 bridges on a network route of 63,500 kilometres. Out of these, about 11,090 bridges are classified as Important / Major bridges [3-4]. Most of the major/important bridges are of steel plate girder, open web type truss and masonry arch type bridges built as per old loading standards. Age-wise profile of the in-service bridges reflects that: 42% bridges are over 100 years old, 62% bridges are over 80 years old and 75% bridges are over 60 years old.

With present growth of economy and increased demand for transportation of goods and people, there is huge requirement for increasing the speed, frequency, loading in the trains. Heavy haulage locomotives are introduced in the railways which exerts additional traction on the bridges along with the increased axle loadings. These longitudinal forces are being considered presently during the design stage itself. But in the case of in-service bridges, these forces have not been accounted for during the design. The sub

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Condition Assessment and measures to Repair and Retrofit Baghajatin ROB, Kolkata

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Abstract

This paper provides a comprehensive evaluation of Baghajatin ROB, located on the trunk route of the EM bypass of Kolkata Metropolitan, India. The bridge has been subjected to increased traffic volume, aggressive weathering conditions, and lack of proper maintenance over the years, resulting in its gradual deterioration. This paper aims to highlight the existing state of the ROB and discusses the methodology adopted to repair and retrofit. It includes the current progress of the repair and retrofitting at the site and the challenges involved in construction. This study provides value to engineers, policymakers, and infrastructure stakeholders seeking to develop effective strategies for maintaining and upgrading crucial infrastructure.

Keywords: Non-destructive testing; retrofitting; intermediate supporting arrangement; geocell; peel strength; geogrid; sustainable development.

1 Introduction

1.1 General

The safety of bridges and flyovers in Kolkata came under scanner after three major bridge failures in the city between 2013 and 2018. These tragedies resulted in the loss of about 30 lives, several injuries and immense suffering to their families. In response, the Kolkata Metropolitan Development Authority (KMDA) was tasked with identifying distressed bridges and conducting necessary repairs and retrofitting. The study was conducted by the authors as part of the KMDA's initiative to identify and repair distressed bridges, focusing on Baghajatin ROB.

The study involved a thorough investigation using modern-day assessment techniques which include physical site inspection, partial destructive/non-destructive testing (NDT), traffic and pavement characteristics studies, and analytical investigation. The findings from the assessment helped the team to determine the extent of distress and the best strategy for intervention. This paper provides a detailed account of the repair and retrofitting methodology followed to restore the structural integrity and longevity of the ROB and provide a safe and secure environment for commuters.

1.2 Bridge Location and Year of Construction

The Baghajatin Road Over Bridge (ROB) is situated in southern Kolkata. The Eastern flank/LHS Carriageway was constructed in 1999 and after about 13 years i.e. in 2012 the Western flank/RHS Carriageway came into existence. The ROB serves the people of the following localities: Mukundapur, Chak Gharia, Jadavpur, Santoshpur and Kalikapur. The ROB connects Garia to Ruby and lies between Garia and Baghajatin railway stations. The name of the locality "Baghajatin" holds a great struggle for Indian Independence and it has been named in honour of the legendary freedom fighter Mr Jatindranath Mukharjee.

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1D CONSOLIDATION OF SOIL AT SUMARI UTTARAKHAND CONSIDERING VARIABLE COMPRESSIBILITY

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Abstract

The linear and elastic consolidation theory developed by Terzaghi is commonly used for evaluation of consolidation characteristics of fine-grained soils. As several simplifying assumptions have been made in the derivation of Terzaghi's theory, the application of this theory in many practical problems, especially those involving soft clays, may lead to significant errors. In particular, the assumption of constant value for coefficient of consolidation, C_v, during consolidation process is one of the major limitations in Terzaghi's theory. In this paper, soil sample from the village Sumari near Srinagar Garhwal, Uttarakhand where the permanent campus of NIT Uttarakhand will be constructed has been considered. Finite difference approach is utilized for solving one-dimensional non-linear partial differential equation. Two coefficients (C_n and α) are computed to describe changes in soil characteristics and incorporate the changes in C_v during consolidation. In order to understand the consolidation behaviour considering variable compressibility a simple problem has been considered. It has been observed that the degree of consolidation is over-estimated on consideration of constant coefficient of consolidation C_v and thus may have a substantial impact on the long-term behaviour of the structure resting over ground exhibiting such behaviour.

Keywords: Consolidation; Compressibility; Permeability; Non-linearity; Finite Difference Method; Partial Differential Equation.

1 Introduction

In order to predict the progress of consolidation with time in cohesive soils, the oedometer test is usually performed to determine consolidation characteristics of soil and Terzaghi's linear theory is commonly used for evaluation of the results. Terzaghi (1922) and other researchers assumed coefficient of consolidation constant as consolidation progresses. Barden and Berry (1965), Davis and Raymond (1965) and Xie et al. (2006) established a nonlinear consolidation theory with a variable coefficient of volume compressibility and permeability during consolidation. In some cases, Wei (1987) and Xu (1987) observed that in order to compute foundation settlement hyperbolic model proved to be superior to $e - \log \sigma'$ model. The reason for this was attributed to the fact that former represented the constitutive relationship of soft clay better than the latter. Shi et al. (2001) validated the hyperbolic model for instantaneous loading with laboratory results. Sridharan and Sridharan and Nagaraj (2004) tried to predict the coefficient of consolidation (C_v) based on index properties of soils. They reported that the coefficient of consolidation has a correlation with the shrinkage index, I_s, and proposed a simple equation for the determination of C_v using shrinkage index only. Lekha et al. (2003) derived a theory for consolidation of a compressible medium of finite thickness neglecting the effect of self-weight of soil and creep effects but considering

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Design and Construction Challenges-Extradosed Bridge over River Hatania Doania in West Bengal

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Abstract

Bridge across river Hatania-Doania is a priority project which now connects the island of Bhakkali with the main land Namkhana in South 24 Parganas, in the state of West Bengal at about 100km south of Kolkata. Though Bakkhali and its neighbourhood being a popular tourist attraction, tourists used to avoid the area because of the delay that is caused in crossing the river. To reach Bakkhali, the tourists had to cross Hatania-Doania river by motorboats while vehicles were ferried by the barges. Under emergency, during late night hours, crossing the river was a nightmare. The navigable river serves as a shorter route channel for inland waterway traffic, hence requires a vertical clearance of 10m in 100m central width. Large size barges ply on the route. The project is meant for three lane of traffic and have a main module of 85m+170m+85m extra-dosed bridge deck across main river followed by viaduct portion on either side of the bridge. Bridge Deck is monolithically connected at intermediate pylon location and resting on POT-cum-PTFE bearings at end spans. Deck is laterally supported by 2 plane of stay cables arranged in a semi-fan fashion. The spans are resting on twin-D well foundation at pylon locations.

Keywords: Extradosed Bridge; Long Span Bridge; Cantilever Construction; Well Foundation; Concrete Bridge

1 Introduction

This paper is about long span extradosed bridge in India. Construction of this bridge was entrusted to S.P.Singla Constructions Pvt. Ltd. on EPC mode in December 2014 and the construction was successfully completed in May 2019 after facing several challenges. This bridge is Gold Award winner of National Highways Excellence Award 2019 for outstanding work in challenging conditions. This paper describes the design aspects of the Extradosed bridge along with challenges faced in construction of deep well foundations for the main river bridge.

1.1 About the Project

Owner: Public Work (Roads) Directorate National Highway Wing, Government of West Bengal

Contractor: M/s SP Singla Constructions Pvt. Ltd.

Consultant: M/s B&S Engineering Consultants Pvt. Ltd.

The total length of project is 3.266 km. The project involves construction of a new bridge across river Hatania - Doania including its immediate approach road/embankment and viaduct spans etc. Length of Main Extradosed Bridge is 340m. Figure 1 shows the location map of the bridge.

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Flexural Behaviour of Carbon Textile Reinforced Concrete (CTRC) Panel

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Abstract

Textile-reinforced concrete (TRC) is novel high performance composite material blooming in the 21st century globally. It can be used as not only strengthening material but as a structural load bearing component. This paper aims to investigate the flexural behaviour of carbon textile-reinforced concrete (CTRC) panel through four-point bending test. Optimising the mix using particle packaging for the TRC with grade of mix as M50 using binders were used for the study. Flexural strength and toughness were observed to improve with the increase of the number of textile layers. The textiles were manually prestressed the first-crack flexural stress and pre-cracking flexural stiffness of the CTRC. The results highlight that the behaviour of carbon textile reinforcement under pure flexure performs well with flexural cracks forming only at the pure bending zone. The flexural behaviour of only 4-layer textiles were limited to this study considering the over reinforced design criteria. Further, the performance can be enhanced while optimising the no of layers of textiles(i.e.) the minimum textile reinforcement percentage required in further research.

Keywords: Carbon Textile Reinforced Concrete (CTRC), flexural behaviour, TRC, fine-grained cementitious matrix.

1 Introduction

The growing interest in cost-effective solutions for the structural components has gradually oriented research towards the optimisation of high-performance cement based composited originally conceived for new lightweight constructions. Textile reinforced concrete (TRC) [1-3] describes high performance, cementitious composites containing wo or three-dimensional fabrics made of carbon or alkali resistant glass [4,5]. Their quasi-static tensile behaviour is marked by an extensive strain hardening phase, during which multiple controlled cracking develops in the fine-grained concrete matrix. TRCs high tensile ductility, strength and stiffness enables their applications as thin, slender structural sections. The resistance to corrosion of the textiles permits reduced concrete covers and structural depths and supersedes additional protective polymer layers [6,7]. The higher tensile strength of reinforcement fibres such as carbon. Compared to typical steel allows for further optimisation of cross-sectional designs. With smart use of these materials, large resource savings can be realised in specific areas of concrete construction [8,9]. However, successful dissemination of TRC in practice depends on the

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Classifying Failure Modes of Ultra-High-Performance Fiber Reinforced Concrete Fracture Beams Using Acoustic Emission Technique

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Abstract

Due to its homogenized microstructure and discrete fibers, ultra-high-performance fiber-reinforced concrete (UHPFRC) possesses exceptional compressive and tensile strength. They also have excellent ductility, and durability. As UHPFRC is increasingly used in bridge construction, non-destructive health monitoring can be used to understand its damage behaviour. This study examines the fracture behavior of UHPFRC beams under different parameters, such as fiber volume fractions 1.0% and 2.0%. The Acoustic Emission (AE) is employed to monitor all test beam fracture processes and to determine the crack type. The unsupervised K-means clustering technique is used to analyze AE parameters based on peak frequency and amplitude parameters. The research findings indicated that the failure mode in UHPFRC notched beams was primarily due to fiber pullout. The conventional failure mode classification and k-means clustering are not the same. Similarly, the clustering classification is carried out using the peak frequency versus amplitude. The ranges are decided based on the type of failure modes, such as fiber pullout, matrix debonding, and combined fiber pullout and matrix cracking.

Keywords: UHPFRC; Acoustic emission; Fracture test; Crack classification; Fracture process zone, Machine Learning, K-means.

1 Introduction

Ultra-high performance fiber reinforced concrete (UHPFRC) is a type of concrete that has closely packed fine particles and discrete steel fibers(1–4). Due to the absence of aggregates and more fibers, the failure mode of UHPFRC concrete is different. Due to the excellent mechanical and durability properties of UHPFRC concrete (5–9), structural engineers are inclined to use this material in important structures. To understand the level of damage after certain age or service load, it is

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Effect of Vertical Irregularities on Buildings in Different Seismic Zones of India

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Abstract

Vertically irregular buildings are frequently constructed all over the world for both functional and aesthetic reasons. However, post-earthquake fact-finding survey studies reported that buildings with vertical irregularities were extremely seismically vulnerable. As a result, it is critical to investigate the causes of their high seismic vulnerability in order to enhance their performance. The vertical irregularities in the buildings are caused by asymmetric distributions of mass, stiffness, and strength. These irregularities in the structures results in the floor rotations (torsional response) in addition to floor translations. In this study, the seismic behaviour of vertical irregular buildings located in different seismic zones of India are assessed. The vertical irregular building configurations such as step back, set back, step back-set back, and split foundation are considered in this study. The analysis is performed using finite element software. From the study, it is observed that the performance of vertically irregular building is different in different seismic zones.

Keywords: Include a list of not more than 10 keywords, for example: post-tensioning; anchors; slabs; walls; high-rise buildings.

Keywords: Irregular Building; Seismic Zone, Earthquake resistant design.

1 Introduction

India's seismicity and topography pose significant challenges for building design, as the country is located in a region that is prone to earthquakes and home to a diverse range of geographical features[1]. Several regions of India are classified as high or moderate seismic zones, and buildings and infrastructure in these areas must be designed to withstand seismic forces, including ground shaking, liquefaction, and landslides[2]. Building codes [2] and regulations in India take into account these factors to ensure that buildings and infrastructure are safe and resilient. India's seismic activity is classified into four seismic zones based on the level of seismic activity. These seismic zones are defined in the Indian Standard code of practice for earthquake-resistant design of structures, IS 1893. Zone 2 covers parts of northern India, including Delhi, and is considered a moderate seismic zone. The zone is characterized by low-to-moderate seismicity, and the earthquakes here are usually of small magnitude. Zone 3 covers most of northern and eastern India, including the Himalayan region, and is considered a moderate to high seismic zone. The zone is characterized by moderate-to-high seismicity, and earthquakes of moderate to large magnitude are common. Zone 4 covers parts of Gujarat, Maharashtra, and

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The Sheaf: Expressive Geometry Through Collaborative Computational Design and Low-Tech Construction Methods

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Abstract

This paper presents the design development of The Sheaf — a 12-meter-high iconic timber-diagrid hyperboloid lookout tower, from concept to detailed design. The Sheaf was the winning proposal in an architectural competition in 2019 for a lookout tower in Varberg, Sweden. A close dialogue between architect and engineer propelled the iterative design development, initially exploring the concept and later solving details leading to a sustainable, material-efficient, and expressive tower using simple, affordable building elements. The alternating use of digital parametric models and physical model tests supported the decision-making, allowing quick exploration of viable alternatives and the client to get involved.

Keywords: timber tower; design work; reciprocal; parametric design; sustainability

Figure 1. Competition entry rendering of The Sheaf, a hyperboloid timber-diagrid lookout tower.

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Studying the effect of vertical irregularities on the seismic vulnerability of setback buildings using Linear and Non-Linear methods

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Abstract

In the present study, the behaviour of setback buildings under seismic excitation is analysed using Finite element (FE) method using SAP2000. A model of G+9 storey RC building was considered with setbacks at different floor levels to introduce the vertical irregularities. Three different configurations of the building models, with varying setbacks, are analysed using different methods – 1) Response Spectrum Method (linear dynamic) as per IS 1893:2016 (Part-I), 2) Push over Analysis (non-linear static) using FEMA 356 and 3) Time History Analysis (non-linear dynamic). The response such as base shear, storey displacement, Angle of incidence, Time period, Column and beam moments are analysed in both X and Y directions and compared with the regular model. Effect of irregularities caused due to variation in plan and setbacks, on the response have been discussed, which governs the seismic vulnerability of setback RC buildings.

Keywords: Setback, ground motion, Response spectrum, Pushover, Vertical Irregularity, Target displacement, Time history analysis

1 Introduction

The need for extensive building construction in metropolitan regions has increased due to rising population and urbanization. The expansion of Reinforced Concrete (RC) building construction has constraints in horizontal direction due to the limited land availability. To manage for the same, constructors and designers are looking for the vertical expansion of the multi-storey buildings. Various types of vertical irregularities are provided for the aesthetic consideration or setback due to space requirement at a particular floor level. These building, having irregularities, are susceptible to severe damages in earthquake prone areas leading to the substantial loss of economy and resources.

The behaviour of multi-storey framed buildings during strong earthquake motions depends on the distribution of mass, stiffness, and strength in both the horizontal and vertical planes of buildings. In some cases, these weaknesses may be created by discontinuities in stiffness, strength or mass between adjacent storeys. Such discontinuities between storeys are often associated with sudden variations in the frame geometry along the height. In setback

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Is Nonlinear Analysis Becoming a Standard Tool for Design and Assessment of Reinforced Concrete Structures?

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Abstract

The nonlinear finite element method has become a standard tool serving engineers during the designing of reinforced concrete bridges. Compared to a linear solution, the main advantage is that it can provide a better insight into the realistic material response including crack formation and subsequent redistribution of internal forces. In this paper, the key aspects related to the application in engineering practice are summarised, including the theory behind the nonlinear material model and the explanation of the solution method. Based on validation against experimental data, the accuracy of a given nonlinear tool can be quantified and translated into a model partial safety factor. This factor then serves as a parameter in the evaluation of the design structural resistance. Finally, we show an example of an assessment of a post-tensioned reinforced concrete bridge, where strengthening provisions were adopted to reinforce a critical region with crack formation.

Keywords: finite element analysis, reinforced concrete structures, nonlinear simulation, damage mechanics, smeared crack models, reliability analysis.

1 Introduction

Application of the nonlinear finite element method (FEM) during the designing of reinforced concrete structures offers engineers an important perspective into the realistic behavior of the structure. Advanced material models can evaluate the crushing of concrete when subjected to high compressive stress as well as cracking when the tensile strength is exceeded. Furthermore, for the reinforcement material, yielding and even rupturing can be simulated. By these means, a complex assessment of the structural performance is feasible. Compare to traditional design approaches based on the classic beam theory, nonlinear FEM can accurately consider complex geometries, stress states, and loading histories. This allows assessment of the structural integrity for static, dynamic, and environmental loads as well as consideration of the long-term rheological phenomena such as concrete creep.

The applicability of the nonlinear FEM simulation has been rigorously shown in literature and is often checked in benchmark competitions. Based on these findings, modeling uncertainties can be quantified. To utilize nonlinear analysis in engineering practice, proper guidelines need to be available. Currently, these provisions are given in the *fib* Model Code 2010 [1] and will be introduced in the new generation of Eurocodes. These standards incorporate the model uncertainty, which should be specific to each material model and software package.

This paper is structured to first give a brief theoretical overview of the non-linear FEM, demonstrate its applicability using examples from benchmark competitions, and finally present a code-based framework for engineering application.

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Innovative Solution to Urban Infrastructure: Special Solution to Conventional Structure Planning

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Abstract

Most ancient cities are unplanned, with most businesses in the central core and people from suburbs working there. CBD traffic loads are growing rapidly, straining commute facilities. Urban road infrastructure and unrestrained expansion severely impede mobility. Today, construction project duration and environmental impact matter most. Innovation involves applying solutions that meet new requirements through an engineering process that may not be fully new but adapts the approach to the local constraint and is more evolutionary than revolutionary. Innovative solutions must be optimal in design, cost-effective, and improved in constructability with prototype testing often being used to validate the design, constructability, loopholes to fix, and construction timeframe to adopt. This paper describes some of the creative construction approaches utilised to improve urban built environments, safety, and construction time.

Keywords: Innovation, Innovative Structure, Precast Unit

1 Introduction

In today's materialistic society, time is the most vital resource. The utilisation of time as a resource shortens the gestation period of civil infrastructure projects, hence expediting returns. Rapid construction can ensure prompt outcomes. After project conception and design, the remaining tasks can be completed rapidly.

Globally, innovation in structure design leads to a significant increase in the efficiency of the material used, thereby achieving overall economy, in addition to optimising the time and resources that are required for construction.

This paper will describe few innovations globally that culminate in achieving overall economy along with few examples in India on which the lead author is involved personally.

2 Innovation in Design and Planning of Infrastructure

In an unplanned growth, ancient city engulfs the surrounding suburbs for expansion, however, connecting roadways to the city become insufficient to serve the growing number of commuters.

Solutions to such problem usually fall into two categories: Either by creating a Mass Transit

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A roadmap for implementing integrated asset management for sustainable water Infrastructure in India

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Abstract

Water is a crucial resource for the economic and social development, and its depletion poses significant challenges. A major portion of India is facing high levels of water stress and rapid depletion of groundwater reserves, impacts millions of people. This paper proposes a roadmap for sustainable water resource management in India through an integrated approach, considering water supply and wastewater systems, and highlighting the significant role of civil engineers in balancing cost, risk, and performance. The framework provides guidance for planning, functions, and interactions with flexibility for varied conditions. The study emphasizes need for a wholesome approach to water resources management and highlights the variables that influence the effectiveness. The proposed framework can aid water resource managers and policymakers to make informed sustainable decisions, contributing to improved practices in India.

Keywords: Water resource; Roadmap; Integrated Asset Management; Environmental Sustainability; Water Infrastructure; SDG; Water & Sanitation; IWRM; Civil Engineers

1 Introduction

Water is a crucial constituent of existence and is pivotal to both economic and social progress. Despite the abundance of water on the planet, only a small fraction is of sufficient quality, in the right location, and accessible. The importance of water cannot be overstated as it has a direct impact on all elements of development and is linked to Sustainable Development. It drives economic growth, maintains healthy ecosystems, and is fundamental to life.

Unfortunately, more than 663 million individuals do not have access to safe and clean sources of drinking water, highlighting the need for better planning and management of water resources. Decreased water resources can lead to slower economic growth, as water is a critical component of production. By the year 2050, losses related to water in agriculture, health, income, and overall prosperity could potentially reduce growth rates by up to 6% of GDP in certain regions [1].

Water insecurity can have a significant drag on global economic growth, as water and water-related hazards have a statistically significant effect on the economy. For example, the Niti Aayog's 2018 Composite Water Management Index (CWMI) study found 21 major cities in India, including Delhi, Bengaluru, Chennai, and Hyderabad, are rapidly depleting their groundwater reserves, and are approaching a state of zero groundwater levels, disrupting the availability of water for 100 million people [2]. By 2030, the nation's water market is predicted to be double the existing supply, leading to catastrophic water shortages for hundreds of millions of people and a 6% loss in GDP.

Initiatives to enhance water resources can also drive developments in various industries, including agriculture, tourism, energy, and health. Ensuring

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Different Approach of the Construction Sustainability

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Abstract

The paper presents a new approach for obtaining the sustainability of the construction works. The application of the sustainability aspects is presented on two different types of constructions.

The **first application** considers into account the analysis of a multi-store structure. The structure is made of three different types of structural elements: R.C. structure, Steel structure and Masonry structure. The parameters for the sustainability approach were: energy consumption, direct cost, manpower and horizontal capacity force.

The **second study** shows the sustainability of a structural and hydrothermal rehabilitation intervention on a historical building. The analysis will refer at three situations of the building: initial state; the common methods for insulating layer, the innovative solution with aired layer between the heat insulating and the masonry.

Keywords: building sustainability; specific model; sustainability index; sustainability cost; multi-store structure; hydrothermal rehabilitation; R.C. structure; steel structure; masonry structure.

1. The building sustainability

Most of the existing models which evaluate the sustainability performances of construction works are very comprehensive and with high applicability, like: BREEM, LEED, CASBEE, DGNB, SB Tool, Green Star, HK–BEAM, EN 15643-1, ISO and so on [1], [2], [3].

In many cases such models show some disadvantages: any of models do not cover all three dimensions; they include a great number of criteria and many of them are difficult or impossible to quantify; the tools are focused manly on entire buildings, and they can be applied with some difficulties on other types of construction works and activities.

To avoid disadvantages, the author and his collaborators had proposed a new assessment method, called specific model [1]. The main advantages of this method are covering the three dimensions of sustainability; high degree of applicability; includes only quantitative parameters.

The new approach, presented in this paper, is based on the specific model but instead of the calculation of **the sustainability index SI** the evaluation considers the price of each parameter of the tree dimensions and finally **the sustainability cost SC** is obtained [4], [5], [8].

1.1 Specific model

The specific model is based on simple mathematical equations, which combine the results of the quantified parameters in a rational way, obtaining finally a Sustainability Index SI:

$$SI = S_{env} + S_{eco} + S_{soc} \quad (1)$$

$$S_{env} = \sum_{i=1}^{n} \alpha_i \times \frac{P_{i,env}^{R}}{P_{i,env}}; \quad S_{eco} = \sum_{i=1}^{n} \beta_i \times \frac{P_{i,eco}^{R}}{P_{i,eco}};$$

$$S_{soc} = \sum_{i=1}^{n} \gamma_i \times \frac{P_{i,soc}^{R}}{P_{i,soc}} \quad (2)$$

Where:

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A sustainable roadmap for affordable housing in India. A benchmarking approach to achieve the SDGs

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Abstract

Addressing the housing shortage in developing nations such as India has recently become a burning socio-economic problem. Meeting these housing needs contributes significantly to the economic and social growth of such economies. However, promoting such extensive housing development programs drastically strains many natural resources, including energy, water, and land, and leads to higher pollution and carbon emissions. In this context, sustainability benchmarking gains relevance. Benchmarking refers to defining targets or reference points for performance measurement in the context of a firm, product, or process. Therefore, this study introduces a benchmarking scheme for different sustainability indicators in the affordable housing segment in India. The study brings out crucial results regarding the country-level emission targets set for India to meet Goal 13 of the SDGs which is related to climate action.

Keywords: Affordable Housing, Sustainability Benchmarking, Sustainable Development Goals (SDGs)

1 Introduction

Sustainability can be viewed as achieving an equilibrium between humanity and the ecosystem surrounding it and sustaining it for a long time. The term sustainable development was first used by the Brundtland Commission established by the UN to associate the concept of sustainability with human actions [1]. The commission's report (the Brundtland report) highlighted the necessity to direct attention to protecting the environment with due consideration to the economic development and social growth of the countries [2]. Later in 2015, the UN conference on sustainable development decided to formulate Sustainable Development Goals (SDGs) with an agenda to integrate the objectives of the three pillars of sustainability and to set targets for both developing and developed countries to realize sustainable development. India, too, has pledged support for these UN SDGs and also to continue to reduce emissions as per the Paris Agreement. To support the population and sustain a booming economy, India must make significant expenditures in water supply, sewerage, solid waste management, transportation, drainage systems, and affordable housing [3]. This would demand a significant number of natural resources and lead to vast amounts of waste generation and pollution.

Goal 11 of the SDG highlights the construction industry's importance in spearheading a predominant role in sustainable development. This goal also emphasizes providing safe, resilient, and affordable housing and facilitating financial and technical assistance for utilizing local materials to make sustainable buildings. This poses additional challenges to the construction industry, particularly the building sector, especially in developing countries such as India, where 70% of the buildings are yet to be constructed (about a million square meters of commercial and residential space) [3]. It is forecasted that from 19 million housing units in 2012, the demand for

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Life Cycle Cost Analysis and Use of Continuously Reinforced Concrete Pavement (CRCP) in the Bharatmala Pariyojana Project

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1. INTRODUCTION

Transport is a vital infrastructure for rapid economic growth of the country. Speedy transportation of natural resources (such as raw materials), finished goods and perishable materials to all parts of the country including the points of export outlets are basic inputs to economic growth. Recently there has been a major shift in transportation mode from Railways towards the Road sector in India.

Now a day's about 60% of freight and 87% of passenger transport is met by Road transport in India. Transport infrastructure has found to be woefully inadequate to accommodate the growing needs of the steep rise of vehicles. Congestion, delays, waste of fuel, accidents and pollution has reached intolerable limits, which demonstrates the need for development of a good road network.

Roads do more than mere providing connection between towns and villages. They pave the way for increased commerce, trade and prosperity. It is often said that a country pays for its roads whether it has them or not. It only pays more if it does not have them. Considering the importance of development of National Highways and Expressways for fast movement of goods and passengers, the Government of India has taken up Bharatmala Project a mega road and highway project.

Since the investments in road building are very high, proper investigation needs to be made while choosing the right type of pavement. One has to carefully exercise the choice, considering various factors such as traffic, environmental conditions, availability of materials and initial cost of construction, serviceability life of pavement, cost of maintenance, road user cost, resistance to overloading and life cycle costs. Fuel saving and vehicle operating costs also play an important role in deciding the pavement type. Out of the total commercial energy 20% is used in transport sector. Road sector is completely dependent on oil, which accounts for 80% of total fuel consumption. Any little amount of fuel saving is a huge benefit to the nation, because major portion of oil is imported.

Vehicle operating costs studies made in several countries including India show that rigid pavements offer fuel savings of upto 20% in comparison to flexible pavements. Hence, any advantage of flexible pavement on account of low initial cost is not significant on life cycle costs.

Also the concrete's white surface reduces the street lighting cost. Since, concrete road surface has light colour compared to asphalt pavement, the heat generation is lower. Cooler surfaces and air reduce the need for air conditioning, saving energy. Cooler air can also reduce air pollution by slowing the chemical reactions that produce pollution.

Institute for Steel Development and Growth (INSDAG) with its mission to provide and promote the cost effective and efficient designs has carried out a study to establish the techno-economic

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Effects of Moisture Ingression In Building Envelope Through Moisture Index (MI) And Wind Driven Rain Index (WDRI)

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Abstract

Moisture ingression in building envelopes offers significant structural integrity and performance challenges, leading to costly rehabilitation repairs and reduced comfort for residents. Building moisture can cause Inadequate Ventilation, fungal growth and other microbial contamination, corrosion, salt crystallization, and other moisture-related deterioration. This study investigates the effect of moisture ingress due to rainwater infiltration and its diffusion into the building facades. In addition, this research utilizes moisture modelling using moisture index (MI) and wind-driven rain index (WDRI). Furthermore, Indian standard codes and instructions were used for WDRI computations. Finally, hygrothermal analysis was conducted using WUFI simulation software, concentrating on 2D elements (slabs and walls) found in various locations with varied MI and WDRI values. This research highlights the importance of climate change when constructing structures and the potential benefits of sustainable construction techniques to reduce moisture-related problems.

Keywords: Moisture index (MI); wind driven rain index (WDRI); relative humidity(RH); dry-bulb temperature(DBT); wet-bulb temperature(WBT); climate change; sustainable construction; building comfort.

1 Introduction

The building envelope is an essential aspect of architecture and construction that demarcates the border between a structure's interior and the external environment. This dynamic interaction is critical in assuring structures' comfort, energy efficiency, and integrity. Among the various issues that building envelopes encounter, moisture ingression is a dangerous adversary. Moisture diffusion through the building envelope compromises structural integrity, degrades interior air quality, improves energy inefficiency, and increases maintenance costs [1]. Extreme weather events, such as heavy and wind-driven rain, occur more frequently and with greater severity as climate change accelerates [2]. As a result, architects, engineers, and construction experts must have the utmost care for how well building envelopes resist moisture penetration. This concern has inspired a growing interest in studies that use cutting-edge methods and indices to quantify, recognize, and mitigate the impacts of moisture ingression. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) provides more severe problems caused by decisions made by members of various professions [3]. However, these problems can be prevented by employing methods based on water ingress behaviour of buildings. The Moisture Index (MI) and the Driven Rain Index (WDRI) have distinguished themselves among these indices as crucial measures for determining how susceptible building envelopes are to moisture-related problems [4-6]. The importance of this study relies on its ability to offer a thorough framework for tackling the various issues that cause moisture ingress. Researchers may develop a system to

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Protecting Reinforced Concrete Structures with Thermal Sprayed Zinc Anodes

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Abstract

Metallic zinc coatings protect steel from corrosion by acting first as a barrier coating and more importantly as a sacrificial anode. Zinc will provide galvanic protection to the steel. As such, concrete structures reinforced with plain or black steel showing signs of distress can be galvanically protected with external zinc anodes. Thermal sprayed metallic zinc coatings on the exposed surface of the concrete can be electrically connected to the steel reinforcement and provide corrosion protection to the steel.

Thermal sprayed zinc coatings were successfully tested as anodes in cathodic protection systems for reinforced concrete structures in the United States. Subsequent installations were made on numerous structures, including three historic reinforced concrete bridges in the state of Oregon. The 20-plus-year performance confirms that the service life of reinforced concrete structures can be significantly and economically extended by using metallic zinc anodes to protect the plain steel reinforcement from further corrosion.

Keywords: Thermal sprayed zinc; sacrificial anode; corrosion; zinc; rebar.

1 Introduction

Corrosion of black steel reinforcement (rebar) is an important cause of concrete degradation. Due to carbonation, the pH of a concrete structure will decrease with time, which increases the susceptibility of the rebar to corrosion. Exposure to chlorides, whether by atmospheric deposition of chlorides in marine environments or through use of road de-icing salts during winter maintenance periods, can also initiate corrosion of the rebar. The build-up of corrosion products on the reinforcing steel surface exert pressure on the concrete which lead to cracking and spalling of the concrete cover. Initial signs of rebar corrosion are red rust staining seeping out of cracks in the concrete. If left

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Continuous Galvanized Rebar for Corrosion control in RCC structures

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Abstract

Post liberalization, India has witnessed massive infrastructure growth. One of the reasons for this magnificent growth was easy availability of foreign technology, which is required for building massive infrastructure. Being the second fastest growing economy, at an average GDP of 7-8 % for past ten years, the loss due to corrosion is to the tune of USD 40 billion every year, which is about 4 percent of the GDP. Steel corrosion is the most common problem faced by most of the countries. There is a need to find ways and means to plug leakages on maintenance costs due to corrosion and offer the right solutions to enhance the life of civil structures by using suitable cost effective coating on steel. Scientists and engineers are focusing on developing corrosion free material , which has not become reality because of economies of scale. However many new protective coatings have been developed to prolong the life of steel.

The reliability of the built environment, both general construction and infrastructure, is paramount to minimize the ever increasing costs of maintenance. And avoiding the serious costs to society of disrupted transportation routes, failed communication networks, inadequate energy supply, or deficient water control systems, when infrastructure must be repaired or replaced, has become more critical. There is an acute demand for investments that provide long service life buildings and infrastructure. Globally, more than $1.5 trillion will be spent annually over the coming years on new construction, or on repair or replacement of existing infrastructure. Whether for residential or commercial buildings, for energy, water, communications or transportation systems, construction projects will rely heavily on reinforced concrete as a principal building material. Protecting the reinforcing steel (rebar) from corrosion is a critical investment to prolong the life and improve reliability of the built Structure and environment.

Coatings are well established as a means to protect rebar from corrosion. Hot-dip galvanized rebar (HDG) has been used successfully for over 50 years although it is sometimes perceived as a niche product. With the advancement of technology, low cost continuous grade Galvanized Rebar is a recent development. Furthermore, by using a small aluminum-containing zinc bath, it will produce a galvanized reinforcing product with 40-60 microns of pure zinc coating that can not only

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Challenges in Design and Construction of an Innovative and Sustainable Built Environment

18th Congress Report, Seoul 2012
Innovative Infrastructures - Toward Human Urbanism

17th Congress Report, Chicago 2008
Creating and Renewing Urban Structures Tall Buildings, Bridges and Infrastructure

16th Congress Report, Lucerne 2000
Struct. Eng. for Meeting Urban Transportation Systems

15th Congress Report, Copenhagen 1996
Struct. Eng. in Consideration of Economy, Environment and Energy