Testing of modular expansion joints – America's leading role

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Summary

Laboratory testing to verify the functionality, performance and durability of bridge deck expansion joints has become increasingly important in recent years in certain markets around the world, and indeed it has an important role to play in many circumstances. Testing has particular potential in the case of modular expansion joints, which offer great benefits to bridge designers but which are, of necessity, relatively complex mechanical structures. Nowhere has the demand for testing of modular joints, and the specification of what testing should be carried out and how, been stronger than in the United States, where a comprehensive range of standards has been published. This includes highly demanding testing to assess an expansion joint's suitability in a number of key areas. This testing is described, and the consequences of the unnecessary requirement for such testing for a project are discussed, enabling recommendations for the setting of such requirements to be made.

Keywords: Modular expansion joint, testing, performance, durability, necessity, implications.

1. Introduction

Modular expansion joints have a great deal to offer the designers and constructors of bridges everywhere, thanks to their ability to facilitate very large longitudinal movements and their great flexibility [1]. This has led to modular expansion joints being the preferred solution for many of the world's largest bridges in recent years, and to an increasing focus on performance standards and testing requirements for such joints by owners and engineers.

2. Full-scale testing of modular joints – America takes the lead

Fig. 1: Seismic testing of a modular joint

The use of modular expansion joints has increased substantially in North America in recent years, and this is reflected in the advancement of national standards. In fact, standards published and promoted by the American Association of State Highway and Transportation Officials (AASHTO) took on a leading role in terms of testing requirements for such joints in particular, with highly demanding testing defined to determine an expansion joint's suitability in a number of key areas, including fatigue performance, daily movements, traffic vibrations, elastomeric seal strength, and performance during a seismic event.

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2.1 Testing of fatigue performance

Fatigue testing of modular joints is defined by the 1997 NCHRP (National Cooperative Highway Research Programme) Report 402, "Fatigue Design of Modular Bridge Expansion Joints". The onerous testing required by this report simulates the fatigue-inducing movements and stresses of a service life on a full-scale section of a joint which contains all critical members and connections. Ten data points are required, gained from a series of tests to determine the number of load cycles to which the joint can be subjected before failure occurs. Using these data points, an S-N curve is plotted, correlating stress (S) to number of load cycles withstood (N) on a logarithmic scale. This enables the fatigue performance of the joint during an extended lifetime to be determined. Such a series of tests can require over six months of non-stop use of a test rig, and the testing facilities which are widely recognised as being capable of conducting the testing are very few. This means that such testing, if properly conducted, is very expensive, and must be planned well in advance to allow the testing to be conducted within the timeframe of a project.

2.2 Testing of daily opening movements, vibrations from traffic and seal strength

NCHRP Report 467 of 2002 defines two types of test. The Opening Movement Vibration (OMV) test simulates, on the one hand, the opening (and closing) movements that can be expected to occur during a 75-year lifetime due to daily thermal cycles. At the same time, the test simulates the vibrations caused by traffic, with a 33 kN force applied to a lamella beam at high frequency for the entire duration of the opening movement testing. Following completion of the OMV test and all evaluations, the Seal Push-Out (SPO) test is recommended. This test assesses the strength of the connection of the elastomeric seals to the lamella beams which support them, and thus indirectly tests the important ability of the joint to remain watertight. The SPO test is carried out on the same joint which has already been subjected to the rigours of an OMV test, and thus simulates the weakened condition that an elastomeric seal may exhibit after years of service.

2.3 Testing of seismic performance

With its history of destructive earthquakes, it is not surprising that the state of California plays a leading role in the development of technology to withstand seismic events, with bridge components such as expansion joints falling under the remit of the California Department of Transportation (Caltrans). Testing on a full-scale modular joint with seven gaps and four support bars is described, with the joint subjected to large, rapid longitudinal and transverse movements (Fig. 1).

3. The implementation of these testing requirements

Although the development of laboratory testing specifications has been comprehensive, the application of testing requirements has been less uniform. This very often makes the process of complying with project specifications in different states an uncertain one for suppliers, increasing the risks and thus the costs, which must ultimately be borne by the project itself. Clear indications at an early project stage of the requirements for testing, and how previous testing may be considered sufficient, will thus help to considerably reduce the effort and expense of acquiring modular joints for a project, or avoid later lack of agreement on what new testing can be expected.

4. Conclusions

Testing of expansion joints comes at a high price, and places high demands on scheduling of design and manufacture of joints for a project, if months of testing must be planned and completed before fabrication of the joints which are to be supplied. On the other hand, the assurance that the testing can provide that the joints will be fit for purpose can be of great value in certain circumstances– for example, where new or improving suppliers cannot demonstrate the performance and durability of their joints from many years of "real life testing". And although expensive, the cost of testing is likely to be much less than the cost, both direct and macro-economic, of greater maintenance effort and early replacement of a poorly performing joint. The careful consideration of such issues can avoid unnecessary or overly demanding laboratory testing, saving considerable expense and time.

[1] SPULER T., LOEHRER R., O'SUILLEABHAIN C., "Challenges and Solutions for Expansion Joints on Super Long Span Bridges", *Proc. IABSE Congress*, Seoul, Korea 2012.