Concrete Bridge Perimeter Strips using Micro Hollow Spheres

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Summary

The freeze-thaw resistance of concrete is influenced by the properties of the raw materials and the air-void system. Usually the required micro-pores are created by adding air entraining agents while mixing the concrete. Some problems with the unerringly production and placement of air entrained concrete in the past made it interesting to look for durable alternatives. So for the bridge perimeter strips of one bridge in Bavaria micro hollow spheres were used. The hollow spheres with a density of 0.2 kg/l and a mean diameter of about 50 µm are mantled by plastic materials.

For the Bavarian pilot project two different mixtures were used. On both mixtures suitability tests were performed in the concrete plants. Besides the usual properties of the fresh concrete the content of pores was determined using the Roll-A-Meter method according to ASTM C173. The performed CDF-Tests as well as the characteristics of the air-voids indicated a sufficient freeze-thaw resistance. Before casting on site the handling of the mixtures was tested on formworks with realistic dimensions. Quality control was guaranteed by scientific support given by Technische Universität München (University of Technology, Munich, Germany). Future inspection will proof the required durability of the bridge perimeter strips.

Keywords: Durability; infrastructures; concrete bridges; exposure to freeze and de-icing salts; micro-pores; air-void system; curing; perimeter strip.

1. Situation in Germany

The durability of concrete structures is one important cornerstone of sustainable infrastructures. In Germany a lot of de-icing salt is used on roads and bridges. Damages at concrete members that are exposed to freeze and de-icing salts are well-known. Bridge perimeter strips are particularly affected. To get high resistance against freeze thaw and de-icing salts minimum contents of cement and air pores are required in Germany. Usually the required micro-pores are created by adding air entraining agents while mixing the concrete. Some problems with the unerringly production and placement of air entrained concrete in the past made it interesting to look for durable alternatives.

2. Accurate design of air-entrained concrete by pre-fabricated air voids

If the creation of stable air voids is difficult in a certain diameter range due to the large number of influences, it appears obvious to add pre-fabricated micro air-voids, so called micro hollow spheres, to the concrete. Micro hollow spheres are tiny, pre-fabricated air voids with a resilient, chloride-free plastic envelope with a mean diameter of 50 µm. They are added to the concrete instead of an air-entraining agent. This method ensures that only effective micro air voids are introduced which do

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not undergo further changes during transport, pumping, placement and compaction of the fresh concrete. Therefore, they will also be present at exactly the same level also in the hardened concrete. In the case of freeze attack, the plastic envelope will be destroyed by the pressure of the ice, so that the void becomes available as an expansion space. In the fresh concrete pre-fabricated air voids cannot be measured in the common pressure gauge (air-void test vessel). For this reason, the wash-out method in the so-called Roll-A-Meter according to ASTM C-173 [1] was chosen to determine the air void in the fresh concrete.

3. Bavarian pilot project using concrete with pre-fabricated air voids

3.1 Project and initial considerations

For a first application of concrete with pre-fabricated air voids the retrofitting project of the concrete bridge perimeter strips of a bridge was chosen. At the bridge there are two perimeter strips in the middle and two at the edges. The perimeter strips of the two traffic directions should be cast with two different concrete types and different delivery methods (pump resp. chute). The treatment of each perimeter strip should differ (covered by foil or sprayed with a curing compound).

3.2 Concept for quality assurance, testing and surveillance

Technische Universität München (Munich, Germany) was charged by the owner of the bridge to prepare a quality assurance concept with instructions for the concrete mixing plants and for the building contractor. All responsible persons should have to be fixed in protocols and only staff with special training should be deployed. All work has to be kept under surveillance of Technische Universität München.

After the mixing procedure at initial type testing the density, the slump and the content of micro hollow spheres (determined by a Roll-A-Meter according to ASTM C173 [1]) was measured. By these results a minimum content of micro hollow spheres of 1.5 Vol-% was required by the quality plan for the casting of the perimeter strips of the pilot project. After the initial type testing for both mixtures handling tests with the different delivery methods were performed by the staff that also should be employed on site. This was tested on formworks with realistic dimensions and realistic reinforcement. On both types of concrete CDF-tests were successfully performed.

3.3 Execution of the project

Before the concrete was delivered to the bridge, tests on the fresh concrete were performed at the concrete mixing plant according to the requirements of the quality plan. On site the roll-a-meter test the determination of the slump were repeated. All measurements agreed with the requirements of the quality plan defined by the results of the initial type testing.

4. Conclusion

The air void content could be verified as well when using a pump as when using the chute of the concrete mixing truck. Thus, it is shown that pumping of concrete is not destroying the micro hollow spheres. In spite of the high resistance against freeze-thaw and de-icing salt quality assurance is essential. By the pilot project is shown that the erection of durable concrete bridge perimeter strips is possible. The acceptability should also be examined for other structural members that are also exposed to freeze-thaw and de-icing salt.

5. References

[1] AMERICAN SOCIETY FOR TESTING AND MATERIALS, “ASTM C173: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method”, 2007