Experience with EMC-50q at Bridge casting.

MEMORANDUM

Date: 15.01.2000

Prepared by: HANS HEDLUND

Experiences of EMC-50q at Bridge casting

Background

In a joint task within the Centre of High Performance Cement (CHPC) and the Swedish National Road Administration, Region North, a bridge with a span equal 16m was to be cast with approximately 200m^3 concrete using Energetically Modified Cement (EMC). The EMC binder contained 50% of fine quartz sand and 50% of Swedish Standard Slite cement (CEM I 42.5 R from Cementa AB, a subsidiary of Heidelberger Zement).

The bridge was built by Skanska AB; one of the leading construction group's in the world.

The bridge was located some 50 km south of the Polar Circle where the temperature often drops below -30°C during winter and rises above +20°C in the summer period. The transportation time from the ready mix factory was approximately 50 - 60 minutes.

Performance requirements for the concrete was as follows:

* Suitable for the use of pumping equipment
* Good workability - slump at app. 100mm on site
* Air content of 4.0 - 4.5% at site
* Frost resistance (Borås-method)
* Strength class of K55 - K60
* Topping of steel fibre reinforced concrete (SFRC)

A key performance element for casting a concrete bridge in such severe climate is frost resistance which requires the use of a well-distributed air void system. From an architectural as well as an economic point of view a high strength and slender structure was desired. Another key element to achieving a long lasting bridge is to have excellent performance during casting. This requires a good composition of the fresh concrete.

Conclusions

A comparison between laboratory tests and tests of on site casting shows that bridge concrete made of EMC-50 cement has equal performance to concrete using 100% OPC. (See table attached.)

Preliminary Laboratory testing

In co-operation with the ready-mix factory, Kallax Betong och Grus, in Kalix and Luleå University of Technology (LTU) the EMC concrete mix was designed and tested to follow the desired requirements.

Testing was done at the concrete laboratory of the Structural Engineering Division at LTU. Strength development and maturity, temperature development (generated heat), frost resistance, shrinkage, free deformation together with workability aspects were tested (see Norberg 1998).

Workability of the fresh EMC-50 concrete was designed to fit the production procedure chosen by the contractor.

Nearly 50 different fresh concrete mixes were tested to evaluate slump loss, loss of air content due to transportation, early age strength development, etc.

The optimal sieve curve of aggregate consisted of 52% gravel and 48% coarse aggregate in combination with a relatively low cement/binder content.

Tests were done using EMC-50 binder content ranging between 530 - 600 kg/m^3. Best results over all were obtained using 530 kg of EMC-50 per cubic meter concrete.

Initial slump after casting was about 180 – 200mm. Investigations showed 70 - 80mm slump loss one hour after mixing in a simulated transportation.

In the same way the air content decreased about 1.0 -1.5%.

These results are all in line with those normally achieved with 100% OPC. (See table attached.)

Bridge casting experience

During bridge casting the ambient temperature was in average -5°C and windy.

The production of the main bridge was cast using a concrete pump and vibrating sticks and the topping was cast directly on the wet main deck using a bucket and a vibrating beam. The creating personal was pleased with the remarkable good workability after such a long transportation and it was no problem to place it. The concrete had the same consistency as ordinary concrete, but behaved more like self-compacting concrete.

The site manager from Skanska remarked that the surface appearance was significantly better than for ordinary concrete. It was also appreciated that the concrete surface had a much lighter colour compared with ordinary bridge concrete.

The strength development of the chosen concrete mix reached 75% of its 28-day compressive strength within ten days of maturity. The slight retardation in early strength development was caused by slightly higher dosages of superplastisizer used to achieve the good workability (lignosulfonate based) (0.5% in comparison with average value 0.3-0.4% by cement weight for OPC). The strength development started about 10 - 12 maturity hours after casting. The heat evolution started earlier – before the strength development - preventing the concrete from freezing thus confirming the winter concreting potential of the EMC binder.

Analysis of the heat liberation of the bridge concrete has been performed in parallel with both semi-adiabatic and adiabatic equipment. The measurements performed by Skanska at the bridge were in line with the temperature development calculated in the laboratory. The EMC-

50 mix has significantly lower final value of generated heat compared with heat liberation of the base cement (Slite Std P). No thermal cracks occurred during construction work.

The frost resistance was tested according the Borås method up to 56 freeze and thaw cycles. The Borås method is periodical cycles with 3% sodium-chloride solution as the temperature changes from +20°C - -20°C and back to +20°C within a 24-hour period. The EMC-50 concrete mix had an air content of 5.3% giving good frost resistance of the bridge mix.

Measurements of the autogenous deformation indicate shrinkage of the same magnitude as high performance concrete (HPC) with the same level of water-binder ratio. This effect may be due to the amount of superplastisizer used. Thermal dilatation is of the same magnitude as for ordinary concrete mixes containing ordinary Portland cement.

About one week before casting of the main bridge and deck it was decided to use a steel fibre reinforced concrete (SFRC) topping cast on the bridge. The same requirements were set as for the main bridge. Using 60 kg/m^3 of steel fiber the slump measured 120mm after casting and 80mm one hour later.

The SFRC topping showed the same experiences as mentioned above.

References

Norberg, J, (1998), "Concrete of the future - a comparision of some mechanical properties for energetically modified cement and Portland cement", Luleå University of Technology, Division of Structural engineering, 1998:256 CIV, pp 60. (in Swedish)

Hans Hedlund, Average test results (laboratory tests, casting tests and reference OPC concrete tests, see table A5-1.

Luleå, January 15, 2000

Hans Hedlund

Table A5-1. **Average test results of EMC and OPC concretes (laboratory tests and data from bridge casting**)

Mix type	**Binder type**	**Binder content, kg/ m^3**	**w/B**	**Slump, mm**	**Density, kg/m^3**	**Compressive strength, MPa**			
						1 d	**3 d**	**7 d**	**28 d**
Laboratory	EMC-50	530	0.38	175 - 180	2400	15-18	32	41	66
In-situ casting	EMC-50	530	0.38	180 - 200	2400	17	31	40	63
Reference (lab)	OPC	530	0.38	175 - 190	2400	18-20	30	40-45	60-65