IABSE-JSCE Joint Conference on Advances in Bridge Engineering-III, August 21-22, 2015, Dhaka, Bangladesh. ISBN: 978-984-33-9313-5
Amin, Okui, Bhuiyan, Ueda (eds.) www.iabse-bd.org

Recent advances in admixture technology for bridge construction

A.A. Patil
BASF India Limited, India

F. Shahadat
BASF Bangladesh Limited, Bangladesh

ABSTRACT: Infrastructure development is an important aspect for the development of any country and in that bridge construction is a major link to improve the transportation network within the country. Bridges are required to provide serviceability for long periods and hence it becomes important to factor, during the design and implementation, the external environment that can affect the durability of the concrete. This paper addresses the impact of admixture technology that has made possible design of high performance concrete as a smart material and also enhanced the overall concreting process (placing, transportation and compaction).

1 INTRODUCTION

It is essential for every concrete structure to perform its intended functions, specially required strength and serviceability, at least during the specified service life. It follows that concrete should be able to withstand the processes of deterioration to which it is expected to be exposed. Such concrete is said to be durable. "*High-performance concrete (HPC) is defined as concrete which meet special performance and uniformity requirement that cannot always be achieved by using only the conventional material and mixing, placing and curing process. The performance requirement may involve enhancement of compaction without segregation, long term mechanical properties, early-age strength, toughness, volume stability, or service life in severe environments*".

2 CAUSE OF INADEQUATE DURABILITY

Inadequate durability manifests itself by deterioration which can be due to either external factors or internal causes within the concrete itself. The various actions can be physical, chemical, or mechanical. It should be observed that the physical and chemical processes of deterioration can act in a synergistic manner. For these reasons, it is sometimes difficult to assign deterioration to a particular factor, but quality of concrete in the broad sense of word, though with a special reference to permeability, nearly always enters the pictures. Indeed, with the expectation of mechanical damage, all the adverse influences on durability involve the transportation of fluids through the concrete. For this reasons consideration of durability require an understanding of the phenomena involved.

3 TRANSPORATION OF FLUID IN A CONCRETE

There are fluids particularly relevant to durability that can enter concrete: water, pure or carrying aggressive ions, carbon dioxide and oxygen. They can move through the concrete in different ways, but all transportation depends primarily on the structure of the hydrated cement paste. As stated earlier, durability of concrete largely depends on ease with which fluids, both liquids and gases, can enter into, and move through, the concrete; this is commonly referred as permeability of concrete. It is commonly known that permeability refers to flow though the porous medium. But movement of fluids can also create diffusion and absorption, therefore the main concern is with permeability of concrete. Nevertheless, the commonly accepted term 'permeability' will be used for the overall movement of fluids into and through concrete excepted where, for clarity, distinctions between the various types of flow to be made.

4 CHALLENGES IN HIGH PERFORMANCE CONCRETE

It is not enough that a concrete mix is correctly designed, transportation, placing and compaction, it is of utmost important that the concrete must be placed in a systematic manner to yield optimum results. As stated earlier the permeability is a major factor for durability of concrete and it is related to density of concrete. The density of concrete is majorly affected due to the improper compaction of concrete.

The creation of a durability of concrete structure required adequate compaction by skilled workers. However, gradually reduction in skilled workers and availability of workers in a construction industry has led to reduction of quality of construction. One solution for achievement of durable concrete structure independent of construction of quality of work is the use of self-consolidate concrete, which can be compacted into every corner of formwork, purely by means of its own weight and without need of vibrating compaction. The necessity of these types of concrete is proposed by Prof. Okamura in 1986. Studies to develop self-compacted concrete, including fundamental study of workability of concrete have been carried out by Ozawa and Meakawa at university of Tokyo (Ozawa 1989, Okamura 1993 and Meakawa 1999).

4.1 *Case Study I*

A typical application example of Self-compacting concrete is the two anchorages of Akashi-Kaikyo (Straits) Bridge (Figure 1) opened in April 1998, a suspension bridge with the longest span in the world (1,991 meters). The volume of the cast concrete in the two anchorages amounted to 290,000 m^3. A new construction system, which makes full use of the performance of self-compacting concrete, was introduced here.

Figure 1. Akashi Kaikyo Bridge

The concrete materials were more or less same as normal concrete but with the addition of fine lime powder, about 120 to 180 kg/m^3, to maintain water to powder ratio in SCC. The maximum size of aggregate was 40 mm. The recipe used as a powder type SCC (without viscosity modifying agent) and Poly-carboxylic ether based superplasticizer (MasterGlenium SKY) used in SCC mix design. The concrete was mixed at the site batching plant, and was pumped 200 meters ahead through pipes where the pipes were arranged in rows 3 to 5 meters apart. The concrete was casted from gate valves located at 5 meter intervals along the pipes. These valves were automatically controlled so that a surface level of the cast concrete could be maintained. In the final analysis, the use of self-compacting concrete shortened the anchorage construction period by 20%, from 2.5 to 2 years.

4.2 *Case Study II*

Vivekananda Setu, located at Kolkata in India, had become redundant and there was need for a second Vivekananda bridge (Nivedita Setu) (Figure 2). The main challenge of this work was to design and construct a new bridge that did not mar the view of the old Vivekananda Setu that carried substantially higher levels of fast traffic for around half a century. The bridge rests on deep-well foundations going down to the river bed level. It carries six lanes for high speed traffic. The carriageway is supported by 254 pre-stressed concrete girders. Cables from 14m high pylons extend additional support. Nivedita Setu is the first bridge in the India that is a single profile cable-stayed bridge. The bridge is the India's first multi-span, single-plane cable supported extradosed bridge; with short pylons and seven continuous spans of 110 m, totaling a length of 880 m (2,887 feet). It is 29 m wide and will be able to support 6 lanes of traffic. In this project, center segment on the top of the pier called as pier table segment was most important in terms of structural design. Pier table segment was center segment of cable stay and all cable tendons pass through this segment. As density of reinforcement was very high along with pre-stressing cable ducts, achieving of 100% compaction of M60 grade of concrete was the main concern. In that situation, consultant and contractor decided to move with self-compacting concrete for ensuring the durability of pier table segment. All the pier table segments constructed using M60 SCC concrete. The maximum size of aggregate was 20 mm. The recipe used as a combination powder and viscosity modifying agent type SCC. In this project MasterGlenium 51 was used as hyper range superplasticizer along with MasterMatrix 2 (MasterGlenium Stream 2), as viscosity modifying agent.

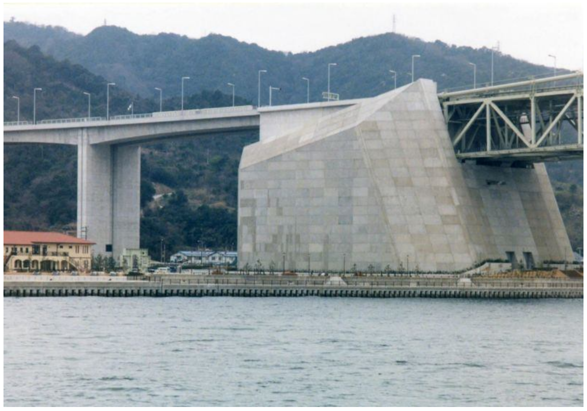

Figure 2. Second Vivekananda Bridge, Nivedita Setu- Kokkata

5 CONCLUSIONS

Self-compacting Concrete is currently being cast-off in various construction projects and makes it as 'Standard Concrete' rather than 'Special Concrete'. Despite shorten the construction period of large-scale construction, SCC is succeeded in creating durable and reliable concrete structure that require very little maintenance cost. SCC adds economical, ecological and ergonomic values to concrete and has the potential to move the market up to the next level of advanced construction practice.

REFERENCES

Adam M Neville , Properties of concrete,

Hibimo, M Okuma M and Ozawa k (1998) "Roll of viscosity agent in self-compacting concrete", Proceeding of the sixth East Asia conference on structural Engineering and construction, 1313-1318.

Meakawa K and Ozawa K (1999), " Self compacting high performance concrete", social Institute Japan 20-32