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Permeability Behaviour of Self Compacting Concrete

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Abstract- For several years, the problem of durability of concrete structure has been a major problem posed to engineers. To make durable concrete structure, sufficient compaction is required. Excess of vibration causes segregation whereas under vibration leads to improper compaction. Answer to this problem is Self compacting concrete(SCC) which can get compacted into every corner of form work and gap between steel, purely by means of its own weight and without the need for compaction. Durability of concrete depends largely upon the permeability of concrete that is defined as the ease with which it allows the fluids to pass through it. This paper aims to focus on experimental study of permeability test on selected SCC trial mixes after giving different exposure condition. A suitable mix was selected on the basis of self compactability properties which can be checked by various tests such as slump test, U Box test, L Box test and V Funnel test. The various specimens were exposed to different conditions such as normal (lab environment), heat cool cycles and wet dry cycles. The results of the exposed specimens was compared with the specimen cast and kept at room temperature so as to estimate the durability parameters for duration of one month.

Keywords — Aggregate, Coefficient, Durability, Exposure, Permeability, Self Compacting Concrete, Specimens

INTRODUCTION

Nowadays, performance required for concrete structure is more complicated and diversified. The concrete is required to have high fluidity, high strength, self compatibility, and long service life concrete structures. SCC is highly engineered concrete that addresses these requirements. Although compressive strength is a measure of durability to a great extent it is not true that the strong concrete is always durable concrete. It is now recognized that the strength of concrete alone is not sufficient, the degree of harshness of the environmental condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered explicitly at the design stage.

Rapid chloride permeability, water absorption, water permeability, drying shrinkage is some of the test which can be done to measure durability. Permeability and strength are related to each other through the capillary porosity, as a first approximation, the factors that influence the strength of concrete also influence the permeability. Permeability tests measure the transfer of a liquid or gas into the concrete under the action of a pressure gradient. They can be either Steady state or non-steady state depending on the condition of flow established within the pore system of the concrete.

LITERATURE REVIEW

Okamura proposed the use of SCC in 1986.Studies to develop SCC including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo and by 1988 the first practical prototypes of SCC were produced. By the early 1990 Japan started to develop and use SCC and as of 2000, the volume of SCC used for prefabricated products and ready mixed concrete in Japan was over 520,000yard3.

In India the first development work on SCC were reported by Subramanian and Chattopadhyay in 2002. They mentioned in their study that the self compatibility test (U Tube) and deformability test (Slump Test) are adequate for SCC. They have also reported that trial proportions suggested by Okamura and Ozawa appear to be suitable for rounded gravel aggregate, when using crushed angular aggregates, the proportions are to be adjusted incorporating more fines.

Dr. R. Malathy and T. Govindasamy in 2006 developed SCC following EFNARC specifications. They developed mix design of SCC for different grades, M 20 and M 60 and their flow properties such as passing ability, filling ability, compaction factor and strength properties such as compressive and split tensile strength were studied. They developed comparison charts for different grades of SCC and conventional concrete.

In 2009, an article written by M. Hunger and A.G. Entrop suggested a behavior of SCC containing micro encapsulated phase change materials. Phase change materials which have ability to absorb and to release thermal energy at a specific temperature.PCM and its influence on mechanical properties of SCC.

Even though durability is a key factor affecting longevity of concrete structures, unfortunately very limited information is available in literature about this important aspect. Available literature reveals that significant research programs have been carried out regarding the fresh properties of self compacting concrete but only few studies are available regarding the durability characteristics of self compacting concrete.

EXPERIMENTAL PROGRAMME

The present study comprises of water permeability test of SCC specimens after giving different exposure conditions. After 28 days of water curing, the specimens were divided into three groups and exposed to conditions for duration of one month detailed given below:

- Control (Lab environment)
- Heat -cool (Heating at 60^{o}C and then cooling at room temperature on alternate days)
- Wet – dry(Wetting for 1 day and then drying for 1 day)

1. MATERIAL

- Cement: The cement use for the experimental studies was Ultratech 43 grade OPC as per the specifications of Indian Standard Code IS: 8112-1989.
- Aggregate: The source of fine and coarse aggregates was from the course of Gaggar River which flow in the foot hills of Shivalik range. The coarse aggregate and fine aggregates were crushed aggregates. The aggregates were procured from a crusher installed at a location. The sieve analysis and physical properties of coarse and fine aggregate satisfied the requirement of IS: 383-1970, which is mentioned in following Table 1.

TABLE 1

Type of Aggregate	Specific gravity	Fineness modulus
Coarse Aggregate	2.70	3.7
Fine Aggregate	2.60	2.11

- Superplasticizer: Structuro 202 which is light yellow in color having Ph value 6.5 was used as a plasticizer.
- Fly Ash: Fly ash used in the present work was procured from Guru Gobind Singh Thermal Power Plant, Ropar (Punjab). To assess the properties of fly ash, laboratory tests conducted by Central Soil and Material Research Station (CSMRS), New Delhi and CBRI-Roorkee are considered.

  Various trial mixes has been done to achieve the acceptance criteria of self compatibility. Trial mix mentioned in Table 2 has achieved the acceptance criteria which are given in Table 3 for all the self compacting test methods.

TABLE 2

WATER(Litre)	CEMENT(kg)	SAND(kg)	COARSE AGGREGATE(kg)	STONE DUST(kg)	FLY ASH(kg)	SUPERPLASTICIZER (Litre)
191.78	400.2	431.72	820.04	421	87.95	6.62

TABLE 3

CONTENTS	**SLUMP FLOW**	**T_{50} SLUMP FLOW**	**V-FUNNEL T_{5min}**	**L-BOX (H2/H1)**	**U-BOX(H2-H1)**
TRIAL MIX	700	4	3	0.9	25
RANGE OF ACCEPTANCE	650 TO 800 (MM)	2 TO 5 (SECOND)	0 TO 3(SECOND)	0.8 TO 1	0 TO 30(MM)

2. WATER PERMEABILITY TEST

- Apparatus: There are three permeability cells for 150mm cube specimens. Each cell consists of a metal cylinder with a ledge at the bottom and flange at the top, with a removable cover plate and a funnel. A control panel with three independent control circuits for three permeability cells, each control circuit consisting of a water reservoir, graduated gauge, glass tube, air inlet valve, pressure regulator, pressure gauge 0-15 kg/ sq cm an air bleed valve, a drain cock for water reservoir and a shut off valve for the permeability cell. A common air inlet for the three units is provided for connecting the air compressor. There are three glass bottles to collect the percolated water. (Test set up shown in picture)

- Testing of Apparatus: Before testing the specimen for water permeability, annular space between the cell and specimen is tightly filled to a depth of about 10 mm using cotton. Then molten sealing compound is poured into the gap and it is completely filled. A mixture of commercial wax and rosin were used for making a sealing compound to fill the gap. It is essential that the seal is watertight. This may be very conveniently done by bolting on the top cover plate, inverting the cell and applying air pressure of 2 kg/cm^2 from below. A little water poured on the exposed face of the specimen is used to detect any leaks through the seal, which would show up as bubbles along the edge. In case of leaks, the specimen shall be taken out and resealed. Number of trial mixes was made mentioned in Table 4 (Paraffin wax: rosin) i.e.

TABLE 4

Trial Ratio	Paraffin wax: Rosin
TR1	2 : 1
TR2	2 : 2
TR3	2.5 : 2

TR 3 fulfilled the above criteria and was used for sealing the specimen. When water passes freely through the drain cock it was closed and the water reservoir filled. The reservoir water inlet and air bleeder valve was then closed. With the system completely filled with water, the desired test pressure 50kg/cm^2 was applied to the water reservoir. After number of hours (i.e. 2-3 hours) the pressure decreased and then with the help of air compressor pressure is increased to the same value i.e. 50kg/cm^2. In the beginning the rate of water intake is more than the rate of outflow, as the steady state of flow is approached the two rates tends to become equal and the outflow reaches a maximum and stabilizes. Permeability test continues for 24 hours after steady rate of flow has been reached and the outflow is considered as average of the entire outflow measured during this period of 24 hours. Then the coefficient of permeability calculated by using the following formula:

$$K=Q/\ (A*T*\sum (H/L))$$

Where:

K= coefficient of permeability

Q= Quantity of water in milli litre percolating over the entire period of test after the steady state has been reached.

A= Area of the specimen face

T= Time in seconds over which Q is measured

H/L = Ratio of the pressure head to the thickness of specimen

The coefficient of water permeability for specimens exposed to all the three conditions investigated in this study is presented in following Table 5

TABLE 5

Exposure	Average coefficient of water permeability (m/s)
Normal	$4.011\text{x } 10^{-12}$
Wet Dry	$1.742\text{x } 10^{-12}$
Heat Cool	$3.443\text{x } 10^{-12}$

CONCLUSION

When concrete permeability was tested after exposure of one month of three different conditions following conclusions were obtained.

- Water permeability coefficient in case of wet-dry exposure was less when compared to specimens exposed to normal conditions.
- Values of the water permeability coefficient for normal and heat-cool exposure are almost same.
- Average water permeability coefficient for the SCC specimens under normal conditions was found 4.011 x 10^{-12}, whereas value of water permeability coefficient in case of wet-dry and heat-cool exposure was found 1.742 x 10^{-12} and 3.443 x 10^{-12} respectively.

Average value of water permeability coefficient for the SCC specimens under normal conditions is lower than the maximum permissible value of the water permeability coefficient 15 x 10^{-12}m/sec which is recommended by ACI 301-89

PERMEABILITY TEST APPARATUS

REFERENCES:

[1] M. Shahul Hameed , V . Sraswathi, A.S.S. Sekar, "Rapid chloride permeability test on SC high performance green concrete",

[2] Okamura, H. and Ozawa, K. (1994), "Self compactable HPC in Japan", SP 169, ACI, Deitrot.

[3] Okamura, H., "Mix Design for Self-Compacting Concrete", Concrete Library of JSCE, Vol.25, 107-120, 1995

[4] IS: 383-1970 (Reaffirmed 1997) "Specifications for Coarse and Fine Aggregates from natural sources", Bureau of Indian Standards, New Delhi, 1997.

[5] IS 8112 (1989): "Specification for 43 grade ordinary Portland cement", Bureau of Indian Standards, New Delhi, 1989.

[6] Subramanian, S. and Chattopadhyay, D., "Experiments for mix proportioning of self compacting concrete".

[7] Y.V.Mahesh and Manu Santhanam, "Simple test methods to characterize the rheology of self compacting concrete", The Indian concrete journal, June 2004

[8] Sonebi, M., Bartos, P.J.M., Zhu, W., Gibbs. J., and Tamimi, A., "Final Report Task 4 on the SCC Project; Project No. BE 96-3801; Self-Compacting Concrete: Properties of Hardened Concrete," Advanced Concrete Masonary Center, University of Paisley, Scotland, UK, May 2000

[9] Petersson, O, Billberg, P., Van, B.K., "A Model for Self-Compacting Concrete", Proceedings of RILEM, International Conference on Production Methods and Workability of Fresh Concrete, Paisley, Italy, 1996

[10] Okamura, H., "Mix Design for Self-Compacting Concrete", Concrete Library of JSCE, Vol.25, 107-120, 1995

[11] Influence of aggregate characteristics on uniformity of SCC by Anirwan Sengupta and Manu Santhanam in Indian Concrete Journal, June 2009

[12] EN197-1 Cement Composition, Specifications and Conformity Criteria. EFNARC, http://www.efnarc.org/efnarc/SandGforSCC.PDF

[13] Bauzoubaa N et al, "SCC incorporating high volumes of Class F fly ash, preliminary results", Cement and Concrete Research, Vol.31, 413-420, 2001