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INVESTIGATIONS AND STUDY ON THE EFFECT OF AR GLASS POLYMER FIBRES IN SELF-COMPACTING SELF-CURING CONCRETE

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ABSTRACT

This experimental study is exposing the relationship between permeability and compression strength of AR Glass fiber-reinforced concrete. In addition, it inspects the influence of AR Glass fiber reinforcement on concrete permeability. The AR Glass fibers decrease permeability of specimens with increased volume of fibres. Here an attempt is made to study the permeability of super plasticised concrete with different types of fibres. The fibres are added at the percentages varying from 0.2% to 1.0% by weight of cement at intervals of 0.20%. To maintain a good workability, superplasticiser is added at the dosages of 0.8% by weight of cement. The dosage is arrived considering the workability and strength on simultaneous reduction of cement and water content ranging from 5% to 20% of the reference concrete. The experiment was conducted in a six cell permeability cell at the pressure of 10 kg/cm^2 for 100 hours. Water permeability test is conducted as per IS: 3085-1987 and it is found that on addition of fibres, the co-efficient of permeability of concrete is reduced considerably.

Keywords: AR glass fibre, compressive strength, micro cracks, permeability, super plasticiser, workability.

1. INTRODUCTION

Fiber-reinforced concrete is becoming an increasingly popular construction material due to its improved mechanical properties over UN reinforced concrete and its ability to enhance the mechanical performance of conventionally reinforced concrete. Though much research has been performed to identify, investigate, and understand the mechanical traits of fiber-reinforced concrete, relatively little research has concentrated on the transport properties of this material. Material transport properties, especially permeability, affect the durability and integrity of a structure. Permeability of concrete is due to internal movement of water or other fluids, transporting aggressive agents through the pore structure of the concrete. High permeability, due to porosity or cracking, provides ingress for water, chlorides, and other corrosive agents. If such agents reach reinforcing bars within the structure, the bars corrode, thus compromising the ability of the structure to withstand loads, which eventually leads to structural failure. A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service [1]. After 1963, fibres became an essential component of concrete by the pioneering research of Romualdi and Batson on steel fibre reinforced concrete [2]. Fibres are effective in increasing Compressive strength up to 1.0 percent fibre content, beyond which the increase is not much effective [3]. The microcracks in concrete are formed due to the drying shrinkage at the intertransition zones. The inclusion of fibres can prevent microcracks in the transition zones where microcracks originate and cause enhancement of permeability which in turn affects the durability of structures [4, 5]. Durability of Palm tree frond fibre reinforcement as an inclusion of natural fibres was studied by Samir. In his study he reported that addition of substantial amount of fibers in concrete shows significant increment in inherent tensile and durability characteristics of concrete [6]. In another study addition of cellulose fibers into concrete retain the durability even after exposing to environmental and biological attack [7]. Inclusion of steel fibers into concrete resulted in significant decrease in permeability due to arrest of plastic shrinkage cracks [8, 9].

2. RESEARCH SIGNIFICANCE

There has been greater concern over Permeability of concrete among civil Engineers than its strength in structures like hydraulic structures, marine structures and structures near chemical industries. There are lots of fibres in the market and there is confusion among the users to choose the best one to withstand the permeability. Also attempts were made so far about the study of permeability tests with steel and natural fibres. No attempts were made in the synthetic fibres regarding permeability of fibrous concrete. To fill up the gap an attempt is made to develop a new concrete with good workability and better resistant against permeability with the addition of fiber to the superplasticised concrete. In this study grade of concrete considered as M20. The fibers are added at the percentages varying from 0.2% to 1.0% by weight of cement at intervals of 0.20%. Superplasticiser is added with a dosage of 0.8% by weight of cement and dosage is arrived on simultaneous reduction of cement and water content ranging from 5% to 20% of the reference concrete with a view to eliminating the effects of creeps, shrinkage and other thermal stresses [10, 11]. The Co-efficient of permeability was determined by carrying out water permeability test.

3. PRELIMINARY INVESTIGATIONS

3.1 Materials

The materials used for casting the test specimens consisted of Type I cement of 53 grade, locally available river sand and hard blue granite of size 20 mm coarse aggregates were used. The aggregates were in the angular shape. The properties of ingredients are shown in Table-1.

Table-1 Properties Of Ingredients

Items	Properties
Specific gravity of cement	3.1
Specific gravity of coarse aggregates	2.65
Specific gravity of fine aggregates	2.6
Grade of sand	zone II
Water absorption of course aggregates	1.1%
Water absorption of fine aggregates	2.51%

3.2 Chemical admixtures and fibers

Sulphonated Naphthalene based Superplasticiser. Type F conforms to IS: 9103- 1989. The details of fibres used in this study are presented in Table-2.

Table -2 The Properties of AR Glass Fibres

PROPERTIES	AR GLASS FIBRE
Density	2.6 t/m^3
Number of fibres	212 Million / Kg
Cut length	12 mm
Diameter	14µm
Aspect ratio	857:1

4. DESIGN OF REFERENCE MIX

BIS method is adopted to design the reference mix. Target mean compressive strength at 28 days is 26.6 N/mm^2. As per the design, the mix ratio is 1: 1.56: 2.9: 0.49. To formulate the revised mix ratio, various mixes were exercised by reducing the cement and water content simultaneously at the level of 5%, 10%, 15% and 20% and by adding 0.4%, 0.8% and 1.2% of superplasticiser by weight of cement at each level of reduction. It was found at the level of 15 % reduction of cement and water content and at the dosage level of 0.8 % of superplasticiser that concrete had attained high workability as well as high strength. Later the reference mix (NR) is fixed as 1: 1.83: 3.5:0.49.

5. EXPERIMENTAL PROGRAMME

The following tests were carried out on the specimens to evaluate the behavior of fibre added superplasticised concrete at plastic and hardened stage.

Phase 1

It was decided to conduct the experiments in terms of workability, strength as well as durability. To cater to the needs of the above test the slump and compaction factor tests were performed for workability, Compression test was conducted for strength and Permeability test were conducted on the reference mix.

Phase 2

To the reference mix, Alkali Resistant Glass Fibres were added at 0.2%, 0.4%, 0.6%, 0.8 % and 1.0% by weight of cement. At each volume workability, compression strength and permeability values were determined. For evaluating permeability of concrete Steady flow method and Depth of penetration method were followed. The notations are followed for easy reference for each mix.

Notations

RMX: 1: 1.83: 3.51: 0.49
NR: Reference Mix
RMX + 0.8% of super plasticizer by weight of cement
1: 1.83: 3.51: 0.49 + 0.8% SP
NG 1: NR + 0.2% AR Glass Fibres
NG 2: NR + 0.4% AR Glass Fibres
NG 3: NR + 0.6% AR Glass Fibres
NG 4: NR + 0.8% AR Glass Fibres
NG 5: NR + 1.0% AR Glass Fibres

5.1 Workability test

Workability tests were performed using standard sizes of Slump Mould as per ASTM C 143-90a and Compaction Factor apparatus which was developed in the UK and is described in BS 1881:Part 103: 1993

5.2 Compressive strength test

The Steel mould of size 150 x 150x 150 mm size is well tighten and oiled thoroughly. They were allowed for curing in a curing tank for 28days and they were tested in a 200-tonne electro hydraulic closed loop machine. The test procedures were used as per IS: 516-1979. The load was applied at the rate of 140 kg/cm^2/minute till the cube breaks and recorded the failure load.

5.3 Permeability test

Although there are no recognized standard test method to measure the permeability of concrete by ASTM and BS13, Permeability test procedures were carried out as per the standard IS: 3085-199714. To conduct the permeability test cubes of size 150mm were casted and cured for 28 days. After 28 days of curing, specimens were placed properly in the six cell permeability apparatus. A Rubber sheet of 8mm thick and 150 x 150mm size with a central hole of 100 x 100mm was taken. This rubber sheet was then placed on the top and bottom surface of the cube in the permeability cell. Cover plate was then tightened properly. The rubber sheet acts as a washer and prevents the leakage of water through the annular space between specimen and cell. Suitable arrangements were made for supplying compressed air at 10kg/cm^2 to the cell by a compressor with an adequate supply of cleaned deaired water to be available for the purpose of water may be easily de-aired and constant supply of pressurized water. Collecting jar was placed

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under the concrete specimen to collect the discharged water from the concrete. The test was conducted continuously for 100hrs. After 100hrs cubes were then taken out from the cell. During the test it was found that there was no any permeate through the concrete. As there was no any permeation of water the steady flow method was discarded. Hence to find the co-efficient of permeability Depth of Penetration method was employed by which the cubes were splitted and depth of penetration was measured in the specimen at different locations and average depth of penetration was obtained. The method was developed by Valenta, equivalent to that used in Darcy's Law

$$K = \frac{D^2 P}{2TH}$$

Where K = coefficient of permeability in m/s

D = Depth of penetration in cm
P = Porosity of concrete measured as a fraction=0.149
T = time in sec
H = pressure head=100m

6. TEST RESULTS AND DISCUSSIONS

6.1 Workability test

Adequate workability is required for proper placement, consolidation and finishing of concrete. The workability of FRC has been investigated at various volumes of fibres. As a precautionary measure it was decided to find workability of RMX type concrete. Test results shows RMX has very low workability and after adding superplasticiser there was an increased slump occurred. From the experimental results it was found that there has been substantial amount of slump loss occurred with the increased volume of fibres. Beyond 1% volume of fibres it was found that fibres showed some balling effects and made difficult to mix. Similarly compaction factor test results are showed in the Table-3 and Figures 1 and 2.

Table 3. Slump and Compaction Factor

MIX	Supr Plast (%)	Vol Fib (%)	Slump Value In mm *	Compaction Factor *
RMX	0	0	10	0.880
NR	0.8	0	145	0.970
NG1	0.8	0.2	140	0.960
NG2	0.8	0.4	130	0.950
NG3	0.8	0.6	120	0.940
NG4	0.8	0.8	70	0.930
NG5	0.8	1	40	0.920

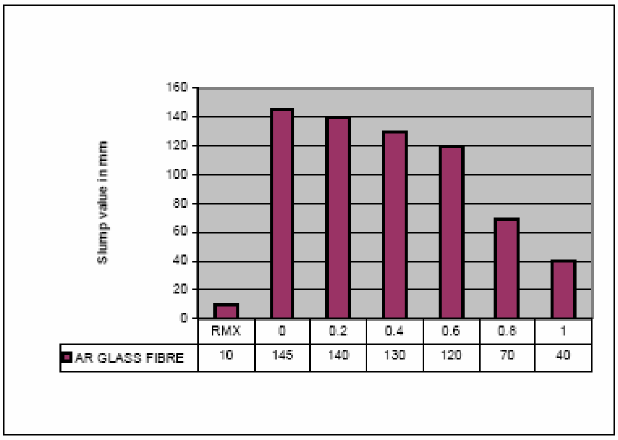

Fig. 1 Slump value

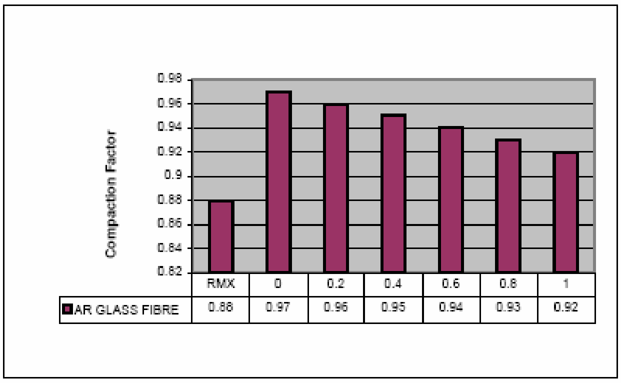

Fig. 2 Compaction Factor

6.2 Compression test results

It was noted that a substantial increment in compressive strength occurred with the increase of volume of fibres. The values are presented in Table-4. It was found that at the level of 1% Vol of fibres, max increase in strength was 22%.

6.3 Permeability test result

It has been observed that the influence of fibres is more effective in resisting the permeability of concrete. When the cubes were splitted, it was observed that invariably all the cubes had depth of penetration less than 5 cm. When the percentage of fibres increases permeability gets decreased. Referring Table-5, the depth of penetration, at the volume of fibres 0.2%, showed the depth of penetration less than 5cm. In the investigation, it was seen that AR Glass fibres had showed very low depth of permeability. It was found that at the level of 1% of Glass fibre resistant to penetration was found as 95.11% with respect to reference mix. Figure-3 shows the measurement of permeability.

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Fig 3 Permeability Study

Table 4. 28 Days Compressive Strength

MIX	Supr Plast	Vol of Fib	Comp strength Mpa
RMX	0	0	37.78
NR	0.8	0	40.30
NG1	0.8	0.2	47.56
NG2	0.8	0.4	48.10
NG3	0.8	0.6	48.89
NG4	0.8	0.8	48.98
NG5	0.8	1	49.19

Table 5. Depth of Penetration and Co-Efficient of Permeabilty

MIX	Supr Plast (%)	Vol Fib(%)	Depth of Penetration in cm *	Co-efficient of Permeability 10 x $^{-11}$ *
RMX	0	0	10.56	2.310
NR	0.8	0	9.3	1.800
NG1	0.8	0.2	4.33	0.389
NG2	0.8	0.4	3.80	0.300
NG3	0.8	0.6	3.10	0.101
NG4	0.8	0.8	2.31	0.097
NG5	0.8	1	2.06	0.088

* average value

7. STATISTICAL APPROACH

In order to predicte the volume of fibres for permeability values of superplasticised fibrous concrete using experimentally observed values, it was decided to plot the graph between compression and permeability values as shown in Figure-4. Here RMX mix was discarded due to the experimental interest on superplasticised concrete. After carrying out various best fit curves straight line equation was chosen as the best fit and gave the equation.

$Kf = - 1.9504\ \sigma + 96.6$ ………….…………………… (1)

Similarly, but on the contrary, using experimentally observed values and statistical approach exponential equation was found as best fit for permeability of fibrous concrete can be expressed as in equation 2 and was plotted as shown in Figure-5.

$Kf = Kp\ e^{-(1.197+2.052\ Vf}$ ……………………………… (2)

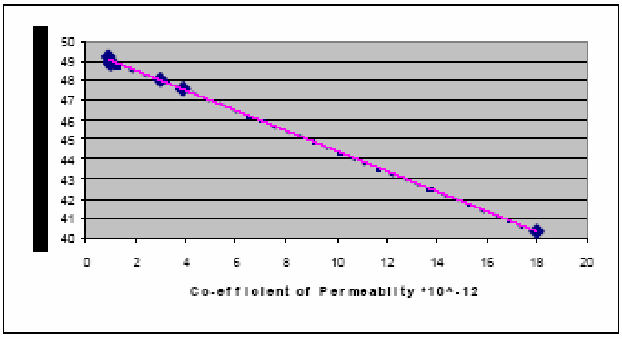

Fig. 4 Comp strength Vs Co-efficient of permeability

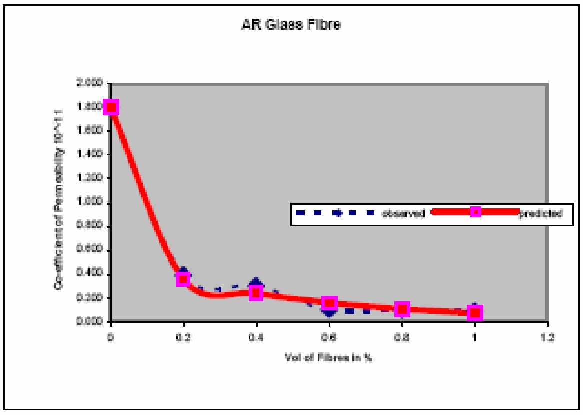

Fig. 5 Co-efficient of permeability Vs Volume of fibres

In which Kp, Kf are the co-efficient of permeability of plain and fibrous concrete and σ, Vf are compression strength and percentage volume of fraction of fibres respectively. Kf can be used to predict co-efficient of permeability of AR Glass fibrous concrete. It was found that the predicted values from the above equations were very close to the experimental values and therefore the above equations can be used to predict the volume of fibres and co-efficient of permeability of fibrous concrete from the compressive strength of concrete from Figures 4 and 5.

8. CONCLUSIONS

Based on the results obtained in this investigation, four major conclusions were drawn from this research.

a) Even at the lowest volume of fibres 0.2%makes the concrete impermeable with good workability and more compression strength;
b) The maximum compressive strength of 49.19N/mm2 was obtaining at 1.0% volume of fibres with 0.8% of super plasticizer. The percentage improvement of the

compressive strength over the reference concrete is 22%;

c) With the increased volume of fibres the resistant to penetration of water in the concrete was increased. And at the level of 1% volume of fibres with 0.8% of super plasticizer, the maximum resistance to penetration was found as 95%; and
d) A reasonable estimate for volume of fibre and co-efficient of permeability of AR Glass fibrous concrete can be made using equations 1 and 2.

REFERENCE

[1] IS: 456- 2000. Indian standard code of practice for plain and reinforced concrete. Bureau of Indian Standards, New Delhi.

[2] Romualdi. J.P. and Batson. J.B. 1963. Mechanics of Crack Arrest in Concrete, Journal of Engineering Mechanics Division Proceedings. ASCE. Vol. 89, EM3. pp. 147-160.

[3] Saluja. S.K., Sarma S.K, Singh. M.S and Sunil Kumar. 1992. Compressive Strength of Fibrous Concrete. Indian Concrete Journal. 66: 99-102.

[4] Dale P. Bentz. 2000. Fibres,Perccolation and spalling of High Performance Concrete. ACI Materials Journal. 97(3): 351-359.

[5] Neville A.M. 1990. Properties of Concrete. Longman Scientific and Technical, Longman Group, London.

[6] Samir Abdel-Azim. 1995. Durability of Palm-Tree-Frond Fiber Reinforcement. Concrete International. pp. 27-31.

[7] Parviz Soroushian. 1997. Secondary Reinforcement-Adding Cellulose Fibres. Concrete International. pp. 28-34.

[8] Sing. A.P. and Dhirendra Singhal. 2001. Effect of Cement and Fiber Contents on Permeability of SFRC. Journal of Structural Engineering. 28(1): 49-54.

[9] Antoine E Naaman. E., Thanasak Wongtanakitcharoen and Gabriel Hauser. 2005. Influence of Different Fibers on Plastic Shrinkage Cracking of concrete. ACI Materials Journal. 102(1): 49-58.

[10] 1993. ACI Committee ACI 212.4 Report. Guide for the use of High Range Water-Reducing Admixtures (Superplasticiser). Concrete International. pp. 38-47.

[11] Ramezanianpour A.A. 1995. Superplasticiser: Their Effect on the Strength Properties of Concrete. Concrete International. pp. 30-35.

[12] IS: 9103. 1999. Indian standard code of practice for specification for concrete admixture. Bureau of Indian Standards, New Delhi.

[13] Neville. A.M. and Brooks J.J. 1987. Concrete Technology. ELBS, Longman.

[14] IS: 3085-1965 (Reaffirmed 1997). Indian standard code of practice for method of test for permeability of Cement Mortar and Concrete. Bureau of Indian Standards, New Delhi.

[15] IS: 516-1959 (Reaffirmed 1999). Method of test for strength of concrete. Bureau of Indian Standards, New Delhi.

[16] Perumal P. DR., Maheswaran J. DR., Elangovan. G. 2006. Behavioural study on the effect of AR Glass fiber reinforced concrete. New building materials and construction world. 12(4): 174-180.

[17] Perumal P. DR., Maheswaran J. DR., Elangovan. G. 2007. Behavior of superplasticised concrete on simultaneous reduction of cement and water content. New building materials and construction world. 12(7): 154-158.