Durability Analysis of Mechanical Properties of High Strength Concrete using Steel Fiber, Glass Fiber, Silica Flume and Fly Ash

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Abstract- *A review of literature regarding the requirements of ingredient-materials for producing high strength concrete (HSC) along with the results of an experimental study on achieving HSC has been reported in this paper. Use of quality materials, smaller water-cement ratio, larger ratio of coarse aggregate (CA) to fine aggregate (FA), smaller size of coarse aggregate, and suitable admixtures with their optimum dosages are found necessary to produce HSC. In the experimental study, the targeted strengths of concretes were from 30 MPa to 50 MPa. A larger ratio of CA to FA (1.81 except one mix of 1.60) was considered in the study. While the variables considered were the water-cement ratio (from 0.45 to as low as 0.33). Test results are found to support the reviewed information on HSC production. Also the water-cement ratio and the suitable admixtures with their optimum dosages are found to be the most important parameters for producing HSC.*

Keywords- Discrete event simulation, queuing system, size delay function

I. INTRODUCTION

The development of high strength concrete has been taken place in the last thirty years or so. Due to industrial demand the development of high strength concrete have improved rapidly because the industrial demand of new features in concrete members with serious advantages such as increased capacity and stiffness.

The benefit of increased compressive strength is to lower volumes and produce smaller designs in terms of design prospective, thus allowing its immediate application into design. The concept of helical reinforcement. of beams came after the demand of industry due to the improvement of stiffness factor; this improvement was associated with increasing of brittleness phenomenon in the compression zone, having said that, it is significant to minimize this problem.

For the last few years there is a remarkable increase in the compressive strength of structural concrete. In Australia concrete has been used up to 100 MPa in some cases while in some countries they used concrete with compressive strength up to 130 MPa.

II. LITERATURE REVIEW

In their work "Development of Hybrid Polypropylene-Steel Fiber Reinforced Concrete" Qian and Stroeven measured the compressive strength, split tensile strength, and modulus of rupture of different mixes incorporating various volume fractions of steel and polypropylene fibers.

A common concrete matrix was used in all mixes, with a water cement ratio of 0.40 and cement content of 400 kg/m3. Properties of the fibers are shown in Table 2. Volume fractions of fibers and obtained test results are presented in Tables 3 and 4 respectively.

In their work "Mechanical Properties of Hybrid Fiber Reinforced Concrete at Low Fiber Volume Fraction", Yao, Li, and Wu studied the effects of combined use of carbon, steel, and polypropylene fibers at relatively low volume fractions on the mechanical properties of concrete. Compressive strength, splitting tensile strength, and flexural tensile strength tests were conducted on various mixes.

Flexural toughness was also measured in accordance with ASTM C 1018. A common concrete matrix was used in all mixes. Properties of the fibers are presented in Table 5, fiber contents of mixes and obtained test results are presented in Table 6. Scope

Since fibers include steel fibers, glass fibers, synthetic fibers and natural fibers, but in this experimental study, only glass fibers and steel fibers are used with different percentages. Also Steel, Glass and their Manufacturing methods for steel and Glass fibers are explained. Effects of steel and Glass fiber inclusion on concrete in the hardened and fresh states are overviewed. Durability characteristics of steel fiber reinforced concrete (SFRC) and Glass fiber reinforced concrete (GFRC) are briefly mentioned. In addition to fibers, mineral admixture such as Fly Ash about 5% and 10% and silica fume 1% and 2% is also added. Definitions related to HSC are given and provided with a literature review on HSC. Mix design recommendations, mixing, placing, compaction, and finishing techniques and practical applications of SFRC and GFRC are summarized. Advantages and shortcomings of these test methods are discussed.

III. METHODOLOGY

1. Experimental Program

In this study, the aim is to determine the experimental studies on HIGH STRENGTH CONCRETE and then to characterize its properties, especially the mechanical properties in the hardened state. Two different types of fibers were used in combination. For this purpose eight mixes, one plain control mix and seven fiber reinforced mixes were prepared. In four of the fiber-reinforced mixes, Fly ash and silica fume as admixture were used.

The volume percentage of fibers was kept constant at 1.0% and 2.0% this value was chosen after a careful examination of available literature considering the capability of compaction equipment in the laboratory. Steel fibers constituted most of the total fiber content in a hybrid mix whereas the remaining part was composed of glass fibers in hybrid fiber reinforced mixes.

Slump test was performed for each mix in the fresh state. Compressive strength, Split tensile strength is carried out for each mix in the hardened state.

2. Materials

In this experiment, the materials used are as follows:

(i) Ordinary Portland cement.
(ii) Fine aggregates.
(iii) Coarse aggregates.
(iv) Water.
(v) Fibers.
(vi) Silica fume as admixture.
(vii) Fly ash as admixture.

Ordinary Portland cement

Cement is a hinder, a substance that sets and hardens as the cement dries and also reacts with carbon dioxide in the air dependently and can bind other materials together. portland cement is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450 °C in a kiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix.

Fine aggregates

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz.

Coarse aggregates

Coarse aggregate is that aggregate of which it consists of either crushed stone or gm. el. Gravel has several advantages over crushed stone, but crushed stone is commonly used because it is more economical. A crushed stone which is passed through 20mm and retained on 12 min sieve and 33% passing through 12 microns and retained On 10 microns sieve are taken and which possesses angular in structure and less flaky. The size of coarse aggregate has a bearing on the concrete's cost.

Fibers

Steel Fibers

The early theoretical studies, initiated by Romualdi, Batson, and Mandel, in the 1950's and 1960's focused mainly on the characteristics of steel fiber reinforced concrete (SFRC). Only straight steel fibers were used in the beginning. Though remarkable improvements in toughness and ductility were obtained, problems in mixing and workability were encountered. These problems were overcome with the advent of deformed steel fibers and high range water reducers. Today steel is the most commonly used fiber type for concrete reinforcement. with the exception of asbestos fibers.

Glass fibers

Glass fiber reinforced concrete consists of 4-4.5 per cent by volume of glass fibers. Basically concrete material utilizes glass fibers for the reinforcement, as a substitute of steel. The glass fibers are normally resistant to alkali. Alkali resistant glass fiber is used extensively since it has a greater resistant to the environmental effects. GFRC is a combination of cement, glass fibers, and polymers. It is normally cast in thin sections. As the fibers are not rusted like steel, protecting concrete coat is not necessary for the prevention of rust. The material characteristics will be influenced by the concrete reinforcement spacing, and the concrete reinforcement

MIX DESIGN

Mix design earn be defined as the process of selecting suitable ingredients of concrete and determining the relative proportions with the objective of producing concrete of certain minimum strength and durability as economically as possible. There are many methods available for mix design. Here Indian Standard method, based on IS 10262- 1902 is adopted.

Mix design for control cubes, for optimization of steel slag using zone I sand and for optimization using zone II and zone III combinations are carried out in this section.

Table 1. Mix design calculation for M30

Cement Kg/m^3	Fine Aggregates Kg/m^3	Coarse Aggregate kg/m^3	W/C ratio
428.21	496.67	1218.8	192.696
1	1.61	2.84	0.45

Table 2. Mix design calculation for M35

Cement Kg/m^3	Fine Aggregates Kg/m^3	Coarse Aggregate kg/m^3	W/C ratio
427.35	419.4	1319.85	170.94
1	0.98	3.26	0.40

Table 3. Mix design calculation for M40

Cement Kg/m^3	Fine Aggregates Kg/m^3	Coarse Aggregate kg/m^3	W/C ratio
466.2	398.373	1292.99	186.48
1	0.85	2.77	0.40

IV. RESULTS

Table 4. Compressive and Split tensile strength results for M30

S. no	Mix designation m30 (I: 1.16 :2.84)	Type of mix	Compressive strength (N/mm^2)	Split tensile strength (N/mm^2)
1.	M30 W/c=0.45	Ordinary	35.33	2.65
2.	M30 W/c=0.45	1% Glass fiber	36.5	2.75
		2% Glass fiber	37	2.8
3.	M30 W/c=0.45	1% Steel fiber	37	2.7
		2% Steel fiber	37.5	2.75
4.	M30 W/c=0.45	1% Silica fume	37	2.7
		2% Silica fume	38	2.79
5.	M30 W/c=0.45	5% Fly ash	37	2.7
		10% Fly ash	38	2.71

Table 5. Compressive and Split tensile strength results for M35

S. No	Mix designation m35	Type of mix	Compressive strength (n/mm^2)	Split tensile strength
1.	M35 W/c=0.40	Ordinary	37.5	2.7
2.	M35 W/c=0.40	1% Glass fiber	38	2.82
		2% Glass fiber	38.5	2.9
3.	M35 W/c=0.40	1% Steel fiber	38.5	2.9
		2% Steel fiber	39.5	2.8
4.	M35 W/c=0.40	1% Silica fume	37.5	2.72
		2% Silica fume	39.5	2.8
5.	M35 W/c=0.40	5% Fly ash	38	2.75
		10% Fly ash	39	2.78

Table 6. Compressive and Split tensile strength results for M40

S. No	Mix designation m40 (1: 0.85 : 2.77)	Type of mix	Compressive strength (n/mm²)	Split tensile strength (n/mm²)
1.	M40 W/c=0.40	Ordinary	43.22	2.8
2.	M40 W/c=0.40	1% Glass fiber	44	2.9
		2% Glass fiber	44.5	2.95
3.	M40 W/c=0.40	1% Steel fiber	44.3	2.8
		2% Steel fiber	45	2.9
4.	M40 W/c=0.40	1% Silica fume	44.5	2.75
		2% Silica fume	46	2.92
5.	M40 W/c=0.40	5% Fly ash	45	2.82
		10% Fly ash	46	2.85

Table 7. Testing (Conventional Concrete):

Grades	Compressive Strength (N/mm²)	Split Tensile Strength (N/mm²)
M30	35.33	2.95
M35	43.22	2.8
M40	49.42	2.8

V. CONCLUSION

On observing the experimental investigations conducted on the carted cubes and cylinders, the usage of fibers and admixtures with conventional concrete have given predominant outputs in physical and mechanical properties of concrete. Since the steel fibers and glass fibers are of high elastic modulii. The following conclusions were drawn as follows,

1. Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M30 showed a maximum increase in compressive strength to 5.78%
2. Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M30 showed a maximum increase in compressive strength to 4.5%.
3. Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M35 showed a maximum increase in compressive strength to 3.85
4. Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M35 showed a maximum increase in compressive strength to 5.59%.
5. Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M40 showed a maximum increase in compressive strength to 5.05%.
6. Concrete with 1% & 2% glass fiber, steel fiber, silica fume and 5% & 10 % fly ash when compared with the conventional concrete of grade M40 showed a maximum increase in compressive strength to 4.27%.

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