Investigation on Mechanical Properties of M-30 and M-90 Grade of Concrete and it's Effects

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Abstract - *High strength concrete (HSC) has been widely used in civil engineering in recent years. This is because most of the rheological, mechanical and durability properties of these materials are better than those of conventional concrete. High strength is made possible by reducing porosity, inhomogeneity and micro cracks in concrete and the transitionzone. This is achieved by using superplasticizers and supplementary cementing materials such as silica fume/ micro silica. Fortunately, micro silica is an industrial by-product and help in reducing the amount of cement required to make concrete less costly, more environmentally friendly and less energy intensive. HSC offers many advantages over standard concrete (SC). Its high compressive strength is advantageous and used in compression members like columns and piles. Higher compressive strength of concrete, results reduction in column size and increases availablefloor space. HSC can also be effectively used in structures such as domes, folded plates, shells and arches where large in-plane compressive stresses exist. The relatively higher compressive strength per unit volume, per unit weight will also reduce the overall dead load on foundation of a structure with HSC. In pre-stressed concrete construction, a greater span to depth ratio for beams may be achieved with the use of high strength concrete. In marine structures, the low permeability characteristics of high strength concrete reduce the risk of corrosion of steel reinforcement and improve the durability of concrete structures. In addition, high strength concrete can perform much better in extreme and adverse climatic conditions and can reduce maintenance and repair costs. The production of HSC may or may not require the special materials, but it definitely requires materials of highest quality and their optimum proportions. In the production of HSC, use of strong, sound and clean aggregates is essential. The reduction of the capillary pores in the matrix and improving the bond strength between cement matrix andaggregate is essential. These can be accomplished by using low water-cement ratio and incorporating ultra-fine particles (particles much smaller than the grains of cement, such as silica fume) in the concrete mix. Finally, high strength concrete having strength greater than 100 MPa is achieved using micro silica and superplasticizer. Utilization of standard and high strength concrete has increased enormously.*

Key Words: M30, M90, Compression test, Split tensile test, Flexural strength test.

1.INTRODUCTION

Concrete has a highly heterogeneous and complex microstructure. Therefore, it is very difficult to design realistic models to predict the behaviour of the constituent materials in concrete. However, knowledge of the microstructure and properties of the individual components of concrete and their relationship to each other is useful for exercisingcontrol on the properties. Concrete microstructure consists of two major components namely aggregate and hydrated cement paste. The interfacial transition zone between the two components is generally the weakest part which may fail during the application of load. Hence, it is necessary to study the mechanical behaviour of concrete which in turnis influenced by the three phases of it. Each of the three phases (namely aggregate, cement paste and interfacial transition zone) is itself a multiphase in character. The major components and the interfacial transition zone may contain several micro cracks and voids which greatly affect the strength of concrete. Therefore, it is difficult to generate the theoretical relationship models between the aggregate, matrix and the interfacial transition zone for predicting the behaviour of materials due to heterogeneous distribution of cracks. In solids, there is an inverse relationship between porosity and strength. In multiphase material like concrete, the porosity of each component of the microstructure is one of the factors which affect the strength. Natural aggregates are generally dense and strong. Therefore, the porosity of the cement paste matrix as well as the interfacial transition zone between the matrix and coarse aggregate determines the strength of normal concrete.

1.1 Factors affecting the strength

Concrete strength is affected by many factors which include properties and proportions ofmaterials that make up the design mix, degree of compaction and heat of hydration. The water-cement ratio and porosity are important factors as they affect the fluidity between the matrix and the interfacial transition zone. Direct determination of porosity of the individual components of concrete is impractical and therefore precise models of predicting concrete strength cannot be developed. However, over a period of time many empirical relations have been found, which provide indirect information about the influence of numerous factors on compressive strength. Strength of concrete due to its complex structure is dependent on various factors: (1) characteristics and proportions of materials (2) curing conditions and (3) testing parameters. The selection of materials and their proportions is the first step toward obtaining aproduct that would meet the specified strength. Many design parameters are inter- dependent and therefore their influences should be studied.

1.2 Water cement ratio (w/c)

The water cement ratio in concrete is one of the key factors for weakening of the matrix caused by increasing porosity. As the water content increases, there is an increase in porosity of the matrix as well as interfacial transition zone which reduces the strength of concrete. But in case of low strength concrete, strength is not much influenced by the water cement ratio. The porosity in the matrix and the interfacial transition zone determines the strength in low grades of concrete

2. EXPERIMENTAL PROGRAM

The experimental program has been carried out in three phases. First phase is related to the evaluation of properties of materials used in concrete, mix design of M 30 and M 90 grades of concrete, specimen shape and size effect on M 90 grade concrete. In second phase, thermal stability of standard concrete (M 30) and high strength concrete (M 90) at ambient temperature and at elevated temperatures up to 400°C has been carried out using thermogravimetric analysis. The study of the effect on compressive strength, split tensile strength and flexural strength.

2.1 Material has taken and properties

- ✓ Cement
- ✓ Fine aggregate
- ✓ Coarse aggregate
- ✓ Water
- ✓ Micro Silica
- ✓ Superplasticizer

2.2 Standards for experimental work

- ✓ Mix proportions of standard concrete (M 30) are based on guidelines of IS: 10262-2009.
- ✓ For high strength concrete (M 90), mix proportions are achieved using ACI 211.4R-2008.

Table -1: Physical and chemical properties of cement

S.No	Particulars	Test Results	Requirements as per IS: 12269-1987
	Chemical properties	------	-------
1	Insoluble material (% by mass)	0.68	28.96 Maximum
2	Magnesia (% by mass)	1.16	6.00 Maximum
3	Sulphuric anhydride (% by mass)	1.73	3.00 Maximum
4	Loss on ignition (% by mass)	1.15	5.00 Maximum
5	Total chlorides (% by mass)	0.006	0.10 Maximum
	Physical properties	------	--------
1	Fineness as weight retained on IS 90 micron sieve	5.50%	10% Maximum
2	Standard consistency (%)	30	--------
3	Setting time	-------	--------
	a) Initial (minutes)	125	30 Minimum
	b) Final (minutes)	225	600 Maximum
4	Soundness	------	--------
	a) Le-chatelier method(mm)	--------	--------
	b) Autoclave method (%)	1	10.0 Maximum
	----------------	0.026	0.8 Maximum
5	Compressive strength (MPa) at 3 days	--------	----------
	at 7 days	39.61	27 Minimum
	at 28 days	50.05	37 Minimum
	-----------------	63.6	53 Minimum

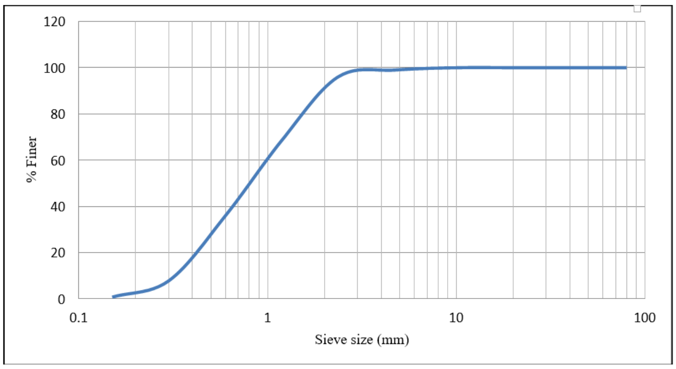

Chart -1: Grading system for FA (Fine aggregate)

2.3 Design consideration

Type of cement: OPC 53 grade
Minimum cement content: 320 kg/m³
Exposure condition: severe
Type of aggregate: crushed angular aggregate

Specific gravity of cement	= 3.11
Specific gravity of fine aggregate	= 2.65
Specific gravity of coarse aggregate	= 2.78
Fineness modulus of fine aggregate	= 2.92
Fineness modulus of coarse aggregate	= 7.38
Dry rodded density of coarse aggregate	= 1700 kg/m³

Table -2: Study of mix proportions

S.No.	Ingredient	Standard concrete M 30	High strength concrete M 90
1	Cement (OPC 53 grade)	370 kg/m³	594 kg/m³
2	Micro silica (10% of cementitious material)	Nil	66 kg/m³
3	Fine aggregate	740 kg/m³	650 kg/m³
4	Coarse aggregate	1214 kg/m³	1105 kg/m³
5	Water	165 *l*/m³	145 *l*/m³
6	Superplastcizer	Nil	0.8% by weight of cementitious material
7	Workability	45 mm slump	0.85 compaction factor

3. INVESTIGATION FOR CASTING AND CURING

Based on the design mix proportions, cubes, cylinders and prisms of concrete are cast andtested in order to investigate compressive strength, split tensile strength and flexural strength for standard concrete (M 30) as well as high strength concrete (M 90) subjected to thermal cycles after cured for 28 days. Each thermal cycle consists of heating of the specimens for 8 hours and subsequent cooling for the remaining period in a day. In the present chapter, experimental set up and testing methods for compressive strength, split tensile strength and flexural strength are mentioned.

Grade of concrete: Standard concrete (M 30) and high strength concrete (M 90)

Temperature: 27, 100, 200, 300 and 400°C

Number of thermal cycles: 1, 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50

Parameters: compressive strength, split tensile strength, flexural strength and weight loss

3.1 Casting and curing for concrete specimens

The sequence of feeding ingredients in the pan mixer depends on the properties of mix and those of mixer. In this work, a small amount of water is fed first in pan mixer as shown in fig-1, followed by coarse aggregate in saturated surface dry condition and fine aggregate. These materials are mixed uniformly and then cementitious material is fedinto the mixer. After attaining uniform mixture of all ingredients, water is added.

Fig-1: Pan mixer used for mixing

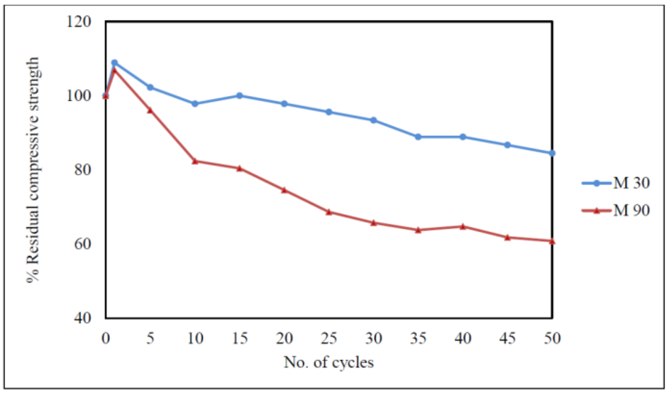

Chart -2: Compressive strength for M30 and M90

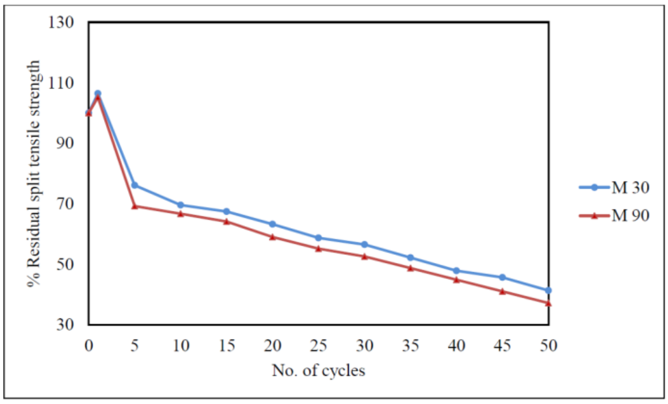

Chart -3: Split tensile strength for M30 and M90

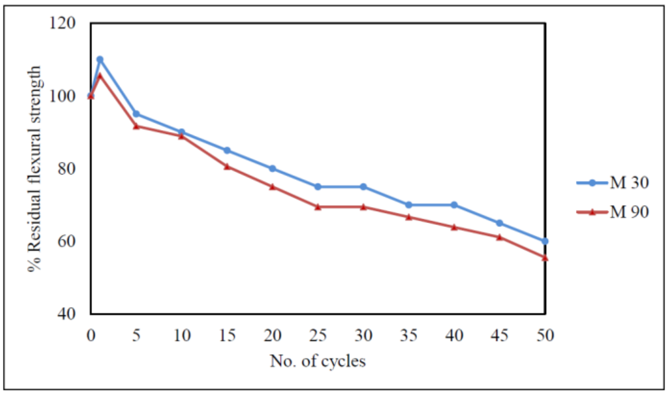

Chart -4: Flexural strength for M30 and M90

4.CONCLUSIONS

1. The cycles have more adverse effect on compressive strength of HSC than SC.
2. At high temperature, the first thermal cycle causes bulk loss in strength. SC loses 2.22, 4.44 and 11.12% at 200, 300 and 400°C respectively after first thermalcycle.
3. But 23.53, 26.47 and 30.39% losses in strength are exhibited by HSC specimens.
4. When concrete is heated to 200°C, SC retained 82.22% of its initial compressive strength whereas HSC retained only 58.82% .
5. At 300°C and after 50 thermal cycles, the residual flexural strength of SC is 50% but HSC retained 47.22% of its original strength.
6. As the number of thermal cycles increased, the residual split tensile strength decreased for both grades of concrete except at first thermal cycle.

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