Mix Design for High Strength Concrete for Building Construction

Nishant Kumar Sah[1], Mukesh Sah[2]

[1,2]Dept. of Civil, CBS Group of Inst., Jhajjar

ABSTRACT

In designing concrete mix, the most widely used and most popular methods are the ACI method and BS method. This research paper depicts the result of mix design for high strength concrete. This research involves the procedure of finding out experimentally the most suitable mix in order to obtained desired compressive strength. In this research work 53 grade OPC, smooth textured and round shaped sand, 12mm coarse aggregate were taken to decide the proportion of high strength concrete of grade M60. Each mix two 150 x 300 mm cylinders were cast after checking the slump of the concrete. The specimens demoulded after 24 hours and kept curing for 28 days.

INTRODUCTION

Concrete is a material that literally forms the basis of our modern history. It is by far the most widely used construction material today. Concrete-both 'good' and 'bad', surprisingly are made of the same ingredients. Bad concrete, often a substance of unsuitable consistence, hardening into a honeycombed, no homogeneous and weak mass, is made simply by mixing cement, aggregate and water, the same as that of good concrete. Here comes the necessity of proper proportioning of the constituents of concrete, which is otherwise known as Concrete Mix Design. This is done, incorporating the knowledge of the properties of the constituent materials, in the process of choosing a suitable proportion that will allow for.

- Sufficient workability of fresh concrete, for convenient transportation, placement and compaction.
- Sufficient strength and durability of hardened concrete that will enable it to withstand the load imposed on it throughout its design life, without much distortion.

Thus, the primary concern in attaining the desired strength, from the designers' viewpoint, although high-strength concrete is often considered a relatively new material, its development has been gradual over many years. As the development has continued, the definition of high-strength concrete has changed. Objective of research are following:

- To study the ACI methods of mix designs, having considered all the parameters and material properties involved.
- To study the applicability of the ACI method of mix design to broken brick aggregates, in terms of the ability of this method to suggest a rational and suitable mix proportion of cement, fine aggregate and coarse aggregate.
- To study the attainment of the design strength of concrete specimen cast with the mix proportions derived using ACI method employing brick aggregate.
- To check the findings of the past studies regarding the failure of the ACI method in rational proportioning of fine aggregates where coarse aggregate of lower unit weight is used

LITERATURE REVIEW

Okamuraet.al, proposed a mix design method for SCC based on paste and mortar studies for super plasticizer compatibility followed by trail mixes. However, it is emphasized that the need to test the final product for passing ability, filling ability, and flow and segregation resistance is more relevant.

Kosmatka, S. H., B. Kirchhoff, et al. reported that concrete made with higher w/cm shows a higher permeability index for the same duration of curing and the same curing temperature. A wetter sample will have lower air permeability due to the water blocking the pores of the concrete and increases the time for the passage of air. A permeable concrete is more susceptible to ion penetration (which can lead to corrosion of Metals usually steel reinforcement) to stresses that are induced by the expansion of water as it freezes, and to chemical attack (leaching, efflorescence, sulphate attack). If properly cured, most concretes become significantly less permeable with time. Therefore, it is important to specify the age at which the permeability is measured. There is no universally accepted standard test method for measuring the permeation properties of concrete. Permeation procedures may be categorized by their respective transport mechanisms as given below. Water absorption, Water permeability (flow), Ionic flow (Rapid Chloride Permeability Test).

Tiwari and Momin et.al, presented a research study carried out to improve the early age compressive strength of Portland slag cement (PSC) with the help of silica fume. Silica fume from three sources- one imported and two indigenous were used in various proportions to study their effect on various properties of PSC.

Beam - column joints have been recognized as critical elements in the seismic design of reinforced concrete frames (ACI 1999, AIJ 1990, Euro Code 1994, SNZ 1995). Numerous studies were conducted in the past to study the behaviour of beam-column joints with normal concrete (Shamim and Kumar 1999, Gefken and Ramey 1989, Filiatrault et al 1994). ACI- ASCE committee 352 (2002) makes recommendation on the design aspects of different types of beam-column joints, calculation of shear strength, and on reinforcement details to be provided (ACI 2002). These recommendations are however not intended for fibre reinforced concrete.

Jiuru et al (1992) studied effect of fibres on the beam column joints and developed equation for predicting shear strength of joints for normal strength concrete. Bayasi and Gevman (2002) also experimentally proved the confinement effects of fibres in the joints reason and reduction in the lateral reinforcement by the use of fibre concrete. Besides these, there are several investigations on the effect of addition of fibres on the strength and durability of flexural members. Oh (1992) also indicated that the ductility and ultimate resistance of flexural members are increased remarkably due to the addition of steel fibres. ACI committee 544(1998) also reported considerable improvement in strength, ductility and energy absorption capacity with an addition of steel fibres. All these studies are, however, confined to normal strength concrete and the research in the area of High Performance Lightweight Fibrous Concrete joints is limited.

Yung Chih Wang (2007) studied reinforced concrete beam column junctions strengthened with Ultra high steel Fibre reinforced Concrete (UFC). It was concluded that UFC displayed excellent performance in terms of mechanical and durability behaviour. The test results showed that UFC replaced joint frame behaves very well in seismic resistance. The performance was found to be much better than the frame strengthened with RC jacketing as normally seen in the traditional retrofit schemes.

Bilodeau et al. measured water and chloride permeability of concretes having 55 to 60 % cement replacement with various sources of fly ash. They reported coefficient of water permeability of fly ash concretes in the range of 1.6 x 10-14 to 5.7 x 10-13 m/s. The values of chloride permeability (less than 650 coulombs at 91 days) observed in this investigation for fly ash concretes were comparable to that for silica fume concrete.

Hooton et.al, investigated on influence of silica fume replacement of cement on physical properties and resistance to sulphate attack, freezing and thawing, and alkali-silica reactivity. He reported that the maximum 28-day compressive strength was obtained at 15% silica fume replacement level at a w/b ratio of 0.35 with variable dosages of HRWRA.

Vengala et.a1, found that use of fine fly ash for obtaining Self Compacting Concrete resulted in an increase of the 28 day Compressive Strength Concrete by about 38%. Self Compacting Concrete was achieved when volume of paste was between 0.43 and 0.45.Subramanian and Chattopadhyay et.al, described the results of trails carried out to arrive at an approximate mix proportioning of Self Compacting Concrete. Self Compatibility was achieved for Water to

Powder ratio ranging from 0.9 to 1.1 when Coarse Aggregate and Sand content were restricted to 46 % and 40% of the mortar volume respectively.

Dr.Srinivasa Rao. Prasad et.al., had proposed the relationship between Splitting Tensile Strength and Compressive Strength by the test results and found that Split Tensile Strength is proportional to 0.78 power of Compressive Strength for normal concrete. Dr.Malathy et.al, had developed the mix design for different grades of concretes and studied the flow properties and strength properties for Self compacting Concrete.

Prasad et al. has undertaken an investigation to study the effect of cement replacement with micro silica in the production of High strength concrete. Yogendra et.al investigated on silica fume in High-strength concrete at a constant water-binder ratio (w/b) of 0.34 and replacement percentages of 0 to 25, with varying dosages of HRWRA.

The maximum 28-day compressive strength was obtained at 15% replacement level.

Lewis presented a broad overview on the production of micro silica, effects of standardization of micro silica concrete-both in the fresh and hardened state. Bhanja and Gupta et.al, reported and directed towards developing a better understanding of the isolated contributions of silica fume concrete and determining its optimum content. Their study intended to determine the contribution of silica fume on concrete over a wide range of w/c ratio ranging from 0.26 to 0.42 and cement replacement percentages from 0 to 30.

Bakir (2003) conducted extensive research on parameters that influence the behaviour of cyclically loaded joints and has derived equations for calculating shear strength of the joints. A study conducted on fibre reinforced normal strength concrete by Filiatrault et al (1994) indicated that this material can be an alternative to the confining reinforcement in the joint region. The study conducted by Gefkon & Ramey (1989) illustrated that the joint hoop spacing specified by ACI-ASCE committee can be increased by a factor of 1.7 by the addition of fibres in the concrete mix.

EXPERIMENTAL WORK

In order to attain the objectives of this research, following activities were undertaken –

- A through survey of the related literatures was carried out. The properties of the constituent materials of concrete, methods of investigation of materials, methods of proportioning of concrete mixes and properties of hardened concrete were covered.
- Investigations of the materials were done and relevant material characteristics were evaluated.
- Mix designs have been performed using broken brick chips as coarse aggregate and smooth textured Sand as fine aggregate for one batch and 12mm coarse aggregate and round shaped Sand as fine aggregate for the other batch. Both batches were prepared according to the ACI method of Mix Design.
- Casting of Concrete was done according to the mix design results achieved in accordance with the ACI method.

The activities requiring laboratory work conformed to specifications stated by relevant regulatory agencies. Ordinary Portland cement of 53 grade as per IS 12269- 1987 is used in the investigation. The 12mm and well graded coarse aggregate is used. The specific gravity is 2.74. Fine aggregates with a rounded particle shape and smooth texture have been found to require less mixing water in concrete and for this reason are preferable in High strength concrete. High strength concrete typically contains such high contents of fine cementations' materials that the grading of the Fine aggregate used is relatively unimportant. However, it is sometimes helpful to increase the fineness modulus as the lower Fineness modulus of fine aggregate can give the concrete a sticky consistency (i.e. making concrete difficult to compact) and less workable fresh concrete with a greater water demand.

Totally three mix were designed in this research. Each mix two 150 x 300 mm cylinders were cast after checking the slump of the concrete. The specimens demoulded after 24 hours and kept curing for 28 days.

RESULT AND DISCUSSION

Specimens were tested to determine the characteristic compressive strength of high strength concrete. The cylinders were loaded in a 200T compression testing machine at the rate of 0.3 N/mm2/s until failure.

Age(days)	Specimen No.	Surface Area(Sq.Inch)	Load (Tons)	Compressive Strength(PSI)	Average Compressive Strength (PSI)
7	Cylinder 1	28.82	32	2160	2200
	Cylinder 2	28.87	33	2220	
	Cylinder 3	29.04	33	2210	
14	Cylinder 1	29.04	45	3035	3090
	Cylinder 2	29	45	3042	
	Cylinder 3	29.02	46	3170	
28	Cylinder 1	28.6	47	3230	3225
	Cylinder 2	28.95	47	3180	
	Cylinder 3	28.98	48	3255	

CONCLUSIONS

In this research high strength concrete mix is designed and tested for compressive strength. The conclusions are following:

1. With increase in content of cement, strength of concrete also increases.
2. As the silica fume content increases the compressive strength increases up to 15% [HPC4] and then decreases. Hence the optimum replacement is 15%.
3. The 7 days and 28 days cube compressive strength ratio of HPC is 0.84 to 0.9
4. The percentage replacement of cement by silica fume increases, the workability decreases.

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