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Analysis on High Performance Concrete

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Abstract

High performance concrete is a concrete designed to have enhanced performance compared to conventional concrete. High Performance Concrete(HPC) is a typeof high strength concrete which is based on the durability characteristics.HPC is used for concrete mixtures which possess high modulus of elasticity, high strength, high workability, high dimensional stability, low permeability and resistance to chemical attack. Reduction of w/c ratio will result in high strength concrete. The concrete mix is designed based on the principle that the concrete should be leveled and can be compacted without segregation or bleeding. The ingredients for HPC are similar to other plasticized concrete. It consists of cement, coarse and fine aggregate,water,mineral and chemical admixtures. The properties of high performance concrete – Grade M70 is determined by using experimental methods. The experimental results obtained shows the HPC will be accepted and adopted in our country to enhance the durability of concrete structures. HPC can provide a clear economic benefit to the construction industry.

Keywords: M70 concrete, concrete mix design, compressive strength of concrete, chemical admixtures.

INTRODUCTION

High performance concrete is a concrete designed to exceed the performance of ordinary concrete.The HPC is achieved using an optimized concrete technology,extremely low water to cement ratio – ratio and the addition of silica fume. In HPC, reinforcement can be minimized. This type of concrete is mainly used for columns, walls within high-rise buildings,as an alternative to steel structures. The features of high performance concrete include wide range of grain size, high compressive strength (60 MPa to 800 MPa), optimal water-binder ratio with very little free water, reduced flocculation of cement grains, no bleeding homogenous mix, less capillary porosity, discontinuous pores, stronger transition zones at the interface between cement paste and aggregate, low free lime content, endogenous shrinkage, powerful confinement of aggregate, little micro-cracking until about 65-70% of characteristic strength of the concrete and smooth fracture surface. Table 1 shows the primary contribution of the material in the concrete.

Table 1 Primary contribution of the Concrete materials

Material	**Primary contribution/ Desired property**
Portland cement	Cementing material / Durability
Blended cement	Cementing material/ Durability/High strength
Fly ash/ Silica fume/Slag	Cementing material/ Durability/High strength
Calcined clay/ Metakaolin	Cementing material/ Durability/High strength
Super plasticizers	Flowability
High range water reduces	Reduce water – cement ratio
Hydration controls admix	Control setting

The following are the advantages of HPC:

1. Reduction in member size,resulting in increase in plinth area/useable area and direct savings in the concrete volume saved.
2. Reduction in self-weight and super imposed DL with the accompanying saving due to smaller foundations.
3. Reduction in form-work area and cost with the accompanying reduction in shoring and stripping time due to high early-age gain in strength.
4. Construction of high-rise buildings with the accompanying savings in realestate costs in congested areas.
5. Longer spans and fewer beams for the same magnitude of loading.
6. Reduced axial shortening of compression supporting members.
7. Reduction in the number of supports and the supporting foundations due to the increase in spans.
8. Reduction in the thickness of floor slabs and supporting beam sections which are a major component of the weight and cost of the majority of structures.
9. Superior long term service performance under static,dynamic and fatigue loading.
10. Low creep and shrinkage

Prabir Basu(2003) stated that durability is affected by different physical and chemical factors. Permeability and early age cracking play important role and its control is most essential for improved durability. Use of mineral admixtures leads to reduction in alkalinity in concrete. Even then, HPC is durable due to low permeability. HPC appears to be vulnerable to high temperature. A holistic approach to durability must place equal emphasis on the structural design, selection of material, mixture proportions etc.

Vinayagam (2012) stated that the optimum percentage of cement replacement by Silica fume is 10% for achieving maximum compressive, split tensile and flexural strength and elastic modulus.The 7 days to 28 days compressive strength ratio of HPC is 0.75 – 0.80. Use of silica fume in concrete reduces the workability. The compression failure pattern of concrete is due to crushing of coarse aggregate and not due to Bond failure.

Vijayasekhar Reddy(2012) stated that high performance concrete is a complex system of materials that perform most effectively when placed in severely aggressive environments. In HPC mix design as water – cement ratio adopted is low, super plasticizers are necessary to maintain requited workability. As the percentage of mineral admixtures is increased in the mix the percentage of superplasticizers should also be increased, for through mixing and for obtaining the desired strength. In M70 Grade concrete the Water – Cement ratio of 0.317 was sufficient to provide the good workability hence superplasticizer was necessary for M70 Mix.

Faseyemi Victor(2012) attempted to reduce the amount and cost of building materials, because particularly the cost of cement is currently so high that only rich people and governments can afford meaningful construction. Studies have been carried out to investigate the possibility of utilizing a broad range of materials as partial replacement materials for cement in the production of concrete. This study investigated the strength properties of Silica fume concrete. Cement replacement up to 10% with silica fumeleads to increase in compressive strength, for C30 grade of concrete. From 15% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period. The maximum replacement level of silica fume is 10% for C30 grade of concrete. Both the physical and chemical properties of microsilica and cement are in compliance with thestandard except SO_3 analyzed from cement.

Materials and Methods

The mix proportion for M70 grade of concrete was found to be compatible with the required properties and hence it was selected and designed. The super plasticizers used in the present study are Varaplast PC 100 and Varaplast PC 354 which are Naphthalene formaldehyde based.

Specific gravity of cement is found with the help of le-chaliter flask and is found to be 3.15.Fineness of cement has an important bearing on the rate of hydration and is found with the help of Blaine's permeability and is found to be 290 m^2/kg.

Initial setting time is the time elapsed between the moment that the water is added to the cement to the time that the paste with 0.85 times the water of the consistency value. Introducing the paste in to the vicat mould, the needle is lowered until it penetrated a depth equal to 5 to 7mm from bottom. The Initial setting Time of Cement = 120 min

The specific gravity andwater absorption percentage of 20 mm coarse aggregate are determined as 2.76 and 0.46 % respectively, as detailed in Table 2.

Table 2 Specific gravity of 20 mm coarse aggregate

S. No	Details	Weights (Grams)
1	Weight of the saturated aggregate in water + Wire basket weight in water (A_1)	4658.0
2	Weight of the wire basket in water (A_2)	1460.0
3	Weight of the saturated aggregate in water : A= (A1-A2)	3198.0
4	Weight of the saturated surface-dry aggregate in air (B)	5000.0
5	Weight of oven-dried aggregate in air (C)	4977.0
Specific gravity (C/(B-A))		2.76
Water absorption ((B-C)/C)*100		0.46%

By similar procedure, the specific gravity and water absorption percentage of 10 mm coarse aggregate and river sand are found to be 2.71 and 0.88 %, 2.63 and 1.11 % respectively.The properties of the mix design for M70 grade concrete is shown in Table 3.

Table 3 Mix Design For M70 Grade

a.	Cement - OPC 53G	=	430 kg/m^3
b.	Fly ash	=	45 kg/m^3
c.	Water	=	152 kg/m^3
d.	Fine aggregate	=	733 kg / m^3
e.	Coarse aggregate		
	1) 20MM	=	553 kg/m^3
	2)10MM	=	553 kg/m^3
f.	Admixture 1 - PCE	=	2.85 kg/m^3
g.	Admixture 2 – PCE	=	1.90 kg/m^3
h.	Water cement - ratio	=	0.32

Results and Discussion

Concrete with cement to fine aggregate to coarse aggregate ratio of 1 : 1.54 : 2.33 is made and tested. Two specimens of 15 cm and 10 cm diameter are used for testing. Fig. 1 shows the results of the average compressive strength values.

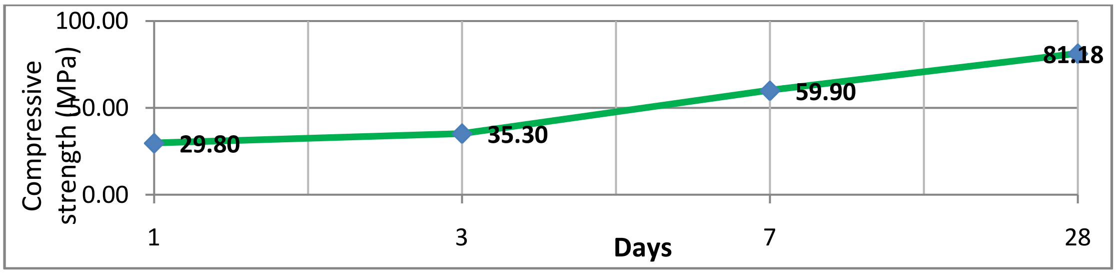

Fig. 1 Compressive strength of concrete

Table 4 shows the flexural strength test details for the 28 days old concrete. The split tensile strength details are summarised in Table 5.

Table 4 Flexural strength of 28 days concrete

S.No	Age	Weight Kg	Load KN	Flexural strength MPa	Average stress MPa
1	28 days	12.6	17.89	7.16	7.11
		12.4	17.76	7.10	
		12.3	17.66	7.06	

Table 5 Split tensile strength results

S.No	Age	Weight Kg	Load KN	Split Tensile strength MPa	Average MPa
1	28 days	12.72	294	4.16	4.12
		12.74	290	4.10	
		12.75	289	4.09	

The water absorption result for 28 days concrete is found to be 2.91 %. The results of the Rapid Chloride Penetration Test (RCPT) is summarised in the Table 6.

Table 6 RCP Test

Charge passed (in coloumbs)	Chloride Permeability as per ASTM C1202
>4000	High
2000 – 4000	Moderate
1000 – 2000	Low
100 – 1000	Very low
<100	Negligible

The water permeability test(WPT) is presented in Table 7.

Table 7 Water permeability result

S.No	Age of test	Weight kg	Water Penetration mm	Average
1	28 days	8.45	0	2 mm
2		8.36	2	
3		8.42	4	

The behavior of hardened concrete can be characterized in terms of its short-termand long-term properties. Short-term properties include strength in compression, tension and bond, and modulus of elasticity. The long-term properties include durability characteristics such as porosity and permeability.The properties of high performance concrete are tabulated below :

Table 8Properties of High performance concrete

S.no	Description	Results	Limitations
1	Compressive strength a) 1 day b) 3 days c) 7 days a) 28 days	 29.8 MPa 35.3 MPa 59.9 MPa 81.2 MPa	70-140 MPa @ 28 to 91 days
2	Flexural strength	7.11 MPa	Max. 7 MPa
3	Split Tensile strength	4.12MPa	---
4	Water Absorption	2.91%	Max. 5%
5	RCPT	165 coulombs	Less than 1000 coulombs
6	WPT	2 mm	0 to 10 mm

The properties of the present high performance concrete is found to be superior to the conventional concrete in the terms of strength and durability.

CONCLUSION

High performance concrete appears to be better choice for a durable structure. In high performance concrete mix design as water/cement ratio adopted is low, superplasticizers are necessary to maintain required workability. Fresh concrete containing is more cohesive and less prone to segregation.Better performance of HPC is primarily due to a considerable improvement in the microstructure of concrete composites, especially at the transition zone. Mineral admixture such as fumed silica is an ideal constituent' for high performance concrete as it has the inherent ability to contribute to continued strength development through their pozzolanic / cementations reactivity and to enhance durability and reduced absorptivity characteristics.It is known that conventional concrete designed on the basis of compressive strength does not meet many functional requirements such as durability, impermeability, resistance to frost, thermal cracking adequately. But High performance concrete (HPC) successfully meets durability in severe environments and energy absorption capacity in earthquake-resistant structures.

REFERENCES

[1] Faseyemi Victor.A. (2012), “Global Journal of Research in Civil Engineering and Structural Engineering”, Volume No. 12, Issue No 1, Version 1.0, January, pp. 1-5.

[2] Hand Book on Concrete Mixes, SP.23: 1982, BIS, New Delhi.

[3] Indian Standard: Plain and Reinforced Concrete – Code of practice IS 456:2000 4th revision, Bureau of Indian Standards, New Delhi, India.

[4] IS 10262-1982 : Recommended guidelines for concrete “Mix Design” BIS New Delhi.

[5] IS 516-1959 : Recommended guidelines for Method of Test for Strength of Concrete.

[6] Shetty, M.S. (2005), Concrete Technology Theory, Published by S. Chand and Company Ltd., New Delhi.

[7] Prabir Basu.C. (2003), Recent Trends in Concrete Technology and Structures, Interline Pubilishing, Bangalore, pp. 13 - 29

[8] Ramana Reddy.I.V., (2012) "ARPN Journal of Science and Technology", Volume No. 3, January. pp.1-5.

[9] Vinayagam.P. (2012), International Journal of computer and Communication Engineering, Vol. 1, No. 2, July, pp. 168 – 171.

[10] Vijayasekhar Reddy (2012), International Journal of Advanced Research in Engineering and Technologhy (IJARET), Volume no. 4, Issue 1, January – February, pp. 96 - 104.