JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

STUDIES ON ELASTIC PROPERTIES OF HIGH-PERFORMANCE CONCRETE

Ravi B Hosamani,
Head of department,
Civil Engineering department,
Government polytechnic, Rabakavi- Banahatti, India

Abstract : This paper discussed and investigated the elastic properties of High-Performance Concrete including compressive strength, modulus of elasticity and Poisson's ratio and compared those with normal strength concrete. The stress-strain behavior under uniaxial compression of HPC was also observed. The HPC of grade M60, M80 and M100 and NSC of grade M40 were considered for the study. Results have been shown that the compressive strength of HPC is most spectacularly improved and Cylinder compressive strength is 0.9 times of cube compressive strength. The Modulus of Elasticity is also increased and is observed from the steeper slope of ascending part of stress-strain curve. The values of modulus of elasticity obtain are in the range of 39, 44 and 53 Mpa for grade of 60, 80 and 100 respectively. Poisson's ratio of HPC is found to be lower than that of NSC, which means HPC experiences less lateral deformation than NSC when it is subjected to the same level of loading.

Keywords - *High Performance Concrete, Elastic properties, Poisson's Ratio, Elastic modulus, Compressive strength, stress-strain curves***.**

1. INTRODUCTION

Concrete is an extraordinary and key structural material in the human history. As written by Brunauer and Copeland in 1964, "Man consumes no material except water in such tremendous quantities". It is well known that the development of modern concrete industry also launch many environmental problems such as pollution, waste dumping, emission of dangerous gases, depletion of natural resources etc. the minimization of cement content and use of binder material in the preparation of concrete is very much essential in now a days. So, development of use of sustainable material emerges in the construction industry.

Sustainability is defined as "development that meets the needs of the present without compromising the ability of future generation to meet their own needs". The prediction for the 21st century concrete construction, Swamy stated "bearing in mind the technical advantages of incorporating pulverized fuel ash (PFA), slag, silica fume and other industrial pozzulanic by products in concrete and the fact that concrete with these materials provides the best economic and technological solution to waste handling along with the sustainable materials". The recent advancement in concrete technology and the availability of various types of chemical admixture and very powerful admixtures, concrete with a compressive strength of up to 100 Mpa can now be produced commercially with the use of ordinary aggregate. This leads to the evolution of HPC in construction industry.

ACI defines the HPC as concrete which meets special performance and uniformity requirements that cannot be always be achieved routinely by using only conventional materials and normal mixing, placing and curing practices. With this interest, the study on elastic properties of HPC was investigated. The main objective of the study is to cram the elastic properties of HPC with 60, 80 and 100 MPa and to compare these with NSC. The elastic properties include compressive strength, Elastic modulus and Poisson's Ratio.

2. EXPERIMENTAL PROGRAM

An experimental investigation has been conducted on elastic properties of HPC. The HPC with 60, 80 and 100 Mpa strength and NSC of 40 Mpa were considered for the study. The standard tests were on cubes and cylinders to investigate the elastic properties such as compressive strength, modulus of elasticity and Poisson's ratio

3. TEST SPECIMENS

The compressive strength of cube specimen as well as cylindrical specimen was studied. The cube specimens of size 150 mm x 150 mm x 150 mm and cylindrical specimens of size 150 mm in diameter and 300 mm in height were used. For each grade of concrete, five cylinders specimens were cast and tested to generate the relation of elastic properties.

4. DETAILS OF MATERIALS

Ordinary Portland Cement confirming to IS-8112 [Indian Standards (IS) 2003], crushed coarse aggregate, fine aggregate confirming to IS- 10262 (IS 2009), fly ash of fineness of 230-600 m^2/kg and specific gravity of 2.06, silica fume of 920D grade having density of 500-700 kg/m^3 confirming to ASTMC 12400 having specific surface more than 15 m/gm, water and superplasticizers were used in the concrete for the preparation of test specimens. River sand of specific gravity 2.62 and fineness modulus 2.44 was used as the fine aggregate. The maximum size of coarse aggregate was limited to 20 mm. Superplasticizer of Glenium B233 was used as high range water reducing admixture.

5. MIX PROPORTIONS AND SPECIMEN PREPARATION

HPC used in this study was designed for a characteristic strength of 40, 60, 80 and 100 MPa. The characteristic strength is the minimum statistical value of strength such that not more than a percentage (approximately 5%) of test results expected to exhibit lower strength than these characteristic values (IS 456)). Table 1 summarizes the mix proportions used in the HPC. In this work concrete was mixed in the concrete laboratory using drum type and a ribbon type mixer of half bag and 125 Kg capacity respectively. The sand and binder were mixed first for a while without water. About 70% of water was then added to the mixer and the coarse aggregate was added with rest of water. The required quantity of superplasticizer was added with water and properly stirred. The drum is rotated until homogeneous mix is obtained. Usually for high strength concrete the mixing time is more than the mixing time for normal strength concrete.

Table 1. Mix Propositions Used in HPC

MATERIALS	GRADE OF CONCRETE			
	40	**60**	**80**	**100**
Water cement ratio	0.5	0.35	0.3	0.25
Cement kg/m^3	350	366	414	440
Fine Aggregate kg/m^3	850	692	659	672
Coarse Aggregate kg/m^3	1100	1100	1100	1100
Water kg/m^3	175	160	155	137.5
Fly ash kg/m^3	-	91	103	69
Silica fume kg/m^3	-	-	-	41
Superplasticizer Glenium B233 %	-	0.4	0.4	0.6
SLUMP VALUE RANGE	100-130	95-130	85-120	75-100

6. TEST SETUP AND INSTRUMENTATION

The cube and cylinder specimens were tested under an external load cell of 300-ton capacity and two LVDT's were used. For capturing the data, a computer data acquisition system having 24 channels capacity and capturing rate of 0.1 per second was used. Modulus of elasticity is calculated using stress-strain curves at 40% of ultimate load as per ASTM C469. Circumferential extensometer was used to detect the lateral strain of the concrete cylinder.

6.1 COMPRESSIVE STRENGTH

The test on cube specimens carried out according to IS: 516- 1959 and cylinder specimens were according to ACI standards. Cube and cylinder compressive strength of HPC with different grades are tabulated in Table 2. Fig. 1 shows that the relation between cube and cylindrical compressive strength of HPC different grades.

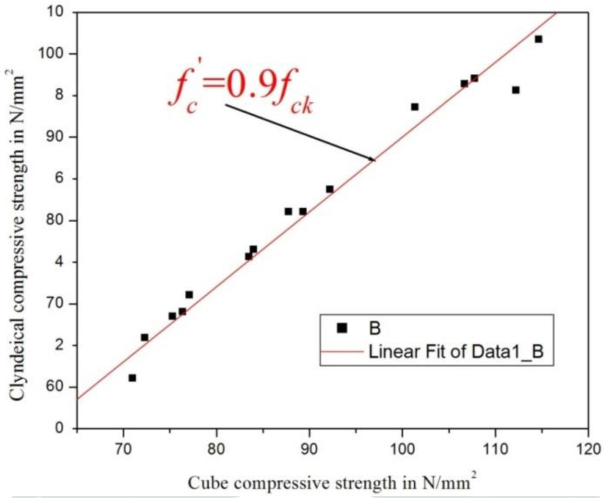

Fig. 1. cylinder Copressive Strength vs Cube Compressive Strength

Table 2. Cube and Cylindrical Compressive Strength

DESIGNATION OF CONCRETE	CUBE COMPRESSIVE STRENGTH (MPA)	CYLINDRICAL COMPRESSIVE STRENGTH (MPA)
M40	48.84	40.18
M60	74.40	67.13
M80	87.36	79.62
M100	108.53	96.90

6.2. MODULUS OF ELASTICITY

The Modulus of elasticity of concrete provides a bridge between stress and corresponding strain or between force and deformations and represents one of the most important mechanical properties of concrete. The modulus of elasticity, made on the basis of static chord. Which is accordance with ASTM C469 at 40% of ultimate load from stress-strain curve. From the test results, the elastic modulus vs $\sqrt{f_c}$ is plotted as shown in Fig. 2 and from regression analysis the following equation was predicted. Modulus of elasticity of different grades of present work are compared with available codes is presented in Fig.2. It is clearly showing that the available codes of HPC are under estimate the modulus of elasticity.

Modulus of Elasticity = $5058\sqrt{f_{ck}}$ in Mpa ----1

6.3. STRESS STRAIN CURVE

The complete stress-strain relationship is vital information for the analysis and design of concrete structures. The testing procedure of ASTM C469 standard was followed to generate stress strain curves of cylindrical concrete specimens. Results have been shown that the HPC confirms the maximum strain dependent on peak stress. From the Fig.3, It can be seen that the strain at peak stress increases from about 0.0023 to 0.0031 as the concrete strength changes from 40 to 100 Mpa. A regression analysis carried out on the set of test data gives the following relationship between strain at peak stress and compressive strength of concrete

Maximum strain = $0.000644\,(f_c')^{0.33}$ -----2

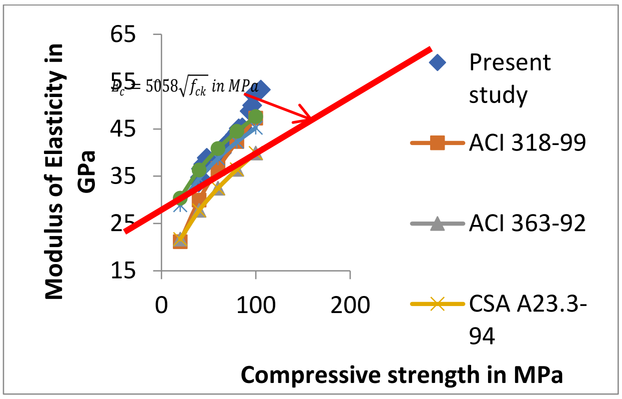

Fig. 2. Elastic modulus vs $\sqrt{f_{ck}}$

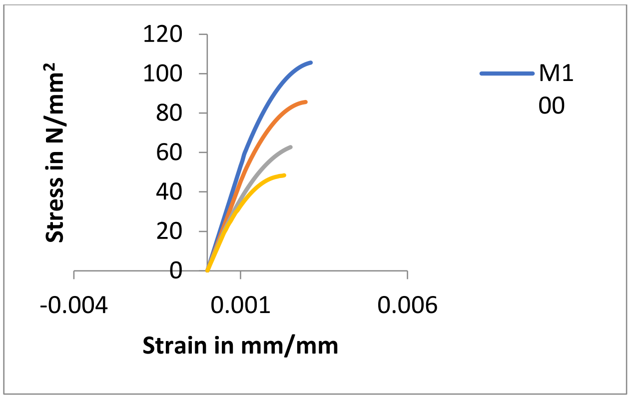

Fig. 3. Typical stress-strain curves

6.4 Poisson's Ratio

Experimental values of Poisson's ratio of HPC with different grades are shown in Fig. 4. Based on the tested data Poisson's ratio of HPC seems to be in the range of 0.13 to 0.25. from the Fig. 4, it can be seen that as strength of concrete decreases the Poisson's ratio increases. The recommendations from FIP/CEB report the Poisson's ratio of HPC is in the range of 0.18 to 0.24.

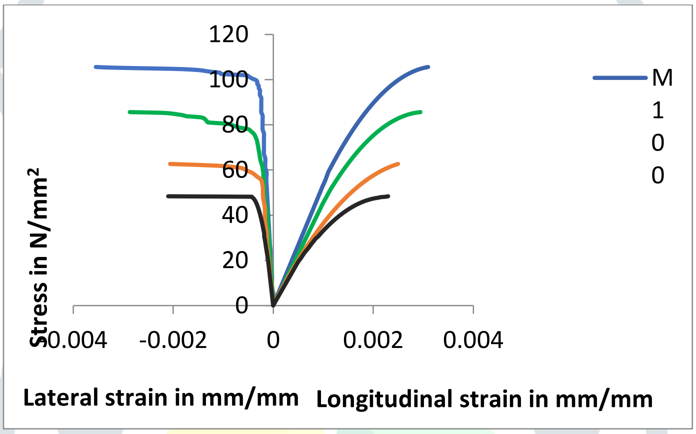

Fig. 4. Poisson's ratio of HPC

7. Conclusions

On the basis of results obtained from this work, the following conclusions has been drawn

- As the targeted strength increases the mix is very cohesive, sticky and less prone to segregation even though the slump values are in the range of 75-130 mm. The loss in the slump value is very rapid with the time.
- For HPC, the cylindrical compressive strength is 0.9 times the cube compressive strength.
- The different codes available are underestimate the modulus of elasticity of HPC but IS: 456-2000 overestimates the value. For modulus of elasticity of HPC the following equation is recommended.
  $E_c = 5058\sqrt{f_{ck}}$ in Mpa for 60 Mpa < f_c < 100 Mpa
- For HPC, the shape of the ascending part of stress-strain curve is more linear and steeper. The slope of descending part also steeper compared to NSC because of decrease in the extent of internal micro-cracking occurred in concrete.
- The strains associated with maximum stress increases as the strength of the concrete increases and it is clearly indicating that the strain at maximum stress highly dependent on the compressive strength of concrete. For HPC the following equation is recommended for maximum strain.
  $\varepsilon_{max} = 0.000644\,(f_c')^{1/3}$ for 60 Mpa < f_c' < 100 Mpa
- Poisson's ratio decreases as the strength of the concrete increases. From the test data, the Poisson's ratio for HPC is 0.17 and for NSC is 0.2.

Acknowledgment

The Author wish to thank Mr. Mohan Kumar D, Professor and Head, Department of Civil Engineering, Government Polytechnic, Mudhol for his expert guidance, valuable time spent, relentless effort and constant encouragement in the entire tenure of the Project work.

References

[1] Aitcin P. C., "High Performance Concrete," *E & FN Spon, An imprint of Routledge, New Fetter Lane*, London, 1998, 591 pp.

[2] Rashid M. A., Mansur M. A. and Paramasivam P., "Correlation between mechanical properties of high-strength concrete," *Journal of materials in civil engg., ASCE*, May-June 2002, pp. 230-238.

[3] ACI 318 R-08, "Building Code Requirements for Structural Concrete" *(ACI 318-08) and Commentary (ACI 318R-08)*, Detroit

[4] ASTM C469-94, "Standard test method for static modulus of elasticity and Poisson's ratio of concrete in compression," 4 pp

[5] Alexander M. G. and Milne T. I., "Influence of cement blend and aggregate type on stress-strain behavior and elastic modulus of concrete," *ACI material journal, Vol. 92, No. 3*, May-June 1995, pp. 227-235.

[6] Wee. T. H., Chin M. S., and Mansur M. A., "Stress-strain relationship of high strength concrete in compression," *ASCE Journal of materials in Civil Engineering, Vol. 8, No. 2*, May 1996, pp. 70-76.

[7] Francis A. O., Edwin G. B., and Harold deatherage J., "Elastic modulus, Poisson's ratio, and compressive strength at early ages," *ACI material journal, Vol. 88. No. 1*, Jan.-Feb. 1991, pp. 3-10.

[8] Wee. T. H., Chin M. S., and Mansur M. A., "Stress-strain relationship of high strength concrete in compression," *ASCE Journal of materials in Civil Engineering, Vol. 8, No. 2*, May 1996, pp. 70-76.

[9] Said Iravani, "Mechanical properties of high-performance concrete," *ACI material journal, Vol. 93, No. 5*, Sep.-Oct. 1996, pp. 416-425.

[10] CSA, "Design of concrete structures for buildings" *(CAN3-A23.2-94), Canadian Standards Association*, Rexdale, Ontario, 1994, 199 pp.

[11] IS 456-2000, "Plain and reinforced concrete-code of practice," *Fourth Revision, Bureau of Indian Standards*, New Delhi, 2000, 107 pp.

[12] Habib A. M., Mohamed L., and Aitcin P. C., "Determination of elastic properties of high-performance concrete at early ages," *ACI material journal, Vol. 99, No. 1*, Jan.-Feb. 2002, pp. 37-41.

[13] Seong-Tae Yi, Jin-Keuren Kim, Tae-Keun Oh, "Effect of strength and age on the stress-strain curves of concrete specimen." *Cement and Concrete Research, Vol. 33, 2003, pp. 1235-1244.*

[14] Insang Lee, Wonsiri Punurai, and Cheng-Tzu Thomas Hsu, "Complete stress-strain behavior of high-performance concrete,"*15th ASCE Engineering Mechanics Conference, June 2-5, 2002, Columbia University*, New York, NY, pp. 1-6.

[15] CEB-FIP Model Code, Bulletin d' Information No 213/214. *Committee Euro – International du Beeton*, London: Thomas Telford, 1990

[16] CEB-FIP, "State-of-the-art Report: High Strength Concrete*," Bulletin d' Information, CEB-FIP MC90*, August 1990, 212 pp.

[17] Eurocode-02, "Design of concrete structures," *European Committee for Standardization*, Brussels, 1999.

[18] Carrasquillo R. L., Nilson A. H., and Slate F. O., "Properties of high strength concrete subjected to short term loads," *ACI Journal*, May-June 1981, pp. 171-177.

[19] ACI Committee 363, "State of the Art Report on High-Strength Concrete (ACI 363R- 92)," *American Concrete Institute*, Detroit, 1992 (Revised 1997), 55 pp.

[20] Mary Beth D. H., Praveen Chompreda, David Trejo, Daren B. H., and Peter B. K., "Mechanical properties of high-strength concrete for prestressed members," *ACI structural journal, Vol. 101, No. 4*, July-Augast 2004, pp. 457-465

[21] Rachel J. D., and Mehta P. K., "Chemical and physical effects of silica fume on the mechanical behavior of concrete," *ACI material journal, Vol. 86, No. 3*, Nov.-Dec. 1989, pp. 609-614.

[22] ASTM 1240-01, "Standard specifications for use of silica fume as a mineral admixture in hydraulic cement concrete, mortar, and grout, "2001, 6 pp.

[23] Indian standards (IS-12269), "Specifications for 53-grade ordinary Portland cement," *Bureau of Indian Standards*, New Delhi, 1987, 20 pp.

[24] Indian standards (IS-383), "Testing aggregates in cement concrete," *Bureau of Indian Standards*, New Delhi, 1970, 21 pp