International Journal of Research in Management, Science & Technology (E-ISSN: 2321-3264)
Vol. 5, No. 1,122-127, April 17
Available at www.ijrmst.org

A COMPARATIVE STUDY OF MICROSILICA BASED HIGH PERFORMANCE CONCRETE USING IS AND DOE METHOD

Narinder Kaur[1], Mukesh Kumar[*2,]
[1,2]*Department of Civil Engineering,*
Prannath Parnami Institute of Management and Technology, Hisar, Haryana, India
[2]mukeshsamota2386@gmail.com

Abstract- **There is abundance use of HPC in construction industry for marine and important structures. To get this type of concrete different types of admixtures are added to increase the strength, durability and workability of concrete. For designing HPC various types of admixtures are available in market like fly ash, rice husk ash, alccofine, micro silica etc. These admixtures can be used up to a limit at which it gives maximum strength and beyond that limit strength of concrete decreases.The present experimental work is investigated on replacement of micro silica with cement for 0%, 5%, and 8% with addition of super plasticizer. The concrete mix of M55 High Performance Concrete is used in this experimental work. Two design mix specifications i.e. Indian Standard (IS) and Department of Environment (DOE) British method are adopted for this work. Comparison of these two is carried out for slump test and compressive strength of concrete. It has been found that with 5% replacement of cement with micro silica the slump decreases 5.16% and with 8% replacement the slump decreases 7.74% as per IS method. Whereas, with 5% replacement slump decreases by 3.33% and with 8% replacement slump decreases by 6.67% as per DOE method. As per compressive strength 7 days compressive strength with 8% replacement of cement with micro silica shows high strength for both IS and DOE method. Compressive strength increases 8.481% as per IS method and 6.81% as per DOE method. For 28days compressive strength 5% replacement shows high strength. With 5% replacement there is 9.059% increase in strength by IS method and 8.92% increase in strength with DOE method. DOE method shows 0.96% more strength than IS method after 28 days with 5% replacement level. Cost of DOE method is more than IS method, but strength of both methods is almost same, DOE method has only 0.96% more compressive strength than IS method. So we can say that IS method is more economical than DOE method.**

Keywords**-Micro silica, Compressive Strength, IS method, DOE method**

I. INTRODUCTION

The concrete is a widely used construction material than any other type of construction material. It is more popular because of its durability, strength and economical and can be easily manufactured at site. We can conveniently form it into desired shape and size. Due to moulding property of concrete, we can build multi-storey buildings, dams, bridges, with ease in any type of environment like aggressive, polluted and industrial, whereas other construction materials are not economical and durable. As there are advancement and new discoveries in Civil Engineering, different types of new materials are used while designing of concrete. A High Performance Concrete is also designed by adding admixtures in concrete. M.S.Shetty defines the HPC as it is a concrete which possess high workability, high strength, high density, low permeability and resistance to chemical attack. It has more workability with less water cement ratio. High strength concrete and high performance concrete are different from each other. A high performance concrete is more workable without any segregation or bleeding while transporting and placing. For designing high performance concrete we use admixtures, which may be mineral / pozzolanic admixtures or chemical admixtures. Mineral admixtures are fly ash, rice husk ash, micro silica or silica fume, surkhi, metakaolin and alccofine etc.

By Sudarasana et al (2014)[2] HPC designed by low water cement ratio, so it gave high strength. But low w/c ratio affects the workability of concrete. For making concrete more workable super plasticizers are used, that makes concrete more workable with less w/c ratio. Gana and Okoye (2015)[3] described HPC as with high strength and low permeability. For high strength and low permeability, concrete should have low volume of pores. For this silica fume is used in concrete. They also describe characteristics of HPC which are as follow: Early age strength, Density, Toughness, Heat of Hydration, Ease of placement and Compaction without segregation and Durability. Micro silica improves the fine strength of concrete because it has more specific surface area and very fine particles. For designing of concrete a design process is required. This design process is given by Mix Design. As defined by M.S.Shetty Mix Design is the process of selection of suitable materials and suitable amount of each material to produce concrete of minimum required strength, workability and durability in economical way. Good designing of concrete has two objectives – one it should give minimum strength as

per requirement of project and second should be in economical limits. These all parameter depend on quality and quantity of aggregates, cement, water and other special ingredients. The quality of ingredients and ratio during concrete making gives strength and durability. Two types of mix design are used: Nominal Mixes and Design Mixes

II. PROPOSED METHOD

Design Mixes

In design mixes there is provision of use of other special quality materials other than basic concrete making material. These materials are different type of admixtures. It designs the concrete as requirements of projects and makes concrete more economical as well as gives proper strength as required. M.S.Shetty describes various design codes, these are as follows:

1. Maximum Density Method
2. Fineness Modulus Method
3. Indian Road Congress, IRC 44 Method
4. High Strength Concrete Mix Design
5. Road Note No. 4
6. ACI Committee 211 Method
7. DOE Method
8. Indian Standard Recommended Method IS 10262:2009

In our present study we compare two methods Department of Environment (British Method) and Indian Standard (IS method).

(a) IS method (IS: 10262-2009)

These steps are followed while designing of concrete using this code:

Find the target mean strength of concrete

Determine water/binder ratio

Determine binder(cement, micro silica) content from curve

Determination of desirable contents of super plasticizer

Determine the proportion of coarse and fine aggregates

(b) DOE method (British method):

There are steps that should follow during designing of concrete as per DOE method:

Determine the target mean strength

Determination of w/c ratio from curve for crushed or uncrushed aggregate

Get the value of cement content

Determine the wet density of concrete

Determine quantity of super plasticizer

Determination of value of total aggregate required

Find values of coarse and fine aggregates

Aim of Present Study

In present study we work on comparison of Micro silica based High Performance Concrete using IS and DOE method. In HPC admixtures are added to normal concrete. In our comparative study we use micro silica and super plasticizer as admixtures:

M55 grade concrete is designed with partial replacement of cement with micro silica

IS method and DOE method are used for designing concrete

Three replacement levels 0%, 5% and 8% are designed by both Indian Standard (IS) and DOE (British method)

Slump values and compressive strength of concrete is compared.

In this study we use micro silica as partial replacement of cement in concrete. Super plasticizer is used for making the concrete more workable with low w/c ratio. Various research works is done in the past using micro silica as a replacement material with cement. We study these research papers for our study. Some literature of these research papers is discussed here.

Partial replacement of silica fume was used for designing different concrete grades by using IS method and compared the compressive strength, flexural strength and split and tensile strength of different partial replacement levels [4,5]. In their experiment work micro silica was used as replacing material for two concrete grades and their compressive strength was compared [6]. Micro silica and nano silica both admixtures were used as partial replacement with different percentage of both admixtures and compare the mechanical properties of concrete mix [7]. Other combination of two admixtures fly ash and silica fume was used for increasing the strength of concrete and they got optimum level of replacement by IS method [8]. DOE method was used for designing HPC with partial replacement of micro silica and they studied mechanical properties of concrete [9]. Next paper also focused on the effects of silica fume on main properties of concrete in fresh and hardened state by using British standard [10].DOE, IS and ACI methods were compared by using different replacements of micro silica and fly ash [11]. Comparison of different design codes IS, ACI and DOE (British method) was studied and compared on HPC by micro silica replacement. [12,13].

Material Used

CEMENT: Ordinary Portland Cement (OPC) 43 grade is used for experimental work. That is ULTRATECH OPC cement. Different tests are carried out on cement before use for work. Result of consistency, specific gravity and fineness of cement are 29.5%, 3.15 and 1.91% respectively.

FINE AGGREGATE: In present study fine aggregate of Zone-II as per IS: 383-1963 is used. Sieve analysis of fine aggregates is done by different sieve sizes(10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ).the result values of specific gravity, fineness modulus and water absorption are 2.80, 2.78 and 1.2 respectively.

COARSE AGGREGATE: Two types of coarse aggregates of 20mm and 10mm size are used in present study. For IS method 65% and 35% ratio of 20mm and 10mm is used and for DOE method 55% and 45% is used. This values determined by trials. Specific gravity, fineness modulus and water absorption of 20mm aggregates are 2.88, 6.89 and 0.40. Specific gravity, fineness modulus and water absorption of 10mm aggregates are 2.88, 6.88 and 0.50 respectively.

WATER: Potable water free from impurities is used for mixing of concrete and also for curing of specimens.

MICRO SILICA: It is a by product of silicon used in electric arc furnaces and has finer particles than cement particles. Micro silica fume for this work is obtained from PRECISION DRAWELL PVT LTD, NAGPUR (MH). It is of gray colour and has specific gravity of 2.2. Micro silica is used in concrete in 0%, 5% and 8% by weight of cement.

SUPER PLASTICIZER: It is used as a chemical admixture. For this work BASF MASTER POLYHEED 8100M is used. It is in light brown colour and has specific gravity 1.

III. RESULTS

Experimental Programme

This experimental work is investigated on the M55 grade concrete by designing of two designing codes IS method and DOE method. Comparison of two methods is investigated in process of mix design. All the materials used for investigation is taken same for both methods . Partial replacement of micro silica is used as 0%, 5%, 8% and compares them by both methods. Super plasticizer by weight of cement 0.5% is used for workability of concrete. For designing high performance concrete workability of concrete is high so slump of concrete is also high.

Mix Proportion

Method	Cement	CA	FA	Water
IS code	1	2.20	1.55	0.41
DOE code	1	1.97	1.18	0.40

For designing of M55 grade HPC concrete mix proportions of both methods are determined by using the designing process of each method and by using the curves and tables given in codes. Water- cement ratio for IS code is 0.347 and for DOE method 0.395≈0.40. Mix proportion for both shown

TABLE NO.1: MIX PROPORTIONS OF MATERIALS

In this experimental work two types of coarse aggregate is used 20mm and 10mm. In IS method their ratio is 65% and 35% and for DOE method their ratio is 55% and 45% for 20mm and 10mm respectively. These are taken after different trails testing. For the desired workability 20% less water is used for DOE method. All materials are free from impurities and correction of materials is taken at site. Accurate weighting of materials for all trails is done as

TABLE NO.2: QUANTITY OF MATERIALS IN KG/M3

Method	Cement	Coarse aggregate	Fine aggregate	Water
IS code	500	1102.464	776.16	173.5
DOE code	562	1103.89	662.3	225

requirement of batches. Drum type lab. mixer is used for mixing of materials; slump for all trails is also tested. Table vibrator is used while filling of cube moulds with concrete mixes. 150mm×150mm×150mm cast iron and oil coated inside is used for cube specimens. Cubes are demoulded after 24 hours and placed in curing tank. 7days and 28days strength is tested on compression testing machine (CTM) of 2000KN capacity. Average of 3 cubes is taken as final reading for that mix. Comparison of two methods is analysed. 6 final trails for both methods is designed and studied. Total 36 cubes are casted and tested while experimental study. Results of that trails are shown in table no.4.

Fig No.1: Testing of cubes

Slump Testing and its Results

Slump test shows that results according to Table No.3:

TABLE NO. 3: VALUES OF SLUMP TESTING

Sr No.	Mix designation	Slump (mm)	
		IS method	DOE method
1.	MX(0)	155	150
2.	MX(1)	147	145
3.	MX(2)	143	140

TABLE NO.4: COMPRESSIVE STRENGTH RESULTS

Methods	7days compressive strength			28days compressive strength		
	0%	5%	8%	0%	5%	8%
IS	39.50	41.89	42.85	54.99	59.97	56.38
DOE	40.51	42.68	43.27	55.59	60.55	58.34

- IS method gives slightly more slump than DOE method.
- Highest slump of 155mm is obtained for High Performance Concrete

Reasons of slump variation are described as:

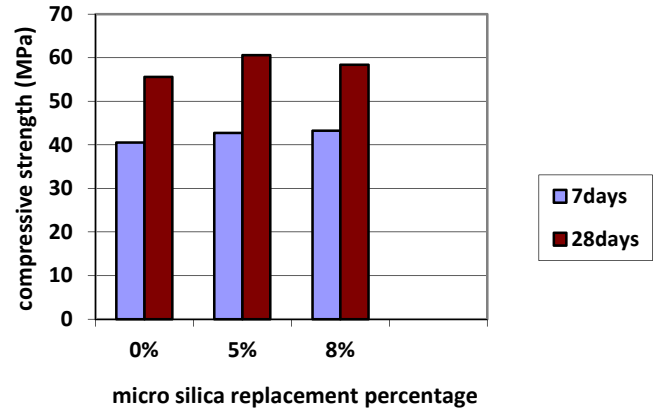

Fig No.2: Results of slump testing

Addition of micro silica reduced the value of slump because due to more fineness of micro silica requires more water.

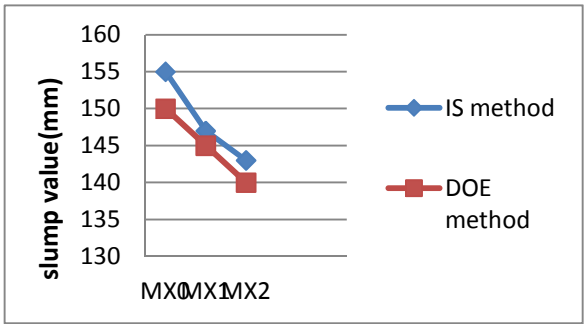

Fig No.3: Compressive Strength by IS method

Results of Compressive Strength

Results of Compressive strength are tested as per IS 516: 1959, "Indian standard method of tests for strength of concrete".

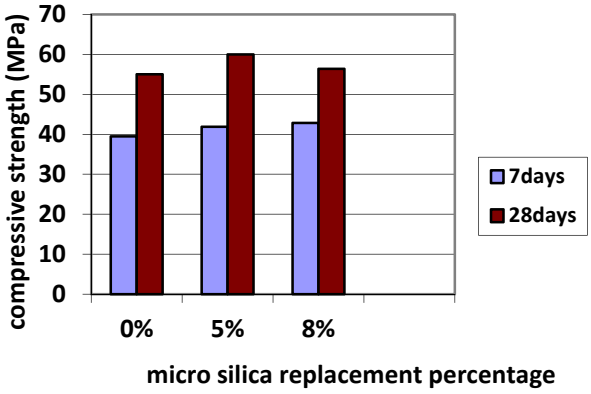

Fig No.4: Compressive Strength by DOE method

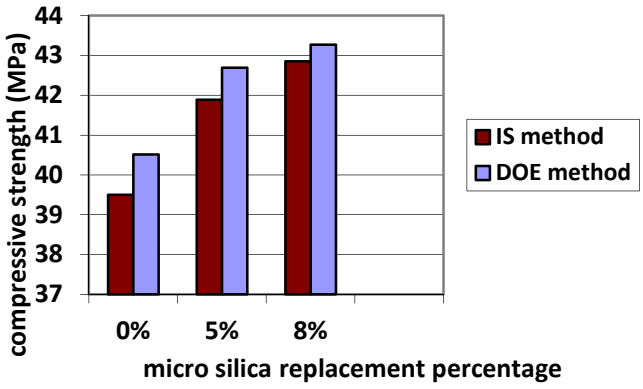

Fig No.5: Comparison of 7days Compressive Strength

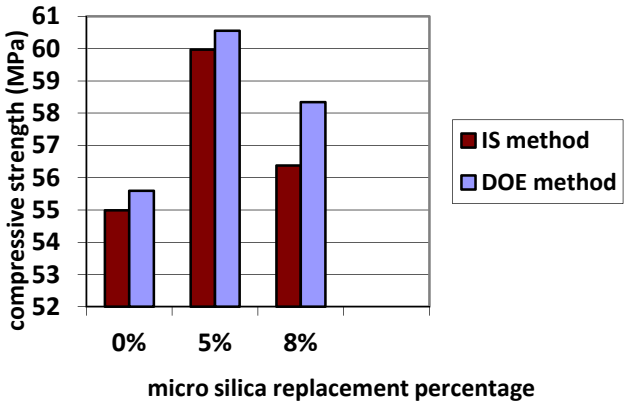

Fig No.6: Comparison of 28days Compressive Strength

IV. CONCLUSION

Micro silica replacement in conventional concrete is recently used now a day. It is a waste material and used in concrete at place of cement. It has cementitous property and hundred time finer particles then cement. Micro silica particles fill the voids of cement particles that make concrete less permeable then conventional concrete. Due to filling of voids with micro silica particles the strength of concrete mix also increases. The present study is investigated on behaviour of micro silica dosage to concrete mix with use of super plasticizer. In this study we also compare the two design mixes IS code design mix and DOE design mix. The conclusion of present study is discussed here.

i. It has been found that with 5% replacement of cement with micro silica the slump decreases 5.16% and with 8% replacement the slump decreases 7.74% as per IS method.

ii. Whereas, with 5% replacement slump decreases by 3.33% and with 8% replacement slump decreases by 6.67% as per DOE method.

iii. Compressive strength increases 8.481% as per IS method and 6.81% as per DOE method.

iv. In 28days compressive strength, for 5% replacement there is 9.059% increase in strength by IS method and 8.92% increase in strength with DOE method.

v. The cost of DOE method is more than the IS method. But compressive strength of DOE method after 28 days is only 0.96% more than IS method.

vi. From cost analysis we can say that IS method is more economical than DOE method.

REFERENCES

[1]. M S Shetty (1987, Concrete Technology Theoryand Practices, Chand & Company, New Delhi.

[2]. SudarsanaRao.Hunchate,Sashidhar.Chandupalle, Vaishali.G.Ghorpode and Venkata Reddy.T.C (2014), "Mix design of High Performance Concrete using Silica Fume and Super plasticizer" International Journal of Innovative Research in Science, Engineering and Technology ISSN: 2319-8753, Volume3, Issue3.

[3]. Dr. Engr. Gana A.J COREN Regd, MNSE, MNICE, Istructe Lond(U.K.) ICE Lond(U.K) and Engr. Okoye S.S.C (2015), "Relevance of High Performance Concrete applications in Modern Civil Engineering Construction" International Research Journal of Engineering Science, Technology and Innovation(IRJESTI)(ISSN:2315-5663)Vol.4(1).

[4]. Rituraj S. Rathore, Rashwinder Walia (2016), "Partial replacement of OPC by Silica Fume with M55 grade concrete", SSRG International Journal of Civil Engineering (SSRG-IJCG) - Volume3 Issue7.

[5]. Muthu Kumar.T, Sirajudeen.K (2016), "Experimental investigation on HPC using alternate materials", International Journal Science, Engineering and Technology Research IJSETR, Volume5, Issue1.

[6]. Partha Pratim Das, Farhana Naznin, Nayanmoni CHETIA (2015), "Concrete mix proportioning using Micro Silica", Proceedings of 4th IRF International Conference on 19th April 2015, Cochin, India.ISBN:978-93-82702-98-6.

[7]. S.Tanveer Hussain, KV.S.Gopala Krishna Sastry (2014), "Study of strength properties of concrete by using micro silica and nano silica" International Journal of Research in Engineering and Technology(IJRET) eISSn: 2319-1163/pISSn:2321-7308 Volume3 Issue-10oct2014.

[8]. Magudeaswaran P, Eswaramoorthi P (2013), "Experimental investigations of Mechanical properties of micro silica (silica fume) and fly ash as partial cement replacement of HPC" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume6,Issue(may-june 2013),PP57-63.

[9]. Mr. Sabale Vishal Dhondiram, Miss Bargave Manali Deepak, Mr. Shinde Suraj Dadsaheb, Miss Bhagwat Mayuri Dattatray (2013), "Experimental study on HPC", International Journal of Electronics, Communication and Soft Computing Science and Engineering. ISSn: 2277-9477, Volume3, Issue1.

[10]. Des King (2012), "The effect of silica fume on the properties of concrete as defined in concrete society report 74, cementitous materials", 37th conference on our world in concrete and structures. 29-31 august, 2012, Singapore.

[11]. Popat D. Kumbhar, Pranesh B. Murnal (2012), "Assessment of suitability of existing mix design methods of normal concrete for designing high performance concrete mixes", International Journal of Civil and Structural Engineering, Volume3, No.1, ISSN:0976-4399.

[12]. Jeevendra Kumar Chandrakar, S. P. Mishra (2012), "Comparison of IS, BS and ACI methods of concrete mix design and proposing function equations based design", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development(IJCSEIERD) ISSN-2249-6866, Volume2, Issue1.

[13]. Kwan Wai Hoe, Mahyuddin Ramli (2012), "Rational Mix design approach for High strength concrete using sand with very high fineness modulus", American Journal of Applied Sciences, 7(12):1562-1568, ISSN1546-9239.

[14]. Arjun P, K Shyam Kumar (2014), "Effect of mineral admixture on the mechanical and durability properties of high performance concrete", International Journal of Structural and Civil Engineering Research, ISSN:2319-6009, Volume 3, No. 4.

[15]. IS- 456: 2000, "Indian standard Code of Practice for Plain and Reinforced Concrete", 4th Revision, Bureau of Indian Standards, New Delhi.

[16]. IS 10262: 2009, "Indian standard recommended guidelines for Concrete Mix Design", 1st Revision, Bureau of Indian Standards, New Delhi.

[17]. IS 10262: 1982, "Indian standard Recommended guidelines for Concrete Mix Design", 5th Reprint 1998, Bureau of Indian Standards, New Delhi.

[18]. IS 383-1970, "Indian standard Specifications for coarse and fine aggregates from natural sources for concrete", Bureau of Indian Standards, New Delhi.

[19]. [23] IS 15388: 2003, "Indian standard Specifications for silica fume [CED 2: cement and concrete]", Bureau of Indian Standards, New Delhi

Materials		Price of Materials (per Kg)	Material (Kg/m^3) (IS)	Cost of Materials (IS) (Rs)	Material (Kg/m^3) (DOE)	Cost of Materials (DOE) (Rs)
Cement		5.4	500	2700	562	3034.8
MS	0%	----	0	0	0	0
	5%	20	25	500	28.1	562
	8%	20	40	800	45	900
Water		0	187.6	0	237.85	0
FA		0.9	766.85	699.16	654.35	588.91
CA	20mm	0.9	713.74	642.36	604.68	544.21
	10mm	0.9	383.97	345.57	494.32	404.38
SP		70	2.5	175	2.81	196.7
Total Cost (0%)		---	---	4562.09	---	4769
Total Cost (5%)		---	---	5062.09	---	5331
Total Cost (8%)		---	---	5362.09	---	5669