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Admixtures in Pile Concreting: A Case Study

Nehal H Shah[1], Dhiren J Panchal[2], Karan V Rupani[3], Vivek D Patel[4]

[1] *Assistant Professor, CIVIL ENGINEERING, Babaria Institute of Technology, shah.nehal710@gmail.com*
[2] *Assistant Professor, CIVIL ENGINEERING, Babaria Institute of Technology, dhiren.panchal87@yahoo.com*
[3] *B.E. final year student, CIVIL ENGINEERING, Babaria Institute of Technology, rupani.karan@yahoo.in*
[4] *B.E. final year student, CIVIL ENGINEERING, Babaria Institute of Technology, patelvivek308@yahoo.com*

Abstract:
Pile foundations are deep foundations used to transmit heavy loads of the superstructure to the soil below. Pile foundations are normally used when soil below the structure has low bearing capacity and load on the foundation is high. Concreting in cast in situ bored piles are done via trimie pipe underwater in the bore hole which is heavily reinforced. The paper deals with the problems faced during concreting of pile foundations, and to find possible solution of main problems such as 1) Segregation of concreting and 2) Jamming of trimie pipe by proper use of admixture by the case study and suggest the finalize mix for the concrete used piles with good workability.

Keywords*-Pile; Admixture; Segregation; Superplasticizer; Negative friction; Under water concreting; Bore hole stabilization; Bentonite slurry.*

I. INTRODUCTION

Piles are structural members that made of steel, concrete, and/or timber. They are used to build pile foundations, which are deep and which cost is more than shallow foundations. Despite the cost, the use of piles often is necessary to ensure structural safety. Piles are classified in many ways such as i) Mechanics if Load Transfer ii) Method of Installation and iii) Types of materials. From all these piles major problem facing in Cast-in-situ piles.

Cast-in-situ concrete piles may be either installed by making a bore into the ground by removal of material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as "bored piles" and "driven piles" respectively. Cast-in-situ concrete piles may be cast in metal shells, which may remain permanently in place. However, other types of cast-in-situ concrete piles, plain or reinforced, cased or uncased, may be used if the site conditions permit.

Wherever practicable, concrete should be placed in a clean dry hole. The concrete should invariably be poured through a tremie with a funnel so that the flow is directed and concrete can be deposited in the hole without segregation.

Boring shall be carried out using rotary or percussion type equipment. Prior to the lowering of the reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials. Cover to reinforcing steel shall be maintained by suitable spacers.

The properties of the concrete can be easily modified by proper use of admixture. Thus required properties of concrete can be achieved by proper use of admixture. Admixture is nothing but the anything that modifies the properties of concrete and is an ingredient of concrete used to impart physical and economic benefits to concrete. Admixtures are added to increase in workability, increase in homogeneity and cohesiveness, increase in strength, increase in durability, increase or decrease in setting time, increase in soundness, etc.

Pile concreting is different from normal concreting in following ways:-

- It is to be placed deep below the ground level via trimie pipe.
- It is placed underwater.
- It is not possible to apply compaction to concrete in piles.
- Intrusion of foreign material from surrounding soil.
- Concrete is placed in piles which is heavily reinforced so there are chances of segregation.

So pile concrete should have properties like higher strength, self-compacting, anti-wash out, durability and high workability.

II. BORED CAST IN SITU CONCRETE PILES

The construction of bored cast in situ concrete piles are formed by drilling and auguring and then reinforcement is placed and concrete is poured into the hole.
For bored cast in-situ piles foundation in stiff clays, the toe of the hole can be enlarged by under-reaming to provide greater end bearing capacity for the piles.
Once the pile shaft has been formed, reinforcement is placed and concrete poured into the hole. To combat difficulties caused by groundwater during piling, the hole can be lined with a casing which is driven ahead of the bore.

2.1. Standard acceptance & Tolerance in bored piles:

- Variation in cross-sectional dimensions:+50mm,-10mm
- Variation from vertical or specified rake: 15mm
- Variation in the final position : 50mm
- Variation of level of top of piles : ± 25mm

2.2. Major problems observed in pile concreting:

- In pile concreting main problem is segregation of mix.
- Intrusion of foreign material into concrete of pile.
- Even after re-dosages in concrete, with the time loss of slump occurs.
- Triemie blockages.
- Negative Friction.

2.2.1. General Requirements and Precautions for under water concreting:

- Concreting of pile must be completed in one continuous operation with high slump and restricted water cement ratio.
- The sides of the bore-hole have to be stable throughout.
- The minimum slump of concrete for driven cast-in-situ piles shall be 100 mm to 150 mm and that of bored cast-in-situ piles 150 mm to 200 mm. The slump should not exceed 200 mm in any case.
- Grade of concrete to be used in cast-in-situ piles shall not be less than M 25 and the cement content shall not be less than 400 kg per cubic meter of concrete. Maximum water cement ratio shall be 0.5 for cast-in-situ piles and 0.45 for precast piles.
- Concrete mix should have homogeneous mixture with required workability for the system of piling adopted. Suitable and approved admixtures may be used in concrete mix where necessary.
- Where piles are exposed to action of harmful chemicals or severe conditions of exposure due to presence of sulphate, chloride etc, it may be preferable to opt for higher grades of concrete restricting water cement ratio to 0.45. Special types of cement, such as sulphate resistant cement may be used where considered appropriate.

III. OBJECTIVES

- Design concrete having high workability which having slump between 150-180 mm.
- To design self-compacting concrete.
- Reduce water cement ratio.
- Design of concrete having rough surface which results in high friction between soil & concrete of piles.
- Design concrete having higher cohesion which resists segregation and intrusion of foreign material in the concrete of piles.

IV. PROBLEMS INDENTIFICATION & SUGGEST MIX DESIGN STUDY

As Pile concreting is a complex process compare to the normal concreting so proper attention is to be paid while the process of concreting is going on. Few problems identified on the housing society site are like segregation of concrete, trimie blockages, suspension of foreign materials in to the pile concrete, etc, So to overcome such problems the design mix has to be suggested by using the different admixtures, GGBS and fly ash.

4.1. Method and Material:

Method of construction of pile foundation includes 4 main phases:

Pile boring: In this method first decide the pile location after that the rig was settled which will be settled centered on the pile point and drilling will be done by using auger/bucket to a required depth. The excavation is generally performed by rotation using a rotary drill, composed of a rotary table. At or site manually operated auger is used for drilling.

Reinforcement cage lowering: In this phase the reinforcement cage shall be fabricated as per the drawing and bar bending schedule.

Flushing the bore hole: In this phase the bore hole will be stabilized by using the bentonite slurry or solution till consistency of bottom slurry becomes less than 1.20.

Pile concreting: Minimum time interval between the completion of boring and placing of concrete will be maintained. The gap between the bottoms of the bore to the end of tremie pipe will be maintained minimum 300mm. The diameter of the tremie pipe will be not less than 200mm. The tremie pipe shall be removed in stages during pouring of concrete ensuring that the tremie bottom is always inside the concrete.

4.2. Method for designing the mix:

The Mix design calculations per unit volume of concrete shall be as follows and the Design Mix proportion is finding by the Ref. IS: 10262-2009 which is shown in below Table:

Table: 1 Mix Calculation

Sr. No.	Description	Calculation	Quantity
1	Volume of concrete		1.0000 m^3
2	Volume of cement	(Mass of cement ×1) / (Specific gravity of cement ×1000)	0.06349 m^3
3	Ground Granulated Blast Furnace Slag	(Mass of ground granulated blast furnace slag × 1) / (Specific Gravity of ground granulated blast furnace slag × 1000)	0.0719 m^3
4	Volume of water	(Mass of cement × 1) / (Specific gravity of cement × 1000)	0.1600 m^3
5	Volume of Chemical	(Mass of chemical admixture × 1) / (Specific gravity of chemical admixture × 1000)	0.00390m^3
6	Mass of Coarse	==========	0.70118m^3
7	Mass of Fine aggregate	==========	1193.8 kg
8	Specific gravity of admixture	==========	726.3 kg

By done trial & error method in above mix design calculation following mix proportion has been recommended shown in Table:

Table: 2 Recommended Mix proportion

proportion	water	cement	GGBS	sand	Coarse aggregate		Chemical admixture
					20mm	10mm	
by weight(kg/m3)	160.0	200.0	200.00	726.3	716.3	477.5	4.8
weight	0.40	1	1.00	1.82	1.79	1.19	-
volume	0.40	1	1.20	1.66	1.78	1.23	-
FOR 1 BAG OF CEMENT, THE QUANTITIES OF MATERIALS ARE:							
By weight/bag	40.0lit	50.0kg	50kg	181.1kg	179.0kg	119.4kg	1200.0

For Mix design the Excel sheet has also be prepared in which one can design any grade of concrete and some silent features are described below.

- Concrete of any grade can be designed within fraction of seconds.
- The design can be done for different types of sand and aggregate as their specific gravity is kept a variable quantity
- All the values of design are obtained from different curves of IS-10262:2009 which are clearly defined in sheet 2 of excel workbook, so they can be easily referred if required.
- The sheet can be easily calibrated as per site conditions and can be used for different types of sites.
- The rates of different materials can be easily varied in the sheet and proper current rate of materials used in concrete can be found out.
- The design is done as per IS standards which guarantees adequate strength and serviceability though the design can be changed as per site requirements or due to different properties of materials.
- In short the concrete design sheet is a handy tool for mix design as per IS -10262:2009.

Some screenshots of the sheet are shown below:

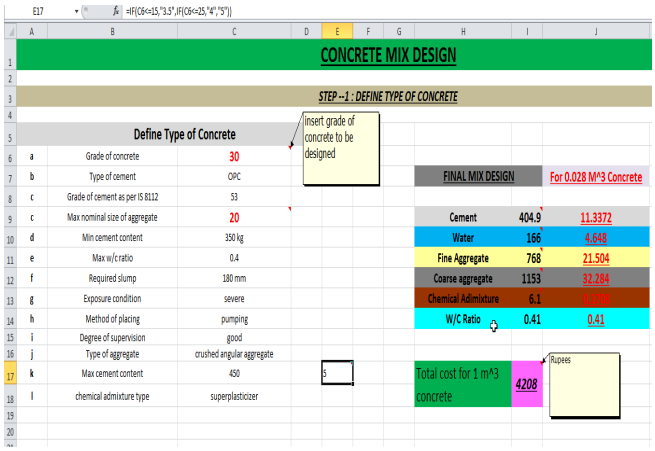

Figure: 1 Layout of Excel sheet which is used for mix design.

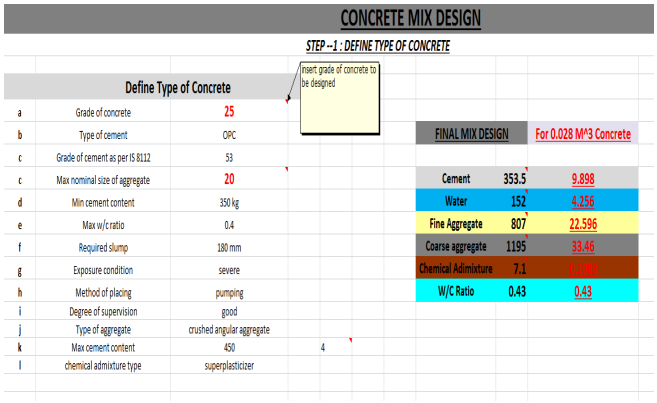

Figure: 2 Step 1 of mix design

1) Insert the rate of materials used and test result data of the raw material.

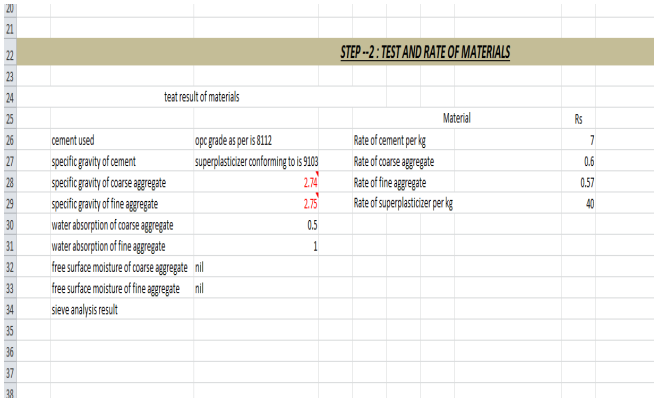

Figure: 3 Step 2 of mix design

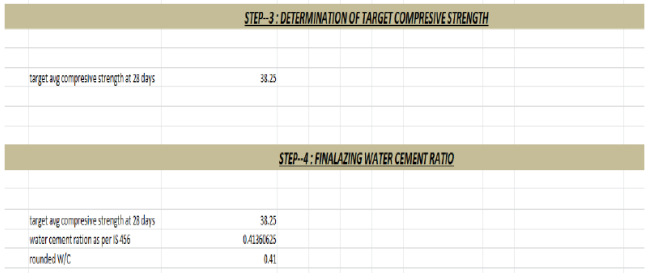

Figure: 4 Step 3 and 4 of mix design

2) Figure shows the selection of water content

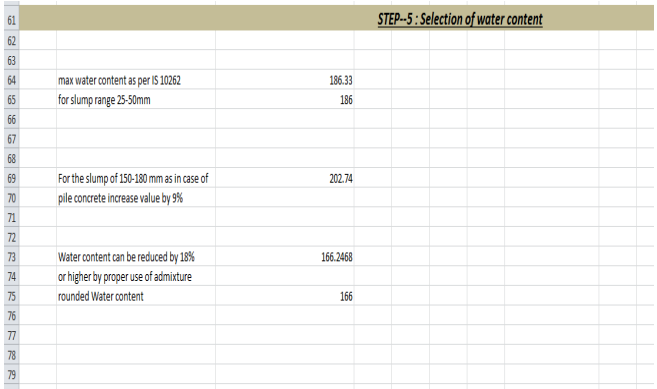

Figure: 5 Step 5 of mix design

3) Following figure shows excel sheet calculating contents of the concrete.

	STEP--6 : Calculation of cement content	
water cement ratio		0.41
cement content		404.8780488
rounded cement content		404.88
	STEP--7 : Propotion of coarse and fine aggregate	
vol of coarse aggregate for W/C=.50		0.65
present W/C		0.41
diffreence		-0.09
change in aggregate content		0.018
total volume of coarse aggregate		0.668
10% vol of coarse aggregate duduction		0.6012
for pumpable concrete		
final volume of coarse aggregate		0.6012
final volume of fine aggregate		0.3988

Figure: 6 Step 6 and 7 of mix design

4) Following figure shows the mix calculation which is done in excel sheet.

	STEP--8 : MIX CALCULATION	
Mix calculation		
Volume of concrete		1
volume of cement		0.128533333
volume of water		0.166
volume of chemical admixture		
ADMIXTURE		
specific gravity		1.145
vol by mass of cement		1.5
volume of chemical admixture		0.005304105
mass of admixture		6.0732
volume of all in aggregates		0.700162562
mass of coarse aggregate		1153.369386
mass of fine aggregate		767.8682816

Figure: 7 Step 8 of mix design

5) The following shows the water/cement ratio curve v/s target mean strength with its equation and how water cement ratio is found with respect to target mean strength.

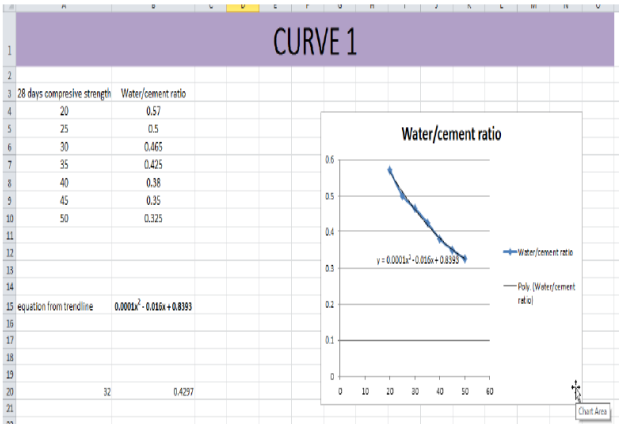

Figure: 8 Curve-1 which is used in excel sheet

6) Following fig show a curve between changes in coarse aggregate with the change in water cement ratio.

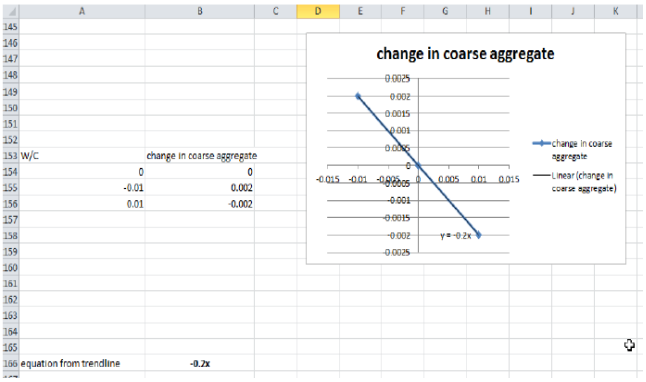

Figure: 9 Curve-4 which is used in excel sheet

4.3. Superplasticizer:

In our case study we used superplasticizer of Conplast SP 430, Conplast SP 550 supplied by Fosrock Company a leading company of admixtures. Both these admixtures are SMF based superplasticizers.
The present mix used at the site is described below in which the admixture used is SMF 40. The mix design is for 1 cubic meter of concrete.

Table: 3 Details of present mix design

Cement in Kg.	400
Water in Kg.	165
Fine Aggregate in Kg.	796
Coarse Aggregate in Kg.	1243
Chemical Admixture (SNF 40) in Kg.	6.1
W/C ratio	0.41

We suggest 4 different types of mix by using above two mentioned admixtures are:
1. Type 1: Admixture Used Fosrock Conplast 430 @ 1.5% of wt. of cement.
2. Type 2: Admixture Used Fosrock Conplast 430 @ 1.7% of wt. of cement.
3. Type 3: Admixture Used Fosrock Conplast 500 @ 1.5% of wt. of cement.
4. Type 4: Admixture Used Fosrock Conplast 500 @ 1.7% of wt. of cement.

The variable study of following different mix was done in our project study the mix of concrete is shown below:

Table: 4 Mix Design of Different types of mixes

Name	Type: 1	Type: 2	Type: 3	Type: 4
Cement in Kg.	419	419	405	405
Water in Lit.	172	172	166	166
Fine Aggregate in Kg.	756	756	768	768
Coarse Aggregate in Kg.	1136	1136	1153	1153
Chemical Admixture	6.1	7	6.1	7
W/C ratio	0.41	0.41	0.40	0.40

Table: 4 Details of material used

Brand of cement	Sanghi cement
Grade of cement	53 Grade
Type of Cement	OPC
Specific gravity of cement in Kg/m^3	3.15
Source of fine aggregate	Orsang River, Sankheda
Specific gravity of Fine aggregate in Kg/m^3	2.75
Source of coarse aggregate	Savelia
Terminology of coarse aggregate	Angular
Specific gravity of coarse aggregate in Kg/m^3	2.74

V. TESTS PERFORMED AND TEST RESULTS:

The test performed are slump test and compressive test for determining the properties of concrete as it also helps to decide the final design mix.

The first step was to determine the slump of the concrete produced the slump test was done as per method of slump test in Indian standards and the result of the same as shown in below table:

Table: 5 Slump Test Results

Name of mix	Slump in mm	Required Slump in mm for Pile concrete as per IS:456-2000
Type 1	160	150-180
Type 2	180	150-180
Type 3	140	150-180
Type 4	180	150-180
Present Design mix (SNF 40)	162	150-180

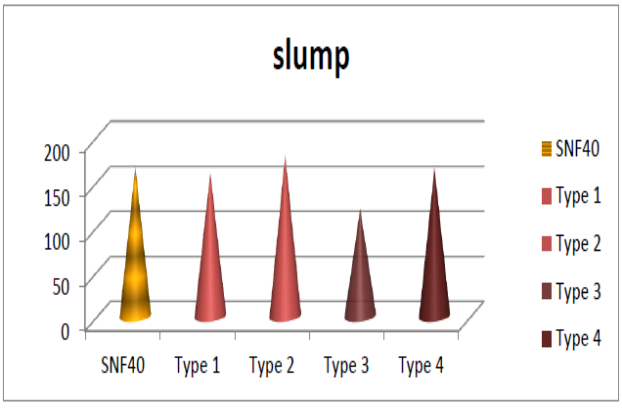

Figure: 10 Slump V/S Admixture Type

Based on the test results two of mixes type 1 and type 2 best matches the result criteria so two mixes are selected for doing compression test. The compression test was performed as per Indian standards and the test results are shown in below table:

Table: 6 Compressive Strength Test Results

Sr. No.	Name of mix	7 days Average Compressive Strength in N/mm^2	28 days Average Compressive Strength in N/mm^2
1	Type 1	34.22	46.81
2	Type 2	N/A	N/A
3	Type 3	N/A	N/A
4	Type 4	34.81	47.85
5	Present Design mix (SNF 40)	36.15	47.56

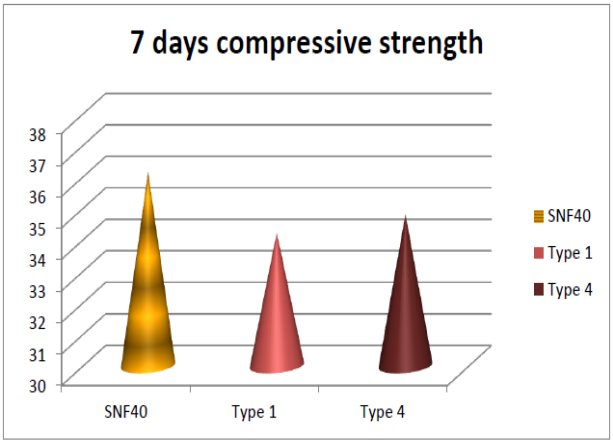

Figure: 11 7 Days Comp. Strength V/S Admixture Type

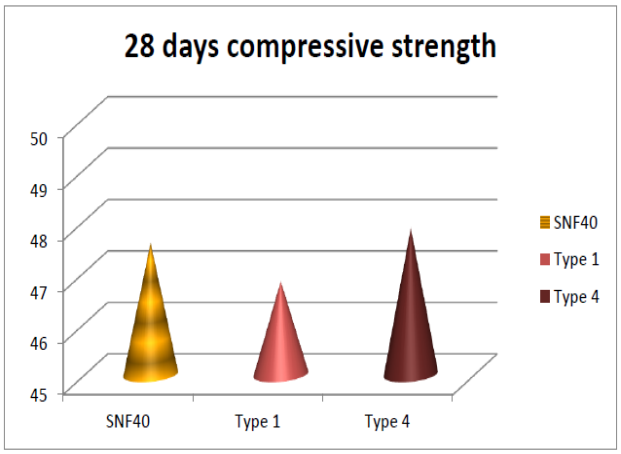

Figure: 12 28 Days Comp. Strength V/S Admixture Type

VI. CONCLUSION:

On the basis of above test results we can conclude that both the different chemical admixtures (i.e. SNF 40, Fosrock Conplast 430 and Fosrock Conplast 500) produces workable and high strength concrete. Though strength of concrete produced with superplasticizer fosrock conplast 500 is higher but it has some problems with slump and also the cost of production also increases.

REFERENCES

[1] A.Verhassete and J.pairon, "Rapid methods of distinguishing plasticizers from superplasticizers and assessing superplasticizers dosage, in superplasticizers and other chemical admixture in concrete", proc. third

international conference, Ottawa, ed.v.mmalhotara, ACI SP-119, pp. 133-56, Detroit,Michigan,1989.

[2] E.Hana, K. Luke, D.Perraton and P.C. Aiticin, "Rheological behavior of Portland cement in the prescence of superplasticizer, in superplasticizers and other chemical admixture in concrete" , proc. third international conference, Ottawa, ed.v.mmalhotara, ACI SP-119, pp. 171-88, Detroit,Michigan,1989.

[3] E.Ishta and A Verhasset , "Chemical characterization of plasticizer and superplasticizer, in superplasticizer and other chemical admixture in concrete" , proc. third international conference, Ottawa, ed.v.mmalhotara, ACI SP-119, pp. 99-116, Detroit,Michigan,1989.

[4] F massaza and M. Testolin , "Latest development in the use of admixture for cement and concrete", il cement, 77, no. 2, pp.73-146, 1980.

[5] G. Chiocchio, T.Mangialardi and A. E. Paolini, "Effects of addition time of superplasticizer in workability of Portland cement pastes with different mineralogical compositions", IL Cemento, 83, no. 2, pp. 69-79,1986.

[6] V.M. Malhotara, "Superplasticizer in concrete, cement report MRP/MSl77-213", 20 pp., Canada centre of mineral and energy technology, Ottawa, aug. 1977.

[7] V.M Malhotara, "Superplasticizers, aglobal review with emphasis on durability and innovative concretes in superplasticizer and other chemical admixtures in concrete", proc. third international conference, Ottawa, ed.V.M Malhotara, ACI SP-119, pp. 1-17, Detroit,Michigan,1989.

[8] Tomlinson, M.J. Foundation engineering, ELBS, Longman Group, U.K. Ltd., England 4th edition, 1995.

[9] J.J. Brooks, P.J.Wainwright and A.M.Neville, "Time-dependent properties of concrete containing superplasticizingadmixture,in superplasticizers in concrete", ACI SP-62, pp. 293-314, Detroit, Michigan,1979.

[10] Trimie concrete, methods of placing concrete under water by W.Malisch

[11] IS 2911(PART-1 SEC-1) code of practice for design and construction of pile foundation.

[12] IS 2911(PART-1 SEC-2) code of practice for design and construction of pile foundation.

[13] IS 2911 (Part 1/Sec 3) : 2010 design and construction of pile foundations code of practice.

[14] IS : 2911 (Part III) – 1980 code of practice for design and construction of pile.

[15] IS 2911 (PART 4) code of practice for design and construction.

[16] IS 9103 : 1999 -concrete admixtures – specification.

[17] B C Punamia, Soil Mechanics And Foundation 16th edition Dec 10, 2010.

[18] Properties of concrete, fourth and final edition by A.M. Neville.

[19] www.onlinecivil.net

[20] www.academia.edu

[21] www.science direct.com

[22] www.fosrock.com

[23] www.concrete.org