Experimental Approach to Study Performance of RMC Plants in Western Maharashtra: Case Study

Hanumant P. Naiknavare, Sushma S. Kulkarni

Abstract— Increase in the use of concrete in construction has brought with it a rapid increase in the number of ready mixed concrete plants.In order to ensure that concrete produced is of desired quality, it is necessary that quality control is exercised at all the stages right from receipt of raw material to delivery of concrete at site. Thus, while planning to use Ready Mixed Concrete (RMC), it should be ensured that producer of RMC has adopted quality assurance programme. This paper is an attempt to study the effect of proposed schematic RMC process chart and type of fly ash on performance of RMC plants in western Maharashtra. This paper presents the results of an experimental study carried out to determine the concrete compressive strength at different RMC plants using fly ash. The various control charts are drawn to know the corrective measers to be takenduRMC production. The used fly ash may be classified or unclassified. The tests are carried out in accordance with IS standards. In this study, standard deviation of RMC plants with classified fly ash & unclassified ash was also investigated. From the results, it can be concluded that, performance of RMC plant is significantly affected by schematic RMC process chart and type of fly ash.

Index Terms— RMC, Case study, Schematic RMC Process Chart, Classified Fly Ash, Concrete Strength, Plant Deviation, Contol Charts.

1 Introduction

As per Indian Standard code of practice (IS 4926 - 2003) Ready Mixed
Concrete (RMC) is defined as the concrete delivered in plastic condition and requiring no further treatment before being placed in position in which it is to set and harden. RMC is a specialized material in which the cement, aggregates and other ingredients are weigh-batched at a plant& mixed in a central mixer or truck mixer, before delivery to the construction site in a condition ready for placing. Thus, `fresh' concrete is manufactured in a plant away from the construction site and transported within the estimated journey time. Ready mix concrete is produced under factory conditions and permits a close control of all operations of manufacture and transportation of fresh concrete

This study was undertaken with an objective to compare the quality control variation analysis of RMC plants from Western Maharashtra. In order to do so, five RMC plants were selected four of them are using Fly ash as ingredient in manufacturing of RMC.

2 Materials

The raw material used to produce RMC, at plants under study are as below.

2.1 Cement

All plants under study use (OPC) Ordinary Portland Cement. Two common cement grades are used in RMC plants under study, i.e. OPC 43 and OPC 53. Their source is from three different cement factories.

2.2 Aggregates

The aggregates used are crushed basalt stone with desired gradation. The coarse and fine aggregates used in plants under study are confirming IS 383-1998

2.3 Water

Bore well water is commonly used as mixing water in all of the plants under study. The PH value test is performed on bore well water before use.

2.4 Fly Ash

Fly ash is used in all RMC plants under study. It may be classified or unclassified. Basically fly ash is comprised of the non combustible mineral portion of coal. When coal is consumed in a power plant, it is first ground to the fineness of powder. Blown into the power plant's boiler, the carbon is consumed—leaving molten particles rich in silica, alumina & calcium. These particles solidify as microscopic, glassy spheres that are collected from the power plant's exhaust before they can "fly" away---hence the product's name: Fly Ash

Changes in boiler operations or alteration of air emissions control systems at power plants will alter the quality of fly ash produced. Factors that may impact fly ash quality in this way include:

1. A reduction in the pozzolanic reactivity caused by increased proportion of coarse particles.
2. The presence in the fly ash of excessive unburned carbon (UBC),
3. Chemical residuals from post-combustion emission control.

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There are two standard processes to achieve consistent particle size control for fly ash.

1. Screening: -It is common practice to use screens to remove coarse particles from powdered products. Typical fly ash has a large proportion of the particles (typically more than 50 percent) finer than 45 micron. The use of coarse screens (100 or 80 mesh), might be effective for the removal of most of the coarse particles, many of which comprise UBC.
2. Air classification:-Classification systems that use air to separate particles by size and weight are also used to retain the finer ash proportion. Air classification may be performed on ash for the removal of coarse particles or the selective concentration of fine particles.

From this, classification of fly ash means separation of particles according to size and fulfilling standard characteristics as per IS 3812 (Appendix A). There are two different fly ash suppliers supplying the classified and unclassified fly ash to RMC plants under study. The fly ash is purchased in bunkers and stored in silos at RMC plants. The specifications for fly ash supplied are available and provided by supplier as per Appendix A.

3 Mode of Data Collection

To study the performance for quality control and monitoring for RMC industry, the data have been collected from five operational RMC plants, which are from Western Maharashtra (India). The grades of concrete produced are M15 to M50 with both 43 and 53 grade cements, at every RMC plant under study. One plant from Nandani, District Kolhapur, has a production capacity of 30 cu m / hr. This is referred as Case I. This plant is using unclassified fly ash. The other plant from Solapur district is with a production capacity of 30cu m/hr. This plant has been set up by a contracting organization for supplying concrete for their in-house projects also. This is referred as CASE II. This plant uses classified fly ash. The plant of Pune district is fully automatic and has production capacity of 30 cu m / hr. This plant is using fly ash of brand name "Tech pozzo",which is considered as classified fly ash supplied from Parali thermal power station. This is referred as CASE III. The other plant from Kolhapur district is semi automatic with a production capacity of 30cu m/hr. This plant is using fly ash brand name "Bell ash "which is unclassified fly ash. This is referred as CASE IV. The fifth plant is from Phaltan, District Satara (IVRCL Group) which is semi automatic with a production capacity of 30 m^3/hr. This plant has been set up by an organization for supplying concrete for their in-house projects only. This is referred as CASE V. There is no silo in this plant for storing cement. Fly ash is not used in this plant. Data is collected through questionnaire and observations made at plants.

4 Schematiic RmcProcess Chart

In this present research, a schematic RMC Process chart is prepared and which is accepted by RMC Plant (Case II). It is shown in figure 1.

In this process chart, the quality control laboratory is equipped with sophisticated instruments and manned by trained and widely experienced personnel. By using this schematic process chart, it is observed that, the quality is monitored at every stage, right from receipt of raw material to dispatch and placing of concrete, which ensures that consistent quality reaches the customer. The incoming materials particularly raw materials like cement, coarse aggregate 10 mm, coarse aggregate 20 mm, fine aggregate, admixtures should be subjected to testing as per adopted acceptance sampling plan. For this the supplier is identified and certain prequalified documents are verified, e.g. Government tax clearance, black listed supplier etc. A scheme for the basic tests to be conducted for raw materials, fresh concrete and hardened concrete along with their frequency of testing.

The Figure No 1 shows various steps of the work to be done are explained below.

1) Mix Design: This is the step done the mix design is very important step. The various quantity of material is decided at this step. The tested or received material is supplied to the laboratory where Mix design is done. This laboratory should be approved or authorized to do the mix design.

2) Approved by Authority: In this step the manager in charge or panel of directors should approve the Mix design, and then forward it to quality control department for next action.

3) The Establishment of QC/ QA Laboratory: It is important step in RMC process. For this unit the service from mix design unit is supplied, and this unit casts the cubes as per given mix design and verifies the target strength, if target strength, is satisfactory, then this Mix design is confirmed and data is send to central Mixture plant as recipes. And if target strength is unsatisfactory then, the data from Mix design is send back for revision/ redesign or resolution.

4) Receive in Coming Material: This step gives the idea to inventory stock, as and when required the material i.e. cement, sand, aggregates admixture is purchased

5) Testing and Inspection: This is the stage, where the quality of incoming material is checked. Three various activities are done i.e. (i) quality checking, (ii) visual checks, and (iii) if the same material from same source is coming at the stock, and the testing as per IS code is previously done. Acceptance of sampling is next step. This gives the requirement of field tests e.g. fields' tests on aggregates and cement if necessary are carried out. But if any material coming from new location or material with new brand, the laboratory testing becomes necessary. The aggregates are tested according to IS 383-1998, and cement according to grade of cement. But the loose cement i.e. about 14 tones is purchased at a time, and then the factory testing is cheeked.

6) Material Stored: The material should be stored in such a way that, it should not lose its standards. The aggregates should not get mixed with each other. The moisture should not come in contact with material. Sufficient quantity of the material should be at the stock.

7) Central Pan Mixture: This is the heart of RMC plant. Here the mix design data supplied from QC/QA unit. As a recipe for various mixes i.e. M 15, M 20, M 35 etc., as the case may be. The pan mixture is horizontal with single or double shaft. In pan mixture the material is feed by weight. The computer controlled hydraulic jacks are used to feed each material for particular mix design. The concrete from pan mixture is directly supplied to transit mixture.

8) Final Mixed Concrete: It is the output of pan mixture; here to check the quality, the cubes are casted by QC/QA unit, while the transit mixture is leaving the RMC plant. At this stage the slump and temperature is observed, if satisfactory the transit mixture is allowed to go further; if not corrective measures are taken by QC/QA unit.

9) Loading Transit Mixure: The transit mixture is taken to weighing balance to know the weight of concrete. It helps in calculating the density of wet concrete. It also helps, to

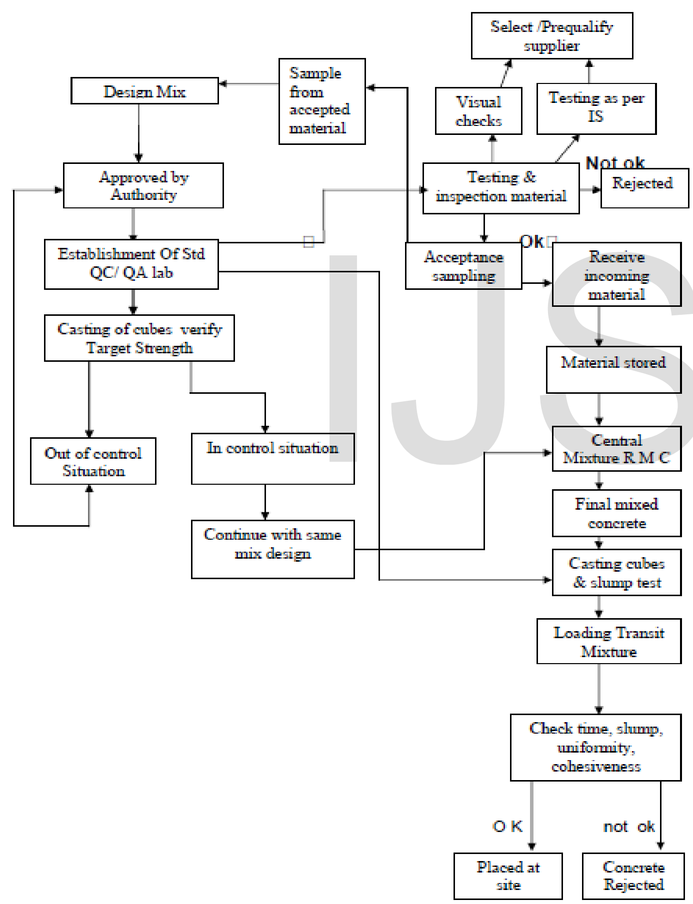

Figure No 1 Schematic process chart for RMC plants.

know exact quantity of concrete supplied, if partly concrete is delivered from transit mixture.

10) Check the slump of concrete: At the time of delivery on site, sample from transit mixture is taken out, slump test is carried out, the temperature and uniformity is checked if the test found OK then only concrete is allowed to place at site, if not OK then concrete is to be rejected. The concrete is taken back to RMC plant, investigation is done and defects are taken out such that no more such failure should occur.This schematic RMC process chart is used in at Solapur RMC plant (Case II).

In this study, the type of fly ash used as an ingredient is also considered.

The two plants referred as Case II and Case III are using classified fly ash, where as Case I and Case IV are using unclassified fly ash for production of RMC, where as Fly ash is not used in Case V. To study the performance of RMC plants, data is collected through questionnaire and observations. (Appendix AI) The cube compressive strength of 28 days curing for M20 concrete grade is collected for study (Appendix C)

5 Analysis of Case Studies

For study, cube compressive strength data from RMC plants in slot of two months (20.08.12 to 04.11.12) is collected vide Case I, II, III and IV. Here "M20" is the specified grade of concrete where "M" is Mix and 20 is the characteristic compressive strength at 28 days. In our case it is 20 N/mm2 or 20 Mpa. A systematic procedure of casting and curing is followed. The cubes are tested on hydraulically operated compressive strength testing machine. The results are presented in (Appendix C).

A comparative presentation of all the samples collected from Cases I, II, III, IV and V along with the calculated range of strength (minimum and maximum), mode, and plant standard deviation is presented in Table No 1.

Table No. 1 Statistical parameters about concrete strength at different RMC plants

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Parameter	Case I	Case II	Case III	Case IV	Case V
Mean(MPa)	25.83	24.72	23.25	26.75	25.39
Minimum (MPa)	21.33	20.44	19.11	19.33	23.70
Maximum (MPa)	31.11	26.67	31.11	32.54	27.26
Mode(MPa)	24.44	24.89	26.67	26.59	25.78
Standard deviation	2.05	1.48	2.62	3.39	0.80
UWL(MPa)	29.93	27.69	28.49	33.53	26.99
LWL(MPa)	21.72	21.75	18.00	19.97	23.79
U C L(MPa)	31.99	29.17	31.11	36.92	27.79
L C L(MPa)	19.66	20.27	15.38	16.58	22.99
UWL(MPa)	29.93	27.69	28.49	33.53	26.99

6 Experimental Details

6.1 Test Results

Concrete test samples are colleted from transit mixture before leaving the plant. The concrete cube test is considered for quality of RMC manufactured. After twenty eight days of the curing, the concrete cube samples were removed from curing tank & tested accordance with IS 456-2000. The compressive strength results from RMC plants under study are given in Appendix C.

6.2 Data Control Charts

While graphical plots can give useful information about the pattern of a production process, the control chart becomes a much more powerful tool if statistical rules are also applied to the data. Shewhart control systems measure variables in the production processes (e.g. target mean strength).They make use of calculated control limits and apply warning limits based on the measured variation in the production process.

The Shewhart chart will have a horizontal central line which represents the expected mean value of the test results on the samples taken from production; in the case of concrete, the Target Mean Strength for a chart controlling compressive strength. Lines representing the upper control limit (UCL) lower control limit (LCL), upper warning limit (UWL) and lower warning limit (LWL) may also be added. Generally action is required if a result is beyond either of the control limits.

The UWL and LWL are set at a level so that most of the results will fall between the lines when a system is running in control. These are not specification limits but 'warning' limits based on the variability of the production process.Therefore in practice, both upper and lower warning limits are used even for a variable that has a single limit value, e.g. concrete strength. Setting upper and lower warning limits at 1.96s leads to the expectation that 95% of the results will fall within these limits and 2.5% in each of the 'tails' of the normal distribution. If a margin of 3.0 x s is adopted, there is very little chance of a result falling outside this limit due to natural variation. A Shewhart control chart can be constructed with

UCL = TMS + 3 x s
LCL = TMS – 3 x s
UWL = TMS + 2 x s
LWL = TMS – 2 x s

The values for plants under study are tabulated in table No 1. The charts are drawn and presented from **Figure No 2 to Figure No 6.**

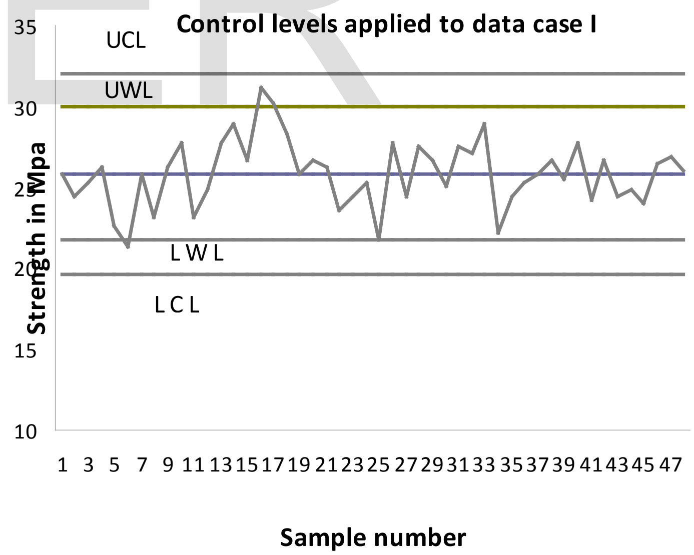

Figure No.2 Graph showing control levels for concrete strength for RMC plant case I

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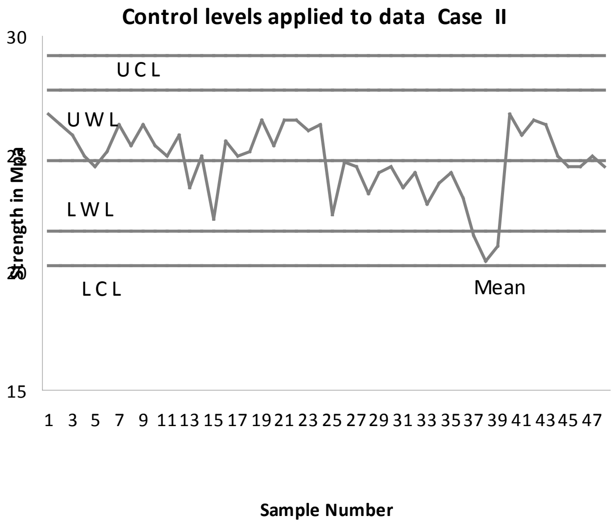

Figure No.3 Graph showing control levels for concrete strength for RMC plant case II

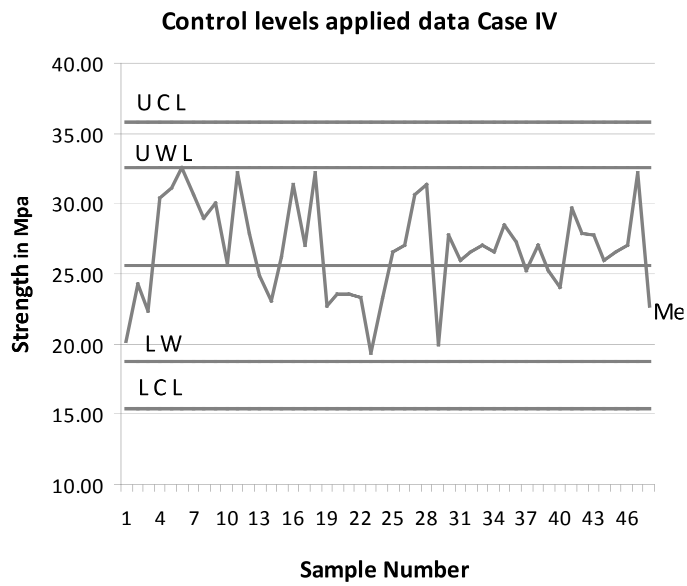

Figure No.5 Graph showing control levels for concrete strength for RMC plant case IV

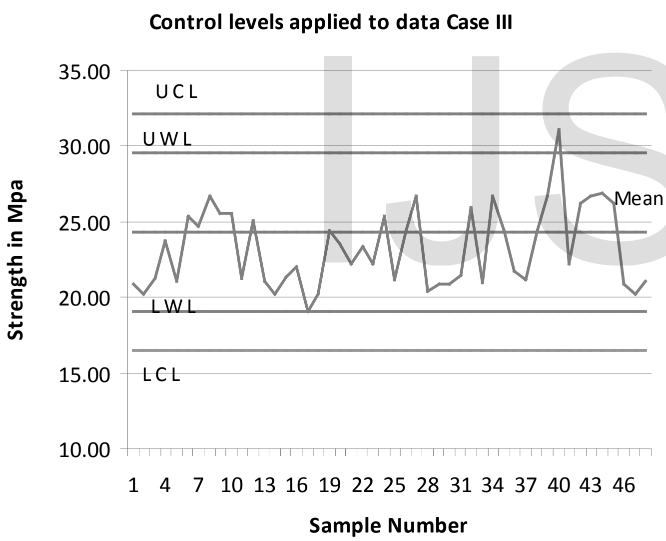

Figure No.4 Graph showing control levels for concrete strength for RMC plant case III

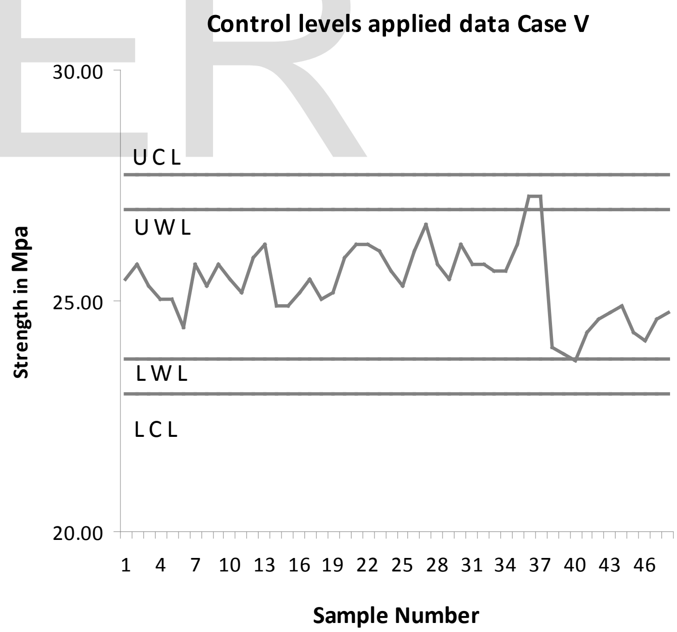

Figure No.6 Graph showing control levels for concrete strength for RMC plant case V

7 Result & Discussion

The table no 3 shows the plant's deviation in producing RMC. The plant in Case II is having lowest standard deviation value. In this table there is highest standard deviation for RMC plant in Case IV, i. e. 3.39. To produce consistent Ready mixed concrete this value of standard deviation should be as less as possible.

The table no 1 gives Statistical parameters about concrete strength at different RMC plants. These values are of strength for M20 grade of concrete. With this values and strength (Appendix C), the quality control chart is drawn for all RMC plants.This chart is useful to check the productin quality level , if graph reaches the warning level of chart then certain measures are taken to produce consistant concrete. If chart shows graph beyond control levels, it indicates poor production of concrete.

In the figure no 2 to figure no 6, it is observed that, the Case II show less fluctuations in compressive strength amongs the RMC plants using fly ash. In the figure no 6 the graph shows good production control of RMC. But as this plant is not using flyash the concrete is costy. Now from other four RMC plants Case II is showing better performance.

This study also shows the use of fly ash in concrete. The fly ash may be classified or unclassified. There are standerds for fly ash (annuxure I) in India as wellas in other countries.
In this study various percentage of fly ash is used by different RMC plants. The maximum is 32% used by Case II. The Schematic RMC process chart is also implemented at Case II.

8 Conclusion

The study shows that optimal performance is achieved by replacing up to 32 % of the cement with classified fly ash. While it is possible to use less, then benefits are not fully realized. The use of fly ash in concrete becomes eco friendly, With this experimental results it can be concluded that, to monitor the standard deviation of RMC plant and control the fluctuations in the compressive strength of concrete after 28 days, the use of Schematic process chart is necessary. Similarly, as RMC plant using classified fly ash shows less variation in compressive strength. The unclassified fly ash should be treated and converted to classified one, so that it gives good results.

9 Aknowledgement

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Appendix A
National Codes for Fly ash

Sr.No	Characteristics	Unit	ASTM C-618 Class F	BS 3892	IS 3812	Tech pozzo™ Classified fly ash
1	Fineness % retained on 45 micron in wet sieving	%	34.0	12.0	34.0	Below 18%
2	Loss on lgnition (Max) study.	%	6.0	7.0	5.0	0.82
3	Moisture Content	%	3.00	2.0	2.00	1
4	Sio2(silicon dioxide)+ AL_2O_3(aluminum oxide) + Fe2O3(iron oxide)	%	70.0 min	Not Speci-fied	70.0 min	96.79
5	SiO_2 Silicon dioxide	% Speci-fied	Not Speci-fied	--	35.0 min	61.16
6	MgO	%	-	--	5.0 max	0.50
7	SO_3	%	5.0 max	2.0 max	3.0 max	0.37
8	Na2O	%	Not Speci-fied	Not Speci-fied	1.5 max	Below 1.5

Appendix B

Observations at different RMC plants

Item	Case I	Case II	Case III	Case IV	Case V
Plant model/ make	CP 30 Schwing Stetter	CP 30 Schwing Stetter	CP 30 Universal	CP 30 Schwing Stetter	CP 30 Universal
Mix designed by	Own Design at site	S V Design Solutions Mumbai	Duracrete Lab Pune	Walchand college at Sangli	Own Design at site
Mini. Cement content Kg/m^3	240	260	235	260	325
Days within which cement is used for production	10 to 12 Days	2 to 3 Days	8 to 10 Days	4 to 5 Days	1 to 5 Days
Use of fly ash	Yes 28 to 33 %	Yes 32 %	Yes 31 %	Yes 18 to 20 %	No
Source of fly ash	"Bel ash" Jaygad Dist. Ratnagiri	"Tech pozzo" Parali, Dist. Beed	"Tech pozzo" Parali, Dist. Beed.	"Bel ash" Jaygad Dist. Ratnagiri	--------
Production Mini. per day m^3	15	06	20	30	06
Production Maxi. per day m^3	150	230	175	180	190
average production per day m^3	55	100	55	50	50
Time for batch mixing	15 sec	15 sec	20 sec	20 sec	35 sec
Slump Test	Yes 170 to 180	Yes Pumping 120 Dumping 100	Yes 110 + 10	Yes Pumping 170 Dumping 100	Yes 100+20
Dose of Admixture	2.1 lit /m^3	2.6 lit /m^3	2.36 lit /m^3	2.4 lit /m^3	3.25 lit/m^3

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Appendix C
Concrete cube strength in Mpa after 28 days of curing of RMC plants

Sample	Case I	Case II	Case III	Case IV	Case V
1	25.77	26.67	20.89	20.15	25.48
2	24.44	26.22	20.22	24.33	25.78
3	25.33	25.78	21.22	22.37	25.33
4	26.22	24.89	23.72	30.37	25.04
5	22.66	24.44	21.11	31.12	25.04
6	21.33	25.11	25.33	32.54	24.44
7	25.77	26.22	24.65	30.69	25.78
8	23.11	25.33	26.67	28.97	25.33
9	26.22	26.22	25.56	30.08	25.78
10	27.78	25.33	25.56	25.72	25.48
11	23.11	24.89	21.22	32.26	25.18
12	24.88	25.78	25.11	27.90	25.93
13	27.77	23.55	21.11	24.85	26.22
14	28.88	24.89	20.22	23.10	24.89
15	26.67	22.22	21.33	26.16	24.89
16	31.11	25.55	22.00	31.39	25.19
17	30.22	24.89	19.11	27.00	25.48
18	28.22	25.11	20.22	32.26	25.04
19	25.77	26.44	24.44	22.70	25.18
20	26.67	25.33	23.56	23.58	25.93
21	26.22	26.44	22.22	23.56	26.22
22	23.55	26.44	23.33	23.33	26.22
23	24.44	26	22.22	19.33	26.08
24	25.33	26.22	25.33	23.33	25.63
25	21.77	22.44	21.12	26.59	25.33
26	27.78	24.67	24.44	27.03	26.08
27	24.44	24.44	26.67	30.66	26.67
28	27.55	23.33	20.44	31.33	25.78
29	26.66	24.22	20.89	20.00	25.48
30	25.11	24.44	20.89	27.77	26.22
31	27.55	23.55	21.44	26.00	25.78
32	27.11	24.22	25.89	26.59	25.78
33	28.88	22.89	21.00	27.03	25.63
34	22.22	23.78	26.67	26.59	25.63
35	24.44	24.22	24.44	28.53	26.22
36	25.33	23.11	21.74	27.33	27.26
37	25.78	21.55	21.12	25.29	27.26
38	26.67	20.44	24.44	27.03	24.00
39	25.53	21.11	26.67	25.29	23.85
40	27.78	26.67	31.11	23.98	23.70
41	24.22	25.78	22.22	29.65	24.30
42	26.67	26.44	26.22	27.90	24.59
43	24.44	26.22	26.67	27.77	24.74
44	24.88	24.89	26.89	26.00	24.89
45	24.00	24.44	26.22	26.59	24.30
46	26.44	24.44	20.89	27.00	24.15
47	26.89	24.89	20.22	32.26	24.59
48	26.00	24.44	21.11	22.70	24.74