Tests on Quality Control of Ready Mixed Concrete

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Abstract- *Concrete is one of the most important components in the construction industry. Hence quality of concrete plays a vital role in structures. The quality of concrete has direct effect on the strength and durability of a structure. Construction sites have limited equipment in their quality control laboratory. Hence proper material tests are not done on site. To make concrete strong and durable testing of all ingredients of concrete is necessary which are done daily or weekly in Ready Mix Concrete plants. Ready-mix concrete (RMC) is a ready-to-use material, with predetermined mixture of Cement, sand, aggregates and water. RMC is a type of concrete manufactured in a factory According as per specifications of the customer, at a centrally located batching Plant. It is then send or Delivered to a worksite, often in truck mixers capable of mixing the ingredients of the concrete.*

Keywords- Concrete, Quality Control, Onsite test, Ready Mix Concrete

I. INTRODUCTION

Construction is the second largest industry in India, next only to agriculture and concrete is the largest man made material of construction all over the world. Ready Mixed Concrete (RMC) is preferred to on site concrete mixing because of the precision of the mixture and reduced work site confusion. It assures consistent quality through accurate computerized control of aggregates and water as per mix designs. It minimizes cement wastage due to bulk handling and there is no dust problem and therefore, pollution free. As per Indian Standard 4926:2003 Ready Mix Concrete is defined as the concrete deliver in plastic condition and requiring no further treatment before being placed in position in which it is to set and harden.

Ready Mix Concrete is specialized material in which concrete ingredients are weigh-batch at a plant in a central mixer, before delivery to the construction site. In the case of a centrally mix type, the drum carrying the concrete revolves slowly so as to prevent the mixed concrete from "segregation" and prevent its stiffening from initial set. This paper represents how one can produce consistent quality of concrete. To make good quality concrete it very necessary to test the raw material of concrete on daily or weekly basis.

This paper represents the maintenance of quality of Ready Mix Concrete. As the Ready Mix Concrete is widely used all over the world hence consistent quality concrete is necessary. The main objective of this paper is that the QA/QC engineer in RMC plant and site civil engineer should have the knowledge of advantages of Ready Mix Concrete over the site mix concrete. This paper will also help to the fresher's in maintaining the quality of concrete. The engineer will going to know what will be the steps for making good quality of Ready mix Concrete. With effective strength, workability & durability

II. NEED OF READY MIX CONCRETE

Ready Mix Concrete has following advantages over the site mix concrete:

- Ready Mix Concrete has better quality than the site mix concrete because of sophisticated equipment for batching and other process of making concrete.
- Use of Ready Mix Concrete increases speed of construction. Typically site mix concrete is produce at the rate of 4-5 m3 per hour, where a basic RMC plant can produce 60m3 per hour, with the larger plants producing much more.
- With the use of RMC, customers are not required to procure and store cement, aggregates, sand, water and admixtures at site. This not only drastically reduces the space requirements at construction sites but also minimizes efforts on the part of customers to procure different materials, ensure their proper storage and check their quality parameters from time to time.
- Site-mixed concrete is a labour-intensive operation and managing lage labour force is a big hassle for the customer. With the use of RMC the labour requirements are minimized considerably, thus benefiting customers. Further, as RMC-India looks after the entire QA & QC needs, the customer"s manpower requirement for QA & QC operations is minimized. This is a saving for the customers.
- In site-mixed concrete job, wastage occurs in handling of all materials, including cement. The latter is generally of the order of about 2-3 kg per 50 kg bag of cement. All such wastages are considerably minimized at RMC facility.

- Use of Ready Mix Concrete is also eco friendly.

III. MATERIAL

Cement:

Cement is a binder material which sets and hardened independently. Cement can bind other ingredients of concrete together. Cement has following chemical composition:

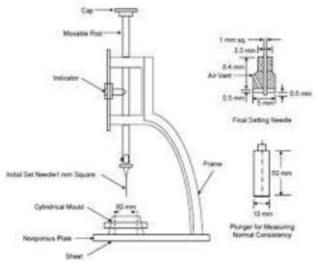
INGREDIENTS	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	Alkalies	SO_3
AMOUNT(%)	60-67	17-25	3-8	0.5-6	0.1-4	0.4-1.3	1.3-3

Cement used for making concrete should have fulfilled following requirements:

S. N.	Characteristics of Cement	Value specified by IS 8112:1989
1.	Specific gravity	3.15
2.	Standard consistency	25-35%
3.	Initial setting time	30 minutes
4.	Final setting time	600 minutes
5.	Compressive strength	7day 28day
	OPC33 (IS269:1989)	23N/mm² 33N/mm²
	OPC43 (IS8112:1989)	33N/mm² 43N/mm²
	OPC53 (IS12269:1987)	37N/mm² 53N/mm²

Apparatus required for cement tests:

1 Vicat Apparatus – Vicat apparatus conforming IS:5513:1976.



Standard consistency, initial setting time, final setting time and compressive test for cement should confirm Indian Standards 4031 (Part 4 to Part 6).

Aggregate:

Aggregates are important ingredient in concrete. They give power to the concrete. In RMC plant aggregate are stored in bins, either on ground level or elevated. The aggregates have occupied 70-75% volume of a concrete.

Aggregates are divided into two categories from the size consideration

Coarse Aggregate

Fine Aggregate

The size of the aggregate more than 4.75 mm are consider as coarse aggregate and below 4.75 mm are consider as fine aggregate.

Sampling:

All aggregates are to be sampled before taking them to testing. Sampling is done either by Riffle machine or by hand. The slot of Riffle machine should be less than 1.5 times the largest aggregate size. The other process of sampling is as follows:

1. Collect the aggregates from different locations and from different depths from the bins immediately after unloading of truck. Collect the samples at least from 10-15 different locations.

- Then thoroughly mix the material.
- Then make divide that material into four equal quarters.
- Discard any two diagonally opposite segment of quartered sample.
- Collect the remaining two samples and remix.
- Now take this remaining sample or aggregates for testing.

Tests carried out for aggregates used for concrete

1. Sieve Analysis/Particle size distribution/Grading-

COARSE AGGREGATE	FINE AGGREAGATE
80 MM	4.75MM
63MM	2.36MM
40MM	1.18MM
31.5MM	0.600MM
25MM	0.300MM
20MM	0.150MM
12.5MM	0.075MM
10MM	
6.3MM	
4.75MM	

Fine aggregate used for concrete should confirm one zone among the four specified by Indian Standard 383:1970. Zone of aggregate is determined by percentage of aggregate passing through 600 micron sieve.

2. Moisture Content:

Moisture content is determined by using oven or hot plate. It is expressed as percentage.

Moisture content= WET weight of sample – DRY weight of sample

DRY weight of sample

3. Specific Gravity and Water Absorption:

Specific gravity of fine aggregate is determined by Pycnometer and that of coarse aggregate is determine by basket Method. Specific gravity of aggregates test should be done as per Indian Standard 2386 (Part 3)-1963.

4. Aggregate Impact value:

The aggregate impact value may be determined the aggregate impact value may be determined in accordance with the method specified in IS: 2386 (Part IV)-1963. The aggregate impact value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces and 30 percent by weight for concrete for wearing surfaces, such as runways, roads and pavements.

5. Aggregate crushing value:

It is an alternative method for Aggregate Impact value test. This test is also done the aggregate impact value may be determined in accordance with the method specified in IS: 2386 (Part IV)-1963. The aggregate crushing value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces and 30 percent by weight for concrete for wearing surfaces, such as runways, roads and pavements.

6. Flakiness and Elongation Index:

As per Indian standard 2386:1963 (Part 1) the Flakiness Index of an aggregate is the percentage by weight particles in it whose least dimensions or thickness is less than three-fifths of their mean dimension. This test is not applicable for aggregate of size smaller than 6.3 mm. Flakiness Index in excess of 35 to 40% is undesirable.

The Elongation Index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifths times their mean dimension. Normally, the properties of interest to the engineer are Sufficiently covered by the flakiness Index test. The elongation test is not applicable to sizes smaller than 6.3 mm.

IV. FLY ASH

Fly ash is a by- product of coal-fired electricity generating power plant. The coal used in these power plants is mainly composed of combustible element such as carbon, hydrogen and oxygen. Use of fly ash improves quality of concrete, by making it strong, more durable and more resistant to chemical attack. Fly ash particles less than 10 micron are contributed to the 7 and 28 day strength. Particles between 10 to 45 micron are contributed to the strength after 28 day up to one year.

The fly ash fineness is determined by wet sieving through a 45 micron sieve following Indian Standard 460:1962. Fineness of fly ash is also determined by Blain‟s air permeability method following by Indian Standard 1727:1967. Indian Standard 3812:2003 (Part1) specifies that fineness of fly ash by Blain‟s air permeability method should be more than 320m ²/kg, which is a maximum of 34% residue on 45 micron sieve and IS 3812:2003 (Part 2), specifies 200 m²/kg fineness corresponding to the residue on 45 micron sieve of maximum 50%. Fly ash is generally used in concrete as partial replacement of cement up to 10% to 15 %. This replacement gives good strength, more workability and more durability to the concrete.

V. GROUND GRANULATED BLAST-FURNANCE SLAG (GGBS)

GGBS is a by-product of iron and steel manufacturing industries. It is obtained by quenching molten iron slag from a blast-furnance, in water, to produce a glassy fine powder. While making concrete GGBS can replace cement from 25% to 75%. Typically 30% to 50% replacement is widely used. Concrete made with GGBS sets more slowly than normal concrete. Concrete made using GGBS continues to gain strength over a long period. Use of GGBS in concrete enhances properties like durability, workability and strength of a concrete. Use of GGBS reduces the risk of damage caused by alkali silica reaction; it provides higher resistance to chloride and sulphate attack.

Admixtures:

A material other than cement, aggregate, water and other additives like pozzolana or slag added to the concrete batch immediately before or during the its mixing to modify one more of the properties of concrete in the plastic or harden state. There are different types of admixture are as follows:

a) Accelerating admixtures: It accelerates setting of concrete. It is mainly used in cold weather concreting.
b) Retarding admixtures: It expands the setting time of concrete. It is mainly used in hot weather concreting.
c) Water- reducing admixtures: This reduces the amount of water without affecting workability of concrete.

d) Air-entraining admixtures: It is mainly used in concrete exposed to freezing and thawing conditions.

e) Super-plasticizing admixtures: it is used to significantly reduce the water content while maintaining workability and to gain high strength. Generally admixture is used 0.5% to 1% of weight of total cementations material i.e., (cement+flyash+GGBS).

In Ready Mix Concrete Plant admixtures mainly perform the following functions:

- Reducing water content and hence increasing strength.
- Increasing durability of concrete.
- Accelerating and decreasing setting time of concrete.
- Avoiding segregation and bleeding in concrete.
- Increasing pump ability of concrete.

Water:

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The pH value of water should not be less than 6. Water stored in curing tank should be replaced with clean water at least in a week. Water found satisfactory for mixing is also suitable for curing of concrete which confirms Indian Standard 456:2000. Water used for concrete should have following limits

PERMISSIBLE LIMIT FOR SOLIDS (IS456:2000)			
SR. NO.		TESTED AS PER	PERMISSIBLE LIMITS(MAX)
1.	Organic	IS 3025 (Part 18)	200 mg/l
2.	Inorganic	IS 3025 (Part 18)	3000 mg/l
3.	Sulphates (as SO_3)	IS 3025 (Part 24)	400mg/l
4.	Chlorides (as CL)	IS 3025 (Part 32)	2000mg/l for PCC 500 mg/l for RCC
5.	Suspended matter	IS 3025 (Part17)	2000 mg/l

VI. STORAGE OF MATERIAL IN READY MIX CONCRETE PLANT

Cement: Generally in Ready Mix Concrete plant cement is stored in silos of different capacity. The loading of cement is generally done with the help of pneumatic blower systems. Cement is weighed separately, and is transported from the silo into the mechanical weighed by screw conveyor.

Aggregates: Aggregates in Ready Mix Concrete are stored into the bins. Bins are separate for different sizes of aggregate. Bins are generally covered by sheets to avoid rain and direct sunlight.

Water: Water is generally stored in tanks located close to the plant. Water tank should be clean and neat. ADMIXTURE: Generally admixtures are store in drums but it can also store into the tanks. Admixture drum should be shaken before the use.

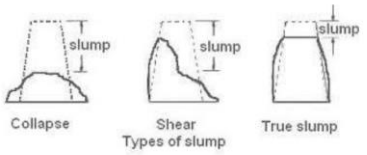
Properties Of Fresh Concrete:

There are two main properties of fresh concrete which are of main interest:

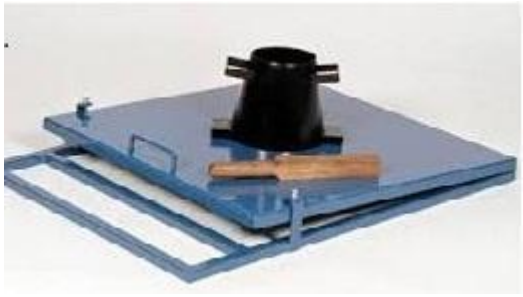
Workability:

Concrete is said to be workable if it is easily transported, placed, compacted and finished without any segregation. Generally workability of concrete is measured by slump test.

Slump Test: It is related with the ease with which concrete flows during placement.



Flow Test: Flow test is generally used for highly workable concrete. Flow of concrete can be measured by flow table. Workability of Ready Mix Concrete should be maintained as per demand of purchaser and environmental conditions given in Indian standard 456:2000 clause no. 7.1.



Cohesiveness:

Cohesiveness is one of the important properties of fresh concrete. Concrete should always be cohesive or in homogenous mass. Cohesiveness of concrete is a measure of resistance offered by concrete to segregation and bleeding. There is no recognized test for cohesiveness. So this is usually done by „visual inspection".

VII. SAMPLING OF CONCRETE IN RMC WAY

Sample of concrete should be taken from middle of the truck. Sampling of concrete should be done as per Indian Standard 1199. As per IS 4926-2003, after the truck-mixer has re-mixed its delivery on site allow at least the first one-third of a m3 of concrete to be discharged prior to taking any samples. Take at least 4 incremental samples from the remainder of the load avoiding sampling the last cubic meter of concrete.

VIII. PROPERTIES OF HARDEN CONCRETE

Compressive test of concrete:

Some cubes are casted on site and in the RMC plant. After remolding, cubes are placed in curing tank for curing. At least 3 cubes should be casted for compressive test. In Ready Mix Concrete plant cubes are generally tested on 3, 7 and 28 days. Cubes are cast in 150*150 mm cube moulds. As per a thumb rule concrete should developed 50% strength in 3 days, 67 to 80% in 7days and 100% in 28 days. Concrete cube strength is determined by compressive testing machine. Calibration of CTM should be done time to time.

IX. MIX DESIGN

Following data is required for design of concrete.

a) Grade designation
b) Type of cement
c) Maximum nominal size of aggregate
d) Minimum cement content
e) Maximum water-cement ratio
f) Workability
g) Exposure conditions as per Table 4 and Table 5 of IS -456
h) Maximum temperature of concrete at the time of placing
i) Method of transporting and placing
j) Early age strength requirements, if required
k) Type of aggregate
l) Maximum cement content
m) Whether an admixture shall or shall not be used and the type of admixture and the condition of use.

After getting all above data concrete mix design can be started. For calculating target mean strength standard deviation is required. With the help of past cube strength results standard deviation can be calculated. But at least 30 sample cube results should be available for the standard deviation. If in case sample or past data is not available then refer Indian standard 10262:2009 table no. 1. And select the standard deviation, and then design a Mix.

After making Mix Design, trial should be taken of that and find whether the mix is considerable according to all aspects like workability, strength etc. Before starting a new

mix design trail should be taken every time. As per Indian Standard 4926: Concrete is to be measured in m3 only.

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