महाराष्ट्र शासन

क्रमांक:-संकिर्ण-२०१३/(१५४/२०१३)निवसं-३

जलसंपदा विभाग,
मादाम कामा मार्ग,
हुतात्मा राजगुरू चौक,
मंत्रालय,मुंबई-४०००३२
दिनांक- १०/११/२०१५

प्रति,

महासंचालक,
संकल्पन, प्रशिक्षण, जलविज्ञान,संशोधन,सुरक्षितता
महाराष्ट्र अभियांत्रिकी संशोधन संस्था,
दिंडोरी रोड, नाशिक-४२२००४.

विषय:-संधानक (concrete) या विषयावरील परिपूर्ण माहिती देणारे Handbook chapter तयार करण्याकरीता गठीत समिती Ready mix concrete विषयी अंतिम मसुदा

संदर्भ:- आपले समक्रमांक साचा/रेप्र/म.अ.स.सं/७००/२०१५ दिनांक २९ जुलै २०१५ चे पत्र

उपरोक्त संदर्भिय पत्रान्वये सादर करण्यात आलेला redmix concrete (R.M.C) च्या मसूद्यास शासनस्तरावर मान्यता देण्यात आलेली आहे. अभियांत्रिकी क्षेत्राशी निगडीत सर्व शासकीय यंत्रणांना उपरोक्त मसूदा आपल्या स्तरावरून तात्काळ उपलब्ध करून देण्यात यावा तसेच करण्यात आलेल्या कार्यवाहीबाबत शासनास अवगत करण्यात यावे.

(सु.का.वावीकर)
शासनाचे अवरसचिव

प्रत-
कार्यासन निवस.-३ संग्रहार्थ

सामग्री चाचणी रेफरल प्रयोगशाळा	
वै.संशोधन अधिकारी	
सहा.सं. अधिकारी/ वैज्ञानिक अधिकारी	26/11

की. जाधव
कार्यवाहीस्तव.

PWD Handbook Chapter No. 41
READY MIXED CONCRETE

1. INTRODUCTION & SCOPE

1.1 Introduction

Concrete is a versatile & most widely used material in civil engineering constructions. Based on Method of production concrete can be classified as Site Mixed Concrete & Ready Mixed Concrete (RMC).

International Scenario

Ready Mixed Concrete is an old technology, as old as 1903 when it was first patented in Germany. The first commercial delivery of RMC was made in Baltimore, USA in 1913 and first small capacity revolving type transit mixer was used in 1926. RMC got introduced by late 1930's in some of the European countries. The industry in Europe & USA witnessed remarkable growth in the latter half of the 20^{th} century; and spread its wings in smaller countries of Europe & East Asian countries.

Currently, RMC is a matured industry in Europe & USA. As much as 75% of cement in USA is consumed through RMC route and is supposed to be the highest level of mechanization achieved in concrete construction any where in the world. In Europe about 47% of cement is consumed through the RMC plants.

In all these countries RMC is a well established produce with national codes and well established quality verification schemes. In USA, the NRMCA - National Ready Mixed Concrete Association is the QA/QC certification and technical audit & regulatory framework making body, while in Europe the ERMCO – European Ready Mixed Concrete Organization has 21 – nation members for the certification/audit of RMC. The RMCAO – Ready Mixed Concrete Association of Ontario, Canada is another such body which has come out with there "Concrete Quality Plan " document dealing with plant certification program.

Status in India

The concept of RMC came to India in 1950's but remained confined to Mega-Projects as captive mechanized batch mixing plants. Growth of commercial RMC is a recent phenomenon in India. During the past decade, the construction industry in India has witnessed remarkable growth, in which the ready-mixed concrete (RMC) industry is a major player. During the past few years, housing and infrastructure have remained the major expansion areas. Faster speed and improved quality of concrete have been the two major demands of these sectors. Ready-mixed

concrete was the right solution for this and it was the RMC industry which responded positively to these demands. The result was the rapid growth of the RMC industry.

In Water Resources Department also the Contractors started using Mechanized Batch Mixing Plants both as a need to match the speed and also for the quality & consistency that gets ensured. The popularity of RMC is increasing as RMC is produced in controlled conditions.

The first commercial ready-mixed concrete (RMC) facility in India was set up in Pune in 1992 and was followed by establishment of similar facilities in Mumbai, Bangalore, Chennai, Delhi, etc. The growth of the construction industry, particularly the rapid expansion of the housing and the infrastructure sectors, placed heavy demand on speed as well as quality in concrete construction. This gave an impetus to the growth of RMC industry. Even though the exact data on the growth of RMC industry is not available, it is estimated that India produced about 25-30 million m^3 of ready-mixed concrete as on December 2008 from around 400-500 RMC facilities and the number has been growing continuously. In terms of cement consumed through the RMC route the total percentage is too low and it stands at around 7-8% of the total quantity of cement produced in India during 2010-11. The experts prostitute that the percentage of cement consumed through RMC may reach the 10% mark by 2013-14. Thereafter, the growth may be faster and the cement consumption through RMC may reach the 25% mark by 2022. In India, RMCMA – Ready Mixed Concrete Manufacturers' Association was established in 2002 which is a non-profit industry organization of leading RMC producers of India. The important area of work of RMCMA was to evolve a self-regulatory framework by setting Quality Standards. Accordingly RMCMA had introduced audit-based Quality Scheme for Ready Mixed Concrete in December 2008 and the same is available in the two Manual published by RMCMA. Recently, this scheme is being upgraded and the scope is enlarged by making the scheme a truly third-party certification scheme. The scheme will not be owned by the RMCMA but jointly by the Quality Council of India (QCI) and Building Materials & Technology Promotion Council (BMTPC) under the Ministry of Housing and Urban Poverty Alleviation, Government of India.

The spread of RMC facilities in urban India has brought in its wake certain challenges. Since RMC is not a finished product and the quality of the final product is dependent upon a host of factors, some of which are beyond the control of the RMC producers. There is likelihood of a variation in the uniformity and quality of the final product This highlighted the need of developing the guidelines for use and the framework of quality for RMC. Also since RMC is a new technology for the Water Resources department it is always desirable to adopt it with caution. Thus, prior to its adoption and use, thorough study is necessary. So a literature study was carried out on RMC technology and based on the study the guidelines are prepared.

The guidelines in this chapter involve evolving guidelines in line with the provisions in the current codes of the Bureau of Indian Standards, specifying a checklist for technical audit of various aspects of RMC facilities, developing guidelines for the quality control and quality assurance of the final product, etc.

1.2 Scope

This chapter covers the requirements for the production and supply of Mechanized batched mixed concrete produced in captive batching plants and/or concrete produced in and procured from commercial ready-mixed concrete plants. It does not cover the placing, compaction, curing or protection of concrete after delivery.

1.3 Advantages and Limitations Of RMC

A) Advantages:

Ready Mix Concrete offers following advantages:-

i. Production by weigh batching in a Mechanized Batch mixing plant with computer/Numerical controls.
ii. Quality of concrete – The concrete is produced in controlled condition with excellent control on w/c ratio and consistent quality of raw materials begets quality control.
iii. Speedy construction – Due to mechanization the production of concrete is fast with minimum wastage.
iv. Eliminates the problems and inconvenience associated with stacking of construction material on construction sites, public pathways etc. Also the pilferage of material gets eliminated.
v. Lowers the labor and supervisory cost also lowers inventory and overheads.
vi. Reduced pollution – creates a clean environment with reduced noise and air/dust pollution.
vii. RMC is not only a “Material” but also a “Service”.

B) Limitations:

i. Delay in setting of concrete- Generally the admixtures / Retarders are used to delay the setting time due to transit time involved is more. Excess dosage of set retarding admixture may cause the delay in setting time substantially. Hence, it is necessary to arrive at optimum dosage of set retarding admixture such that there is no undue delaying than required. This will also establish the compatibility between cement and admixture.

ii. Requirement of good formwork- Since the placement speed of concrete is more the formwork required shall be strong enough to sustain the load of fresh concrete.

iii. Concrete supplied from RMC has either more slump than specified or has become stiff making it difficult to pump. Doubts will always be raised if the concrete supplied at site has more slump than specified. Addition of water during transit can be suspected which is bound to affect the quality of concrete. Concrete loosing workability making it difficult to pump is another area of concern. In such cases, water added to make concrete pumpable which again affects quality of concrete. Re-dosing of admixture, if adopted, has to be done under technical supervision following recommendation of manufacturer of admixture. Otherwise it may lead to delayed setting of concrete.

2. REFERENCES

The references given in this chapter are as per Annexure A. All standards are subject to revision, and the most recent editions of the standards indicated in Annexure A shall be referred to.

3. TERMINOLOGY

The Indian Standard *IS 4926* gives various terms and definitions which are adopted for the purpose of this PWD chapter. Some terms are modified to some extent for easy understanding; as well some terms are added.

3.1 **Agitator**: Truck mounted equipment designed to agitate concrete during transportation to the site of delivery.

3.2 **Batch**: Quantity of concrete mixed in one cycle of operations of a batch mixer or the quantity of concrete conveyed ready-mixed in a vehicle or the quantity discharged during 1 min from a continuous mixer.

3.3 **Characteristic Strength**: The value of strength of concrete below which not more than 5 percent of the population of all possible strength measurements of the specified concrete are expected to fall. It is also numerically equal to or more than the specified strength at specified age.

3.4 **Concrete**: A mixture of aggregate, cement and water with or without admixtures and/or additions and including entrapped or entrained air, for all uses but excluding all mortars other than for use as floor or roof screeds.

3.5 **Density of Fresh Concrete**: Mass of a quantity of compacted fresh concrete divided by its volume, expressed in kg/m3 in accordance with *IS 1199:1959*.

3.6 **Mix Proportion:** Mix for which the purchaser of concrete is responsible for specifying the required performance and the producer is responsible for selecting the mix proportions to produce the required performance.

3.7 **Free Water-Cement Ratio**: Ratio of the mass of free water (that is excluding the water absorbed by the aggregate in a saturated surface dry condition) to the mass of cement including mineral additives (as per 8.2) in a concrete mix.

3.8 **Grade of Concrete**: Numerical value of characteristic compressive strength of 150 mm cube of concrete at 28 days, designated by 'M' followed by this strength value in N/mm^2.

3.9 **Minimum Cement Content**: The minimum mass of cement including mineral additives in accordance with the provisions of *IS 456* required by the purchaser to be present, in unit volume of specified mix (See also Note 2 under Table 5 of *IS 456/ IS 457*).

3.10 **Maximum Cement Content**: The maximum mass of cement in accordance with the provisions of *IS 456 / IS 457* that can be mixed with concrete by the producer, unless otherwise agreed to by the parties. (See also Para 8.2.4.2 of *IS 456:2000*).

3.11 **Prescribed Mix**: Mix for which the purchaser specifies the proportions of the constituents and is responsible for ensuring that these proportions will produce a concrete with the performance required.

3.12 **Producer/Seller**: Agency or authority entering a contract to supply ready-mixed concrete.

3.13 **Purchaser/User**: Agency or authority entering a contract to buy ready-mixed concrete or using the RMC.

3.14 **Ready-Mixed Concrete**: Concrete mixed in a stationary mixer in a central batching and mixing plant or in a truck- mixer and supplied in the fresh condition to the purchaser either at the site or into the purchaser's vehicles.

3.15 **Truck-Mixer (Transit mixer):** A mixer generally mounted on a self propelled chassis, capable of mixing the ingredients of concrete and of agitating the mixed concrete during transportation. It also acts like agitator.

4. MATERIAL STORAGE AND HANDLING

All the materials required for RMC should be stored in such a way as to prevent the risk of contamination. Different materials shall be stored separately by taking due precautions and care, to avoid intermixing.

For storage of cement and aggregates the instructions given in *IS 4082* should be followed.

Stock piles should be arranged in such a way so as to prevent intermingling of adjacent materials. Different size fractions of aggregate (say 10-20 mm, below 10 mm) should be stored separately. Coarse and fine aggregate may be of different types and from different sources, and accordingly these should be separately stored. (*Photo -1)*

For better performance & quality, storage bins must be used to store materials. Open stock-piles are prone to contamination & there is no control over moisture content during wet season. Moisture probe can effectively measure water content of the aggregates.

Photo 1: Aggregate stockpile

The handling procedures of loading and unloading aggregate should be such as to reduce the segregation to minimum. This can be done by using rock ladders below the conveyor belts

The RMC manufacturer shall ensure suitable transfer & feed systems.

Various aspects to be looked into for material storage and handling are listed in the check list for this item. (Check list1; Page no. 49-50)

5. BATCHING AND MIXING CONTROL EQUIPMENTS

The Batching and Mixing control equipments consists of Scales; weigh Batchers/ Dispensers; batcher controls; recorders and the Central Mixer.

Batching control should be such that process identification at every stage and back traceability (later on) can be ensured. It is always desirable to have automation in batching process and its control. Preferably a SCADA system shall be installed. SCADA is Supervisory control and data acquisition, is a type of industrial control system for monitoring and control industrial processes that exist in physical world. Similarly it should be ensured that the computer printouts are taken for every batch and proper record shall be kept. (*Photo -2 & Photo -3)*

Photo 2: Computer controlled system.

Photo 3: Batch mixer control

Additionally for concrete of Road and Bridge work the guidelines given in section 1707, 1708.1 and 1708.2 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

A well documented inspection and calibration/recalibration systems and procedure for the plant and all other requirement shall be prevalent. The record should maintain regularly and be available during inspection and submitted to the concerned authorities.

5.1 Batching Controls

Batching controls are the part of the batching equipment that provides means for operating batching device for an individual material. They may be mechanical, hydraulic, pneumatic, electrical, etc. or a combination of these means. A batching system is a combination of batching devices and batching controls necessary for the accurate and consistent batching of concrete ingredients in the desired proportions. (**Photo 4 and Photo-5**). Normally, a batching system would include batching devices and controls for cementitious materials, aggregates, water, and admixtures. Adequate dosing outlets must be available for different admixtures & fibers. High strength concrete with silica fume will need at least four outlets.

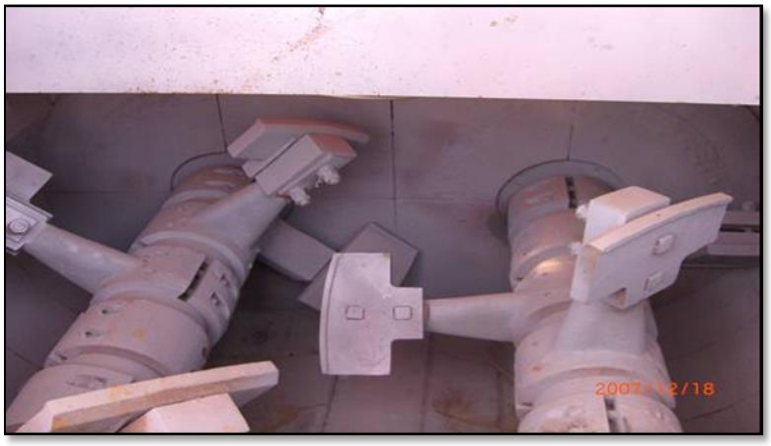

Photo 4: Paddles of Twin shaft mixer

Photo 5: Turbo Pan Mixer

5.2 System Requirements

Automatic System: A combination of the necessary individual weigh- batchers and volumetric batching devices (for water & admixture), the controls of which are all automatic.

Photo 6: Tilting mixer's in batching plant

Various items to be checked during inspection of Batching and Mixing control equipments are listed in the Check list for this item. (Photo 6 & Photo 7) (Checklist 2; Page no.: 51-55)

Photo 7: Batching weighments control and weights for calibration.

5.3 Mixing:

The mixer capacity and performance must be commensurate with the plant design. Type of mixer does not matter as long as it can deliver properly mixed concrete. There are basically three types of mixers.

1. Drum Mixers- Which can be further classified as
    a) Tilting Type. 0.25 to 4.5 cum capacity
    b) Non Tilting Type. 0.5 to 3.0 cum capacity
    c) Reversible Type. 1.0 to 6.0 cum capacity.
2. Pan Mixers- These are further classified as
    a) Planetary Counter current Mixers. 0.25 to 4.5 cum capacity
    b) Turbine Pan Mixers. 0.25 to 6.0 cum capacity
3. Twin Shaft Mixers 1.5 to 4.5 Cum capacity

6. TRANSPORT OF CONCRETE

6.1 General

Ready Mixed Concrete shall be transported from the mixer to the point of placing as rapidly as possible and practicable by methods that will maintain the workability and will prevent segregation loss of any constituents or ingress of water or foreign matter. The concrete then shall be placed as soon as possible after delivery. (Photo 8)

Photo 8: Transit mixer for transport of concrete

It shall always be emphasized that concrete should be laid in the position without any loss of time to avoid reduction in workability, setting and stiffening of concrete. This aspect becomes very critical in case of Ready Mixed Concrete where the time interval in between mixing and placing of concrete is considerable. As concrete stiffens with passage of time, delay in placement of concrete reduces workability of concrete. In addition, after sometime setting of concrete may also take place.

Reduction in workability may lead to difficulty in placement of concrete. Thus, while planning for use of Ready Mixed Concrete, the aspect of loss of workability in the likely transit time involved should be taken into account. By measuring slump/ compacting factor immediately after mixing at RMC plant and after a lapse of predetermined time (i.e. anticipated average transit time), loss of workability may be estimated. Desired workability at the time of delivery should be clearly specified in the specification or tender conditions.

The ticketing system is given in Annexure 'G' of *IS 4926* shall be referred. The producer shall ensure that a proper delivery ticket is issued which should contain quantity of concrete loaded, the raw material content of the concrete mix, time of delivery from mixer, truck/lorry number, signature of Plant operator etc. The standard proforma as given in Annexure B shall be filled and given to driver of

truck/lorry who will hand over the same to the supervisor in charge of site. The delivery ticket will form the basis of invoicing.

The transport of RMC to site shall be by transit mixer and agitators. They shall confirm to IS 5892

Before the delivery of concrete produced in Ready Mixed Plant/ captive Batching Plant it is the responsibility of the producer to ensure that each truck mixer is inspected to confirm its compliance with the requirements given in check list of this section. (Checklist 3; Page no.56)

6.2 Transit Time and placement time of concrete:

a) The concrete shall be delivered at the site of work and discharge shall be completed with-in Two hours of adding mixing water to the dry mix of cement and aggregate. (Photo 9 & Photo 10)

Photo 9: Delivery of concrete from transit mixer

Additionally for concrete of Road and Bridge work the guidelines given in section 1708.4 and 1708.5 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

Photo 10: Discharge of concrete from transit mixer

Concrete received after the transit time, as specified above, shall not be accepted. (Specify the transit time limit by deducting anticipated time required for placement of concrete from initial setting time specified in approved Mix proportion (Design mix)).

b) Concrete, thereafter, shall be placed in position with-in the designed initial setting time. At the end of initial setting time, the left over portion of concrete, if any, shall be rejected.

6.3 Re-tempering with water

Under any circumstances addition of any water shall not be allowed after the initial mixing of concrete, as retempering will reduce the compressive strength of concrete.

6.4 Re-tempering by chemical admixture

Retempering of mix is permitted only by adding plasticizer in two installments. The first application is at the plant & second application after the transit mixer reaches the site & before the concrete is unloaded. The two applications and their respective quantities is part of the mix design and must be done while designing the mix along with field trials to confirm the dosages.

6.5 Pumping of RMC

The RMC can be placed into position by using pump, in such case it is a pumpable concrete. Similarly, the RMC can be placed by using other methods such as buckets, cradles, conveyor belts, chutes etc in such case the RMC will be non-pumpable. However most of the RMC nowadays is a pumpable concrete. Hence detail information about mix proportioning, types of pumps, pumping pressures, formwork and its stability, compaction methods is necessary for the quality concrete. For the guidance on these aspects a separate PWD chapter is in the offing and hence the engineers/user of this chapter shall refer to the PWD chapter on placement of concrete.

7. LABORATORY

It is necessary to have a laboratory attached to RMC production facility called as field (Plant) laboratory, to carry out the routine testing *(Photo -11)* . In addition there can be a central laboratory or Third party laboratory that can be used to carry out testing. However it shall be ensured that such laboratories have been audited and that the validity of audit has not expired.

Generally, the field (Plant) laboratory will not have facilities for testing physical and chemical properties of cement/SCM's/admixture. However, a record of test certificates provided by manufacturer or third party lab shall be kept. The field (Plant) laboratory shall have the facilities to test the product i.e. concrete. The following tests shall be done in field laboratory.

1) Slump
2) Plastic density
3) Cube
4) Silt content of sand
5) Bulkage of sand
6) Fineness Modulus of sand
7) Sieve analysis of Coarse Aggregate

The Checklist gives all the details to be verified and ensured. (Checklist 4, Page no. 57-58) (Checklist 5, Page no. 59-60)

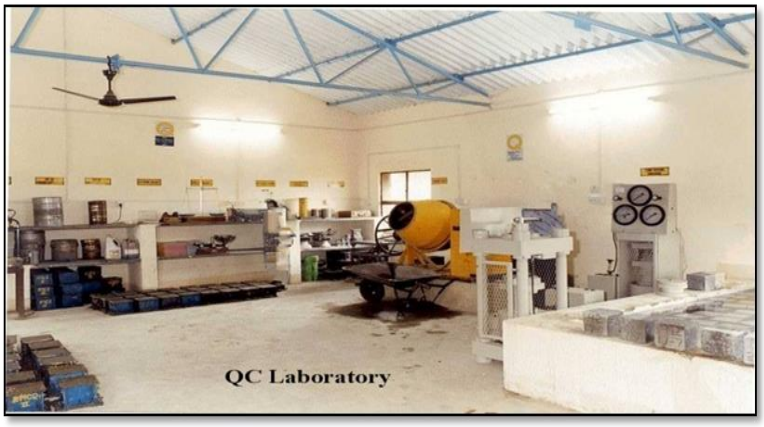

Photo 11: Field Laboratory

8. MONITORING QUALITY OF INGREDIENTS

8.1 General

Materials used should satisfy the requirements for the safety, structural performance, durability and appearance of the finished structure, taking full account of the environment to which it will be subjected. The selection and use of materials shall be in accordance with *IS 456*. Materials used shall confirm to the relevant Indian Standards applicable. Where materials are used which are not covered by the provisions of the relevant Indian Standard, there should be satisfactory data on their suitability and assurance of quality control. Records and details of performance of such materials should be maintained.

8.2 Cement

In India RMC producers commonly use three types of cements, namely

i OPC- Ordinary Portland cement
   a. 43grade conforming to IS 8112
   b. 53grade conforming to IS 12269
ii PPC – Portland pozzolona cement conforming to IS 1489(Part I)
iii PSC- Portland slag cement conforming to IS 455

The cement used for concrete shall be in accordance with requirement of *IS 456*, and shall confirm to the requirements in the contract or purchase order.

Although cement is a factory-produced material, there may be variation in the properties between two consignments, even from the same factory. Since the properties of the cement have close bearing on the properties of concrete, it would be appropriate to document the key physical properties of cement. All cement manufacturers have to provide a test certificate on the properties on regular basis, enabling documentation of such properties. Some RMC producers have facility for testing certain key physical properties of cement in their central laboratory. If such a facility is in use or in case RMC producers get the cement sample tested from a third party laboratory, the result should be appropriately documented.

8.3 Supplementary cementitious materials (SCM's)

RMC producers generally use the following three types of supplementary cementitious materials (SCMs)

i Fly ash – conforming to *IS 3812 (part I and II)*
ii Ground granulated blast furnace slag (GGBS) – conforming to *IS 12089*
iii Condensed silica fume – Conforming to *IS 15388*

SCM's possessing either pozzolanic or latent hydraulic properties, improve properties of concrete, both in its fresh and hardened states. The use of these materials improves the workability and helps concrete in achieving higher long-term strength gain, reduced permeability and improved durability and enhances sustainability. However, these benefits would be achieved only when it is ensured that the SCMs posses the requisite properties, otherwise they may just act as inert fillers. The best way to ensure this is to verify as to whether the physical and chemical properties of the SCM used conform to the code-specified requirements. It is important to observe that the properties are within limits specified. The SCM's or mineral admixtures shall be permitted in accordance with the provisions of *IS 456*.

Additionally for concrete of Road and Bridge work the guidelines given in section 1714.1, 1714.2,1714.4, 1715.2 and 1705.2 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

8.4 Chemical admixtures

Ready- mixed concrete needs to be transported over long distances and it needs to be workable to enable proper placement, compaction and finishing. Therefore, use of chemical admixtures, which modify a variety of properties of concrete in its fresh and hardened states, becomes vital. In typical tropical weather conditions prevalent in most part of India, the commonly used admixtures are plasticizers, superplasticizers, and retarders or combinations of these. The chemical admixtures used should conform to the requirements specified in *IS 9103*.

Before selecting any brand of admixture, laboratory tests are carried out by RMC producer to establish compatibility of the cement-plasticizer/super plasticizer system and also to determine the optimum dosage of admixture, initial slump, extent of slump retention with time, and compressive strengths at various ages as percent of control sample etc. Cementitious –chemical admixture or cement-chemical-mineral admixture compatibility needs to be resolved during the selection of chemical admixture. For this purpose, help can be sought from chemical admixture manufacturer. Results of compatibility tests shall be valid for the cement plant and the admixture formulation from a particular manufacturer.

For each batch of admixture the manufacturer needs to provide certificate as per para 10.1 and 10.2 of *IS 9103* , giving various properties of the material. It is quite likely that there is variation in the quality of the material being supplied from time to time. To verify this, *IS 456* recommends that the relative density of admixtures shall be checked for each batch and compared with the specified value before acceptance. This practice should be followed. Change in workability of concrete may indicate the change in the admixture quality.

In addition to this, *IS 9103* specifies four more uniformity tests to be carried out on admixtures. It may be advisable to get these tests carried out by an independent laboratory and the values so obtained may be compared with those furnished by the manufacturer. *IS 9103* does not specify the frequency at which the testing for uniformity can be done. The suggested frequency shall be one for every new batch, before acceptance.

Use of chemical admixture shall be permitted in accordance with the provisions of *IS 456*.Admixture shall be stored in a manner that prevents degradation, contamination and consumed before the expiry period as indicated by the admixture manufacturer. It has been experienced that the admixtures are supplied in 200 lit. drum and shall be stirred thoroughly before use in line with the instructions of the manufacturer to prevent setting of solids which will affect the slump to considerable extent.

Additionally for concrete of Road and Bridge work the guidelines given in section 1705.1, 1714.3 and 1715. of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

8.5 Water

Water used for mixing shall be potable and free from oils, acids, alkalis, salts, sugar, organic materials or any other substances which may be detrimental to steel or the concrete. Water used shall be in accordance with the requirements of *IS 456* and the permissible limits of impurities shall be as specified in *IS 456*. Mixing and curing by sea water is not recommended because of presence of harmful salts in sea water. Unless otherwise agreed, the testing frequencies for water shall be as given in Annexure B of *IS 4926*. Reduction of fresh water use in plant operations by use of treated recycled process water and captured storm water shall be encouraged in various plant operations with a rider that the quality of water must confirm to BIS Code. The quality of concrete produced is no way affected and the chlorides and sulphates are within the overall limits.

8.6 Aggregates

Aggregates which form nearly 70-80% of volume of concrete needs to be clean, inert, strong, tough and durable. RMC plant stacks large quantities of aggregates and hence it is essential to conduct of tests on concrete as specified in *IS 2386(Part I to VII)*. The aggregate used for concrete shall be in accordance with the requirements of *IS 383*. Unless otherwise agreed, the testing frequencies for different tests shall be as per annexure B of *ARE 4926*.

Physical properties of aggregate affect the strength of concrete whereas chemical properties may affect the durability of concrete. Gradation of aggregates has important effect on workability and properties of hardened concrete. Good

grading implies that the sample contain all fractions of aggregates in required proportions resulting in minimum voids and consequently requires minimum paste to fill up the voids. The grading of course, fine aggregates and also the combined grading of coarse and fine aggregates shall conform to tables as given in *IS 383*. For other tests on aggregates such as deleterious substances etc. *IS 2386 (Part I to VII)* shall be referred. As the source of an aggregate changes or there is indication of the change in a property, all relevant tests shall be done for the aggregate.

Additionally for concrete of Road and Bridge work the guidelines given in section 1706 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

9. SAMPLING AND TESTING OF CONCRETE

Sampling is as important as the sample itself. Incorrect sampling affects the Test results, so utmost care shall be taken in sampling.

The sample shall be representative and sampling may be carried out jointly by the purchaser and the supplier. The sample shall be taken at delivery location when discharged from producer's transit mixer/agitator truck.

As per *Annex C of IS 4926, clause 6.1,* on reaching the point of placement the truck should remix its contents and allow at least the first one third of cubic meter to be discharged before any samples are allowed to be taken. Four incremental samples from the remainder of the load should be then taken, avoiding the last cubic meter of concrete. The sampler shall be precoated with cement and fines by holding it in the discharge stream and then take the sample of concrete from moving stream. Then the composite sample should be thoroughly re-mixed either in a clean mixing tray or in the clean sampling bucket and the required testing should commence only after this. A typical report shall provides the time history, sampling, location, truck & ticket nos, properties of concrete in its fresh state such as slump, unit weight as well as number of cubes made should be recorded. A record of other parameters such as ambient temperature, concrete temperature should also be made in the report.

IS 4926 suggests that unless otherwise agreed between the parties involved , the minimum testing frequency to be applied by the producer should be one sample for every 50 m^3 of production or every 50 batches, whichever is the greater frequency. The size of the sample should generally be not less than 0.035 m^3 when it is to be used for strength test. Smaller sample can be taken if used for routine slump tests. Three test specimen shall be made up for each sample for testing at 28 days. For test at any other age as required, three specimens for each age of test shall be taken.

Additionally for concrete of Road and Bridge work the guidelines given in section 1717 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

Slump and compressive strength of concrete are two critical parameters to judge concrete's quality. As regards strength test, it is important to follow standard procedures described in *IS 1199* and *IS 516* meticulously for making, curing and testing cube specimens. Test cubes which are made from fresh concrete are very sensitive to method of handling and storage conditions during the first few hours. Hence, the moulds filled with concrete shall be kept covered by damp matting. The specimens shall be marked and removed from moulds after 24$\pm$ ½ hour from the time of mixing water and submerged in fresh and clean water. It is essential to employ trained operators for ensuring that adequate precautions are taken during sampling and testing of specimens.

10. QUALITY CONTROL

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. Controlling the quality of Ready Mixed Concrete is similar to any process control system. The nature of the raw materials used in the manufacture and the large number of factors, which affect the strength of RMC, makes it highly variable product. A further complication is the variety of concrete mixes used in the construction process. Hence, the need for good QC & QA. Thus, while planning to use Ready Mixed Concrete, it should be ensured that producer of Ready Mixed Concrete has adopted quality assurance programme. Quality control system should be prevalent at Ready Mixed Concrete plant. As per IS 4926 the Quality Assurance and Quality Control Programme of ready-mixed concrete can be broadly divided into three components, Initial control, Production control and Corrective control. RMC manufacturer should have plant laboratory facilities to carry out necessary tests to ensure quality control at all stages during production of concrete. The proper record of results of such tests should be available with R.M.C. manufacturer.

10.1 Initial control

Initial control covers all aspects which are to be taken care prior to production of concrete. Initial control and consequent corrective action are essential aspects of quality control. Initial control includes the following.

10.1.1 Control of Quality of raw material

A control system shall be operated to provide assurance that all materials purchased for and used in the production of concrete conform to the Indian Standards agreed with the material supplier and the requirements of the producer's mix design methodology and quality control procedures. This may include visual checks, sampling and testing, certification from material suppliers and information from material suppliers.

10.1.2 Control of Materials Storage

Materials should be stored in such a way as to prevent the risk of contamination. The producer should utilize suitable transfer and feed systems. Aggregate storage areas should be free draining. Measures should be taken to prevent freezing or excessive solar heating of aggregates. Admixtures should be clearly identified and protected from sunlight (where applicable) and the risk of contamination.

10.1.3 Mix Design and Mix Design Modification

The producer shall maintain a record of all mix designs and modifications current on the plant.

10.1.4 Inspection and Maintenance of Plant Equipments

The producer shall be able to demonstrate that a documented plant and TM maintenance procedure is in place. Regular plant inspections should be carried out with faults reported and rectified.

10.1.5 Transfer and Weighing Equipment

The producer shall be able to demonstrate that a documented calibration procedure is in place. Calibration shall be done by duly trained persons. Calibration records should contain details of any corrective action required; the date of the next calibration, confirmation that any required corrective action has taken place and the signature of the designated manager for that plant. The producer shall also maintain a daily production record for that plant, including details of which customers were supplied, which mixes were supplied and which delivery dockets were dispatched. There should be a record of what materials were used for that day's production including water and admixture. The use of electro-mechanical weighing and metering systems, that is, load cells, flow meters, magmeters, etc, is preferable over purely mechanical systems, that is, knife edge and lever systems.

10.1.6 Plant Mixers and Truck Mixtures

Plant mixers where present and truck-mixers used shall be in an operational condition and shall be purchased from a supplier of proven experience and quality. The producer should ensure that regular maintenance is performed as per requirements. Mixer blades should be regularly checked for its wear and its clearance from the drum (or body of container), and information recorded. If gap is more than that recommended by the mixer manufacturer, it shall be adjusted to the requirement. Blade should be changed once adjustment limit is exhausted. With the high clearance of blade, the mixing efficiency would reduce. Mixing efficiency should be observed weekly.

10.1.7 Transportation arrangement

For transportation of concrete to site, concrete agitators conforming to *IS: 5892-1970* "Specification for concrete transit mixers and agitators" should be used. For all TM manufactured in India now, the minimum revolutions are six and maximum are fourteen, hence the agitating speed of the agitators should not be less than five revolutions per minute nor more than fourteen revolutions

per minute of the drum. Transit mixers should be checked for minimum and maximum speed of rotations. Speed limits lower than that recommended by TM manufacturer, indicates malfunctioning and gives advance warning of major problem in near future.

10.2 Production control

Production control is concerned with instant action to control the quality of the concrete being produced. It includes the production control and product control.

10.2.1 Production Control

i The production of concrete at each plant shall be systematically controlled. This is to ensure that all the concrete supplied shall be in accordance with the requirements and with the specifications. The concrete shall also be as per requirement of Mix design adopted.

ii Each load of mixed concrete shall be inspected before dispatch and prior to discharge.

iii The workability of the concrete shall be controlled on a continuous basis during production and any corrective action necessary taken.

iv For each load, written, printed or graphical records shall be made of the mass of the materials batched, the estimated slump, the total amount of water added to the load, the delivery ticket number for that load, and the time the concrete was loaded into the truck.

v Regular routine preferably weekly inspections shall be carried out on the condition of plant and equipment including delivery vehicles.

vi No additional water, other than the amount required to produce the specified workability, shall be added to the truck mixer drum before discharge unless specifically requested, and the entry made in the delivery ticket.

10.2.2 Product Control

i Concrete mixes shall be randomly sampled and tested for workability, and where appropriate, plastic density, temperature and air content. Where significant variations from target values are detected, corrective action shall be taken.

ii It is important to maintain the free water at its correct value. The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in the aggregates. Suitable adjustments should also be made in masses of the aggregates due to this variation (see *IS 456*). Any change in water content due to change in aggregate grading shall be taken care of by forward control by suitable modifications to mix proportion.

iii When the assessment of moisture content is carried out continuously using a suitable instrument a system shall be provided to indicate the necessary changes in added water for changes in moisture content. If moisture sensor is used, it should be checked and calibration to be verified on daily basis.

iv Mixing time should not be less than that recommended by the manufacturer.

10.3 Corrective control

Corrective control is concerned with those factors that influence the control of concrete quality that cannot be assessed at the time of production. Corrective control may cover any property of materials or concrete, such as aggregate grading, slump, or air content, but is particularly associated with 28-day cube strength because by its very nature it is not a property which can be measured ahead of, or at the time of, manufacture. Strength of concrete and permeability are such factors which cannot be assessed at the time of production.

10.3.1 Mix Performance

Broadly Mix performance is the main factor that has to be taken care by the producer. The producer shall ensure the following.

10.3.1.1 Designed mixes

A quality control system shall be operated to control the strength and workability of designed mixes to the levels required and shall be based on random tests of mixes which form the major proportion of production. The system shall include continuous analysis of results from cube tests to compare actual with target values together with procedures for modifying mix proportions to correct for observed differences. Compressive strength testing shall be carried out using a machine that meets the requirements of *IS 14858*.Compressive strength shall be checked as per IS 516 and workability test as per IS1199.

10.3.1.2 Prescribed mixes

Periodic and systematic checks shall be made to ensure that the cementitious material contents of prescribed mixes comply with their mix descriptions

10.3.2 Stock Control of Materials

The producer shall operate a materials stock control and have a procedure in place an effective system to enable verification of total

quantities used and to confirm that only approved materials have been received and to enable correction of non compliance identified and on complaints.

10.3.3 Complaints

The producer shall have a procedure in place to enable the diagnosis and correction of faults identified from complaints.

11. GENERAL REQUIREMENTS OF RMC

11.1 Basis of Supply

All concrete shall be supplied and invoiced in terms of cubic meters (full or part) of compacted fresh concrete as discharged from the transportation unit. The RMC shall be supplied in the quantity and having the quality in accordance with the requirements agreed by the producer or supplier and purchaser or user; however the concrete supplied shall generally comply with the requirements of *IS 456/ IS 457 and IS 4926*.

The volume of fresh concrete in a given batch shall be determined from the total mass of the batch divided by the density of the concrete. The total mass of the batch shall be determined as the mass of the concrete in the batch including the total mixing water. All Batching shall be carried out by mass, except water and admixture, which may be measured by volume.

11.2 Specifying Concrete – Ordering

RMC shall be manufactured and supplied on either of the following basis.

a) Performance basis: Specified characteristic strength based on 28 days (or any other specific age) compressive strength in accordance with *IS 456/ IS 457*.
b) Prescriptive basis: Specified Mix Proportion.

When concrete is supplied on the basis of specified strength, responsibility for proportioning of mix rests with the producer/ seller whereas in case of specified mix proportion, the responsibility for proportioning of mix rest with the purchaser and the purchaser accepts the responsibility for concrete strength and its performance. Thus, it is desirable to place the supply order on specified strength basis. This system is based on performance parameters and is best way to order the RMC because RMC producer, who is expert in the field would design an economical mix with desired properties.

In all cases the purchaser/user is required to furnish the following information for the guidance of the producer/ seller.

a) Type of cement to be used.
b) The max. Size and type of aggregates to be used.
c) The workability specified by slump or any other requirements.
d) Following additional requirements should be specified to satisfy durability requirements:
    i) Minimum and maximum cement content to be used in production of concrete.
    ii) Maximum water cement ratio to be kept.

iii) Total chloride content in concrete:- Total chloride content should not exceed 0.15% by mass of cement in case of RCC work (*IS:456*) . For prestressed concrete work, total chloride content should not exceed 0.06% by mass of cement .*(IS: 1343)*

iv) Total sulphate content: - It should not exceed by 4% by mass of cement.

v) Permeability test requirements. (if any)

vi) Any special requirements such as pumpability or self compacting concrete (SCC) etc.

11.3 Mixing of Concrete

Ready mix concrete is mixed and delivered to the point/site designated by the purchaser/user by means of one of the following combinations of operations.

a) Central Mixed or Stationary mixed Concrete:

Concrete that is mixed in a stationary mixer at plant that mixes the concrete completely before it is discharge into either in a truck agitator or truck mixer operating at agitating speed or in non agitating equipments as agreed to by the purchaser/user. Central mix plants are sometimes referred to as wet batch or pre mix plants. When a truck mixer or agitator is used for transporting concrete which has been mixed before leaving the plant, the concrete shall agitated during transit and re-mixed at the site for at least 2 minutes so that the concrete is of the required uniformity.

b) Shrink Mixed Concrete:

Concrete that is first partially mixed in a stationary mixer and then mixed completely in a truck mixer. The time of partial mixing shall be minimum required to intermingle the ingredients. After transfer to the truck the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete. Generally it is two minutes of mixing in truck drum at mixing speed. This is not being practiced.

c) Truck mixed concrete:

Although, truck mixed concrete is also one of the methods of mixing of Ready Mixed Concrete, for the purpose of this chapter , truck mixed concrete shall not be allowed as RMC, as automatic record keeping arrangement such as digital computer slips etc. are not possible in such type of mixing.

Regarding mixing whether in a stationary or central mixer it shall be ensured that it complies with performance criteria of mixing efficiency test as per *IS 4634:1991*.Mixing efficiency test shall be performed at least once in a year.

Additionally for concrete of Road and Bridge work the guidelines given in section 1708.3.2 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

11.4 Information to be supplied by the purchaser/user of RMC plant

The purchaser shall provide the details of the concrete mix or mixes required by him and all pertinent information on the use of the concrete and the specified requirements. Where the purchaser specifies a designed mix to be supplied it is essential that all relevant information is conveyed to the producer. In order to assist in this, the format given in *IS 4926* Annex D may be completed and forwarded to the producer at the time of enquiry.

The concrete mix shall be specified by its constituent materials and the properties or quantities of those constituent to produce a concrete with the required performance. The assessment of the mix proportions shall form an essential part of the compliance requirements. The purchaser shall provide the producer with all pertinent information on the use of the concrete and the specified requirements. In order to assist in this, the format given in IS 4926 Annex D may be followed with suitable modifications as applicable to prescribed mixes.

Purchaser responsibilities: The purchaser of Ready mix concrete has the following responsibilities

i When placing procedures can potentially alter the characteristics of fresh concrete, it is the responsibility of the purchaser to inform the producer of changes to the mixture requirements to accommodate these effects. An example is pumping concrete in place.

ii When a job uses more than one type of concrete mixture, it is the purchaser's responsibility to verify the mixture delivered and direct it to the correct placement location.

iii The purchaser should check and sign the delivery ticket and document any special occurrences on the ticket.

iv When strength tests are used for acceptance of concrete, the samples should be obtained at the point of discharge from the transportation unit.

v The purchaser or his representative should ensure that proper facilities are available for curing the test specimens at the jobsite and that standard practices are followed for subsequent curing and testing. Certified personnel should conduct the tests.

vi Test reports should be forwarded to the producer in a timely manner to ensure that deficiencies are rectified.

11.5 Information to be supplied by the producer/owner of RMC plant

Upon the request, the producer shall provide the purchaser with the following information before any concrete is supplied:

a) Nature and source of each constituent material.
b) Source of supply of cement, and
c) Proposed proportions or quantity of each constituent/m^3 of fresh concrete.
d) When requested, the producer shall provide the purchaser the following information of admixtures:
    i) Generic type(s) of the main active constituent(s) in the admixture.
    ii) Whether or not the admixture contains chloride and if so, the chloride content of the admixture expressed as a percentage of chloride ion by mass of admixture.
    iii) Where more than one admixture is used, confirmation of their compatibility.

Producer's responsibilities: The producer of Ready mix concrete has the following responsibilities

i) The concrete producer is responsible for the concrete slump as specified for a period of 30 minutes after the requested time or the time truck arrives at the placement site, whichever is later.
ii) The concrete producer is required to deliver concrete at the requested slump and air content, within the accepted tolerances, as measured at the point of discharge from the transportation unit.

Note: The purchaser shall not alter the quality of concrete by any addition or modification at the job site. These include addition of water, admixture, fiber or special products into the ready mix concrete supplied by the producer; in case the purchaser does this, then producer is not responsible.

12. GENERAL INFORMATION ABOUT RMC FACILITY

12.1 Location of RMC Plant

The RMC plant from where the concrete is being procured by the purchaser/user can be a commercial plant owned/operated by a third party or a captive plant owned and operated by the constructor/user himself.

In case of commercial plant the location is already decided as they are operational plants and the user of RMC has no control on its location. The nearness to the site and availability of good haul roads can be the deciding factors in such cases.

However, when the RMC plants are captive plants and are erected on the site the constructor/user has to see the location of plant is suitable from all the considerations, the factors to be considered while deciding the location of plant can be

1) Availability of land
2) Availability of Raw materials such as sand, aggregates , cements, fly-ash etc. and their leads.
3) Availability of Electric power
4) Availability of water
5) Nearness to site
6) Nearness to village
7) Environmental concerns; waste management, dust and noise control, safety etc. Hence, it is necessary that the owner of captive batching plant takes a judicious decision by considering all the above factors with respect to their technical and financial viability.

12.2 Components of RMC plant

RMC plant/facility has in general the following components

i) Basic structure of the plant (**Photo 12**)

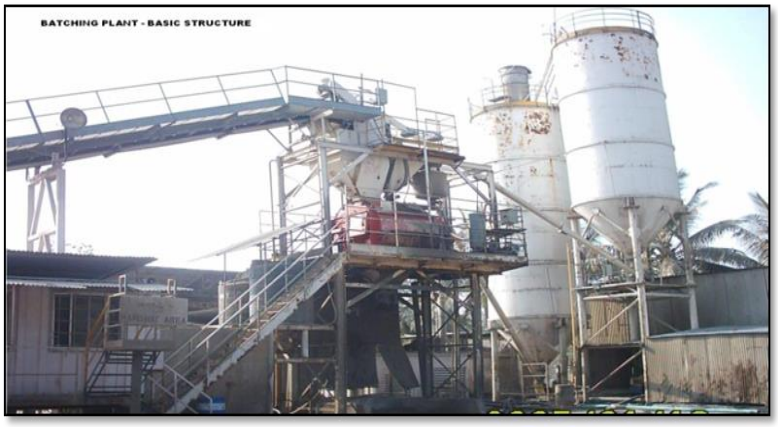

Photo 12: Batching plant-Basic structure

ii) Cement silos. (Photo -13 & Photo 15)

Photo 13: Cement silo-Cement feeding

iii) Aggregate bins
iv) Aggregate batching gates
v) Aggregate weighing system
vi) Cement weighing system
vii) Water weighing system
viii) Compressor
ix) Turbo mixers. (Photo 5)
x) Mixture discharge hopper. (Photo -14)

Photo 14: Mixture discharge into transit mixer

xi) Conveyor for cement. (Photo -15)

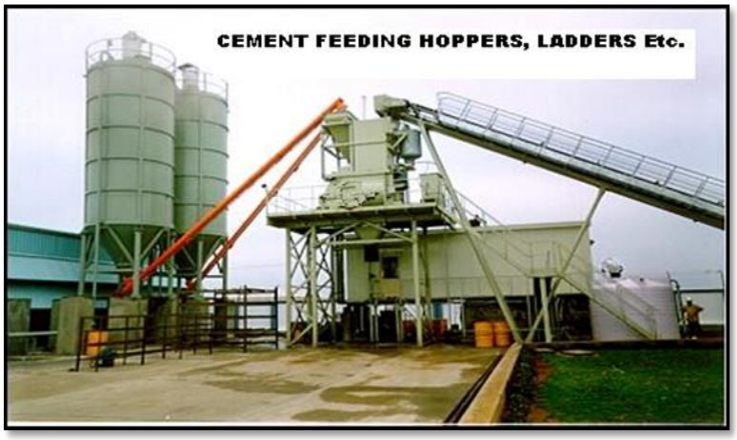

Photo 15: Cement feeding hopper, ladders etc.

xii) Cement feeding hopper. (Photo 15)
xiii) Admixture weighing system (if required).
xiv) Unit control board. (Photo 3)
xv) Micro computer control system. (Photo 2)
xvi) Transit mixers. (Photo 8)
xvii) Water tank.
xviii) Ladders for operator cabin and mixer platform. (Photo 15)

12.3 General Information of RMC Facility / Production facility

The RMC producer or captive Batching plant owner shall furnish the General information about the Ready Mixed facility. The information in general shall consist of contractor's name, company address, location of plant, Personnel's information, testing facilities available etc. The details of information to be supplied is as per the checklist (6:1 to 6:3; Page no.: 61-63) attached herewith.

13. PROPERTIES OF FRESH CONCRETE

13.1 Workability of concrete

Workability is a broad term which encompasses a range of properties of fresh concrete such as consistency (fluidity) , mobility (ability of concrete to move around the reinforcement and in restricted areas), compatibility, finishibility and pumpability (for pumped concrete). The degree of workability varies depending upon the type of construction and method of placing, compacting and finishing. Workability is measured in terms of slump of concrete using the standard procedure laid down in *IS 1199:1959*. The *IS 456* provides guidance on the range of workability requirements for different placing conditions and applications. Consistency of fresh concrete is considered to be a close indication of its workability and slump test has been the most widely used test for ascertaining consistency and hence workability. For applications requiring very high slumps (higher than 150mm) the *IS 9103* recommends use of flow table test. For a majority of concrete supplied by RMC producers, slump test is the most commonly used test.

The *IS 4926* specifies the following tolerance limits of workability as criteria for acceptance.

i) Slump: $\pm$ 25 mm or $\pm$ 1/3rd of the specified value whichever is less.

ii) Compacting factor : $\pm$ 0.03 For specified value $\geq$ 0.9
$\pm$ 0.04 For specified value $\leq$ 0.9$\geq$ 0.8
$\pm$ 0.05 For specified value $\geq$ 0.8

iii) Flow Table Test: Acceptance criteria to be established between the producer and the purchaser.

The test for workability needs to be performed upon discharge from producer's delivery vehicle on site or upon discharge into the purchaser's vehicle. On some occasions, lack of preparedness on the part of purchaser at construction site may result in delay of placement. RMC producer will be responsible for maintaining the slump within the permissible range for a period of 30 minutes starting from arrival of transit mixers at job site. However, after 30 minutes, the *IS 4926* clearly states that the responsibility for delay passes on the purchaser. Slump of concrete is quiet sensitive to a variety of environmental and other factors such as concrete temperature, ambient temperature, surface rate of evaporation, changes in grading, batch mass differences, admixture dosage, presence of mineral admixtures or otherwise, variation in air content, variation in testing, etc.

13.2 Density of concrete

The plastic density (unit weight) of conventional normal-weight concrete varies depending upon the variation in the density of different ingredients , the amount of entrapped air and entrained air (if air –entraining agents are used), the maximum size of aggregate and water and cement contents in the mix. Increasing the aggregate volume and reducing the cement paste would increase the density of concrete.

Ready Mixed concrete is measured on the basis of volume. The volume of fresh concrete can be determined by dividing the total weight of all batched materials by the unit weight or plastic density of concrete determined in accordance with *IS 1199*. Sometimes there is likelihood a discrepancy in the concrete ordered and that actually supplied. Also it should be understood that the volume of hardened concrete may be or appear to be less than expected. There could be variety of reasons for this discrepancy. These include wastage and spillage of concrete, over excavation, miscalculation in form volume, deflection or distortions of forms, settlement of wet mixes, loss of entrained air, etc. Such difference can be reconciled if plastic density of concrete is monitored regularly.

While carrying out mix Proportioning, the plastic density of designed (Proportioned) mix is measured and tallied with the theoretical density. It would be a good practice to measure the plastic density at regular interval so as that the quantities supplied match orders. The plastic density measurement can be done by filling a container of known volume with fully compacted concrete and taking the mass of concrete in that volume by following procedures detailed in *IS 1199*.

Additionally for concrete of Road and Bridge work the guidelines given in section 1717.7.3 and 1717.7.4 of MORT&H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

13.3 Air content of fresh concrete

In most parts of India, tropical weather prevails, necessitating adoption of adequate precautionary measures associated with hot weather concreting practices. Absence of adequate measures may lead to rapid loss of workability, accelerated stiffening of concrete, poor compatibility and finishibility, and cracking of concrete owing to plastic and/or thermal shrinkage. To avoid adverse effect of hot weather, both RMC producer and the purchaser need to take adequate precautionary measures. It shall also be noted that generally retarding effect of retarder is smaller at higher temperatures and sometimes few retarders seem to be in-effective at extremely high temperatures. Thus it is desirable to keep the temperature of concrete as low as possible. Although in the *IS 4926:2003* the requirements of temperature of concrete

has been deleted it is advisable that the temperature of concrete produced shall not be less than 5^0 C and shall not exceed 35^0 C

Additionally for concrete of Road and Bridge work the guidelines given in section 1708.5 and 1715.6 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

As far as RMC producer is concerned, he needs to design the concrete mix using a combination of OPC and supplementary cementitious materials or blended cement for reducing the heat of hydration. The aggregate stockpiles in the plant should be covered to avoid direct exposure to sun and water should be sprinkled on the stockpile to bring down the temperature. Some RMC producers use chilled water or ice flakes to bring down the temperature of mixing water during hot summer months. Covering the drum of transit mixer by hazien cloth helps in maintaining the temperature of concrete during transit. *(Photo -16)*

Photo 16: Temperature control-
Wrapping the drum of Transit mixer by hazien cloth.

The requirements of extreme weather (hot weather conditions) concreting are given in *IS 7861(part 1):1975* and shall be referred to.

13.4 Air content of fresh concrete.

In most parts of India, except certain places in northern and north eastern parts, the freeze-thaw conditions do not prevail, so it is not necessary to use air entrained concrete. Where such conditions are there it is essential to use air entrained concrete to counter the effects of freeze – thaw conditions. When air entrained concrete is desired the purchaser shall specify the total air content of the concrete.

14. PROPERTIES OF HARDENED CONCRETE

14.1 Strength of concrete

a. Concrete Cubes:-

When strength of concrete is used as a basis for acceptance of concrete, which is generally adopted parameter, the standard specimen shall be made, cured and tested at 28 days in accordance with *IS 516*.The compliance shall be assessed against the requirements of *IS 456*. The testing frequencies and sampling shall be as per para 9.0 – sampling and testing of concrete of this guideline.

While the strength at 28 days has emerged as a basis for contract specification; in order to get relatively quicker idea of the quality of concrete, compressive strength at 7 days may be carried out; however it is important to establish a relationship between early age and 28 days strength for a particular concrete. But in all cases 28 days compressive strength shall alone be the criteria for acceptance or rejection of concrete.

b. Concrete Cores:-

The most widely accepted method of determining the in-place compressive strength of concrete in existing structures, pavements and linings is the testing of core specimens obtained by drilling with a diamond core bit.

While core strength tests are more reliable than the less expensive & less tedious non-destructive test methods now in use, the results can be affected by many structure and testing variables which must be controlled or taken into consideration while evaluating the concrete strength.

Where possible, a length to diameter ratio L/D of 2 should be used but the diameter of core should be at least three times the nominal maximum size of coarse aggregate (MSA) and in no case shall the diameter of specimen be lower than twice the maximum nominal size of aggregate(MSA). Any specimen intended for strength testing shall not contain embedded reinforcing steel.

Testing variables includes considerations such as method of end preparation. Often sawing is necessary, to thin cores so that ends are perpendicular to the axis of the core, to eliminate reinforcing steel or honeycombed areas or to eliminate surface irregularities.

Usually cores shall be capped to produce the required plainness for testing and it shall be ensured that good practices of capping are followed as per *IS 516*. The capping shall be thin with a strong material. The use of thick caps or ones that are not properly bonded to the specimen or are made with a weak material may cause markedly reduced core strengths specially in short cores of L/D less than 2.0.

Shorter cores with L/D less than 2.0 give a higher indicated strength which increases as L/d decreases, therefore these higher strengths must be corrected by a factor (correction factor) given in *IS 516* for each ratio which, on the average, will produce a corrected strength on a parity with the standard L/D = 2.0 specimen. The equivalent cube strength of the concrete shall then be determined by multiplying the corrected cylinder strength by 5/4.

14.2 Acceptance criteria for concrete

a. Cubes

The IS 456:2000 provides guidance on the acceptance criteria of concrete based on compressive strength and shall be adhered to. Accordingly,

i. The test results of the sample shall be average of the strength of the three specimens. The individual variation should not be more than $\pm$ 15% of the average. If more, the test results of the sample are invalid.

ii. The concrete shall be deemed to comply with the strength requirements when both the following conditions are met

The mean strength determined from any group of four consecutive non overlapping test results complies with appropriate limits in column 2 of **Table 1**.
Any individual test result complies with the appropriate limits in column 3 of **Table 1**.

Table1: Characteristic compressive strength compliance Requirement

Specified Grade	**Mean of the group of 4 Non-overlapping consecutive test results in N/sq.mm**	**Individual test results in N/sq.mm**
(1)	**(2)**	**(3)**
M15	> or equal to f_{ck}+ 0.825x established standard deviation (rounded off to nearest 0.5 N/sq mm) or f_{ck} +3 N/sq mm whichever is greater.	> or equal to (f_{ck}– 3) N/sq mm
M20 or above	> or equal to f_{ck}+ 0.825x established standard deviation (rounded off to nearest 0.5 N/sq mm) or f_{ck} +3 N/sq mm whichever is greater.	> or equal to (f_{ck}– 3) N/sq mm
NOTE: In the absence of established value of standard deviation, the values given in the **Table 2** may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.		

Additionally for concrete of Road and Bridge work the guidelines given in section 1717.7 of MORT &H specifications published by IRC (Fifth revision) 2013 as given in references in Annexure I shall be referred to.

Table 2: Assumed Standard deviation.

Grade of Concrete	Assumed Standard Deviation N/sq.mm
M10	3.5
M15	
M20	4.0
M25	
M30	5.0
M35	
M40	
M45	
M50	

b. Cores

The *IS 456:2000* gives the acceptance criteria for the core test on concrete. Accordingly, Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85% of the cube strength of the grade of concrete specified for the corresponding age and no individual core has strength less than 75%.

15. QUALITY AUDITS & Q.C.TECHNIQUES

15.1 General

RMC is both a service and a product. It is essential that the user is assured of quality of concrete received from RMC producer/plant. Unfortunately, there are no guidelines on the regulatory framework in India through which a certain level quality is assured to the user about the product being supplied to him.

To maintain the quality & to have the quality assurance the following measures can be taken:

1) Quality Audit
2) Internal quality audits
3) Cusum Techniques or its variants.

15.2 Quality Audit

The RMC production facility/plant shall be audited by Third party audit on annual basis. In such case the owner and the auditors are involved in a audit called as appraisal – that is someone other than the owner or purchaser is to decide whether the owner/production plant can be certified as meeting prescribed quality standards/norms. In India, RMCMA having its office in Mumbai which has developed regulatory framework based on RMC quality schemes in developed countries and which have certified /accredited quality auditors used to carry out the third party audits of RMC and they had audited and certified around 250 RMC plants at 45 locations in India.

Recently this scheme was upgraded by RMCMA and scope enlarged by making the scheme truly third party certification scheme. The scheme is owned jointly by Quality Council of India (QCI) and Building Materials & Technology Promotion Council (BMTPC) and they have developed a document – Criteria for RMC production control –Basic level certification for production control of RMC, the draft of which is under wide circulation and finalization. Hence, QCI-BMTPC can be contacted for third party audit of RMC plants.

Additionally, there can be external audit called as second party audit, where in the purchaser of RMC or his representative will decide whether the plant/ RMC production facility is well/ enough organized to be able to meet their requirements as per quality standards.

15.3 Internal quality audits

Internal quality audit also called as First party audit in which the owner of RMC plant or the same group will help the plant meet and improve on its own quality standards. For this, each RMC plant shall preferably develop its own QA-QC plan and documentation. Each plant Owner/producer can develop its own quality norms over and above the provisions in Indian Standards. The RMC producer shall bear in mind that there is always the scope for continuous improvement in quality and should strive for it. There shall be a system for reporting on quality parameters to the organization; for that there shall be norms and well defined practices to monitor and control quality of input and output materials.

The QA-QC plan incorporated as internal quality audit shall consists of information such as source & properties of all ingredients of concrete; Mix design; process control; information on fresh and hardened properties of concrete; statistical analysis of results etc.

15.4 Control charts

Control charts are constructed from tests on samples of the concrete. Graphs are normally used to present this data. By plotting the concrete's quality variable i.e. the test result values over a period of time a visual representation of changing quality with time is provided.

The control charts can be of following types

i) Shewhart charts

ii) Cusum charts and its variants

i) Shewhart charts:

This Control chart approach was developed by W.A.Shewhart in 1924 and the control charts are used in U.K. & U.S.A. as a control system for strength mixes. Shewhart charts are powerful tools for monitoring a process. For concrete, the monitoring can be based on Target mean strength and Target standard deviation, to ensure compliance with the failure rate. In this approach a simple control is constructed with lines called as upper and lower control lines or action lines and an additional pair of control lines called as warning lines. To determine the trends within Shewhart charts a knowledge of statistics is required, further these charts visually give very little information about the process and also simultaneous combinations of trends (e.g. change in mean strength coupled with a change in standard deviation) are highly difficult to interpret and hence a alternative control chart system in common use is the Cusum system of Quality Control.

ii) Cusum Charts or Cusum Technique and its variants

The Cusum Technique developed in UK in 1960 to control a variety of production system. This system was further developed for application in Ready Mixed Concrete and from early 1970 became the prime method of controlling the strength of ready mixed concrete. The QSRMC – Quality Scheme for Ready Mixed Concrete in UK when formed in 1984 adopted this system as an approved method of Q.C., and was quickly adopted the world over due to the simplicity of data entry.

This technique is used for monitoring the trends in mean strength, standard deviation and the relationship between the early age and 28 day strengths. It indicates the point of action to be taken to increase the parameters to meet the specifications by detecting the changes in these parameters/properties.

The principle behind this technique is that difference between results and their target values are calculated and added cumulatively to form a cumulative sum (Cusum). When this Cusum is plotted as a graph against the sequence of results, a visual presentation of trends relative to the target level is produced.

The Cusum Techniques are of following three types

1) **Cusum M** – Mean Strength – Monitor difference between the target mean strengths and estimated mean strengths (Based on 7 day results)
2) **Cusum R** – Range – Monitors the range of values of mean strength and the standard deviation.
3) **Cusum C** – Correlation – Monitors the differences between the estimated and the achieved mean strengths at 28 days.

Apart from this, RMC producers can adopt variants of Cusum Techniques; standard software packages; failure analysis etc.

16. ENVIRONMENTAL CONCERNS AND SITE SAFETY

16.1 Site Safety

As in all civil engineering constructions, at the RMC plant safety shall be given a paramount importance and "Safety first" rule shall be followed. Ready Mixed Concrete plants are industrial operations relying on heavy equipment and vehicles with potential for accidents. So safety of workers should be a critical objective. All guardrails and machinery guards shall be fixed securely in position and walkways kept clean and with clear access. The facility shall provide suitable communication system between batching plant operator, transit mixer and delivery site. The RMC producer shall provide working conditions which have regard to the health and safety of employees .Plant should adopt a written safety program that includes formal safety trainings and provide incentives for workers who maintain safe practices.

The following arrangements shall be ensured from safety point of view.

i Earthing arrangement: RMC equipment essentially needs to be earthed in view of abundant use of metal. Necessary earthing facility needs to be created by the owner/producer.

ii Air conditioning: Control unit of the RMC plant needs to be kept air-conditioned for trouble free running of computer systems and to provide good environment to the operators and staff.

iii Plumbing and drainage work: Water supply network needs to be laid at site for availability of water at different locations. Similarly, site drainage for rainwater or spillages need to be provided to keep it workable.

16.2 Environmental Considerations

Due regard shall be given to the environment in any RMC production facility. The technologies used shall be such that to reduce the environmental impact to the lowest realistic level at the same time the technologies shall be proven, economic and reasonable.

The RMC facility shall endeavor that plant operations are well landscaped and screened from the surrounding residential or rural community such that the impact is minimal.

The producer shall ensure that the traffic routes chosen are such as to avoid congested and sensitive areas wherever practicable and to minimize the fuel consumption. Concrete spillage on the public highway roads and pathways shall not be there. On the rural roads the dust menace shall be reduced by watering the pathways/roads near the rural community/site.

As concrete producers in RMC plant the producer shall be aware and know the details of responsibilities regarding the environmental regulations such as Air Quality

Permits; Discharge permits; Storm water management, clean water permits, Solids management, Hazardous waste regulations, Dust control, Recycling, reuse and sustainability.

16.3 Air and Noise Pollution and Vibration

Particulate matter emissions to air, also known as dust emissions are the major air quality concerns at the ready mixed plant site. These very small particles can pose a health and safety risk to persons who may inhale those particles. The dust emissions can be process (point source) emissions and fugitive emissions. Process or point source emissions occur at discrete and definable locations during various activities such as silo filling; material handling and stacking; truck batching etc.

Fugitive dust emissions are difficult to pin point and may arise from onsite vehicle movement, loading/transfer activities. The dust emissions can be reduced by plant enclosures and dust suppression wherein water is sprayed at the source of dust to prevent it from becoming airborne.

There are many techniques and strategies available and the producer shall utilize appropriate technology to prevent or minimize dust emissions in line with local and national regulations.

Noise is defined as ‘‘unwanted sound’’ and is primarily a concern of surrounding community and plant employees. While sound is inherent to RMC facility there are many areas where noise can be minimized, and the producer should take steps to ensure that plant and vehicle noise are minimized through plant designs, landscaping, berms and sound walls, and through the use of appropriate technology and strategies.

16.4 Fuel, Oil and chemical spillage

The risk of leaks and spills can be minimized by proper design of storage facilities. The producer shall take appropriate measures and employ best management strategies to prevent leaks and spills and prevent pollution of surrounding areas and ground water by accidental effluent discharges and fuel, oil and chemical spillage.

16.5 Waste management

Waste is defined as materials disposed of in an unproductive manner for example being land filled or discarded in a quarry or back lot. Comprehensive waste management and programs will reduce environmental burden of waste disposal. Re use of the waste material alleviates the burden of raw materials extraction. Excess concrete and returned concrete mainly forms the solid waste in RMC industry and forms the major waste concern. The producer shall introduce processes, strategies and practices that minimize the production of waste.

16.6 Training

It is the responsibility of RMC producer to ensure that the employees/workers are properly trained and educated in safe handling of materials, hazardous chemicals and responsibility towards the environment. The producer shall give high priority to site care and good housekeeping along with participation of local community. It is also essential that emergency response procedures be established and employees be made familiar with the procedures. A formal training plan shall be prepared and implemented. Drivers play a key role in fuel management. Training to drivers can improve fleet efficiency and reduce spillage and leaks.

ANNEXURE 'A'

LIST OF REFERRED STANDARDS & LITERATURE

INDIAN STANDARDS	Title
IS 383 : 1999	Coarse and fine aggregates from natural sources for concrete— Specification (third revision**)**
IS 456:2000	Plain and reinforced concrete— Code of practice (fourth revision) (Reaffirmed 2005)
IS 457:1957	Code of practice for Plain and reinforced concrete for Dams & other Massive structures.
IS 516:1959	Method of test for Strength of concrete.
IS 1199: 1959	Methods of sampling and analysis of concrete.
IS 1343:2012	Code of practice for prestressed concrete
IS 1791:1985	General requirements for batch type concrete
IS 2386(Part I):1963	Methods of test for Aggregates for concrete, Part I: particle size and shape, (Reaffirmed 2007)
IS 2386(Part III):1963	Methods for test for Aggregates for concrete, Part III: specific gravity, Density, Voids, Absorption and Bulking (Reaffirmed 2007)
IS 2430:1986	Methods for sampling of Aggregates for concrete(First Revision),(Reaffirmed 2005)
IS 3812(Part 1):2003	Pulverized fuel Ash For use on Pozzolana in Cement, Cement Materials and concrete
IS 3812(Part 2):2003	Pulverized fuel Ash For use on Admixture in Cement, Cement Materials and Concrete
IS 4082:1996	Recommendations on stacking and storage of construction materials and components at site (second revision)
IS 4634:1991	Methods for testing performance of batch-type concrete mixers (first revision)
IS 4925:1968	Specification for concrete batching and Mixing
IS 4926:2003	Ready Mixed Concrete – Code Of Practice
IS 5816:1999	Splitting tensile strength of concrete Method of
IS 5892:2004	Specification for concrete transit mixers and
IS 7861 (Part I):1975	Guidelines for concreting in Extreme weather conditions (Hot weather conditions)
IS 8142: 1976	"Method of test for determining setting time of concrete by penetration resistance.
IS 9103: 1999	Concrete admixtures—Specification (first revision) (Reaffirmed 2004)

IS 10262:2009	Recommended Guidelines for concrete mix design
IS 11155:1994	Construction of spillways and similar overflow structures code of practice
IS 12089:1987	Granulated Slag for the manufacture of Portland
IS 15388:2003	Silica Fume
B) OTHER CODES 1) ASTM Designation : C94/C94M-09a-Dec'09 2) British Standard BSEN 206-1:2000 3) IRC, New Delhi, 2013	 Standard specification for Ready Mixed Concrete. Concrete-Part I- Specification, Performance, production and confirmity MORT&H: Specifications for Road & Bridge work (Fifth Revision).

LITERATURE

1. Building Materials and Technology Promotion Council, New Delhi and Quality Council of India, New Delhi (BMTPC-QCI) (Draft-2012) "Criteria for RMC Production Control"
2. Indian Railway "Guidelines on use of Ready Mixed Concrete"
3. National seminar on Ready Mixed Concrete held at Nagpur on 22 & 23rd sept.2007
4. Ready Mixed Concrete Manufacturers' Association (RMCMA) (2008) , "Guidelines on Quality control and Quality Assurance of Ready Mixed Concrete"
5. RMC Research and Education Foundation of National Ready Mixed Concrete Association (NRMCA), U.S.A. "Sustainable concrete plant Guidelines"

ANNEXURE 'B'

TRANSPORT OF CONCRETE

TICKETING SYSTEM (Also refer Annex G of *IS 4926*)

(A) The delivery ticket should contain the following information

1	Name of Work	
2	Location of Plant	
3	Serial No. of ticket	
3	Delivery date	
4	Truck No.	
5	Name and location of the site	
6	Grade of concrete or mix description of concrete	
7	Cement content (if specified)	
8	Type of cement and Grade (if specified)	
9	Nominal maximum size of aggregate	
10	Type or name of chemical admixtures included	
11	Type or name of mineral admixtures included	
12	Quantity of concrete in m^3	
13 ing	Time when loading was stored	
14	Signature of authorized person	

(B)

On site information		
1	Time of arrival at site	
2	Time when discharge was completed	
3	Any extra water/admixture added at request of the site supervisor or his representative and his signature	
4	Pour location (if informed by purchaser/user)	
5	Signature of the site in charge or his representative conforming discharge of the load	

Annexure 'C'
COMMITTEE COMPOSITION

(Ref: Final Order no.1 vide no. MTD/META/Concrete handbook /Committee/13/2013 Dt.3/01/2013)

Sr.No.	Name	Organzation
1	Shri.V.B.Pandhare.	Chairman Committee and Chief Engineer, DTRS, META, Nashik
2	Shri B.M Sukre	Chief Engineer & Administrator, Command Area Development Authority, Aurangabad (Special Invitee – Individual Capacity)
3	Shri R.D. Patankar	Superintending Engineer & Joint Director, MERI, Nashik and Committee member.
4	Shri R.V Shrigiriwar	Superintending Engineer, (Masonry Dam) ,CDO, Nashik and Member committee.
5	Shri K.M. Shah	Superintending Engineer, Quality Control Circle, Pune and Committee member.
6	Shri V. D. Nemade	Superintending Engineer, Quality Control Circle, Aurangabad and Committee member.
7	Shri R.M. Chouhan	Superintending Engineer, Quality Control Circle, Nagpur and Committee member.
8	Shri S.D.Kulkarni	Scientific Research Officer, Material Testing Division, MERI, Nashik and Member secretary committee.
9	Shri K.C. Tayade	Executive Engineer and Principal, Regional Training Centre, Nagpur and Committee member.(Individual capacity)
10	Shri R.G. Mundada	Executive Engineer, Quality control Division , Nanded and Committee member.(Individual capacity)

CHECK LIST 1
For Section 4—Material Storage and Handling (Ref: Page No.: 8)

Description	Observations
4.1 CEMENTITIOUS MATERIALS **4.1.1 CEMENT** 4.1.1.1. Condition of silos /bins and the cement feeding area, are they weather-proof ? Pl. specify:- Good/Bad Yes/no 4.1.1.2. How is cement supplied – Bags/ Bulk a) If supplied in bags – Describe how it is stored. (In weather-proof, damp-proof, well ventilated and reasonably free from dust, check for test reports; identification tags indicating date of receipt of lot and type. Quarantine area for damaged bags) b) If supplied in bulk – Describe how it is fed to silo and from silo to mixer; whether the loading and handling system permits free flow & easy discharge of cement.	
4.1.2 SUPPLLEMENTARY CEMENTITIOUS MATERIALS (SCMs). 4.1.2.1 How is storage system for SCM's .Is it separate for each type of SCM's . – Describe how it is stored (In weather-proof, damp-proof, well ventilated and reasonably free from dust) 4.1.2.2. If supplied in bulk, describe how it is fed to silo and from silo to mixer; whether the loading and handling system permits free flow & easy discharge of cement/ SCM's.	

4.1.3.AGGREGATES 4.1.3.1 Describe the provisions for storage for each size and type for aggregates. (Does the system prevents mixing of different sizes and types; are there proper signboards etc) 4.1.3.2. What adequate precautions taken to prevent intermixing of aggregates with dust ,mud, soil and other deleterious materials. Are they adequate ? 4.1.3.3 What provision regarding water sprinklers or other system made to bring down the temperature of aggregates in hot weather ?	
4.1.4. WATER **4.1.4.1 What is the source of water** ? Is sufficient quality and required quantity available? Are test reports available ? If yes, pl. specify. 4.1.4.2 What precautions are taken so as to protect the water storage facility from contamination by deleterious substances?	
4.1.5. CHEMICAL ADMIXTURES 4.1.5.1 – What chemical admixtures are being used ? what is the shelf life ? what specifications are supplied by manufacturer; Test reports availability; Are they OK? Are the admixtures supplied with proper marking and information as per clause 10.1 & 10.2 of IS9103. 4.1.5.2 Is there proper arrangement to store the chemical admixtures so as to avoid contamination and degradation on exposure to direct sunlight? 4.1.5.3 Are liquid admixtures properly agitated before use & used before expiry date. Pl. specify the mode of agitation (Manual / Mechanical)	

CHECK LIST 2
For Section 5 –Batching And Mixing Control Equipment (Ref Page No.-9-12)

Description	Observations
5.1 SCALES 5.1.1 What type of Scale is there? Are they readable by the by batch operator from his position? Is SCADA system installed? 5.1.2 Have the preset controls been calibrated in increments not exceeding 5kg or less each for cement and mineral admixtures, 10 kg or less for aggregates and 2 kg or less for water ? (Clause E-1 (c) of Annex E of *IS 4926*) Pl. specify. 5.1.3 For continuous mixer plants has the calibration been done in increments not exceeding 10 kg/m^3 each for cement and mineral admixtures, 25 kg/m^3 for aggregates and 10 lit/m^3 for water ? (Clause E-1 (d) of Annex E of *IS 4926*) Pl. specify. 5.1.4 Do the digital read-outs have a scale increment not exceeding 2 kg each for cement and mineral admixtures, 10 kg for aggregate and 1 liter of water ? (Clause E-1 (e) of Annex E of *IS 4926*) Pl. specify. 5.1.5 What is the frequency of recheck of scales carried out (at least every 3 months for electrical/ load cell system) ? (Clause E-1 (j) of Annex E of *IS 4926*) Pl. specify. 5.1.6 Is the recalibration done promptly and correction carried out if the plant is moved or non compliance is indicated in the 3-month rechecking ? Pl. specify. 5.1.7 What is the record of calibration of weighing and measuring system ? Is it maintained properly. 5.1.8 Are adequate permanent facilities provided for the application of test weights to the weighing hopper or system ? (Clause E-1 (j) of Annex E of *IS 4926*) Pl. specify. 5.1.9 State the number of personnel involved in the work of calibration of weighing equipments. Are they competent and adequately trained ? (Clause E-1 (p) of Annex E of *IS 4926*) Pl. specify.	

5.2. WEIGH BATCHERS (Clause 9.1.2 and 9.1.3 of *IS 4926*) 5.2.1 Are the hoppers for weighing cement, aggregates, and also water and admixtures (if measured by weight) consist of suitable containers freely suspended from a scale, and are they equipped with necessary charging and discharging mechanisms ? 5.2.2 Are the hoppers capable of receiving maximum rated load without contact of the weighted material with charging mechanism ? 5.2.3 Are hoppers self-cleaning and fitted with means to facilitate complete discharge ? What is the observation? 5.2.4 Are vibrator or other equipment installed in such a way as not to affect accuracy of weighing ?	
5.3 BATCHING DEVICES FOR WATER 5.3.1 How water is measured – (Volume / weight) 5.3.2 Are water meters/ weigh batchers equipped with a cut-off device capable of stopping flow within the tolerances. Is it without leakages ?	
5.4 DISPENSERS FOR LIQUID ADMIXTURES (Clause 9.1.2 and 9.1.3 of *IS 4926*) Chemical admixtures shall be added to the concrete mixture with the help of a dispenser – a device for batching of liquid admixtures ; preferably with an agitator.. Admixtures shall not be administered manually. 5.4.1 How are liquid admixtures measured (Volume/ Weight) 5.4.2 Whether each dispenser of liquid admixture has been provided with an accurately calibrated container (if measured by volume) in which the admixture can be collected when it is desired to check the accuracy of measurement & within tolerances .	

5.5. ACCURACY OF PLANT BATCHING (Clause E-1 of Annex E of *IS 4926*) 5.5.1 The accuracy, sensitivity and arrangement of weighing devices shall be such as to enable the materials to be batched within the following tolerances : A) Cement and mineral admixtures: Within ± 2 percent of the quantity of constituents being measured . Pl. specify the accuracy- B) Aggregate, chemical admixture and water: Within ± 3 percent of the quantity of constituents being measured Pl. specify the accuracy-	
5.6. BATCHING SYSTEMS 5.6.1 Batcher Controls 5.6.1.1 Weigh Batcher Controls:- Cementitious materials and aggregates must be batched by weight; water and admixtures may be batched in a weigh batcher or by volume . Check and specify about this. Automatic Control – When actuated by a single starting signal, an automatic weigh-batcher control shall start the weighing operation of cementitious materials, aggregate, water, or admixture, and stop the flow automatically when the designated weight has been reached. Pl. check and write details.	

5.7 RECORDERS : 5.7.1 Are the devices (Digital only) that provide a permanent record of the quantity of cementitious materials, aggregate, water or admixture measured into a particular batch of concrete. Whether Digital recorders are installed for each of the aforesaid material. 5.6.7.2 Pl. check and specify about the following points ;Are recorders :- 1) Properly protected, that is, provided with effective security to prevent tampering with records. 2) Provide traceability of the particular batch with the corresponding delivery ticket. 3) Register the quantity of ingredients batched; such as cementitious, aggregates, water, admixture etc.	

5.8 CENTRAL MIXER **(**i) Check whether the mixer is capable of producing uniform concrete within the time specified in the operational manual of manufacturer of the plant (Clause 9.1.4.2 of *IS 4926*)and specify. (ii) In automated plants ,is the mixer equipped with a timing device that will not permit the batch to be discharged before the pre-determined mixing time has elapsed ? 5.8.1 Condition of blades and paddles – Pl. specify whether i) The central mixer maintained in an efficient and clean condition ? ii) There is any accumulation of hardened concrete in the mixer drum and on the mixer blades ? 5.8.2 Mixer blade wears The wear of mixer blade shall be checked at the point of maximum drum diameter nearest to the drum head. [The blade is considered excessively worn if height of the blade at this point measured from the drum shell , is less than 2/3 rd of the original radial height (Clause 9.1.4.4 of *IS 4926*)]Pl. Check whether the blades of central mixer free of excessive wear & tear ?	

CHECK LIST 3
For Section 6 --Transport of Concrete. (Ref.Page No. -13-15)

Description	Observations
6.2 **DELIVERY FLEET INSPECTION** 6.2.1 Hardened concrete built up in mixer drum and on blades 6.2.1.1 Are the truck mixers maintained in an efficient and clean condition ? 6.2.1.2 Is there an appreciable accumulation of hardened concrete in the mixer drum and on the mixer blades ?	
6.2.2 **Charging hopper** 6.2.2.1 Is the surface of charging hopper clean and smooth?	
6.2.3. **Discharging opening, hopper and chute** 6.2.3.1 Is the surface of discharging opening, hopper and chute clean and smooth? 6.2.3.2 Are the discharging opening, hopper and chute free from appreciable accumulation of concrete ?	
6.2.4 Speed of agitation The recommended operating speed for agitation (in rpm) shall as per the recommendation of the manufacturer. The mixing speed generally be in the range of 4 rpm to 14 rpm. Minimum and maximum operating speed shall be visually verified . Is the agitating mixer capable of operating at mixing speed in the range as specified by manufacturer of truck mixer/agitator .	
6.2.5 Water tank, meter and pump system 6.2.5.1 Is the gauge /meter on water tank fitted to the truck mixer clean and legibly graduated? 6.2.5.2 Is the water pump/injection system in good working condition? 6.2.5.3 Is there any leakage of water from the nozzle into the mixer? 6.2.5.4 Check on calibration of water meter(should not show variation beyond 2%)	

CHECK LIST 4

Table 4: List of Minimum Testing Equipment for Laboratory attached to RMC Facility (Ref. Page No. 16)

Sl. No.	Relevant test and BIS Standard	Name of equipment	Minimum no. of units	Calibration frequency and relevant code	Whether calibration done as specified and records kept	
					Yes	No
1.	Slump test (IS 1199-1959)	Slump cone test apparatus with all accessories such as base plate, tamping rod, etc.	2 sets	Yearly IS 1199		
3.	Preparing concrete test specimens (IS 1199)	Cube moulds of size: 150 mm x 150 mm x 150 mm 100 mm x 100 mm x 100 mm	30 nos.	Yearly IS 10086		
4.	Sieve analysis of fine and coarse aggregates (IS 2386-Part I)	IS Test sieves for fine and coarse aggregates For Coarse aggregate 80mm,40 mm, 25 mm, 20 mm, 12.5 mm, 10 mm, 6.3mm, 4.75 mm, and lid+pan For Fine Aggregate 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm, 150 µm, 75 µm, 45 µm and lid+pan	one set for coarse and fine agg. each	Yearly IS 2386 – Part I		
8.	Unit weight of concrete (IS 1199)	Bulk density pot for fresh concrete (10 lit)	one no.	Yearly IS 2386–Part III		
9.	Aggregates Bulk density(IS 2386- Part III)	Bulk density pot for fine (3 or 5 lit) and coarse aggregates (7 or 10 lit)	one no each for coarse & fine agg.	Yearly IS 2386 – Part III		
10.	Silt content of sand	Graduated glass cylinder (500 ml) for determining silt content	one no.			
11.	Specific gravity of aggregates	Pyknometer and density basket or Gas Jar for determining specific gravity of aggregates (P.T.O)	one no.	Yearly IS 2386–Part III		

16.	Other accessories	Electronic weighing balance of adequate capacity with accuracy of 1 g.	One	Yearly		
		Laboratory mixer (min 50 lit)	One	Man. specified		
		Concrete compaction equipments (Table vibrator / needle vibrator, tamping rods)	One	Yearly		
		Curing tank with provision to maintain 27±2° C temperature of water	One	-		
		Shovels, trowels, flexible spatulas, meter, etc.	Sufficient nos.	-		

Alternatively, shaking of sieves done manually and sampling of aggregates done by quartering technique shall be permitted.

* In case the CTM m/c is not available in the lab., concrete cubes shall be tested in the RMC Company/Organization's other lab.in the same city/nearest lab., provided due care is taken to transfer the cubes with proper precaution and identification for standard curing for 28 days. Wherever flexural strength is specified in addition to compressive strength, it is essential have nine nos. of beam moulds of 150x150x700mm size. It is also essential to have the facility of additional attachment for the CTM to carry out this test.

CHECK LIST 5
For Section 7 -- Laboratory (Ref. Page No.-16)

Description	Observations
7.1 Test facilities 7.1.1 What is the facility available. Is the laboratory in-house attached to RMC plant or Central Lab. Or Third Party Lab. Pl. specify. 7.1.2 Plant laboratory / central laboratory/third party laboratory has facilities to carry out the following test. Aggregates Sampling (conforming to *IS 2430*) Moisture content (conforming to *IS 2386-Part III)* Bulk density (conforming to *IS 2386-Part III*) Sieve analysis (conforming to *IS 2386-Part III*) Concrete Slump (conforming to *IS 1199*) Unit weight (conforming to *IS 1199*) Strength (conforming to *IS 516*) 7.1.3 Are proper records of suppliers' certificates /third party testing reports on cement, SCMs and chemical admixture available ? 7.1.4 Are the equipments used for different tests mentioned in 7.1.2 in conformity with the requirements specified in different codes ? Mention the shortcomings if any. 7.1.5 Are the tools and equipment used for carrying various tests mentioned in 7.1.2 maintained in neat and clean condition? 7.1.6 Are the measuring and testing equipments (weighing balance, weights, sieves, proving ring of compression testing machine, etc.) calibrated regularly ? 7.1.7 Mention the frequency of calibration and the date till which current calibration can be considered valid for each of the following apparatus: Frequency Validity a) Weighing balance b) Weights c) Proving ring d) Measure for unit weight 7.1.8 Is a proper record of calibration kept in the laboratory? 7.1.9 Are the dimensions of cube and beam moulds within the code specified tolerances after repeated use ?	

7.1.10 Type of mixer used in laboratory & its condition, cleanliness etc. Tilting drum – Hand operated/ electrically operated. Pan-type Other (describe)	
7.2 Testing procedures 7.2.1 Are the minimum testing frequency specified in *IS 4926* and other relevant codes followed for the conduct of tests mentioned in 7.1.2 ? 7.2.2 Are well documented test procedures available in the laboratory ? 7.2.3 Are the well-documented test procedures displayed in laboratory for the guidance of Lab. Technician/lab. supervisor. 7.2.4 Are the test procedures given in relevant codes or equipment manufacturer's manual followed meticulously in day-to-day practice ? 7.2.5 Are original or certified copies of relevant codes available in the laboratory? 7.2.6 Are the lab technicians/ lab. supervisors adequately trained and qualified to carry out day-to-day routine testing on ingredients and concrete ? 7.2.7 Are the duties and responsibilities of lab technicians supervisors / clearly defined and well documented ? 7.2.8 If yes, record the details of in-house and external training undergone by the technicians & supervisors during the past one year in the following format. (use separate sheet if needed)	

Name of technician	Training topic	Date of training	Agency name

CHECK LIST 6.1
For General Information Of Ready Mixed Concrete Facility (Ref. Page No.-32)

Company/Contractor's Name	
Company's Address (Registered office) with Tel.; Fax; e-mail	
Location of Plant(Site)	
Address of Plant with Tel.; Fax; e-mail	
Personnel Information • Plant-in-charge/Manager • QC personnel	Name Telephone Name Telephone
Material Testing Facilities	Location and address Name of lab in-charge Telephone
Statutory Permissions*	Certificate from Pollution Control Board Yes No Not applicable Expiry date : Approval from factory inspector Yes No Not applicable Expiry date : Approval from Local Authorities (Municipal/Corporation/other) Yes No Not applicable Expiry date :

*Please attach photocopies of all relevant statutory permissions and certificates.

CHECK LIST 6.2

For General Information on Concrete Production Facilities (Ref. Page No.-32)

Name of Plant Manufacturer (Make)	
Type of Plant	
Plant's Rated Capacity, m^3 /hour	
Type of Mixer (√) as applicable	Rotating -drum type Power mixer - Pan type, Pan- type with agitator Single shaft, Twin shaft
Mixer batch size, m^3	
Storage Capacity	
Cement, tonnes	
Fly ash, tonnes	
Slag, tonnes	
Other cementitious material, tonnes	
Coarse aggregates, tonnes 10-mm 20-mm 40-mm	
Fine aggregates, tonnes or m^3 River sand Manufactured sand	
Crusher fines, tones or m^3	
Water,litres	
Chemical admixtures, liters	
Plasticizer Super plasticizer Retarder Any other (Pl.specify)	
Others (like fibers etc.)	
Brief description of recycling facility,(if any)	
Number of trucks with rated capacities	
Name of drum and truck manufacturer	1 2 3
Additional information on plant and trucks, if any (attach extra sheet if necessary)	

Check list: 6.3
For General Information on Material Handling (Ref. Page No.: 32)

Material	***Delivery to Plant***	***Storage***	***Storage to weigher***
Cement	Bulk Bags	Silo Bins Godown	Screw conveyor Manual Air slide
Coarse aggregates	Trucks	Star pattern In-line bins Compartments Tall/pocket silos	Conveyor Skip bucket Bucket conveyor
Fine aggregates	Trucks	Star pattern In-line bins Compartments Tall/pocket silos	Conveyor Skip bucket Bucket conveyor
Fly ash	Bulk Bags	Silo Bins	Screw conveyor Manual
Slag	Bulk Bags	Silo Bins	Screw conveyor Manual
Micro silica	Bags	Silo Godown	Screw conveyor Manual
Other cementitious material (specify)	Bags	Silo Bins	Screw conveyor Manual
Water	Munci. mains Wells Ponds	Underground/over- Ground tank Muncipal mains	Pumping Gravity flow through pipe network
Chemical admixtures(Liquid)	Drums Tankers	Drums Tankers	Dispenser
Chemical admixture or additives	Bags	Godown	Manual
Special arrangement for supplying temperature controlled concrete, if used	Use: Occasional use Not used Arrangement 1. Addition of ice slabs in mixing water tank 2. Addition of ice flakes in mixing drum 3. Chilling Plant 4. Combination of above (1/2/3)		

*Tick (√) in appropriate box. If materials/provisions not used, write N.A. in the boxes.