Readymixed Concrete - Innovations in Production and Process

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26th Oct 2019

Innovations made in the field of Concrete Technology

- Innovations in Materials
- Innovations in Plant and Machineries
- Innovations in Process
- Innovations in Special Concrete Products

Ingredients of Concrete

- **Basic ingredients**

Cement

Coarse Aggregates

Fine Aggregates

Water

- Additional ingredients – A Mixture of Admixtures

Chemical

Fly ash, GGBS, etc.

Advancements in Concrete Production

- **Material**
  - Cement
  - Aggregates
  - Concrete Admixtures
    - Chemical Admixtures
    - Mineral Admixtures
  - Fibres
  - Pigments
  - etc.

Main Types of Cements

- IS 456 permits the use of 10 different types of cements. However, RMC producers in India commonly use following three types of cements, namely,
  - Ordinary Portland Cement (OPC) conforming to IS 269
  - Portland Pozzolana Cement (PPC) conforming to IS 1489
  - Portland Slag Cement (PSC) conforming to IS 455
  - Sulphate–Resisting Portalnd Cement conforming to IS 12330

The NGT served the order to stop illegal mining activities in all states

Initially, the bench banned illegal sand mining on the beds and banks of rivers Yamuna, Ganga, Hindon, Chambal, Gomti, amongst others, but later modified its order saying the issue of illegally removing sand has nationwide implications.

"We restrain any person, company, authority to carry out any mining activity or removal of sand, from river beds anywhere in the country without obtaining Environmental Clearance from MoEF/SEIAA and license from the competent authorities", the bench said, while issuing notices to all respondents seeking their response by August 14.

Read more: http://www.dailymail.co.uk/indiahome/indianews/article-2385050/Outrage-J-Ks-female-bureaucrat-gets-punishment-posting-serving-government-officials-sandwiches-wanted-biryani.html#ixzz2jvTD0bDf

Alternatives ?!

FILTERED SAND

Can Poor Quality River/ Pit sand Provide Good Concrete?

VSI Coarse Aggregates

Crushed Stone Sand (CSS)

Aggregates from Natural Sources: IS 383 Classification

- **COARSE AGGREATES**
  a. Uncrushed stone or gravel from natural source
  b. Crushed stone or gravel produced from crushing of hard rock
  c. Product of blending (a) and (b)
  d. Manufactured by processing using thermal or processes such as separation, washing, crushing, scrubbing.

- **FINE AGGREGATES**
  a. **Natural Sand (River/Lake)**
  b. **Crushed Sand**
     a. **Crushed stone sand (CSS)**
     b. **Crushed gravel sand (CGS)**
  c. **Mixed Sand**
     a. **Produced by blending natural sand and** CSS/CGS **in suitable proportions.**
  d. **Manufactured Sand**
     a. **Fine aggregate manufactured from other than natural sources, by processing using thermal or processes such as separation, washing, crushing, scrubbing.**

Stages in Crushing Process of Hard Rock

- Primary crushing
  - Large boulders are reduced to more manageable sizes
  - Types of crushers used: Jaw or gyratory
- Secondary crushing
  - Material from primary stage is crushed further to produce aggregates suitable for use in concrete
  - Types of crushers used: cone crushers or impact breakers
- Tertiary crushing
  - Sometimes tertiary phase is essential to aggregates of acceptable quality. Improves particle shape
  - Types of crushers used: Vertical Shaft Impactor (VSI)

Grading Limits for FA

Table 9 Fine Aggregates
(*Clause* 6.3)

Sl No.	IS Sieve Designation	Percentage Passing			
		Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
(1)	(2)	(3)	(4)	(5)	(6)
i)	10 mm	100	100	100	100
ii)	4.75 mm	90-100	90-100	90-100	95-100
iii)	2.36 mm	60-95	75-100	85-100	95-100
iv)	1.18 mm	30-70	55-90	75-100	90-100
v)	600 µm	15-34	35-59	60-79	80-100
vi)	300 µm	5-20	8-30	12-40	15-50
vii)	150 µm	0-10	0-10	0-10	0-15

NOTES

1 For crushed stone sands, the permissible limit on 150 µm IS Sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted in **6.3** applying to other sieve sizes.

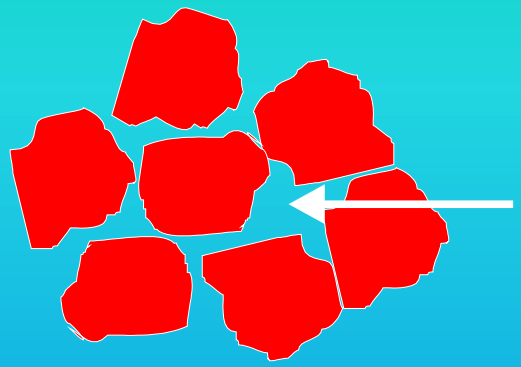
2 Fine aggregate complying with the requirements of any grading zone in this table is suitable for concrete but the quality of concrete produced will depend upon a number of factors including proportions.

3 As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to IV, the ratio of fine aggregate to coarse aggregate should be progressively reduced. The most suitable fine to coarse ratio to be used for any particular mix will, however, depend upon the actual grading, particle shape and surface texture of both fine and coarse aggregates.

4 It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

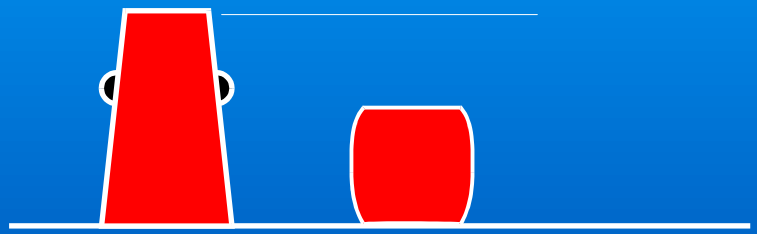
Chemical Admixtures

Cement without admixture



Trapped Water

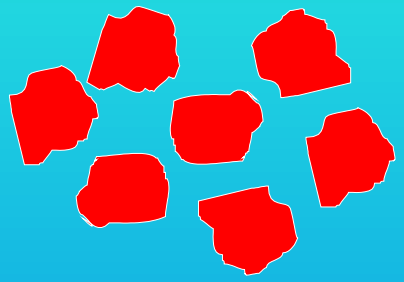
- Cement naturally flocculates
- Mix water is trapped within flocs
- Trapped water is not available for workability
- Workability is low with lower W/C ratio



Chemical Admixtures Contd…..

Cement with Plasticising admixture

- Cement is deflocculated
- Entrapped water is released
- Cement particles move freely
- Workability increases
- Cement hydration is improved



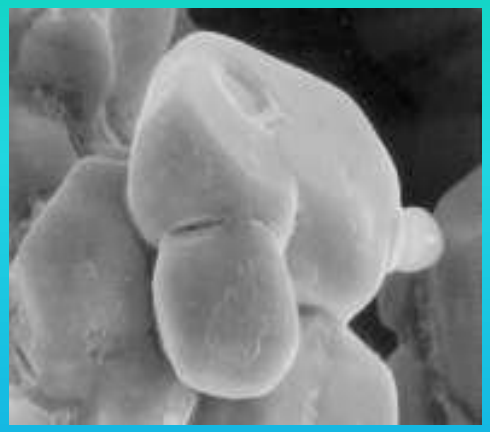
Chemical Admixtures Contd….

Water reduction

- Instead of increased workability, mix water can be reduced

Water:Cement ratio	0.40	0.40	0.34
Slump	40 mm	160mm	45 mm
28 day strength	48 N/mm^2	47 N/mm^2	55 N/mm^2

Blended Concrete Using Fly Ash



OPC/silicates

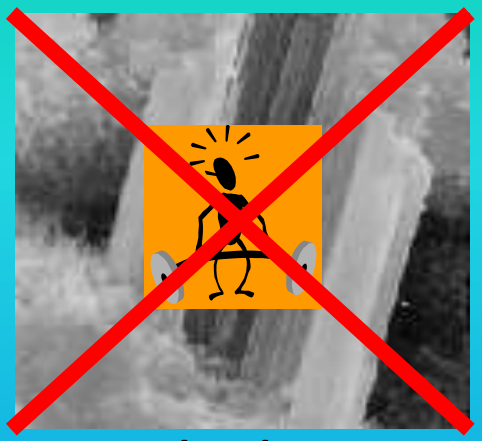
+

Water

Hydration reaction

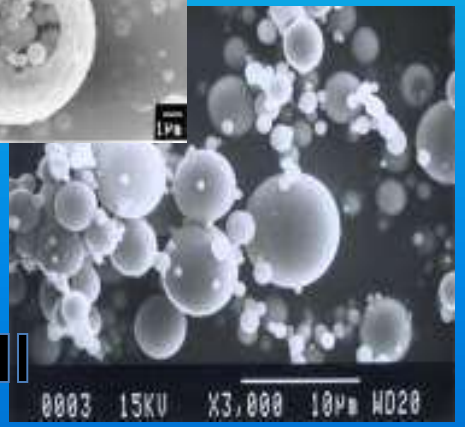
C-S-H

+



$Ca(OH)_2$ or Portlandite

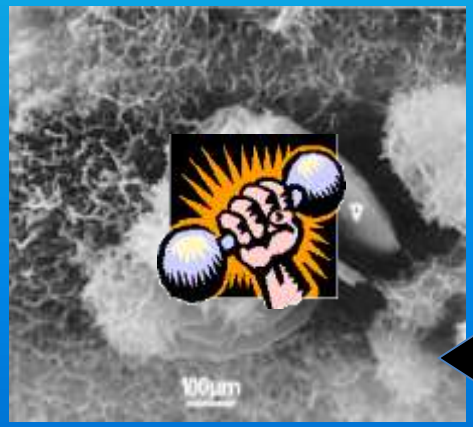
+



Fly ash

Pozzolanic reaction

C-S-H



Code-specified Limits of SCMs

Type of SCM	*Provisions in IS 456: 2000 (% by weight of cementitious content)*		*Provisions in IRC 112-2011 (% by weight of cementitious content)*	
	Minimum	**Maximum**	**Minimum**	**Maxi mum**
Fly ash	**15**	**35**	**20**	**35**
Ground granulated blast furnace slag (GGBS)	**35**	**70**	**50**	**70**
Other SCMs like silica fume, ultrafine GGBS, etc	**No limits specified in Indian standards. Depending upon applications, the limits may vary from 5 to 15% of the cementitious content.**			

90-day Strength Gain with Fly Ash

Grade	M10	M15	M20	M25	M30	M40
Cement + Fly ash, kg	165 + 105	195 + 105	215 + 105	255 + 85	270 + 90	335 + 100
7-day strength, MPa	9.5	15	17	24.5	27.5	37
28-day strength, MPa	16	21	27	33.5	36	47
90-day strength, MPa	22	28	34	39	43	53

Advancements in Concrete Production Contd…..

- **Plant and Machineries**
  - Readymixed Concrete Plants
  - Transit Mixers
  - Concrete Pumps
  - Form Work
  - Shuttering Material
  - etc.

Beginning of RMC Production

1903	Germany
1912	Spain
1913	USA
1918	Holland
1926	Denmark
1930	UK
1930	Norway
1932	Sweden
1933	France
1933	Swtizerland
1949	Japan

1956	Belgium
1958	Finland
1961	Austria
1961	Ireland
1962	Italy
1963	Israel
1966	Portugal
1968	Greece

1970s & 1980s

Developing countries like Taiwan Malaysia, Indonesia, etc.

RMC Industry: Europe

- **Status -2011(20 nation)**
  - **No. of plants: 8211 (ERMCO)**
  - **Concrete Production: 387 mil. m^3**
  - **% of Cement to RMC: 51.4%**

Start of RMC Industry in India

- First plant : Pune RMC in 1992
- Real growth commenced from second half of 1990's
- Main drivers: Housing and infrastructure
- Main demands: Faster speed and quality

CURRENT STATUS OF RMC INDUSTRY IN INDIA

- **The Indian cement Industry:** The second largest in the world with an Installed capacity of 373 million tonnes.

  Production for the year 2016-17 was around **300 million tonnes**

- **Ready-mixed Concrete industry:** Commercial RMC production in India is about 35 to 40 Million Cu m of Concrete annually.

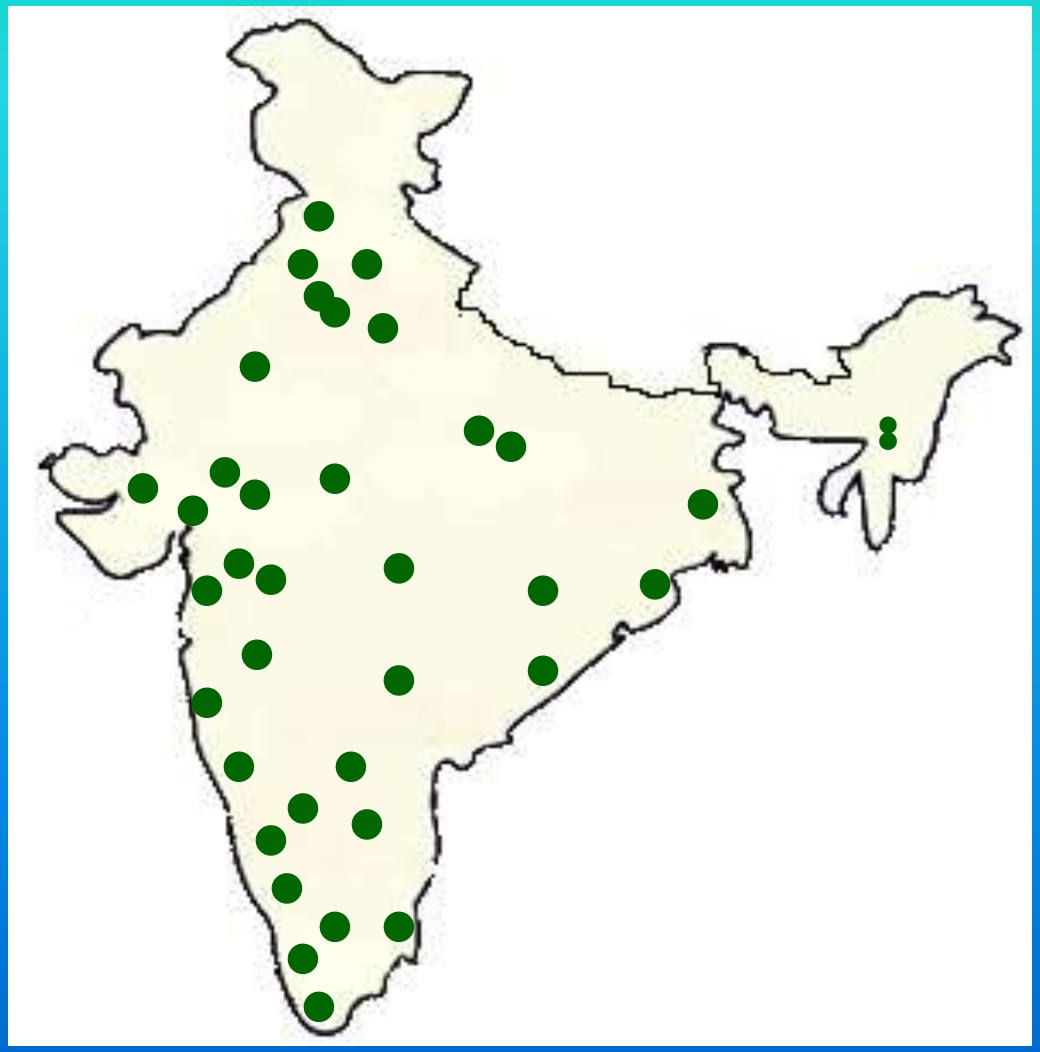
  Market Penetration is about 9 %.

- We have a long way to go and catch up in comparison to the developed countries.

1st Phase of Development

- **Establishment of RMC facilities in metropolitan centres**

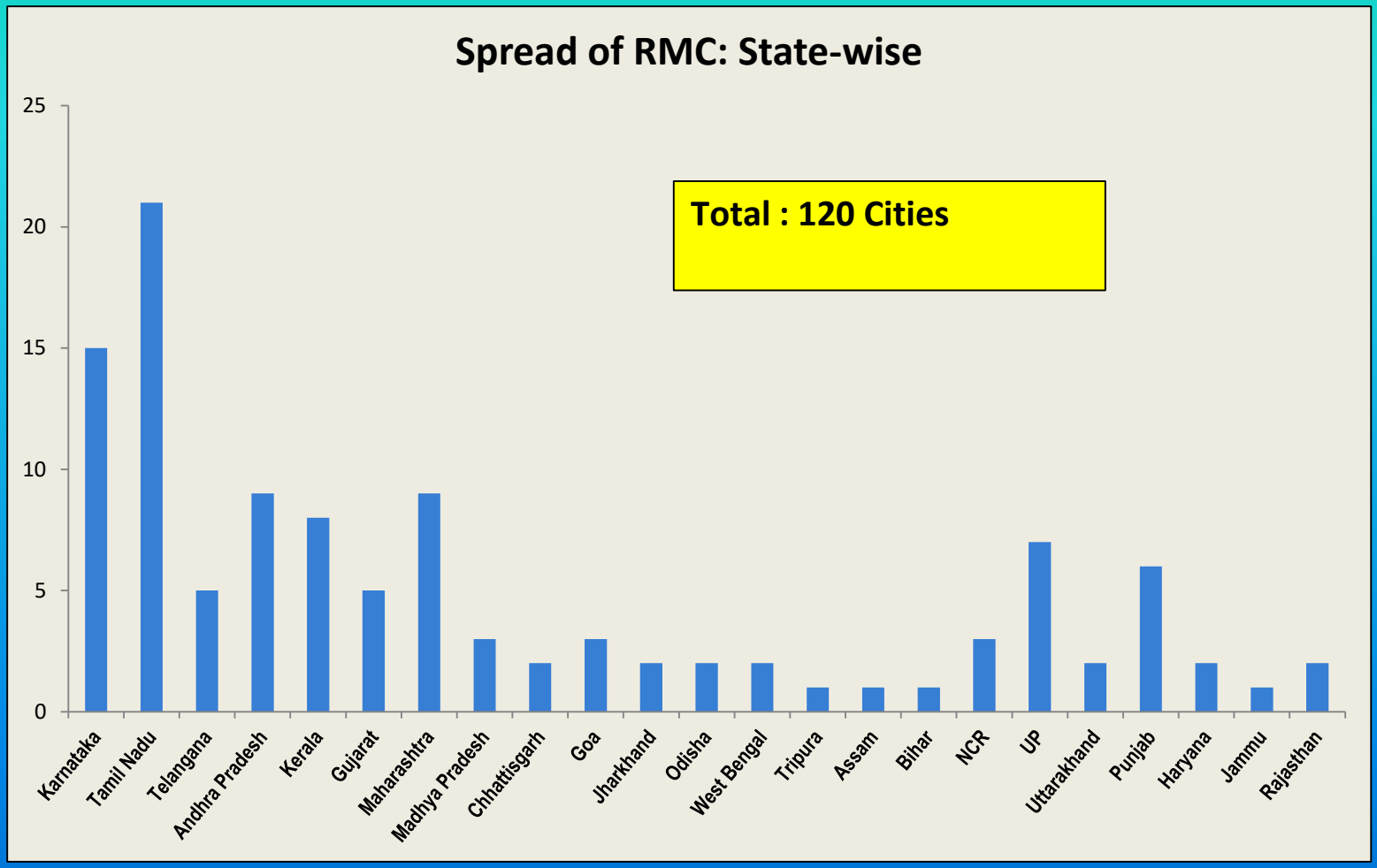
2nd Phase of Development



56 Major Cities

1 Amritsar
2 Ahmedabad
3 Baddi-HP
4 Bangalore
5 Bhubneswar
6 Chennai
7 Coimbatore
8 Derabasi
9 Durgapur
10 Faridabad
11 Giaspura
12 Ghaziabad
13 Gurgaon
14 Gauhati
15 Goa
16 Hyderabad
17 Hubli
18 Indore
19 Jalandhar
20 Jaipur
21 Kochi
22 Kolkata
23 Kolhapur
24 Lalkuan
25 Lucknow
26 Ludhiana
27 Madura
28 Manipal
29 Mangalore
30 Mohali
31 Mumbai
32 Mysore
33 Nashik
34 Nagpur
35 Navi Mumbai
36 NOIDA
37 Panchkula
38 Pune
39 Ranchi
40 Raipur
41 Rajkot
42 Rudrapur
43 Sahibabad
45 Sonepat
46 Surat
47 Surajpur
48 Thane
49 Trichy
50 Tuticorin
51 Trivandram
52 Thrissur
53 Vapi
54 Vijaywada
55 Visakhapattanam
56 Vadodara

Indian RMC Industry Scenario



State-of-the-Art RMC Facilities

State-of-the-Art Facilities (con'd)

Site Mixed Concrete
Versus
Ready Mixed Concrete

SMC - Vestige of Past

Cement Handling

Cement handling: Site-mixed concrete

Cement handling: RMC

Batching

Batching aggregates : Site-mixed concrete
No control on weighing

Accurate weighing through
Load-cell system

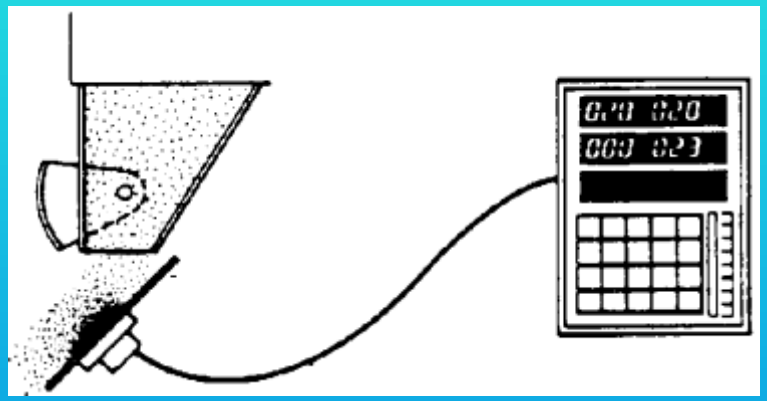
Mixing

Inefficient mixing in Site-mixed mixers

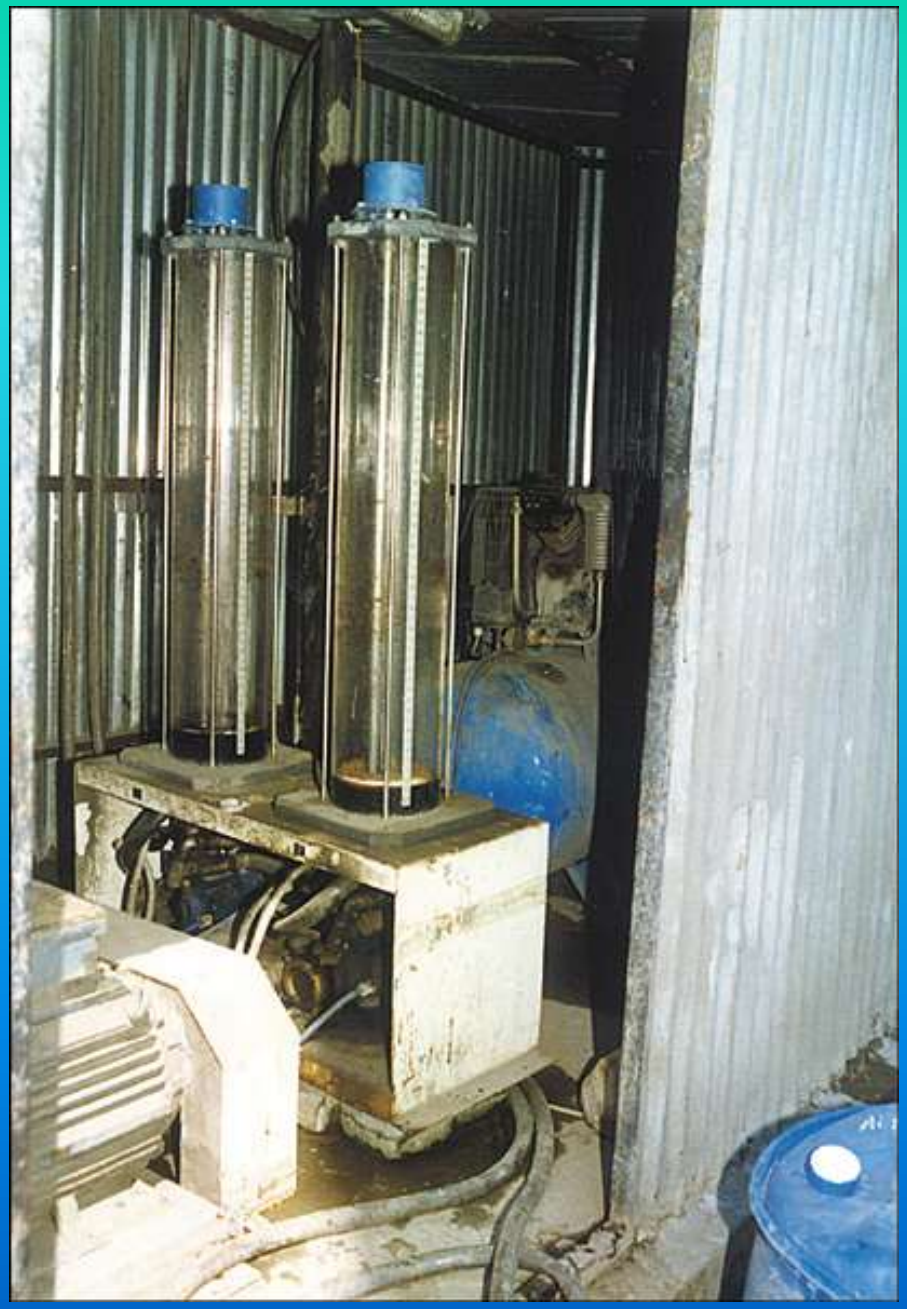
Modern efficient mixers in RMC

Uncontrolled addition of water

Microprocessor-based Moisture Recorder



Admixture Dosing System

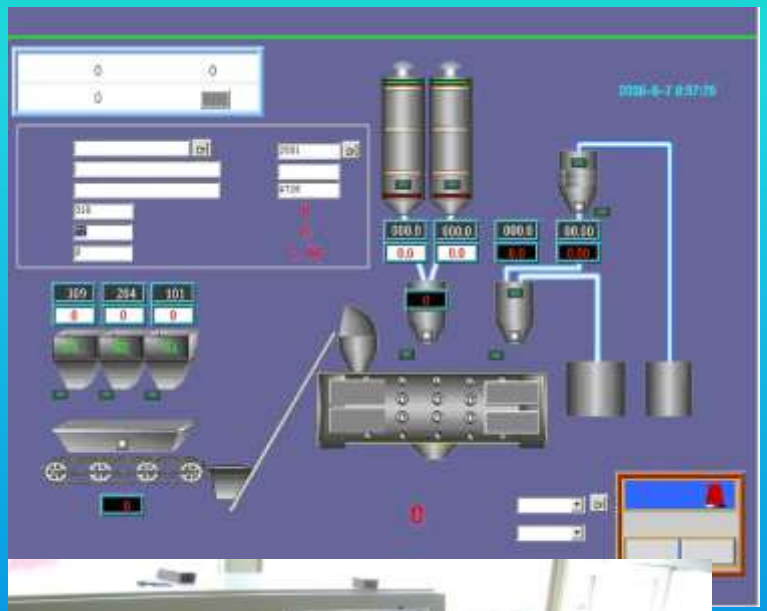


Intermixing of Aggregates

Intermixing of aggregate fractions

Computerised Control

- Storage of recipes
- Automatic moisture adjustment
- Automatic discharging
- Record of delivery and inventory



Transportation

Labor-intensive operation

Transit Mixer – Normally 6 Cu m Capacity

Placing

Manual placing

Placing With Pump

How RMC is Specified by IS 4926?

- **Prescribed mix:**
  - **Client specifies proportions**
    - **Based on his requirements; or**
    - **Based on proportioning work done in a third party lab**
  - **Responsibility for workability and compressive strength**
    - **Not clearly specified in code.**

- **Designed Mix:**
  - **RMC producer provides proportioning details based on:**
    - **Actual lab trials**
    - **Evaluation from Past data**
  - **Freedom to adopt any rational method of design**
  - **Responsibility for workability and compressive strength**
    - **RMC Producer is fully responsible**

Calibration

- Accuracy and sensitivity of weighing devices
  - Tolerances specified in IS 4926
    - Cement & SCMs:
      - ± 2 percent of the quantity of constituents being measured
    - Aggregates, chemical admixture and water:
      - ± 3 percent of the quantity of constituents being measured

Information Needed from Customer

- Information to be supplied by customer to producer (Annex D of IS 4926)
  - Design mix or prescribed mix
  - Concrete grade
  - Type of cement
  - Maximum size of aggregate
  - Minimum (and maximum) cement content
  - Maximum water/cementitious ratio
  - Workability
  - Exposure conditions
  - Maximum temperature at the time of placing of concrete
  - Method of placing
  - Degree of supervision

- **Such information is HARDLY PROVIDED in FULL DETAILS.**
- **What is mostly specified is:**

1. **GRADE**
2. **CEMENT CONTENT**
3. **SLUMP**

Sampling Frequency & Storage

- Frequency of sampling IS 4926
  - One sample for every $50m^3$ or every 50 batches whichever is of greater frequency
  - Yet – every customer seeks his own sample!!
- Who should take samples?
  - Only well trained technicians
  - Chances of failure increase if samples are taken by untrained technician

- **Storage of samples**
  - **Samples shall not kept in open**
  - **After sample preparation, they need to covered with wet hessian cloth till they are transferred to curing tank**

Controlled curing at 27± 2°C

Factors Affecting Strength (con'd)

- **Errors in making cubes**
  - **Filling in three equal layer**
  - **Hand tamping at least 25 strokes per layer**
- **Errors in handling and storing cubes in early stage**
- **Curing conditions**

Controlled curing at 27± 2°C

Factors Affecting Strength (con'd)

Testing Errors

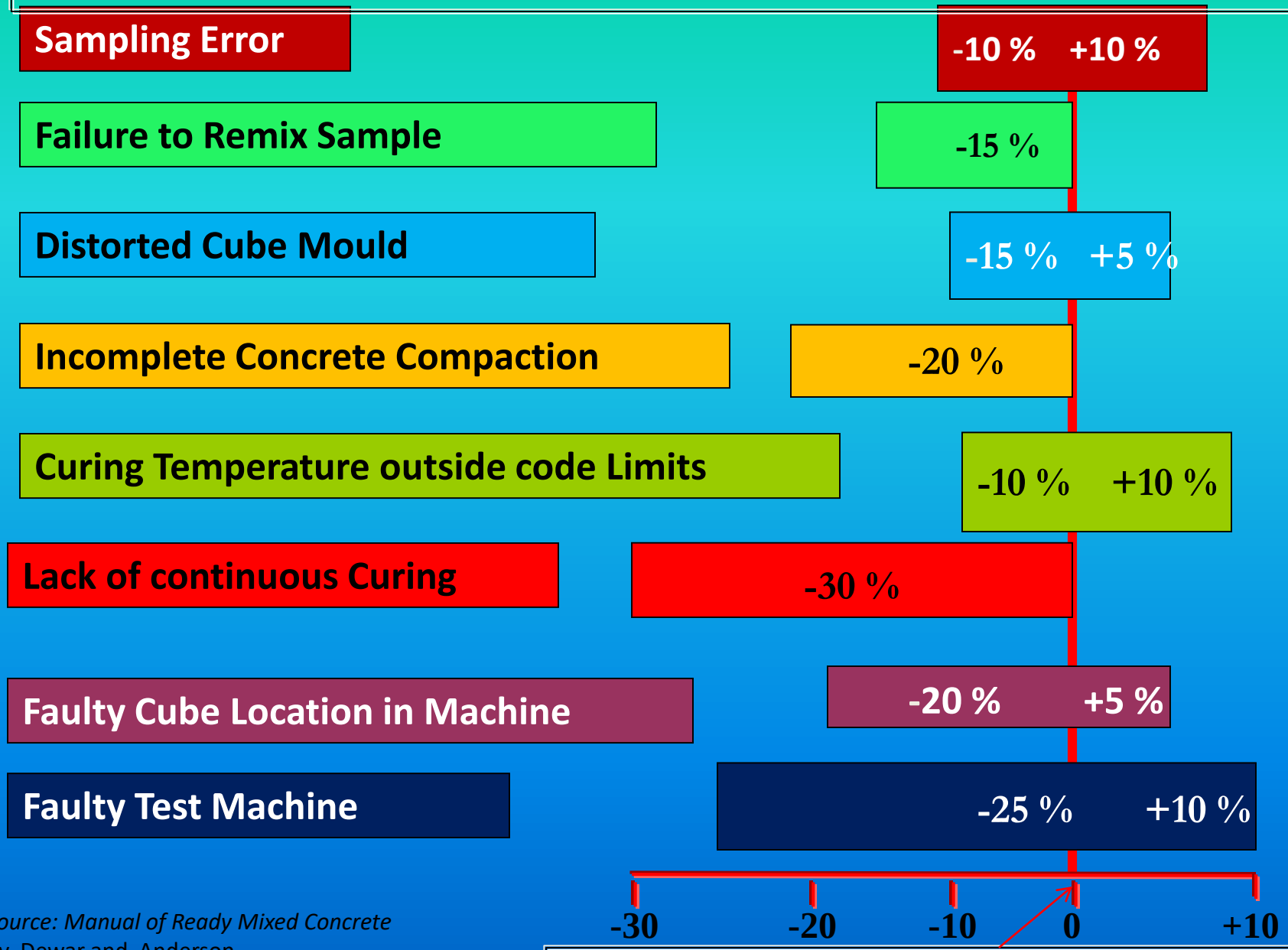
Eccentrically loaded (15-20mm) Sample may result in 20% reduction in strength

Can the rate of loading be accurately controlled with manual operation?

RMC- Advantages

- Improved and consistent Quality of concrete
- Enhanced speed of construction
- Elimination of material procurement requirements by client and storage hassels
- Saving in labour requirement
- Improved durability.

Parameters affecting Strength of Concrete



Source: Manual of Ready Mixed Concrete
by Dewar and Anderson

Other Areas for Research

- Factors affecting Strength of Concrete
- Grading requirement for Manufactured P Sand
- River Sand vs Crushed Stone Sand for Concrete and Plaster
- Chemical Admixtures
- Water Curing vs Curing Compounds
- Mineral Admixtures
- Microsilica – Alcofine – Metakaoline
- 100 mm Cubes vs 150 mm cubes Compressive strength Comparison.
- Etc……

Special Concretes

- High Strength Concrete – HSC
- High Performance Concrete – HPC
- Ultra High Performance Concrete – UHPC
- Light Weight Concrete
- High Density Concrete
- High Early Strength Concrete
- Temperature Controlled Concrete
- Water Proofing Concrete
- Smart Dynamic Concrete - SDC
- Self Compacting Concrete - SCC
- Fibre Reinforced Concrete – FRC
- etc

Pervious concrete

colour concrete

Stamped concretes

Concrete Pool Decks

Concrete Walkways

How RMC is Specified by IS 4926?

- **Prescribed mix:**
  - **Client specifies proportions**
    - **Based on his requirements; or**
    - **Based on proportioning work done in a third party lab**
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  - **Responsibility for workability and compressive strength**
    - **RMC Producer is fully responsible**

Common Field Problems

- Short Measure in Concrete supplies
- Delayed Setting of Concrete
- Low Compressive Strength Results
- Shrinkage Cracking

Main Challenges in Producing Quality Concrete?

- Challenge is to Effectively Manage:
  - **Variations in Properties of Ingredients**
  - **Production Control Parameters**
  - **Sampling and Testing**

Quality Scheme

Criteria for Production Control of RMC

Certification Process for RMCPCS

Provisional Approval for CBs for RMCPCS

Download from http://qcin.org/CAS/RMCPC/

Two Schemes

- **Ready-Mixed Concrete Plant Certification Scheme (RMCPCS)**
  - **RMC Capability Certification: A Must**

  - **RMC 9000+ Certification: Optional**

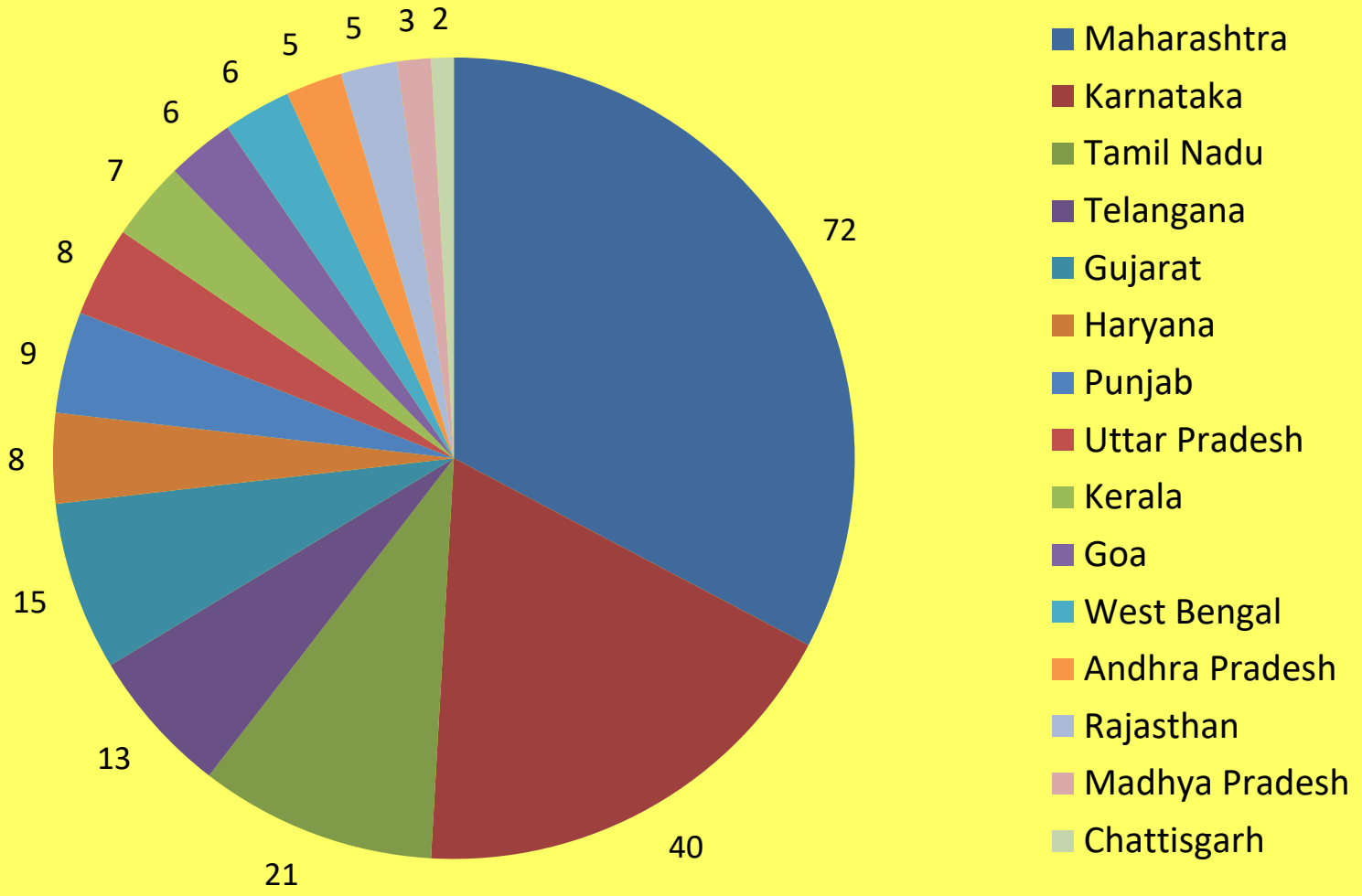
Certification Scheme Launched in Delhi

- **Quality Scheme launched on May 17, 2013 in Delhi**

Production Control Criteria: Broad Contents

- **Section A**
  - Resource Management
    - Plant and equipment
    - Laboratory
    - Key personnel
  - Control on quality of incoming materials
  - Concrete design
  - Production and delivery
  - Control on process control equipments and maintenance
  - Non Conformities
  - Criteria for Auditors
  - Complaints
  - Feedback
  - Certification , Validity & Audit frequency
- **Section B**
  - Check List (182 Item)
- **Tables:**
  - Table No 1 to 11

QCI RMCPCS Footprint*



About 300 RMC plants of RMCMA Companies in 15 states

Specifications

- Specify and Use Readymixed Concrete from a rmc plant which is certified as per the QCI-Quality Scheme.

- RMC Users to buy Concrete only from certified plants as per the QCI – Quality Scheme.

PWD Karnataka Schedule of Rates

Sl. No.	Description	Unit	Rate Rs. Ps.
4.47	Lift charges for steel of all diameters for additional floors over ground floor per floor height of 3.5 m. or part thereof cost of labour, complete as per specifications. Specification No. KBS	Tonne	445.00
4.48	Providing and laying cement concrete using 20 mm and down size granite coarse aggregates and fine aggregates of ready mixed concrete (RMC) M 20 for R.C.C works laid in 15 cms thick layers and well compacted vibrating, curing, for raft foundation column footing , main and secondary beams with all lead and lifts etc., complete (exclusive of cost of steel and fabrication charges.)	cum	5,863.00
4.49	Providing and laying cement concrete using 20mm and down size granite coarse aggregates and fine aggregates of ready mixed concrete for RCC works laid in 15 cm thick layers and well compacted including vibrating curing etc., with all lead and lift etc., complete. (exculsive of cost of steel and fabrication charges)		
4.49.1	Ready mixed Cement concrete for Beams, Staircase and Roof with M-20	cum	5,863.00
4.49.2	Ready mixed Cement concrete for Beams, Staircase and Roof with M-25	cum	6,048.00
4.49.3	Ready mixed Cement concrete for Beams, Staircase and Roof with M-30	cum	6,227.00
4.49.4	Ready mixed Cement concrete for Beams, Staircase and Roof with M-35	cum	6,469.00
4.49.5	Ready mixed Cement concrete for Beams, Staircase and Roof with M-40	cum	6,711.00
	Note : The RMC should be obtained only from the plants certified by the quality council of India as per letter No. CE, C&B, AE-2, 2015-16 Dt. 02.09.2015		
4.50	Providing and mixing synthetic fibers 100% virgin triangular monofilament polyester fibers, 12mm in cut length for use as secondary fiber reinforcement in concrete works. Application per cubic meter shall be 125 grams per bag of cement or 0.25% by weight of cement.		
4.50.1	- do - For 1:2:4 Concrete	cum	310.00
4.50.2	- do - For M-20 Concrete	cum	400.00
4.51	Providing and mixing fibermesh MD(Multi Dimensional) Graded (fibermesh inforce e3) fibrilated (interconnected bundles of fibers that open up during the mix process) 100% virgin Polypropylene fibers contains no reprocessed olefin materials and are specially manufactured with 25 individual unique fiber design to an optimum gradation for use as complete secondary reinforcement. Application per cubic meter shall equal a minimum of 0.1% by volume (0.9kg per cubic meter) in the concrete. Fibermesh MD Graded Polypropylene fibrilated fiber should confirm to ASTM C 1116 type III 4.1.3 ASTM C 1116 performance level 1% ASTM C 1339 (Minimum average residual strength of 0.35 Mpa).	cum	710.00
4.52	Providing and mixing fibermesh stealth e3 Fibermesh150multi dimensional graded multifilamenrt 100%virgin polypropylene fibres contains no reprocesserd olfrin materials and are specifically manufactured for use as concrete secondary reinforcement. Application per cubic meter shall be @ 0.9kg to 1.8kg per cum of concrete. Fibermesh stealth e3 shall confirm to ASTM C 1116 type 111.4.106.	cum	410.00
4.53	Providing and casting reinforced cement concrete racks with design mix M20, granite or trap jelly 12mm and down size 5 cms thick and below	sqm	843.00

Recommendation of RMCPCS BY CONSULTANTS

esignTree
Service Consultants Pvt Ltd

Date: 10-07-2015

The CEO, NABCB
Quality Council of India
2nd Floor, Institution of Engineers Building
Bahadur Shah Zafar Marg, New Delhi-110 002

Dear Sir,

Sub: Recommendation of Ready Mix Concrete (RMC) Plant Certification Scheme (RMCPCS) of QCI and insistence of RMC from certified plants reg.
Ref: Letter from Mr. R D Khatri, Consultant, RMC-QCI dated 29th Dec2014 and meeting with Dr. Aswath M U, Technical Advisor-RMCMA on 10-07-2015

We are happy to note that **Quality Council of India**, India's apex quality facilitation body, set up by the Central Govt. has designed and launched the **"RMC Plant Certification Scheme"**. We appreciate and acknowledge the efforts made by **Ready Mixed Concrete Manufacturer's Association (RMCMA)** in promoting the quality of concrete in general and Ready Mixed Concrete in particular.

We at DesignTree Service Consultants Pvt. Ltd., Bangalore have already recommending all our clients to procure the RMC from the QCI certified RMC Plants only. However we will include the following detail in our specifications henceforth wherever applicable.

"Ready Mixed Concrete shall be procured from Ready-Mixed Concrete plants which are certified in accordance with Quality Council of India(QCI)'s Ready Mix Concrete Plant Certification Scheme (RMCPS).

for DesignTree Service Consultants Pvt Ltd.

K. Srinivasa Reddy
Managing Director

Copy to: The President
RMCMA-Mumbai

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Recommendation of RMCPCS BY CONSULTANTS

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www.sterlingengg.com

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PHONE : 2207 3578, 2207 0582
FAX : 2207 3584
E-MAIL : secspl@bom3.vsnl.net.in

To,
The CEO, NABCB
Quality Council of India
2nd Floor, Institution of Engineers Building
Bahadur Shah Zafar Marg
New Delhi-110 002

CIN: U28920MH197BPTC020333

28-11-2015

Dear Sir,

Sub: Recommendation of Ready Mix Concrete (RMC) Plant Certification Scheme (RMCPCS) of QCI and insistence of RMC from certified plants reg.

Ref: Discussions during the Round Table meet at Bengaluru and subsequent meetings with Dr. Aswath M U, Technical Advisor-RMCMA

We appreciate and acknowledge the efforts made by **Quality Council of India and Ready Mixed Concrete Manufacturer's Association (RMCMA)** in promoting the quality of Ready Mixed Concrete. The **"RMC Plant Certification Scheme" is very effective and ensures the quality of RMC to a great extent. Sterling Engg Consultancy supports any efforts towards the improvement of quality of RMC.**

We at Sterling Engg Consultancy, Bangalore have already recommending all our clients to procure the RMC from the QCI certified RMC Plants. However we will include the following detail in our specifications henceforth wherever applicable.

"Ready Mixed Concrete shall be procured from Ready-Mixed Concrete plants which are certified in accordance with Quality Council of India(QCI)'s Ready Mix Concrete Plant Certification Scheme (RMCPS). The procedure for certification, as detailed in the QCI web site shall be followed meticulously. For certification, contact: rmcpcs@qcin.org or info@rmcmaindia.org"

N. N. Nagendra

Er. N. N. Nagendrakumar
Resident Director
Sterling Engg Consultancy
Banglore-560 025

Copy to:
The President
RMCMA-Mumbai

CONCLUSIONS

- Specify the rmc technical requiremnets in detail.
- Vendor evaluation: Only QCI Certified Plants.
- Visit to Plant: Plant, Machineries, System, Materials, Trained Man Power, etc
- Check for Calibration reports
- Witness Yield test
- At Site: Keep Site ready for concreting so that avoid delay in starting concreting.
- Check the delivery dockets and Cycle data before start unloading.
- Monitor Redosing of Admixtures at site.
- Proper Sampling, slump check & Casting as per Standards.
- Initial on Cubes casted
- Protection of Cubes from wind & Sun.
- Winess testing of Cubes.
- Third Party Laboratory Services.
- Carry out Research based on Industry needs and Application Oriented.


Thank You All!