Bridging the Gap in Concrete mixes

Path with Specifications

G.Sivakumar

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Concrete Specifications

Concrete Code of Practice
IS 456 / IRC 112

Specifications
CPWD / IRC / MORTH / MES / METRORAIL / RAILWAYS / TNPWD / CORPORATION

OPC / PPC / PSC
IS 8112/269 / 1489 / 455 / IS4031 / 4032

Pozzolana
IS 3812 / 12089 / 15388 / IS 1727

Superplasticizer
IS 9103

Aggregates
IS 383 & 2386

Water
IS 456

Mix Design Proportioning	
IS 10262 / SP23	IRC SP 44/76

Ready Mix Concrete
IS 4926

Sampling & Testing
IS 1199 / IS 516 ASTM / BS-EN

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Site may experience undesirable concrete quality at times.

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Cement

Technical Reference		IS 269:2015 (Revision VI)		
Test Conducted		**Test Method**	**Result**	**Requirements**
Fineness	Blaine's Permeability	IS 4031 Part-2:1999 (Reaffirmed 2013)		Not less than 225 m^2/kg
Normal Consistency		IS 4031 Part-4:1988 (Reaffirmed 2014)		---
Setting Time	Initial Setting Time	IS 4031 Part-5:1988 (Reaffirmed 2014)		Not less than 30 min
	Final Setting Time			Not more than 600 min
Soundness	Le-Chatelier Mould	IS 4031 Part-3:1988 (Reaffirmed 2014)		Not more than 10 mm
	*Autoclave Method	IS 4031 Part-3:1988 (Reaffirmed 2014)		Not more than 0.8 %
Specific Gravity	Le-Chatelier Flask	IS 4031 Part-11:1988 (Reaffirmed 2014)		---
Compressive Strength	3 days	IS 4031 Part-6:1988 (Reaffirmed 2014)		Not less than 27 MPa
	7 days			Not less than 37 MPa
	28 days			Not less than 53 MPa

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Aggregates

IS Sieve Designation	Grading Zone I	Grading Zone II	Grading Zone III
10mm	100	100	100
4.75mm	90-100	90-100	90-100
2.36mm	60-95	75-100	85-100
1.18mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

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Concrete Specifications

- Concrete materials are not “truly” manufactured
- Variation in properties of materials is inherent
- Codes for materials are handy in Quality Control
- Precise specification is required for Quality Assurance

Concrete Specifications

- Mix design formulation, Validation & Approval is a long process
- It is always difficult and time consuming exercise to revise the mix design and obtaining the approval in the middle of the project
- By the time a lot would have happened with the mix that was not fitting to the need
- Hence, the gaps should never be left out

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Concrete Specifications

Structural Engineer assumes that concrete is homogenous and uniform

Knowing that concrete is heterogeneous, Concrete Technologist works towards making concrete as homogenous as possible

Precise detailing form the Foundation of mix design

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Concrete Specifications

Workability

Concrete Specifications - Workability

Obsolete workability criteira in IS 456 – Old approach to control w/c

Placing Conditions	*Degree of Workability*	*Slump* (mm)
(1)	(2)	(3)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	*See* **7.1.1**
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; Floors; Hand placed pavements; Canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns; Slipform work; Pumped concrete	Medium	50-100 75-100
Trench fill; *In-situ* piling	High	100-150
Tremie concrete	Very high	*See* **7.1.2**

Too low a workability

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Concrete Specifications - Workability

Low workability criteira in MoRTH for Modern day structures

1704.1 Requirements of Consistency

The mix shall have the consistency which will allow proper placement and compaction in the required position. Every attempt shall be made to obtain uniform consistency. Slump test shall be used to measure consistency of the concrete.

The optimum consistency for various types of structures shall be as indicated in Table 1700-4, or as directed by the Engineer. The slump of concrete shall be checked as per IS:516.

Table 1700-4 : Requirements of Consistency

	Type	Slump (mm) (at the Time of Placing of Concrete)
1)	a) Structure with exposed inclined surface requiring low slump concrete to allow proper compaction	25
	b) Plain cement concrete	25
2)	RCC structure with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining	40 – 50
3)	RCC structure with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts, well curb, well cap, walls with thickness greater than 300 mm	50 – 75
4)	RCC and PSC structure with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm	75 – 125
5)	Underwater concreting through tremie e.g. bottom plug, cast in-situ piling	150 – 200

Notwithstanding the optimum consistency indicated against Sl. No. 1 to 3, the situation should be property assessed to arrive at the desired workability with the adjustment of admixture in each case, where the concrete is to be transported through transit mixer and placed using concrete pump. Under these circumstances, the optimum consistency during placement for the items of work of Sl. No. 1 to 3, can be considered ranging from 75 mm to 150 mm. This is, however, subject to satisfying the other essential criteria of strength, durability etc. and approval of the Engineer.

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Concrete Specifications - Workability

Silver lining in MoRTH

1715 HIGH PERFORMANCE CONCRETE

1715.1 General

High Performance Concrete shall be used where special performance requirements of high strength, high early strength, high workability, low permeability and high durability for severe service environments, are required. Production and use of such concrete in the field shall be carried out with high degree of uniformity between batches and very stringent quality control.

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Concrete Specifications - Workability

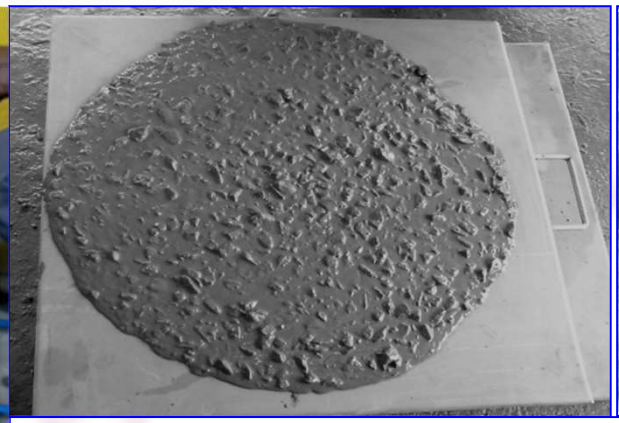
For the same w/c ratio, concrete with different workability can be designed and produced – Admixture has become integral part of the mix

50mm

100mm

140mm

180mm



FLOW (JOLTING METHOD) & SLUMP FLOW (SCC)

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Concrete Specifications - Workability

Application that requires moderate workability

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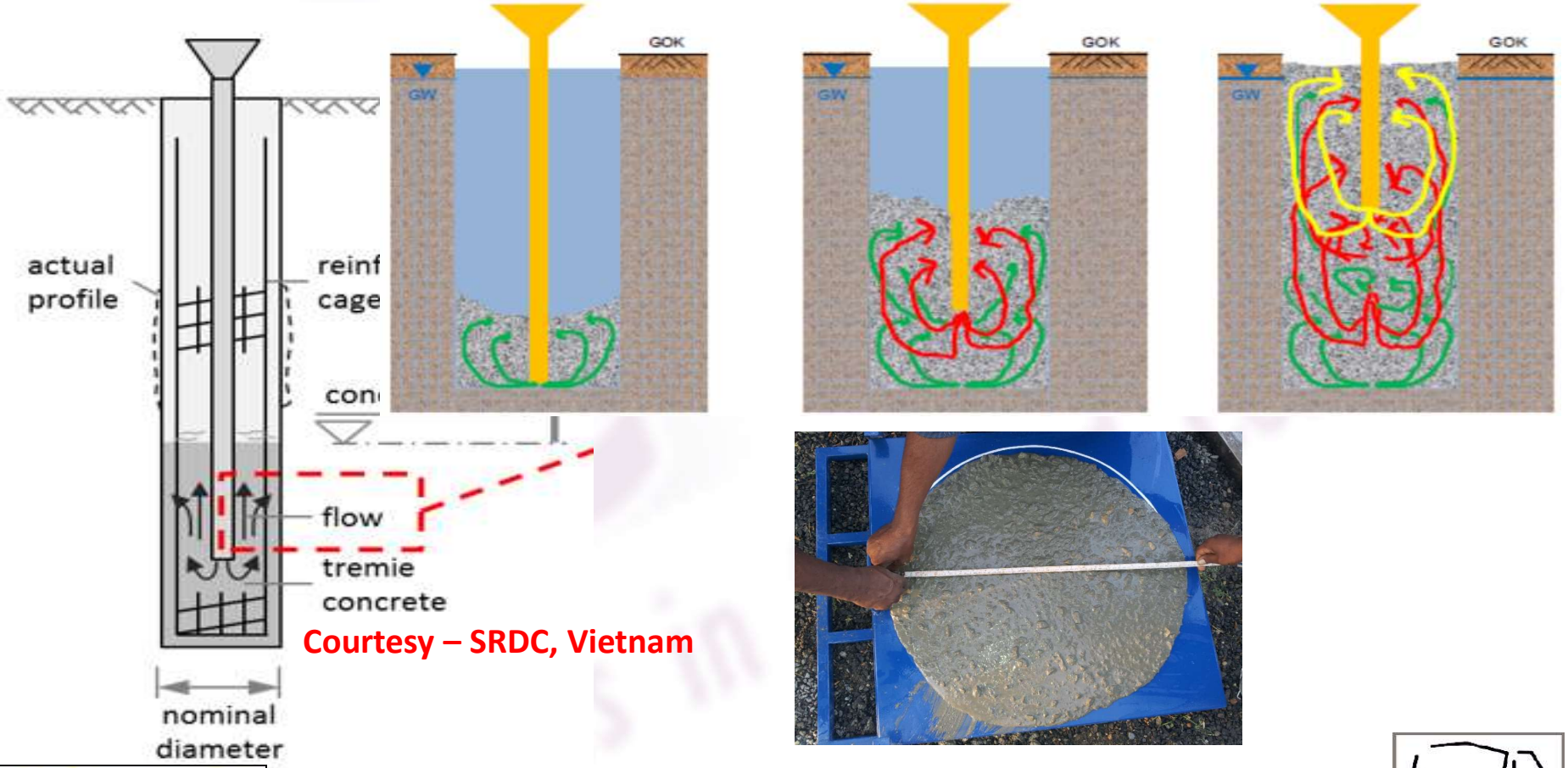
Concrete Specifications - Workability

Pile requires higher workability, more precisely flowability, to fill and obtain compaction by virtue of high slump/flow



Courtesy – SRDC, Vietnam

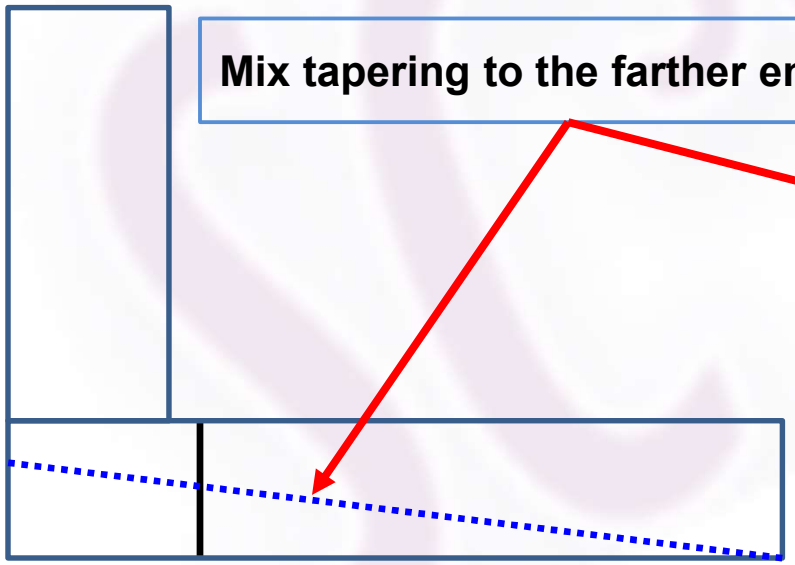
Flow Table method of Flow measurement – IS 9103

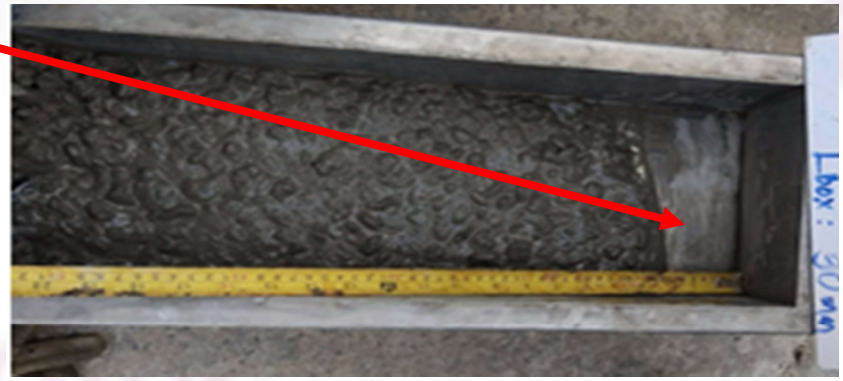
Concrete Specifications - Workability

Bored Pile

Countries including SEA have moved ahead with higher workability clause by opting for L-Box text.

Mix tapering to the farther end is the criterion (and not flat like SCC)





Courtesy – SRDC, Vietnam

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Concrete Specifications - Workability

Applications like Mivan that requires high flow concrete mix

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Concrete Specifications - Workability

Column / Wall

What should be the slump when the mix is expected to reach the cover from core and get compacted???

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Concrete Specifications - Workability

For vertical structures like Columns or Walls high slump concrete mix makes placing and compaction efficient

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Concrete Specifications - Workability

Pile cap & Raft becoming critical structures in terms of grade of concrete and Rebar congestion

Even a slump of 120 – 150mm would not be sufficient to send the mix from top rebar-mat. How will this mix cover rebars at the bottom?

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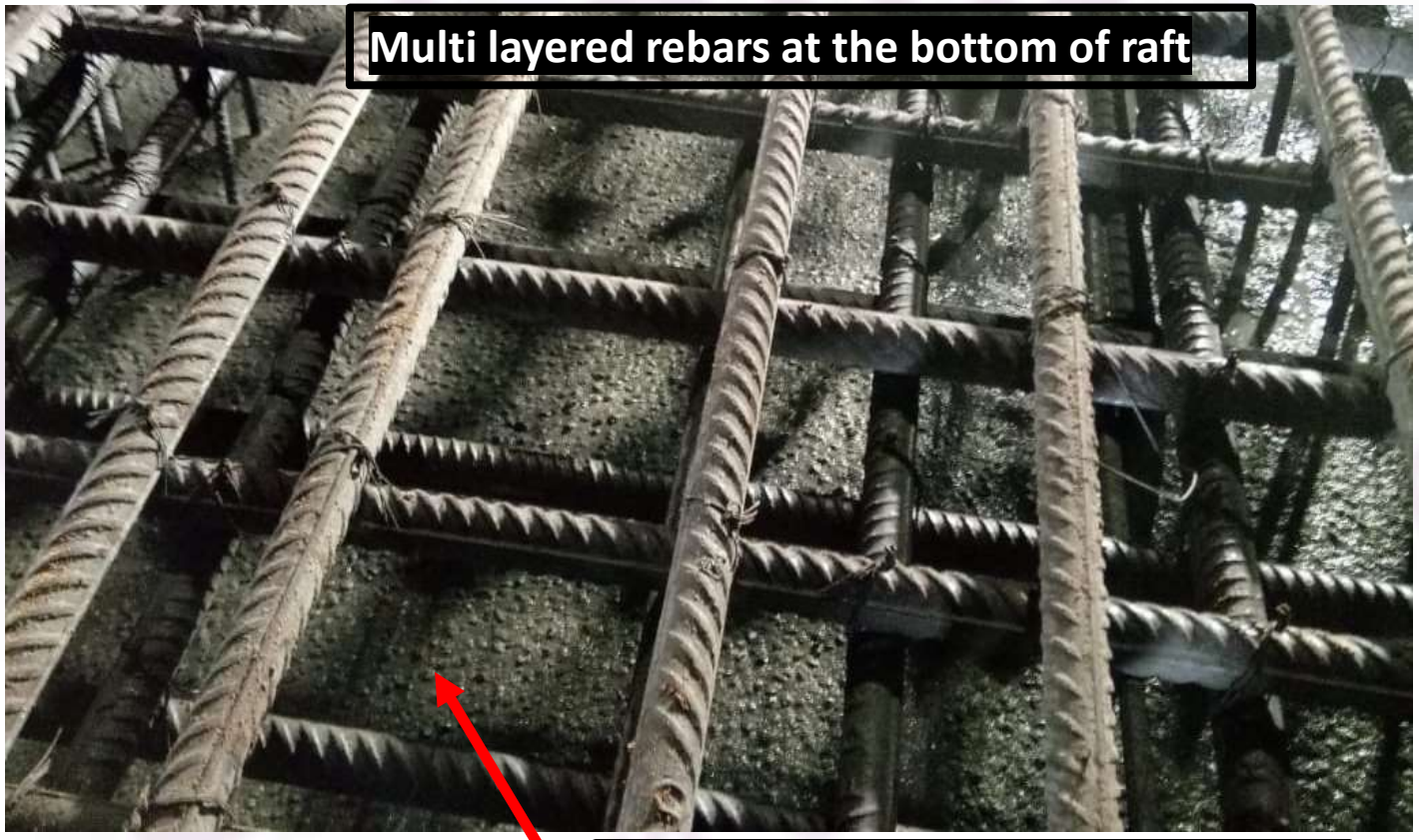
Concrete Specifications - Workability

Raft – Though larger in size rebar placing requires higher workability



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Concrete Specifications - Workability

Slump for isolated Footing – 100mm?

Not only the structure, but also placing methodology determines the workability.

- What is the slump required for the mix to flow through the chute? 100mm! Not really!

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Concrete Specifications - Workability

No to tapered finish that would not be compacted.

Yes to casting rigid Stepped footing

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Concrete Specifications - Workability

Criticality ➔ SCC

Forget about compaction, pouring itself is a challenge!

Self Compacting Concrete is a savior for critical structure!

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Concrete Specifications - Workability

Varying slump range based on the Structures

Structures	Slump @ Site
Precast Elements	< 75 mm
Footing & Raft & Flooring	100+/-25 mm
Slab & Pile caps with nominal reinforcement / thickness	150+/-25 mm
Slab / Raft with two or multiple layers reinforcement	175+/- 25 mm
Column & Wall with moderate reinforcement	175+/-25 mm
Piers, Shear walls, Piles & Diaphragm walls	200+/-25 mm or 500 to 600 mm flow
Critical Structures	SCC Flow of 550 to 850 mm

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Concrete Specifications – Workability Retention






Longer retention (or keeping concrete fresh)!

To avoid cold joint !

Example : Pile and Diaphragm wall

No.	RETENTION								Bleeding Test (ml)	
	5 min	60 min	120 min	180 min	240 min	300 min	360 min	420 min	30 min	
Mix 3	210	220	225	220	210	210	205	-	20.0	

Courtesy – SRDC, Vietnam

Concrete Specifications

Strength requirement for mix design approval

Concrete Specifications

Strength requirement for mix design approval

- Is it the Characteristic Strength value, "f_{ck}"?
- Or Target Mean Strength, "f_{ck} + k*SD " ?

Both are not correct

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Concrete Specifications - Additives

MoRTH Specification for Trial Mix result acceptance

For each trial mix, a set of six cubes shall be made from each of three consecutive batches for purposes of testing. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these Specifications. The mean strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus 3.5 MPa.

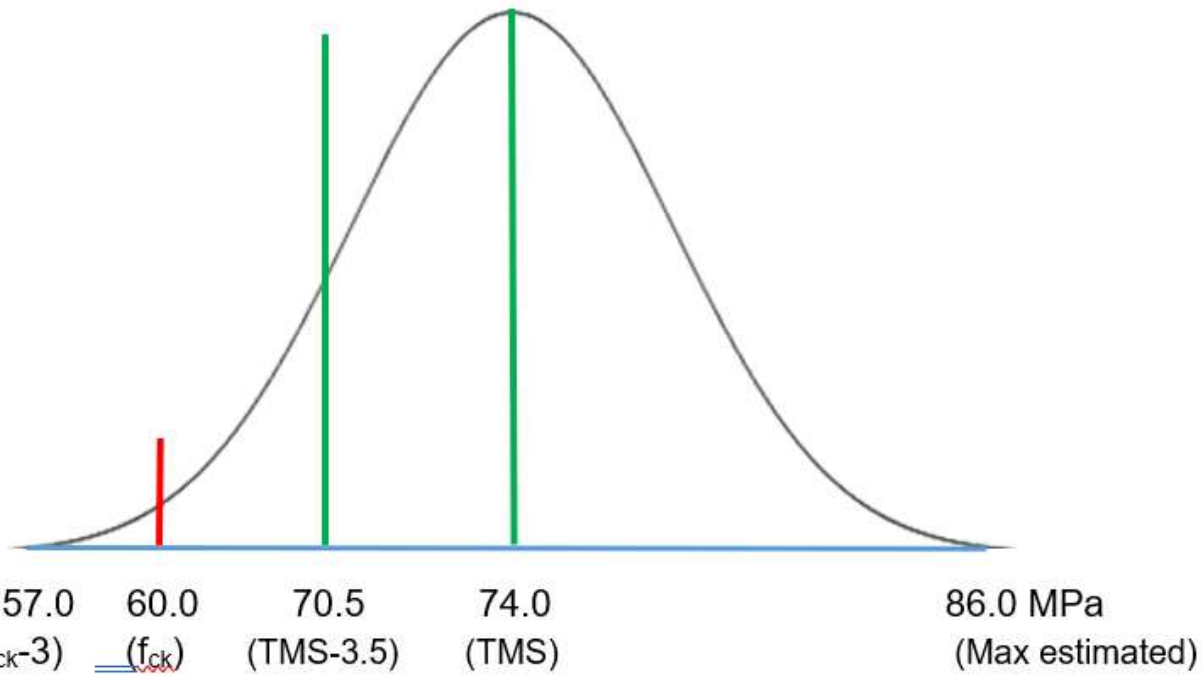
Concrete Specifications - Additives

Example for M60 for the Plant without established Standard Deviation:

The mean strength of 9 cubes tested at 28 day age shall be not less than

For a new plant ➔ 60 + (14 - 3.5) = **70.5 MPa**

An overview of Normal Distribution Curve with limits for different requirements for M60



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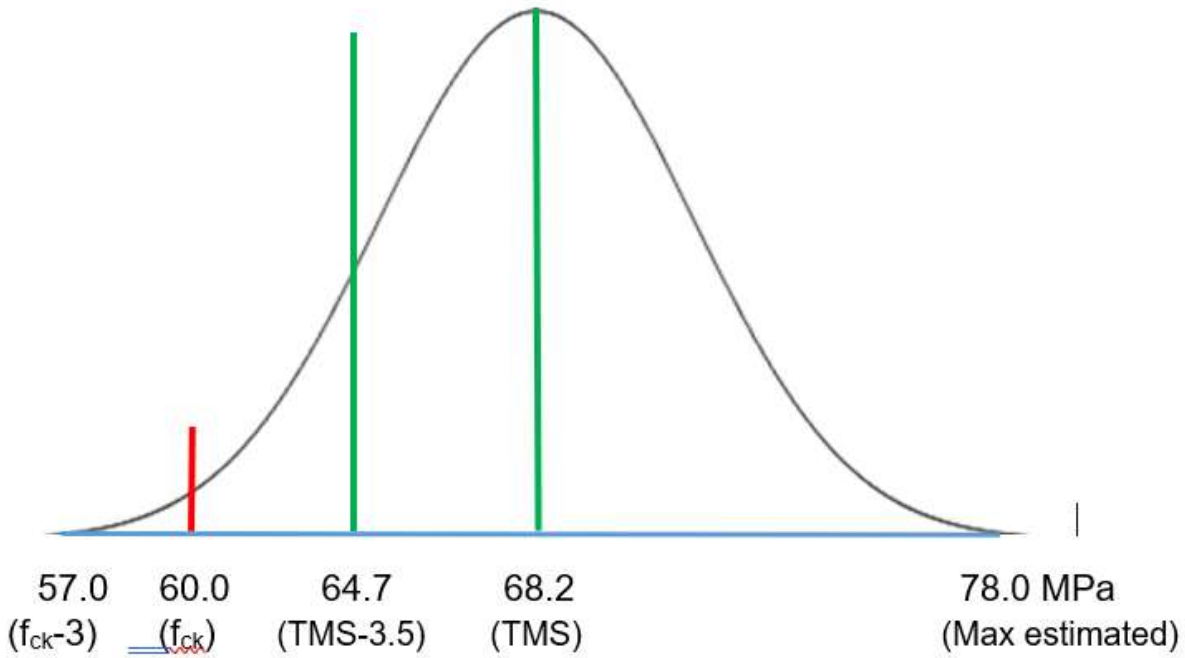
Concrete Specifications - Additives

Example for M60 for the Plant with established Standard Deviation:

The mean strength of 9 cubes tested at 28 day age shall be not less than

For a plant having a Standard Deviation of 5 MPa ➔ 60 + (8.2-3.5) = **64.7 MPa.**

An overview of Normal Distribution Curve with limits for different requirements for M60



Concrete Specifications

Additives

Concrete Specifications – Additive VMA

Segregation due to height of pouring?

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Concrete Specifications – Additive VMA

Viscosity Modifying Agent (VMA) that can make the fresh mix robust!

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Concrete Specifications – Additive VMA

Good VMA's ability - preventing segregation even from a free-fall. A real binding agent in fresh state!

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Concrete Specifications – Additive VMA

VMA could be handy in preventing blemishes especially in mixes with lesser binder content.

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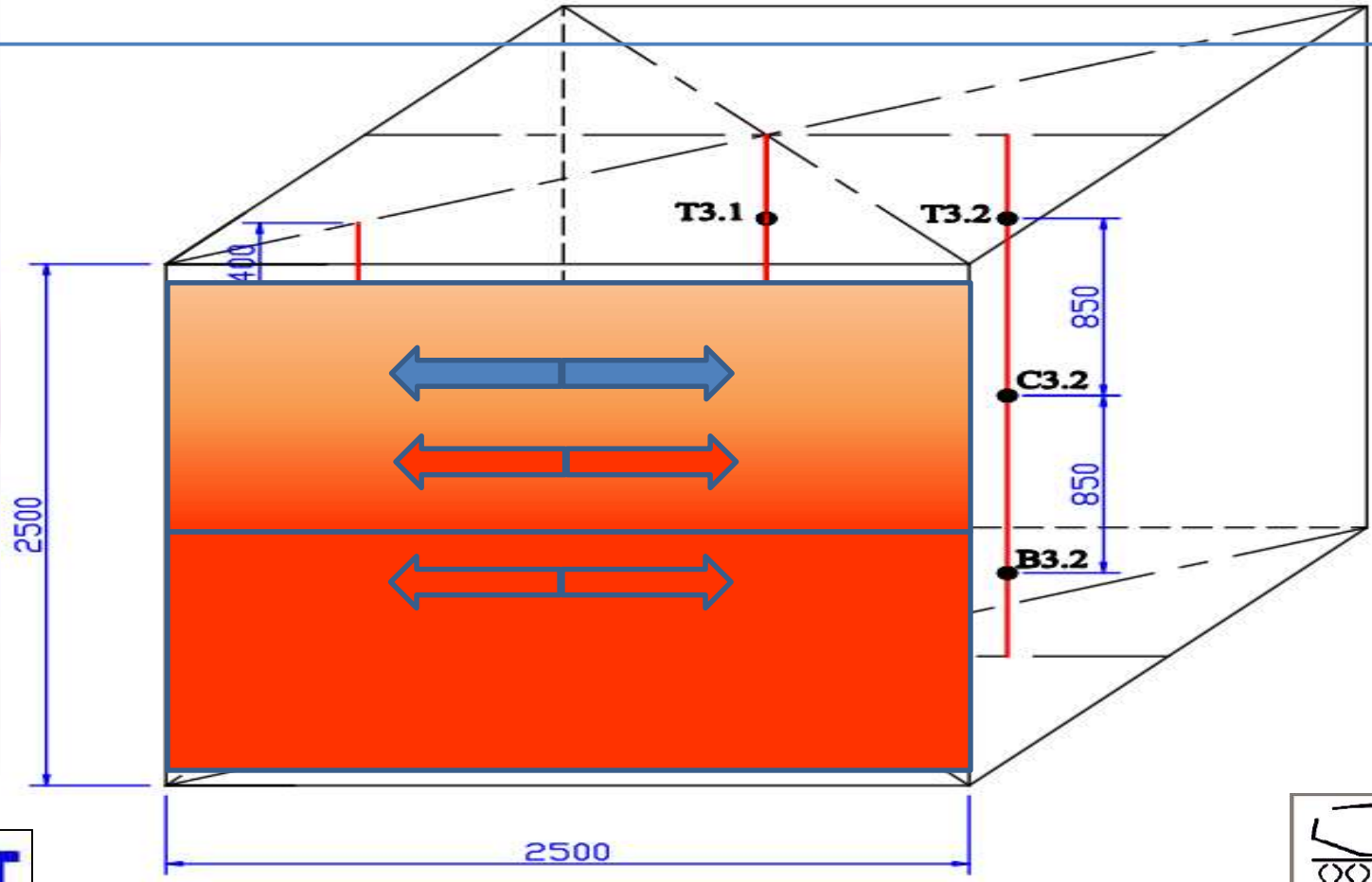
Concrete Specifications – Additive Retarder

Mass Concrete Criticality - Temperature in concrete

Peak and Differential Temperature arising from exothermic property of cement



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Concrete Specifications – Additive Retarder

- **Usual addition**

ICE Flakes / Cubes, Chill Water, Fly Ash or GGBS

- **An often neglected yet important additive is Retarder**

It is the most efficient additive to control peak temperature and differential temperature

It is a critical additive to nullify PCE admixture effect, i.e., early hydration due to sudden withdrawal effect of PCE admixture, which can be noticed in the form of high early one day to three day strength compared to the concrete mix with SNF admixture.

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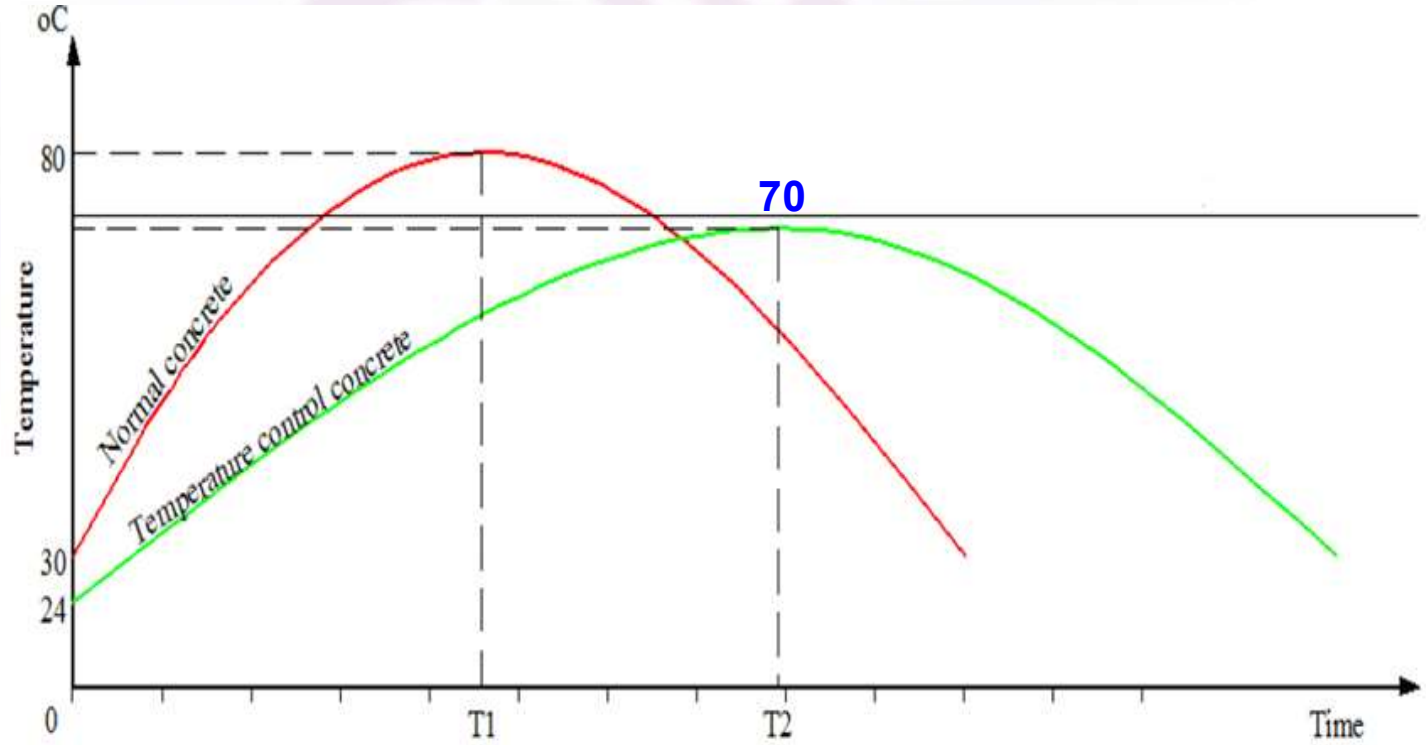
Concrete Specifications – Additive Retarder

Chemical Set-Retarder's ability along with "Mineral Retarder" Fly Ah in reducing the Peak temperature and delaying its onset (from Time 1 to Time 2)



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Concrete Specifications – Additive Synthetic Fibers

- Ability to control the crack propagation especially at micro level
- Will not be able to prevent the cracking totally

Fire ➔ Synthetic Fibers Act like pressure relieve valves

- HSC could fail explosively when exposed to higher temperature during fire because of its low permeability and lower water-cement ratio.
- When Synthetic fibers are added in HSC, at higher temperatures fibers melt and provide channels for pore pressure release
- This gives fire fighters more time both to evacuate structures and to extinguish the fire safely.

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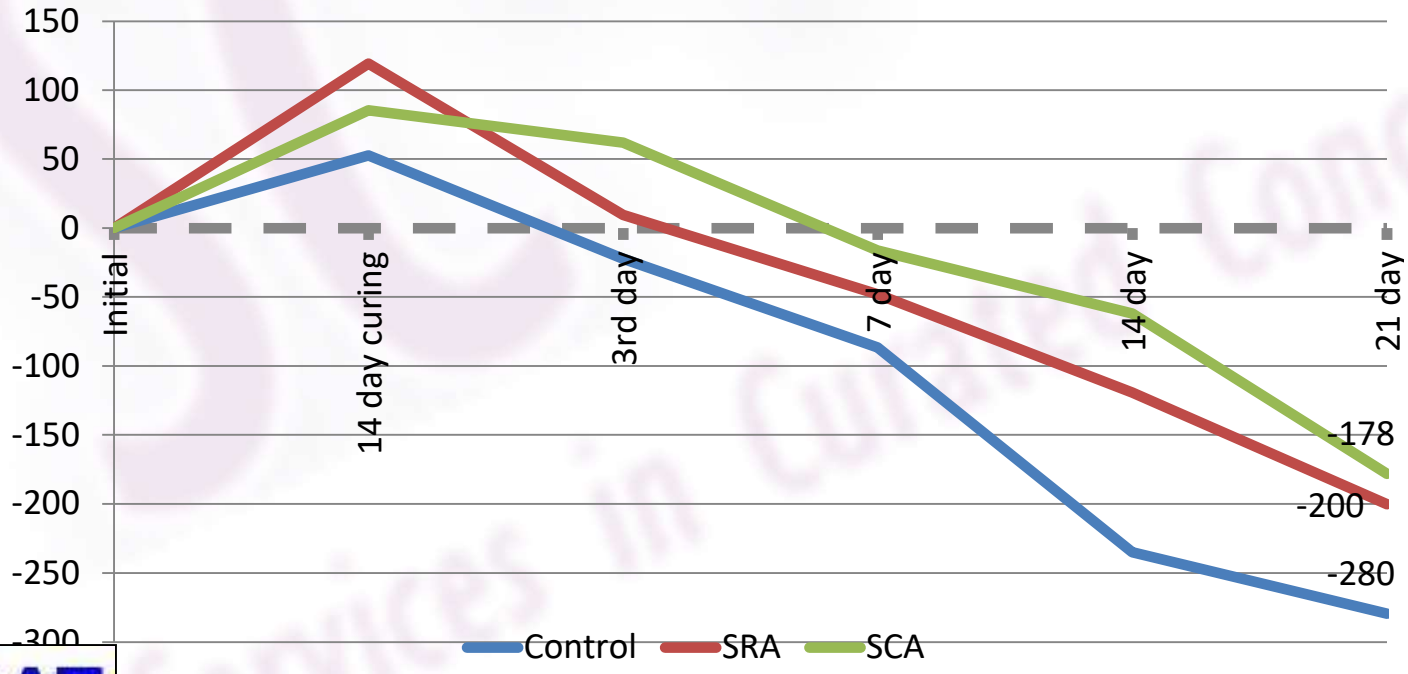
Concrete Specifications – Additive : Shrinkage mitigation

Concrete would Shrink

– Physically (Drying Shrinkage) or Chemically (Autogenous Shrinkage)

Mitigation through additives

- **Shrinkage Reducing Admixture - SRA**
- **Shrinkage Compensating Additive – normally CSA**



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Concrete Specifications - Additives

Automation is very essential to remove manual error, even blunders!

Automated multiple Dispenser system in batching plant

Courtesy – SRDC, Vietnam

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Concrete Specifications

Critical Tests

Concrete Specifications – Bleeding Test

Bleeding in Bored Pile

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Concrete Specifications – Bleeding Test

Bleeding Test as per IS9103 for normal structure – Not suitable for Bored Piles or Diaphragm Walls

Not possible to identify bleeding characteristic of a mix in a small cylinder

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Concrete Specifications – Bleeding Test

Hydrostatic pressure due to the depth will influence bleeding, enormously

600mm dia and 3.0 m high casting did not show bleeding

Same mix exhibited bleeding at site - Hydrostatic pressure due to the depth of Pile

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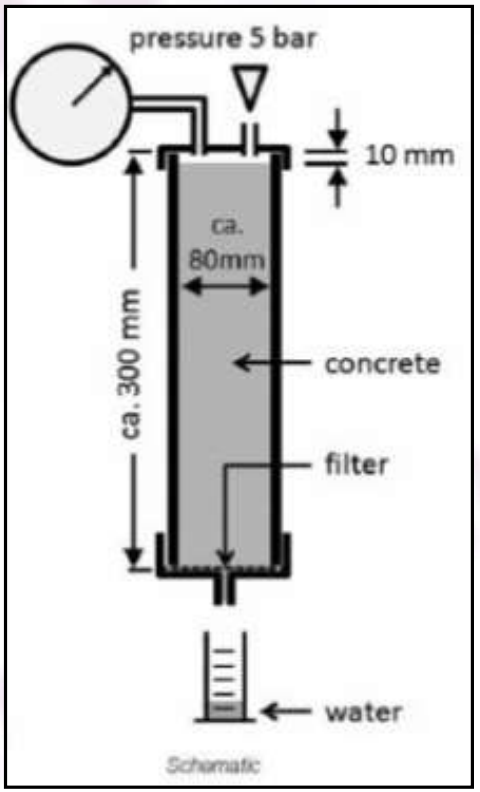
Concrete Specifications – Bleeding Test

Bauer Bleeding Test for Pile – Simulation of Pressure is an ideal way



Courtesy – SRDC, Vietnam

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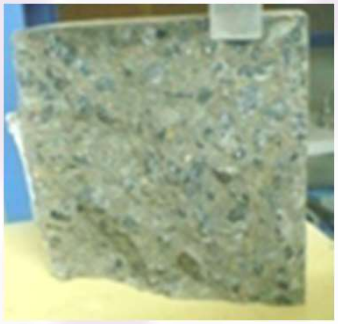
Concrete Specifications – Water Penetration Test

WPT, a must for

- **Any Water retaining / resisting structure**
- **Qualifying any Water Proofing Additive**



Water Penetration Test @ 5 bar pressure for 72 hours (DIN 1048 / IS 516)

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Concrete Specifications – Early age Strength Test

Wall/ Column De-shuttering be scientific

To specify Form work removal Strength as Cube strength ≥ 7 MPa

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Concrete Specifications

QCI Certified Plants

– Ensuring the production facility and quality standards

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Quality Council of India - Certification

Quality Council of India
Working for "National Well Being"

Ready Mix Concrete Plant Certification Scheme (RMCPCS)

Quality Council of India (QCI) has taken an initiative to establish an independent third party voluntary **"RMC Plant Certification Scheme"** in the country to assure quality in operations and processes of RMC Plants. This scheme was developed with the active participation and technical support from Ready Mixed Concrete Manufacturers' Association (RMCMA), a Mumbai based non-profit industry organization of leading Ready Mix Concrete (RMC) producers in India; Building Materials & Technology Promotion Council (BMTPC) under Ministry of Housing & Urban Poverty Alleviation, Government of India and various other stakeholders.

Documents

1. Brief Note
2. Criteria for Production Control of RMC
3. Certification Process
4. Provisional Approval System for Certification Bodies
5. Application Form
6. List of Auditors
7. Approved Certification Body

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

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Quality Council of India - Certification

Key Features

- Third party Audit through NABCB Accredited Certifying bodies
- Checklist of 182 points to ensure the capabilities of the RMC manufacturer in line with world class standards
- Surprise surveillance audit (less than 48 hours notification, even).
- Random sampling – to trace customer requirements vs actual supply
- Nodal officer in every RMC company to focus on Customer complaints & Feedback
- Traceability to establish Transparency

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Quality Council of India - Certification

Key Features

- QCI Certification is Batching Plant Specific and not Company Specific
- Batching System shall be reliable with data retrievable features
- Laboratory set up with Mix design capability of QC Team shall be established
- In-House Testing and External Testing are mandatory
- RMC Products Supply shall be made only based on the customer requirement, after establishing the same through Mix Designs.
- "Customer requirements ➔ Mix Designs Submission ➔ Customer's PO/Approval ➔ Supply as per requirements" shall be evidenced through documents.

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Concrete Specifications

Concrete Construction Utilizes enormous amount of natural resources and Time

Extended service life of the Structures forms one of the sustainable construction practices

We ought to “Sow” more details to “Harvest” better concrete

THANK YOU

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