PROPORTIONING OF CONCRETE MIXES FOR PRECAST ELEMENTS

STPL

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Bangalore-Hyderabad-VijayawadaBy

TYPICAL PRECAST CONCRETE CONSTRUCTION SITE

What is Precast Concrete ?

Precast concrete means a concrete member that is cast and cured at a location other than its final designated location.

Advantages of Precast Concrete

- **Saves Construction Time**
- **Quality Assurance**
- **Usage of Prestressed Concrete**
- **Cost effective**
- **Durability**
- **Aesthetics**
- **Safe working Platform**

Disadvantages of Precast Concrete:

- **High Initial Investment**
- **Transportation Issue**
- **Handling Difficulties**
- **Modification**
- **Sensitive Connection Works**

Precast concrete ensures fast construction times, high profitability and excellent quality. Still, requirements for beautiful, modern buildings are not compromised.

IMPORTANCE OF CONCRETE TECHNOLOGY IN PRECAST CONSTRUCTION

- Visual (surface) quality comes primarily from the concrete mix being used
- Structural (Load bearing capacity) quality comes primarily from the mix being used
- Cost of concrete primarily decides the cost of precast construction
- Use of industrial byproducts from the environmental effect point of view.

CONCRETE INGREDIENTS:

- CEMENT
- MINERAL ADMIXTURES – POZZOLANIC AND HYDRAULIC – FLYASH, GGBS
- ULTRA FINE MATERIALS- MICROSILICA, NANOSILICA & ULTRAFINE GGBS (ALCOFINE)
- FINE AGGREGATE- CRSUHED STONE SAND FROM A VSI CRUSHER
- COARSE AGGREGATE- FROM A VSI CRUSHER
- WATER
- CHEMICAL ADMIXTURES
- FIBRES

Different factors affect the consistency and compactability of the concrete mix

- Water increases flowability and reduces strength.
- Binders increase the need for water.
- Round aggregate shapes improve compactability and reduce tensile strength.
- An optimal grading curve improves compactability.
- Plasticizers reduce water demand.
- An increase in temperature – or a delay in casting – reduces compactability.

In a concrete mix-

- **Maximize the aggregate volume**
- **Minimize the volumes of cement and water**

Remember that aggregate is a natural material and the variation in quality and properties is larger in comparison to cement and other components.

Emphasis in QC in a factory lab should be on aggregates

JAW CRUSHER AGGREGARES- FLAKY ELONGATED

VSI CRUSHER AGGREGARES

$$Packing\ Density\ (\phi) = \frac{Solid\ volume}{Total\ volume}$$

$$\phi = \frac{V_s}{V_t} = \frac{V_s}{V_s + V_v} = 1 - e \qquad (1)$$

Where :

Vs = volume of solids

Vt = total volume = volume of solids plus volume of voids

e = Voids = volume of voids over total volume to

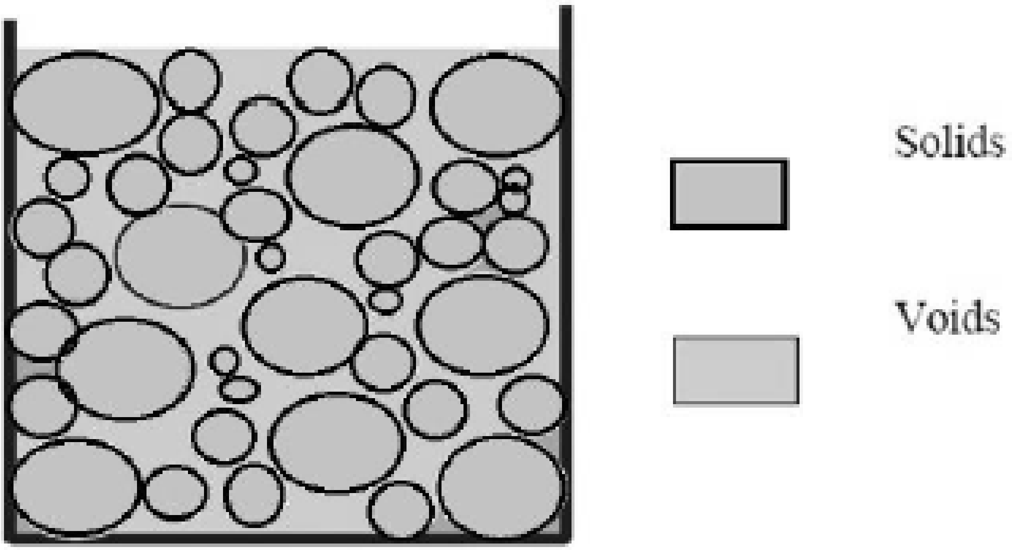
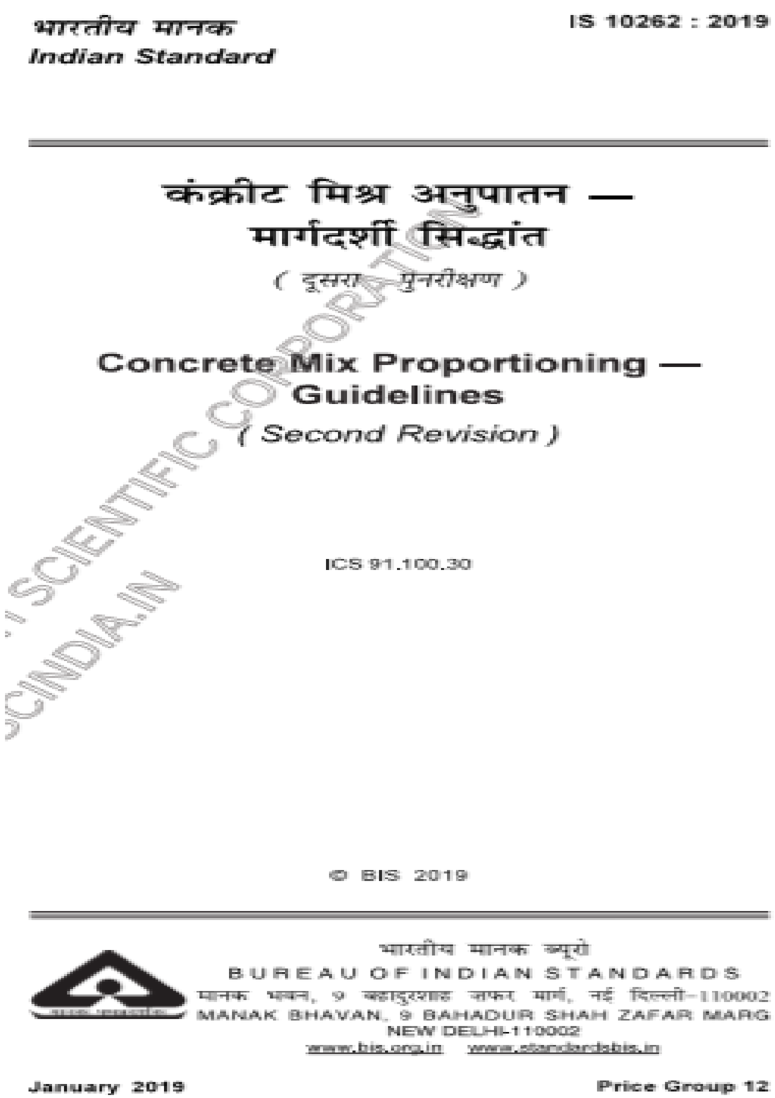


Fig. 1 Definition of Packing Density

MIX PROPORTIONING OF PRECAST CONCRETE IS SIMILAR TO SITE MIXED CONCRETE OR READY-MIXED CONCRETE



भारतीय मानक
Indian Standard

IS 10262 : 2019

कंक्रीट मिश्र अनुपातन — मार्गदर्शी सिद्धांत

(दूसरा पुनरीक्षण)

Concrete Mix Proportioning — Guidelines

(Second Revision)

ICS 91.100.30

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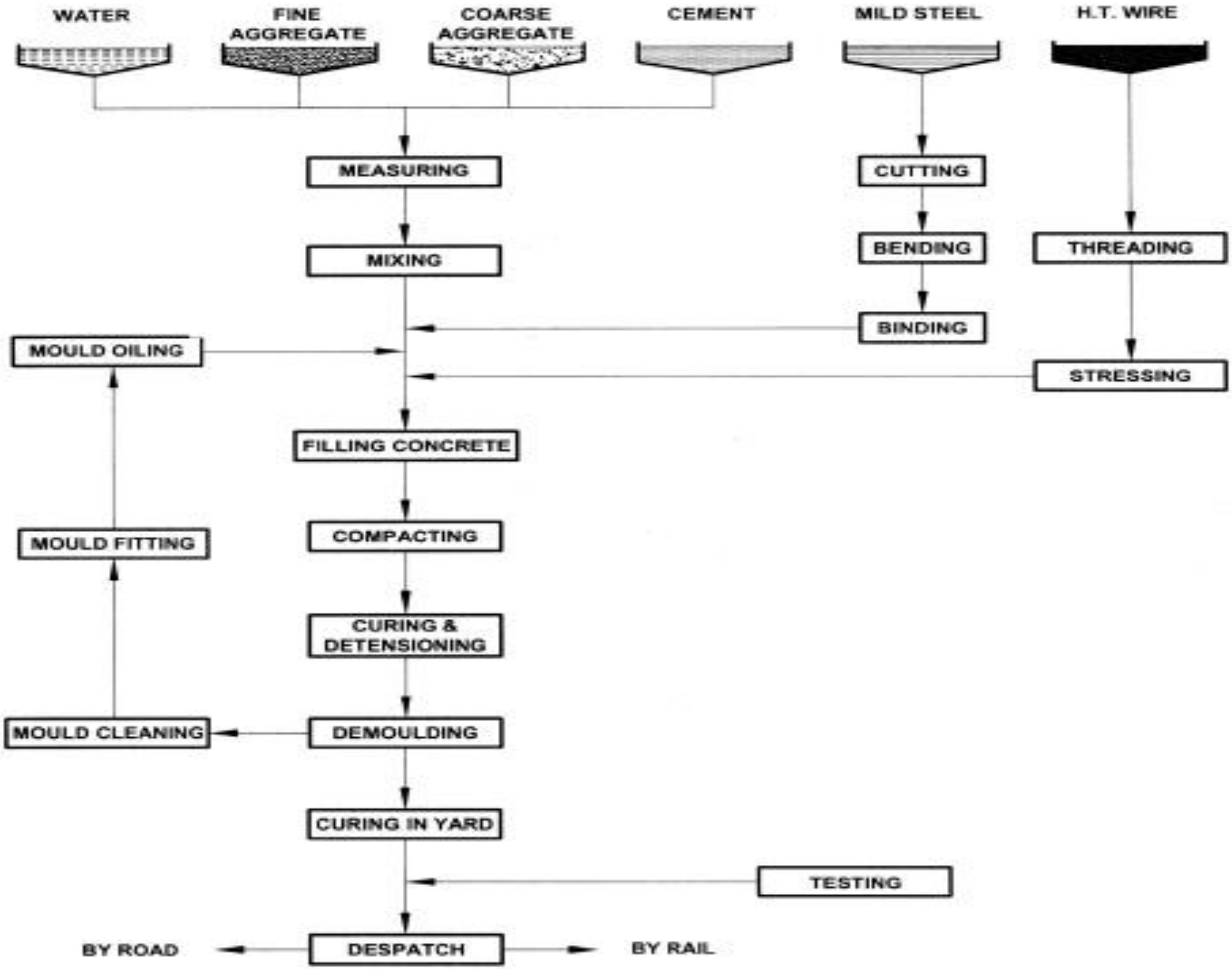
BUILDING DESIGN AND ERECTION USING PREFABRICATED CONCRETE — CODE OF PRACTICE


WATER
FINE AGGREGATE
COARSE AGGREGATE
CEMENT
MILD STEEL
H.T. WIRE
MEASURING
CUTTING
MIXING
BENDING
THREADING
BINDING
MOULD OILING
STRESSING
FILLING CONCRETE
MOULD FITTING
COMPACTING
CURING & DETENSIONING
MOULD CLEANING
DEMOULDING
CURING IN YARD
TESTING
BY ROAD
DESPATCH
BY RAIL

(Clause 11.1.[illegible])

Sl No. (1)	Precasting Stage No. (2)	Name of Process (3)	Operations Involved (4)
i)	1	Procurement and storage of construction materials	Unloading and transport of cement, coarse and aggregates, and steel, and storing them in bins, silos or storage sheds
ii)	2	Testing of materials	Testing of all materials including steel
iii)	3	Design of concrete mix	Testing of raw materials, plotting of grading curves and trial of mixes in laboratory
iv)	4	Making of reinforcement cages	Unloading of reinforcement bars from wagons or lorries and stacking them in the steel yard, cutting, bending, tying or welding the reinforcements and making in the form of a cage, which can be directly introduced into the mould
v)	5	Applying form release agent and laying of moulds in position	Moulds are cleaned, applied with form release agent and assembled and placed at the right place
vi)	6	Placing of reinforcement cages, inserts and fixtures	The reinforcement cages are placed in the moulds with spacers, etc as per data sheet prepared for the particular prefabricate
vii)	7	Preparation of green concrete	Taking out aggregates and cement from bins, silos, etc, batching and mixing
viii)	8	Transport of green concrete	Transport of green concrete from the mixer to the moulds. In the case of precast method involving direct transfer of concrete from mixer to the mould or a concrete hopper attached to the mould this prefabrication stage is not necessary
ix)	9	Pouring and consolidation of concrete	Concrete is poured and vibrated to a good finish
x)	10	Curing of concrete and demoulding	Either a natural curing with water or an accelerated curing using steam curing and other techniques. In the case of steam curing using trenches or autoclaves, this stage involves transport of moulds with the green concrete into the trench or autoclave and taking them out after the curing and demoulding elements. Cutting of protruding wires also falls in this stage. In certain cases the moulds have to be partly removed and inserts have to be removed after initial set. The total demoulding is done after a certain period and the components are then allowed to be cured. All these fall in this operation
xi)	11	Stacking of precast elements	Lifting of precast elements from the mould and transporting to the stacking yard for further transport by trailer or rail is part of this stage
xii)	12	Testing of finished components	Tests are carried out on the components individually and in combination to ensure the adequacy of their strength
xiii)	13	Miscellaneous	a) Generation of steam involving storing of coal or oil necessary for generation of steam and providing insulated steam pipe connection up to the various technological lines

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Concrete Mix Proportioning — Guidelines

(Second Revision)

In this second revision, the following major modifications have been made:

a) The standard has been divided into five sections, as follows:

1) Section 1 General
2) Section 2 Ordinary and standard grades of concrete
3) Section 3 High strength grades of concrete
4) Section 4 Self compacting concrete
5) Section 5 Mass concrete

Mix proportioning procedure for high strength concrete for M 65 or above (up to target strength of M 100) has been included.

The initial data to be provided for mix proportioning has been made more encompassing, covering the provisions of revised IS 383 : 2016 'Coarse and fine aggregates for concrete (*third revision*)', use of admixtures, etc.

The target mean strength for mix proportioning formula has been refined to include a new factor based on the grade of concrete. This has been done to ensure a minimum margin between the characteristic compressive strength and the target mean compressive strength.

The calculations for standard deviation have been detailed.

A graph of water-cement ratio versus 28 days strength of concrete has been introduced for different grades and types of cement, as an alternate method for assuming the initial water-cement ratio.

Illustrative annexes for concrete mix proportioning for PPC, OPC with fly ash, OPC with ggbs, high strength concrete, self compacting concrete and mass concrete have been provided.

Guidelines on using/selecting water reducing admixtures have been introduced as an informatory annex (*see* Annex G).

The consideration of air content in design of normal (non-air entrained) concrete mix proportion, has been reintroduced.

4.2 Target Strength for Mix Proportioning

In order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be proportioned for higher target mean compressive strength f'_{ck}. The margin over characteristic strength is given by the following relation:

$$f'_{ck} = f_{ck} + 1.65\,S$$

or

$$f'_{ck} = f_{ck} + X$$

whichever is higher.

where

- f'_{ck} = target mean compressive strength at 28 days, in N/mm^2;
- f_{ck} = characteristic compressive strength at 28 days, in N/mm^2;
- S = standard deviation, in N/mm^2 (*see* **4.2.1**); and
- X = factor based on the grade of concrete, as per Table 1.

Table 1 Value of X

(*Clause* 4.2)

Sl No.	Grade of Concrete	Value of X
(1)	(2)	(3)
i)	$M10$, $M15$	5.0
ii)	$M20$, $M25$	5.5
iii)	$M30$, $M35$, $M40$, $M45$, $M50$, $M55$, $M60$	6.5
iv)	M65 and above	8.0

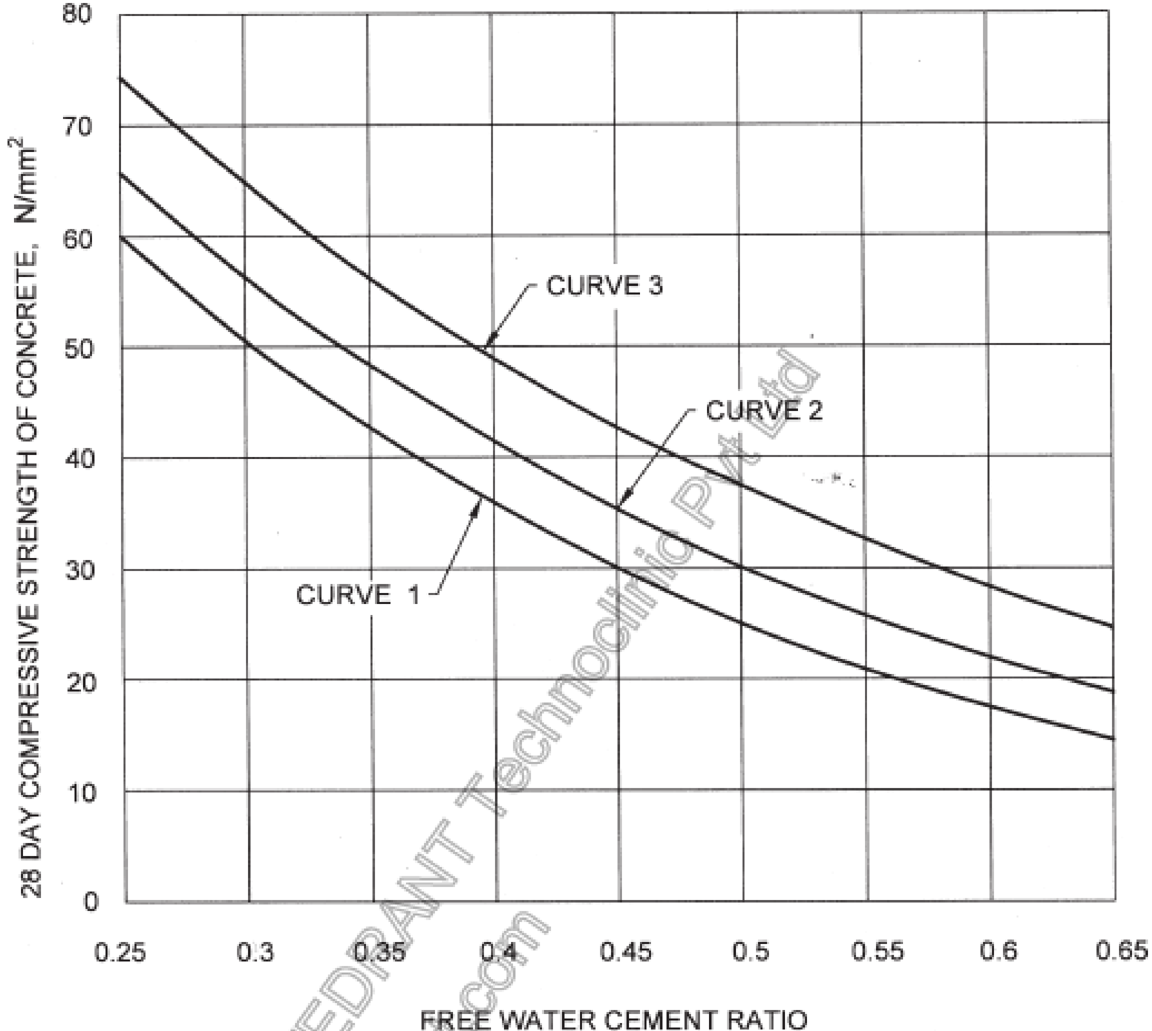
Table 2 Assumed Standard Deviation

(*Clause* 4.2.1.3)

Sl No.	Grade of Concrete	Assumed Standard Deviation N/mm^2
(1)	(2)	(3)
i)	M10 M15	3.5
ii)	M20 M25	4.0
iii)	M30 M35 M40 M45 M50 M55 M60	5.0
iv)	M65 M70 M75 M80	6.0

Table 3 Approximate Air Content
(*Clause* 5.2)

Sl No.	Nominal Maximum Size of Aggregate mm	Entrapped Air, as Percentage of Volume of Concrete
(1)	(2)	(3)
i)	10	1.5
ii)	20	1.0
iii)	40	0.8



Curve 1 : for expected 28 days compressive strength of 33 and < 43 N/mm².
Curve 2 : for expected 28 days compressive strength of 43 and < 53 N/mm².
Curve 3 : for expected 28 days compressive strength of 53 N/mm² and above.

NOTES

1 In the absence of data on actual 28 days compressive strength of cement, the curves 1, 2 and 3 may be used for OPC 33, OPC 43 and OPC 53, respectively.

2 While using PPC/PSC, the appropriate curve as per the actual strength may be utilized. In the absence of the actual 28 days compressive strength data, curve 2 may be utilized.

Fig 1. Relationship Between Free Water Cement Ratio and 28 Days Compressive Strengths of Concrete

Table 4 Water Content per Cubic Metre of Concrete For Nominal Maximum Size of Aggregate

(*Clause* 5.3)

Sl No.	Nominal Maximum Size of Aggregate mm	Water Content[1)] kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

[1)] Water content corresponding to saturated surface dry aggregate.

NOTES

1 These quantities of mixing water are for use in computing cement/cementitious materials content for trial batches.

2 On account of long distances over which concrete needs to be carried from batching plant/RMC plant, the concrete mix is generally designed for a higher slump initially than the slump required at the time of placing. The initial slump value shall depend on the distance of transport and loss of slump with time.

Table 5 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate for Water-Cement/Water-Cementitious Materials Ratio of 0.50

(*Clause* 5.5)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.54	0.52	0.50	0.48
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.73	0.72	0.71	0.69

NOTES

1 Volumes are based on aggregates in saturated surface dry condition.

2 These volumes are for crushed (angular) aggregate and suitable adjustments may be made for other shape of aggregate.

3 Suitable adjustments may also be made for fine aggregate from other than natural sources, normally, crushed sand or mixed sand may need lesser fine aggregate content. In that case, the coarse aggregate volume shall be suitably increased.

4 It is recommended that fine aggregate conforming to Grading Zone IV, as per IS 383 shall not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

SECTION 4 SELF COMPACTING CONCRETE

7 GENERAL

Self compacting concrete (SCC) is highly flowable, non-segregating concrete that fills uniformly and completely every corner of formwork by its own weight and encapsulate reinforcement without any vibration, whilst maintaining homogeneity.

7.1 Application Area

Self compacting concrete (SCC) may be used in precast concrete applications or for concrete placed on site. SCC is used to cast sections with highly congested reinforcement and in areas that present restricted access to placement and consolidation, including the construction of tunnel lining sections and the casting of hybrid concrete-filled steel tubular columns. It may be manufactured in a site batching plant or in a ready-mixed concrete plant and delivered to site by truck mixer. It may be placed either by pumping or pouring into horizontal or vertical forms.

7.2 Features of Fresh Self Compacting Concrete

A concrete mix can only be classified as self-compacting concrete, if the requirements for all below mentioned characteristics are fulfilled:

a) Filling ability (Flowability),

b) Passing ability,

c) Segregation resistance, and

d) Viscosity

ILLUSTRATIVE EXAMPLE ON CONCRETE MIX PROPORTIONING FOR SCC

E-0 An example illustrating the mix proportioning procedure for SCC concrete is given in **E-1** to **E-13**.

E- 1 STIPULATIONS FOR PROPORTIONING

a)	Grade designation	: M30
b)	Type of cement	: OPC 43 grade conforming to IS 269
c)	Nominal maximum size of aggregate	: 20 mm
d)	Exposure conditions as per Table 3 and Table 5 of IS 456	: Severe (for reinforced concrete)
e)	Characteristics of SCC	
	1) Slump flow class	: SF3 (slump flow 760 mm – 850 mm)
	2) Passing ability by L box test	: Ratio of $h_2/h_1 = 0.9$
	3) V- Funnel flow time (Viscosity)	: Class V1 (flow time $\leq$ 8s)
	4) Sieve segregation resistance	: SR1(<15percent)
f)	Degree of site control	: Good
g)	Type of aggregate	: Crushed angular aggregate
h)	Maximum cement content (OPC Content)	: 450 kg/m^3
j)	Chemical admixtures type	
	1) Superplasticizer	: normal (PCE type)
	2) Viscosity modifying agent	
k)	Mineral admixture	: Fly ash conforming to IS 3812 (Part 1)

E-2 TEST DATA FOR MATERIALS

a) Cement used : OPC 43 Grade conforming to IS 269

b) Specific gravity of cement : 3.15

c) Chemical admixture : Superplasticizer conforming to IS 9103

d) Specific gravity of

1) Coarse aggregate (at SSD condition) : 2.74

2) Fine aggregate (at SSD condition) : 2.65

3) Chemical admixture : 1.08

e) Water absorption

1) Coarse aggregate : 0.5 percent

2) Fine aggregate : 1.0 percent

f) Free (surface) moisture

1) Coarse aggregate : Nil (absorbed moisture also nil)

2) Fine aggregate : Nil (absorbed moisture also nil)

g) Sieve analysis

1) Coarse aggregate:

IS Sieve Sizes mm	*Analysis of Coarse Aggregate Fraction*		*Percentage of Different Fractions*			*Remarks*
	I (20-10 mm)	II (10 - 4.75 mm)	I 50 percent	II 50 percent	100 percent	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
20	100	100	50	50	100	Conforming of Table 7 of IS 383
10	2.8	78.3	1.4	39.15	40.55	
4.75	Nil	8.70	Nil	4.35	4.35	

2) Fine aggregate : Conforming to grading Zone II of Table 9 of IS 383

E-3 TARGET STRENGTH FOR MIX PROPORTIONING

$$f'_{ck} = f_{ck} + 1.65\ S$$

or

$$f'_{ck} = f_{ck} + X$$

whichever is higher.

where

- f'_{ck} = target average compressive strength at 28 days,
- f_{ck} = characteristic compressive strength at 28 days,
- S = standard deviation, and
- X = factor based on grade of concrete.

From Table 2, standard deviation, $S = 5$ N/mm^2.

From Table 1, $X = 6.5$.

Therefore, target strength using both equations, that is

a) $f'_{ck} = f_{ck} + 1.65\ S$

$= 30 + 1.65 \times 5 = 38.25$ N/mm^2

b) $f'_{ck} = f_{ck} + 6.5$

$= 30 + 6.5 = 36.5$ N/mm^2

The higher value is to be adopted. Therefore, target strength will be 38.25 N/mm^2 as 38.25 N/mm^2 > 36.5 N/mm^2.

as per IS 1199 (Part 6) and adjustments to the initial mix shall be made till satisfactory characteristics are achieved.

The various mix design parameters given in this example are only indicative and it may be necessary to carry out adjustments to these parameters during the use of the concrete mix at the project site.

E-7 PROPORTIONING FOR INITIAL MIX

E-7.1 Selection of Water Content and Cement/Fly Ash Content

The class of slump flow is specified to be SF3 having a slump flow between 750 and 850 mm. To start with, a water content of 190 kg/m^3 along with a superplasticizer @ 0.6 percent by mass of cementitious material content is selected for the initial mix. However, the water content can be reduced further by increasing the dose of super plasticizer.

This water content of 190 kg/m^3 will correspond to a cement content of 442 kg/m^3 for water cement ratio of 0.43 as worked out in **E-5.**

The cement content of 442 kg/m^3 can be further divided into OPC and fly ash. Generally fly ash content of 25 to 50 percent is adopted for SCC. In this illustration, as the cement content is on the higher side, the fly ash content is taken as 35 percent. Therefore, the OPC content is for 287 kg/m^3 and fly ash content will be 155 kg/m^3.

E-7.2 Selection of Admixture Content

E-7.2 Selection of Admixture Content

E-4 APPROXIMATE AIR CONTENT

From Table 3, the approximate amount of entrapped air to be expected in normal (non-air-entrained) concrete is 1.0 percent for 20 mm nominal maximum size of aggregate.

E-5 SELECTION OF WATER-CEMENT RATIO

From Fig. 1, the free water-cement ratio required for the target strength of 38.25 N/mm^2 is 0.43 for OPC 43 grade curve. This is lower than the maximum value of 0.45 prescribed for 'severe' exposure for reinforced concrete as per Table 5 of IS 456.

$$0.43 < 0.45, \text{ hence O.K.}$$

E-6 The initial mix shall be first estimated based on the typical ranges of mix constituents as per **8.3** and keeping in view, the characteristics of the fresh concrete such as flowability, passing ability, segregation resistance and viscosity as per the data for the mix proportioning in **E-1.**

The initial mix shall be tested for various characteristics

Taking an admixture dose of 0.6 percent by mass of cementitious material, the mass of admixture

$$= 0.6/100 \times 442 = 2.65 \text{ kg/m}^3.$$

E-7.3 Selection of Powder Content and Fine Aggregate Content

The powder content (fines < 0.125 mm) required for SCC is generally in the range of 400 to 600 kg/m^3. Since, the SR of class 1 and viscosity of V1 is required; the mix shall be sufficiently cohesive, (having enough fines). Therefore a powder content of 520 kg/m^3 is selected. This powder content will constitute the entire OPC, entire fly ash, and around 10 percent of Zone II fine aggregates.

Fines required to be contributed by fine aggregate = Total powder content – (Fly ash content + cement content)

$$= 520 - (155 + 287) = 78 \text{ kg/m}^3$$

The fine aggregate has 8 percent materials < 0.125 mm (*see* **8.1**). Therefore, the fine aggregate quantity = 78/0.08 = 975 kg/m^3.

E-7.4 Selection of Coarse Aggregate Content

Let V_{ca} be the volume of coarse aggregate.

Assuming 1 m^3 of concrete, V_{ca} = (1 - Air content) - (Vol of water + Vol of cement + Vol of fly ash + Vol of admixture + Volume of fine aggregate)

$$V_{ca} = (1-0.01) - \frac{190}{1\times1\,000} + \frac{287}{3.15\times1\,000} + \frac{155}{2.2\times1\,000} + \frac{2.65}{1.08\times1\,000} + \frac{975}{2.65\times1\,000}$$

$$= 0.99 - (0.19 + 0.091 + 0.07 + 0.002\,5 + 0.368)$$

$$= 0.269 \text{ m}^3$$

Mass of coarse aggregate

= V_{ca} x specific gravity of coarse aggregate × 1 000

= 0.268 × 2.74 × 1 000

= 737.06 kg/m^3 ≈ 737 kg/m^3

E-7.5 Calculation of Volume of Powder Content

Vol of powder content = Vol of OPC + Vol of fly ash + Vol of portion of fine aggregate < 0.125 mm

$$= \frac{287}{3.15\times1\,000} + \frac{155}{2.2\times1\,000} + \frac{78}{2.65\times1\,000}$$

$$= 0.191 \text{ m}^3$$

NOTE — Aggregates shall be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregates are dry, the amount of mixing water shall be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. The surface water and percent water absorption of aggregates shall be determined according to IS 2386 (Part 3).

E-9 The total mass of coarse aggregate shall be divided into two fractions of 20 - 10 mm and 10 - 4.75 mm, in a suitable ratio, to satisfy the overall grading requirements for 20 mm max size aggregate as per Table 7 of IS 383. In this example, the ratio works out to be 50:50 as shown under **E-2** (g).

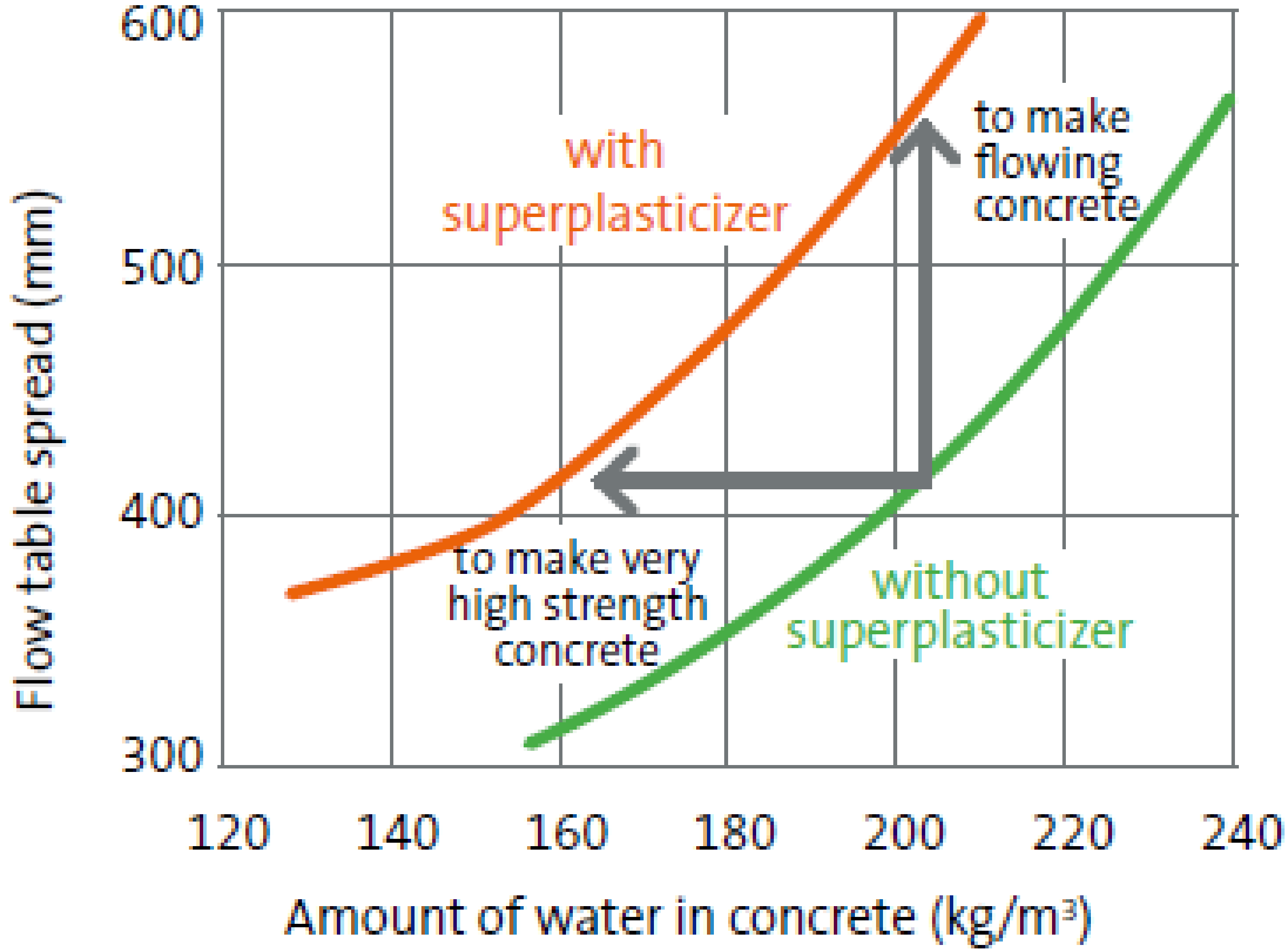
E-10 The various tests for flowability (slump flow test), for passing ability (L box test), for sieve segregation resistance and for viscosity (V funnel) shall be carried out and the values obtained shall be verified as per the data given in **E.1** (e).

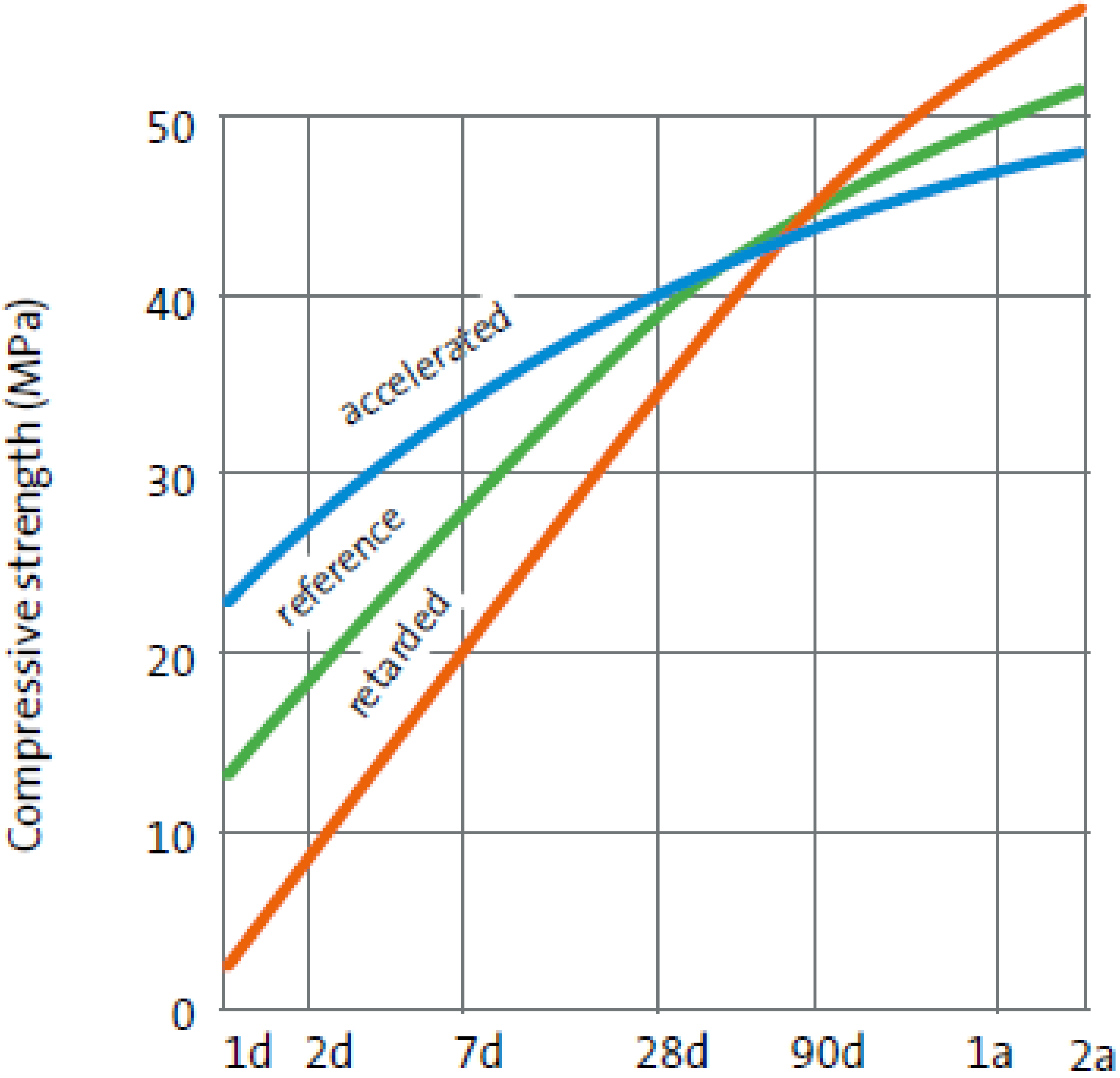
In the event that satisfactory performance is not obtained, the initial mix shall be redesigned. Depending on the apparent problem, the following courses of action might be appropriate:

a) Adjust the cement/powder ratio and the water/ powder ratio and test the flow and other properties of the paste.

E-8 MIX PROPORTIONS FOR TRIAL NUMBER 1

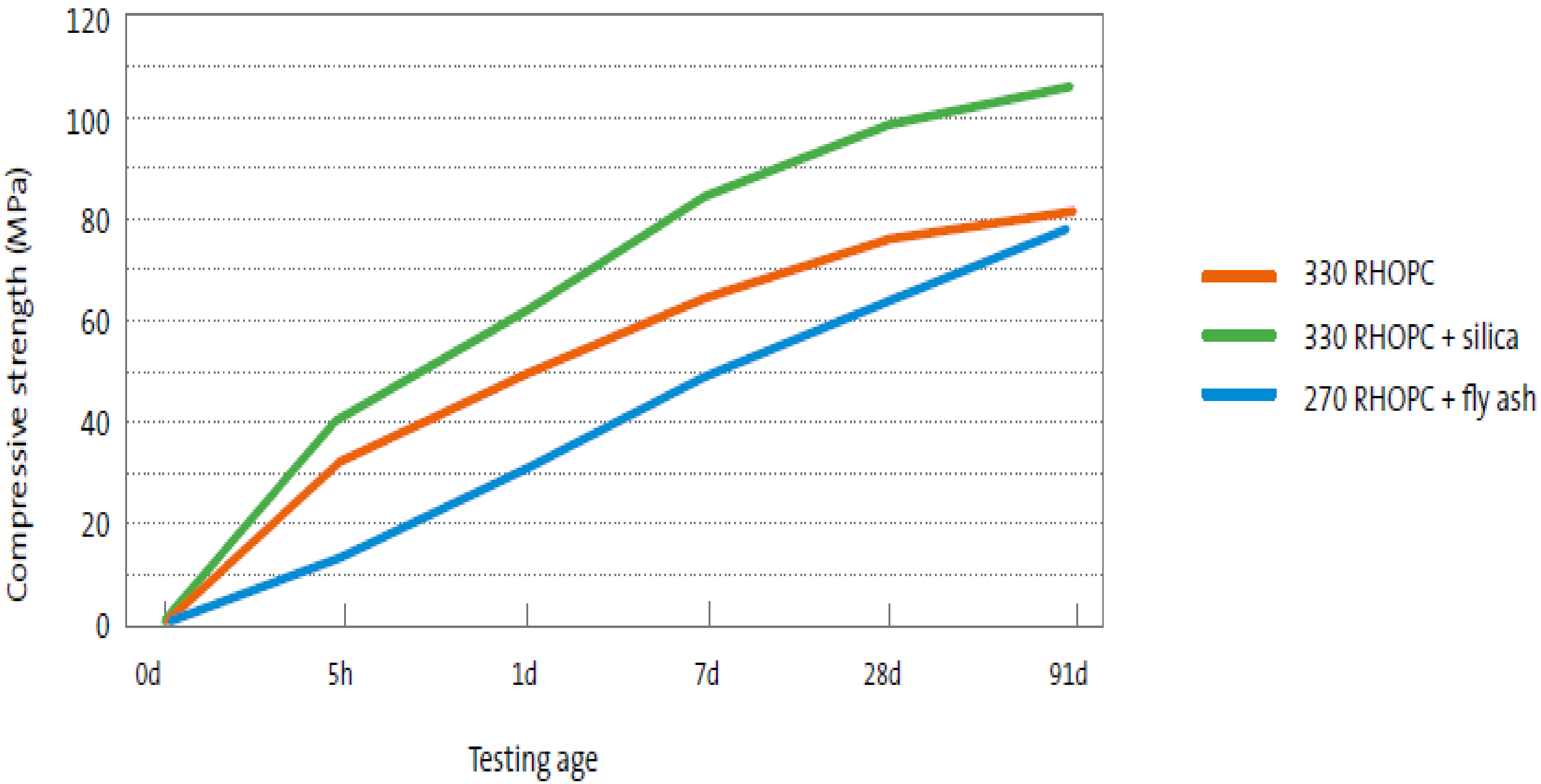
Cement	= 287 kg/m^3
Flyash	= 155 kg/m^3
Water (net mixing)	= 190 kg/m^3
Fine aggregate (SSD)	= 975 kg/m^3
Coarse aggregate (SSD)	= 737 kg/m^3
Chemical admixture	= 2.65 kg/m^3,
Free water-cement ratio	= 0.43
Powder content	= 520 kg/m^3
Water powder ratio by volume	= 0.99


600
500
400
300
Flow table spread (mm)
with
superplasticizer
to make
flowing
concrete
to make very
high strength
concrete
without
superplasticizer
120
140
160
180
200
220
240
Amount of water in concrete (kg/m³)



Compressive strength (MPa)
50
40
30
20
10
0
1d
2d
7d
28d
90d
1a
2a
accelerated
reference
retarded

Below an example is shown about the strength development with different binder (cement, silica and fly ash) materials.



The main properties of Precast Concrete are:

- Cost effective mix design (Factory like QC)
- Strength according to the design demand
- Fast and controlled hardening and importance of early strength
- Proper workability according to the casting method
- Good durability according to the design requirements

WAYS OF ACHIEVING DESIRED EARLY STRENGTH

1. **USE OF RAPID HARDENING CEMENT/ OPC 53 GRADE CEMENT/ HIGH EARLY STRENGTH CEMENT**

2. **USE OF TEMPERATURE CURING/STEAM CURING**

3. **USE OF ACCELERATING ADMIXTURES –PCE BASED**

4. **PROPER COMBINATIONS OF CEMENT + GGBS/FLYASH + MICROSILICA/ALCOFINE**

Steam curing is curing in water vapor at atmospheric or higher pressures. When cured at atmospheric pressure, the enclosure temperatures are usually between 40 and 70°C . Steam curing is used where early strength gain is needed and where heat is required for hydration, such as in cold weather.

In prestressing and precast plants, steam at atmospheric pressure provides high early strengths, enabling rapid demolding and reuse of forms. Excessive rates of heating and cooling may result in large, harmful volumetric changes and should be avoided.

MIX DESIGN TRIALS FOR PRECAST CONCRETE

SL. NO.	Cement used	Mix Designation	Aggregate Max. size (mm)	Cement Content (kg/cu.m)	UGGBFS (kg/cu.m)	Free Water Cement ratio (max)	Suggested Mix Proportions C:CSS:CA
1	53 Grade OPC-High 1 day strength	M40	20	380	-	0.30	1: 2.39: 3.28
2		M40	20	380	-	0.30	1: 2.39: 3.28
3	53 Grade OPC-Low 1 day strength	M40	20	410	-	0.30	1: 2.16: 2.96
4		M40	20	410	-	0.30	1: 2.16: 2.96
5	Normal 53 Grade OPC	M 35	20	380	-	0.41	1 : 1.91 : 3.00
6		M 40	20	380	-	0.38	1 :1.94 : 3.05
7	OPC 53 S with 7 day strength not less than 37.5 MPa	M40	20	375	-	0.30	1: 2.33: 3.46
8		M40	20	380	-	0.31	1: 2.27: 3.38
9		M40	20	380	-	0.31	1: 2.38: 3.27
10	Normal 53 Grade OPC	M40	20	400	30	0.3	1 : 1.78 : 2.69
11		M40	20	440	-	0.3	1 : 1.73 : 2.61

SL. NO.	Dosage of Admixture by weight of cement (%)	Slump Obtained (mm)		Compressive Strength (N/mm2)				
		Initial	1 Hour	12 hour	14 hour	24 hour	7 day	28 day
1	1.0	Collapse	110	17.3	19.8	28.9	65.5	74.7
2	1.0	Collapse	120	17.7	20.7	29.5	66.9	75.2
3	0.9	Collapse	105	13.8	15.8	24.0	63.7	78.5
4	0.9	Collapse	110	13.5	15.5	23.6	63.0	77.6
5	0.2	35	-	-	-	-	29.8	44.8
6	0.15	40	-	-	-	-	37.8	50.6
7	0.75	Collapse	100	15.3	19.1	29.9	66.5	75.0
8	0.70	Collapse	120	15.3	18.4	29.2	66.0	74.8
9	0.70	Collapse	80	15.2	18.8	28.8	65.8	74.3
10	0.5	Collapse	120	-	23.0	-	80.3	87.1
11	0.5	Collapse	110	-	22.1	-	77.2	82.8

INFERENCES:

1. WHILE ACHIEVING HIGH EARLY STRENGTH OF CONCRETE ONE-DAY STRENGH OF CEMENT CAN BE A CRITERIA. RANGE OF 1-DAY STRENGTH IS 12 MPa TO 18 MPa.
2. ONE DAY STRENGTH OF CEMENT CAN BE AS HIGH AS 23 MPa
3. IT IS OBSERVED THAT CEMENTS HAVING HIGHER ONE DAY STRENGTH OF CEMENT HAVE PERFORMED BETTER IN TERMS OF HOURLY STRENGTHS STARTING FROM 12 Hr TO 24 Hr.
4. SLEEPER GRADE CEEMNTS CAN BE USED TO GET HIGH EARLY STRENGTH OF CONCRETE

Optimization of Curing Regimes for Precast Prestressed Members with Early-Strength Concrete

EXPERIMENTAL WORK

By

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2. Experiments

2.1 Mix Proportions

Compressive tests of ESC were performed for three different f'_{cd} s of 30, 40 and 50 MPa with target slump of 200 ± 20 mm and air content of 3 ± 1 %. Table 1 summarizes mix proportions for the ESC. Crushed gravels with 20 mm nominal maximum size, specific gravity of 2.6 g/cm^3, and fineness modulus of 6.8 were used. River sand was used as fine aggregates, which had a specific gravity of 2.6 g/cm^3, and fineness modulus of 2.2. Superplasticizer (SP) was used to increase workability.

Table 1 Mix proportions.

f'_{cd} (MPa)	W/C	Slump (mm)	$S/(S+G)$	Weight per unit volume (kg/m^3)				SP/C
				W	C	S	G	
30	0.46	200	0.38	177	385	644	1051	0.01
40	0.41	200	0.37	177	433	606	1040	0.01
50	0.35	200	0.36	177	506	570	1022	0.01

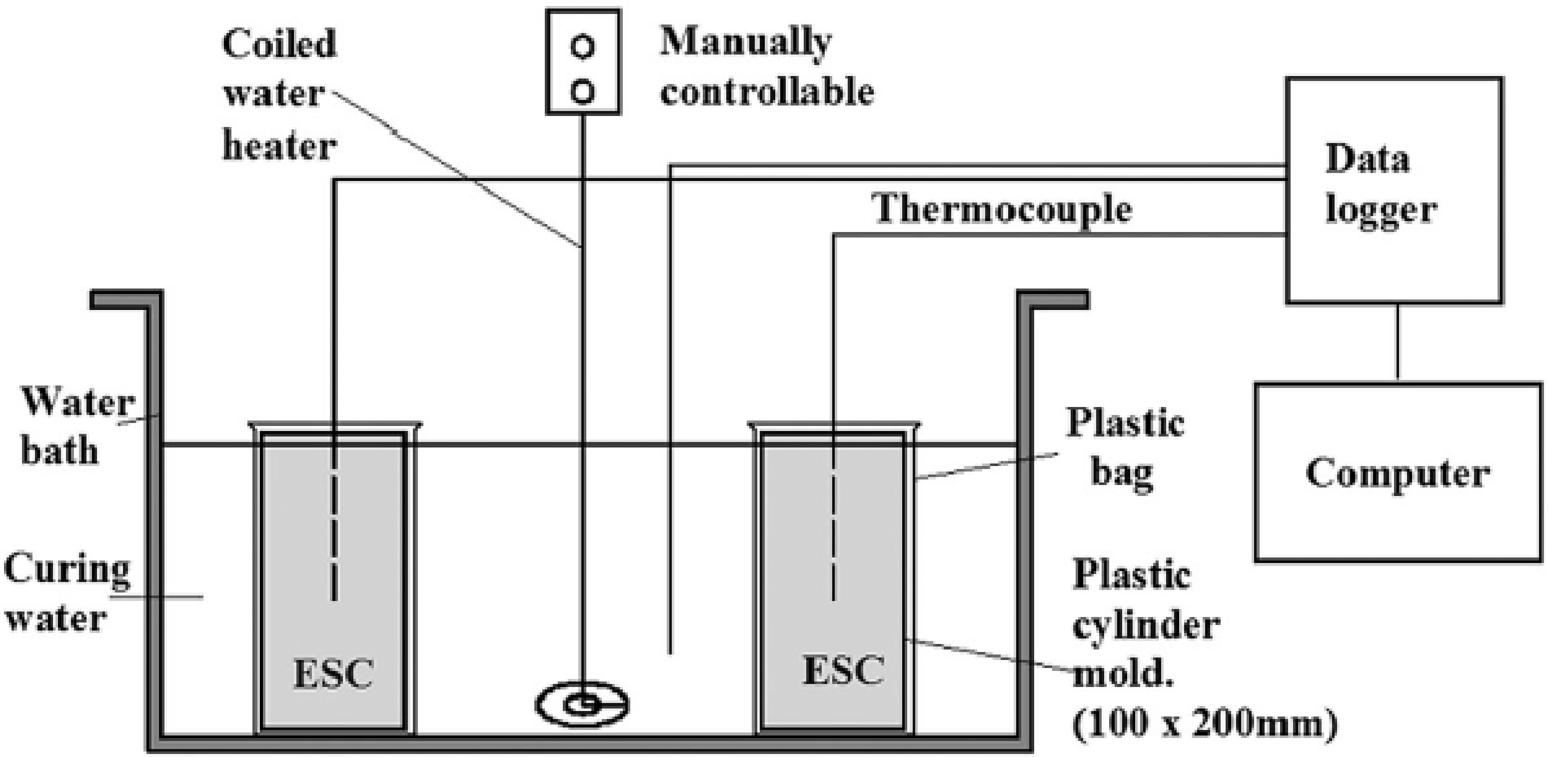

Fig. 1 Curing scheme of ESC in water bath.

FINDINGS OF THE EXPERIMENTAL WORK

Early-strength-concrete (ESC) made of Type I cement with a high Blaine value of 500 m2/kg reaches approximately 60 % of its compressive strength in 1 day at ambient temperature. Based on the 210 compressive test results, a generalized rate constant material model was presented to predict the development of compressive strengths of ESC at different equivalent ages (9, 12, 18, 24, 36, 100 and 168 h) and maximum temperatures (20, 30, 40, 50 and 60 C) for design compressive strengths of 30, 40 and 50 MPa.

The developed material model was used to find optimum curing regimes for precast prestressed members with ESC. The results indicated that depending on design compressive strength, conservatively 25–40 % savings could be realized for a total curing duration of 18 h with the maximum temperature of 60 C, compared with those observed in a typical curing regime for concrete with Type I cement.

IN CONCLUSION….

Concrete is the most commonly used building material in the world, and precast concrete components and structures provide a creative way to extend the use of concrete.

Challenges on the industry- climate change, energy saving and environmental protection, engineers need a new vision for the potential of precast structures as well as for the sustainable use of concrete in general.

In thinking about sustainable construction, we need to find innovative ways to reduce the impact of construction activity on our environment.

For your kind attention