GUIDELINES ON USE OF READY MIXED CONCRETE

1. Introduction:

1.1 Concrete is a versatile, economic, and principal construction material used in Civil Engg. structures. There are two options regarding use of concrete i.e. site mixed concrete or ready mixed concrete. Site mixed concrete is prepared at construction site, whereas Ready Mixed Concrete is prepared at Central Batching and Mixing Plant and transported to construction site. Site mixed concrete is more preferred in our country. Ready Mixed Concrete is widely adopted in developed countries. The reasons for popularity of Ready Mixed Concrete(RMC) are assured good quality, as RMC is produced under controlled conditions and its readily availability. In India, use of RMC is in initial stage. Many RMC plants have come up in metro -cities.

1.2 It is always desirable to adopt new technology with cautions. Thus, prior to adoption of new technology, thorough study about it, is quite essential. In this connection, literature survey was carried out on RMC technology. Based on the study of literature, this report has been prepared which covers all the aspects related to production and transportation of Ready Mixed Concrete.

1.3 This report covers the requirement for production and supply of ready mixed concrete. It does not cover requirement for placing, compaction and curing of concrete, as these aspects are already covered separately under IRS Concrete Bridge Code and the booklet titled as “Quality Assurance Programme For Prestressed Concrete Construction” prepared by RDSO.

GUIDELINES ON USE OF READY MIXED CONCRETE

2. Ready Mixed Concrete:

2.1 Ready Mixed Concrete means concrete produced by completely mixing cement, aggregates, admixtures, if any and water at a central batching and mixing plant and delivered in fresh condition to purchaser at site of construction. IS: 4926 deals with specification for Ready Mixed Concrete. Sometimes Ready Mixed Concrete is produced by placing cement, aggregates and admixtures, if any, in a truck mixer at the batching plant and mixing operation alongwith addition of water is carried out during the journey or on arrival at the site of delivery. Such type of Ready Mixed Concreteh as not been included in this report as use of such concrete may lead to complication and loss of centralised quality control.

2.2 Ingredients in Ready Mixed Concrete are the same as that of site mixed concrete i.e. cement, coarse aggregates, fine aggregates (sand) and water. It may or may not contain admixture. Batching and mixing plant carries out four distinct operations i.e. storage of material and handling towards the batching system, weighing as per required mixed proportion, then discharge to the mixer and followed by the mixing. Generally, cement is stored in silos and aggregate in stock piles or hoppers. These raw materials are then conveyed to elevated tower for batching. Batched materials are fed to the mixers where mixing is carried out alongwith addition of predetermined quantity of water and admixture. From the batching plant concrete in fresh stage is transported to delivery point i.e. construction site by truck agitators (mobile agitators). Considerable advancement have taken place in Central batching and mixing plants where the batching and control operations are fully automated. More than one proportions (recipes) / grade of concrete can be produced by the control panel.

2.3 Technically, there is no difference between Ready Mixed Concrete and site mixed concrete. But, as far as user is concerned, there is significant difference. The site mixed concrete is immediately available for laying where as Ready Mixed Concrete is available only after lapse of transit time. Effect of transit time is covered under para 3. While planning for use of ready mixed concrete, it is absolutely essential that this aspect is taken care-of. Another significant difference between Ready Mixed Concrete and site mixed concrete is that most of the operations involved in preparation of Ready Mixed Concrete are performed by the machines under centrally controlled conditions as against manual operations carried out in case of site mixed concrete. Briefly a comparison of activities performed during production of concrete in case of site mixed concrete and Ready Mixed Concrete are given in Table-1. As most of the operation of production of concrete in case of Ready Mixed Concrete are with automated controls, therefore, quality of Ready Mixed Concrete is

expected to be far superior than site mixed concrete. In addition, the rate of production of concrete is much higher in case of RMC.

Table-1: Comparison of activities in site-mixed concrete and RMC

Activity	Site-mixed concrete	Ready Mixed Concrete
Raw material handling	Required near mixer	At batching plant
Weigh batching	Manually (approx. qty)	Automated
Adjustment for moisture	Approximate	Automated
Water cement ratio	Manually (approx. qty)	Automated
Admixture ratio	Manually (approx. qty)	Automated
Mixing	Tilting mixers	Turbo mixers
Mixing time	Approximate	Auto Timer
General production range	3 Cu M/ hr/ Mixer	30-120 Cu M/hr/ plant

GUIDELINES ON USE OF READY MIXED CONCRETE

3. Effect of transit time on Ready Mixed Concrete:

3.1 Loss of workability:

3.1.1 It is always emphasized that concrete should be laid in the position without any loss of time to avoid reduction in workability and setting & 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. This is due to continued hydration reaction of cement, evaporation of mixed water and absorption of mixed water by the aggregates. Typical relationship in between loss of workability and transit time is given in figure-1. This figure should be taken as indicative only, because the actual result will depend upon the constituent material, mixed proportion, ambient temperature, humidity and method of transport etc. 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 & after a lapse of predetermined time (i.e. anticipated transit time), loss of workability may be estimated. Desired workability at the time of delivery should be clearly specified in tender conditions.

3.1.2 In order to reduce rate of loss of workability generally water reducing agent / superplasticizer is used. Use of water reducing agent/ admixtures should be permitted after testing their suitability in proposed concrete mix. Dose of water reducing agent/ super plasticiser should be decided on trials. Excessive dose may lead to segregation. In addition, there may be retardation also.

3.1.3 IS: 4926-1976 which is currently under revision, permits retempering i.e. addition of water in concrete at site to restore the workability, provided requirement for uniformity, as specified in IS: 4926-1976, are met with. Uniformity requirement specify variation limits for properties like air content, slump, compressive strength & density etc. At site, there is no way to judge whether specified uniformity requirement are met or not. Moreover, addition of water affects the strength and durability characteristic of concrete. Thus, it is advised that retempering i.e. addition of water after mixing, should not be permitted at all either during transit or at the site of construction.

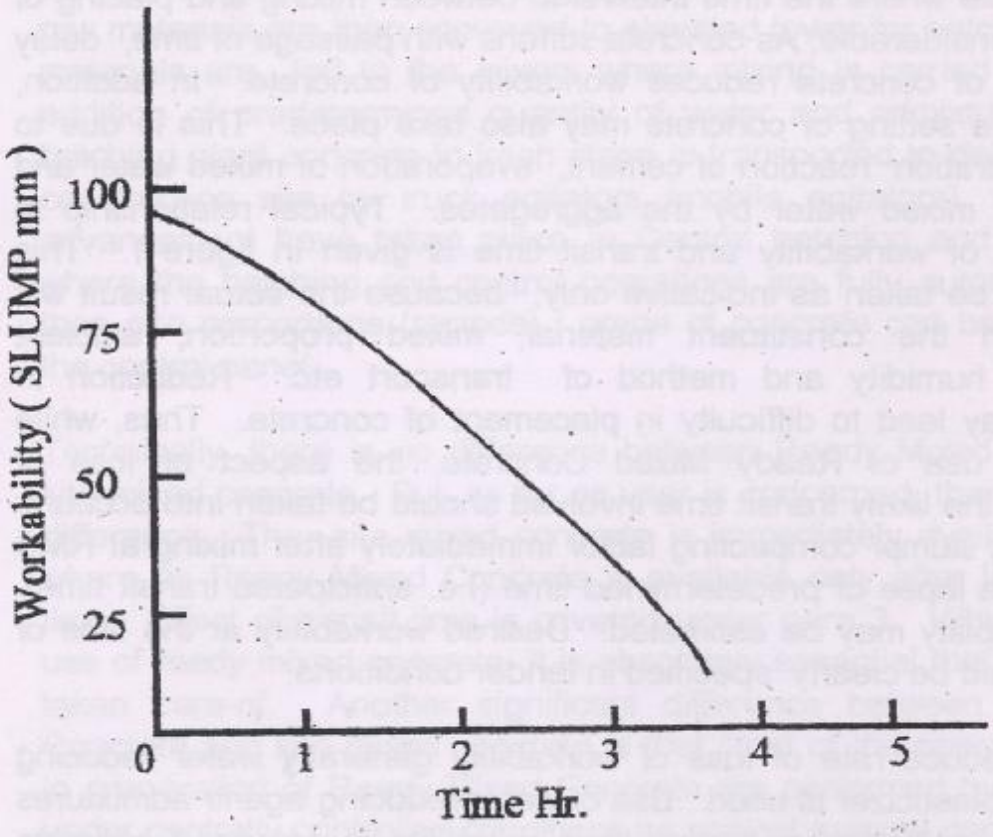


Fig. 1 Typical Loss Of Workability with Transit Time
(For Concrete without Admixture)

3.2 Setting of concrete:

3.2.1 Excessive delay in transportation of concrete may lead to initial setting of concrete and may render it unusable. In order to avoid setting of concrete, generally retarder i.e. retarding admixture is used which prolong the setting of concrete. While permitting use of retarder, it should be ensured that the suitability and dose of retarder is decided after conducting necessary trials. It may be noted that generally retarding effect of retarder is smaller at higher temperature and sometimes few retarders seem to be in-effective at extremely high temperature. Thus, it is desirable to keep the temperature of concrete as low as possible. Influence of temperature on retardation of initial setting time of concrete as mentioned under Chapter V of the book "Properties of Concrete" by A.M. Neville is furnished in Table-2. The values furnished in Table-2 are based on Lab. results obtained under specific condition and can not be generalised for use.

Table-2:
Influence of the temperature on retardation in initial setting time.

ASTM C 494-92 Type	Nature of Admixture	Retardation in initial setting time (h:min) at temperature of:		
		30^{o} C (86^{o} F)	40^{o} C (104^{o} F)	50^{o} C (122^{o} F)
D	Sodium salt of hydroxylic acid	4:57	1:15	1:10
D	Lignin based calcium salt	2:20	0:42	0:53
D	Calcium-lignosulfonate based	3:37	1:07	1:25
B	Phosphate-based	-	2:20	2:30

3.2.2 In view of above, it is necessary that suitability of retarding admixture is judged at the maximum ambient temperature likely to be achieved during concreting. In addition, it is also important that a dose of retarding admixture is tested by conducting trials. Large quantity of admixture/ retarder may delay the setting of concrete adversely or may prevent the setting of concrete totally. Some time dosing of admixture is done in stages to ensure desired workability. In such cases, admixture should be mixed at delivery site only. Addition of admixture should not be permitted during transit.

3.2.3 Curing:- Use of retarders also may increase the risk of plastic shrinkage. Good curing, soon after finished concrete surface shows sign of initial set, will reduce plastic shrinkage cracks. Protecting the concrete surface against hot and windy condition by covering the surface with wet hessain cloth also reduces shrinkage. Usually, Ready Mixed Concrete needs fast curing than normal concrete. The starting time of curing should be carefully decided and proper curing started once the concrete shows sign of initial set.

3.3 Time period for delivery of concrete:

In order to control loss of workability and setting of concrete, IS: 4926, Cl. 6.3.1 specifies that concrete should be delivered completely to the site of work within one and half hours (when the atmospheric temperature is above 20^{o} C) and within two hours (when the atmospheric temperature is at or below 20^{o} C) of adding the mixing water to the dry mix of cement and aggregate or adding the cement to the aggregate which ever is earlier. Adequacy of the time period, required for delivery of concrete, should be checked. In case, location of site of construction is such that this time period is inadequate, delivery time period should be increased and specified clearly duly keeping some margin for hurdles in the way (i.e. level crossing/ check post/ heavy traffic congestion locations etc).

3.4 Checking suitability of admixture:

As explained earlier, generally admixture like water reducing agents/ retarders are used in Ready Mixed Concrete for retention of workability and to avoid setting of concrete. IS: 9103 “Specification for admixtures for Concrete” may be referred to judge the suitability of admixtures. According to it, the concrete mix should be prepared both with and without admixture using the same raw materials as proposed to be used for the work. The later being treated as the reference or controlled concrete mix. Test samples from both the mixes should be prepared and tested for physical requirements as laid down under Table-3. The properties of the concrete mix with admixture should conform to the requirements specified under Table-3.

GUIDELINES ON USE OF READY MIXED CONCRETE

4. Ordering for supply of Ready Mixed Concrete:

4.1 As per IS: 4926 Ready Mixed Concrete shall be manufactured and supplied on either of the following basis:

a) Specified strength based on 28 days compressive strength of I5 cm cube tested in accordance with IS: 456.

b) Specified mix proportion.

Table-3: Physical requirements for concrete containing admixtures (As specified under Table 1 of IS: 9103- 1979)

Sl. No.	Requirement	Retarding Admixture	Water reducing admixture
I)	Water content, percent of control sample. Max.	-	95
ii)	Time of setting, allowable deviation from control sample, hours:		
	Initial		
	Max.	+3	± 1
	Min.	+1	
	Final		
	Max.	+3	± 1
	Min.	-	
iii)	Compressive strength, percent of control sample, Min.		
	3 days	90	110
	7 days	90	110
	28 days	90	110
	6 months	90	100
	1 year	90	100
iv)	Flexural strength, percent of control sample,		
	Min:		
	3 days	90	100
	7 days	90	100
	28 days	90	100
v)	Length change, percent increase over control sample, Max.		
	28 days	0.010	0.010
	6 months	0.010	0.010
	1 year	0.010	0.010

vi)	Bleeding, percent increase over control sample, Max	5	5

4.2 When concrete is supplied on the basis of specified strength, responsibility for design of mix rests with the manufacturer whereas in case of specified mix proportion, the responsibility for design of mix rest with the purchaser. Thus, it is desirable to place the supply order on specified strength basis. This aspect should be incorporated in contract conditions.

4.3 When supply order is placed on the basis of specified strength, the purchaser is required to furnish the following information for the guidance of the manufacturer:

a) Type of cement to be used. Relevant IS: Specification should be specified.

b) The max. size and type of aggregates to be used alongwith relevant IS: specification.

c) **Type of admixture to be used**:- It may be left at the discretion of the manufacturer. Manufacturer may check the suitability of admixture and produce necessary record for determining its suitability.

d) The minimum acceptable compressive strength / flexural strength determined from samples of plastic, concrete taken at the time of placing of concrete.

e) The slump or compacting factor or both or any other requirements for workability at the place and time of delivery of the concrete. Values specified in para 5.3 of IRS Concrete Bridge Code may be used for guidance.

f) The ages at which the test cubes are to be tested and frequency and number of tests to be made. Para 8.7 of IRS Concrete Bridge code may be referred.

g) **Any other requirements:-** Following additional requirements should be specified to satisfy durability requirements:

   i) Minimum and maximum cement content to be used in production of concrete. Clause 5.4.5 of IRS Concrete Bridge Code may be referred to for guidance.

   ii) Max. Water Cement ratio to be kept. Clause 5.4.3 of IRS Concrete Bridge Code may be referred to.

   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) **Temperature of concrete:-** it should be in between 5 to 35^{o}C.

vi) Initial setting time should not be less than specified (Initial setting time should be assessed by Rlys. and specified).

vii) Permeability test requirements.

h) Wherever pumping of concrete is required as per site condition, it needs to be specified alongwith desired lead and lift.

GUIDELINES ON USE OF READY MIXED CONCRETE

5. Materials:

5.1 Material should satisfy the requirements for safety, structural performance, durability and appearances of the finished structures taking into account the environment to which it will be subjected. As technically, there is no difference between Ready Mixed Concrete and site mixed concrete, thus, the specification of materials, which are applicable to site mixed concrete as laid down under IRS Concrete Bridge Code, are also applicable to Ready Mixed Concrete. User is advised to refer IRS Concrete Bridge Code while finalising the specifications for work.

6. 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. 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. Quality Assurance Programme for Ready Mixed Concrete can be broadly divided into t.hree components i.e. Forward control, Immediate control and retrospective control. RMC manufacturer should have laboratory facilities to carry out necessary tests to ensure quality control at all stages during production of concrete. In case, some tests, which are not frequently required, are done by out side agencies, the proper record of results of such tests should be available with R.M.C. manufacturer.

6.1 Forward control:

Forward control covers all the aspects which are to be taken care prior to production of concrete i.e. control of material quality and storage, mix design and modifications, plant maintenance etc.

6.1.1 Control of quality of raw material:- A control system should be operated to provide assurance that all materials purchased and used in the production of concrete conform to standards specified. It may include visual checks, sampling and testing and certification/ information from suppliers of materials.

6.1.1.1 Cement:- As cement is the main constituent of concrete, therefore, quality of cement is quite important for production of quality concrete. It should conform to relevant standards, as specified. Preferably, cement should not be older than 3 months. It should not have any lumps. It should give smooth feeling. Manufacturers/ producers of Ready Mixed Concrete should have test records of each lot of cement. Results of chemical tests (i.e. ratio of percentage of lime to percentage of Silica,

Alumina and Iron oxide, Ratio of percentage of Alumina to that of Iron oxide and percentage of In-soluble residue, Magnesia, total Sulphur content, total loss on ignitia etc.) & physical tests (i.e. fineness, soundness, setting time, compressive strength etc.) should be within the limits, as specified in relevant standard and their records should be available with the RMC producer. Test results furnished by manufacturers may be considered valid provided cement is fresh. In case of any doubt or when cement is old, fresh testing of cement is necessary, specially for compressive strength and setting time. Producer of concrete should also furnish the test results of chloride contents in the cement, as control on chloride content in concrete is one of the most important aspect related to durability of concrete. IS:12423 may be referred for determination of chloride content.

6.1.1.2 **Aggregates**:-Quality of aggregates affect the quality of concrete. Therefore, it is necessary that quality of aggregates is checked prior to their use in concrete. Aggregates should conform to IS:383. They should be tested frequently for physical & chemical properties & grading.

i) **Physical and chemical properties:-** Aggregates should be natural, clean, inert, strong, durable and free from injurious amount of deleterious substances. Physical properties of aggregates affect the strength of the concrete where as chemical properties may effect durability of concrete. In order to ensure that aggregates are sufficiently strong and tough, aggregates crushing value/ impact value and abrasion value should be determined. Broadly, the aggregate should be tested for deleterious material content, physical and chemical properties etc. as listed in Table-4. Maximum permissible limits for deleterious material content and other properties for coarse and fine aggregates are given in the Table-4:

ii) **Grading of aggregates:-** Gradation of aggregates has important effect on workability and properties of hardened concrete. Good grading implies that a sample of aggregates contain all standard fraction of aggregates in required proportions such that the sample contain minimum voids and consequently requires minimum paste to fill up all the voids. Grading of coarse aggregates should be within the limits, as specified under Table-2 of IS: 383, which is reproduced as Table- 5 in this report. Grading of fine aggregates should be within the limits,as given in Table-4 under IS: 383, which is reproduced as Table-6 in this report. Fine aggregates conforming to grading Zone IV should not be used in RCC and prestressed concrete works. The combined grading of all aggregates i.e. coarse and fine aggregates together should conform to the Table-5 of IS: 383, which is reproduced as Table-7 in this report.

iii) **Additional test for aggregates:-** In order to ensure that the concrete produced is as per the design mix, following additional tests on aggregates are necessary. These tests will help in determining correct quantity of water and aggregates to be mixed while preparing desired mix concrete. For conducting various tests for aggregates, IS 2386 (part I to VIII) may be referred.

a) Absorption Test for coarse and fine aggregates;
b) Surface moisture content tests for coarse and fine aggregates- This test should be conducted daily.
c) Specific gravity of coarse and fine aggregates.
d) Soundness test:- This test should be conducted for concrete likely to be exposed to frost action.

6.1.1.3 Water:- Quality of water should be tested for solid contents. It should be free from injurious amount of impurities like oils, acids, alkalis, salt, sugar etc. Excessive chlorides present in water may lead to corrosion of reinforcement. The content of solids should be determined in accordance with IS: 3025. Content of solids should not exceed the limits laid down in Table-1 under IRS concrete Bridge code, which is reproduce as Table-8 in this report.

6.1.1.4 Admixtures:- Admixture should conform to IS:9103 and clause 4.4 of IRS Concrete Bridge Code. Suitability of admixtures should be judged by conducting trials as discussed in para-3.4. Concrete made with admixture when compared with identical concrete made without admixture should conform to the requirement given in Table-3.

6.1.1.5 Mineral Admixture:- If mineral admixtures like Pozzolanic flyash or Grounded granulated blast furnace slag (GGBFS) are proposed to be used in concrete, they should be tested for various properties as laid down under IS: 3812 and 1208 respectively.

Table-4: Properties of Aggregates

Sl. No.	Property	Method of Test	Fine Aggregate Percentage by Weight, Max.		Coarse Aggregate Percentage by Weight, Max.	
			Un-crushed	Crushed	Un-crushed	Crushed

1.	Deleterious substance content					
i)	Coal and lignite	IS:2386 (Pt.II)	1.00	1.00	1.00	1.00
ii)	Clay lumps	-do-	1.00	1.00	1.00	1.00
iii)	Materials finer than 75 μ	IS:2386 (Pt.I)	3.00	15.00	3.00	3.00
iv)	Soft fragments	IS:2386 (Pt.II)	-	-	3.00	-
v)	Shale	-do-	1.00	-	-	-
vi)	Total of percentages of all deleterious materials (except mica)		5.00	2.00 * *total for item (i) & (ii) only.	5.00	5.00
2.	Aggregated crushing/ Impact value	IS: 2386 (Pt.IV)			30% for wearing surface concrete 45% for other concrete	
3.	Aggregate Abrasion value	IS: 2386 (Pt.IV)			30% for wearing surface concrete 50% for other concrete	

Note 1: The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete. It is advisable, therefore, to investigate the mica content of fine aggregate and make suitable allowances for the possible reduction in the strength of concrete or mortar.

Note-2: The aggregate shall not contain harmful organic impurities (tested in accordance with IS: 2386 (Part-II-1963) in sufficient quantities to affect adversely the strength or durability of concrete. Fine aggregate which fails in the test for organic impurities may be used, provided that, when tested for the effect of organic impurities on the strength of mortar, the relative strength at 7 and 28 days, reported in accordance with 7 of IS: 2386 (Part VI)-1963 is not less than 95 percent.

Table- 5 : Grading requirement for Coarse Aggregates:

IS Sieve Designat-ion	Percentage passing for single sized aggregate of Nominal Size						Percentage passing for Graded Aggregate of Nominal Size			
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm

80 mm	100	-	-	-	-	-	100	-	-	-
63mm	85 to 100	100	-	-	-	-	-	-	-	-
40mm	0 to 30	85 to 100	100	-	-	-	95 to 100	100	-	-
20mm	0 to 5	0 to 20	85 to 100	100	-	-	30 to 70	95 to 100	100	100
16mm	-	-	-	85 to 100	100	-	-	-	90 to 100	-
12.5 mm	-	-	-	-	85 to 100	100	-	-	-	90 to 100
10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4.75mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2.36 mm	-	-	-	-	-	0 to 5	-	-	-	-

Table- 6 : Grading requirement for Fine Aggregates

IS Sieve Designation	Percentage passing for			
	Grading Zone- I	Grading Zone- II	Grading Zone- IIII	Grading Zone- IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Table- 7 : All-in-Aggregate Grading

IS Sieve Designation	Percentage passing for All-in-Aggregate of	
	40mm Nominal Size	20 mm Nominal Size
80mm	100	-
40mm	95 to 100	100

20mm	45 to 75	95 to 100
4.75mm	25 to 45	30 to 50
600 micron	8 to 30	10 to 35
150 micron	0 to 6	0 to 6

Table-8 : permissible limits for solids under water

Organic	200 mg/l
Inorganic	3000 mg/l
Sulphates (as so_4)	500 mg/l
Chlorides (as Cl)	2000 mg/l for plain concrete works 1000 mg/l for reinforced concrete works and 500 mg/l for prestressed concrete works.
Suspended matter	2000 mg/l

6.1.2 Control of material storage:

Materials should be stored in such a way so as to prevent the risk of contamination. The producer should utilise suitable transfer and feed systems. Various aspects to be looked into for storage of raw materials are described in subsequent paragraphs.

6.1.2.1 Storage of cement:

i) There should be separate storage for different types and grades of cement .

ii) Bins or silos should be weather proof and permit free flow and efficient discharge of the cement.

iii) Each silo or compartment of silo should be completely separate and fitted with the filter or alternative method of dust control. Each filter or dust control system should be of sufficient size to allow delivery of cement to be maintained at a specified pressure and should be properly maintained to prevent undue emission of cement dust and prevent interference with weighing accuracy by build up of pressure.

iv) Where cement is received and stored in bags, building / shades should be completely weather proof. The bag should be stacked close together so as to restrict the circulation of air around them. The stack should be 30 cm clear of the wall and should be arranged in such a manner so that stored cement can be taken out

in the same order in which they are received. The bag should be stacked on dry board platform, about 20cm above ground level. Broadly the instructions given in IS:4027 should be followed.

6.1.2.2 Aggregates:

i) Stock piles should be free draining and arranged in such a way so as to avoid contamination and to prevent inter-mingling with adjacent material.
ii) Stock piles should preferably have shades so as to prevent heating of aggregates under the effect of sun and to prevent moisture absorption from rain water.
iii) Provision should be made for separate storage for each nominal size and type of aggregates. The method of loading of storage bins should be such to prevent inter-mingling of different sizes and types of aggregates.
iv) Handling procedure of loading and unloading aggregate should be such so as to reduce the segregation to minimum.

6.1.2.3 Water:- Adequate supply of water should be available when water is stored on the plant. Storage facility should be designed in such a manner that the risk of its contamination is minimum.

6.1.2.4 Admixture:- Admixtures should be stored in water tight drums or tanks protected from direct sun or excessive cold. Each tank or drum containing admixture should be clearly labeled for identification purpose. Pot life and date of expiry should also be indicated. Agitation should be provided for liquid admixtures, which are not stable solution.

6.1.3 Batching equipments:

i) Hoppers for weighing cement and aggregates should consist of suitable containers freely suspended from a scale or other suitable load measuring device and equipped with a suitable discharging mechanism.
ii) The method of control of loading mechanism should be such that as the quantity required in the weighing hopper is approached, the material may be added at a controlled rate .

iii) The weighing hopper should be so constructed so as to discharge efficiently and prevent the build up of materials.
iv) Preferably dust seal should be provided on the cement hoppers between the loading mechanism and the weighing hopper and

should be fitted in a manner so as to prevent the emission of cement dust and not to affect weighing accuracy.

v) There should be sufficient protection to cement and aggregate weighing hoppers and weighing mechanisms to prevent interference with weighing accuracy by weather conditions or external build up of materials.

vi) When more than one type / grade of cement is used, the weighing device and discharge screw or other part of transfer system should be emptied before changing from one type of cement to another.

vii) Batching control should be such that process identification at every stage and back tracebility (later on) can be ensured. It is desirable to have automation in batching process and its controls.

6.1.4 Mix design:

i) Design mix concrete should only be used for production of required grade & strength of concrete. Mix design should be finalised after conducting trials. For mix design, the guidance may be taken from IS:10262 “Recommended Guidelines for Concrete Mix Design” or any other standards. For guidance of users, broad guidelines on mix design, alongwith example as per IS:10262, are given in Annexure-I. For finalising and approval of mix design, permeability test should also be conducted in addition to cube strength test. Permeability test may be conducted as per DIN 1048. Contractor/ manufacturer of Ready Mixed Concrete should produce all the records for approval of mix design.

ii) R.M.C. plants may have some designed recipes (mix proportion for different grades). They may be considered if they fulfill all requirements. In that case straight away trial may be carried out with suitable recipe.

6.1.5 Inspection and maintenance of plant equipments:

i) The producer should be able to demonstrate that a documented inspection and calibration procedure for the plant and all other equipment is prevalent.

ii) All scales should be inspected and tested over their range at least once in a month and the results should be recorded. Calibration record should contain details of any corrective action taken. The records should be furnished to railways for perusal.

6.1.6 Transportation arrangement:

For transportation of concrete to site, concrete agitators conforming to IS: 5892 “Specification for concrete transit mixture and agitators” should be

used. Agitating speed of the agitators should not be less than two revolution per minute nor more than six revolution per minute.

6.2 Immediate control:

Immediate control is concerned with instant action to control the quality of concrete being produced. Broadly it includes following:

(i) **Adjustment for surface moisture content of fine and coarse aggregates:**

For producing the desired mix concrete the amount of water to be added depends upon the surface moisture content of aggregates. There should be standard arrangement for testing surface moisture content of coarse and fine aggregates. This test should be conducted daily. Method described in IS:2386 pt. III may be used for this purpose. If necessary, test may be carried out more than once, in case aggregates subjected to rain water. In case, any other method is being used for determination of surface moisture content, then test results should be calibrated with standard method as given in IS:2386 Pt.-III. Based on the test results, necessary adjustment in the quantity of aggregate and water should be determined and furnished to the plant operator. Grading of coarse aggregates also should be checked regularly.

ii) **Measurement of materials and subsequent operations:**

a) Cement and cementitious material should be measured by weight in a hopper or compartment separate from those used for other materials.
b) Aggregate should be measured by weight after necessary adjustment taking into account the free surface moisture content / water likely to be absorbed by aggregate.
c) Water may be measured by volume or weight. It should be measured after necessary adjustment taking into account free surface moisture/ quantity of water likely to be absorbed by aggregates.
d) Solid admixture should be measured by weight. Liquid admixture may be measured either by volume or by weight.
e) After measurement, all materials should be discharged into the mixture without any loss of time.
f) Fully automatic production system should be fitted with control equipment to allow correct operation of the plant to be monitored during weighing and batching. Automatic control system on batching plant should not commence

batching until all hoppers have been emptied and scales zeroed.

g) The mixing time should be measured from the time all the materials required for batching, including water are in the drum of the mixture.

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

i) For each load immediately after discharge of concrete from drum, the producer or his representative staff should provide the purchaser or his representative with printed delivery ticket with the necessary information about concrete load like total quantity of concrete, quantities of raw material per cubic meter of concrete, time of mixing, date and truck number etc.

6.3 Retrospective control:

Retrospective control is concerned with those factors that influence the control of concrete quality which can not be assessed at the time of production. Strength of concrete and permeability are such factors which can not be assessed at the time of production. Broadly mix performance is the main factor that has to be taken care by the producer. The producer should introduce suitable control procedure to monitor the performance of design mix. Quality control system should be operated to check the strength of design mix from random sampling of actual quality of concrete produced at the plant. Cube test results should be compared with targeted strength of the concrete. In case, substantial difference is observed in the two values, proper analysis should be made for the factors which would have resulted in deviation from the targeted strength of design mix. Subsequently, corrective action should be taken.

GUIDELINES ON USE OF READY MIXED CONCRETE

7. Deputation of supervisors at batching and mixing plant:

Even though producer of Ready Mixed Concrete generally adopts quality assurance programme, there is need to depute Railway supervisor at centralised batching and mixing plant, on the days on which Ready Mixed Concrete is produced for Railways. Railway supervisor should have the competency certificate as laid down in Cl. 5.6.1.1 of IRS Concrete Bridge Code. Presence of railway supervisor at plant will reduce/ avoid the chances of short cuts, if any, adopted by the concrete manufacturers. Functions of railway supervisor at batching and mixing plant may be as under:

i) To ensure that grading of coarse aggregate and moisture content of aggregates has been tested by taking fresh samples and necessary adjustments are made in raw material content (i.e. quantities of aggregate and water) in the concrete mix based on the results of the fresh tests on aggregate.

ii) To check quality of aggregates and admixtures visually.

iii) To be available with operator during batching and mixing operation to make sure that adjusted quantity of raw materials are fed in the computer during production of concrete.

iv) To note down the time of completion of mixing of concrete load and its dispatch to site and to communicate the same to site of construction. He will also communicate quantity of concrete and truck number in which concrete has been dispatched to site.

v) To ensure that proper delivery ticket is issued by the producer which should contain quantity of concrete loaded, the raw material content of concrete mix, time of completion of mix, truck/ lorry number of concrete agitator in which concrete load has been dispatched and signature of operator etc. In addition, standard proforma as suggested in Annexure-II should be filled up by him and given to driver of the truck agitator, who will hand over the same to supervisor incharge at site. Standard proforma may be slightly modified if necessary to incorporate other details.

GUIDELINES ON USE OF READY MIXED CONCRETE

8. Testing of Ready Mixed Concrete at site of construction (i.e.delivery point):

On arrival of RMC at construction site, concrete should be checked for transit time elapsed, workability and strength.

8.1 Transit time & workability:

It should be ensured that the concrete has arrived to the site within the permissible time limit from the time of mixing of concrete. In case transit time has exceeded the permissible time limit, concrete should not be accepted. Further on arrival of Ready Mixed Concrete at site, it should be tested for specified workability (i.e. slump etc.).

8.2 Testing for strength:

8.2.1 Sample should be taken from concrete delivered at placing point for testing of strength of concrete. Sample should spread over entire period of concreting and cover each load brought by truck agitator. Frequency of testing of concrete may be as specified under IRS concrete Bridge Code Cl. 8.7.2.2 which is as under:

Quantity of Concrete in the work, m^3	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50 m^3 or part thereof

Note: At least one sample shall be taken from each load brought by the truck agitator.

8.2.2 Three test specimens should be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 3 or 7 days or at the time of striking the formwork etc. Specimen should be tested as described in IS: 516. The test strength of the sample shall be the average of the strength of three specimens. The individual variation should not be more than $\pm$ 15 percent of the average. If more, the test results of the sample are invalid.

8.2.3 **Acceptance criteria**:- The concrete shall be deemed to comply with the strength requirements when it fulfills the criteria laid down in IRS Concrete Bridge Code Cl. 8.7.6, which are as under:

Compressive strength:- When both the following conditions are met, the concrete complies with the specified compressive strength:

a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column A of table-9 of this report;
b) Any individual test results complies with the appropriate limits in column B of table 9 of this report.

Flexural strength:- When both the following conditions are met, the concrete complies with the specified flexural strength:

a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.
b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2.

TABLE 9: Characteristic compressive strength compliance requirements

		A	B
Specified grade	Group of test results	The mean of the group of test result exceeds the specified characteristic compressive strength by at least:	Any individual test result is not less than the characteristic compressive strength less:
		N/mm^2	N/mm^2
M20 & above	Any conse-cutive 4	3	3

GUIDELINES ON USE OF READY MIXED CONCRETE

9. Aspects to be taken care of at the site of construction:

9.1 Approach at the site of construction and decisions regarding laying of Ready Mixed Concrete:

Ready Mixed Concrete is supplied in bulk quantity. Therefore, the construction site should be examined regarding accessibility of Transit agitators. Final decisions should be made about stationing Transit agitators (Mobile Mixer), handling of concrete, network of pipelines, availability of concrete pump, etc. As far as possible, manual handling of concrete should not be considered because the same may be time consuming and the requirement of labour is much higher than the normal concreting operations.

9.2 Pumping:

9.2.1 For transporting Ready Mixed Concrete across running lines or at heights, concrete pump is very useful. Pumps are capable of placing any quantity between 20-30 cum./hour in position and accordingly arrangements need to be made for adequate number of vibrating equipment and sufficient manpower for final placement of concrete. The end capacity of placement of concrete finally, would also regulate the dispatches of concrete from the plant, to avoid detention of transit agitators at the site of construction. The various stages of concrete should be planned in such a way that manual handling of concrete is minimised.

9.2.2 The placement of concrete at site is done either by a stationary line pump or by placer boom. In case of stationary line pump, the pipe line is to be laid in advance before the arrival of transit mixer. If the concrete is to be placed with the placing boom, the transit mixer and boom placer may go together also. The pumping rate should be compatible with both the production rate and the rate that the placing gang can cope with.

9.2.3 Concrete pumps being costly equipment, their availability with the RMC suppliers may be limited or there may be pre-conditions attached for supplying the pump with some minimum quantity of concrete. Various concreting operations may have to be planned accordingly. This aspect should be finalised in consultation with the RMC supplier.

9.2.4 The RMC supplier should be asked to advise the working capacity of the lead and lift of the pumps. Adequate compensation should be made for the bends used in the pipelines. Accordingly, pumping should be planned. Choking of concrete in the pipelines is a high probability. In case, there is a substantial delay in the pumping operations, the “ball” should be passed through the pipelines so that choking is avoided.

9.2.5 Initial grouting with cement slurry for lubricating the pipe line must be done to avoid choking / blockages in the initial stages of work.

9.2.6 Concreting should be started at the farthest point from the pump and work should proceed by detaching a length or two of the pipeline.

9.3 Regulation of concrete despatches:

In case of high volume of concrete work at a time, number of concrete transit agitators would be required at site. Following aspects should be looked into.

a) Proper planning should be done to ensure regular availability of concrete at the placement site, without causing undue detention to the transit agitators at site. It should also ensured that the delivered concrete is used within the specified initial setting time.

b) Good communication between the construction site and the RMC plant is essential to regulate the flow of concrete. In case of unavoidable delay at site, further despatches can be regulated.

c) For better use and planning of concreting, a pre-trial run between the plant and the site would be desirable to have an accurate assessment of transit time. It will also help in identification of any hurdles in the way like octroi post, traffic jam locations etc., so that contingency plans can be kept in mind, if such an eventuality arises.

9.4 Shuttering and centering:

RMC is generally flowing concrete used with pumping arrangements. Thus, the shuttering and centering are subjected to sudden load in a very short time. Unlike the site mixed concrete, which is placed at a very slow rate (4-5 cum/ hr.), the rate of placement of concrete in case of Ready Mixed Concrete is substantially high. Therefore, Form Work and Centering should be strong enough to take care of this much of load. Shuttering joints should be made water tight, otherwise, the slurry may start flowing through the joints. If concrete is to be placed in narrow sections such as thin beams, walls, fins etc. the forms should be fitted with chutes to prevent wastage by spilling.

9.5 Additional aspects to be considered by site supervisors:

9.5.1 Once the concrete is delivered at the site, further uses are to be supervised by the Railway Supervisors along with the contractor's supervisors meant for this purpose. As soon as the concrete is received,

the Site Supervisor must accordingly study the accompanying challan which is duly signed by the Railway Supervisor present in the plant. He should specifically observe the time when the concrete was mixed and the time limit by which the concrete is to be received and used. He should immediately decide and convey to the contractor's representative, whether the concrete is acceptable or not.

9.5.2 He should also notice the booster doses of admixtures to be added at site, if any, and the recommended mixing time for the booster dose. He should supervise the addition of complete quantity of booster dose of admixture and its mixing for adequate time in the Mobile Mixers. Only after completing this activity, the concrete should be used.

9.5.3 Necessary arrangement should be made at construction site for testing of delivered Ready Mixed Concrete for workability and strength.

GUIDELINES ON USE OF READY MIXED CONCRETE

10. Temperature of concrete:

Concrete is not recommended to be placed at a temperature above 40 ^{o} C and below 5^{o} C without proper precaution as laid down in IS: 7861 (Pt.I or pt. II as the case may be). IS:7861 pt. I deals with hot weather concreting and Pt.II deals with cold weather concreting.

10.1 Hot weather concrete:

10.1.1 Any operation of concreting done at atmospheric temperature above 40 ^{o}C may be put under hot weather concreting. In the absence of special precautions as laid down under IS: 7861 (Pt.I), the effect of hot weather may be as follows:

a) **Accelerated setting:** A higher temperature of fresh concrete results in a more rapid hydration and leads to reduced workability/ accelerated setting. This reduces the handling time of concrete.

b) **Reduction in strength:** Concrete mixed, placed and cured at higher temperature normally develops higher early strength than concrete produced and cured at normal temperature but at 28 days or later the strength are generally lower.

c) **Increased tendency to crack:** Rapid evaporation may cause plastic shrinkage and cracking and subsequent cooling of hardened concrete would introduce tensile stresses.

10.1.2 In order to avoid harmful effect of hot weather concreting IS: 7861 (Pt.1) recommends that temperature of ingredients should be controlled so that the temperature of produced concrete is lower. Mixing water has the greatest effect on lowering of temperature of concrete. The use of chilled water/ flaked ice in mixing produces adequate reduction in concrete temperature.

10.1.3 In order to control the temperature of concrete and to avoid adverse effect of hot weather, it is desirable to limit the maximum temperature of concrete as 35^{o} C to keep margin for increase in temperature during transit.

10.2 Cold weather concreting:

10.2.1 Any concreting operation done at a temperature below 5 ^{o} C is termed as cold weather concreting. IS: 7861 (Pt.II) recommends special precautions to be taken during cold weather concreting.

10.2.2 In the absence of special precautions, the effect of cold weather concreting may be as follows:

a) **Delayed setting**:- When the temperature is falling to about 5^{o}C or below, the development of strength of concrete is retarded compared with development at normal temperature. Thus, the time period for removal of form work has to be increased.

b) **Freezing of concrete at early stage**:- The permanent damage may occur when the concrete in fresh stage is exposed to freeze before certain pre-hardening period. Concrete may suffer irreparable loss in its properties to an extant that compressive strength may get reduced to 50% of what could be expected for normal temperature concrete.

c) **Stresses due to temperature differentials**:- Large temperature differentials within the concrete member may promote cracking and affect its durability adversely.

10.2.3 In view of above, it is desirable to limit the lowest temperature of concrete as 5^{o} C

GUIDELINES ON USE OF READY MIXED CONCRETE

11. Benefits and limitations of Ready Mixed Concrete:

11.1 Benefits:- Ready Mixed Concrete offers following benefits over the site mixed concrete.

i) Quality assured concrete:- Concrete is produced under controlled conditions using consistent quality of raw material.

ii) High speed of construction- Speed of construction can be vary fast in case RMC is used. It has come to notice that RMC was used in MSRDC flyovers in Mumbai wherein 25 piles (200 m^3) were cast in one day. Similarly, deck slabs of 370m^3 were cast in one day and the projects are being completed 3-5 months ahead of schedule.

iii) Versatility in uses and methods of placing: The mix design of the concrete can be tailor made to suit the placing methods of the contractor.

iv) Timely deliveries in large as well as small pours.

v) No need for space for storing the materials like coarse and fine aggregate, cement, water and admixtures.

vi) No delay due to site based batching plant erection/ dismantling; no equipment to hire; no depreciation of costs.

vii) Reduced noise and air pollution; less consumption of petrol and diesel and less time loss to business.

11.2 Limitations:

I) As the Ready Mixed Concrete is not available for placement immediately after preparation of concrete mix, loss of workability occurs. In addition, there are chances of setting of concrete if transit time involved is more. Therefore, generally admixture like plasticisers/ super plasticisers and retarders are used. Addition of retarders may delay the setting time substantially which may cause placement problems. In addition, it may also affect the strength of concrete. Therefore, it is necessary that the admixtures i.e. plasticisers and super plasticisers/ retarders used in Ready Mixed Concrete are properly tested for their suitability with the concrete. In case loss of strength is observed, the characteristic strength may have to be enhanced so that after loss of strength, required characteristic strength is available.

ii) Because of large quantity of concrete available in short span, special placing and form work arrangement are required to be made.

GUIDELINES ON USE OF READY MIXED CONCRETE

12. Condition under which use of Ready Mixed Concrete is desirable:

Ready mixed concrete is suitable for small and medium projects where cost of development of adequate infrastructure for producing quality concrete will be disproportionate. Ready Mixed Concrete is also convenient for congested site where adequate space is not available for storage of raw materials and other concrete manufacturing operations. For large construction project like important bridges etc. where adequate space is available, site mixed concrete appears to be more suitable, provided adequate quality control is exercised at all the stages similar to the control being exercised by the Ready Mixed Concrete plants.

13. Special conditions to be incorporated in tender documents for use of Ready Mixed Concrete:

As explained in para 2 & 3, there is significant difference in between the Ready Mixed Concrete and site mixed concrete as far as user is concerned. Therefore, there is need to incorporate special conditions in the contract regarding use of Ready Mixed Concrete. Mainly, following conditions should form part of tender document. If necessary, these conditions may be modified depending upon site requirement. Other condition, as felt necessary, depending upon nature of work and site condition, may be added by Railways.

I. **Planning for use of Ready Mixed Concrete:**
In case the tenderers plan to use Ready Mixed Concrete for the work, he should ensure that these conditions shall be complied by his RMC manufacturer. It would be in his interest, if these conditions are incorporated in his agreement entered with RMC supplier.

II. **Ready Mixed Concrete:**
Ready Mixed Concrete means concrete produced by completely mixing cement, aggregates, admixtures, if any and water at a central batching and mixing plant and delivered in fresh condition to purchaser at site of construction.

III. **Necessary information for guidance of manufacturer of Ready Mixed Concrete.**

(a) _____ Type cement conforming to IS:_____ shall be used for manufacturing of Ready Mixed

GUIDELINES ON USE OF READY MIXED CONCRETE

Concrete (type of cement and relevant IS: specification to be filled up by the Zonal Railways).

(b) _____ maximum size of natural aggregates conforming to IS: 383 shall be used for production of Ready Mixed Concrete (Max. size of aggregate to be filled by Zonal Railways).

(c) Water proposed to be used in concrete shall be in accordance with clause 4.3 of IRS Concrete Bridge Code.

(d) Admixture: Contractor/ manufacturer may use any suitable admixture (i.e. water reducing agent/ retarder etc.) of reputed make. The suitability of the admixture shall be tested in accordance with requirements specified in IS: 9103. Records of all the tests, carried out to judge the suitability of admixture, shall be furnished by the RMC manufacturer to Railways. For judging the suitability of admixture, tests for workability, time of setting, compressive strength/ flexural strength at 7 and 28 days shall be carried out under the supervision of railway representative. However, in case of small works, if RMC supplier has adequate record for judging suitability of admixture for the same design mix for the same brand of cement, the record may be relied upon.

(e) The Minimum compressive/ flexural strength and slump/ compacting factor required for workability at the placement of concrete shall be as under:

S. No.	Member	Comp. Strength	Flexural Strength	Workability (Slump/ Compacting factor)

(Values of strength & workability for various members have to be furnished by Zonal Railways. Para 5.3 of IRS Concrete Bridge Code may be referred for workability requirements)

(f) The test cubes/ beams shall be tested at the age of _____ days. The frequency and number of tests shall be made in accordance with clause 8.7.2 of IRS Concrete Bridge

Code-1997. (The age at which cubes are required to be tested shall be furnished by the Railways).

(g) Other miscellaneous requirements including durability requirements:

i) Only design mix concrete shall be used for production of the required grade and strength of concrete.
ii) Minimum cement content shall be _____ kg/m^3. Maximum cement content shall be limited to 500 kg/m^3. (Depending upon the exposure environment, minimum cement content shall be furnished by Zonal Railways. Para 5.4.5 of IRS Concrete Bridge Code may be referred for guidance.)
iii) Maximum water cement ratio shall be _____ (Depending upon the exposure environment, maximum water cement ratio shall be furnished by Zonal Railways. Para 5.4.3 of IRS Concrete Bridge Code may be referred for guidance).
iv) Maximum total chloride content shall be restricted to 0.15% / 0.06% by mass of cement for RCC/ prestressed concrete works respectively.
v) The total amount of soluble sulphate content shall be less than 4% by mass of cement.
vi) **Permeability for design mix:-** Permeability test shall be conducted as per the requirement of Appendix-G of IRS Concrete Bridge Code (DIN: 1048). The maximum moisture penetration depth in the test specimen shall not exceed 25mm.
vii) Initial setting time for design mix shall not be less than _____ hours. (Value for initial setting shall be assessed and furnished by the Railways taking into account the time involved in transportation of concrete & placement of the same).

IV. Quality control:

The producer of RMC shall adopt quality assurance programme, which shall get approved by Railways. It shall cover Forward control, Immediate control and retrospective control. He shall have necessary laboratory facilities to carry out necessary tests to ensure quality control at each stage during production of concrete. In case, few tests are done outside, which are not required frequently, the record of test results shall be available with RMC manufacturer.

V. Approval of Design Mix Concrete:

GUIDELINES ON USE OF READY MIXED CONCRETE

Only design mix concrete shall be produced for the required grade and strength of concrete. For design of concrete mix, IS: 10262 or any other standard may be used for guidance. The design mix computation shall be submitted in advance to the Railways by the contractor. Based on the proposed design mix, cubes shall be cast and tested under the supervision of Railways representative. In addition to strength, proposed design mix shall be tested for workability, initial setting time, permeability, total chloride content & sulphate content. Only after satisfying the requirements of initial setting time, workability, strength, permeability, total chloride & sulphate content, the design mix shall be approved by the Railways.

In case there is any change in ingredients or in the process/ plant, design mix shall be redesigned and got approved by Railways.

VI. **Loss in workability and strength of concrete during transportation:**

The loss in workability and strength of concrete during the transit time involved in transportation of concrete, from mixing plant to the place of work, shall be determined before hand. The loss of workability and strength shall be accounted while designing the concrete mix.

VII. **Access to Railways officers/ officials to Ready Mixed Concrete plant:**

RMC Manufacturer shall allow the Railways officers/ officials to supervise the operations involved in concrete production. Adequate facilities shall be provided by the manufacturer to the Railways officials to supervise the materials proposed to be used in production of concrete, the process of manufacture and method of delivery of concrete. He shall also provide adequate facility to the Railway officials to take samples for materials used.

VIII. **Accessibility of technical records maintained by RMC manufacturer:**

RMC manufacturer shall allow Railway officers/ officials to peruse the past & present technical records maintained by him.

IX. **Deputation of Railways supervisor:**

Manufacturer shall allow deputation of Railways supervisor at Ready Mixed Concrete plant on the days on which concrete is likely to be produced for Railways. Railway supervisor will ensure that concrete is being produced as per the requirement of work. He will also ensure that other conditions, as agreed to, are being followed.

X. **Temperature of concrete:**

Temperature of produced concrete shall not be less than 5^{o} C and shall not exceed 35^{o}C.

XI. **Transportation of concrete:**

The concrete shall be transported in concrete transit agitators conforming to IS: 5892. Agitating speed of the agitators during transit shall not be less than 2 revolution per minute nor more than 6 revolution per minute.

XII. **Transit Time and placement of concrete:**

a) The concrete shall be delivered at the site of work and discharge shall be completed with-in _____hours of adding mixing water to the dry mix of cement and aggregate. Concrete received after the transit time, as specified above, shall not be accepted. (Railway shall specify the transit time limit by deducting anticipated time required for placement of concrete from initial setting time specified for approval of design mix).

b) Concrete, there after, 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.

XIII. **Re-tempering:**

Under any circumstances addition of any water shall not be allowed after the initial mixing of concrete.

XIV. **Testing for workability and strength at the time of placement of concrete:**

The concrete shall be tested for the required workability and strength at the time of placement. Concrete shall be deemed to satisfy/ comply with the strength requirement when it fulfills the criteria laid down in IRS Concrete Bridge Code clause 8.7.6.

XV. **Dosing of admixture at site of concreting:**

After arrival of Ready Mixed Concrete at site, additional dose of admixture, if provided for in approved mix design, shall be added in presence of Railway supervisors.

XVI. **Measurement of concrete:**

Measurements of concrete work so done will be based on finished concrete work. No measurement shall be done for green concrete.

GUIDELINES ON USE OF READY MIXED CONCRETE

14. Conclusion:

Considering the relative benefits, it is desirable to use Ready Mixed Concrete on small and medium projects like buildings/ small bridges. In addition, Ready Mixed Concrete, should be used on congested site for all types of works. For large works like important bridges etc., a choice may be left at the discretion of the contractor to either use Ready Mixed Concrete or site mixed concrete. While going in for Ready Mixed Concrete, it is essential that prior to placement of supply order, it is ensured that proper Quality Assurance Programme is being followed by the manufacturer, to control quality at all the stages right from procurement of raw material to production of concrete. While planning to use Ready Mixed Concrete, it is extremely important that effect of transit time involved in transportation of concrete is taken care-of. Admixtures, proposed to be used to counteract the effect of transit time, should be tested for their suitability.

GUIDELINES ON USE OF READY MIXED CONCRETE

Annexure I

CONCRETE MIX DESIGN

A.1. Basic considerations

A.1.1 The proportioning of concrete mixes consists of determination of quantities of different concrete-making materials necessary to produce concrete having the desired workability and 28-days compressive strength of concrete for a particular grade of concrete and durability requirements. Emphasis is laid on making the most economical use of available materials so as to produce concrete of required attributes at the minimum cost.

A.1.2 Concrete has to be satisfactory both in fresh and hardened states. The proportioning of concrete mixes is accomplished by the use of certain established relationships from experimental data which provides reasonably accurate guidance for selecting the best combination of ingredients so as to achieve the desired properties of the fresh and hardened concrete. Out of all the physical characteristics of concrete compressive strength is often taken as an index. Therefore , the mix design is generally carried out for a particular compressive strength of concrete coupled with adequate workability so that the fresh concrete can be properly placed and compacted. In addition the mix proportions are also checked against the requirement of adequate durability for the type of exposure condition anticipated in service. The following basic assumptions are made in design of concrete mixes of medium strength:

a) For given aggregate characteristics, the workability of concrete is dependent on its water content.
b) The compressive strength of concrete is related to its water-cement ratio.

A.1.3 For high strength concrete mixes, considerable interaction occurs between these two criteria and validity of. such assumptions may become limited. Moreover, there are various other factors which affect the properties of concrete e.g. the quality and quantity of cement, water, aggregates and admixtures (if used); procedures of batching, mixing, placing, compaction and curing etc. Therefore, the specific relationships that are used in proportioning concrete mixes, should be considered only as a basis for trial mixes . Concrete mix design on the basis of recommended guidelines is really a process of making an initial guess at the optimum combination of ingredients and final mix proportions are arrived at, only on the basis of further trial mixes.

A.2. Factor in the choice of mix design

The design of concrete mix is based on the following factors:

a) Grade of concrete
b) Type of cement and its strength

c) Desired workability of concrete
d) Maximum nominal size of aggregate
e) Minimum cement content and Maximum water-cement ratio to satisfy durability requirements.

Out of these, the grade of concrete provides the characteristics strength requirement of concrete. Depending upon the level of quality control expected to be exercised at the site, the concrete mix has to be designed for a target mean strength which is somewhat higher than the characteristics strength.

The workability of concrete for satisfactory placing and compaction is related to the size and shape of the section to be concreted, the quality and spacing of reinforcements, and the methods to be employed for transportation, placing and compaction of concrete.

Provision of minimum cement content and maximum water cement ratio ensure adequate durability of the structure to with stand environmental loads.

A.3. **Concrete mix design procedure as per Indian Standard recommended guidelines (IS:10262-1982)**

A.3.1 The Indian Standard recommended guidelines give a procedure for proportioning concrete for general type of construction using concrete-making materials normally available. The mix design is carried out for a desired workability and 28 days compressive strength of concrete, using continuously graded coarse aggregates. The mix design procedure is for normal concrete mixes(non-air-entrained), both for medium and high-strength concrete. In this method, the water content and proportion of sand(as % of total aggregate by absolute volume) are determined for fixed values of w/c ratio, workability and grading of sand. The water content and % of sand are then adjusted for any difference in workability, w/c ratio and grading of sand. The batch weight of materials per m^3 of concrete is finally calculated by the absolute volume method.

In case of RMC, generally admixtures are used which may reduce the strength of concrete to 90%. Thus, while designing the mix, the characteristic strength should be enhanced to that extent.

A.3.2 The following basic data are required:
a) Grade of concrete alongwith characteristic strength (fck)
b) Degree of workability desired (Slump or compacting factor value)
c) Degree of quality control expected to be exercised at the construction site,
d) Exposure condition at the construction site
e) Type and maximum size of aggregate to be used.
f) Standard deviation (S) of compressive strength of concrete samples.

A.3.3 The following test data on materials are required:

i) Specific gravity of cement

ii) Test data on cement-testing (28 days strength of cement-mortar),if available,

iii) Specific gravity and water absorption (%) for coarse and fine aggregates,

iv) Grading of coarse and fine aggregates,

v) Accelerated strength of "reference" mix concrete(if 28 days cement-strength data is not available)

A.3.4 Procedure of concrete mix design

(i) The 28 days target mean strength ($\overline{fck}$) is first calculated from the following formula:

$$\overline{fck} = fck + 1.65\ S$$

The value of Standard deviation S (if not available from the construction site) can be assumed as given in Table: 2, depending on the degree of quality control expected to be exercised as given in Table: 4.

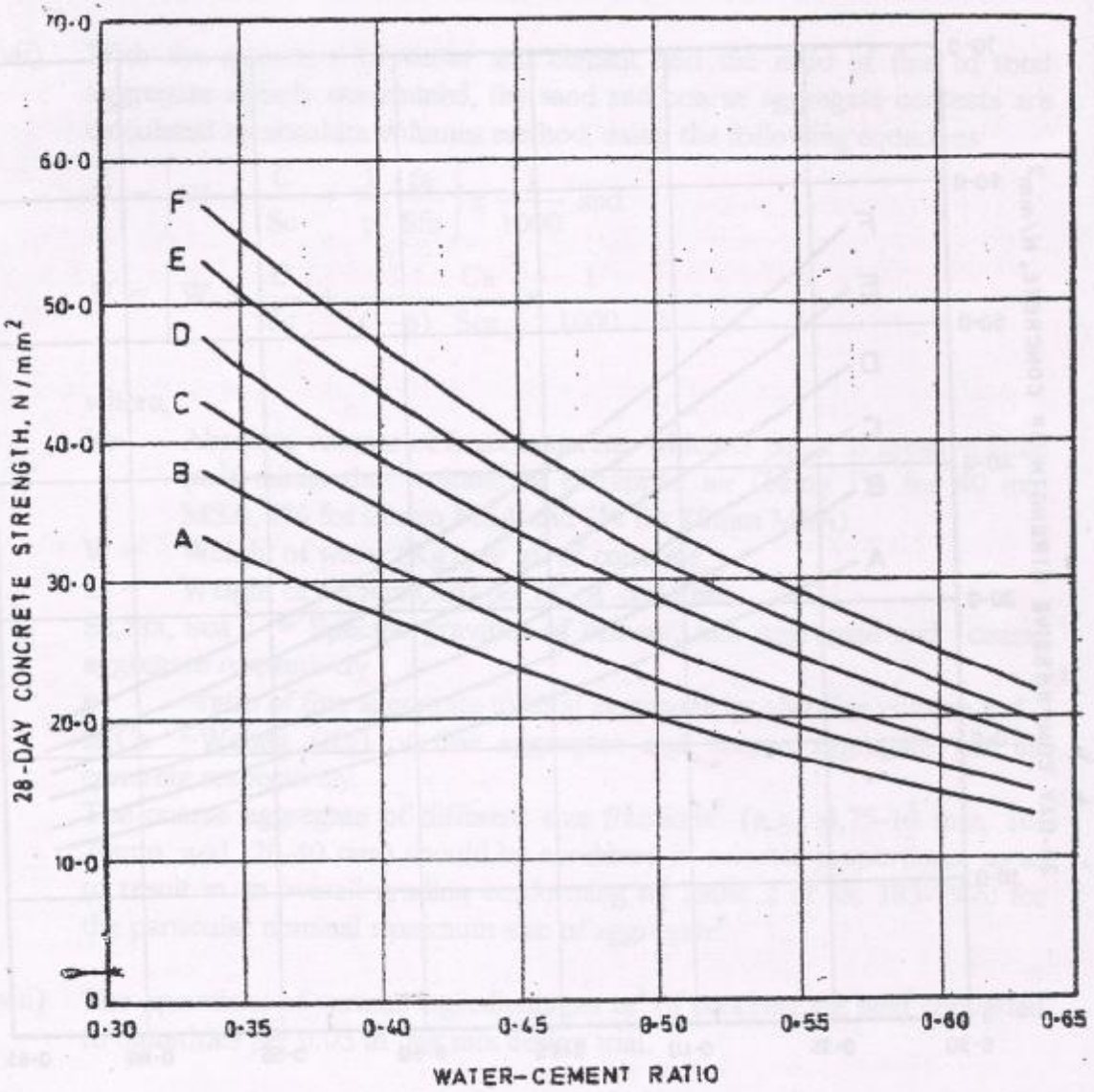
For concrete containing admixtures (retarders) characteristic strength (fck) should be enhanced to take into account loss of strength due to retarder. Enhanced value of characteristic strength should be used in the above formula.

(ii) For the target mean strength, w/c ratio is selected from Fig. 1, if 28 days cement-strength is known. If it is not available, accelerated strength test should be conducted to obtain the accelerated strength of 'reference' concrete mix. In that case, the w/c ratio for the target mean strength is selected from fig.2. Brief details regarding method of estimation of water cement ratio based on accelerated strength test are described in para A.4.

(iii) The W/c ratio selected should be checked against the limiting W/c ratio for the durability requirement (Table: 3) and the lower of the two values is to be adopted.

(iv) The water content and % of sand in total aggregate by absolute volume are next selected from Tables: 5 and 6 (For 'medium' and 'high-strength' concretes respectively), for fixed workability of 0.80 C F and W/c ratios of 0.60 and 0.35 respectively for crushed (angular) coarse aggregate and for sand conforming to grading zone II.

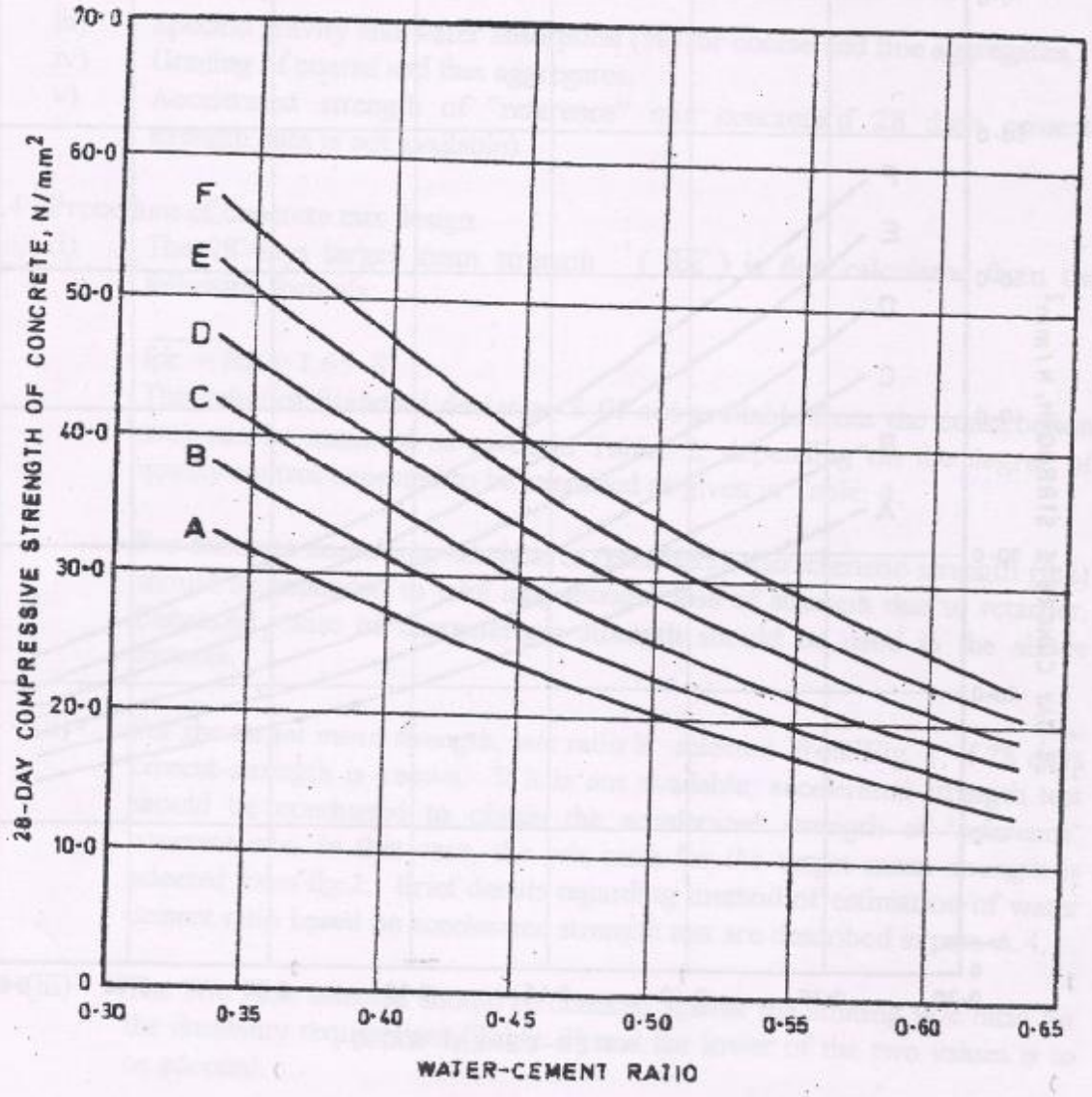
(v) For other conditions of workability, W/c ratio, grading of sand, and for rounded coarse aggregate, certain adjustments on the quantity of mixing water and % of sand given in Tables 5 and 6 are to be made according to Table 7.



28-Day Strength of Cement, Tested According to IS : 4031-1968

A = 31·9-36·8 N/mm² (325-375 kg/cm²)
B = 36·8-41·7 N/mm² (375-425 kg/cm²)
C = 41·7-46·6 N/mm² (425-475 kg/cm²)
D = 46·6-51·5 N/mm² (475-525 kg/cm²)
E = 51·5-56·4 N/mm² (525-575 kg/cm²)
F = 56·4-61·3 N/mm² (575-625 kg/cm²)

FIG.1 RELATION BETWEEN FREE WATER-CEMENT RATIO AND CONCRETE STRENGTH FOR DIFFERENT CEMENT STRENGTHS



Accelerated Strength (Tested According to IS : 9013-1978) of Reference Mix

A = 12·3-15·2 N/mm² (125-155 kg/cm²)
B = 15·2-18·1 N/mm² (155-185 kg/cm²)
C = 18·1-21·1 N/mm² (185-215 kg/cm²)
D = 21·1-24·0 N/mm² (215 245 kg/cm²)
E = 24·0-27·0 N/mm² (245-275 kg/cm²)
F = 27·0-29·9 N/mm² (275-305 kg/cm²)

FIG. 2 RELATION BETWEEN FREE WATER-CEMENT RATIO AND COMPRESSIVE STRENGTH OF CONCRETE FOR DIFFERENT CEMENT STRENGTHS DETERMINED ON REFERENCE CONCRETE MIXES (ACCELERATED TEST-BOILING WATER METHOD)

(vi) The cement content is calculated from the W/C ratio adopted and for the final water content after adjustment. The cement content so calculated is next checked against the minimum cement content for the durability requirement (Table-3), and the greater of the two values is to be adopted.

(vii) With the quantities of water and cement and the ratio of fine to total aggregate already determined, the sand and coarse aggregate contents are calculated by absolute volumes method, using the following equations:

$$V = \left[W + \frac{C}{Sc} + \frac{1}{p} \frac{fa}{Sfa} \right] x \frac{1}{1000} \text{ and}$$

$$V = \left[W + \frac{C}{Sc} + \frac{1}{(1-p)} \frac{Ca}{Sca} \right] x \frac{1}{1000}$$

where,

V= Absolute volume of fresh concrete, which is equal to gross volume (m^3) minus the volume of entrapped air (being 1% for 40 mm MSA, 2% for 20mm MSA and 3% for 10mm MSA)

W = Weight of water (Kg) per m^3 of concrete,

C = Weight of cement (Kg) per m^3 of concrete,

Sc,Sfa, Sca = Specific gravities of cement, fine aggregate and coarse aggregate respectively

p =ratio of fine aggregate to total aggregate by absolute volume and

fa,Ca =Weight (Kg) of fine aggregate and coarse aggregate per m^3 concrete respectively.

The coarse aggregate of different size fractions (e.g.. 4.75-10 mm, 10-20mm and 20-40 mm) should be combined in suitable proportions, so as to result in an overall grading conforming to Table 2 of IS: 383-1970 for the particular nominal maximum size of aggregate.

(viii) The quantities of various ingredients per m^3 of concrete are next converted to quantities per 0.05 m^3 for mix design trial.

(ix) The quantities of aggregates calculated above are for saturated surface dry condition of aggregates. If dry aggregates are used, the amount of mixing water should be increased by an amount equal to the moisture likely to be absorbed by the aggregates. If wet aggregates are used, necessary reductions should be made for mixing water by an amount equal to the free (surface) moisture contributed by the coarse and fine aggregates. Accordingly quantity of coarse & fine aggregates should also be adjusted.

(x) The calculated mix proportions shall be checked by trial mixes. If the measured workability satisfies the workability desired, 6 cubes can be cast

(3 for accelerated curing and 3 for 28-days compressive strength test). This becomes trial mix no.1.Two more trial mixes (Trial mixes No.2 and 3) shall be made with the water content same as trial Mix.no.1, and varying water cement ratio by $\pm$ 10% of the preselected value. For these two additional trial mixes no.2 and 3, the mix proportions are to be recalculated for the changed condition of water-cement ratio with suitable adjustments in accordance with Table -7.

(xi) The three trial mixes cast on the same day will provide sufficient information on the relationship between water-cement ratio and 28-day compressive strength of concrete for the materials used, from which the water-cement ratio for the target average 28 days compressive strength of concrete can be arrived at. The water-cement ratio and hence the final mix proportions can be recommended for field trials.

A.4 Method of Estimation of Water Cement Ratio based on accelerated strength test.

A.4.1 Use of Fig.1 will necessitate testing of the cement for its 28 day compressive strength and another 28 days are needed to obtain the compressive strength of concrete according to the trial mixes. As an alternative, a rapid method of concrete mix design which will take only 3 days for trials is described in this paragraph. The procedure is based on the use of accelerated curing (boiling water) method for determination of compressive strength of concrete according to IS: 9013-1978.

A.4.2 Procedure

A.4.2.1 Determine the accelerated strength (boiling water method) of a 'reference' concrete mix, having water cement ratio as 0.35, compacting factor as 0.80 with the cement proposed to be used, on 150mm cube specimens. The nominal maximum size of aggregate of the 'reference' concrete shall be 10mm and fine aggregate used shall conform to Zone II of Table 4 of IS: 383-1970. .

Typical concrete mix proportion per m^3 of concrete for the reference concrete mix are as follows:

Cement (Proposed to be used in construction) = 530 kg.

Water	= 200 litre
Sand (Zone II)	= 460 Kg (S S D)
Coarse aggregate (10mm MSA)	= 1178 Kg (S S D)

A.4.2.2 Corresponding to this accelerated strength, determine the water cement ratio for the required target strength of the concrete mix from Fig. 2.

A.4.2.3 Work out the mix proportions according to A.3.4 (iii to ix) and further action may be taken as per A.3.4 (x) so as to make three trial mixes.

A.4.2.4 Determine the accelerated compressive strength of all the three trial mixes (boiling water method) and estimate their 28 days compressive strength with the help of correlations between accelerated and 28 days strength of concrete. From these results, the required water cement ratio and final mix proportion can be recommended for field trials.

TABLE -1
Approximate Air Content

Nominal maximum Size of coarse aggregate (mm)	Entrapped air (% of volume of concrete)
40	1.0
20	2.0
10	3.0

TABLE-2
Suggested Values of Standard Deviation

Grade of concrete	Standard deviation for different degree of control (N/mm^2)		
	Very good	Good	Fair
M10	2.0	2.3	3.3
M15	2.5	3.5	4.5
M20	3.6	4.6	5.6
M25	4.3	5.3	6.3
M30	5.0	6.0	7.0
M35	5.3	6.3	7.3
M40	5.6	6.6	7.6
M45	6.0	7.0	8.0
M50	6.4	7.4	8.4
M55	6.7	7.7	8.8
M60	6.8	7.8	8.8

Table-3
MINIMUM CEMENT CONTENT & MAX. WATER CEMENT RATIO REQUIRED IN CEMENT CONCRETE TO ENSURE DURABILITY UNDER SPECIFIED CONDITIONS OF EXPOSURES

(Extract of para 5.4.3 & 5.4.5 of IRS Concrete Bridge Code)

Exposure	R.C. Concrete		Prestressed Concrete	
	Minimum cement content	Maximum water cement ratio	Minimum cement content	Maximum water cement ratio
Mild	350	0.45	400	0.40
Moderate	400	0.40	400	0.40
Severe	400	0.40	430	0.40
Very Severe	430	0.38	440	0.35
Extreme	430	0.35	440	0.35

Table - 4
DEGREE OF QUALITY CONTROL EXPECTED UNDER DIFFERENT SITE CONDITIONS

Degree of Control	Conditions of Production
Very Good	Fresh cement from single source and regular tests, weigh batching of all materials, aggregates supplied in single sizes, control of aggregate grading and moisture content, control of water added, frequent supervision, regular workability and strength tests, and field laboratory facilities.
Good	Carefully stored cement and periodic tests, weigh batching of all materials, controlled water, graded aggregate supplied, occasional grading and moisture tests, periodic check of workability and strength, intermittent supervision, and experienced workers.
Fair	Proper storage of cement, volume batching of all aggregates, allowing for bulking of sand, , weigh-batching of cement, water content controlled and occasional supervision and tests.

Table - 5
APPROXIMATE SAND AND WATER CONTENTS PER CUBIC METER OF CONCRETE
(Applicable for concrete upto grade M 35)
Zone II Sand, W/C Ratio = 0.60, Workability = 0. 80 C.F

Maximum size of aggregate (mm)	Water content including surface water, per cubic meter of concrete (Kg)	Sand as percent of total aggregate by absolute volume
10	208	40
20	186	35
40	165	30

Table - 6
APPROXIMATE SAND AND WATER CONTENTS PER CUBIC METER OF CONCRETE
(Applicable for concrete above grade M 35)
Zone II Sand, W/C Ratio = 0.35, Workability = 0. 80 C.F

Maximum size of aggregate (mm)	Water content including surface water, per cubic meter of concrete (Kg)	Sand as percent of total aggregate by absolute volume
10	200	28
20	180	25

Table - 7
ADJUSTMENT OF VALUES IN WATER CONTENT AND SAND PERCENTAGE FOR OTHER CONDITIONS

Change in conditions stipulated for tables	Adjustment required in	
	Water content	% sand in total aggregate
For sand conforming to grading Zone I, Zone-III or Zone IV of Table-4, IS: 383-1970	0	+ 1.5 for Zone I - 1.5 for Zone III - 3.0 for Zone IV
Increase or decrease in the value of compacting factor by 0.1	$\pm$ 3%	0
Each 0.05 increase or decrease in water-	0	$\pm$ 1%

cement ratio		
For rounded aggregate	- 15 kg/m^3	- 7%

A.5. Typical Example :

I. Design Stipulatios

1.1 Characteristics strength of concrete specified : 25 N/mm^2

1.2 Maximum size of aggregate to be used: 20 mm

1.3 Desired workability of concrete : 25- 50mm slump (0.88 - 0.92 C F).

1.4 Exposure condition specified : Mild

1.5 Degree of quality control expected to be exercised at site : Good.

II. Test Data on Materials

2.1 Specific gravity of cement (OPC) = 3.15

2.2 Specific gravity of coarse aggregate = 2.60

2.3 Specific gravity of fine aggregate = 2.59

2.4 Water absorption of Coarse aggregate = 0.5%

2.5 Water absorption of fine aggregate = 1.0%

2.6 Free (Surface) moisture for coarse and fine aggregates = Nil & 2% respectively.

2.7 Absorbed moisture for coarse and fine aggregates = Nil & 1 % respectively.

2.8 Grading of Fine Aggregate

Sieve Size	**Percentage passing**
4.75 mm	100
2.36mm	97.5
1.18mm	86.3
000 microns	52.2

150 microns 10.6

The fine aggregate conformed to grading zone II as per Table 4 IS : 383-1970

2.9 Grading of Coarse Aggregate

Sieve Size (mm)	Coarse Aggregate Fractions I (percentage passing)	II (percentage passing)
20.00	96.6	100.0
10.00	6.7	82.7
4.75	0.8	32.6
2.36	-	9.4

2.91 Combined Grading of Coarse Aggregate Fractions

Sieve	Coarse Aggregate Fractions		Combined Grading	Desired Grading as per
Size	I	II	(70% of Fraction I+30% of fraction II)	Table 2 of IS:383-1970
20	96.6	100	97.6	95-100
10	6.7	82.7	29.5	25-55
4.75	0.8	32.6	10.3	0-10
2.36	-	9.4	2.9	-

The coarse fraction aggregate fraction I and II to be used for concrete mix are 70% & 30% respectively, which satisfy the grading requirement as per IS:383.

III. Reference Mix

10mm MSA, C F = 0.80, W/C Ratio = 0.35

Zone II clean sand

Accelerated strength of reference mix = 28.9 N/mm^2

IV. Mix Design

4.1 Standard deviation (from Table 2) = 5.3N/mm^2
(for Good control)

4.2 Target average 28-day compressive strength of concrete
= 25 + 1.65 X 5.3 = 33.745 N/mm^2

Note: In case of concrete containing retarder, strength of concrete may get reduced to 90%. Thus, target characteristic strength is required to be enhanced to this extent. In such case, targeted strength shall be 36.522 (25 ÷ 0.9 + 1.65 x 5.3) N/mm^2.

4.3 Water - cement ratio (from Fig. 2) = 0.52 (using data from 3.0 and 4.2)

4.4 Maximum water - cement ratio specified for durability condition = 0.45 (from Table-3)

4.5 Water cement ratio to be adopted for concrete = 0.45 (Lower of 4.3 and 4.4)

4.6 Water content from Table -5 = 186 (for a workability of 0.80 C F)

4.7 Sand as percentage of total aggregate by absolute volume from Table- 5 = 35% for W/C ratio of 0.60

4.8 Adjustment of water content (using table-7)
(For C F of 0.90) = 186 + .03 x 186 = 191.6 kg/m^3.

4.9 Adjustment for sand content (using Table -7)
35% - 3.0% = 32% (for W/C of 0.45)

4.10 Modified water content = 191.6 litre

4.11 Modified sand content = 32%

4.12 Cement content = $\frac{191.6}{0.45} = 425.8 \text{ kg / m}^3$

4.13 Minimum Cement content = 350 kg/m^3 (from Table-3 specified for durability condition)

4.14 Required Cement content = 425.8 kg/m^3 (Higher of 4.12 and 4.13)

4.15 Entrapped air, as percentage of volume of concrete = 2 %

4.16 Sand content

$$V = \left[W + \frac{C}{S_C} + \frac{1}{(p)} \frac{f_a}{S f_a} \right] \text{ x } \frac{1}{1000}$$

$$(1 - 0.02) = \left[191.6 + \frac{425.8}{3.15} + \frac{1}{0.32} \frac{f_a}{2.59} \right] \frac{1}{1000}$$

$\Rightarrow$ fa = 541.4 kg/m^3

4.17 Coarse Aggregate Content

$$V = \left[W + \frac{C}{S_C} + \frac{1}{(1-p)} \frac{C_a}{S\, C_a} \right] \text{ x } \frac{1}{1000}$$

$$(1-0.02) = \left[191.6 + \frac{425.8}{3.15} + \frac{1}{0.68} \frac{C_a}{2.60} \right] \times \frac{1}{1000}$$

$\Rightarrow$ Ca = 1154.9 kg/m^3

4.18 (10-20 mm) size coarse aggregate (70%) = 0.7 x 1154.9 = 808.43 kg.

4.19 Below 10mm size coarse aggregate (30%) = 0.3 x 1154.9= 346.47 kg.

4.20 Extra water required for absorption of coarse aggregate = (@ 0.5%) x 1154.9
= 5.77 litre

4.21 Extra water available as surface moisture in fine aggregate = (@ 2.0%) x 541.4
= 10.83 litre

4.22 Actual quantity of water to be added = 191.6 + 5.77- 10.83= 186.5 litre.

4.23 Actual quantity of sand. = 541.4 x 1.02 = 552.23

4.24 Actual quantity of coarse aggregate

10-20 mm :808.43 /1.005 = 804.4 kg
below 10 mm : 346.47 /1.005 = 344.8 kg

4.25: Quantities of Ingredient for trial mix shall be as under

Quantites	Cement (kg)	Water (litre)	Sand (kg)	Coarse Aggregate (10-20mm) (kg)	Coarse Aggregate below 10mm (kg)
per cum	425.8	186.5	552.23	804.4	344.8
per 0.05 m^3	21.29	9.325	27.61	40.22	17.24

GUIDELINES ON USE OF READY MIXED CONCRETE

Annexure-II

Proforma for Delivery of Ready Mixed Concrete

(To be filled up by Railway Supervisor)

Name of work _____ Date_____

(A) RMC Plant Location & Company Name _____

(B) Design Mix Strength _____

(C) Ingredients used in the batch of _____ cum.

(i) Cement _____ kg

(ii) Coarse aggregate -I (20mm) _____ kg

(iii) Coarse aggregate -II (10mm) _____ kg

(iv) Fine Aggregate _____ kg

(v) Water _____litre

(vi) Admixture _____ ml

(D) Time of Concrete Mixing _____hrs.

(E) Concrete to Reach at site before _____hrs.

(F) Concrete to be used before _____ hrs.

(G) i) Admixture, if any, to be added at site _____ ml
ii) Duration and RPM for Mixing of admixture at Site. _____ min./nos.

Signature of
Representative of Contractor/ RMC Manufacturer

Signature of
Rly. Official