Public Works Department

Water Resources Organisation

IAMWARM PROJECTS

QUALITY CONTROL WORKSHOP
COURSE MATERIALS

Central Quality Control Laboratory,
Tharamani, Chennai – 113.

CHIEF ENGINEER, WRO, PWD
DESIGN, RESEARCH & CONSTRUCTION SUPPORT
CHENNAI – 600 005.

INDEX

DUTIES OF FIELD AND QUALITY CONTROL STAFF IN RELATION TO QUALITY OF WORKS

JUNIOR ENGINEER/ASSISTANT ENGINEER CONSTRUCTION	JUNIOR ENGINEER / ASSISTANT ENGINEER QUALITY CONTROL
1. Shall see that the mark out of the area to be tackled is properly given, shuttering, centering, reinforcement are done as per drawing and technical specifications, to record the Pre levels/ foundation levels, and to see that mark-out for canal excavation is perfectly given as per drawings. Prelevels, classification levels and final levels of canal shall be taken as per specification.	1. Shall check the mark out of foundation and centering/shuttering reinforcement arrangement and inform the Assistant Engineer construction to rectify the defects if any.
2. Shall see that the construction equipments like mixers, vibrators, compaction equipment, pumping arrangements for curing/watering are arranged before starting of any work.	2. Shall check the adequacy of the construction equipment and curing/ watering arrangements before start of work and during execution.
3. Shall see that sufficient quantities of input materials as per agreement specifications are made available at site of work and to arrange testing equipment, men and material required for conducting field tests, sending samples of input materials for testing to central lab, regional laboratories as per norms.	3. Shall conduct / get conducted by different laboratories, the field tests on input materials and record the results and to inform the Assistant Engineer construction to rectify the defects if any.
4. Shall write O.K. Cards after area is ready to start the work and to inform the Assistant Engineer Quality Control and Executive Engineer construction and take permission to start the work .Shall also permit OK in case quality control A.E. is not available.	4. Shall check and write the O.K. card and record the deviations, defects if any or otherwise to record the final OK and to inform Executive Engineer quality control and to permit to start the work.
5. Shall supervise and ensure that correct quantities of input materials as per mix design communicated by the central laboratory are fed into the mixers/batching plants etc., and shall ensure specified mixing time. (minimum 2 ½ minutes)	5. Shall make regular checks of the feeding of input materials, mixing time and suggest the quantity of water depending on the moisture content of sand as and when required.

6. Shall ensure proper vibration, rolling etc., during course of day to day work. Shall conduct D.B.D test of earth work, gradation of material, slump test, core drill test and to extract field samples of material and finished products to be sent to different laboratories. Also provide men and material required for extracting samples of finished product for quality control staff.	6. Shall ensure slump test, core tests, proctor density etc., conducted as per norms by the construction and quality control staff and to extract field samples of finished product to be sent to central/Regional laboratory later.
7. Shall ensure proper curing of samples extracted till the curing time is over and to make arrangements to send the samples to central lab or other suitable lab.	7. Shall assist the Assistant Engineer in Proper handling/transport of samples to central / Regional lab.
8. Shall ensure timely green cutting of concrete with proper air - water gun; nicking & chipping (wherever so warranted) so as to prepare the surface for next concrete lift for effective bond at the lift/construction joints.	8. Shall check and see that the preparation of the surface is adequately done for starting the next lift.
9. Shall ensure proper curing/watering and allow removal of shuttering only after the time limit prescribed in the specifications and to see that the surface are finished to the plumb/ straight lines etc., after removal of shuttering.	9. Shall check the adequacy of curing/ watering and see that the final surfaces are finished neatly plumb/straight lines etc.
10. Shall maintain (1) mark-out register (2) OK Card files (3) Load Register.	10. Shall maintain registers of field tests conducted.

DUTIES OF EXECUTIVE ENGINEERS

EXECUTIVE ENGINEER CONSTRUCTION	EXECUTIVE ENGINEER QUALITY CONTROL
1. Shall supervise, check, advise, and instruct the J.E./A.E. Construction regarding discharge of their functions properly.	1. Shall supervise, check, advise and instruct the A.E.. Quality control regarding discharge of their functions properly.
2. Shall intimate the Executive Engineer quality control regarding signing of agreement for starting of any new work, duly endorsing a copy of work order. Shall supply copies of contract documents, drawings construction programme etc., to Executive Engineer Quality Control.	2. Shall maintain copies of approved Designs, reports, contract document, drawings, construction programme, extracts of inspection notes etc., and shall see that his subordinates go through the above documents.
3. Shall get all ingredients of concrete, masonry got tested before use. Shall see that the soils are tested for various properties like OMC, MDD, etc., before starting of Embankment work.	3. Shall remind and verify whether test results are available or not before starting up of any new work and during execution of work.
4. Shall see that all the Machinery / Equipment being used by the contractor is got periodically calibrated.	4. Shall assist in upkeep and calibration of equipments.
5. Shall see that OK Cards are written and kept at site of work before starting of any work. Also will ensure rectification of work before releasing payments.	5. Shall inspect and sign on O.K. Cards during field visits. Defects of construction will be pointed out and remedies suggested for achieving good quality construction.
6. Shall order the suspension of work if any defects are noticed or reported by quality control staff and resume the work only after rectification of defects in the presence of quality control staff of needed.	6. Shall order the stopping of work if major defects are noticed or reported by quality control staff and intimate his counter part to see that defects are rectified. Also defects noted during construction are to be reported to the E.E. and S.E./Quality Control & construction.

7. Foundations and reinforcement, shuttering, centering where heavy reinforcement is involved is to be checked by Executive Engineer invariably before starting the work.	7. Foundations and reinforcement, shuttering, centering where heavy reinforcement is involved is to be tallied by Executive Engineer invariably before starting the work, during his field visits.
8. Shall personally see that the samples to the laboratories are sent regularly, obtain the results and communicate the same to Executive Engineer quality control	8. Shall pursue and keep track of sending of samples to various laboratories and to keep record of results received.
9. Shall take the help of quality control Ex. Engineer whenever a dispute is referred.	9. Shall co-ordinate with the EE/ Construction and render assistance in resolving the issues referred to him.

CO-ORDINATIONS

The construction staff and quality control staff must act in tandem to achieve good quality of the finished product and construction as per the contract specifications.

Construction staff should make it a point to inform the quality control staff, the date of starting of any activities or component of the work well in advance so as to enable the quality control staff to schedule their work plan and attend the particular work on the particular date.

In turn quality control staff should schedule their programme, so as to attend to the work on the dates required by the construction staff and ensure that, the progress of work is not hampered.

The defects, if any, noticed by the quality control staff during their course of inspection shall be brought to the notice of the construction staff then and there. It is the primary responsibility of the Quality Control & Inspection staff to draw the attention of the construction staff, whenever they notice defective work during their course of inspection. It is the duty of the construction staff to attend to the rectification and maintain proper specifications as pointed out by their counter part of the Quality Control organisation.

Quality Control staff will monitor that all tests required as per agreement and I.S. Codes are carried out in different laboratories by the field staff; they will also test check to the extent of minimum 10% (or as decided by Chief Engineer of the required and co-relate with the other tests conducted in different laboratories.

All observations regarding substandard or below specification work will be duly recorded in the inspection / visit books kept at site by inspecting officer. Such substandard or below specification works should be got stopped/ dismantled immediately by execution unit. The defects pointed out by Quality Control Unit will be communicated to the execution unit for compliance immediately. The compliance report should be sent by execution unit with in ten days.

The quality control staff can not supervise the placement of concrete on a mix to mix basis continuously. They can only conduct random check of input materials, mixing time, placement of concrete, vibration etc. It is the primary responsibility of the construction staff to ensure adequate supervision of mix to mix placement of concrete.

The Operations of the Quality Control Staff shall not interfere in any way, with the executive powers vested with the officers in charge of execution. They will also in no way diminish the responsibility of the officers in charge of execution. The field officers in charge of works are primarily responsible for the quality of all works and to carry out the work as per the technical specifications.

In case of difference of opinion between quality control staff and construction staff, it should be sorted out by way of discussions in cordial atmosphere and mutual trust as per the guide lines indicated below. In case it involves any design feature/problem/aspect, the design office should be duly consulted and the advice given from the designs office should be accepted.

In case of difference of opinion between Assistant Executive Engineer, Construction and Assistant Executive Engineer, Quality Control it would be referred to Executive Engineer, Construction, who would discuss the matter with Executive Engineer, Quality Control and settle the issue. Similarly, when the Executive Engineer, Quality Control is not readily available, the Executive Engineer Construction can over rule after recording the reasons in writing. In such cases the Executive Engineer, Construction has to discuss with Executive Engineer, Quality Control, at the earliest opportunity and modify his earlier orders, if necessary.

O.K. CARDS

GENERAL:-

Since O.K. Cards contain important entries/information on execution of works at all stages and are liable to be referred/perused at a later stage also, particularly during the Internal Quality Audit of works, the O.K. Cards shall be maintained in multi colours. The O.K. Cards, relating to any particular work, shall be put in a round shaped water tight tin box and placed right at the construction site. The exterior of the tin box shall be painted yellow. Senior officers shall also check the O.K. Cards during their field inspections to ensure that those are being maintained and properly/genuinely filled.

An O.K. Card is a condensed form of specifications and essential requirements for achieving specified workmanship and quality level of output. Each work is sub-divided into various construction activities in proper sequence / order of construction. Such activities are listed in chronological order on the O.K. Cards

For various stages of construction activities where laboratory tests or checks with reference to drawing and specification are required from quality control unit, O.K. Cards System shall be followed. The O.K. Cards should be made available on the site in regular manner. Approval of the component of work in progress at the time of inspection should be recorded by the inspecting officer.

The O.K. Card consists of two parts for each work. First part covers the initial preparedness for the work and indicates pre-requisites where as the second part covers the daily performance of activities based on pre-requisites and also gives permission to perform the job by the construction as well as Quality Control staff. Besides the location and type of work, the first column of O.K. Card is to be filled by the construction agency by preparing each feature and making it ready for inspection by the project construction engineer who Okays through his signatures and then puts up to the Q.C./Q.A. engineer for his final O.K. If Q.C./Q.A. engineer is not available at site then O.K. given by construction engineer will be treated as final, if any thing otherwise is not observed. Should anything otherwise be found, the O.K. card shall not be signed by him and ask the construction engineer/agency for necessary rectification.

Subsequently, O.K. card should refer to the defects removed, if pointed out previously in OK card and counter reference to the previous check and should be signed or Okayed.

It must be borne in mind that work can not be held up unduly for disposal of O'K Card. The Assistant Executive Engineer (Quality Control)/Construction will be the okaying authority for concentrated work like dam. spillway, head regulator etc. and Assistant Engineer/Junior engineer construction will be the okaying authority for scattered works like canals and small structures. Random checks by the Supervising officers should be recorded on O'K Cards at site. Weekly report of OK Cards maintained by construction unit should be submitted to E.E. of the area who has to monitor and ensure that adequate check is being maintained by field staff. Confirmation regarding rectification of defects be obtained from A.E.E./Q.C. before making payment once in three bills and final bill of the contractor.

After processing through various levels and entering observations and rectification O'K Card will be closed at the time of taking measurements for releasing payments to the contractor. Photocopy of the OK Cards will be kept at site and the original will be attached with the bill and will be kept on record by the division office while making payments to the contractor.

O.K Card

O.K. Card for raising/Strengthening of Earthen Embankments/Fill Placement & Compaction (Part-I)

IAMWARM PROJECT, GO TN

Name of Work

Agency Contract/Package No.

Location Date

Description of activities	Remarks and dated signature of the construction Agency	Remarks and Dated Sign. Of Construction Staff		Remarks & Dated Sign. Of QC/Inspection Engineer
		JE/ AE	AEE	
Layout/Demarcation/Fixing & checking T.B.M.				
Removal of Vegetation, debris & Site clearance				
Benching, stripping of base (± 20 cm)				
PRE-REQUISITES				
(1) Proctor's density of borrow area				
(2) Designation of borrow area & checking of required moisture				
(3) Excavation and shaping of rain cuts and its refilling				
(4) Weather key- trench made and/or plowing of old embankments done if required.				
(5) Watering of base				

OK FOR FILL PLACEMENT				
Thickness of loose layer (cm)				
Removal of oversize (more than 7.5 cm size) layer				
Moisture content (%) - initial				
Moisture content (%) final (OMC = %)				
Weather soil laid as per profile				
OK FOR COMMENCING COMPACTION				
Checking of Type of Compaction Equipment/Roller				
Checking of In place density (D.B.D.)				
Compaction Efficiency (%)				
Specified Compaction (%) of Proctor				
Re-Rolling/Re-compaction if required				
D.B.D. after Re-Rolling				
OK FOR NEXT LAYER				
Removal of extra /loose earth from – U/S & D/S faces				

O.K. Card

TNPWD IAMWARM

Supplementary O.K. Card for subsequent layers (Part II)

Name of Work

Agency Contract/Package No.

Location Date

Description of activities	Remarks and dated signature of the construction Agency	*Dated Signature of construction*		Remarks & Dated Sign. Of QC/Inspection Engineer
		JE/ AE	*AEE*	

O.K Card
TNPWD IAMWARM

O.K. Card for Sub grade preparation for placement of lining (Part-I)

Name of Work

Agency Contract/Package No.

Location Date

Description of activities	Remarks and dated signature of the construction Agency	Remarks & Dated Sign. of Construction		Remarks & Dated Sign. Of QC/ Inspection Engineer
		JE/ AE	AEE	
Chainage				
Removal of Vegetation, debris				
Completion of dewatering				
Filling of over excavation, depressions/ Pockets in soil/rocky strata as per specification				
Watering of sub-grade				
Compaction of sub-grade (bottom & sides) through slope compaction/Pneumatic rammer/ power roller to specific density (%)				

Final Lip cutting & checking sub-grade surface to ensure within permissible tolerances (up to 6.5 mm on sides, up to 12.5 mm on Bed)				
Laying of under-drainage arrangement (a) Porous Plugs (b) Longitudinal & Transverse Drains (c) Porous Panels				
Final wetting of sub-grade to 15 cm depth				
Checking of quantity and quality of material stacked at site Cement, Aggregate, Sand, Water				
Checking of mixer, vibrator & power				
Checking of form work/ Shuttering true to line and grade				
O.K. for lining placement				

O.K. Card
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O.K. Card for placement of cast-in-Situ Concrete lining (Part II)

Name of Work

Agency Contract/Package No.

Location Date

Description of activities	Remarks and dated signature of the construction Agency	Dated Signature of construction staff		Remarks & Dated Sign. Of QC/Inspection Engineer
		JE/AE	AEE	

O.K. Card

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O.K. Card for Random Rubble Stone Masonry

Name of Work _____

Agency _____ Contract/Package No._____

Location _____ Date _____

Description of Activities	Remarks and dated signature of the construction Agency	Remarks & Dated Signature of Construction Staff		Remarks & Dated Sign. Of QC/Inspection Engineer
		JE/AE	AEE	
Stone - Quality Size				
Suitability of a) Cement b) Sand c) Water				
Mortar i) Mix, measurement ii) Mixing, Consistency				
Pointing, thickness of joints, staggering of joints, laying of stones, hearting stones, bond stones spacing..				
Whether samples of mortar collected in cubes for testing				

Green cutting with proper air water gun/sand blasting				
Adequacy of curing for masonry work.				
Verticality of structure check by using plumb bob				
Embedded Materials.				
Final OK for masonry work				

O.K. Card

TNPWD IAMWARM

O.K. Card for Plain & Reinforced Cement Concrete

Name of Work _____

Agency _____ Contract/Package No. _____

Location _____ Date _____

Description of Activities	Remarks and dated signature of the construction Agency	Remarks & Dated Signature of Construction Staff			Remarks & Dated Sign. Of QC/Inspection Engineer
		JE/AE		AEE	
Material Suitability 1 Cement 2. Steel 3. Aggregate 40mm, 20 mm 4. Sand 5. Water 6. Admixture					
O.K. for materials					
Form Work & Centering i) Tightness, Stability, Smoothness. ii) Cleaning, oiling, perfectness of form work.					

iii) R.L. of Centering iv) Checking of reinforcement.					
O.K. for reinforcement					
<u>Tools & Plants</u> i) Mixers & Vibrator ii) Adequacy of concrete production/transportation , placement, consolidation.					
O.K. for Placement					
1. Design mix, measurement 2. Mixing/Consistency 3. Slump 4. Compaction of Concrete 5. Joints 6. Finishing 7. Casting of Cubes 8. Curing 9. Compressive strength at 28 days					
Final O.K.					

Note: Before pouring of concrete, the reinforcement should be got checked by the Q.C.Unit. Working standby vibrator & mixer should be kept at site before start of concreting.

O.K Card

TNPWD IAMWARM

O.K. Card for PCC Slab Canal Lining

Name of Work

Agency Contract/Package No.

Location Date

Description of activities	Remarks and dated signature of the construction Agency	Remarks and Date Sign. Of Construction Staff		Remarks & Dated Sign. Of QC/Inspection Engineer
		JE/ AE	AEE	
A. Materials Suitability: i) Cement ii) Aggregate 40 mm, 20 mm iii) Sand iv) Water v) Treatment of soil if any				
OK for Materials				
B. Formation of Canal Banks: i) Stripping/Removal of vegetation ii) Cutting canal bed & sides to the geometric section/shape iii) Consolidation iv) Trimming				

C. Casting of PCC Slabs: i) Mix, Measurement by weight ii) Mixing, consistency iii) Slump iv) Water Cement Ratio v) Casting of PCC Slabs vi) Casting of cubes of concrete mix vii) Providing sub base if necessary viii) Laying/Placing in position PCC Slabs ix) Construction joints x) Contraction Joints xi) Pointing with CM xii) Curing xiii) Pressure Relief Hole xiv) Flexural Strength of PCC Slabs				
Final OK				

LIST OF REGISTERS TO BE MAINTAINED AT SITE

1. Bulkage Register
2. Load Register
3. Cement Day Book
4. Register for Sieve Analysis (Fine Aggregate)
5. Register for Sieve Analysis (Coarse Aggregate)
6. Slump Register for Concrete
7. Register for strength of Cement mortar
8. Register for strength of Cement Concrete

FORMAT OF REGISTERS

1. BULKAGE REGISTERS

H_1 = Initial Height

H_2 = Final Height after flooding with water

P = Percentage of Bulkage = $\frac{H1 - H2}{H_2} \times 100$

(Left side of Book)

S.No	Date	Time	H_1	H_2	P	
					Actual	Allowed

(Right side of Book)

A.E.	A.E.E.	E.E	Q.C.	Remarks

2. LOAD REGISTER

S.No	Date	Time	Load No	Cement	Fine Aggregate	Course Aggregate	Water

3. CEMENT DAY BOOK

(Left Side of Book)

S.No	Opening Balance	Receipt	Total Receipt	Issues	Total Issues	Closing Balance
1	2	3	4	5	6	7

(Right Side of Book)

Theoretical Requirement	Actual Consumption	Remarks
8	9	10

4. SIEVE ANALYSIS for Fine Aggregates

S.No	I.S. Sieve No.	Weight Retained	Percentage weight retained	Cumulative % of wt retained	Percentage Finer [100-(5)]	Remarks
1	2	3	4	5	6	7
1	10.00					
2	4.75					
3	2.36					
4	1.18					
5	600 mic					
6	300 mic					
7	150 mic					
8	Pan					
			TOTAL			

FINE NESS MODULUS = (5)/100

5. SIEVE ANALYSIS for Coarse Aggregates

S.No	I.S. Sieve No.	Weight Retained	Percentage weight retained	Cumulative % of wt retained	Percentage Finer [100-(5)]	Remarks
1	2	3	4	5	6	7
1	40.00					
2	20.00					
3	10.00					
4	4.75					
5	Pan					
			TOTAL			

FINE NESS MODULUS = (5)/100

6. SLUMP, REGISTER FOR CONCRETE

(Left side of Book)

S.No	Date	Time	Initial height H_1 (300mm)	Height after Subside H_2	Slump $H_1 - H_2$
1	2	3	4	5	6

(Right side of Book)

A.E.	A.E.E.	E.E	Q.C.	Remarks
7	8	9	10	11

7. COMPRESSIVE STRENGTH OF CEMENT MORTAR

S.No	Date	Time	No. of Sample	Mix	3rd Day strength	7^{th} Day strength	Remarks
1	2	3	4	5	6	7	8

8. COMPRESSIVE STRENGTH OF CEMENT CONCRETE

(Left side of Book)

S.No	Date	Time	No. of Sample	Mix	7th Day strength	28th Day strength
1	2	3	4	5	6	7

(Right side of Book)

Cast in presence of				
A.E.	A.E.E.	E.E	Q.C.	Remarks .
8	9	10	11	12

FREQUENCY OF TESTING

Sl. No.	Test	Frequency of Test	Purpose	Test Designation
1.	Grain size analysis For classification and Atterberg limits	For every 3000 m^3	To know the classifications of soil actually put in the embankment	As per IS-2720-IV-1975
2.	Field Density and Moisture content	One test for every 1500 m3 of earth work and at least one test in each layer laid on embankment.	To determine the placement density and moisture content.	IS-2720-XXVIII-1974 IS-2720-XXIX-1966 IS-2720-XXXIII-1971
3.	In-situ permeability Test	One test every 3m of embankment height or for 20,000 m3	To determine permeability characteristics of the fill material	IS-2720-XVII-1966
4.	Triaxial Shear Test	One test in every 3m of embankment or for 20,000 m3	To know the shear characteristics of fill material (in-situ)	IS-2720-XII-1975
5.	Consolidation Test	1 set of 3 samples in every 6m height of embankment or for 30,000 m^3	To know the settlement rate and its magnitude	IS-2720-XV-1965
6.	Standard Proctor Test	For every 10,000 cum of compacted earth or where there is change in the borrow area or change of soil texture, limited to minimum three samples and maximum 10 samples.	To determine MDD and OMC of the soil and compare the results with Laboratory value	IS-2720-VII-1970
7.	Moisture content	One test in each sample	To know the moisture content of the sample	IS-2720-II-1975
8.	Shrinkage Factor	One test in 5 mtrs of embankment height.	To determine shrinkage limit	IS-2720-Part-VI-1972

FILTERS				
9.	Grain Size Analysis	One test for every 200m^3 of filter (sand) One test for every 200 m^3 of filter (Aggregate)	To find % of the D10, D15, D30, D50, D60 and D85 grain sizes of materials	IS-2385-Part –I
10.	Clay lumps and organic impurities	One test for every 200 m^3 (sand) One test for every 200 m^3 (Aggregate)	To find out clay lumps & Organic impurities level	IS-2386-Part II

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	**CEMENT** a) *Chemical* i) Alkalies ii) Minor, major oxides by Calorimetry iii) Chloride	For each consignment	a) 269-1989 b) 1489-1976 c)IS-4032-1985	OPC < 0.60% PPC < 0.70% PPC/OPC < 0.05%
	b) *Physical* i) Fineness ii) Soundness(Le Chatelier) iii) Consistency iv) Setting time (Initial & Final) v) Compressive Strength vi) Heat of Hydration vii)Drying shrinkage	For each consignment	a) 269-1989 b) 1489-1976 4031-1988	Not < 2250 cm^2/gm Not > 10 mm Penetration upto 5 to 7 mm from base IT-Not < 30 min FT-Not > 600 min 3 days - 160 kg/cm^2 7 days- 220 Kg/cm^2 28 days-330 $Kg./cm^2$ PPC 7 days - 65 Cal./gm OPC 28 days - 75 Cal/gm <0.15%

Sl. No.	Test	Frequency	Purpose	IS	Allowable Limits
1.	**FINE AGGREGATE** i) Screen Analysis (Fineness modulus)	One test for every 150 m^3 of sand used in concrete	To know grain size and the fineness modulus of sand	IS 2386 Part-I 1963	2.2 to 3.2
	ii) Unit Weight and Bulkage of sand	-As above- (also once in a shift or for every consignment)	To utilize data for mix design computation	IS 2386 Part III 1963	Allowable limit of Bulkage of sand is 20%
	iii) Organic impurities	-As above-	To assess the quality of sand	IS-2386 Part II 1963	As explained in Sec. 4.2.2
	iv) Soundness	One test for every 150 cum of sand used in concrete	To assess the quality of sand	IS 2386 Part II 1963	Loss Not > 10% after 5 cycles of immersion in $Na_2 So_4$
	v) Silt Content	One test for every 150 cum of sand used in concrete	To assess the silt content present in the sand	IS 2386 1963	Not greater than 3% for natural FA and Not grater than 5% for crushed FA.
	vi) Specific Gravity, moisture content and absorption	One test for every 150 cum of sand used in concrete	To utilise the data for mix design computations	IS 2386 part III 1963	
2.	**COARSE AGGREGATE**				
	i) Sieve Analysis	One test for every 150 m3 or less	To know gradation and percentage of various size	IS 2386 part I 1963	
	ii) Specific Gravity, Bulk Density, Moisture content, Absorption & Silt Continent	-do-	To utilize data for mix design computation	IS 2386 part III 1963	Not > 2.6 Not more than 5% by weight Not > 3%

	iii) Soundness test (Sodium Sulphate method)	-do-	To assess the quality of course aggregate	IS 2386 Part V 1963	Loss Not > 12% after 5 cycles of immersion in Na_2SO_4
	iv) Abrasion, Impact & Crushing Value	-do-	-do-	IS 2386 part IV 1963	Wearing Surfaces: Loss Not > 30% Non Wearing Surface Not > 45%
	v) Organic Impurities (Mica content)	-do-	-do-	IS 2386 part II 1963	Less than 1%
	vi) Alkali reactivity (Alkali-Aggregate reactivity)	Twice in one working season	To know the `innocuous' or `deleterious' nature of aggregate	IS 2386 part VII 1963	* Falling in left side of Sc/Re curve. `Innocuous' *Falling in right side of Sc/Re curve. `Deleterious'
	vii) Petrographic Examination	Twice in one working season	To know the deleterious constituents and silt in aggregate	IS 2386 part VIII 1963	Deleterious constituent plus silt shall not exceeds 5%

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	**GRAVEL** i) Size of Gravel ii) Liquid limit iii) Plasticity Index	For each stack	IRC 19-1977	Not larger than ¾" < 20% <6%
2.	**WATER** PH value Organic In-organic Sulphate Chloride Suspended Solids	Two samples for each source	3025 Part II Part XXIV Part XXXII Part XVII	6 to 8 Not greater than 200mg/lit Not greater than 3000mg/lit Not greater than 500mg/lit Plain Concrete : Not greater than 2000mg/lit RCC Work : Not greater than 1000 mg/lit Not greater than 2000mg/lit
3.	**RR STONE** i) Abrasion value ii) Crushing strength iii) Specific Gravity iv) Water Absorption v) Durability	For each quarry	1124-1974 1121-1974 1124-1974 1126-1974	Not to exceed 6% Granite -1000 Kg/cm2 Basalt-400 kg/cm^2 2.60 (min ?) Not to exceed 5%
4.	**REINFORCEMENT** Weight Diameter Ultimate Test Strength Yield Stress Elongation	For each consignment	1786-1985 432-1966	Dia ≤ 8mm ± 4% Dia ≤ 8mm ± 2.5% Dia ≤ 25mm ± 0.5% Refer the table below for allowable limits.

Allowable limits for Reinforcement Bars

Types of reinforcement	**Characteristic strength (yield stress of 0.2% proof stress) N/mm^2**	**Ultimate tensile stress, N/mm^2**	**Minimum elongation on gauge length of 5.65x Sq.rt Cross - sectional area (%)**
Mild steel of grades	255	412	20-23
I	236	373	20-23
II	231		
	211		
Medium tensile steel	353	538	17-20
	348		
	323		
Cold worked deformed bars	415	15% more than the actual 0.2% proof stress	14.5
	500	10% more than the actual 0.2% proof stress	12
Hot Rolled	412	15% higher than the yield stress	14.5
SAIL-MA of grades	300	440-560	20
300 HY	350	490-610	20
350 HY	410	540-660	19
410 HY			

Frequency of Testing Cement Mortar, Masonry and Concrete

Sl. No.	Test	Frequency	IS	Allowable Limits
1.	Cube Test for concrete	3 tests specimens per 50 m^3 of concrete subject to a minimum of three samples per day for each grade of concrete.	456-2000	
2.	Cube test for cement mortar in masonry	3 tests per each grade of mortar per day	2250-1981 Appendix A	
3.	Permeability test on cement mortar	Once in a week	3085-1965	Not greater than $2.5x10^{-8}$ mm per sec. for rich mortar & $4.8x10^{-8}$ for lean mortar.
4.	Permeability test on masonry (applicable for masonry dams)	At least two holes in every block for every lift, one in upstream and one in downstream in staggered fashion.	11216-1985	Not grater than 2.5 Lugeons in masonry in CM :1:3 and 5 Lugeons in masonry in CM 1:4 for dams.
5.	Slump test	One test in each shift on at frequent intervals to checked workability	IS 1199	As per Mix design.

The actual frequencies shall be determined by the Engineer-in-charge to suit the nature and variability of material placed and the rate of fill placement with the objective of ensuring best quality control and quality construction.

Some DOs and DO NOTs

EARTH WORK

(IS CODES : 2720, 4701, 8237, 9481, 4081, 1200 and 9451)

The procedures to be adopted while doing earth work excavation for various jobs and the precautions to be taken are prescribed in the IS specified above. The important Do's and Don'ts are given below for ready reference.

A) EXCAVATION OF CANALS

DO'S	DO NOTS
1.Fixup the centreline and set the curves correctly.	
2.Take working levels, real variation in ground levels and classification of soils.	
3. Get top soil vegetation etc., removed	
4. Form spoil bank as per drawing and away from the side drain with suitable gaps for drainage into the valley.	
5. Form Dowel Bank, as per drawing .	
6. Form Inspection path to a uniform longitudinal gradient and with gentle transverse slope towards drains.	
7. Compact over excavation/ breakage portion with suitable soils, gravel, spalls.	
8. Provide CNS treatment in expansive black cotton soils.	

DO'S	DO NOTS
B) FORMATION OF EMBANKMENTS	
1. Get the top spoil, vegetation and sand patches removed to complete depth.	1. Soil required for embankment to be obtained from borrow area should be got tested for proctor density & O.M.C. before start of work.
	2. Do not raise the bank in piecemeal.
2. Scarify the ground and wet properly.	3. Do not allow new layer without scarification and wetting of old layer.
3. Obtain Proctor density OMC for the useful soils and borrow soils.	4. Do not allow new layer unless the old layer compacted up to required density.
	5. Don't leave any loose layer un-rolled at the end of the day in rainy season.
4. Raise embankment to full width with uniform horizontal layer of 15 cm to 22.5 cm thickness.	6. Don't allow compacted layer to be more than 150mm.
5. Break clods, remove roots, big boulders and other materials etc. larger than 75mm from the soils used in embankment.	7. No new layer to be laid unless the over moistured layer is either completely removed or allowed to dry.
6. Supplement deficit moisture whenever required.	8. Don't dump soils in heaps
7. Compact with 8 to 10 tonnes power roller or Fuel - operated vibratory plate compactors.	9. Don't dump the soils in water and slush.
8. Conduct field compaction tests and determine compaction efficiency.	11. Do not forget to provide settlement allowance of 2 cm/mtr. Of Height of bank.
9. Check embankment profiles periodically.	

A) FOR FOUNDATION: (CONCRETE WORK)

DO'S	DO NOTS
1. Verify dimensions and foundation levels as per drawing.	1. Do not forget to compare bearing capacity of actual soils met with design strength.
2. Wet the foundation surface to a depth of 150 mm or to impermeable material.	2. Don't lay the foundation concrete without wetting the surface.
3. Compact with suitable bedding materials in case of over excavations and with M-5 grade concrete in case of rock.	3. Don't allow admixtures, which will harm the strength of concrete.
4. Ensure the rock surface free from oil, objectionable coating unsound fragments.	4. Do not lay the concrete under water and over slush.
5. Check-up correct batching of ingredients.	5. The minimum mixing time should not be less than 2 min.
6. Check the batch of cements and its make.	6. Do not forget to keep stand by vibrator and needles.
7. Check-up water cement ratio and slump test.	7. Do not place concrete in raw in sufficiently heavy to wash mortar from concrete.
8. Ensure uniform mixing in a mixer for at least 2 ½ minutes	8. Do not forget to cast the cubes
9. Ensure proper compaction with vibrators and keep stand-by vibrator and needles.	9. Do not allow segregation of concrete
10. Operate immersion type vibrators nearly in vertical position to vertical drain.	10. Do not use unsatisfactory mix.
11. Cure with water for 28 days.	

B) FOR SUPER STRUCTURE

DO'S	DO NOTS
1. Check the form work	1. Avoid abrupt surface irregularities.
2. Apply cement slurry after cleaning the surface at vertical joints.	2. Do not deviate from specified dimensions of cross section from -6mm to +12 mm.
3. Clean and cover with a layer of 10 to 15 mm thick mortar of the same proportion of concrete mix for horizontal joints.	3. Do not allow concreting until all form work installation of items to be embedded and preparation of surface involved are approved.
4. Place the concrete, preferable at temperature not exceeding about 90° F.	
5. The concrete shall be discharged with in half an hour after introduction of the mix water and cement.	

C. REINFORCED CEMENT CONCRETE SLABS

(I.S. CODES 2502, 1786)

DO'S	DO NOTS
1. Check the reinforcement as per drawing and I.S. Code with particular reference to concrete cover.	1. Do not pass without specified cover.
2. Provide asphaltic pad and water stopper as per drawing.	2. Do not allow less lengths in over laps.
3. Ensure lightning arrangement if the work is to be carried out during night.	
4. Ensure stand by vibrator & mixer in working condition at site before start of work.	
5. Fill up the cubes of concrete samples for testing.	

Canal Lining Preparation of Sub grade

DO'S	DO NOTS
1. Check the model section to the canal profile i.e., bottom or lining viz side slopes, bed width, top width, slant length, smoothness of slant length.	1. Do not allow concrete lining on loose sub-grade.
2. Check the canal profile with reference to model section. Profile be prepared at 15 M intend in case of tile lining.	2. Do not allow any root or stumps to be on sub-grade.
3. Remove roots and stumps completely from the sub-grade	3. Do not allow lining in expansive soils without treatment with C.N.S. soils.
4. Compact over-excavation in soils with earth gravel duly wetted.	4. Do not place the porous plug below the surface of the lining.
5. Compact over-excavation in rocky area or fill up with not concrete as per specification.	5. Do not allow lining without wetting the sub-grade suitably.
6. Provide treatment with C.N.S. soils in expansive soils.	6. Do not allow movement of labourers after preparation of subgrade.
7. Provide porous plugs of specified size in each panel with specified local filters of graded metal and sand.	
8. Check whether porous plugs are freely draining or not.	

DO'S	DO NOTS
1. Check the canal prism and verify the bed levels.	1. Do not allow concrete lining on loose sub-grade.
2. Check the gradation analysis of fine and coarse aggregate to the requirement of mix at batching plant.	2. Do not allow lining without wetting sub-grade
3. Allow the ingredients of fine and coarse aggregate as per required mix by weigh batching.	3. Do not allow C.C. lining manually without vibration.
4. Check the calibration of weighing machine at batching plant.	4. Do not allow segregation of concrete while laying through discharge conveyor.
5. Check the water meter and its discharge.	5. Do not allow concrete directly on subgrade from transit mixer.
6. Check the batch of cement. its make and test results.	6. Do not form contraction joints over longitudinal drains.
7. Check the water cement ratio and record the slump.	7. Do not fill up contraction joints with sealing compound without cleaning with air water jet or sand blast.
8. Check whether any retarders and air entraining agents are added.	8. Do not allow any projections or contraction joint over the surface of the lining.
9. Maintain load register.	9. Do not allow the C.C lining without applying suitable primer to sides.
10. Record the No. CC cubes cast and its compressive strength.	10. Do not remove the channels immediately before setting of C.C.
11. Cure CC Lining with water for 28 days.	11. Do not use untested cement.
12. Ensure smooth surface with paver roller passes.	12. Do not allow to sink the porous plugs in the drains.
13. Form the contraction and construction joints as per approved drawing.	13. Do not allow lining without making proper arrangements for curing with water.

14. Check the thickness of C.C. lining for each panels.	14. The Co-efficient of variation in the compressive strength of cement should not be more than 8%.
15. Checking placing of mastic pad at structures of construction joints.	
16. Allow concrete lining at temperature between 15o C and 32o C.	
17. Check periodically the coefficient of variation in the compressive strength of cement.	
18. The batching plant to be used shall confirmed to the required of IS 4925-1968.	

MASONRY

I.S. CODES 1597, 1812, 1200 383, 269, 2116

DO'S	DO NOTS
1. The stone shall be of uniform colour, texture, strong, hard durable.	1. Do not use soft stones of crushing strength less than the specified strength.
2. Dress C.R.S. stone to a depth of 75 mm on all four sides.	2. Do not allow projections more than 40 mm on the face.
3. Wet the stones before placing in position clean and cover with fresh mortar.	3. Do not allow stones of length more than 3 times the height.
4. Place stones in layers to the line and plumb.	4. Do not allow stone of breadth less than height of ¾ of thickness of wall.
5. Provide weep holes at 2 mtrs interval staggered as per drawing.	5. Do not allow breaking of vertical joints less than 75 mm.
6. Chisel dress the corner stones.	6. Header shall not project not less than 10 cm beyond stretcher.
7. Face stones shall be laid alternately in headers and stretchers.	7. Do not place stones in position without cleaning and wetting.
8. Provide bond stones at 2 mtrs. Interval in each layer and mark.	8. Do not allow skin stones, weathered stones.
9. Place the heating stones on its broadest face.	9. Do not place stone in position without wetting.
10. Ensure perfect heating to make the masonry water tight.	10. Smaller stones shall not be placed in lower crores.
11. Mortar shall be used within 30 min. after discharge from mixer.	11. Joints thickness should not be more than 12 mm.

12. Sieve analysis for sand shall be done periodically.

13. For flush pointing the mortar shall be finished off flush and level with edges of the stones.

14. Joint shall be raked out to minimum depth of 12 mm when the mortar is Zgreen.

15. Cure the masonry with water for 14 days.

16. Cure the plastered surface with water for 14 days.

17. Cure the pointing surface with water for 7 days.

12. Do not allow mixing less than 3 minutes for thorough mix.

13. Do not add more water than required to have a consistency of 90 to 130 mm.

14. Avoid spreading of mortar over the surface of the masonry. Mortar should be spreaded over the stone just before laying the next layer.

15. No pointing to be commenced without washing and wetting the joints thoroughly.

Embankment failures in Irrigation Projects
Causes and testing required

S. No	Symptoms	Type of failure	Soil testing
1	2	3	5
1	i) Bank settlement - loss of longitudinal profile ii) Heaving of soil beyond toe iii) Leaning of telegraph posts, trees, etc. on the bank and at the toe	Base failure	i) Soil Classification tests ii)Consolidation tests iii) Natural moisture content and Natural dry density tests. iv) Peak and residual shear strength tests
2	i) Flattening of Bank/slope ii) Bulging of slope surface. iii) Longitudinal cracks on cess/slopes	Slope failure	i) Classification and swell tests ii) Peak and Residual Shear strength tests iii) Natural moisture content and Natural dry density tests.
3	i) Soil heaving on cess and on slopes ii) Excessive – cross level variations	Subgrade failure (by shear)	i) Soil Classification and swell tests ii) Shear strength tests iii) Natural Moisture content and Natural Dry Density tests
4	i) Impaired drainage ii) Excessive cross level variations in Monsoon	Subgrade failure (by mud pumping)	i) Soil Classification and swell tests ii) Shear tests iii) Natural Moisture Content and Natural Dry Density tests
5	i) Cut slope failures ii) Choked side drains iii) Seepage of water .iv) Saturated subgrade	Failure of Cuttings	i) Classification of soils ii) Recording of profile side slope, longitudinal drain sections, HFL and Ground water table iii) Natural Moisture Content and Natural Dry Density tests iv) Lab. Shear tests

FIELD TESTING OF MATERIALS – FOR QUICK APPRECIATION

FIELD TESTS TO VERIFY QUALITY OF CEMENT

1. Date of manufacture must be checked,because aging reduces the strength.
2. Open the bags -- No lumps should be present (Means no setting)
3. Thrust your hand into the cement - There should be cool feeling (means no heat of hydration and no setting)
4. Pinch of cement between fingers-It should give smooth feeling (means no setting).

Period of storage	%age of 28-days strength
Fresh	100%
3 months	80%
6months	70%
12months	60%
24 months	50%

5. Handful of cement thrown on water, should float initially before finally settling.
6. Take 100 gm of cement, make stiff paste, prepare cake with sharp edges, put on glass plate and Immerse in water.
    a. Shape shouldn't be disturbed
    b. It should set and attain strength.

Detection of Adulteration

1.Take a small sample of doubtful cement on a steel plate and heat it thoroughly for 20 minutes on a stove. Adulterated cement will change its colour on heating.

In genuine variety there will be no change in colour.

However this test cannot detect the addition of pozzolana in cement as it is also produced under high temperatures.(Max. pozzolana allowed : 35%)

2. To detect adulteration with coal ash take a small quantity of doubtful cement in test tube or a glass tumbler and add water till the container is half full. Shake the container thoroughly and allow it to settle for a few minutes. Cement particles will settle down and ash particles will either be found floating on the surface or held in suspension because of their lightness.

Note: If there is a chance to collect the sample of Flyash used in the cement the fineness and presence of objectionable ash can be checked in the field by mixing the flyash in a bucket half full of water and passing the resulting slurry through an IS sieve 150 microns.No residue shall be left behind on the sieve in the case of a good sample of flyash.

Setting and Hardening action

1. Prepare three small pats each 75mm x 75mm x 25mm in size from the sample given with 28 percent water by weight.

2. Prepare similar number of pats with good quality of cement.

3. Cover the pats with moist cloth for 24 hours

4 Make thumbnail impression or scratch. Good quality cement will resist this impression.

5. If cement doesn't resist this Impression then continue curing it up to 48 hours after which try to break it with pressure of thumb. Bad quality cement will easily break under the pressure.

6. If 48 hours-test show improvement in hardening but does not attain hardness comparable with genuine cement further trail should be made after 72 hours of curing. If the only defect in the cement under test is it's slow setting quality it will become as strong as genuine cement m this third test.

Ascertaining soundness of cement

1.Make a pat of cement 75 mm in diameter and 15 mm thick and cure it with moist cloth for 24 hours and then boil in water for a period of 6 hoursObserve the surface of the pat. If the cement is sound the surface will not develop a pattern of cracks as shown in the figure.

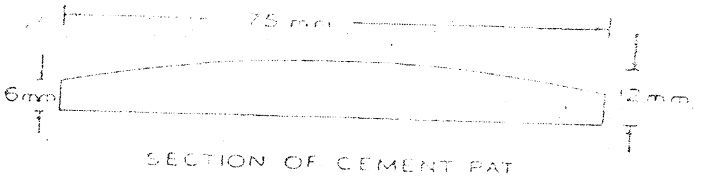
In sound cement cracks are thin and uniformly distributed all over the surface.

Precautions

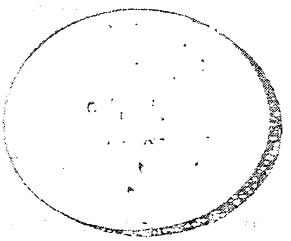
1. In a test for soundness of cement the cracking of unsound cement should not be confused with the contraction cracks.

2. Contraction cracks develop during boiling where the test pats might have been exposed to heat or drying winds.

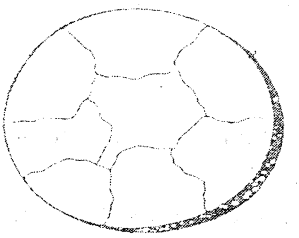
Contraction cracks are a few well-defined cracks running from edge to edge as shown in figure and those do not indicate any thing wrong with the sample.



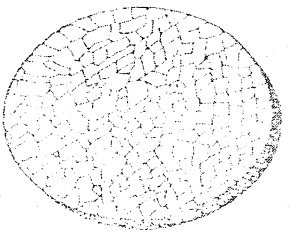
SECTION OF CEMENT PAT



NO CRACKS APPEARS ON SURFACE AFTER BOILING.



II SURFACE BETWEEN TH CRACKS DOES NOT SH CRAZING. (MINUTE CRA



III CRAZING ALL OVER THE SURFACE DUE TO EXPANSION OF UNSOUND CEMENT.

FIELD TESTS FOR SAND

Fine aggregate (Sand) is one which passes through 4.75 mm IS sieve

(5-10% oversize permitted by IS : 383-1970)

PROPERTIES OF GOOD SAND

1. It should be chemically inert.
2. It should be clean and coarse. It should be free from any organic or vegetable matter.
3. It should contain sharp, angular grains.
4. It should not contain salts, which attract moisture from the atmosphere.
5. It should be well graded i.e. should contain particles of various sizes in suitable proportions.
6. It should be free from silt and clay.

FIELD TESTS FOR SAND

1. Sand is actually tested and from its taste, presence of salts is known.
2. Sand is taken from a heap and it is rubbed against fingers. If fingers are stained, it indicates that sand contains silt OR clay
3. A guide to the amount of clay and silt in sand can be obtained from the field settling test. An excessive amount recorded in this test will indicate that other more sensitive tests should be made.

The test involves placing about 50 ml of a 1% solution of common salt in water in a 250 ml measuring cylinder. Sand as received, is then added gradually until the level of the top of the sand is at the 100 ml mark and more solution is added to bring the liquid level to the 150 ml mark. The cylinder is shaken vigorously and the contents allowed to settle for about three hours. The thickness of the silt layer is measured and expressed as a percentage of the height of the sand below the silt layer.

The amount of clay and silt in the sand may be considered acceptable if it does not exceed 10%.

If a measuring cylinder is not available, a jam jar filled to a depth of 50 mm with sand and to a depth of 75 mm with the solution, will give a comparable result if the contents are allowed to settle for three hours. The thickness of the silt layout in this case should not be more than 3 mm.

4.For detecting the presence of organic impurities in sand, solution of sodium hydroxide or **caustic soda** (3% Solution) is added to sand and it is stirred.

a. **A colourless** liquid shall indicate clean sand free from organic matter.

b. **A straw** coloured liquid indicates presence of some organic matter but not enough to be objectionable.

c. A **dark colour** means that the sand contains injurious amount and accordingly it is not to be used unless it is washed and re-test shown that it is satisfactory

IS sieve designation	**Percentage passing for**			
-------	**Grading zone I**	**Grading Zone II**	**Grading Zone III**	**Grading Zone IV**
10 mm	**100**	**100**	**100**	**100**
4.75 MM	**90-100**	**90-100**	**90-100**	**95-100**
2.36MM	**60-95**	**75-100**	**85-100**	**95-100**
1.18 MM	**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**

1 Sand falling in Grade I is coarse and that falling in Zone IV is fine.

2 Sand falling in Grade IV shall not be used in reinforced concrete.

3 Ideally, Sand conforming to Zone II or Zone III should be used for concrete wherever possible.

4 Zone I sand tends to give harsh concrete that is sensitive to moisture changes and is prone to segregation.

5 Zone IV sand tends to give concrete of too much cohesion and the resultant mix is sticky and difficult to compact.

IS sieve designation	Percentage passing by Weight	
	For Masonry Works (IS:2116-1980)	For Plastering Works (IS:1542-1977)
10 mm	-	100
4.75 MM	100	95-100
2.36MM	90-100	95-100
1.18 MM	70-100	90-100
600 micron	40-100	80-100
300 micron	5-70	20-65
150 micron	0 -15	0 - 50

COARSE AGGREGATES

Coarse Aggregate is one : Which is retained on 4.75 mm IS : sieve

(5-20% passing the sieve are permitted)

PROPERTIES OF GOOD COARSE AGGREGATE

1 Specific Gravity -It should have good crushing strength and Density.

2 Surface Texture –It should be angular and should have sharp edges.

3 Particle Shape – It should not be flaky.

4 Porosity - It should have very low water absorption.

5 Stability- It should be chemically inert.

6 Impurities-It should be free from mineral impurities like mica which decay and also clay and silt.

7 Compactness-It should be graded, as then only the voids can be less.

**Angular aggregates are superior to rounded aggregates from the following points of view:-

1.Angular aggregates exhibit a better interlocking effect in concrete, which property makes it superior in concrete.

2.The total surface area of rough textured angular aggregate is more than smooth rounded aggregate for the given volume. By having greater surface area, the angular aggregate may show higher bond strength than rounded aggregates.

Gradation requirement of Coarse Aggregates (20 mm)

IS sieve designation	Percentage passing by Weight
40 mm	**100**
20 mm	**95-100**
16 mm	-
12.5 m	-
10 mm	**25-55**
4.75mm	**0 -10**
2.36 mm	-

WATER

The water used in making and curing of concrete, mortar and grout shall be free from objectionable quantities of silt, organic matter injurious amounts of oils, acids, salts and other impurities etc. as per I.S. Specification No. 456 - 2000.

Potable water (water fit for drinking) is generally considered fit for mixing.

Permissible limits for solids when tested in accordance with I.S. 3025 - 1964 shall be as tabulated below.

PERMISSIBLE LIMITS FOR SOLIDS IN WATER

	Maximum permissible limit
1. Organic	200 mg/litre
2. Inorganic	3000 mg/litre
3. Sulphate (as SO4)	400 mg/litre
4. Chlorides (as Cl)	2000mg/litre for plain concrete work 500 mg/litre for RCC work.
5. Suspended matter	2000mg/litre

The PH value of water shall generally be not less than 6.

Water suitable for mixing is suitable for curing also. But it should not leave objectionable stain or unsightly deposits on the surface. The presence of tannic acid and iron compounds is objectionable.