GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

QUALITY CONTROL MANUAL

VOL-II

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GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

QUALITY CONTROL MANUAL VOLUME-II

ANNEXURE NO.1

STATEMENT SHOWING DETAILS OF FIELD/LABORATORY TESTS AND REFERENCE TO INDIAN STANDARDS

S.No.	Test	Reference to Indian Standards	Page No.
1	2	3	4
1.	**WATER**		
	1. pH value	IS 3025 (Part 11) 1983 Reaff. 2002	35
	2. Chlorides(as Cl)	IS 3025 (Part 32) 1988 Reaff. 2003	36-37
	3. Sulphites	IS 3025 (Part 28) 1986 Reaff. 2003	37-38
	4. Acidity	IS 3025 (Part 22) 1986 Reaff. 2003	38-40
	5. Alkalinity	IS 3025 (Part 23) 1986 Reaff. 2003	40-42
	6. Hardness	IS 3025 (Part 21) 2009	42
	7.Non Filterable Residue (TSS)	IS 3025 (Part 17) 1984 Reaff. 2012	43-44
	8. Volatile and fixed Residue(Total Filterable and Non- Filterable)	IS 3025 (Part 18) 1984 Reaff. 2012	44-46
	9. Turbidity	IS 3025 (Part10) 1984 Reaff. 2002	46-47
	10. Total Solids	IS 3025 (Part 15) 1984 Reaff. 2009	47-48
2.	**FINE AGGREGATE**		
	1. Deleterious material	IS 383: 1970	51-52
	2. Unit Weight or Bulk Density	IS 2386 (Part 3) 1963 Reaff. 2002	52-53

	3.Specific Gravity & water Absorption of Aggregate smaller than 10 mm including Fine Agge.	IS 2386 (Part 3) 1963 Reaff. 2011	53-54
	4. Surface Moisture	USBR Manual Designation 11	54-55
	5.Silt Percentage	USBR Manual Designation 15	55-56
	6. Sieve analysis	IS 2386 (Part 1) 1963 Reaff. 2002	56-57
	7.Necessary Adjustment for Bulking of Fine Aggregate (Field Method)	IS 2386 (Part 3) 1963 Reaff. 2011	57-58
	8. Mortar Making Properties of fine Aggregate	IS: 2386 (Part 6): 1963 Reaff. 2011	58-59
	9. Surface Moisture field Method	IS 2386 (Part 3) 1963 Reaff. 2011	59-63
	10. Soundness of fine Aggregate	IS: 2386 (Part 5) 1963 Reaff. 2011	63-65
	11. Bulkage of sand	IS: 2386 (Part 3)1963 Reaff. 2011	65-66
	12. Determination of clay, fine silt and fine dust(sedimentation)	IS 2386 (Part 2):1963 Reaff. 2011	66-69
3.	**COARSE AGGREGATE**		
	1. Deleterious material	IS 383: 1970	70
	2. Unit Weight	IS 2386 (Part 3): 1963 Reaff. 2002	70-71
	3. Water Absorptions and Specific Gravity	IS: 2386 (Part 3):1963 Reaff. 2011	71-72
	4. Surface Moisture	USBR Manual Designation 11	72-73
	5. Sieve analysis	IS 2386 (Part 1): 1963 Reaff. 2002	73-74
	6.Combined Flakiness and Elongation Index	IS 2386 (Part 1): 1960	74-77

	7. Abrasion Value	IS: 2386 (Part 4):1963 Reaff. 2011	77-79
	8. Impact Value	IS: 2386 (Part 4):1963 Reaff. 2011	79-80
	9. Crushing Value	IS: 2386 (Part 4):1963 Reaff. 2011	80-81
	10.Alkali Aggregate reactivity	IS 2836 (Part 7) 1963, Amd. No. 2 Reaff. 2002	81-83
	11. Petro-graphic examination	IS 2836 (Part 8)1963 Reaff.2002	83-84
	12. Soundness of Coarse Aggregate	IS: 2386 (Part 5): 1963 Reaff. 2011	84-87
4.	**CEMENT**		
	1. Fineness of Cement by dry Sieving	IS 4031 (Part 1) 1996 Reaff. 2005	88-89
	2. Specific Surface	IS: 4031 (Part 2):1999 Reaff. 2004	89-90
	3. Specific Gravity of cement	IS: 1727 1967 Reaff. 2004	90-91
	4. Consistency of Cement	IS: 4031 (Part 4):1988 Reaff. 2005	91-92
	5. Setting Time	IS: 4031 (Part 5):1988 Reaff 2005	92-93
	6. Soundness	IS: 4031 (Part 3):1988 Reaff.. 2005	94
	7. Compressive Strength	IS: 4031 (Part 7):1988 Reaff. 2005 IS: 4031 (Part 6):1988 Reaff. 2005	95-96
5.	**POZZOLANA (SURKHI)**		
	1. Specific surface	IS: 1727:1967 Reaff. 2004	98-101
	2. Fineness by sieveing	IS: 1727:1967 Reaff. 2004	101-102
	3. Lime reactivity (Soundness)	IS: 1727:1967 Reaff. 2004	102-105
	4. Compressive strength	IS: 1727:1967 Reaff. 2004	105-106

	5. Specific Gravity	IS: 1727:1967 Reaff. 2004	106
6.	**CONCRETE/ MORTER**		
	1. Slump	IS: 1199: 1959 Reaff. 2004	107-108
	2. Compressive strength of concrete	IS: 516:1959 Reaff. 2004	108-109
	3. Permeability	IS: 3085: 1965 Reaff. 2002	109-111
	4. Rapid Estimation of cement in mortar concrete	By D.D. Research, Patna (Bihar)	111-112
	5.Density and Air content of fresh concrete	IS: 1199: 1959 Reaff. 2004	113
	6. Non Destructive Test (a) Pulse Velocity Meter	IS:13311 (Part 1),1992	113-114
	(b) Rebound Hammer Test	IS:13311 (Part 2),1992	114
	6. Core specimen form hardened 7. concrete	T.C. 57 Vide Memo No. 3484002/ BODHI/ Speci/TC Date 23.10.2013	114-116
	8.Design of Concrete mix	IS: 456: 2000 Reaff. 2005, IS: 457 & IS: 10262	116
	9.Design of Mortar mix	IS: 456: 2000 Reaff. 2005, IS: 457 & IS: 10262	116
	10. Compressive Strength of Mortar and Cubes	IS: 516- 1959 and IS 1199, IS 2250 and TC No. 23/BODHI/ R &C/TC/11/88 Dt 31.08.1989	116-118
7.	**NATURAL BUILDING STONES**		
	1. Compressive strength	IS: 1121 (Part 1):1974 Reaff. 2008	119-120
	2. Weathering	IS: 1125:1974 Reaff. 2003	120-123

	3. Toughness	IS: 5218:1974 Reprint 1997	123-124
	4. True specific gravity, Apparent Specific Gravity, Water Absorption and Porosity of Natural Building Stone	IS: 1122:1974 Reaff. 2003	124-127
	5. Durability test	IS: 1126:1974 Reaff. 2008	128-129
8.	**BRICKS**		
	1.Water Absorption Test	IS:3495 Part 2 1976 Reaff. 2002	130-132
	2. Compressive Strength	IS:3495 Part 1 1976 Reaff. 2002	132-133
9	**LDPE FILM**		
	1.Determination of Density	IS : 2508 – 1984 Reaff. 2003	134-135
	2. Determination of Thickness	IS : 2508 – 1984 Reaff. 2003	135
	3. Determination of Yield Tolerance	IS : 2508 – 1984 Reaff. 2003	136
	4. Determination of Tensile Strength and Elongation at Break	IS : 2508 – 1984 Reaff. 2003	136-137
10	**TILES**		
	1.Flexural Strength of Manufactured Tiles	IS : 10646 :1991 Reaff. 2004	138
11.	**REINFORCED STEEL** (As prescribed by the Engineer in charge of the project).		
	1. Ultimate Tensile Strength	IS 1608:2005	139
	2.0.2% Proof Strength	ASTM E-8 M-09	139
	3. Elongation	IS : 3600 (P-3)1989,ASME 5 EC-IX	139

	4. Bend Test	IS :1599, IS 2329,2005 , IS 3600 (P5,6)1983	139
	5. Rebend Test	IS 1786 :2008	139
	6.Effective Cross-Sectional Area and mass of Deformed Bars and wires	IS 1786 :2008	140-141
12.	**(A) SOILS**		
	1. Grain size analysis	IS: 2720 (Part 4): 1985 Reaff. 2010	143-147
	2. Atterberg's limits(Liquid &Plastic)	IS: 2720 (Part 5): 1985 Reaff. 2010	148-151
	3. Shrinkage limits	IS: 2720 (Part 6): 1972 Reaff. 2011	152-155
	4. Standard compaction test	IS: 2720(Part 7): 1980 Reaff. 2002	156-159
	5. Shear strength		160
	(i) Triaxial shear test	IS: 2720 (Part 11):1971 Reaff.2011	161-162
	(ii) Consolidated undrained test	IS: 2720 (Part 12): 1981 Reaff. 2011	162-167
	6. Permeability tests	IS: 2720 (Part 17): 1986 Reaff. 2011	168-175
	7. Swelling pressure	IS: 2720 (Part 41): 1971 Reaff. 2011	176-178
	8. Total soluble solids	IS: 2720 (Part 21): 1977 Reaff. 2010	179-180
	9. Specific gravity	IS: 2720 (Part 3 sec.1): 1971 Reaff. 2011	181
	10. Free swell index of soils	IS:2720 (Part 40)-1977	182
	11.Water content of Soil	Ref: Soil Mechanics and Foundation by Dr B.C. Punmia ,1982	183

	12.Bearing Capacity of Soil	IS 1888-1992	183
Note:-	Test procedures shall confirm to Indian Standards.		

ANNEXURE NO. 2-A

STATEMENT SHOWING FREQUENCIES & ACCEPTABLE STANDARDS OF VARIOUS TESTS FOR EARTH-WORK

S.No.	Name of Test	Investigation	Design	Construction	Record Test	Acceptable standards
1	**2**	**3**	**4**	**5**	**6**	**7**
1.	Moisture Content	Not required	Not required	Before the commencement of day's work/shift, one sample shall be tested for each of the construction soils separately. Sample is to be collected from the spot where the material is proposed to be brought on embankment.	As directed by Engineer In-charge	Refer to page No.33
2.	Specific Gravity	For each 0.75 Mm^3 of soil explored 3 tests for every zone separately including filter 3 tests minimum for each quarry.	For each 0.15 Mm^3 of each soil type investigated, 5 tests for each of the zone including filter, 5 tests minimum for each quarry.	As per record tests*	Only tests mentioned at S.No. 1 to 7, 9 to 12 of this annexure to be conducted as Record Tests.	From 2.3 to 2.7

* In addition to field density tests "Record Tests" are also conducted for earthen dams. The purpose of this test is.
(i) To give a continuous picture of the materials placed in the dam and the compaction attained. This ensures a record of quality of work executed as compared with design assumptions. (ii) To check on the use of control curves when used. The record tests are carried out on representative samples both disturbed and undisturbed. The frequency of One test means as average of at least three complete tests. Separate tests are to be conducted for each zone.

S.No.	Name of Test	Investigation	Design	Construction	Record Test			Acceptable standards
1	2	3	4	5	6			7
3.	Grain Size Analysis	For every 1 Mm^3 or less soil explored, 6 tests for material to be used in each of the zone of the embankment separately. 12 tests for filter zones, 3 tests minimum for each quarry.	For every 0.15 Mm^3 or less of each soil type investigated for each zone 5 tests for each zone and 20 tests for filter. 5 tests minimum for each quarry.	Two samples for 150m x 150m borrow areas proposed to be utilized. For any change of material minimum 2 samples shall be tested.	The frequency for each of these tests is as below:			Particle size varies in Soil (from < 2µ to > 20 mm), that represent clay, silt, sand & gravel
					Total Earth Work	Frequency (for each work for each zone)		
				For casing material the test shall be conducted before and after compaction to study the breaking effects during compaction	Below 0.5 Mm^3 0.5 Mm^3 to1.5Mm^3 1.5 Mm^3 to 3Mm^3 above 3 Mm^3	1 per 10,000 m^3 1 per 15,000 m^3 1 per 20,000 m^3 1 per 40,000 m^3	About 25 percent tests shall be conducted for analy-sing fraction below75µ	Particle size varies in Soil (from < 2µ to > 20 mm), that represent clay, silt, sand & gravel
4.	Atterberg Limits	Same as above, no tests for filter material	Same as above, no tests for filter	As per record tests.	Separate tests are to be conducted for each zone. Samples to be			In percentage

S.No.	Name of Test	Investigation	Design	Construction	Record Test	Acceptable standards
1	2	3	4	5	6	7
			material		collected from different locations and elevations so as to be truly representative.	from 20 to 90
5.	Shrinkage Limit	Not Required	Not Required	As per record tests.	In addition to the above, a set of record tests is to be taken at instrument installation. One undisturbed sample shall be taken at each embankment piezometer tip immediately prior to the excavation of offset side trench.	In percentage <15 to > 60
6.	Compaction (Light proctor compaction)	For each 0.75 Mm^3 soil explored, 12 tests for each zone separately; minimum 3 tests for each quarry.	For each 0.15 Mm^3 of each soil type invted, 5 tests for each zone separately; minimum 5 tests for each quarry.	For Total progress up to 1,500 m^3 per day, one test/day shall be conducted i.e. one day on Hearting soil, next day on Casing soil, and third day on Random fill and so on. If there be any change in soil, additional one test/day shall be conducted. For total progress beyond 1,500m^3 per day, daily	In case of vertical settlement gauge installation, two samples shall be taken for each cross arm installation, one at the bottom of trench excavated for cross arm and the other in the tamped back fill of the trench after it has been brought upto the adjacent embankment level.	1.04 to 2.16 (in g/cm^3) (Light compaction)

S.No.	Name of Test	Investigation	Design	Construction	Record Test	Acceptable standards
1	**2**	**3**	**4**	**5**	**6**	**7**
				one test for each of the construction soils shall be conducted.		
7.	Triaxial Shear	For each 0.75 Mm^3 soil explored, 6 tests for each of the zones, separately, minimum 3 tests for each quarry.	For each 0.15 Mm^3 of each soil type investigated 5 tests for each of the zones; minimum 5 tests for each quarry.	As per record tests.	Tests mentioned at S.Nos. 1 to 7 of this annexure are to be conducted as Record Tests.	Refer to page no. 33
8.	Relative Density	Not required	If directed specifically.	One test per 1,500 Mm^3 of material	Not required	
9.	Consolidation	Not required	As directed by design office.	As per record tests	Tests mentioned at S.Nos. 1 to 7 of this annexure are to be conducted as Record Tests.	Value depends on soil charac-teristic
10.	Permeability	5 tests on each type of soil	2 tests for each zone separately including filter, minimum 5 tests for each quarry.	As per record tests	-do-	Refer to page no. 33

S.No.	Name of Test	Investigation	Design	Construction	Record Test	Acceptable standards
1	**2**	**3**	**4**	**5**	**6**	**7**
11.	Field Density for soil (sand replacement method)	Not required	Not required	Per day two tests per first 300 cum of Earth work and then one test per every additional 300cum. Separately; separate tests shall be conducted for each zone	As directed by Engineer In-charge	Refer to page no. 33 for density
12.	Field Density Test for soil (Core cutter Method)	Not required	Not required	Same as per test No. 11	As directed by Engineer In-charge	Refer to page no. 33 for density
13.	Placement moisture (penetrometer method)	Not required	Not required	One test per 20 sq.m. of the placed material before rolling. Minimum 3 tests shall be performed on the placement.	As directed by Engineer In-charge	Refer to page no. 33 for moisture content
14.	Needle Density (Penetrometer Method)	Not required	Not required	The penetration resistance shall be observed at 20m along length and breadth of area under compaction	As directed by Engineer In-charge	Refer to page no. 33 for density

S.No.	Name of Test	Investigation	Design	Construction	Record Test	Acceptable standards
1	**2**	**3**	**4**	**5**	**6**	**7**
				and also at places of doubtful compaction.		
	Water 1. Physical Test (a) Suspended Solid (b) Organic matter (c) Inorganic matter	Once for every source approval every quarterly	Not Required	Not required.	Not Required	2000mg /l Max 200 mg/l Max 3000mg /l Max

Note:- Tests should be conducted as per IS codes.

ANNEXURE NO. 2-B

STATEMENT SHOWING FREQUENCIES & ACCEPTABLE STANDARDS OF TESTS TO BE CONDUCTED FOR CONCRETE/MASONRY

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
1.	Tests for cement*:- (i)Adulteration of cement. (ii)Fineness (iii)Consistency & setting time (iv)Specific gravity (v)Soundness (vi)Compressive strength	One per every 50 tonnes of cement.	One per every 50 tonnes of cement.	One per very 50 tonnes of cement	Refer to page No 25-32
2.	Particle size analysis of aggregate.	(i) Once a week. (ii) Additional if source is changed.	(i) Once a fortnight. (ii) Additional if source is changed.	(i) Once a fortnight. (ii) Additional if source is changed	Refer to page no.23,25
3.	Flakiness Index and Elongation Index of coarse aggregate.	As per above	As per above	Nil	Combined Flakiness and elongation index so obtained shall not exceed 40 % for crushed and uncrushed aggregate
*Cement older than 3 months should not be used at any place without testing. Cement older than 6 months should not be used in any important structure.					

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
4.	Silt test on fine aggregate.	(i) Once a day. (ii) Additional if source is changed	(i) Once a day. (ii) Additional if source is changed.	(i) Once a day. (ii) Additional if source is changed.	Not more than 5 %
5.	Clay, fine silt and fine dust in aggregate (Sedimentation method).	(i) Once a week.	Once a fortnight	Once a fortnight	Refer page No. 23
6.	Surface moisture content in fine aggregate (Hot plate method).	Once per shift per stock pile	Once per shift per stock pile.	Once per shift per stock pile.	Depending upon type of fine Aggregate
7.	Surface moisture content in fine aggregate (Laboratory method).	Once a week	Once a fortnight	Once a fortnight	Depending upon type of fine Aggregate
8.	Bulking of fine aggregate	One per shift per stock pile.	One per shift per stock pile.	One per shift per stock pile..	Depending upon type of fine Aggregate

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
9.	Specific gravity and water absorption for aggregates (up to 10mm size).	Once a week.	Once a fortnight..	Once a fortnight.	Depending upon characteristic of Aggregate
10	Aggregate Crushing Value	Once for every source approval	Once for every source approval	Once for every source approval	Not more than 30% for wearing surface and not more than 45 % for non wearing surface
11	Aggregate impact Value	Once for every source approval	Once for every source approval	Once for every source approval	Not more than 30% for wearing surface and not more than 45 % for non wearing surface
12	Aggregate Abrasion value	Once for every source approval	Once for every source approval	Once for every source approval	Not more than 30% for wearing surface and not more than 50 % for non wearing surface
13	Soundness of Aggregate	Once for every source approval	Once for every source approval	Once for every source approval	Refer to page no. 24

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
14	Specific gravity and water absorption for aggregates (above 10mm size).	Once a week.	Once a fortnight.	Once a fortnight	Depending upon Characteristics of Aggregate
15.	Fineness of surkhi by dry sieving	Once a Day	Once a Day	(i) One per shift. (ii) Additional if source is changed	Refer page no. 102
16.	Compressive strength of cement surkhi mortar	(i) Up to 100 cum work per day one per shift per mixer. (ii) For every additional 200 cum work per day one per shift per mixer.	Once per shift pr mixer (separately for each mix proportion)	(i) Up to 100 cum work per day one per shift per mixer. (ii) For every additional 100 cum work per day. One per shift per mixer. (Separately for each mix proportion)	Refer page no. 106
17	Specific gravity and water absorption of stone.	Once a week.	Once a fortnight.	(i) One per fortnight. (ii) Additional if source is	Depending upon Characteristics of Stone

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
				changed.	
18.	Compressive strength of stone.	(i) Once per month. (ii) Additional if source is changed	(i) Once per month. (ii) Additional if source is changed	(j) Once per month. (ii) Additional if source is changed	Depending upon Characteristics of Stone
19.	Fluidity of mortar by flow table.	Three per mixer per shift.	Three per mixer per shift.	Three per mixer per shift.	Depending upon required workability
20.	Slump of cement concrete	One per every two hours working per mixer.	One per every two hours working per mixer.	Not Applicable	Depending upon required workability
21.	Density and air contents of fresh concrete.	(i)One per mixer per week. (ii) Additional if source of aggregate is changed.	(i) One per mixer per month. (ii) Additional if source of aggregate is changed.	Not Applicable	Depending upon grade and used size of Aggregate up to 3 %
22.	(a) Compressive strength of moulded cement concrete specimen.**	(i) Up to 100 cum work per day one per shift per mixer. (ii) For every additional 200 cum work per day one	Once per shift per mixer (separately for each mix proportion)	Not Applicable	Depending upon grade of cement concrete

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
		per shift per mixer.			
	(b) Compressive strength of mortar	Not Applicable	Not Applicable	(i) Up to 100 cum work per day one per shift per mixer. (ii) For every additional 100 cum work per day one per shift (separately for each mix proportion).	Depending upon ratio of cement and sand
23.	Compressive strength of drilled cores.	As directed by Design office.	As directed by Design office.	As directed by design office.	Depending upon grade of concrete
**where concrete is produced at continuous production unit, such as ready mix concrete plant frequency of sampling may be agreed under mutually by suppliers and purchasers.					
24.	Laboratory permeability:				
	(a) Moulded specimen.	One per month for every mix proportion.	_____	One per month for every mix proportion.	K= Permeability Coefficient K= 10^{-7} cm /sec for permeable K= 10^{-9} cm /sec for

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
					impermeable
	(b) Drilled core.	One per monolith per 3 m depth.	One per monolith per 3 m depth.	One per monolith per 3 m depth.	Depending upon grade of concrete
25.	Insitu permeability.	One hole at 20 m distance per working season for full depth duly staggered or minimum one hole per monolith.	One hole at 20m distance per working season for full depth duly staggered or minimum one hole per monolith.	One hole at 20m distance per working season for full depth (Separately for u/s and downstream faces duly staggered) OR Minimum two holes per monolith.	Depending upon grade of concrete
26	Water 1. Physical Test (a) Suspended matter (b) Organic matter (c) Inorganic matter	Once for every source approval Every year	Once for every source approval Every year	Once for every source approval Every year	2000 mg /l max. 200 mg/l max 3000mg /L max.
	2. Chemical Test (a') pH Value	Once for every source	Once for every source	Once for every source	Minimum 6

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
	(b) Chloride (as Cl) (c) Sulphates (as SO4) (d) Neutralization with NaOH(with phenolphtahliein as indicator) (e) Neutralization with H_2SO_4 with mixed indicator)	approval Every Quarterly Chemical Test daily at the site laboratory with testing kits	approval Every Quarterly Chemical Test daily at the site laboratory with testing kits	approval Every Quarterly Chemical Test daily at the site laboratory with testing kits	2000mg /L for concrete containing embedded steel & 500 mg /l for RCC and PSC 400mg/l Max 5 ml of 0.2 normal NaOH to neutralize 100 ml Sample of water Max. 25 ml of 0.02 normal H_2SO_4 to neutralize 100 ml sample of water
27	Steel and Iron Reinforcement bars (CTD ,TMT) 1.Chemical Test (a) carbon (b) Sulphur (c) Phosphorus (d) Sulphur+ phosphorus	Once for every source approval Once for every lot Once every 3 months	Once for every source approval Once for every lot Once every 3 months	Once for every source approval Once for every lot Once every 3 months	0.30 Max. 0.06 max. 0.06 max 0.11 max.

S.No.	Name of Test	Mass Concrete	Small concrete jobs & RCC Works	Rubble Masonry	Acceptable Limits
1	**2**	**3**	**4**	**5**	**6**
	2. Physical Test (a) Ultimate Tensile Strength (b) 0.02%proof stress (c) % Elongation (d) Bend Test (e) Rebend Test (f) Mass per meter run (Kg)	Once for every source approval Once for every lot Once for every 3 month	Once for every source approval Once for every lot Once for every 3 month	Not Applicable	10% more than the actual 0.2%proof stress but not less 485 MPa 415 MPa Min. 14.5 min. To be satisfactory To be satisfactory 6.31±3% for 32 mm dia, 4.830±3% for 28 mm dia,3% for 25 mm dia, 2.470±3% for 20 mm dia, 1.580±5% for 16 mm dia, 0.888±5% for 12 mm dia.

Note: - Test should be conducted as per prescribed IS codes.

ACCEPTABLE STANDARDS

Limits of Deleterious materials (IS: 383-1970): The maximum quantity of deleterious material in the aggregates (both coarse and fine) shall not exceed the limits as specified in the given table 1 below the tested in accordance with IS: 2386-1963, however, the engineer in charge may at his discretion, relax some of the limits as a results of further tests and evidence of satisfactory performance of the aggregates.

Table: 1 Limits of Deleterious Materials (clause 4.2.1 of IS:383-1970)

S.no.	Deleterious substances	Method of test	Fine aggregate % by mass: maximum		Coarse aggregate % by mass: maximum	
			Uncrushed	Crushed/ Blended	Uncrushed	Crushed
1	2	3	4	5	6	7
(i)	Coal and lignite	IS:2386 (part II)	1.00	1.00	1.00	1.00
(ii)	Clay lumps	IS:2386 (part II)	1.00	1.00	1.00	1.00
(iii)	Material finer than75 µm IS Sieve	IS:2386 (part I)	3.00	10.00(see note 1)	3.00	3.00
(iv)	Soft fragments	IS:2386 (part II)	-	-	3.00	-
(v)	Shale	(see note2)	1.00	-	-	-
(vi)	Total of % of all deleterious materials (except mica) including s. no. (i) to (v) for col.4,6, and 7 and s.no. (i) and (ii) for col.5 only		5.00	2.00	5.00	5.00

NOTES:

(i) Crushed sand with material finer than 75 µm IS sieving up to 15 % can be used for making blended sand. The uncrushed sand used for blending shall not have material finer than 75 µm more than 3 %. However, blended sand shall comply with the requirement of 10 % . Maximum for the requirement of material finer than 75 µm IS Sieve.

(ii)When the clay stone are harder, ptaty and fissile, they are known as shale's. The presence and extent of shale's shall be determined by petrography.

(iii) The Presence of mica in the fine aggregate has been found to affect adversely the workability, strength, abrasion resistance and durability of concrete. Where no tests for strength and durability are conducted, the mica in the finer aggregate may be limited to 1.00 % by mass. Where tests are conducted to ensure adequate workability, satisfactory strength, permeability and abrasion (for wearing surface), the mica up to 3.00 % by mass for muscovite types shall be permitted. In case of presence of both muscovite and biotite mica, the permissible limit shall be 5.00 % , max by mass.

This is subject to total deleterious materials (including mica) being limited to 8.00 %by mass for column no. 4 and 5.00% for column no.5.

(iv) 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. A fine aggregate which fails in the testing of organic impurities may be used, provide 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 clause 7 of IS :2386(Part VI)-1963 is not less than 95 %.

Aggregate Crushing Values (IS: 383-1970) : The aggregates crushing value, when determined in accordance with IS: 2386 (PartIV)-1963 shall not exceed 45 percent for aggregates used for concrete other than for wearing surfaces, and 30 percent for concrete for wearing surfaces, such as runways , roads and pavements.

Aggregate Impact Values (IS: 383-1970): The aggregates Impact value may be determined in accordance with the method specified in IS: 2386 (Part IV)-1963. The aggregate impact value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces, and 30 percent for concrete for wearing surfaces, such as runways , roads and pavements.

Aggregate Abrasion values (IS: 383-1970): Unless otherwise agreed to between the purchaser and the supplier , the abrasion value of aggregates , when tested in accordance with the method specified in IS :2386 (Part IV)-1963 using Los Angeles machine, shall not exceed the following values:-

(a) For aggregates to be used in concrete for wearing surfaces 30 percent
(b) For aggregates to be used in other concrete 50 percent

Soundness of Aggregates (IS: 383-1970): For concrete liable to be exposed the action of Frost , coarser and fine aggregates shall pass a sodium or magnesium sulphate accelerated soundness test specified in IS:2386 (part V) -1963 , the limits being set by agreement between the purchaser and the supplier, except that aggregates failing in the accelerated soundness test may be used if they pass a specified freezing and thawing test satisfactory to the user.

Note- As a general guide , it may be taken that the average loss of weight after 5 cycles shall not exceed the following:

(a) For fine aggregate: 10 percent when tested with sodium sulphate (Na_2SO_4), and 15 percent when tested with magnesium sulphate ($MgSO_4$)
(b) For coarse aggregate: 12 percent when tested with sodium sulphate (Na_2SO_4), and 18 percent when tested with magnesium sulphate ($MgSO_4$)

Silt Percentage of Fine Aggregate:
Reference: USBR Concrete manual Designation 15 Page No. 539)
Specifications: - Not more than 5 %

Fine Aggregate (IS: 383-1970) : The grading of fine aggregates, when determined as described in

IS :2386 (PartI)-1963 shall be within the limits given in Table 2 and shall be described as fine aggregates , Grading Zones I, II, III and IV. Where the grading falls out side the limits of any particulars grading zones of sieves other than 600 –micron IS sieve by a total amount not exceeding 5 percent , it shall be regarded as falling with in that grading zone. This tolerance shall not be applied to percentage passing the 600- micron IS sieve or to percentage any other sieve s
ize on the coarse limits of Grading Zone I or the finer limit of Grading Zone IV.

Table 2: Fine Aggregates (as pe Table 4 Fine Aggregate (clause 4.3) of IS 383:1970

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
2.36 mm	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

Note 1:-for crushed stone sands , the permissible limit on 150 –micron IS sieve is increased to 20 percent .This does not affect the 5 percent allowances permitted in 4.3 applying to other sieve sizes.

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

Note 3:- Where concrete of high strength and good durability is required, fine aggregate conforming to any one of the four grading zones may be used , but the concrete mix should be properly designed .As the fine aggregate grading becomes progressively finer , that is , from Grading Zones I to IV , the ratio of finer aggregate to coarse aggregate should be progressively reduced . the most suitable fine to coarse ratio to be used for any particular mix will, however , depend upon the actual grading, particle, shape and surface texture of both fine and coarse aggregates

.

Note 4:- It is recommended that fine aggregates conforming to Grading Zone IV should be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Ordinary Portland Cement 33 Grade –Specification (IS 269:2013)

Table 3: Chemical Requirements for OPC, 33 Grade

Sl.No.	Characteristics	Requirements
1	Ratio of Percentage of lime to percentage of silica, alumina and iron oxide , when calculated by the formula $\frac{CaO - 0.7\ SO_3}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3}$	0.66-1.02
2	Ratio of percentage of alumina to that of iron oxide, *Min*	0.66
3	Insoluble Residue percent by mass, *Max*	5.0
4	Magnesia Percent by mass, *Max*	6.0
5	Total Sulphur content calculated as Sulphuric Anhydride (SO_3) percent by mass, *Max*	3.5
6	Loss on Ignition, Percent by mass, *Max*	5.0
7	Chloride Content , Percent by mass, *Max*	0.1
8	Alkali Content	0.05 (For Pre-stressed Structure, see note)

Note: Alkali aggregate reactions have been noticed in aggregates in some parts of the country. On large and important jobs where the concrete is likely to be expressed to humid atmosphere or wetting action .It is advisable that the aggregate be tested for alkali aggregate reaction. In case of reactive aggregates, the use of cement with alkali content below 0.6 percent expressed as sodium oxide(Na_2O), is recommended where , however ,such cements are not available ,use of alternative means may be resorted to for which a reference may be made to 8.2.5.4 of IS 456. If so desired by the purchaser, the manufacturer shall carry out test for alkali content.

Table4: Physical Requirements for OPC, 33 Grade

Sl.No.	Characteristic	Requirements		Method of Test , Ref to
1	Fineness, m^2/Kg, *Min*	225		IS4031 (Part 2)
2	Soundness: (a) By Le Chatelier method, mm, *Max* (b) By autoclave test method, Percent, *Max*	10 0.8	See Note 1	IS 4031 (Part 3)
3	Setting Time : (a) Initial ,min, *Min* (b) Final ,min, *Max*	30 600	See Note 2	IS 4031 (Part 5)
4	Compressive Strength, MPa (See note 4): (a) 72 ± 1hour, Min (b) 168 ± 2 hour, Min (c) 672 ± 4hour, Min Max	 16 22 33 48		IS 4031 (Part 6)
5	Transverse strength (optional)	See Note 3 & 4		IS 4031 (Part 8)

Notes 1: In the event of cements failing to comply with any one or both the requirements of soundness specified in this table. Further tests in respect of each failure shall be made as described in IS 4031 (Part 3), from another portion of the same sample after aeration. The aeration shall be done by spreading out the sample to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total

period of 7 days. The expansion of cements so aerated shall be not more than 5 mm and 0.6 percent when tested by Le chatelier method and autoclave test respectively.

Note 2 : If cement exhibits false set, the ratio of final penetration measured after 5 min of completion of mixing period to the initial penetration measured exactly after 20 S of completion of mixing period, expressed as percent , shall be not less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS 4031 (Part 5) after breaking the false set , shall conform to the value given in this table

Note 3: By agreement between the purchaser and the manufacturer , transverse strength test of plastic mortar in accordance with the method described in IS 4031 (part 8) may be specified .The permissible values of the transverse strength shall be mutually agreed to between the purchaser and the supplier at the time of placing the order.

Note 4: Notwithstanding the compressive and transverse strength requirements specified as per this table, the cement shall show a progressive increase in strength from the strength at 72 hour.

Ordinary Portland Cement 43 Grade –Specification (IS 8112:2013)

Table 5: Chemical Requirements for OPC, 43 Grade

Sl.No.	Characteristics	Requirements
1	Ratio of Percentage of lime to percentage of silica, alumina and iron oxide , when calculated by the formula $\frac{CaO - 0.7\ SO_3}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3}$	0.66-1.02
2	Ratio of percentage of alumina to that of iron oxide, *Min*	0.66
3	Insoluble Residue percent by mass, *Max*	4.0
4	Magnesia Percent by mass, *Max*	6.0
5	Total Sulphur content calculated as Sulphuric Anhydride (SO_3) percent by mass, *Max*	3.5
6	Loss on Ignition, Percent by mass, *Max*	5.0
7	Chloride Content , Percent by mass, *Max*	0.1
8	Alkali Content	0.05 (For Pre-stressed Structure, see note)

Note: Alkali aggregate reactions have been noticed in aggregates in some parts of the country. On large and important jobs where the concrete is likely to be expressed to humid atmosphere or wetting action .It is advisable that the aggregate be tested for alkali aggregate reaction. In case of reactive aggregates, the use of cement with alkali content below 0.6 percent expressed as sodium oxide(Na_2O), is recommended where , however ,such cements are not available ,use of alternative means may be resorted to for which a reference may be made to 8.2.5.4 of IS 456. If so desired by the purchaser, the manufacturer shall carry out test for alkali content.

Table 6: Physical Requirements for OPC, 43 Grade

Sl.No.	Characteristic	Requirements		Method of Test , Ref to
1	Fineness, m^2/Kg, *Min*	225 370 for 43 –S grade		IS4031 (Part 2)
2	Soundness: (a) By Le Chatelier method, mm, *Max* (b) By autoclave test method, Percent, *Max*	 10 0.8	 See Note 1	IS 4031 (Part 3)

3	Setting Time : (a) Initial ,min, *Min* (b) Final ,min, *Max*	 30 60 for 43 – S grade 600	 See Note 2	IS 4031 (Part 5)
4	Compressive Strength, MPa (See note 4): (a) 72 ± 1hour, Min (b) 168 ± 2 hour, Min (c) 672 ± 4hour, Min Max	 23 33 37.5 for 43-S grade 43 58		IS 4031 (Part 6)
5	Transverse strength (optional)	See Note 3 & 4		IS 4031 (Part 8)

Notes 1: In the event of cements failing to comply with any one or both the requirements of soundness specified in this table. Further tests in respect of each failure shall be made as described in IS 4031 (Part 3), from another portion of the same sample after aeration. The aeration shall be done by spreading out the sample to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total period of 7 days. The expansion of cements so aerated shall be not more than 5 mm and 0.6 percent when tested by Le chatelier method and autoclave test respectively. For 43-S grade cement , the requirements of soundness of unaerated cement shall be maximum expansion of 5 mm when tested by the Le-Chatelier method.

Note 2 : If cement exhibits false set, the ratio of final penetration measured after 5 min of completion of mixing period to the initial penetration measured exactly after 20 S of completion of mixing period, expressed as percent , shall be not less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS 4031 (Part 5) after breaking the false set, shall conform to the value given in this table

Note 3: By agreement between the purchaser and the manufacturer , transverse strength test of plastic mortar in accordance with the method described in IS 4031 (part 8) may be specified .The permissible values of the transverse strength shall be mutually agreed to between the purchaser and the supplier at the time of placing the order.

Note 4: Notwithstanding the compressive and transverse strength requirements specified as per this table, the cement shall show a progressive increase in strength from the strength at 72 hour.

Ordinary Portland Cement 53 Grade –Specification (IS 12269:2013)

Table 7: Chemical Requirements for OPC, 53 Grade

Sl.No.	Characteristics	Requirements
1	Ratio of Percentage of lime to percentage of silica, alumina and iron oxide , when calculated by the formula $\frac{CaO - 0.7\ SO_3}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3}$	0.80-1.02
2	Ratio of percentage of alumina to that of iron oxide, *Min*	0.66
3	Insoluble Residue percent by mass, *Max*	4.0
4	Magnesia Percent by mass, *Max*	6.0
5	Total Sulphur content calculated as Sulphuric Anhydride (SO_3) percent by mass, *Max*	3.5
6	Loss on Ignition, Percent by mass, *Max*	4.0
7	Chloride Content , Percent by mass, *Max*	0.1
8	Alkali Content	0.05 (For Pre-stressed Structure, see note)

Note: Alkali aggregate reactions have been noticed in aggregates in some parts of the country. On large and important jobs where the concrete is likely to be expressed to humid atmosphere or wetting action .It is advisable that the aggregate be tested for alkali aggregate reaction. In case of reactive aggregates, the use of cement with alkali content below 0.6 percent expressed as sodium oxide(Na_2O), is recommended where , however ,such cements are not available ,use of alternative means may be resorted to for which a reference may be made to 8.2.5.4 of IS 456. If so desired by the purchaser, the manufacturer shall carry out test for alkali content.

Table 8: Physical Requirements for OPC, 53 Grade

Sl.No.	Characteristic	Requirements		Method of Test , Ref to
1	Fineness, m^2/Kg, *Min*	225 370 for 53 –S grade		IS4031 (Part 2)
2	Soundness: (a) By Le Chatelier method, mm, *Max* (b) By autoclave test method, Percent, *Max*	 10 0.8	 See Note 1	IS 4031 (Part 3)
3	Setting Time : (a) Initial ,min, *Min* (b) Final ,min, *Max*	 30 60 for 53 – S grade 600	 See Note 2	IS 4031 (Part 5)
4	Compressive Strength, MPa (See note 4): (a) 72 ± 1hour, Min (b) 168 ± 2 hour, Min (c) 672 ± 4hour, Min	 27 37 37.5 for 53-S grade 53		IS 4031 (Part 6)
5	Transverse strength (optional)	See Note 3 & 4		IS 4031 (Part 8)

Notes 1: In the event of cements failing to comply with any one or both the requirements of soundness specified in this table. Further tests in respect of each failure shall be made as described in IS 4031 (Part 3), from another portion of the same sample after aeration. The aeration shall be done by spreading out the sample to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total period of 7 days. The expansion of cements so aerated shall be not more than 5 mm and 0.6 percent when tested by Le chatelier method and autoclave test respectively. For 53-S grade cement , the requirements of soundness of unaerated cement shall be maximum expansion of 5 mm when tested by the Le-Chatelier method.

Note 2 : If cement exhibits false set, the ratio of final penetration measured after 5 min of completion of mixing period to the initial penetration measured exactly after 20 S of completion of mixing period, expressed as percent , shall be not less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS 4031 (Part 5) after breaking the false set, shall conform to the value given in this table

Note 3: By agreement between the purchaser and the manufacturer , transverse strength test of plastic mortar in accordance with the method described in IS 4031 (part 8) may be specified .The permissible values of the transverse strength shall be mutually agreed to between the purchaser and the supplier at the time of placing the order.

Note 4: Notwithstanding the compressive and transverse strength requirements specified as per this table, the cement shall show a progressive increase in strength from the strength at 72 hour.

Portland Pozzolana Cement (PPC)- Specification, Part 1 Fly Ash based (IS1489 (part 1):1991 and Part 2 Calcinied Clay based (IS1489 (Part 2):1991

Table 9: Chemical Requirements of Portland Pozzolana Cement

Sl.No.	Characteristics	Requirements	Method of Test Ref to IS
1	Loss on ignition, percent by mass, *Max*	5.0	4032:1985

2	Magnesia (MgO), percent by mass, *Max*	6.0	4032:1985
3	Sulphuric anhydride (SO_3), percent by mass, *Max*	3.0	4032:1985
4	Insoluble material percent by mass .*Max*	X+4.0(100-X)/100, where X is declared percentage of fly ash in the given PPC	4032:1985

Physical Requirements

Fineness of cement: When tested by Blain's air permeability method, the specific surface of PPC shall not less than 300 m^2/Kg.

Soundness: When tested by Le Chatelier method and autoclave test, un-aerated PPC shall not have an expansion of more than 10 mm and 0.8 percent respectively.

Setting Time: The setting time of PPC , when treated by the Vicat Apparatus method , Shall be as follows:
Initial Setting Time 30 min, Min
Final Setting Time 600 min, Max

Compressive Strength: The average compressive strength of not less than three mortar cubes (area of face 50 cm^2) composed of one part of cement , three parts of standard sand (See Note 2) by mass, and p/4+3.0 percent (of combined mass of cement and sand) water, and prepared , stored and tested in the manner described in Is 4031 (Part 6) :1988 shall be as follows:

(a) At 72 ±1 Hour 16 MPa, *Min*
(b) At 168 ± 2Hour 22 Mpa, *Min*
(c) At 672 ± 4 Hour 33 Mpa, *Min*

Notes 1. P is the percentage of water required to produce a paste of standard consistency
Notes 2. Standard sand shall conform to IS 650 :1966

Portland Cement ,Low heat –Specification (IS 12600:1989)

Table 7: Chemical Requirements for Low Heat Portland Cement

Sl.No.	Characteristics	Requirements
1	Ratio of Percentage of alumina to that of iron oxide	Not less than 0.66
2	Insoluble Residue, percent by mass	Not more than 4 %
3	Magnesia Percent by mass	Not more than 6 %
4	Total Sulphur content calculated as Sulphuric Anhydride (SO_3) percent by mass	Not more than 2.5 and 3.0 when tri-calcium aluminate (see note 1) pecent by mass is 5 or less and greater than 5 respectively
5	Total Loss on Ignition	Not more than 5%

Note1 : The tri-calcium aluminate content (C_3A) is calculated by the formula:

$C_3A = 2.65 (Al_2O_3)-1.69 (Fe_2O_3)$

Where each symbol is brackets refers to the percentage (by mass of total cement) of the oxide ,excluding any contained in th insoluble residue refereed at Sl No. 2.

Note 2: Alkali aggregate reaction have been noticed in aggregates in some parts of the country . On large and important jobs where

the concrete is likely to be exposed to humid atmosphere or wetting action, it is advisable that the aggregate be tested for alkali aggregate reaction. In the case of reactive aggregates, the use of cement with alkali content below 0.6 percent expressed as sodium oxide(Na_2O), is recommended . where however such cements are not available , use of P.P.C or cement pozzolanic admixture is recommended.

Note 3: The limit of total chloride content, in cement for use in plain and other reinforced concrete structures is being reviewed . Till that times, the limit may be mutually agreed to between the purchaser and the manufacturer.

Physical Requirements

Fineness of cement: When tested by Blain's air permeability method, the specific surface of PPC shall not less than 320 m^2/Kg.

Soundness: When tested by Le Chatelier method and autoclave test, un-aerated cement shall not have an expansion of more than 10 mm and 0.8 percent respectively.

Setting Time: The setting time of the cements, when treated by the Vicat Apparatus method , Shall be as follows:

Initial Setting Time in minutes not less than 60, and

Final Setting Time in minutes not more than 600.

Compressive Strength : The average compressive strength of not less than three mortar cubes (area of face 50 cm^2) composed of one part of cement , three parts of standard sand (conforming to IS 650:1966) by mass, and p/4+3.0 percent (of combined mass of cement plus sand) water, and prepared , stored and tested in the manner described in Is 4031 (Part 6) :1988 shall be as follows:

(a) At 72 ± 1Hour not less than 10Mpa,

(b) At 168 ± 2Hour not less than 16 Mpa, and

(c) At 672 ± 4 Hour not less than 35 Mpa.

Notes 1. P is the percentage of water required to produce a paste of standard Consistency.

Heat of Hydration: when tested by the method described in IS 4031 (part 9):1988 the heat of hydration of cement shall be as follows:

(a) 7 days : not more than 272 KJ/Kg. and

(b) 28 days: not more than 314KJ/Kg.

Mechanical Properties of Reinforcement Steel

TABEL 8 : MECHANICAL PROPERTIES OF BARS (IS 432 (PART I) – 1982)				
S.NO.	Type and Nominal Size of Bar	Ultimate Tensile Strength Min N/mm^2	Yield Stress N/mm^2	Elongation Percentage *
1 Mechanical Steel Grade I				
	For bars up to and including 20 mm	410	250	23
	For bars over 20 mm , up to and including 50 mm	410	240	23
2 Mechanical Steel Grade II				
	For bars up to and including 20 mm	370	225	23
	For bars over 20 mm , up to and including 50 mm	370	215	25
3 Medium Tensile Steel				
	For bars up to and including 16 mm	540	350	20
	For bars over 16 mm , up to and including 32 mm	540	340	20
	For bars over 32 mm, up to and including 50 mm	510	330	20

*Elongation on a gauge length 5.65 √So where So is the cross-sectional area of the test piece

AVERAGE PROPERTIES FOR DIFFERENT TYPES OF SOIL :IS 12169-1987 &1498-1970

S. No.	Soil Group	Maximum Dry Density (KG/Cum) IS 1498-1970	Maximum Dry Density (G/Cm^3)IS 1498-1970	Optimum Moisture Content	Cohesion (Kg/Sqm)	Degrees	Permeability Coefficient Cm/s (IS:1498:1970)
1	GW	-	2.00-2.16	-	-	-	$K>10^{-2}$
2	GP	-	1.84-2.00	-	-	-	$K>10^{-2}$
3	GM	>1830	1.92-2.16	<15	NA	>34	$K=10^{-3}$ TO 10^{-6}
4	GC	>1840	1.84-2.08	<15	NA	>31	$K=10^{-6}$ TO 10^{-8}
5	SW	-	1.76-2.08	-	-	-	$K>10^{-3}$
6	SP	-	1.60-1.92	15 ± 0.4	-	-	$K>10^{-3}$
7	SM	1830 ±16	1.76-2.00	15± 0.4	500 ± 500	30 ± 4	$K=10^{-3}$ TO 10^{-6}
8	SC	1840 ±16	1.68-2.00	19 ± 0.7	1100 ± 600	31 ± 4	$K=10^{-6}$ TO 10^{-8}
9	ML,MI	1650 ± 16	1.52-1.92	17 ± 0.03	900 ± NA	32 ± 2	$K=10^{-3}$ TO 10^{-6}
10	CL,CI	1730 ± 16	1.52-1.92	-	1200 ± 200	28 ± 2	$K=10^{-6}$ TO 10^{-8}
11	OL,OI	-	1.28-1.60	-	-	-	$K=10^{-4}$ TO 10^{-6}
12	MH	1310 ± 64	1.12-1.52	36 ± 3.2	2000 ± 900	25 ± 3	$K=10^{-4}$ TO 10^{-6}
13	CH	1510 ± 32	1.20-1.68	25 ± 1.2	1300 ± 600	19 ± 5	$K=10^{-6}$ TO 10^{-8}
14	OH	-	1.04-1.60	-	-	-	$K=10^{-6}$ TO 10^{-8}
15	PT	-	-	--	-	-	

ANNEXURE 2-C

LIST OF QUALITY CONTROL LABORATORIES IN M.P

1	Soil and Material Testing Laboratory ,W,R,D, Hathaikheda , Bhopal	Under concerning Superintending Engineer
2	Soil and Material Testing Laboratory, W.R.D. Jabalpur	Under concerning Superintending Engineer
3	Hydraulic Laboratory for Model Studies ,Hathaikheda ,Bhopal	Under concerning Superintending Engineer
4	Samrat Ashok Sagar Quality Control Sub Division Vidisha	E.E. Water Res. Div. Bhopal
5	Gopi Krishna Sagar Quality Control Sub Division Biora, Guna	E.E. Water Res. Div. Guna
6	Quality Control Sub Division Biora, Rajgarh	E.E. Mohanpura Project Division Rajgarh
7	Tillar Project Head Unit Quality Control Sub Division Aagar	E.E. Water Res. Div. Shajapur
8	Datuni Project Quality Control Headquater Chandra Kesar Bandh Colony, Kantaphod, Dewas	E.E. Water Res. Div. Dewas
9	Quality Control Sub Division No. 2 Labariya	E.E. Mahi Project, Main Dam Dicision, Petlawad, Jhabua
10	Quality Control Water Res. Sub Division Damoh	E.E. Water Res. Div. Damoh
11	Quality Control Water Res. Sub Division Powai Dist. Panna	E.E. Water Res. Div. Powai Dist.Panna
12	Quality Control Unit (From Deolond)	E.E. Water Res. Div. Powai Dist.Panna
13	Quality Control Sub Division No. 2 Manikheda	Q.C.Division Datia
14	Sindh Project, Quality Control Sub Division No.3 Narwar	Q.C.Division Datia
15	Quality Control Sub Division No. 4 Karera	Q.C.Division Datia
16	Pench Diversion Project Quality Control Sub Division Singna Chaurai	Q.C.Division Datia
17	Quality Control Sub Division Moerena	Q.C.Division Moerena
18	Quality Control Sub Division Sheopur	Q.C.Division Moerena
19	Quality Control Sub Division Gwalior	Q.C.Division Moerena
20	Quality Control Sub Division Shivpuri	Q.C.Division Moerena
21	Quality Control Sub Division Sabalgarh	Q.C.Division Moerena
22	Research and Koti Quality Control Sub Division Tawa Nagar	Tawa Project Division, Itarsi
23	Barna Quality Control Sub Division No. 3 Badi	Barna Left Canal Division Badi District Raisen

PROCEDURES FOR MATERIAL TESTS USED IN CONCRETE AND MASONRY WORK:

ANNEXURE 3/1

TESTING OF WATER:

WATER: Natural or treated water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete.

Chemical Analysis

PH (HYDROGEN ION CONCENTRATION): (IS: 3025: PART 11 : 1983)(Reaffirmed 2002)

Theory:

Measurement of ph is one of the most important and frequently used test in water chemistry . Practically every phase of water supply and waste water treatment e.g. acid base neutralization, water softening, precipitation, coagulation, disinfection and corrosion control is ph dependent. At a given temperature the intensity of the acidic or basic character of a solution is indicated by ph or hydrogen ion concentration.

Equipments:

ph meter, Universal indicator reagent.

Procedure:

pH is observed with the help of pH roll or Universal Indicator. In laboratory it is observed by pH meter. Standardize the pH meter with standard pH solution. For standardization follow the manufacturer operating instructions. After standardization dip the ph electrode in beaker containing sample and note reading on pH meter

Observation:

Read the meter according to range

Precautions:

1. Wash the electrode with distilled water after each reading.
2. Electrode should be dip in distilled water when meter is not used.
3. Read the reading very carefully.

CHLORIDES (as Cl) (IS:3025 Part 32:1988)(Reaffirmed 2003)(By Argentometric method)

Principal:

In a neutral or slightly alkaline solution. Potassium chromate can indicates the end point of the silver nitrates titration of chlorides .Silver chloride is precipitated before red silver chromate is formed.

Interference:

Bromide , Iodide and cyanide register equivalent chlorides concentrations sulphite, thiosulphate and sulphide ions interfere but can be removed by treatment with hydrogen peroxide . orthophosphates in excess of mg/lit interfere. Iron in excess of mg/lit interfere by masking the end point.

Apparatus;

Erlenmeyer Flask Capacity 250 ml and Burette capacity 50 ml.

Reagents :

Potassium chromate indicator solution : Dissolved 50 g of potassium chromate in a little distilled water .Add silver nitrate solution until a definite red precipitate is formed. Let it stand for 12 hour , filter and dilute to liter with distilled water.

Standard silver nitrate titrant: 0.0141 N. Dissolved 2.395 g of silver nitrate in distilled water and dilute to 1 liter . Standardize against 0.0141 N sodium chloride solution a prescribed in Procedure para 1.00 ml = 500 µg of chloride. Store in brown bottle.

Standard sodium chloride solution: 0.0141 N .Dissolved 824 .0 mg of sodium chloride (dried at 140 ^{O}C) in distilled water and dilute to 1 liter .1.00 ml = 500µg of chloride.

Special Reagent for removal of interferences: Aluminium Hydroxide Suspension: Dissolved 1.25 g of aluminium potassium sulphate or aluminium ammonium sulphate [Alk $(SO_4)_2$ 12 H_2O or Al NH_4 $(SO_4)_2$.12 H_2O] in 1 liter of distilled water . warm to 60^o C and add 55 ml of concentrated ammonium hydroxide slowly with stirring . Let it stand for 1 h. transfer to a large bottle and wash precipitate by successive additions, with through mixing and decanting with distilled water ., until free from chloride. When freshly prepared, the suspension occupies a volume of about 1 liter.

Phenolphthalein indicator Solution

Sodium hydroxide -1N

Sulphuric acid – 1 N.

Hydrogen peroxide -30 percent.

Procedure:

Use 100 ml sample or a suitable portion diluted to 100 ml. if the sample is highly coloured . add 3 ml of aluminium hydroxide suspention, mix let settle and filter . if sulphide , sulphite or thiosulphate is present . add 1 ml of hydrogen peroxide and stir for 1 minute . directly titrate the samples in the pH range 7 to 10 . Adjust sample pH 7-10 with sulphuric acid or sodium hydroxide if it is not in the range . Add 1.0 ml of pota ssium chromate indicator solution. Titrate woth standard silver nitrate solution to a pinkish yellow end point. Standardize silver nitrate solution and establish reagent blank value by titration method.

Calculation : $mg/l = \frac{(V_1-V_2)X\ N\ X\ 35450}{V_3}$

Where:

V_1 = Volume of ml of silver nitrate used by the sample.

V_2 =Volume in ml of silver nitrate used in the blank titration.

V_3= Volume in ml of samples taken for titration , and

N= normality of silver nitrate solution.

SULPHITES (IS : 3025 Part 28: 1986)(Reaffirmed 2003)

Theory and principle:

Acidified water sample containing sulphite reduces iodate to iodine. Any excess of iodate added after all the sulphite is used up, oxidizes iodide to free iodine under acidic pH condition. Iodine oxidizes sulphite to sulphate. Any excess iodine results in the formation of blue color in presence of starch indicator.

Interferences:

Interferences due to the presence of sulphides may be removed by the addition of Zinc acetate.

Copper ions rapidly accelerated the oxidation of sulphite ions. Certain heavy metals may also react in a similar manner as copper. Proper sampling and immediate fixing by acid addition should minimize such difficulties.

Addition of sulphamic acid helps to eliminate interference due to nitrate.

Sampling and storage:

Highly polluted or contaminated samples should be stored at low temperature, allowing as little contact with air as possible.

Since at pH 8.0 or above sulphite may be oxidized to sulphate, pH should, therefore be adjusted below 8.0.

Fix the sample (at about 50^oC) immediately by adding1 ml EDTA solution for each 100 ml of sample.

Reagents:

Sulphuric acid

Starch Indicator Solution: Add 5.0 g starch to 800 ml boiling distilled water and stir. Dilute to one liter and boil for a few minutes and let settle overnight. Use the clear supernatant liquid. Add a few drops of chloroform or salicylic acid (1.3 g/lit) to preserve the indicator.

Standard Iodide solution (0.0125 M) –Dissolved 0.445 g primary grade potassium iodate (dried for 4 h at 120 ^{O} C) 4.35 g of potassium iodide and 310 mg sodium bicarbonate in distilled water and dilute to 1000 ml . One milliliter of this solution is equivalent to 500 mg of sulphite.

Sulphamic Acid –Crystalline

EDTA reagent: Dissolved 2.5 g of disodium EDTA in 100 ml of distilled water.

Procedure:

Add 1 ml sulphuric acid and about 0.1 g of sulphamic acid crystals into a 250 ml long necked flask. Measure a suitable volume of EDTA stablised sample (50 ml to 100 ml) and transfer to the flask keeping the tip of the pipette below the surface of liquid . Add 1 ml of starch indicator solution. Titrate immediately with potassium iodide-iodate standard solution until a faint permanent blue color develops (view the color change against a white background). Carry out blank, using distilled water instead of sample.

Calculation:

SO_3= (A-B) x N x 40000/V (mg/liter)

Where:

A= volume in ml of standard iodide-iodate solution used for sample.

B= volume in ml of standard iodide-iodate solution used in blank.

N= normality of potassium iodide-iodate solution, and

V= volume in ml of sample taken for the test.

ACIDITY: (Neutralization with NaOH with phenolphthalein as indicator) (IS 3025 ; 22: 1986) (Reaffirmed 2003)

Principle and Theory :

Acidity of water is its quantitative capacity to react with a strong base to a designated ph .it may be defined as equivalent concentration of hydrogen ions in mg/lit. The equation in is simplest forms is as follows:

$H^+ + NaOH = H_2O + Na^+$

Interference:

A fading and temporary end point characterizes the phenolphthalein acidity titration performed at room temperature on a sample containing iron and aluminium sulphate. Better results are obtained by titrating the sample at boiling temperature . Acid samples from mine drainage are subjected to interferences. Colored or turbid samples may interfere in end point. Analyse such samples by potentiometric titration.

Sampling and Storage:

Sampling and storage shall be done as prescribed in IS: 3025 part 1:1986.

Sample preparation:

The test sample used should be free from turbidity or filtered through 045 µm membrane filters.

Apparatus:

Burette, pH meter, magnetic stirring device.

Reagents;

Distilled water: ph should not be less than 6.0. If the pH is less than 6.0, it shall be freshly boiled for 15 minutes and cooled to room temperature. Deionized water may be used provided that it has a conductance of less than 2µS/cm and a pH more than 6.0.

Potassium Acid phthalate: 0.02 N. Dissolved 4.084 g of potassium acid phthalate salt (dried at 120^{o} C for 2 h) in carbon dioxide free distilled water and dilute to 1 liter.

Sodium hydroxide Solution: 15 N

Sodium hydroxide Solution: 1 N .Dilute 67 ml of 15 N Sodium hydroxide solution to one liter with distilled water.

Sodium hydroxide solution: 0.02 N .Dilute 20 ml of 1N sodium hydroxide solution to one siter and standardize using standard potassium acid phthalate.

Phenolphthalein Indicator: Dissolved 0.5 g of phenolphthalein in 100 ml ,: (v/v) alcohol water mixture and add 0.02 N sodium hydroxide solution drop by drop till very faint pink color is observed.

Methyl Orange Indicator: Dissolved 0.5 g of methyl orange in distilled water and make up to 100 ml in a volumetric flask.

Procedure:

Indicator method:

Pipette 20 ml or a suitable aliquot of sample into a 100 ml beaker. The sample size shall be so selected so that not more than 20 ml of titrant is needed for the titration. Determine the pH of water. If pH is less than 3.7 , add two drops of methyl orange indicator into the first sample beaker and titrate with standard 0.02 N sodium hydroxide solution until the color changes to the faint orange characteristic of pH 3.7. Record the volume of sodium hydroxide used. To the second sample

beaker, add 2 to 3 drops of phenolphthalein indicator and titrate with 0.02 N sodium hydroxide solution to the appearances of faint pink colour characteristics of pH 8.3.Record the volume used.

Potentiometric Method:

Pipette 20 ml or a suitable aliquot of sample into a 100 ml beaker. Titrate with standard sodium hydroxide solution to pH 3.7 to 8.3. Record the volume of standard sodium hydroxide used. No indicator is required.

Calculation:

Calculate acidity in the samples is as follows:

Acidity at pH 3.7 as mg/l $CaCO_3$= A x N x 50000/V

Acidity at pH 8.3 as mg/l $CaCO_3$= B x N x 50000/V

Where:

A= Volume in ml of standard sodium hydroxide used to titrate to pH 3.7.

N= normality of standard sodium hydroxide.

V= volume in ml of sample taken for test, and

B= Volume in ml of standard sodium hydroxide used to titrate to pH 8.3.

ALKALINITY : (Neutralization with H_2SO_4 with mixed indicator)(Is: 3025 (Part 23):1986) (Reaffirmed 2003)

Principle and Theory:

Alkalinity of water is the capacity of that water to accept protons. It may be defined as the quantitative capacity of an aqueous medium to react with hydrogen ions to pH 8.3 (Phenolphthalein alkalinity) and then to pH 3.7 (total alkalinity or methyl orange alkalinity). The equation in tis simplest form is as follows:

$CO_3^{--} + H^+ = HCO_3^-$ ----(pH 8.3)

From ph 8.3 to 3.7 , the following reaction may occur:

$HCO_3^- + H^+ = H_2CO_3$

Interference:

Free available residue chlorine markedly affects the indicator color response. The addition of minimum volume of sodium thiosulphate eliminates this interference. Substances such as salt of weak organic or inorganic acids present in large amount may interfere. Oils and greases may also interfere by coating the electrode. Colored or turbid samples may interfere in end point. Analyze such samples by potentiometric titration.

Sampling and Storage:

Sampling and storage shall be done as prescribed in IS: 3025 part 1:1986.

Sample preparation:

The sample aliquot used for analysis should be either free from turbidity or should be allowed to settel prior to analysis.

Apparatus:

Burette, pH meter, magnetic stirring device.

Reagents;

Distilled water: pH should not be less than 6.0. If the pH is less than 6.0, it shall be freshly boiled for 15 minutes and cooled to room temperature. Deionized water may be used provided that it has a conductance of less than 2µS/cm and a pH more than 6.0.

Sulphuric Acid : Dilute 5.6 ml of concentrated sulphuric acid (relative density 1.84).to one liter with distilled water.

Standard Solution of Sulphuric acid : 0.02 N

Phenolphthalein Indicator: Dissolved 0.5 g of phenolphthalein in 100 ml ,: (v/v) alcohol water mixture

Mixed Indicator Solution: Dissolved 0.02 g of methyl red and 0.01 g bromocresol green in 100 ml 95 percent , ethyl or isopropyl alcohol

Procedure:

Indicator method:

Pipette 20 ml or a suitable aliquot of sample into a 100 ml beaker. If the pH of the sample is over 8.3, then add 2 to 3 drops of phenolphthalein indicator and titrate with standard sulphuric acid solution till the pink color observed by indicator just disappear (equivalence to pH 8.3) Record the volume of the standard sulphuric acid solution used. Add 2 to 3 drops of mixed indicator to the solution in which the phenolphthalein alkalinity has been determined. Titrate with the standard acid to light pink color (equivalence to pH 3.7) . record the volume of standard acid used after phenolphthalein alkalinity.

Potentiometric Method:

Pipette 20 ml or a suitable aliquot of sample into a 100 ml beaker. Titrate with standard Sulphuric acid solution to pH 8.3 and then to pH 3.7, using a potentiometer. No indicator is required.

Calculation:

Calculate alkalinity in the samples is as follows:

Phenolphthalein Alkalinity (as mg/l of $CaCO_3$)= A x N x 50000/V

Total Alkalinity (as mg/l $CaCO_3$) = (A+B) x N x 50000/V

Where:

A= Volume in ml of standard Sulphuric acid used to titrate to pH 8.3.

N= normality of acid used.

V= volume in ml of sample taken for test, and

B= Volume in ml of standard sulphuric acid used to titrate from pH 8.3 to 3.7.

HARDNESS: (IS: 3025 Part 21: 2009)

Theory:

Total hardness of water is the sum of the concentration of all the metallic cations other then cations of the alkali metals, expressed as equivalent calcium carbonate concentration. In most waters, nearly all the hardness is due to calcium and Magnesium ions. It is determine by the reaction of calcium and magnesium salts with standard E.D.T.A (Ethylene Di amine Tetra acetic acid) solution.

Apparatus and Reagents:

Pipette (20 ml), conical flask, dropper, standard E.D.T.A solution (0.01N), Ammonia Buffer solution, Eriochrome Black Tea as indicator.

Procedure:

Take 25ml sample in a flask and add 2-3 drops of Ammonia buffer solution to give a ph of 10 to 10.1. Add 1 to 2 drop of Eriochrome black Tea indicator and titrate with E.D.T.A titrant to change in colour from reddish tinge to blue. Select a sample volume that requires less than 15 ml E.D.T.A titrant and complete the titration within 5 min after buffer addition.

Calculations;

Total Hardness (EDTA), mg $CaCO_3$/Lit = V_2 X 1000/V_1

Where: V_2 is volume in ml of EDTA solution required for titration and V_1 is volume of sample taken for test.

Precautions:

1. Clean the pipette and conical flask with distilled water after every test.

2. Observe the colour change very carefully

Physical Analysis:

NON FILTERABLE RESIDUE (TOTAL SUSPENDED SOLIDS) (IS: 3025 Part 17: 1984)(Reaffirmed 2012)

Principal :

Non filterable residue is determined by passing the sample through a weighed filter and drying the filter at 103^{o}C to 105^{o} C or 179 -181^{o}C. Non filterable residue is calculated from the increase in mass of the filter.

Apparatus:

Filters(Gooch Crucible or crucible or Glass Fibre filter disc), Filtering apparatus , Drying Oven, Desiccator , Analytical Balance

Procedure:

Preparation of Glass fibre filter disc: place the glass fibre filter on the membrane filter apparatus or insert into bottom of a suitable Gooch crucible with wrinkled surface up. While vacuum is applied wash the dish with three successive 20 ml volumes of distilled water. Remove all traces of water by continuing to apply vacuum after water has passed through. Remove filter from membrane filter apparatus (or both crucible and filter, if Gooch crucible is used) and dry in an oven at 103 -105^{o}C for 1 hour.Transfer to a desiccators and weigh after half an hour. Repeat the drying cycle until a constant mass is obtained (mass is less than 0.5 mg in successive weighings). Weigh immediately before use. After weighing , handle the filter or crucible filter with forceps or tongs only.

If determination are to be carried out at 180^{o}C then the filter or crucible /filter shall be dried at 180^{o}C.

Sample volume: In potable waters non-filterable residue is usually small . Relatively large volume of water is passed through filter so as to obtain at least 2.5 mg residue. For deciding volume to be taken. Turbidity values may be taken into consideration. If turbidity values of a samples is less than 50 units. Filter 1 liter sample and if turbidity value exceeds 50 units , filter sufficient sample so that non- filterable residue is 50 to 100 mg.

Assemble the filtering apparatus and begin suction. Wet the filter with a small volume of distilled water to seat it again the fitted support.

Shake the sample vigorously and quantitatively transfer the predetermined sample volume selected according to Turbidity value. To the filter using a graduated cylinder. Remove all traces of water by continuing to apply vacuum after sample has passed through.

With suction on, wash the graduated cylinder filter non- filterable residue with portion of distilled water allowing completer drainage between washings . Remove all traces of water by continuing to apply vacuum after the wash water has passed through.

After filteration , transfer the filter along with contents to an oven maintained at either 103-105 oC or 179-181^{o}C for at least 1 hour. Cool in a desiccators and weigh. Repeat the drying cycle till constant mass is obtained. Alternatively , remove crucible and filter from crucible adopter, wipe dry from outside with filter paper and dry at 103-105 ^{o}C or 179-181^{o}C in an oven. Cool in a desiccators and weigh . repeat the drying cycle till constant mass is obtained.

Calculation ;

Calculate the non –filterable residue from the following equation:

Non-filterable residue , mg/l = 1000M/V

Where

M= mass in mg of non –filterable residue, and V= volume in ml of the sample.

Report:

Report in whole numbers for less than 100 mg/l and to three significant figures for higher values. Report the temperature of determination.

Precision of the method is about 5 percent.

VOLATILE AND FIXED RESIDUE(TOTAL FILTERABLE AND NON_ FILTERABLE) (IS : 3025: Part 18 -1984 Reaffirmed 2012)

Scope:

It is a gravimetric method for the determination of volatile and fixed portions of total filterable and non-filterable residues. The method is applicable to all types of water and waste water**.**

Limitations:

The test is subject to many errors due to loss of water of crystallization. Loss of volatile matter prior to combustion, incomplete oxidation of certain complex organics and decomposition of mineral salts during combustion. The results should not be considered as accurate measure of organic carbon in the sample. An important source of error in the determination is failure to obtain a representative sample.

Apparatus:

Evaporating Dish: 90 mm, 100 ml capacity made of platinum, porcelain, silica or borosilicate glass. Platinum is suitable for all tests; porcelain , silica and glass may be used for samples with a pH value less than 9.0.

Steam bath

Drying oven with thermostatic control for maintaining temperature up to 180±2^{o}C.

Dessiccator, Muffle furnace and Analytical balance.

Refrigration or chilling to 4^{o}C is recommended for preservation of sample.

Procedure:

Heat the clean evaporating dish to 180^{o}C for 1 hour, cool, desiccate, weigh and store in dessicator until ready for use.

Selec volume of samples which has residue between 25 and 250 mg . Preferably between 100 and 200mg. This volume may be estimated from values of specific conductance. To obtain a measuerable residue, successive aliquots of sample may be added to the sample dish.

Pipette this volume in a weighed evoparating dish on steam bath. Evaporation may also be performed in a drying oven. The temperature shall be lowered to approximate 98^{o}C to prevent boiling and splattering of the sample.After completer evaporation of water from the residue, transfer the dish to an oven at 103-105^{o}C or 179-181^{o}C and dry to constant mass, that is, till the difference in the successive weighing is less than 0.5 mg. drying for a long duration (usually 1 to 2 hour) is done to eliminate necessity of checking for constant mass. The time for drying to constant mass with a given type of sample when a number of samples of nearly same type are to be analyzed has to be

determined by trial.

Weigh the dish as soon as it has cooled avoiding residue to stay for long time as some residue are hygroscopic and may absorb water from desiccant that is absolutely dry.

After weighing, ignite the dish in a muffle furnace at 550oC for 1 hour. After ignition, allow the vessel to partially cool in air and transfer to dessicator, cool and weigh.

Calculations:

Calculate the fixed residue and volatile residue as follows (total filterable and non-filterable):

Volatile residue, mg/l = (A-B)1000/V

Fixed residue, mg/l= (B-C)1000/V

Where: A= mass in mg of residue and dish/filter before ignition.

B= mass in mg of residue and dish/ filter after ignition.

C= mass in mg of dish/filter ,and V = volume in ml of the sample.

Report:

Report to the nearest number for values up to 100 mg/l and to three significant figures for higher values. Report the temperature of determination.

TURBIDITY: (IS: 3025 Part 10: 1984) Reaffirmed 2002

Theory:

Turbidity in water is caused by suspended matter, such as clay silt, finely dissolved organic and inorganic matter, soluble colored organic compounds and plankton and other microscopic organism. Turbidity is an expression of the optical property that causes lights to be scattered and absorbed rather than transmitted in straight lives through the sample.

Equipment:

Turbidity meter, Test tube etc.

Procedure:

Standardize the Turbidity meter with standard solution. For standardization follow the manufacturer operating instruction. After standardization insert test tube containing unknown samples up to mark in cell holder and note reading on meter in N.T.U.

Observation:

Read the meter according to range.

Calculation:

Direct reading from the meter

Precaution:

The instrument should be kept and operated in environment free from corrosive and acid fumes. Test Tubes are cleaned with detergent and rinsed with distilled water prior to wiping off with tissue paper.

TOTAL SOLIDS: (IS: 3025 PART 15, 1984) Reaffirmed 2009

Theory:

A well missed sample is evaporated in a weighted dish and dried to constant weight in oven at 103^{o} C to 105^{o} C. The increase in weight over that of empty dish represents the total solids.

Apparatus:

100 ml capacity borosil beaker, Desiccators, weight box, Analytical balance 200 gm capacity , oven, measuring cylinder 100 ml capacity.

Procedure:

Weight the empty beaker and note the weight than take 100 ml sample in beaker and put it into the oven at 103^{o} C to 105^{o} C for evaporation. After evaporation when the beaker is completely dried, cool it into the desiccators and weight again

Observation:

Weight of empty beaker = A in gms

Weight of beaker with sample residue after evaporation =B in gms

Volume of sample=C in ml

Calculations;

Total Solids in mg/ liter = (B-A) X1000/ C

Precaution:

1. Clean the beaker with distilled water before use.

2. Weight the beaker, very accurately.

3. Shake the sample well before test.

Test Procedures for suitability of water for making concrete (See Para 5.4 of IS: 456)

TESTING OF MATERIALS

INTRODUCTION

Various types of structures have to be built using different kinds of materials. The quality of the structure shall depend upon the quality of the material used. The testing of the materials of construction is therefore, an important activity to be taken up much before the construction actually starts. Even during process of construction the mortar and concrete made up of tested ingredients have to be tested for their quality to ascertain correctness of the procedure of mixing, curing and the net result. Thus, testing of materials and quality control go hand in hand. They are of great importance to check and ensure the expected result of all the efforts and money spent in building the structure.

MATERIALS

In natural states, materials like stone, sand, timber, earth, mud are available. Some materials are obtained by processing the natural materials e.g. cement, brick, steel, concrete etc.

TEST PROCEDURES

Various properties of these materials are tested as per standard procedures as laid down in IS specifications. Designs will be based on the values obtained during tests.

TESTING OF AGGREGATES

Various tests shall be carried out on aggregates to assess their quality. IS Specification have grouped the tests in eight parts. It may not be always necessary to assess all the qualities of aggregates for particular work/purpose. Therefore, it is necessary to know the purpose for which the aggregate is to be tested. Aggregates larger than 4.75mm I.S. sieve are termed as coarse and those passing through 4.75 mm are fines.

Aggregates to be used for concrete shall confirm to IS: 383-1970. Which lays down the following tests on aggregates: (IS: 2386-1963 part 1 to 8).

Though a number of tests have been specified in the ISI but sieve analysis, water absorption, specific gravity, crushing value, abrasion value, impact value generally give fairly good idea about the quality of aggregate.

SAMPLING OF AGGREGATES IS:2430-1986

Purpose:

To carry out tests on aggregates as described later in this booklet.

Procedure:

A sample of aggregates to be tested is made up to several small samples taken at different places from a stockpile, or bin, or at regular intervals during loading and unloading. These should all be properly mixed together and should add up to about 0.5 m3 or 750 kg. The laboratory sample is now obtained by means of quartering or riffling- a process that essentially divides the sample into similar equal parts until the desired representative laboratory size sample is obtained.

Methods of quartering: The main sample is thoroughly mixed, and in case of fine aggregates, dampened to avoid segregation. The material is heaped into a cone and then turned over to form a new cone. This is repeated twice. Material is always deposited at the apex of the cone so that the fall of particles is evenly distributed around the circumference. The final cone is flattened and divided into quarters. One pair of diagonally opposite quarters is discarded and the other diagonal pair used as the sample for testing. If the sample for is still too large it can be reduced by further quartering. Care must be taken to include all the fine material equally in all the quarters.

Method of riffling: This is done with the help of a riffle box or sample splitter, which has a number of parallel vertical chutes with alternate ones discharging on the left and right of the box. The sample is discharged into the top of the box over its full width and the two halves collected in two separate containers at the bottom of the chutes on either side. One half is discarded and the other half repeatedly riffled until the sample is reduced to the desired size.

Precautions:

While taking samples from a heap avoid coarse material which rolls to the edge and fine material which tends to remain near the centre of the heap. While sampling sand, damp samples should be taken as dry sand segregates and the fine material tends to blow off.

ANNEXURE 3/2

TESTINGS OF FINE AGGREGATE:

Various tests are carried out on aggregates to assess their quality. I.S. Specifications have grouped the test in eight parts. It may be always necessary to assess all the qualities of aggregates for particular work/ purpose. Therefore, it is necessary to know the purpose for which the aggregates large than 4.75 mm are termed coarse and those passing through 4.75 mm are termed fine (Sand).

Aggregates to be used for concrete should conform to I.S. 383-1963. This lays down the following test on aggregates (I.S. 2386-1963) Part- I to VIII.

DELETERIOUS MATERIALS:

Aggregate shall to contain any harmful material, such as pyrites, coal, lignite, mica shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of concrete. Aggregate to be used for reinforced concrete shall not contain any material liable to attack the steel reinforcement.

Limits of Deleterious materials: The maximum quantity of deleterious material in the aggregates (both coarse and fine) shall not exceed the limits as specified in the given table 1 below the tested in accordance with IS: 2386-1963, however, the engineer in charge may at his discretion, relax some of the limits as a results of further tests and evidence of satisfactory performance of the aggregates.

Table: 1 Limits of Deleterious Materials (clause 4.2.1 of IS:383-1970)

S.no.	Deleterious substances	Method of test	Fine aggregate % by mass: maximum		Coarse aggregate % by mass: maximum	
			Uncrushed	Crushed/ Blended	Uncrushed	Crushed
1	2	3	4	5	6	7
(i)	Coal and lignite	IS:2386 (part II)	1.00	1.00	1.00	1.00
(ii)	Clay lumps	IS:2386 (part II)	1.00	1.00	1.00	1.00
(iii)	Material finer than75 μm IS Sieve	IS:2386 (part I)	3.00	10.00(see note 1)	3.00	3.00

(iv)	Soft fragments	IS:2386 (part II)	-	-	3.00	-
(v)	Shale	(see note2)	1.00	-	-	-
(vi)	Total of % of all deleterious materials (except mica) including s. no. (i) to (v) for col.4,6, and 7 and s.no. (i) and (ii) for col.5 only		5.00	2.00	5.00	5.00

NOTES:

(i) Crushed sand with material finer than 75 µm IS sieving up to 15 % cab be used for making blended sand. The uncrushed sand used for blending shall not have material finer than 75 µm more than 3 %. However, blended sand shall comply with the requirement of 10 % . Maximum for the requirement of material finer than 75 µm IS Sieve.

(ii)When the clay stone are harder, ptaty and fissile, they are known as shale's. The presence and extent of shale's shall be determined by petrography.

(iii) The Presence of mica in the fine aggregate has been found to affect adversely the workability, strength, abrasion resistance and durability of concrete. Where no tests for strength and durability are conducted, the mica in the finer aggregate may be limited to 1.00 % by mass. Where tests are conducted to ensure adequate workability, satisfactory strength, permeability and abrasion (for wearing surface), the mica up to 3.00 % by mass for muscovite types shall be permitted. In case of presence of both muscovite and biotite mica, the permissible limit shall be 5.00 % , max by mass. This is subject to total deleterious materials (including mica) being limited to 8.00 %by mass for column no. 4 and 5.00% for column no.5.

(iv) 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. A fine aggregate which fails in the testing of organic impurities may be used, provide 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 clause 7 of IS :2386(Part VI)-1963 is not less than 95 %.

UNIT WEIGHT OR BULK DENSITY [IS: 2386 (PART-3)-1963 REAFF 2011

Purpose:

This test shall be conducted for deciding whether a specified range of value is satisfied by the material being tested. The laboratory test is useful for comparing properties of different aggregates available.

Equipment:

Balance, Cylindrical Metal measures of 3, 15 or 30 litres- capacity, according to the maximum nominal size of the largest particles of aggregate tamping rod of cylindrical cross-section 16mm in

dia. and 60cm long, rounded at one end.

Staff:

Lab Technician and Lab Attendant.

Test Procedure:

A suitable measure shall be selected and filled to about 1/3 capacity with the aggregate, thoroughly premixed and tamped with 25 strokes of the tamping rod. The process shall be repeated with 2/3 fill and again at complete filling, tamping with the rod with 25 strokes each time. Finally surplus aggregate shall be struck off; using the tamping rod as a straight edge. The net weight of the aggregate in the measure shall then be determined and the bulk density calculated in kilogram per cubic meter or kilogram/litre

Precautions:

The sample shall be thoroughly mixed.

Standard measure depending upon the maximum size of the aggregate shall be selected.

Measure shall be filled in 3 layers, compacting each layer with 25 strokes.

SPECIFIC GRAVITY AND WATER ABSORPTION OF AGGREGATES SMALLER THAN 10MM INCLUDING FINE AGGREGATE

(IS: 2386-(Part 3)-1963 Reaffirmed-2011

Equipments:

Balance, weight box, oven, pycnometer, enameled bowls and big tray of area not less than 325 cm^2, container air tight.

Staff:

Lab. Technician and Lab Attendant.

Procedure:

The sample thoroughly washed shall be placed in a tray and immersed in distilled water at least 5 cm of water above top of sample at a temperature of 22ºC to 32ºC. The sample shall be allowed to remain immersed for 24$\pm$1/2 hours and then at saturated surface dry to be weighed as (A).Then

water shall be drained off by decantation through filter paper. Any material retained shall be returned to the sample. The aggregate shall be put in the pycnometer and then the pycnometer shall be filled up with water. The pycnometer shall then be wieghed as B. The contents of the pycnometer shall be emptied in a tray and water shall be carefully drained from the sample through filter paper so that any material retained shall be returned to the sample. The sample shall be dried in the oven to a constant weight at the temperature of 100º to 110ºC. The sample shall be weighed as D. The pycnometer shall be filled with water and weighed as C.

Specific Gravity = $\frac{D}{A-(B-C)}$

Water absorption (Percentage of dry weight) = $\frac{100(A-D)}{D}$

Precautions:

The test sample shall be thoroughly washed and kept immersed in water for 24 hours.

The weight of the test sample shall be taken surface dry.

The pycnometer used for the test shall be dry from outside.
The air bubbles from the pycnometer shall be removed by rolling in the hand before weighing.

SURFACE MOISTURE OF AGGREGATE

Reference: USBR Concrete manual Designation 11 Page No. 530)

HOT PLATE METHOD

General: - This is an approximate method for determining the surface (free) moisture of sand and coarse aggregate.

Apparatus:-

a) A balance having a capacity of 2 Kilograms and sensitive to 0.1 gram.
b) A Small shallow pan
c) A stirring rod or spoon
d) A hot plate or stove

Procedure:

A representative sample of the aggregate (about 500 grams for sand and 1000 grams or more for gravel) is weight and spread in thin layer in the pan.

The sample is heated slowly and stirred frequently as the material approaches a surface-dry conditions, it should be stirred continuously, using extreme care to avoid driving off more than the surface moisture. When a saturated –dry conditions has been obtained, the sample is allowed to cool, after which it is weight.

Computations: -

The amount of surface moisture is computed by one of the following formulas:

$$\text{(Surface moisture, percent, saturated surface –dry basis)} = \frac{S-B \quad X\ 100}{B}$$

$$\text{(Total Moisture, percent, Dry basis)} = \frac{S-A\ X\ 100}{A}$$

Where:
S= Weight of wet aggregate tested,
B = Saturated surface –dry weight of aggregate tested and
A= Weight of oven –dry sample.

DETERMINATION OF SILT PERCENTAGE OF FINE AGGREGATE
Reference: USBR Concrete manual Designation 15 Page No. 539)

Object: Determination of silt and clay percentage in aggregate (sedimentation method)

Theory: Clay and Silt are generally considered as deleterious material and are very harmful and also adversely affect to the strength and other properties of concrete.

Equipments: A 1000 ml measuring cylinder.

Procedures: A 1000 cc graduated cylinder is filled to 400 cc mark with sand , and clear water added to 800 cc mark. This mixture is then taken vigorously and the content allowed to settle for 1 hour . 30 cc of sediment above the sand is roughly equivalent to 3 percent by weight of clay or silt. The sand may be washed, samples again tested two more times, and the sand approved for use if requirements are fulfilled.

Observation: Sediments above sand :-

(i) A) Sediments …….CC B) Silt Percent …….CC
(ii) A) Sediments …….CC B) Silt Percent …….CC
(iii) A) Sediments …….CC B) Silt Percent …….CC

Calculations:

Percentage of clay and fine silt or fine dust: = $\frac{\text{(i) B + (ii) B + (iii) B}}{3}$

Results: Report the results of clay and fine silt to the nearest 0.1 percent.

Specifications: - Not more than 5 %

Precautions:

(i) Mixture should not spread out while shaking mixture.
(ii) Cylinder should not disturb while the contents is allowed to settle

SIEVE ANALYSIS IS: 2386 (PART 1)-1963 Reaffirmed 2011
GRADATION OF SAND (F.M.)

This test shall be performed to determine the grading of the material which is an important factor contributing to the quality of concrete. The grade of the sand or fineness modulus or index must be know. Higher the index, coarser the material.

Equipment:

Sieves of the sizes confirming to IS: 460-1962

Square hole, perforated plate	80-mm, 63-mm, 50-mm,
	40-mm, 31.5mm, 25-mm
	20-mm, 16-mm, 12.5mm,
	10-mm, 6.3mm, 4.75mm
Fine mesh, wire cloth	3.35mm, 2.36-mm, 1.18mm
	600-micron, 300-micron
	150-micron, 75-micron

Balance along with weight box.

Staff:

Laboratory Technician and Lab Assistant

Test Procedure:

The sample for sieving shall be prepared from the laboratory sample by quartering. The sample shall be dried, cooled and weighed. It shall then be passed successively through the sieves starting with the largest. On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh shall be weighed. The percentage obtained on each sieve shall calculate. Cumulative percentage by weight of the total sample passing each of the sieves shall be calculated and recorded to the nearest whole number.

The results shall be noted in a tabular form

Precautions:

Oven dry sample shall be weighed and sieved

Sieving shall be done by using the coarsest sieve first and then proceed downwards.

The residue shall not be rubbed through the sieves.

The specifications for grading of fine Aggregate is given in M.P. Irrigation department specifications of 1971 and for coarse and fine Aggregate is given in IS: 383-1963.

DETERMINATION OF NECESSARY ADJUSTMENT FOR BULKING OF FINE AGGREGATE (FIELD METHOD) IS: 2386 (Part III-1963) Reaffirmed 2011

Introduction:

This method of test covers the field method for determining the necessary adjustment for the bulking of fine aggregate.

Sand brought onto a building site or other works may contain an amount of moisture which will cause it, when loosely filled into a container, to occupy a larger volume than it would occupy if dry. If the sand is measured by loose volume, it is necessary in such a case to increase the measured volume of the sand; in order that the amount of sand put into the concrete may be the amount intended for the nominal mix used (based on dry sand0. It will be necessary to increase the volume of sand by the 'percentage' bulking. The correction to be made is only a rough approximation because the system of measurement by loose volume is a rough method at the best, but a correction of the right order can easily be determined and should be applied in order to keep the concrete uniform.

Procedure :

It depends on the fact that the volume of inundated sand is the same as if the sand were dry. Put sufficient quantity of the sand loosely into a container until it is about two-Thirds full. Level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height. Suppose that it is (h) cm.

Empty the sand out of the container into another container where none of it will be lost. half fill the first container with water. Put back about half the sand and rod it with a steelrod, about 6mm in diameter, so that it's volume is reduced to a minimum. Then add the remainder of the sand and rod it in the same way. Smooth and level the top surface of the inundated sand and measure its depth at the middle with the steel rule. Suppose that it is (h) cm.

Calculations:

The percentage of bulking of the sand due to moisture shall be calculated from the formula:

$$\textbf{Percentage of bulking} = \left(\frac{h}{h^1} - 1\right)\textbf{x100}$$

Results :

Report the percentage of bulking of the sand to the nearest whole number.

MORTAR MAKING PROPERTIES OF FINE AGGREGATE

IS: 2386 (PART-6) 1963 Reaffirmed 2011

Purpose:

This test shall be performed for comparing the compressive strengths of the fine aggregate with that of the standard sand; whether that is within the specified limits.

Equipments:

Flow table and flow mould, Tamper-Trowel, moulds 7.06 cm cubes, Tamping rod, compression testing machine.

Staff:

Laboratory Technician and Lab. Attendant.

Test Procedure;

By maintaining the water-cement ratio of 0.6 by weight, the weight of the fine aggregate (sand) shall be found out at a specific flow i.e. 1005 by filling the mould with mortar (c:s.) by keeping the mould at the flow table, then by removing the mould and finally dropping the table through a height of 12.5 mm ten time in 6 seconds. The quantity of sand shall be determined and the cubes shall be caste (six numbers) for finding out their compression strength at a specific period.

Similarly the cubes shall be casted with standard sand in the ratio of 1:3, c:s by keeping the water-cement ratio as 0.6.

The compressive strengths shall be compared.

Precautions:

The equipment shall be clean and dry.

The tamping pressure shall be sufficient to ensure uniform filling of the mould.

The temperature shall be maintained at $27^{o} \pm 2^{o}C$.

Surface dry each specimen and remove any loose sand grains before testing the specimen for compressive strength.

DETERMINATION OF SURFACE MOISTURE IN FINE AGGREGATE (FIELD METHOD) IS: 2386 (PART-III): 1963 Reaffirmed-2011

Object:

This method of test covers the procedure for determining in the field, the amount of surface moisture in the fine aggregates by displacement in water. The accuracy of the method depends upon accurate information on the specific gravity of the material in a saturated surface dry condition. The same procedure with appropriate changes in the size of the sample and dimensions of the container may be applied to coarse aggregates.

Appratus:

The apparatus shall consist of the following:-

(a) Balance:- A balance having a capacity of 2 kg or more and sensitive to 0.5 gm or less.

(b) Flask:- A suitable container or flask preferably of glass or non-corrosive metal. The container

may be a Pycnometer, a Volumetric Flask, a Graduated Volumetric Flask or other suitable measuring device. The volume of container shall be from 2 to 3 times the loose volume of the sample. The container shall be so designed that it can be filled up to the mark, or the volume of its contents reach, within 0.5ml or less.

Staff:

Research Assistant and Lab. Assistant.

Sample:

A representative sample of the fine aggregate to be tested for surface moisture content shall be selected. It shall weight not less than 200 gm. Larger samples will yield more accurate results.

Procedure:

The surface water content may be determined either by weight or by volume. In each case the test shall be made at a temperature range of 22º to 32ºC

Determination by weight:

The container shall be filled up to the mark with water and the weight in grams dtermined. The container shall the be emptied. Enough water shall be placed in the container to cover the sample, after which the sample of fine aggregate shall be introduced into the container and the entrained air removed. The container shall then be filled to the original mark and the weight in grams determined. The amount of water displaced by the sample shall be calculated as follows:

Vs = Mc + Ms - M

Vs = Weight in gm of water displaced by the sample.

Mc = Weight in gm of container filled up to the mark with water.

Ms = Weight in gm of the sample, and

M = Weight in gm of the sample and container filled to the mark with water.

Determination by volume:

A volume of water sufficient to cover the sample shall be measured in milliliters and placed in the

container. The weighed sample of fine aggregate shall than be admitted into the container and the entrained air removed. The combined volume of the sample and the water shall be determined by direct reading when a graduated flask is used, where a Pycnometer or Volumetric Flask of known volume is used, the combined volume of the sample and the water shall be determined by filling up to the mark with a measured volume of water and subtracting this volume from the volume of the container. The amount of water displaced by the sample shall be calculated as follows:-

$Vs=V_2-V_1$

Where, Vs= Volume in ml of water displaced by the sample.

V_2 = Combined volume in ml of the sample and water.

V_1 = Volume in ml of water required to cover the sample.

Calculations:

The percentage of surface moisture in terms of the saturated surface, dry fine aggregate and in terms of the weight of wet fine aggregate shall be calculated as follows:-

$$P_1 = \frac{Vs-Vd}{Ms-Vs} x100$$

$$P_2 = \frac{Ms-Vd}{Ms-Vd} x100$$

Where, P1 = Percentage surface moisture in terms of saturated surface dry fine aggregate;

Vs = Weight in gm of water displaced;

Vd= The weight of sample divided by the specific gravity on saturated and surface dry basis;

Ms = Weight in gm of the sample; and

P_2 = Percentage surface moisture in terms of the weight of wet fine aggregate.

Note:-

These formulae are readily derived from basic relationships. For convenience, express P_1 in terms of

the ratio γ, i.e. the ratio of the weight of surface moisture to the weight of the saturated surface-dry sample. It follows that:-

$$Y = \frac{Ms - \frac{Ms}{1y}}{\frac{Ms}{1+y}} \qquad \text{.....(1)}$$

If G is the Specific Gravity of the saturated surface-dry fine aggregate, then

$$Vs = \frac{Ms}{G(1+y)} + \left(Ms - \frac{Ms}{1+y} \right) \qquad \text{.....(2)}$$

Where, the first term gives the water displaced by the saturated surface-dry fine aggregate, and the second that displaced by the surface moisture.

From equation-2,

$$\frac{Ms}{1+y} = \frac{Vs - Ms}{\frac{1}{G} - 1} \qquad \text{.....(3)}$$

By definition,

$$Ms = Vd \times G \qquad \text{.....(4)}$$

Substituting for $\frac{Ms}{1+y}$ and Ms in equation 1, and simplifying.

$$y = \frac{Vs - Vd}{Ms - Vs} \qquad \text{.....(5)}$$

The formula for P_2 may be derived by similar reasoning, or directly from that for P_b since

$$P_2 = \frac{\frac{Vs - Vd}{Ms - V_2}}{1 + \frac{Vs - Vd}{M_2 - V_3}} x100 \qquad \text{.....(6)}$$

Reporting of Results:

The surface moisture in the fine aggregate shall be reported to the nearest one percent and also the method of determination i.e. either by weight or by volume.

DETERMINATION OF SOUNDNESS OF FINE AGGREGATE:

IS: 2386 (Part-5)-1963 Reaffirmed 2011

Purpose:

This test is for the assessment of the quality of aggregate for concrete Resistance to disintegration of aggregate is determined by this test. This information is helpful in judging the soundness of aggregate against weathering action.

Equipments:

Sieves for Fine aggregate	:	150 microns, 300 microns, 600 microns,
		1.18mm, 2.36mm, 4.00mm and 4.75mm
Sieves for Coarse aggregate	:	8.00mm, 10mm, 12.5mm 16mm,
		20mm, 25mm, 31.5mm
		40, 50, 63 and 80mm

Containers for immersing the samples

Balance and weight box

Drying oven capable of maintaining a temperature of 105ºC to 110ºC

Saturated solution of Sodium Sulphate is prepared.

By dissolving Sodium Sulphate Anhydrous in water at a temperature of 25º to 30ºC. The solution shall be cooled to a temperature of 27º $\pm$ 2º and maintained at least 48 hours before use.

Actually 420 gms of Anhydrous salt of 1300 gms of the decahydrated salt (Na_2SO_4) per litre of water is used.

Staff:

Research Assistant and Lab Attendant.

Test Procedure for fine Aggregate:

The sample of fine aggregate shall be thoroughly washed on a 300 micron IS Sieve, dried to constant weight at 105ºC to 110ºC and separated into different sizes by sieving given as under:

Passing I.S. Sieve	Retained on I.S. Sieve
10mm	4.75mm
4.75mm	2.36mm
2.36mm	1.18mm
1.18mm	600 microns
600 microns	300 microns

Sample of 100 gms shall be weighed for each fraction separately in separate containers. These samples shall be immersed in the prepared solution of sodium sulphate not less than 16 (sixteen) hours and not more than 18 hours in such a manner that the solution covers them to a depth of at least 15mm. The containers shall be covered to reduce evaporation and prevent the accidental additional of extraneous substances (Temp. 27º $\pm$ 1ºC)

After immersion period, the samples shall be removed from the solution and permitted to drain for 15 $\pm$ 5 minutes and placed in the drying oven maintaining the temperature between 105ºC to 110ºC for not less than 4 hours and not more than 18 hours until constant weights are attained.

After achieving constant weight for each sample, they shall again be immersed in the prepared solution of sodium sulphate.

The process of alternate immersion and drying shall be repeated for five cycles or ten cycles as specified.

After the completion of the final cycle and after the sample has cooled, the sample shall be washed free from sodium sulphate as determined by the reaction of the wash water with Barium Chloride and then each fraction of the sample shall be dried to constant weight at 105º to 110ºC and weighed. Fine aggregates shall be sieved on which it was retained before the test. Actual percent loss shall be

calculated for each fraction of sieved material and calculated the result as given below as illustration.

Suggested recording for soundness of fine aggregates sieve size;

Passing	Retained	Greading of original sample percent	Weight of the test fraction before test	Percentage passing fine sieve after test (actual percent loss)	Weight average 9corrected percent loss) Col. 5x3/100
1	2	3	4	5	6
450 micron		5.00			
300 micron	150 micron	11.4			
600 micron	300 micron	26.0	100	4.2	1.09
1.18 mm	600 micron	25.2	100	4.8	1.21
2.36 mm	1.18 mm	17.0	100	8.0	1.36
4.75 mm	2.36mm	10.8	100	11.2	1.21
10mm	4.75mm	4.6		11.2	0.52
		100.00	400		5.39

The percentage loss (11.2%) of the next smaller size shall be used as the percentage loss for this size, since the size contains less than 5% of the original sample as received.

BULK DENSITY (BULKAGE) OF SAND: IS: 2386 (Part-3)-1963 Reaffirmed 2002

Object: Determination of Bulkage of sand.

Theory:

Presence of moisture below saturation increases the bulkage (volume) of sand . There is no bulkage when sand is dry or saturated. The purpose of the test is to determine the excess volume of the moisture sand which can be accounted for volumetric batching of concrete or cement sand mortar and make correction in the moisture for maintaining water cement ratio. Finer the sand the more is the bulkage.

Equipments:

Graduated glass cylinder 250 cc capacity, steel or glass rod , diameter 6 mm and length 400 mm with half round edge.

Procedure:

Pour sufficient moist sand into the cylinder and shake to adjust it to about 200 cc mark , note the volume V_1. Fill the cylinder with sufficient water to submerged the sand . stir the sand thoroughly with the rod , allow the sand to settle and note the volume of sand (V_2).

Observation:

Volume of the moist sand V_1 in CC.

Volume of the sand on saturation V_2 in CC.

Calculations:

$$\text{Bulkage} = \frac{V_1 - V_2}{V_2} \times 100$$

Results:

Express the results in percentage

Precautions :

Test the sand for bulkage before starting of each shift.

Collect representative sample and the test sample by quartering.

Carry out this test for each type of sand or sand received from different sources.

For same sources, repeat this test once in a week.

DETERMINATION OF CLAY, FINE SILT AND FINE DUST (SEDIMENTATION)
IS: 2386 (Part-II-1963) Reaffirmed-2011

Objects:

This is a gravimetric method for determining the clay, fine silt and fine dust, which includes particles up to 20 micron. Differences in the nature and density of materials or in the temperature at the time of testing may vary the separation point.

Apparatus:-

The apparatus shall consist of the following:-

(a) A water-tight screw-topped glass jar of dimensions similar to a 1-kg fruit preserving jar.

(b) A device for rotating the jar about its long axis, with this axis horizontal, at a speed of 90±20 rev/min.

(c)A sedimentation pipette of the and reason type of approximately 25 ml. capacity and of the general form. This consists mainly of pipette fitted at the top with a two-way tap and held rigidity in a clamp which can be raised or lowered as required and which is fitted with a scale from which the changes in height of the pipette can be read.

The volume of the pipette including the connecting base of the tap is determined by filling with distilled water, by reserving the tap the water is run out into a bottle, weighed and the volume calculated.

(d) A 1000ml measuring cylinder.

(e) A scale or balance of capacity not less than 10 kg. readable and accurate to 1 gram.

(f) A scale or balance of capacity not less than 250 gm, readable and accurate to 0.01 gm.

(g) A well-ventilated oven, thermostatically controlled, to maintain a temperature of 100º to 110ºC.

Chemicals: A solution containing 8 grams of sodium oxalate per liter of distilled water shall be taken. For use, this stock solution is diluted with distilled water to one tenth (i.e. 100 ml diluted with distilled water to one liter).

Test Sample: The sample for test shall be prepared from the main sample taking particular care that the test sample contains a correct proportion of the finer material. The amount of sample taken for test shall be in accordance with table.

Staff:

Research Assistant and Lab. Assistant.

Weight of sample for Determination of Clay, Fine Silt and Fine Dust

Maximum size present in Substantial proportions	approximate weight of sample for test
(mm)	(kg.)
63 to 25	6
20 to 12.5	1
10 to 6.3	0.5
4.75 or smaller	0.3

All in aggregates shall be separated into fine and coarse fractions by sieving on a 4.75 mm ARE sieve and the two samples so obtained shall be tested separately.

Procedure:

Method for fine aggregate: Approximately 300 gm of the sample in the air dry condition, passing the 4.75mm IS sieve, shall be weighed and placed in the screw topped glass jar, together with 380ml of the diluted sodium oxalate solution. The rubber washer and cap shall be fixed, care being taken to ensure water tightness. The jar shall than be rotated about its long axis, with this horizontal, at a speed of 80$\pm$20 rev/minute for a period of 15 minutes.

At the end of 15 minutes, the suspension shall be poured into the 1000 ml measuring cylinder and the residue washed by gentle swirling and decantation of successive 150 ml portions of sodium oxalate solution, the washings being added to the cylinder until the volume is made up to 1000 ml. The determination shall be completed as described.

Method for Coarse Aggregate: The weighed sample shall be placed in suitable container, covered with a measured volume of sodium oxalate solution (0.8 gm/litre), agitated vigorously to remove all adherent fine material and the liquid suspension transferred to the 1000 ml. measuring cylinder. This process shall be repeated as necessary until all clayey material has been transferred to the cylinder. The volume shall be made up to 1000 ml. with sodium oxalate solution and the determination completed as described.

The suspension in the measuring cylinder shall be thoroughly mixed by inversion and the tube and contents immediately placed in position under the pipette. The pipette shall then be gently lowered until the tip touches the surface of the liquid and then lowered a further 10 cm into the liqid, three

minutes after placing the tube in position, the pipette and the bore of tap shall be filled by opening and applying gentle suction. A small surplus may be drawn up into the bulb between tap and tube but this shall be allowed to run away and any solid matter shall be washed out with distilled water. The pipette shall then be removed from the measuring cylinder and its contents run into a weighed container, any adherent solids being washed into the container by distilled water from the tap.

The contents of the container shall be dried at 100º to 110ºC to constant weight, cooled and weighed.

CALCULATIONS:

The proportion of fine silt and clay or fine dust shall then be calculated from the following formula.

Percentage of clay and fine silt or fine dust = $\frac{100}{W_1}\left(\frac{1000W_2}{V} - 0.8\right)$

Where W1 = Weight in gm of the original sample,

W2 = Weight in gm of the dried residue,

V = Volume in ml of the pipette, and

0.8= Weight in gm of sodium oxalate in one litre of the diluted solution. No correction is made for water soluble salts which may be present in the sand, since the amount of such salts should be small.

Reporting of Results

The clay, fine silt and fine dust content shall be reported to the nearest 0.1 percent.

ANNEXURE 3/3

TESTING OF COARSE AGGREGATE:

GENERAL:

Various types of structures have to be building using different kinds of materials. The quality of the structures would depend upon the quality of the material used. The testing of the materials of construction is therefore, and important activity to be taken up much before the construction starts. Even during process of construction mortar and concrete made of tested ingredients have to be tested for their quality to ascertain concrete made of tested ingredients have to be tested for their quality to ascertain correctness of the procedures of mixing, curing and the net results. Thus, testing of materials and quality control go hand in hand. They are to great importance to check and ensure the expected results of all the efforts and money spent in building the structure.

Through a number of tests have been specified in the I.S.I. but Sieve analysis Water absorption, Specific gravity, Crushing value, Abrasion value, Impact value generally give fairly good idea about the quality of aggregate.

DELETERIOUS MATERIALS:

Same as Fine Aggregate section

UNIT WEIGHT OR BULK DENSITY [IS: 2386 (PART-3)-1963 Reaffirmed 2011

Purpose:

This test shall be conducted for deciding whether a specified range of value is satisfied by the material being tested. The laboratory test is useful for comparing properties of different aggregates available.

Equipment:

Balance, Cylindrical Metal measures of 3, 15 or 30 litres- capacity, according to the maximum nominal size of the largest particles of aggregate tamping rod of cylindrical cross-section 16mm in dia. and 60cm long, rounded at one end.

Staff:

Lab Technician and Lab Attendant.

Test Procedure:

A suitable measure shall be selected and filled to about 1/3 capacity with the aggregate, thoroughly premixed and tamped with 25 strokes of the tamping rod. The process shall be repeated with 2/3 fill and again at complete filling, tamping with the rod with 25 strokes each time. Finally surplus aggregate shall be struck off; using the tamping rod as a straight edge. The net weight of the aggregate in the measure shall then be determined and the bulk density calculated in kilogram per cubic meter or kilogram/liter

Precautions:

The sample shall be thoroughly mixed.

Standard measure depending upon the maximum size of the aggregate shall be selected.

Measure shall be filled in 3 layers, compacting each layer with 25 strokes.

WATER ABSORPTION AND SPECIFIC GRAVITY OF COARSE AGGREGATE
IS: 2386 (Part-3): 1963 Reaffirmed 2011

Purpose:

The values of these tests shall be needed for the proper proportioning of concrete mixes. The value of absorption of moisture content are necessary to adjust the water content during mixing.

Equipments:

Balance, weight box, Beaker, small wooden bench, thread, thermostatically controlled electric oven, two dry soft, absorbent cloths each not less than 75 cmsx45 cms, a tray.

Staff:

Research Assistant and Lab Attendant.

Procedure:

A, test piece shall be selected, washed, cleaned and kept immersed in water for 24$\pm$1/2 hours. Its weight shall be determined, after drying the surface. It shall be then hung by thread on the left pan

of the balance, totally immersed in water. And the weight shall be determined again.

The test piece shall be kept in an oven or being dried at temperature 100º to 110ºC and again weighed after complete drying. Apparent specific gravity on saturation and surface dry basis and the percentage of water absorption shall then be determined.

Calculations:

Let the weight of the saturated surface-dry aggregate

Let the weight of the saturated aggregate in water = B gm

The weight of oven dried aggregate in air = C gm

Appearent Specific Gravity= $\frac{C}{C-B}$ Specific Gravity = $\frac{C}{A-B}$

Water Absorption (percentage of dry weight)

= $\frac{(A-C)x100}{C}$

SURFACE MOISTURE OF AGGREGATE

Reference: USBR Concrete manual Designation 11 Page No. 530)

HOT PLATE METHOD

General: - This is an approximate method for determining the surface (free) moisture of sand and coarse aggregate.

Apparatus:-

e) A balance having a capacity of 2 Kilograms and sensitive to 0.1 gram.
f) A Small shallow pan
g) A stirring rod or spoon
h) A hot plate or stove

Procedure:

a) A representative sample of the aggregate (about 500 grams for sand and 1000 grams or more for gravel) is weight and spread in thin layer in the pan.
b) The sample is heated slowly and stirred frequently as the material approaches a surface-dry conditions, it should be stirred continuously, using extreme care to avoid driving off

more than the surface moisture. When a saturated –dry conditions has been obtained, the sample is allowed to cool, after which it is weight.

Computations:- The amount of surface moisture is computed by one of the following formulas:

$$\text{(Surface moisture, percent, saturated surface –dry basis)} = \frac{S-B \times 100}{B}$$

$$\text{(Total Moisture, percent, Dry basis)} = \frac{S-A \times 100}{A}$$

Where:
S= Weight of wet aggregate tested,
B = Saturated surface –dry weight of aggregate tested and
A= Weight of oven –dry sample.

SIEVE ANALYSIS IS: 2386 (PART 1)-1963 Reaffirmed 2011

This test shall be performed to determine the grading of the material which is an important factor contributing to the quality of concrete. The grade of the sand or fineness modulus or index must be known. Higher the index, coarser the material.

Equipment:

Sieves of the sizes confirming to IS: 460-1962

Square hole, perforated plate	80-mm, 63-mm, 50-mm,
	40-mm, 31.5mm, 25-mm
	20-mm, 16-mm, 12.5mm,
	10-mm, 6.3mm, 4.75mm
Fine mesh, wire cloth	3.35mm, 2.36-mm, 1.18mm
	600-micron, 300-micron
	150-micron, 75-micron

Balance along with weight box.

Staff:

Test Procedure:

The sample for sieving shall be prepared from the laboratory sample by quartering. The sample shall be dried, cooled and weighed. It shall then be passed successively through the sieves starting with the largest. on completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh shall be weighed. The percentage obtained on each sieve shall calculate. Cumulative percentage by weight of the total sample passing each of the sieves shall be calculated and recorded to the nearest whole number.

The results shall be noted in a tabular form

Precautions:

Oven dry sample shall be weighed and sieved

Sieving shall be done by using the coarsest sieve first and then proceed downwards.

The residue shall not be rubbed through the sieves.

The specifications for grading of fine Aggregate is given in M.P. Irrigation department specifications of 1971 and for coarse and fine Aggregate is given in IS: 383-1963.

COMBINED FLAKINESS AND ELONGATION INDEX (is 2386(Part I)-1963

DETERMINATION OF FLAKINESS INDEX:

Object :

The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifth of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm.

Apparatus :

Balance (Sensitive and shall have accuracy of 0.1percent of the weight of the test sample. Metal Gauge (Metal gauge shall be a pattern shown in Fig 2 of IS 2386 Part I) and Sieves of sizes shown in given table.

Sample :

A Quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.

Procedure :

Sieving: The sample shall be sieved with the sieves specified in given table

Separation of Flaky Material : Each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig 2 of IS 2386 Part I or in bulk on sieves having elongated slots . The width of the slot used in the gauge or sieves shall be of the dimensions specified in Column 3 of given table for the appropriate size of material.

Table ; Dimensions of Thickness and Length gauges

Size of Aggregate		Thickness Gauge*	Length Gauge**
Passing through IS Sieves	Retained on Is Sieves		
1	2	3(mm)	4
63 mm	50 mm	33.90	-
50 mm	40 mm	27.00	81.0
40 mm	25 mm	19.50	58.5
31.5 mm	25 mm	16.95	-
25 mm	20 mm	13.50	40.5
20 mm	16 mm	10.80	32.4
16 mm	12.5 mm	8.55	25.6
12.5 mm	10 mm	6.75	20.2
10 mm	6.3 mm	4.89	14.7

*This dimension is equal to 0.6 times the mean sieve size.

** This dimension is equal to 1.8 times the mean sieve size.

Weighing of Flaky Material; The Total amount passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

Reporting of Results: The Flakiness index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged

DETERMINATION OF ELONGATION INDEX:

Object:

The Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifths times their mean dimension. Normally, the properties of interest to the engineer are sufficiently covered by the flakiness or angularity tests. The elongation test is not applicable to sizes smaller than 6.3 mm.

Apparatus :

Balance (Sensitive and shall have accuracy of 0.1percent of the weight of the test sample. Metal Gauge (Metal gauge shall be a pattern shown in Fig 3 of IS 2386 Part I) and Sieves of sizes shown in table given in the flakiness index test.

Sample:

A Quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.

Procedure:

Sieving; The sample shall be sieved with the sieves specified in table given in the flakiness index test.

Separation of Elongated Material: Each fraction shall be gauged individually for length on a metal length gauge of the pattern shown in Fig 3 of IS 2386 Part I. The gauge length used shall be that specified in Column 4 of table given in the flakiness index test for the appropriate size of material.

Weighing of Elongated Material; The Total amount retained by the length gauge shall be weighed

to an accuracy of at least 0.1 percent of the weight of the test sample.

Reporting of Results: The Elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged.

DETERMINATION OF ABRASION VALUE
(By Los Angele's Machine-IS: 2386 (Part-4)-Reaffirmed-2011

Purpose:

The test determines the loss due to abrasion of aggregates. This test shall be conducted to assess the quality of aggregates with respect to hardness and toughness of the aggregate against abrasion.

Equipments:

Los Angel machine, 1.70mm IS Sieve, Balance, Weight box.

Staff:

Lab. Technician and Lab. Attendant.

Procedure:

The test sample and abrasive charge (steel balls) shall be placed in the Los Angel's testing machine and the machine shall be rotated at 20 to 33 rev/min. For gradings A,B, C and D, the machine shall be rotated for 500 revolutions, for grading E, F and G, it shall be rotated for 1000 revolutions, As per table given below. The machine shall be so driven and so counter balanced as to maintain a substantially uniform peripheral speed. If an angle is used as the shelf, the machine shall be rotated in such a direction that the charge is caught on the out side surface of the angle. At the completion of the test, the material shall be discharged from the machine and a preliminary separation of the sample made on a sieve coarser than the 1.70mm i.S. sieve. At the completion of the test, the material shall be removed and sieved through 1.70mm IS Sieve. The material coarser than 1.7mm shall be washed and dried in oven at 105ºC to 110ºC to a constant weight and accurately weighed.

Reporting of Results:

The difference between the original weight of the test sample and the final weight of the sample shall be expressed as percentage of the original test sample. Lesser the value harder is the sample against abrasion.

Precautions;

The apparatus shall be as per IS: 2386 (Part-4)- 1963

The test sample shall be clean and dry.

The abrasive charge, depending upon the grading of the test sample as described in previous shall be as follows:

Grading	Number of Spheres	Weight of Charge
A	12	5000±25
B	11	4584±25
C	8	3330±20
D	6	2500±15
E	12	5000±25
F	12	5000±25
G	12	5000±25

Test sample- The test sample shall consist of clean aggregate which has been dried in an oven at 105 to 110ºC to substantially constant weight and shall conform to one of the gradings shown in table II. The grading or grading used shall be those most nearly representing the aggregate furnished the work.

Note-It is recognized that different specification limits may be required for grading E, F and G than for A, B, C and D. It is urged that investigations be conducted to determine the relationship, if any, which exists between results for these coarse grading using the 10000 g samples and the finer ones using the 5000g samples.

Table Ii Gradings of Test Samples

Sieve Size (Square Hole)		Weight in g of test sample for Grade						
passing	Retained on	A	B	C	D	E	F	G

mm	mm							
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	3000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-	-	5000	-	-	-

*Tolerance of $\pm$ 2 percent permitted.

DETERMINATION OF AGGREGATE IMPACT VALUE

IS: 2386 (Part-4)- 1963 Reaffirmed-2011

Purpose:

This test gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregate differs from its resistance to a slow compressive load.

Apparatus:

An impact testing machine, sieves 12.5, 10 and 2.36 mm, measure of internal dimensions 75mm dia, 50mm depth, Tamping rod 10mm in diameter and 230mm long, oven to maintain a temperature of 100º to 110ºC, balance and weight box.

Staff:

Lab Technician and Lab Attendant.

Procedure:

The test sample of aggregate shall consist of material passing 12.5 mm sieve and retained on 10mm

sieve. This shall be oven dried. The measure shall be filled about one-third and 25 strokes are given with the specified tamping rod. Again measure shall be 2/3 filled and 25 strokes with tamping rod are given. Finally the measure shall be filled to over-flowing and tamped 25 times. Net weight of the aggregate in the measure is known as (A). Then the test sample shall be subjected to 15 strokes with the hammer and then sieved through 2.36 mm IS sieve. The fraction passing through the sieve shall be weighed as (B) and calculations shall be completed.

Aggregate Impact value= $\frac{B \times 100}{A}$

Where B = Weight of fraction passing 2.36 mm sieve, and

A= Weight of oven dried sample

At least two tests shall be done.

Precautions:

The impact testing machine shall be as per IS: 2386 (Part 4)-1963

The test sample shall be dried in oven at 100ºC to 110ºC

The impact machine shall rest without wedging or packing up on the level plate block or floor, so that it is rigid and the hammer guide columns are vertical.

CRUSHING VALUE IS; 2386 (PART-4) 1963, Reaffirmed 2011

Purpose:

This test gives a relative measure of the resistance of an aggregate to crushing under a gradually compressive load.

Equipments:

A 15cm. diameter open ended steel cylinder with plunger and base plate, a straight metal tamping rod of circular cross-section 16mm. dia and 40 to 60cm. long, A balance, IS sieve of sizes 12.5 , 10, 2.36 mm. A compression testing, cylindrically metal measure of specific sizes according to the aggregate size.

Staff:

Lab. Technician and Lab Attendant.

Procedure:

Resistance to crushing shall be measured by putting a 10 cm. deep heel of standard size aggregate in a 15cm dia mould to load of 40T. In a compression testing machine. 40 T. load shall be reached in 10 minutes. The load shall be released and whole material shall be removed from the cylinder and sieved through 2.36 mm IS Sieve. The material passing the sieve shall be weighed; the ratio of the weight of fines formed to the total sample weight shall be expressed as percentage. Low crushing value indicates strong aggregates.

Calculations:

Aggregate Crushing value = $\frac{B \times 100}{A}$

Where B = Weight of fraction passing the appropriate sieve, and

A = Weight of surface-dry sample.

Precautions:

Standard apparatus as per IS; 2386 (Part 4)- 1963 shall be used.

The aggregate shall be tested in a surface dry condition by keeping in oven for not more than 4 hours.

Two determinations shall be made.

DETERMINATION OF POTENTIAL ALKALI REACTIVITY OF CEMENT – AGGREGATE COMBINATION
(Reference: IS 2386 part VII)

ALKALI AGGREGATE REACTION:-

Some aggregates containing particulars varieties of silica may be susceptible to attack by alkalis' (Na_2O, K_2O) originating from cement and other sources, producing and expansive reaction which can cause cracking and disruption of concrete. Damage to concrete from this reaction will normally only

occurs when all the following are present together:

A) A high moisture level within the concrete;

B) A cement with high alkali content, or another sources of alkali;

C) Aggregate containing an alkali reactive constituent.

The aggregate shall comply with the requirements as follows, when tested in accordance with IS 2386 (Part 7) as follows:

1) **Chemical Method:** The aggregate when tested in accordance with the chemical method , shall conform to the requirement as specified in IS 2386 (part 7) . This method (for determination of potential reactivity), however , is mot found to be suitable for slowly reactive aggregate as explained in IS 2386 (Part 7).
2) **Mortar Bar Method:-** The permissible limits for mortar bar test at 38^{o} C shall be 0.05 percent at 90 days and 0.10 percent at 180 Days.

   The permissible limit for mortar bar test at 60^{o} C (Carried out for slowly reactive aggregate) shall be 0.05 percent at 90 days and 0.06 percent at 180 days.
3) **Accelerated Mortar Bar Method:** The accelerated mortar bar test shall be carried out at 80^{o} C using 1N NaOH . The test is found to be specially suitable for slowly reactive aggregate. The test does not evaluate combinations of aggregate with cementitious materials. The criteria for this test is as under:

   i) Expansion of less than 0.10 percent at 16 days after casting are indicative of innocuous behavior in most cases (see Note)

      Note: Some granitic gneisses and meta-basalts have been found to be deleteriously expansive in field performance even through their expansion in this test was less than 0.10 percent at 16 days after casting. With such aggregate, it is recommended that prior field performance be investigated. In this absence of field performance data, mitigative measures should be taken.

   ii) Expansion of more than0.20 percent at 16 days after casting are indicative of potentially deleterious expansion {see 4.2.2 of IS 2386(Part 7)}

   iii) Expansion between 0.10 and 0.20 percent at 16 days after casting include both aggregate that are known to be innocuous and deleterious in field performance. For these aggregate, it is particularly important to develop supplemental information as described in 4.2.2 of IS 2386 (Part 7). In such a situation, it may also be useful to take comparator reading until 28 days. It may be useful to support this test with test by mortar at 38^{o} C and 60^{o} C, as applicable.

      Now as days three methods are used to determine the Potential Reactivity of Aggregates. The IS: 2386 (Part 7), -1963 (Reaffirmed in 2002), covers only two

methods of test, while the third methods is described in Amendment No. 3 of IS: 2386 (part 7)

The Methods are as follows:

1. **Mortar Bar Method:-**

   Object: This method of test covers the determination of the potential expansive Alkali reactivity of cement- aggregate combinations by measuring the expansion developed by the combinations in mortar bars during storage under prescribed conditions of test.

2. **Chemical Method:**

   Object: This method of test covers a chemical method for determining the potential reactivity of an aggregate with alkalis' in Portland cement concrete as indicated by the amount of reaction during 24 hours at 80^{o} C between 1N Sodium hydroxide solution and aggregate that has been crushed and sieved to pass a 300 –Micron IS Sieve and be retained on a 150 –micron Is Sieve.

3. **Accelerated Mortar-Bar Method:-**

   Object: This method of test permits detection, within 16 days, of the potential for deleterious alkali silica reaction of aggregate in mortar bars.

Out of the above Test methods, suitable Test Procedures should be used according to site conditions. Detailed Procedures are given in IS: 2386 (Part 7).

METHODS OF TESTS FOR AGGREGATES FOR CONCRETE (PETROGRAPHIC EXAMINATION)
Reference: IS: 2386 Part VIII

Petro graphic Examination are made for the following purposes:

A) To determine the physical and chemical properties of the material that may be observed by petro graphic methods and that haves a bearing on the quality of the material for its intended use,

B) To describe and classify the constituents of the samples and

C) To determine the relative amounts of the constituents of the sample, which is essential for proper evaluation of the sample when the constituents differ significantly in properties that have a bearing on the quality of the material for its intended use?

The Three methods of Petro graphic Examination of aggregates of aggregates for concrete, Methods Ist may be adopted for Routine Purposes. Method IInd for detailed investigation, it shall be treated as a reference method. IIIrd method is Additional Test Method, The IS: 2386 (Part VIII) covers only first two methods while the Third method is described in Amendment NO. 1 June 1999 of IS: 2386 (Part VIII):1963.
The Method are as follows:

1. METHOD I:- This test involves visual inspection and a segregation of the constituents of coarse and fine aggregates according to Petro graphic and chemical differences.

2. METHOD II:- This recommended practice outlines procedures for the petro graphic examination of samples representative of material proposed for use as aggregate in concrete. This specific procedures employed in the petro graphic examination of any sample will depend to a large extent on the purpose of the examination and the nature of the sample.

3. Additional Test Method: This Test method describes procedures for determining undulating Extinction (UE) angle of coarse and fine aggregate and shall be conducted on aggregates containing generally more than 30 percent quartz. The Undualatory extinction angle is the angle between the position of extinction and its disappearance in the grain. It is a measure of the crystal lattices disturbances caused by geological stresses. Various researchers have used UE angle as indication of possible sources for alkali reactivity of the rock.

Out of the above Test methods, suitable Test Procedures should be used according to site conditions. Detailed Procedures are given in IS: 2386 (Part 8).

DETERMINATION OF SOUNDNESS OF COARSE AGGREGATE:

IS: 2386 (Part-5)-1963 Reaffirmed 2011

Purpose:

This test is for the assessment of the quality of aggregate for concrete Resistance to disintegration of aggregate is determined by this test. This information is helpful in judging the soundness of

aggregate against weathering action.

Equipments:

Sieves for Fine aggregate : 150 microns, 300 microns, 600 microns,

1.18mm, 2.36mm, 4.00mm and 4.75mm

Sieves for Coarse aggregate : 8.00mm, 10mm, 12.5mm 16mm,

20mm, 25mm, 31.5mm

40, 50, 63 and 80mm

Containers for immersing the samples

Balance and weight box

Drying oven capable of maintaining a temperature of 105ºC to 110ºC

Saturated solution of Sodium Sulphate is prepared.

By dissolving Sodium Sulphate Anhydrous in water at a temperature of 25º to 30ºC. The solution shall be cooled to a temperature of 27º $\pm$ 2º and maintained at least 48 hours before use.

Actually 420 gms of Anhydrous salt of 1300 gms of the decahydrated salt (Na_2SO_4) per litre of water is used.

Staff;

Research Assistant and Lab Attendant.

Test Procedures for Coarse Aggregate:

The sample of coarse aggregate shall be thoroughly washed and dried to constant weight at 105º to 110ºC and are to be separated into different sieves by sieving given as under:

Size (Square, Hole Sieves) in mm	Yield in gms	Percentage of Yield Retained
10 to 4.7	300	

20 to 10 consisting of 12.5 to 10 20.0 to 12.5	100	33
40 to 20		67
25 to 20		
40 to 25		33
63 to 40	1500	67
50 to 40	3000	50
63 to 50		50
80 and larger sizes by 20 spread in sieve size each fraction	3000	

The proper weight of sample for each fraction shall be weighed out and placed in separate containers for test.

The samples shall be immersed in the prepared sodium sulphate just as mentioned in cases of fine aggregates i.e. for sixteen hours and drying of the samples shall be done for eight hours by keeping these in hot air over at temperature 105º to 110ºC for all the separate fractions till the constant weight is attained.

Like this the cycle of immersion in the solution and drying shall be continued for five times or ten times as required.

After final cycle, the samples are cooled, washed free from sodiumsulphate and dried to constant weight at temperature 105º to 110ºC. These shall be sieved through sieves as mentioned below as weighed and noted percent loss shall be noted.

Size of Aggregate (mm)	Sieve used to determine loss (mm)
63-40	31.5
40-20	16.0
20-10	8.0
10-4.75	4.0

The results are calculated as below:

Passing average Percent	Retained	Grading of original sample	Weight of the test fraction before test	Percentage passing finer sieve after test (actual percent loss)	Weight (corrected loss) 5x3/100
63	40	20	3000	4.8	0.96
40	20	45	1500	8.0	3.60
20	10	23	1000	9.6	2.20
10	4.75	12	300	11.2	1.34
		100	5800		8.10

Specifications

As per IS 383-1970 page 7, the average loss of weight after five cycles shall not exceed the following:

For fine aggregates 10 percent when treated with sodium sulphate solution

For coarse aggregates :12 percent when treated with sodium sulphate solution

Precautions:

The sample shall be thoroughly washed and then oven dried to constant weight at 105ºC to 110ºC

The oven dried sample shall be immersed in solution for not less than 16 hours and not more than 18 hours.

Temperature of the solution shall be kept at 27º $\pm$ 2ºC.

Saturated solution of sodium sulphate shall be prepared as per IS: 255-1950.

ANNEXURE 3/4

TESTING OF CEMENT
(IS; 4031-1988)

INTRODUCTION

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete- which is a combination of cement and an aggregate to form a strong building material. The two main things must essentially follow at the time of use of cement are:-

(i) Cement older than 3 months should not be used at any place without testing.
(ii) Cement older than 6 months should not be used in any important structure.

For suitability of use of the cement, standard methods of its various tests have been adopted to acquire the requisite specifications as referred by ISI Certain methods of tests and specifications are given as below:

DETERMINATION OF FINENESS OF CEMENT BY SIEVING, IS: 4031 (Part-1) 1996 Reaffirmed 2005

Purpose:

To check the fineness with the standard specifications prescribed by ISI.

Equipments:

Weighing balance, weight box, IS Sieve No.9.

Staff:

Laboratory Technician and Laboratory Attendant.

Procedure:

100 gms. of cement shall be weighed and taken on IS Sieve No.9. It shall be continuously sieved for 15 minutes. The residue left on the sieve shall be weighed and percentage retention thus shall be determined.

Residue shall not exceed 10% for ordinary cement & 5% for rapid hardening cement.

Precautions:

Air set lumps in the cement shall be broken with fingers.

Sieving shall be done with gentle wrist motion.

The underside of the sieve shall be lightly brushed with a 25 or 40 mm brittle brush after every 5 minutes of sieving.

SPECIFIC SURFACE OF CEMENT
By Blain's Air Permeability Method
(IS: 4031 (Part-2) 1999 Reaffirmed 2004

Purpose:

For checking the standard prescribed by ISI Specifications.

Equipments:

Blain's air permeability apparatus, specific gravity bottle, balance, weight box, filter paper, non-volatile, non-hydroscopic liquid i.e. light mineral oil (kerosene oil).

Staff:

Research Assistant and Laboratory Attendant.

Procedures:

Specific gravity of cement shall be determined with the help of specific gravity bottle and kerosene oil. Cement required for 0.530 $\pm$ 0.005 porosity for the volume of the cell shall be weighed. It shall be then packed into the cell, keeping filter-paper, discs at the bottom and at the top, and consolidated to 0.530 $\pm$ 0.005 porosity. The top cylinder shall then be removed. The permeability cell shall be attached to the manometer tube, making certain that an airtight connection is obtained. Air shall be sucked out, thereby raising level of liquid in one tube and shall be brought above the top mark. The stop cock shall then be closed and the level allowed to fall due to air pressure exerted by the air after passing through cement. The time taken for the level to fall from the top mark to the lower mark shall be noted. The test shall be repeated twice and average taken. Specific surface shall be then determined.

Computations:

Wt. of cement = Volume of cell x e x S.g.

Where e is the porosity and S.g. is the specific gravity.

Sw = K √T Where Sw is the specific surface, in m^3/kg of the total sample.

K is constant for the apparatus which is determined by use of cement of known specific surface and T is time in seconds.

As per IS: 269-1976, page 7 specific surface for ordinary portland cement shall not be less than 2250 sq. cm/gm.

Precautions:

Standard cement sample shall be used for calibration of the instrument.

At least 3 determinations shall be made for calibration of the instrument.

The connections shall be air tight.

DETERMINATION OF SPECIFIC GRAVITY OF CEMENT
IS: 1727-1967 Reaffirmed 2004

Purpose:

To conform the quality and the period of manufacture of cement.

Equipments:

Le-Chatelier's flask, kerosene oil, balance and weight box etc.

Staff:

Research Assistant and Laboratory Attendant.

Procedures:

The flask shall be filled with kerosene oil to a point on the stem between zero and 1 ml. mark. The flask shall be placed in constant temperature water bath so that at all the times temperature shall remain the same. The flask may be champed in the burete stand clamp.

Then a weighted quantity of cement (say 64 gm) shall be introduced in small amounts by taking care to avoid splashing and cement shall not be adhered to the inside of the flask. The volume rise in the flask shall be noted and calculations completed.

$$\text{Specific Gravity} = \frac{\text{Weight of cement}}{\text{Displaced volume in ml}}$$

Duplicate determination is to be made.

Note: The flask shall be cleaned with warm sodium carbonate solution as acid cleaning shall not be effective owing to the deposition of salicylic acid gel.

As per specification, specific gravity of cement is 3.15.

Precautions:

The inside of the flask shall be dry.

While introducing the cement in the flask care shall be taken to avoid splashing and cement adherence to the inside of the flask.

The cement shall be made free from air in the flask by rolling.

The flask shall be immersed in a constant temperature water bath.

DETERMINATION OF CONSISTENCY OF CEMENT
IS: 4031 (PART 4)(1988 Reaffirmed 2005

Purpose:

The object of conducting this test is to determine the quantity of water for the completion of various tests of cement such as initial setting time, final setting time as well as compressive strength of cement.

Equipments:

Vicat apparatus with plunger of 10 mm dia, balance, weight box, trowel.

Staff:

Research Assistant and Laboratory Attendant.

Procedures:

400g of the cement shall be taken and mixed with a measured quantity of water. The time for mixing shall be maintained between 3-5 minutes. The vicat mould shall then be filled with this paste and the surface shall be smoothened.

The plunger shall then be brought in contact with the surface of cement and allowed to penetrate freely. The vicate plunger shall be penetrating to a point 5 to 7 mm, from the bottom of the vicate mould. This much quantity of water added to cement is termed as the consistency of the cement. If the penetration is less or more than the specified, a fresh paste shall be prepared with less or more water accordingly, till the consistency is reached. Its range shall be from 28% to 33% approximate.

Precautions:

The time of gauging shall be 3 to 5 minutes.

The gauging time shall be counted from the time of adding water.

Clean appliances shall be used for gauging.

The temperature shall be maintained at $27^{o} \pm 2^{o}C$.

DETERMINATION OF INITIAL AND FINAL SETING TIME OF CEMENT IS: 4031 (PART-5) 1988 Reaffirmed 2005

Purpose:

This test shall be performed to conform the quality and the age of cement lying in the store.

Equipments:

Vicat apparatus with initial and final setting time needles, trowels, measuring jar, balance and weight box.

Staff:

Research Assistant and Laboratory Attendant.

Procedures:

A cement paste shall be prepared by gauging cement with 0.85 times the water to give a paste of standard consistency. Time shall be noted just when water is added to make paste of the cement. The Vicat mould kept on non-porous plate is filled up with the paste and smooth off the surface of the paste making it level with the top of the mould.

The initial time setting needle shall be fitted with the Vicat apparatus and brought to the surface of the paste and released in the beginning, the needle is completely pierced. The process shall be repeated till the needle is unable to penetrate 5-7mm, from bottom of the mould shall be recorded. This time is known as the initial setting time of the cement.

Final setting time needle shall be fixed in the Vicat apparatus. The needle shall be gently lowered on the test block and impression of the needle and attachment shall be noted on the test block. So long there shall be no impression of the attachment of the test block i.e. only the impression of the needle is noticed, the final setting time shall be noted since the first addition of water to make paste.

AS PER IS; 269-1976 PAGE 7

Initial setting time	:	Not less than 30 minutes
Final setting time	:	Not more than 10 hours

Precautions:

Vicate apparatus shall be as per IS: 5513-1976

Clean appliance shall be used for gauging

Temperature during the test shall be $27^{o}\pm2^{o}C$.

Non-porous plate for gauging shall be used.

Setting time needles shall be lowered gently and brought in contact with surface of the test block and then quickly released for penetration.

SOUNDNESS TEST FOR CEMENT BY LE-CHATELIER'S METHOD
(IS: 4031 PART-3) - 1988 Reaffirmed 2005

Purpose:

Due to the presence of free lime in the cement sometime, the expansion is caused and hence cracks develop. This test shall be conducted to determine the expansion of the cement.

Equipments:

Le-Chatelier's Mould, measuring jar, Trowels, Hot water bath.

Staff:

Research Assistant and Laboratory Attendant.

Procedures: Chatelier's mould shall be placed on the glass sheet and shall be filled up with cement paste by gauging cement with 0.78 times the water required to give a paste of standard consistency. The mould shall be kept in good condition with the jaws not more than 0.5 mm apart.

The mould shall be covered with another piece of glass sheet. A small weight is placed over it and then whole assembly is immediately submerged in water at a temperature of 27º $\pm$ 2ºC and kept for 24 hours and relative humidity of 50 to 80%.

Results:

The distance separating the indicator points shall then be measured. The whole assembly shall again be submerged in the water at the same temperature. Water shall be brought to boiling point and kept boiled for 3 hours with the assembly submerged. The mould shall be removed from water and allowed to cool. The distance between the indicator points shall then be measured again. The difference between two measurements gives the expansion of cement. As per IS: 269-1976 page 7 expansion shall not be more than 10 mm.

Precautions: The temperature during the test shall be maintained at 27º $\pm$ 2ºC.

The whole assembly shall be immersed and then initial reading of indicator points be taken.

Clean appliances shall be used.

COMPRESSIVE STRENGTH

IS; 4031 (PART 6) 1988 Reaffirmed2005

IS: 4031 (PART 7) 1988 Reaffirmed 2005

Purpose:

This test shell be conducted to confirm about the quality of cement.

Equipments:

Vibration machine, compression testing machine, standard sand, 50 mm cube moulds 6 Nos. trowel, tamping rod, scales and weight box.

Staff:

Research Assistant and Laboratory Attendant.

Procedures:

For casting cubes, cement and standard sand in the ratio of 1:3 by weight shall be taken and uniformly mixed in dry state for one minute. The quantity of water shall be added according to formula (P/4 + 3.00) percent of combined weight of cement and sand, where 'p' is the percentage of water required to produce a paste of standard consistency of cement 9Normal consistency of cement).

Immediately after mixing the mortar, mortar shall be placed in the mould and rodded 20 times in about 8 seconds to ensure elimination of entrained air and honey combing. The remaining mortar shall be filled in the moulds an rodded again just as in first layer. Then the moulds shall be placed on the virbration machine for compaction. In this way 6 Nos. of cubes shall be casted.

The filled mould shall be kept at temperature of 27º $\pm$ 2ºC. In an atmosphare of at least 90 percent or more relative humidity for 48 to 52 hours after completion of vibration. At the end of above period, the cubes shall be removed from the moulds and kept submerged in clean water upto the period of testing.

These shall be tested after 3 days and 7 days three each time and average compressive strength shall be calculated. As per IS: 269-1976 page 8.

3 days strength : 160 kg/cm2 for ordinary

7 days strength : 220 kg/cm2 Portland cement

Precautions:

The specimens shall be clean and the moulds shall be well greased.

The vibration machine shall be of the standard as per IS: 4031-1968

The temperature shall be maintained at $27^{o} \pm 2^{o}C$

Mixing of mortar shall be done on non-porous plate.

First of all dry mixing shall be done and then water be added.

Time for mixing and gauging shall be between 3 and 5 minutes.
Period of vibration shall be 2 minutes.

ANNEXURE 3/5

TESTINGS FOR POZZOLANA

(IS: 1727-1967) Reaffirmed 2004

Burnt clay pozzolana is manufactured by calcinations of clay under controlled conditions at suitable temperature and grinding the resulting product to the required fineness.

FLY ASH

Fly ash is a waste product of thermal power stations. It is a fine powder transported by the gases and is collected by electrical or mechanical precipitators.

It behaves as a highly potential pozzolanic material. It is a siliceous material and does not possess any cementitious properties. In finely, divided form, it reacts in the presence of water with lime liberated during hydration of cement at normal temperature to form compounds having cementitious properties.

SILICA FUME

Silica fume is a by-product resulting from the reduction of high-purity quartz with coal or coke chips in an electric arc furnace during the production of silicon metal or ferrosilicon alloys. The silica fume, which condenses from the gases escaping from the furnaces, has a very high content of amorphous silicon dioxide and consists of very fine spherical particles .

In order to effect economy in the construction these can be advantageously replaced by part of cement without imparting the ultimate strengthened at the same time improving the durability, impermeability, workability of mix, reducing the effect of bleeding and segregation and resisting the attack of sulphate action and finally improving the stress adjustment characteristics.

SURKHI OR CALCINED CLAY POZZOLANA: It is a reactive pozzolanic material, shall conforms to IS; 1344-1981.

It is obtained by powdering of brick bats in respect of the proportion of active clay constituents which in the case of brick-bats would be lower to the extent that it is necessary to blend sandy ingredients in brick-making clays. Surkhi generally produced is much coarser.

Various tests are therefore need to conducted as described below:

DETERMINATION OF FINENESS (IS1727-1967): This test is conducted to determine the suitability of pozzolanas Fineness is an important property as finer the material the greater is the reactivity. It is determine by two types described as follows:

(A) SPECIFIC SURFACE METHOD (IS: 1727-1967, PAGE 13) Reaffirmed 2004

Purpose:

The test shall be conducted to know the fineness for checking with the standard specification.

Equipments:

The Blain's air permeability apparatus, Filter paper No. 40 (Whatman), Stopwatch, Balance, Weight box, Kerosene oil (light mineral oil) and mercury Manometer.

Staff:

Research Assistant and Laboratory Attendant.

Procedure:

First of all, the air permeability apparatus shall be calibrated by using a standard sample of cement approved by National Bureau of Standard (N.B.S.0 No. 114 or any other cement sample having specific surface equal to the appropriate certificate value of NBS standard sample No. 114. The sample shall be at room temperature when tested.

After wards the bulk volume of the compacted bed of powder shall be determined by the mercury displacement method. The permeability cell shall be filled with mercury by placing two filter paper discs below the mercury in the cell and weighing of this mercury and then about a trial quantity of cement i.e. 2.8gm. shall be taken in the cell and compacted. The remaining space in the cell shall be filled with mercury. The mercury shall be removed from the cell and weighed.

The bulk volume occupied by the cement shall be calculated as follows:-

$$V=\frac{Wa-Wb}{D} \qquad \text{..... (1)}$$

Where V = Bulk volume of cement in cm^3.

Wa = grams of mercury required to fill cell, no cement being in cell.

Wb = grams of mercury required to fill the portion of the cell not occupied by the prepared bd of cement in the cell.

D = density of mercury at temperature of test in g/cm^3.

At least two determinations of bulk volume of cement shall be made and average of the two shall be used in calculations.

The weight of the standard sample used for the calibration test shall be that to produce a bed of cement having a porosity of 0.500 ± 0.005 and shall be calculated as follows:

$W = CV (1-e)$ .....(2)

Where W = sample required in grams;

c = specific gravity of test sample (for port land cement, a value of 3.15 shall be used).

v = bulk volume of bed of cement in cm^3 as determined above.

e= desired porosity of bed of cement (0.500 ± 0.005).

The perforated disk of the permeability cell of Blain Air permeability apparatus shall be seated and a filter paper disk shall be placed on the metal disk and pressed. a quantity of cement as determined above shall be weighed and shall placed in the cell. The side of the cell shall be tapped lightly in order to level the bed of the Cement. A filter paper disk shall be placed on the top of the cement and the cement compressed with the plunger until the plunger collar is in contact with the top of the cell. The pluger shall then be removed slowly. Fresh disks shall be used for each determination.

Permeability cell shall be attached to the manometer U-tube. The air in one arm of the manometer U-tube shall be slowly evacuated until liquid reaches the top mark, and the valve shall then be closed tightly. The stop watch shall be started and the time interval in seconds shall be noted as the liquid reaches the next mark.

In calibration of the instrument, at least three determinations shall be made.

Similarly as given above test shall be done with pozzolana sample and calculations be made as follows:

$$S = \frac{S_s P_s (1-e_s)\sqrt{e^3\sqrt{T}}}{p(1-e)\sqrt{e_s^{\,3}\sqrt{Ts}}} \qquad \text{.....(3)}$$

$$S = \frac{S_s P_s (1-e_s)\sqrt{n_s\sqrt{e^3\sqrt{T}}}}{p(1-e)\sqrt{e_s^{\,3}\sqrt{Ts}\sqrt{n}}} \qquad \text{.....(4)}$$

Note:- Equation '3' shall be used when the temperature of test and of the test sample is within $\pm$ 3ºC of the temperature calibration test of the standard fineness sample and other wise equation 4 to be used.

Where

S = Specific surface in cm^2/g of the test simple

Ss= Specific surface is cm^2/g of the standard sample used in calibration of the appratus.

Ps = Specific gravity of standard sample used in calibration of apparatus (assumed to be 3.15).

e_s= Porosity of prepared bed of standard sample used in calibration of apparatus;

e = Porosity of prepared bed of test sample;

T = Measured time interval, in seconds of manometer drop for test sample.

p = Sp. gravity of test sample.

Ts = Measured interval in seconds of manometer drop for standard sample used in calibration of the appratus;

n_s = Viscosity of air in poises at the temperature of test of the standard sample used in calibration of appratus;

n = Viscosity of air in poises at the temperature of test of the test sample.

Values of $\sqrt{n}$ and $\sqrt{e^3}$ may be taken from tables 1 and 2 of IS; 1727 - 1967 page 17 and 20.

SPECIFICATIONS AS PER IS: 1344-1988, PAGE 6

3200 cm^2/g Min. lower value upto 2250 cm^2/g may be accepted provided requirements of strength

and other properties are met satisfactorily.

Precautions:

The calibration shall be done by the same operator who makes the fineness determination

The temperature of test shall be noted and recorded in degrees centigrade

Pozzolana sample shall be tested at room temperature.

The prepared bed of cement shall be firm.

(B) BY SIEVING (IS: 1727-1967, PAGE 21) Reaffirmed 2004

Purpose:

This test shall be conducted to determine the suitability of pozzolana. Fineness is an important property. Finer the material, the greater is the reactivity.

Equipments:

For Dry Sieving: 300-micron IS Sieve, 150-micron IS Sieve.

For Wet Sieving: 75 and 45- micron IS Sieve

Wash bottle (500ml), Balance, Weight Box and trays etc.

Staff:

Laboratory Technician and Laboratory Assistant.

Procedure:

Dry Sieving:

Representative sample not less than 200 gms shall be taken and shall be sieved through 300-micron IS Sieve and 150-micron IS Sieve starting with the largest.

Wet Sieving:

100 gms of the material shall be taken and washed with a jet of water by keeping the sample on 75-

micron IS Sieve and 45-micron IS Sieve separately. Washing shall be continued till the washings appear no more turbid. the sieve and the residue shall be dried in the oven and the residue shall be weighed. hence the percentage retained on the sieves shall be calculated.

Specifications (As per IS: 1344-1981, PAGE 6)

Residue by weight on 45-micron IS Sieve after wet sieving shall be 12% maximum.

Precautions:

A representative sample shall be taken.

Separate determinations shall be made for the percentage of material passing 75-micron IS Sieve and 45-micron IS Sieve by wet sieving.

Washing shall be continued till no more turbid water appears.

DETERMINATION OF LIME REACTIVITY (SOUNDNESS TEST)
(As Per IS; 1727-1967, PAGE 22) Reaffirmed 2004

Purpose:

This test shall be performed for determining the reactivity of the pozzolanic material with hydrated lime as represented by compressive strength of standard mortar test cubes prepared and tested under specific conditions.

Equipments:

50mm cube moulds, Mixing apparatus as per IS: 1727-1967 Page 24 and 25, Flow table, tamping rod, trowels, compression testing machine, balance, weight box and trays etc.

Staff:

Research Assistant and Laboratory Attendant.

Procedure:

First of all the specific gravity of pozzolana and lime shall be determined by Le-Chatelier's flask. Then the amount of water for gauging which shall be equal to that required to give a flow of 70 $\pm$ 5 percent with 10 drops in 6 seconds be determined by making trial mortars with different percentages

of water until specified flow shall be obtained at the flow table.

The dry materials of the standard test mortar shall be Lime : pozzolana : Standard sand in proportion 1 : 2 M :9 by weight blended intimately .

$$\text{Where M (is multiplication factor)} = \frac{\text{Specific gravity of pozzolana}}{\text{Specific gravity of lime}}$$

The following quantities of materials for preparation of mortar for six test specimens are suggested.

150 gms. : Hydrated lime

300 x M/g : Pozzolana

1350 gms : Standard sand

The mixing of the material shail be done mechanically by means of mixing apparatus in the following manner.

(a) Place all the mixing water in the bowl.

(b) Add the pozzolanic mixture to the water, then start the mixer and mix at the slow speed (140 + 5 rev/min) for 30 seconds.

(c) Add the entire quantity of sand slowly over a period of 30 seconds, while mixing at slow speed.

(d) Stop the mixer, change to medium speed (285 $\pm$ 10 rev/min) and mix for 30 seconds.

(e) Stop the mixer and let the mortar stand for one and a half minutes. During the first 15 seconds of this interval, quickly scrape down into the batch any mortar that may have collected on the side of bowl, then for the remainder of this interval cove the bowl with the lid.

(f) Finish by mixing for one minute at medium speed (285 $\pm$ 10 reve/min.)

Upon the completion of mixing the mixing paddle shall be shaken to remove excess mortar into the mixing bowl.

Just after the preparation of the mortar, mortar shall be placed in a 50mm cube mould in a layer of about 25 mm thickness and lamp 25 times with the tamping rod. Similarly second layer shall be filled up in the mould and tamping is done 25 times.

Storage and Curing of Specimen:

The specimens in the mould shall be covered with greased glass plate and are covered with wet gunny bags for 48 hours. Then specimens shall be removed from the moulds and cure at 90-100% relative humidity at the temperature of 50º $\pm$ 2ºC for a period of eight days Samples shall not be cured under water.

Note: This may be achieved by keeping the specimens in wide mouth jar with screwed lid over with a galvanized iron sheet platform placed at the bottom of the jar. The platform shall covered with a piece of paper water is kept to a depth of about 10mm at the bottom, below the level of the platform. After placing the specimen, the lid shall be fitted and kept in the incubator at the temperature of 50º $\pm$ 2º for eight days.

The cubes shall be tested for their compressive strengthafter they reach the room temperature. Not less than three cubes shall be tested.

Specifications:

Specification as per IS: 1344-1968 page 6.

50 kg/cm^2 Mix.

Precautions;

Clean appliances shall be used for mixing.

The temperature when mixing operation is being performed, shall be 27º $\pm$ 2ºC

Flow table top shall be clean and dry.

Curing of the test specimens shall not be done under water.

Curing in the incubator shall be done at the relative humidity 90 to 100 percent and at the temperature 50º $\pm$ 2ºC.

The cubes shall be tested in the compression testing machine without any packing.

DETERMINATION OF COMPRESSIVE STRENGTH OF POZZOLANIC CEMENT MORTAR (IS: 1727-1967) Reaffirmed 2004

Purpose:

This test shall be conducted for the determination of the compressive strength of the pozzolana mortar and to be compared with the compressive strength the of the cement.

Equipments:

Cube moulds 50mm, mixing apparatus, flow table, tamping rod and trowel, compression testing machine, balance, weight box, trays, measuring cylinder etc.

Staff:

Research Assistant and Laboratory Attendant.

Procedure:

The dry materials for the standard test mortar shall be pozzolana: cement: Standard Sand in the proportion 0.2N : 0.8: 3 by weight blended intimately.

$$\text{Where } N = \frac{\text{Specific gravity of Pozzolana}}{\text{Specific gravity of cement}}$$

The amount of water for gauging shall be equal to required to give a flow of 105 + 5% with 25 drops in 15 seconds as stated in lime reactivity test.

The following quantities of materials for preparation of mortar for six test specimens, are suggested:

100x N g Pozzolana

400g Cement

1500g Standard sand

The materials shall be mixed in the mixing apparatus as mentioned in lime reactivity test. Then the cube moulds which are well greased before hand shall be filled up in two layers by roding 25 times for each layer and making them plain from the above. These shall be kept at the temperature of 27º

± 2ºC in an atmosphere of at least 90 percent relative humidity for 24 hours. At the end of this period the test cubes shall be removed from the moulds and immediately submerged in clean fresh water until taken out just for testing. At least three cubes for compressive strength shall be tested at the period of 7, 28 and 90 days, the period being reckoned from the completion of compaction.

In the same way as mentioned above, corresponding test on plain cement-sand mortar cubes is also conducted i.e. the proportion shall be 1:3 of the same cement and standard sand.

Specifications as Per IS: 1344-1981 PAGE 6

Average compressive strength shall be obtained by testing at least three mortar cubes:

(i)At the age of 28 days: Not less than 80% of the strength of corresponding plain cement mortar cube at 28 days.

(ii)At the age of 90 days: Not less than the strength of the corresponding cube cast from the same mix tested at 28 days.

Precautions:

Same as per lime reactivity test except the test specimens shall be submerged in water after 24 hours in the mould at 27º ± 2ºC.

DETERMINATION OF SPECIFIC GRAVITY OF POZZOLANA

(As per IS: 1727-1967, Page 47)

By Lechatelier's Flask Method, already describe in testing of Cement . Follow as it is with pozzolanic material in place of cement.

ANNEXURE 3/6

TESTING OF CONCRETE

GENERAL

Concrete is made with Cement, Sand, coarse aggregate and water but additives and admixtures can also be used for modifying and improving the properties of concrete. The mixture of the four main ingredients is consolidated to a hard mass due to the Chemical reaction between cement and water. Each of the four ingredients has its separate function. Coarse aggregate acts as a main filler, Sand (fine aggregate) fills in the voids in the coarse aggregate. Cement and water forms the binder.

The science of proportioning of concrete is therefore mainly concentrated on the principle of obtaining a durable and strong concrete at the most economical rate possessing a good workability.

SLUMP TEST OF CONCRETE
(IS: 1199-1959) Reaffirmed 2004

Purpose:

This test shall be conducted to determine the consistency of concrete and hence workability. Workability means the case with which concrete can be handled, transported and placed.

Equipments:

Slump Test Apparatus, Tamping rod; Scale.

Staff;

Lab Technician and Lab Assistant

Procedure:

Slump cone mould shall be cleaned and kept on plain non-absorbent surface. The mould is filled to one forth capacity with concrete and tamped 25 strokes with standard rod of bullet pointed end. This process shall be repeated in the same way for second third final layers.

The excess of concrete above the top level of the cone shall be stuck off with tamping rod. The mould is removed from the concrete immediately. This allows the concrete to subside and the slump

is measured being the difference between the height of the mould and that of the highest point of the specimen under test.

Precautions :

1. Slump cone and plane surface shall be thoroughly cleaned before the test is started.

2. Strokes shall be counted carefully shall be well distributed.

COMPRESSIVE STRENGTH OF CONCRETE
(IS: 516-1959) Reaffirmed 2004

Purpose:

Concrete is a variable material. The quality of concrete is usually assessed from the results of crushing strength test on concrete cubes or cylinders.

Equipments:

1. Compression testing machine of 200 tones capacity.

2. Cube moulds 15 cm size or cylinders of 15 cm dia and 30cm height.

3. Tamping rod or vibrator;

4. Trowels etc.

Staff:

Research Assistant and Lab Attendant.

Procedures:

Cube moulds of 15 cm. size or cylinder 15 cm dia and 30 cm in height shall be taken and cast with freshly prepared concrete compaction shall be done in which the number of strokes each time by standard rodding shall not be less than 30 per layer for cylindrical specimen and the number of strokes shall not be less than 35 per layer for cubical specimen. The concrete shall be filled in to the mould in the layers of approximately 5 cm. in depth. The moulds shall be kept overnight under a wet gunny bag and opened after 24 hours. Cubes or cylinders shall be kept for curing. Compressive strength shall be tested at 7 days and 28 days. At least three cubes must be tested and average shall

be taken. These strengths can be compared with the designed or required strengths.

Calculations:

Let load for failure = X tonnes = X x1000 kg.

Area of cube or cylinder = a sq. cms.

$$\text{Compressive strength} = \frac{X \times 100 \text{ kg.}}{a} \quad (Kg/cm^2)$$

Precautions :

1. The temperature shall be 27º $\pm$ 2ºC in the laboratory and in the field temperature shall be 22º to 32ºC

2. Sampling shall be according to IS; 1199 - 1959

3. Frequency of sampling shall be according to IS; 456-1978, page 41.

4. While testing the strength is shall not vary more than 15%

5. The surfaces of the test samples shall be quite smooth and plain

6. Moulds shall be properly greased before casting.

PERMEABILITY TEST OF CEMENT MORTAR AND CONCRETE
(IS: 3085-1965) Reaffirmed 2011

Purpose:

Permeability of cement, mortar and concrete shall be particular significance in structure which shall be intended to retain water or which shall come into contact with water. it is intimately related to the durability of concrete. Hence it is of considerable importance.

Equipments:

Permeability cell, water reservoir, Pressure assembly, supply of compressed air, measuring jar, grinding machine and a watch etc.

Staff;

Research Assistant and Lab. Attendant.

Procedures:

Test procedure shall be based upon the principle of subjecting the mortar or concrete specimen of known dimensions. Contained in a specially designed cell, to a known hydrostatic pressure form one side and measuring the quantity of water percolating through it on the other side during a given interval of time. The results so obtained shall be computed as the co-efficient of permeability.

Test specimens shall be prepared by cutting of specific sizes shall be fitted into the permeability cell. Generally test pieces size shall be 150mm dia and 150mm height. Test specimen size shall be four times than the maximum size of the aggregate present in the concrete. Exact dimensions of the test specimens shall be recorded.

The test specimens shall then be sealed properly by pouring hot mixture or paraffin wax and resin seal shall be cleared from the test area on the top and bottom of the sample. The top plate shall then be tightened and the sealing shall be tested before the test is started by filling water in the cell. The pressure shall then be raised slowly. The pressure shall be ranging from 5 kg/sq.cm, and kept constant till the test is over. The discharge through the sample is collected and measured at convenient intervals of time till it becomes constant. The test thus shall be continued for 100 hours. The co-efficient of permeability shall be calculated.

The co-efficient of permeability.

$$K = \frac{Q}{AT\frac{H}{L}}$$

Where

K = Coefficient of Permeability, in cm/sec.

Q = quantity of water in ml. percolating over the entire period of test after steady state has reached;

A = Area of the specimen incm^2;,

T = Time in seconds in which Q is measured: and

H/L = Ratio of the pressure head to thickness of specimen, both expressed in same units.

Precautions :

1. The test specimens shall be prepared carefully by keeping the top and bottom surfaces rough for proper sealing.

2. The connections shall be thoroughly tightened so that there shall be no leakage from any side.

3. The pressure shall be raised slowly.

RAPID ESTIMATION OF CEMENT IN MORTAR AND CONCRETE
(Method given by the Deputy Director, Research, Patna)

Purpose:

This test shall be conducted to analyses the mortar/concrete with respect to their proportions of the mixed ingredients in the mortar/concrete. This test shall be based upon the determination of calcium content in the mortar, cement and sand.

Equipments:

IS Sieves 850 & 300- microns, chemical balance and weight box, Pestle and mortar, heater, burette, pipette, graduated cylinders, beakers etc. Hydrochloric Acid, ammonium Hydroxide, Sulphuric Acid, Glacial Acetic Acid, Ammonium Oxalate, Potassium Permanganate, Whatman filter paper No. 40 and 42 etc.

Staff:

Research Assistant and Lab. Attendant.

Procedure:

The concrete sample shall be taken. The mortar shall be separated and the material shall be sieved through IS Sieve 850-micron. The material retained on this Sieve shall be taken as metal which is weighed as X' g. The material passing IS Sieve 850-micron is taken as matrix and weighed as 'Y' g.

Matrix or mortar about 10 g shall be taken and after grinding whole of it and shall be passed through IS Sieve 300 micron. Complete grinding shall be done, till the whole mortar has passed through the IS Sieve 300-micron.

One g of the finely powdered mortar shall be taken and digest it with 10-15 ml. of conc. Hydrochloric Acid for 3 to 5 minutes. The solutions shall then be filtered, washed and shall be made up to 100 ml out of which 50 ml shall be just neutralized with Ammonium Hydroxide. The precipitate of Aluminium Oxide and Ferric Oxide etc. thus formed shall be dissolved by just the quantity of Glacial Acetic acid.

It may be noted that 1.00 ml. on N/10 kMnO4 solution is equivalent to 0.002 g of calcium.

Calculations:

Note: As calcium content in cement varies from 36% to 44% so average %age of calcium in cement is taken as 39% for calculations and 2% in sand.

I. Mortar analysis:

$$\frac{CaC-CaM}{CaM-CaS}=n$$

Let the ratio be 1:n by weight

CaC = Calcium percent in cement

CaM = Calcium percent in mortar

CaS = Calcium percent in sand

II. Proportion in concrete

Let the ratio be 1:n : (1+n) $\frac{X}{Y}$

Where

n = sand

X = Weight of metal in the sample

Y = Weight of mortar in the sample.

DENSITY AND AIR CONTENT OF FRESH CONCRETE: It is used to determine the entrapped air percentage in fresh concrete.

NON DESTRUCTIVE TESTS

Non-destructive tests are used to obtained estimation of the properties of concrete in the structure. The methods adopted include Ultra sonic pulse velocity meter {IS: 13311 (Part 1)} and Rebound hammer { IS 13311 (part 2)}. Non Destructive tests provide alternatives to core tests for estimating the strength of concrete in a structure, or can supplement the data obtained from a limited number of cores. These methods are based on measuring a concrete property that bears some relationship to strength. The accuracy of these methods in part, is determine by the degree of correlation between strength and the physical quality measured by the non destructive tests.

ULTRASONIC PULSE VELOCITY METER:

OBJECT:

The ultrasonic pulse velocity test measures the velocity of ultrasonic pulses of longitudinal vibrations passing through hardened concrete and can be used for the following purpose:

(i) The homogeneity of the concrete

(ii) The presence of crakes, voids and other imperfections.

(iii) Changes in the structure of the concrete which may occur with time.

(iv) The quality of the concrete in relations to standards requirements.

(v) The quality of one element of concrete in relation to another, and

(vi) The values of dynamic elastic modulus of the concrete.

Principles involved: The velocity of the ultrasonic pulses is influenced by those properties of concrete which determine its elastic stiffness and mechanical strength. The variations obtained in a set of pulse velocity measurements made along different paths in a structure reflect corresponding variations in the state of concrete.

When a region of low compactions, voids or damaged material is present in the concrete , a corresponding reduction in the calculated pulse velocity occurs and this enables the approximate extent of the imperfections to be determined.

A pulse of longitudinal vibrations is produced by an electro-accoustal transducer which is held in contact with one surface of the concrete under test. After transversing a known path length L, in the concrete, the pulse of vibrations is converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time ,T, of the pulse to be measured an display on a digital scale.

The pulse velocity , v in km/s or m/s is given by

V=L/T where L= path length and T= time taken by the pulse to travel the given length.

An ultrasonic pulse of vibrations is used instead of sonic frequency for two reasons:

(i) To give the pulse a sharp leading edge.

(ii) To generate maximum energy in the direction of propagation of the pulse.

(Detailed procedure are given in IS: 13311, (Part 1), 1992

REBOUND HAMMER:

OBJECT: The Rebound Hammer could be used for:

(i) Assessing the likely compressive strength of concrete with the help of suitable co-relation between rebound index and compressive strength.

(ii) Assessing the uniformity of concrete.

(iii) Assessing the quality of the concrete in relation to standard requirements and

(iv) Assessing the quality of one element of concrete in relation to another.

Principles involved: The test is based on the principle that the amount of rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. In a rebound hammer test, a spring loaded mass has a fixed amount of energy imparted to tit by pressing the plunger against the surface of the concrete under test. Upon release the mass rebounds from the plunger still in contact with the concrete surface. The distance travelled by the mass expressed as a percentage of the initial extension of the spring is called the rebound number. This is indicated by a rider moving along a graduated scale.

(Detailed procedure are given in IS: 13311, (Part 2), 1992

TESTING OF CORE SPECIMEN FROM HARDENED CONCRETE:

Reference: Design Series- Technical Circular No. 57 (Issued Vide memo no. 3484002/BODHI/Specification/TC Dated 23.10.2013)

Scope:

This circular lays down criteria and requirements of test specimen and acceptance criteria for hardened concrete.

Importance:

The most reliable measures of the actual strength of concrete in the structure can be obtained by testing core specimen of hardened concrete obtained from the structure. Also this test is helpful when the designed load on the structure is to be enhanced some times during its service life to

accommodate some modifications in the uses and occupancy of the structures than originally proposed for:

References:

IS Code	Title
IS-456	Code of practice for plain and reinforced concrete
IS-457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
IS-516	Methods of tests for strength of concrete
IS-1199	Methods of sampling and analysis of concrete
IS-3873	Code of practice for laying cement concrete/ stones slab lining on canals.
Sp-23	Handbook on concrete mixes (based on Indian Standards)

Test Specimen:

A core specimens shall have a diameter at least three times the maximum nominal size of the coarse aggregate used in the concrete and in no case shall the final diameter of the specimen be less than twice the maximum nominal size of the coarse aggregate. The length of the specimen, when capped shall be, as nearly as practicable, twice its diameter. In no cases fewer than three cores are tested for concrete laid on single day. The core shall be prepared and tested as mentioned in IS 1199, IS 457 and IS516.

Calculations and Report:

The direction of the application of the load with reference to direction of compaction of the concrete in the structures shall be reported. The compressive strength of each specimen shall be calculated in Kg per sq cm based on the average diameter of the specimen. If the ratio of length to diameter of the specimen is appreciably less than two, allowance for the ratio of length to diameter shall be made by multiplying the compressive strength by the applicable correction factor given in the following table. Values not givenin the table shall be determine by interpretation.

Table 1

S.No.	Ratio of length of cylinder to diameter	Strength correction factor
1	1.75	0.98
2	1.50	0.96
3	1.25	0.94
4	1.10	0.90
5	1.00	0.85

6	0.75	0.70
7	0.50	0.50

The core strength is ultimately required to be expressed in terms of equivalent cube strength acceptance purposed. The equivalent cube strength of the concrete shall be determined by multiplying the corrected cylinder strength by 5/4.

Acceptance Criteria:

The average equivalent cube strength of the cores is equal to the least 85 % of the cube strength of the grade of concrete specified for the corresponding age.

No individual core has strength less than 75 % of the cube strength of the grade of concrete specified for the corresponding age.

DESIGNS OF CONCRETE MIX:

The proportion of cement, fine and coarse aggregate will be given after tests are carried out in the laboratories in accordance with the specifications laid dowm. It should be done as per the Guidelines given in IS 456, 10262 and IS 457 for different types of structures according to flied conditions.

DESIGNS OF MORTAR MIX:

The proportion of cement and fine aggregate will be given after the tests are carried out in the laboratory in accordance with the specifications laid down.

COMPRESSIVE STRENGTH OF CONCRETE AND MORTAR CUBES

Refrence: (IS: 516-1959 AND IS:1199) and (Technical Circulars No. 23 Vide memo No. 123/BODHI/R &C/TC/11/88 Dated 31.08.1989.)

Object:

Determination of compressive strength of concrete and Mortar cubes.

Theory:

Concrete is made with cement, sand , coarse aggregate and water. The mixture of the four main ingredients is consolidated to a hard mass due to the chemical reaction between cement and water. Each of the four ingredients has its separate function. Coarse Aggregate acts as main filler, sand (fine aggregate) fills the voids in the coarse aggregate. Cement and water forms the binder. The

science of proportioning of concrete is therefore, mainly concentrated on the principle of obtaining a durable and strong concrete at the most economical rate possessing a good workability.

Equipments:

(i) Compression Testing Machine of 200 Tones
(ii) Cubes moulds 15 cm size, for concrete, 5 cm size for mortar.
(iii) Tamping rod or vibrators.
(iv) Trowels etc.

Procedure :-

(i) Take 6 no.s cubes mould of 15 cm size, where nominal maximum size of aggregate does not exceed 38 mm.
(ii) Fill the moulds with freshly prepared concrete in three layers, each layer giving 35 strokes by standard tamping rod.
(iii) Finish the open surface of he moulds and keep overnight under a wet gunny bags and open moulds after 24 hours.
(iv) Marks the cubes for their identifications and stores in clean water for curing for 7 and 28 days.
(v) Record daily maximum and minimum temperature.
(vi) Test the specimen for its compressive strength at 7 days amd 28 days.
(vii) Test at least 3 specimens at a time and take average value.
(viii) Compare the strength with specified strength.
(ix) For mortar use 25 mm square bars 20 cms long and fill the moulds with freshly prepared mortar in two layers. Each layer is thoroughly compacted by temping rod. Repeat the procedures. find out the compressive strength of mortar.

Observations:

(i) Load in ton = X Tones.
(ii) Surface area of specimen = A Cm^2

Calculations:-

Compressive strength = $\frac{X \times 1000 \ (Kg/\ Cm^2\ )}{A}$

Results:

Report the compressive strength of concrete / mortar in Kg/ Cm^2.

Precautions:

Moulds should be properly greased before casting

Strokes should be distributed in uniform manner.

Temperature should be maintained as $27^o + 2^o$ in the laboratory and in the field as 22^o—32^o C

While testing, results should not vary more than 15 % sampling should be done accordingly to IS 1199-1959.

Specifications:

S.No.	Grade of Concrete	Compressive Strength		S.No.	Grade of Mortar	Compressive strength	
		7 Days Kg/ Cm^2	28 Days Kg/ Cm^2			7 Days Kg/ Cm^2	28 Days Kg/ Cm^2
1	M 10 1:3:6	67.00	100.00	1	M 5 1:6	34.00	50.00
2	M 15 1:2:4	100.00	150.00	2	M 7 1:5	47.00	70.00
3	M 20 1:1.5:3	134.00	200.00	3	M 10.5 1:4	70.00	105.00
	M 25 1:1:2	168.00	250.00		M 14 1:3	94.00	140.00

ANNEXURE 3/7

TESTING OF NATURAL BUILDING STONE (BOULDER OR RUBBLE)

DETERMINATION OF COMPRESSIVE STRENGTH OF NATURAL BUILDING STONES (IS: 1121 - PART 1-1974) REAFF 2009

Purpose:

This test is conducted for the selection of the material to be utilized for its satisfactory performance and assessing the suitability of building stones.

Equipments:

Compression Testing Machine.

Staff:

Laboratory Technician: 1

Laboratory Assistant: 1

Procedures:

Test pieces of stones in the form of cubes or cylinders of the size not less than 50 mm and the ratio of height to diameter shall be 1:1. For this test at least six specimens shall be taken for testing. The load bearing surfaces shall be finished to as nearly true, parallel and perpendicular planes by grinding and polishing as far as possible.

These test pieces shall be taken and dried in oven at 105º $\pm$ 5ºC for 24 hours and cooled in desiccators to room temperate. These test pieces shall be tested for their compressive strength by placing each piece in the compression testing machine at approximately for applying load rate of 140 kg/sq. cm. of the area per minute until the resistance of the test piece to the increasing load breaks down and no greater load breaks down and no greater load shall be sustained. Average of the three pieces shall be taken.

Three test pieces shall immersed in water maintained at the temperature 20º to 30ºC for 72 hours before testing and shall be tested for the determination of compressive strength as mentioned in above para in saturated condition. Average strength shall be calculated.

Calculations;

$$Cc = \frac{Cp}{0.778 + 0.222(b + h)}$$

Where

Cc = Compressive strength of standard test piece

Cp = Compressive strength of the specimen having a height greater than the diameters or lateral diamension

b = diameter or lateral dimension, and

h = Height

DETERMINATION OF WATHERING OF NATURAL BUILDING STONES (IS: 1125-1974) Reaffirmed 2003

Purpose:

To find out the resistance of stone towards corrosive ground water, wetting and drying, sulphate attack and temperature variations. This standard lays down the procedure for testing weathering of natural building stones used for constructional purposes.

Selection of Samples:

The sample shall be selected to represent a true average of the type or grade of stone under consideration.

Stone from Ledger or Quarries:

The ledge or quarry face of the stone shall be inspected to determine any variation in different strata. Differences in colour, texture and structure shall be observed. Separate samples of stones weighing at least 25 kg. Each of the unweathered specimens shall be obtained from all strata that appear to vary in colour, texture and structure. Pieces that have been damaged by blasting, driving wedges, heating etc. shall not be included in the sample.

Field Stones and Boulders

The different kinds of stones and their condition at various quarry sites shall be recorded. Separate sample for each class of stone that would be considered for use in construction as indicated by visual inspection shall be selected.

Test Pieces:

1. The test pieces shall be either cylinder, 50mm in diameter and 50mm in height, or 50mm cubes.

2. the test pieces shall be finished smooth and the edges shall be rounded to a radius of approximately 3 mm by grinding.

3. At leas three test pieces shall be used for conducting the test.

4. The test pieces shall be dried in a well ventilated oven for 24 hours at a temperature 105 $\pm$ 5ºC and cooled in a desiccators to room temperature (20º to 30ºC).

Staff:

Research Assistant and Lab. Assistant.

Equipments:

Conducting Weathering Apparatus- It shall consist of an encolosed balance of 1 kg. capacity that is sensitive to 0.01 gm and suitable accessories for weighing the specimen in water.

Procedure:

The dried and cooled test pieces shall be weighed to the nearest 0.01 gm and the weight of each is recorded (W_1). The specimen shall then be submerged in water at 20º to 30ºC for 24 hours. Each specimen shall be weighed (W_2) whilst totally immersed and freely suspended in water. (When weighing test pieces in water, they shall be weighed suspended in such a position that air is not entrapped in the cavities). It shall then be removed; the surface water wiped off with a damp cloth and weighed again (W_3). The weighing of each specimen shall be completed within three minutes of its removal from water.

Each specimen shall be placed in a flat dish made of glass, porcelain or glazed stonework, 9cm in diameter and 1.5 cm in depth to which shall be added 2 gm of powdered gypsum and 25 ml of water. The dishes together with specimens shall then be placed in a well ventilated over and

maintained at a temperature of 105 $\pm$ 2ºC for at least 5 hours or until the water has evaporated and the powder becomes dry. The dishes shall be removed from the over and cooled to 25 $\pm$ 5ºC . This completes the first cycle. The cycle shall then be repeated 29 times in the same manner, except that only 25 ml of water shall be added foreach of the subsequent cycles.

At the end of the 30 cycles, the specimens shall be cleaned by brushing with a stiff-fibre brush to remove any particles of gypsum clinging to the surface. Each specimen shall be immersed in water for 24 hours, surface dried, and weighed first in air (W_4) and then in water (W_5)

Calculations:

The increase/change in absorption and the increase in volume of each test piece after the 30 cycles of the test shall be calculated as follows:-

$A_1 = \frac{W_3 - W_1}{W_1} x100$ ..... (1)

$V_1 = \frac{W_3 - W_2}{d}$ ..... (2)

$A_2 = \frac{W_4 - W_1}{W_1} x100$ .....(3)

$V_2 = \frac{W_4 - W_5}{d}$ ..... (4)

Percentage increase in obsorption $\frac{A_2 - A_1}{A_1} x100$ .....(5)

Percentage increase in volume = $\frac{V_2 - V_1}{V_1} x100$ ..... (6)

Where

A_1 = Original absorption of the specimen during 24 hour immersion in water, expressed as percentage by weight.

W_3 = Original weight or surface dried specimen after 24 hour immersion in water.

W_1= Original weight of oven-dried specimen before immersion.

V_1= Original volume of the specimen after 24 hour immersion in water.

W_2= Original weight of specimen freely suspended in water after 24 hour immersion.

d = Density of water at the temperature of observation.

A_2 = Final absorption of the specimen after 30 cycles of the test expressed as percentage by weight.

W_4 = Final weight in air of surface dried specimen after 30 cycles of the test and 24 hour immersion in water

V_2 = Final volume of the specimen after 30 cycles of the test.

W_5 = Final weight of the specimen freely suspended in water after 30 cycles of the test and 24-h immersion in water.

TOUGHNESS OF NATURAL BUILDING STONES
IS:5218(1969) Reaffirmed 1997

Introduction:

The property of toughness of stone is resistance to failure under impact, stones of law toughness are apt to fail when exposed to rough usgae, as occurs on steps, flooring of factories, stories, warehouses, go-down etc. This standard provides a method for measuring toughness of stones.

Apparatus:

Toughness testing machine having holding device for test specimen, striking hmmer, plunger.

Staff:

Lab. Technician and Lab. Attendant.

Procedure;

Test specimens shall be cylinders 25mm long and 25mm in diameter. Three test specimens shall constitute a test set.

One set of specimens shall be drilled perpendicular and another parallel to the plane of structural weakness of the stone, if such plane is apparent. If such plane is not apparent, one set shall be drilled at random.

The cylindrical test specimen shall be securely held in the anvil without rigid lateral support, and under the plunger in such a way that the centre of its upper surface shall, throughout the test, be tangential to the spherical end of the plunger at its lowest point. The hammer shall be given a free fall of 1 cm for the first blow; 2 cm for the second blow, and an increase of 1 cm fall for each succeeding blow until failure of the test specimen occurs.

Test Report;

1. The height of the blow at failure shall be the toughness of the specimen.

2. In cases when a plane of structural weakness is apparent, the individual and average toughness of the three specimens in each set shall be reported and identified.

3. The individual and average toughness of three specimens shall be reported when no plane of structural weakness is apparent.

4. Any peculiar condition of a test specimen which might affect the result, such as the presence of seams, fissures, etc. shall be noted and recorded with the test results.

DETERMINATION OF TRUE SPECIFIC GRAVITY APPARANT SPECIFIC GRAVITY, WATER ABSORPTION AND POROSITY OF NATURAL BUILDING STONES.(1) IS: 1122- 1974, (2) IS: 1124-1974 Reaff 2003

Purpose:

These tests shall conform the properties of the natural building stones. The suitability of the natural building stones shall be for assessing its quality.

Apparatus;

Analytical balance, weight box, drying oven, weighing bottle and Desicator. Specific gravity bottle, thermometer.

True specific gravity as per IS: 1122-1974 page 4 & 5

Staff:

Lab Technician and Lab. Attendant.

Procedure:

Sample selection shall be done on the basis of true average grade of stone Samples of stone weighing at least 22 kg each of unweathered specimen shall be obtained from all strata that appear to vary in colour, texture and structure.

From such specimen 0.5 kg of stone shall be selected, thoroughly washed and dried. It shall be crushed to maximum 3mm size, thoroughly mixed and reduced to 50g. The entire 50g samples shall be grounded and passed through IS Sieve of 150 micron. Any magnetic material introduced during grinding shall be removed by a magnet.

50 g ground sample shall be dried in oven at 105ºC to 110º to a constant weight and is cooled in desicator.

One specific gravity bottle shall be washed and dried to constant weight at 10º5 to 110º and cooled in a desicator and weighed as W_1

About 15 g of the dried stone powder shall be introduced in the specific gravity bottle and weighed let this weight be W_2. Then the specific gravity bottle shall be filled with distilled water and weighed as W_3. The specific gravity bottle is emptied, cleaned and is filled fully with distilled water and weighed as W_4. The room temperature shall be noted as 't'

Evaluations:

$$\text{True specific gravity at t}^{o}\text{ C} = \frac{W_2 - W_1}{(W_4 - W_2) - (W_3 - W_2)}$$

t = room temperature.

W_2 = Weight in g of the bottle with stopper and powder;

W_1 = Weight in g of the empty specific gravity bottle with stopper

W_4 = Weight in g of the specific gravity bottle with stopper filled with distilled water at room temperature; and

W_3 = Weight in g of the bottle with stopper, powder and distilled water to fill rest of the bottle at room temperature.

The true specific gravity shall be based on average of three determinations.

Precautions:

1. For selection of sample piece those have been damaged by blasting, driving wedges and heating etc. shall not be included in the sample.

2. While filling the specific gravity bottle with distilled water when sample is already in the bottle, care shall be taken that entrapped air must be removed by gently boiling the contents after filling the bottle 3/4 with distilled water.

3. The temperature during the test shall be recorded.

APPARANT SPECIFIC GRAVITY OF NATURAL BUILDING STONES (AS PER IS: 1124-1974, PAGE 5) Reaffirmed 2003

Procedure:

The sample shall be crushed or broken and the material passing 20-mm IS Sieve and retained of on 10-mm IS Sieve is to be used for test.

The test pieces weighing about 1 Kg. shall be washed to remove the particles of dust and immersed in distilled water at room temperature 20º-30ºC for 24 hours. The test pieces shall then be placed on a dry cloth and gently surface dried with the cloth. When no further moisture is removed by this cloth, the sample shall be replaced and left exposed to atmosphere by keeping away from direct sun light or any other source of heat. The sample shall then be weighed as (B) and introduced in 1000 ml measuring cylinder. Then water with 100 ml measuring cylinder shall be poured in the 1000 ml cylinder until it reaches 1000 ml mark. The quantity of water thus added shall be noted as "C".

The water in the larger cylinder shall be drained off and the sample shall be carefully dried in an oven at 100º to 110ºC for not less than 24 hours. It shall then be cooled in a desiccator to room temperature and weighed as A. The room temperature during the test shall be noted.

Calculations

Apparant specific gravity = $\frac{A}{1000-C}$

A = Weight of oven dry test pieces in g; and

C = Quantity of water added in 1000 ml measuring cylinder containing test piece in g.

Water Absorption can be calculated from the following formula.

Water Absorption = $\frac{(B-A)x100}{A}$

Where A= Weight of oven dry sample, and

B = Weight of saturated surface dry test piece in g.

Specific gravity can also determine by using pycnometer as well as by hanging with a thread on balance in air and in water as given in the determination of specific gravity of coarse Aggregates.

The apparent specific gravity shall be expressed as numerical value for saturated surface dry sample.

PRECAUTIONS

1. At the time of soaking period entrapped air shall be removed by gentle agitation.

2. Room temperature during the test shall be 20º-30ºC.

3. No direct exposure to Sun light or any other source of heat shall be for the sample during the surface drying.

Absorption porosity = $\frac{(B-A)x100}{1000-C}$

It shall be expressed as a percentage and shall be the average of three determinations.

True porosity = $\frac{\text{True specific gravity-Apparant specific gravity}}{\text{True specific gravity}}$

DETERMINATION OF DURABILITY OF NATURAL BUILDING STONES (IS: 1126-1993) Reaffirmed 2008

Purpose:

This is test is conducted to find out the capacity of stone toresist disintegration and decomposition for the stones to be used for construction purposes.

Equipments:

Hot air oven, balance, weight box enameled bowls, Sodium Sulphate Decahydrate, Barium Chloride.

Staff:

One Research Assistant and one Laboratory Attendant.

Procedure:

Representative samples shall be selected from the quarried stones of unweathered natural rock. The test pieces shall be 50mm cube or natural rock cylinders of 50 mm dia and 50mm height. These test pieces shall be taken for conducting the test. The test pieces shall be dried for 24 hours and weighed. Then they shall be suspended in super saturated solution of Sodium Sulphate Decahydrate for 16 to 18 hours at room temperature 20º to 30ºC. These shall then be air dried for half an hour and then be dried in an oven at 105º $\pm$ 5ºC for four hours. These shall then be cooled to room temperature (20º to 30º) and the cycle of operation shall be repeated for thirty cycle.

After the completion of the final cycle and after the test pieces have been cooled to room temperature, the test pieces shall be thoroughly freed of the Sodium Sulphate solution by repeated washing, if necessary, as determined by the reaction of the wash water with Barium Chloride. The test pieces shall be weighed after every fiver cycles and the change in weight due to disintegration shall be noted.

The test pieces shall be examined during the course of the test for the development of cracks or spalling.

Let W_1 is the original weight of the specimen and W_2 shall be the weight of the specimen after completion of 30 cycles of the test.

The change in weight = $\frac{W_1 - W_2}{W_1} x100$

The average of three results shall be calculated and taken as the durability value of the specimen.

Precautions:

1. The sample shall be selected to represent a true average of the type of grade of stone under consideration.

2. Average of three specimens shall be taken for the final results.

3. After final cycle, the specimens shall be thoroughly washed and dried.

ANNEXURE 3/8

TESTING OF BRICKS

(IS: 3495-1992) Reaffirmed 2011

INTRODUCTION

Brick is the oldest and the most extensively used building material. It is essentially a local building material hence there is considerable variations in the quality and size of the material.

To maintain some standard of the common building brick with regard to its quality and dimensions, ISI has recommended certain methods of tests and requirements of the properties. Some of these tests are given for

TEST OF BURNT CLAY BUILDING BRICKS

(IS: 3495-PAR 1 TO 4 - 1976)

DETERMINATION OF WATER ABSORPTION

(IS: 3495-PART 2-1992 PAGE 3 REAFF 2011)

Purpose:

This test confirms to the quality of bricks for the recognition of the standard of the material.

Equipments:

A sensitive balance, weight box, hot air oven, water tank etc.

Staff:

Laboratory Technician and Laboratory Assistant

Procedure:

The specimen shall dried in hot air oven to constant weight at 105º to 115ºC temperature. It shall be cooled to room temperature and weighed as (M_1). Specimen shall be immersed in clean water at temperature 27º $\pm$ 2ºC for 24 hours. The specimen shall be removed and traces of water shall be wiped out with damped cloth and weighed. This shall be done within three minutes after the specimen has been removed from water, let this weight be (M_2).

% age of water absorption = $\frac{(M_2 - M_1)x100}{M_1}$

Five specimens shall be tested and average results shall be reported.

Precautions:

All apparatus and testing equipment shall be calibrated at frequent intervals.

The number of specimens shall be selected according to IS; 5454-1978.

Specimens shall be dried in oven to constant weight at a temperature of 105º to 115ºC.

The specimens shall be immersed in clean water at a temperature of 27º $\pm$ 2ºC for 24 hours.

The weighing shall be completed after 3 minutes of removing of the specimens from the water.

Specifications:

As per IS: 1077-1986 page 7, water absorption shall not be more than 20% upto class 125 and 15 percent by weight for higher classes.

As per specifications Vol. 1-1991 for Irrigation Projects at page 9-3.

Brick are classed as:

- First class table moulded (TM) Chimney kiln burnt
- Sound class tabled moulded chimney kiln burnt bricks
- Second class T.M. open bhatta or Pajawa burnt bricks
- Kumhar bricks burnt in pajawa.

FIRST CLASS TABLE MOULDED BRICKS.

Size specified, free from saline deposits and made of good earth and sand moulded. Thoroughly burnt of good colour. Shall not absorb water 1/6th of its weight after being soaked in water for twelve hours and shall show no signs of efflorescence on drying.

SECOND CLASS BRICKS

Well burnt as first class, slight irregularity in size shape or colour shall be accepted but not such as

to give irregular or uneven courses when used. A second class brick shall not absorb water $1/5^{th}$ of its weight after being soaked for twelve hours and shall show no signs of efflorescence on drying.

KUMHAR BRICKS

These bricks shall be well burnt or slightly over burnt. Reddish or Reddish-yellow colour. They shall not absorb water more than 1/4 of their weight after 12 hours immersion. Without the permission of Engineer in charge should not be used.

DETERMINATION OF COMPRESSIVE STRENGTH OF BRICKS

(IS: 3495 PAR 1)-1976) REAFF 211

Purpose:

To assess the quality by comparing with the specifications.

Equipments:

A compression testing machine, Ply wood sheets of 3 mm thickness or plaster of paris to ensure uniform surface.

Staff:

Laboratory Technician and Laboratory Assistant.

Procedure:

Unevenness of the two parallel bed faces shall be removed by grinding. Test specimens shall be immersed in water for 24 hours. Then the test specimens shall be taken out of water and the frog shall be filled with cement mortar or plaster of paris. These shall be stored under damp jute bags for 24 hours followed by immersion in water for 3 days. these shall be removed from water and traces of moisture shall be wiped out.

The specimens with their flat faces horizontal and mortar filled faces upwards are kept in between 3-ply plywood sheets each of 3mm thickness and these shall be placed in between the plates of testing machine. Then the load shall be applied till the failure of the specimen.

$$\text{Compressive Strength in } (kg/cm^2) = \frac{\text{Maximum load at failure in Kg.}}{\text{Average area of the bed faces in } Cm^2}$$

Precautions:

The testing equipment shall be calibrated at frequent intervals.

The number of specimens for the tests shall be selected according to IS: 54:5454-1978

The dimensions shall be measured for the nearest 1mm

Unevenness shall be removed by grinding the bed faces of bricks.

The load shall be applied axially at a uniform rate of 140 kg/cm^2 per minute till failure of the specimen.

SPECIFICATIONS AS PER IS: 1077-1976 PAGE 5

Class	Average compressive strength	
Lesignation	Not less than kg/cm2	Less than kg/cm2
350	350	400
300	300	350
250	250	250
200	200	200
175	175	175
150	150	150
125	125	150
100	100	125
75	75	100
50	50	75
35	35	50

ANNEXURE 3/9

TESTING OF LDPE FILM

(IS: 2508-1984) Reaffirmed 2003

INTRODUCTION

The natural and black colour (carbon black pigment) LDPE (Low density polyethylene films), used for packaging , canal lining, agricultural operations and post harvest used, construction work and allied purposes.

The compound used for manufacturing natural ilm shall consist only of polyethylene resins complying with polymers for the natural film shall have a melt flow index between 0.10 to 15.0 g/10 min. The density for the compound from which the film is made shall be between 0.913 to 0.923 g/ml at 27^{O}C (0.915 to 0.925 g/ml at 23^{O}C).

TEST OF LOW DENSITY POLYETHYLENE FILMS

(IS: 2508-1984)

DETERMINATION OF DENSITY

(IS: 2508-1984 REAFFIRMED 2003)

Preparation of Test Specimen:

Cut from the roll/folded film three pieces of the material under test of an area to mm^2 from different parts of the roll/folded film using a sharp blade.

Conditioning of the Specimen:

The specimen shall be conditioned by submerging it in boiling water for minutes flowed by conditioning at 27±0.20 ^{O}C for at least 24 hours to make it bubbles free.

Reagent:

Dilute Alcohal having a density of 0.9026 to 0.9076 g/ ml at 27^{O} C , prepared by diluting ethyl alcohol with distilled water.

Procedure:

Pipette 100 ml of dilute alcohol into a clean Drechsel bottle kept immersed in a water –bath maintained at 27 ±0.1^{O} C . After temperature equilibrium has been attained , lower one test specimen of polyethylene film carefully into the dilute solution avoiding any adhering air bubbles.

Add from a burette distilled water ,0.2 ml at a time ,with stirring . when the specimen remains just suspended in the solution well away from the glass surface, the density of the solution and the specimen is taken to be the same . Prepare a calibration curve for the density of dilute alcohol by adding increasing amount of water and determining the density . Read off the density of the specimen from the calibration curve. For an accurate results , density of solution at the end may also be determined with a Pycnometer or specific gravity bottle at 27 $\pm 0.10^{O}$ C. Carry out the test in a similar manner on the second specimen.

Calculation:

Calculate the density of the two specimens to the fourth decimal place . if the two values vary by more than 0.0005 reject the readings and repeat the tests until the difference between the two values is not greater than 0.0005. Report the mean of the two values as the density.

DETERMINATION OF THICKNESS
(IS: 2508-1984 REAFFIRMED 2003

Apparatus :

A dead weight dial micrometer with a flat anvil of 6 mm diameter or larger in area and 4.8 mm diameter flat surface on the head of the spindle, or a spring micrometer which has been calibrated against a dead weight dial micrometer shall be used . In case of dispute, only dead weight dial micrometer shall be used and the reading shall be taken between 15 seconds and 2 minutes after the load is applied.

This method is capable of producing measurement with a maximum error of ±0.00025 cm .

Specimens:

Test five specimens, at least 5X 5 cm in area, taken uniformly across the width of the test piece.

Procedure:

Dry and clean the surface of the anvil and spindle head, and of the specimen. Place the specimen on the anvil and lower the spindle head on to it slowly. The total load applied by the spindle shall be 110 g. Make one measurements on each specimen approximately at the centre of the specimen. Take mean of the measurements of all the specimens of a sample to obtain the average thickness of the sample.

DETERMINATION OF YIELD TOLERANCE

(IS: 2508-1984 REAFFIRMED 2003

Calculation of Actual Yeild:-

Yeild is the amount of area provided by a given mass of a film of specified thickness. The actual yield Y_a Shall be calculated as follows :

$Y_a \text{ cm}^2/\text{Kg} = 1000/dt$

where

d= density in g/ml as determined by the determination of density.

T= nominal thickness in cm as determined by the determination of thickness.

Calculation of Deviation of Actual yield from the Nominal Yeild:

The deviation of actual yield from the nominal yield shall be calculated as follows:

$$D = \frac{(Y_n - Y_a)}{Y_n} \times 100$$

Where

D = Deviation from the nominal yield in percent ,and

Y_n & Y_a + nominal yield and actual yield respectively determined as above.

DETERMINATION OF TENSILE STRENGTH AND ELONGATION AT BREAK:

(IS: 2508-1984 REAFFIRMED 2003

Tensile Testing Machine :

The tensile testing machine used shall maintain a rate of transverse of one grip as constant as possible. The mean value of the speed of separation shall be such that the initial strainrate on the test specimen is 10 mm/mm of the specimen per minute(for 50 mm specimen gauge length the speed should be 500 mm/min).The load scale shall be accurate to with in one percent or 0.1 N whichever is less. The load range shall be such that the breaking load of the test pieces falls between 15 percent and 85 percent of the full scale reading.

Note – it is recommended that the load scale be calibrated at least once every 12 months , using dead weights added successively.

Preparation of Test Pieces;

Gauge length of the specimen shall be 50 ± 1 mm and the width shall be 10 to 25 mm . cut five test pieces from the sample in the length wise direction and a further five in the corrosive direction . the total length of the specimen should be at least 50 mm longer than the gauge length . measure the thickness using a suitable micrometer.

Procedure:

Condition the test pieces for not less than one hour at a temperature of 27 ± 2^{o} C and 65 ± 5 percent relative humidity and clamp their ends in the machine at the grips separated by 50 mm. start the machine at the preadjusted speed of 500 mm/min and note the load and elongation at break.

Calculation and Report:

Tensile Strength at Break: - the tensile strength at break shall be calculated in MN/m^2(kg/cm^2) from the original area of cross section. The mean of five results shall be expressed for the length wise and crosswise samples.

Elongation at Break : - Elongation at break shall be expressed at percent of the original length between the reference lines. The mean of five results shall be expressed for the lengthwise and crosswise samples.

ANNEXURE 3/10

TEST FOR FLEXURAL STRENGTH OF MANUFACTURED TILE

(IS: 10646-1991) Reaffirmed 2004

When Tested according to the method as per referred IS , minimum breaking load per cm weight of tiles shall not less than 41 kg for 60 mm, 29 kg for 50 mm and 18 kg for 40 mm tiles thickness.

Sample:

Por ascertaining the conformity to the requirements for flexural strength test, one tile from each lot of 500 shall be selected at random and tested.

Let hall be considered conforming to the requirements of the flexural strength test if the sample passes the requirements of the test. In case it fails to satisfy the requirements of the test. Two more tiles shall be selected at random from the same lot and tested for the requirements of flexural strength . if any of these two tested fails to satisfy the strength requirements the lot shall be rejected.

Test:

The specimen shall be immersed in potable water for 24 hours and then taken out and wiped dry .

The specimen shall be placed horizontally on roller bearers. 1.50 mm apart with their length parallel to bearers. The length of the bearers and that of the loading bar shall be longer than the length of the specimen and their contact shall be rounded to a diameter of 25 mm . A Plywood packing 3 mm , thick and 25 mm wide shall be placed between the specimen and the loading bars. The loading bar and the bearers shall be self aligning.

Starting from zero , the load shall be increased steadily and uniformly at a rate not exceeding 2 Kg/cm (measured along with the bearers) per minute up to the load specified (A minimum breaking load per cm length of tile shall not be less than 41 kg for 60 mm , 29 kg for 50 mm and 18 kg for 40 mm tiles thickness) , Which shall be maintained for at least 1 minute. There shall not be any visual crack in the tiles.

ANNEXURE 3/11

TEST OF REINFORCEMENT STEEL

Tor steel is one of the best grade of steel for concrete reinforcement. It is a kind of high adherence steel. Other types of steel are used for less resistance concrete. Thermo mechanically treated (TMT) bars are a type of corrosion resistant steel reinforcing bar used in concrete construction.

Some Mechanical Tests are following:

Ultimate Tensile Strength: This test helps in determining the maximum stress that a material can with stand while being stretched or pulled before necking, which is when the specimen cross-section starts to significantly contract. (for Test Method please referred ASTM A-36, IS 1608:2005)

0.2 % Proof stress/ Yield Stress : Yeild stress is the lowest stress that produces a permanent deformation in a material . In some materials like aluminium alloys , the points of yielding is hard to define . thus it is usually given as the stress required causing 0.2 % plastic strain. This is called 0.2 % proof stress. (for Test Method please referred ASTM E-8 M-09).

Elongation : The Elongation is the increase in the gauge length, expressed as a percentage of the original gauge length. In Resulting elongation values, give both the percentage increase and the original gauge length. (for Test Method please referred IS : 3600(P-3)1989, ASME 5 EC-IX)

Bend Test: This test helps in determining the ductility , but it cannot be considered as a quantitative means of predicting service performance in bending operations. The severity of the bend test is primarily a function of the angle of bend and inside diameter to which the specimen is bent, and of the cross-section of the specimen. These condition are varied accordingly to location and orientation of the test specimen and the chemical composition, tensile properties , hardness type and quality of the steel specified. (for Test Method please referred IS :1599, IS 2329,2005, IS 3600 (P5,6)1983)

Rebend Test (IS:1786:2008) The purpose of rebend test is to measure the effect of strain ageing on steel . The test piece shall be bent to an included angle of 135^{o} using a mandrel of appropriate diameter. The bent piece shall be aged by keeping in boiling water (100^{o}C) for 30 min and then allowed to cool. The piece shall then be bent back to have an included angle of 157 ½ ^{o}. The specimen shall be considered to have passed the test if there is no rupture or cracks visible to a

person of normal or corrected vision on the rebent portion.

Effective Cross-sectional Area and Mass of Deformed Bars and wires: (IS 1786:2008)

For bars wires whose pattern of deformation is such that by visual inspection, the cross-sectional area is substantially uniform along the length of the bar/wire, the effective cross-sectional area shall be the gross sectional area determined as follows , using a bar/wire not less than0.5 min length.

Gross cross-sectional area , in mm2= W/ 0.00785L

Where:

W=mass weighed to a precision of ±0.5 percent in kg; and

L= length measured to a precision of ±0.5 percent, in cm

Table: Nominal cross-sectional Area and Mass

S.no.	Nominal Size in mm	Cross- Sectional Area mm^2	Mass per meter Kg
1	4	12.6	0.099
2	5	19.6	0.154
3	6	28.3	0.222
4	8	50.3	0.395
5	10	78.6	0.617
6	12	113.1	0.888
7	16	201.2	1.58
8	20	314.3	2.47
9	25	491.1	3.85
10	28	615.8	4.83
11	32	804.6	6.31
12	36	1018.3	7.99
13	40	1257.2	9.86

For a bar/wire whose cross-sectional area varies along its length, a sample not less than 0.5 m long shall be weighed (w) and measured to a precision of ± 0.5 percent in the as rolled and/or cold-worked condition, and after the transverse ribs have been removed, it shall be reweighed(w'). The effective cross-sectional area shall then be found as follows:

a. Where the difference between the two masses (w-w')is less than 3 percent of w', the effective cross-sectional area shall be obtained by above formula.
b. Where the difference is equal to or greater than 3 percent, the effective cross-sectional area in mm^2 shall be taken as:

   1.03w'/0.00785L

   Where: w' = mass of the bar with transverse ribs removed, in kg and

   L=length in m.

ANNEXURE 4/1

PROCEDURES FOR DIFFERENT SOIL TEST

METHODS OF SAMPLING FOR IDENTIFICATIONS OF EXPANSIVE SOIL IN SUB GRADE AND ASSESSMENT OF CNS MATERIAL: (Reference: TC No. 17 Issued vide no.105/BODHI/R &C/TC/11/88, Dated 12/12/1988)

For identification of expansive soil in sub grade and identification of burrow area for CNS material, sample should be collected carefully. If the CNS Soil is not properly identified with survey and testing, failures are bound to occur. On the other hand, if expansive soils are misjudged, it may results in unnecessary expenditure on CNS treatment.

Method of Exploration: Explorations should be made by test pits and hands auger holes along canal alignment and burrow areas. However, where the canal is in deep cut, bores may be needed if the depth of cut is beyond the auger hole range.

Spacing and Depth:

Along Canal Alignment: Auger holes/test-pits should be made at an interval of 500 m alone the centerline of the proposed canal. In case of Topography/Site geology demand, the spacing should be reduced to 200-300 m. Auger hole/ test pits should be made down to a depth of 2.0 m below the proposed canal bed level. Ground water table should be determined if encountered.

Borrow Area: Auger holes/test-pits should be taken in a grid of 50 m to 100m spacing. The depth of pit should depend on the depth to which suitable material is available and economic depth of excavation with available equipment. The borrow area lead should be in economical range.

Sampling:

Along Canal Alignment: Representative samples from the auger holes / test-pits should be collected at 1.0 m vertical interval and every change of strata along the canal alignment. About 1.0 kg soil sample should be collected for mechanical analysis and Atterberg limit tests. In addition a few undisturbed samples should also be collected for engineering property tests such as in-situ density, moisture content, triaxial shear/direct shear consolidation etc.

Borrow Areas for CNS: About 20-30 kg of CNS material should be collected from each pit in the borrow area for testing. Engineering properties should be based on field identification tests as well as mechanical analysis, Atterberg limit and in-situ moisture content tests. A few samples should also be tested for standard compaction and specific gravity; Triaxial shear test may be conducted as per need.

SUITABILITY TESTS

GRAIN SIZE ANALYSIS

(IS: 2720 (PART 4) - 1985) Reaffirmed 2010

Introduction:

Grain size analysis gives the distribution of various particle sizes in soil. It comprises of two parts, sieve analysis and sedimentation analysis. Percentage of various sizes above 75 micron is determined by standard sieves whereas percentage of various sizes below 75 micron is determined by analysis. Sedimentation analysis is based on stoke's Law of falling bodies, with the assumption that soil settle independent of other particles in the suspension. A grain size analysis curve with log of Particle size as the abscissa and percentage finer as ordinate, indicates whether the soil is fine grained, coarse grained, well graded or poorly graded.

Equipments:

Balance sensitive to 1.0g, I.S. sieves 80mm, 20mm, 4.75mm, 2mm, 425 microns and 75 microns, oven 105º to 110ºc, sieve-shaker, bottle shaker, chemical balance, volume bottle, ordinary bottle, pipette, china dish, china dish, china crucible 30 c.c., wire brush and distilled water. Thermometer 0º to 50º c accurate to 0.5ºc. Reagents: Hexametaphosphate.

Procedure:

Pipette method (standard method)

The soil sample received from the field shall be prepared for coarse grained and fine grained soil by sieving 4.75 mm I.S. sieve. The portion of the sample retained on 4.75mm sieve shall be weighed and mass recorded. The sample shall be separated into various fractions by sieving through I.S. nos. 20mm and 80mm and mass of material retained on each sieve shall be recorded and percentage shall be calculated on the basis of the total sample taken.

25 gms of the soil sample passing 4.75mm I.S. sieve obtained above shall be oven dried at 105º C to 110ºC. is taken in the ordinary bottle and 200 C.C. of distilled water is added. Then 20 C.C. of dispersion solution of sodium Hexametaphosphate should be added. The mix should be thoroughly stirred in bottle shaker for 6 to 8 hours. The stirred specimen should be washed on the 75 micron I.S. sieve until the water passing the sieve is substantially clean.

The fraction retained on 75 microns should be dried in the oven and sieved through the rest of sieves i.e. 2.0 mm and 425 micron sieve by sieve shaker. The fractions retained on each sieve should be weighed separately and mass recorded. The percentage of soil fraction retained on each sieve should be calculated on the basis of the mass passing 4.75mm I.S. sieve taken for initial analysis.

The portion of the samples passing 75 micron shall be transferred to volume bottle and volume of liquid made 100c.c. by adding more distilled water. The temperature is recorded. The liquid in bottle shall be shake well and with the help of chart (temp. v/s. time0 20 or 25 c.c. of liquid shall be sucked by pipette and shall be withdrawn from the suspension talking approximately 10 sec. to complete the operation. This procedure shall be done at the end of time corresponding to particle diameter 0.002mm.

The liquid of the pipette shall be transferred to china crucible 30 c.c. capacity and should be placed to oven at a temperature 105º to 110º c and evaporated to dryness. After cooling in desiccator's, the content shall be weighed to the nearest 0.001 g. and the mass of solid material in the sample determined. The percentage of particles below 0.002 mm size is determined by deducting the sum of percentage of particles above 0.002 mm size particles from 100 on the basis of the mass of the sample passing 4.75 mm I.S. sieve taken for initial analysis.

Calculations:

After calculating the percentage of coarse grained soil i.e., retained on 4.75 mm I.S. sieve and passing 4.75mm I.S. sieve, the actual percentages of different size of particles with respect to the original mass of sample shall be determined.

Staff:

One Research Assistant or Embankment Inspector or Silt Analyst

One Laboratory Technician 2 Samples per day

Three Helpers

(One Lab. Tech. and Two helpers for coarse grading one R.A. or S.A. or E.I. and one Helper for fine grading).

Application for Results of GSA:

Classification of soil determines its placement in various zones of the dam.

It helps in the approximate assessment of permeability of soil.

APPENDIX-A
(CLAUSE 6.1)

FORM FOR THE RECORD OF RESULTS OF GRAIN SIZE ANALYSIS

PROJECT..... DETAILS OF SOIL SAMPLE

SIEVE ANALYSIS OF FRACTION RETAINED 4.75MM IS SIEVE

Weight of total soil sample taken for analysis.....

Water content.....

ISSIEVE DESIGNATION	MASS OF SOIL RETAINED+ MASS OF CONTAINER	MASS OF CONTAINER	MASS OF SOIL RETAINED	CUMULATIVE MASS RETAINED	SOIL RETAINED AS PER CENTAGE OF SOIL TAKEN	SOIL PASSING AS PER CENTAGE OF SOIL TAKEN	COMBINED PERCENTAGE PASSING AS PER CENTAGE OF TOTAL SOIL SAMPLE

SIEVE ANALYSIS OF FRACTION PASSING 4.75MM IS SIEVE BUT RETAINED ON 75-MICRON IS SIEVE

Mass of partial sample taken for analysis.....

Water content.....

ISSIEVE DESIGNATION	MASS OF SOIL RETAINED+ MASS OF CONTAINER	MASS OF CONTAINER	MASS OF SOIL RETAINED	CUMULATIVE MASS RETAINED	SOIL RETAINED AS PERCENTAGE OF SOIL TAKEN	SOIL PASSING AS PERCENTAGE OF PARTIAL SOIL SAMPLE TAKEN FOR ANALYSIS	COMBINED PERCENTAGE PASSING AS PERCENTAGE OF TOTAL SOIL SAMPLE

ANALYSIS OF SOIL PASSING 75-MICRON IS SIEVE

Mass of air dry soils (Wa)

Water content of air dry soil (W)

Mass of oven dry soil after pre-treatment (Wb)

Loss in mass in pre-treatment in percent

Pipette Analysis

Specific gratity of soil

Volume of suspension taken in pipette (Vp)

Depth at which sample was taken

Mass of dispersing agent in the volume of suspension sampled

DATE	TIME ELAPSED BEFORE SAMPLING	TEMPERATURE OF SUSPENSION	MASS OF CONTAINER + OVEN DRY SOIL FRACTION	MASS OF BOTTLE	MASS OF SOLID MATERIAL IN BOTTLE INVOLUME VP.	MASS OF SOLID MATERIAL IN 500ML.	CORRECT MASS OF SOIL MATERIAL IN 500 ML.	DIAMETER OF SOIL GRAIN IN MM	PERCENTAGE FINER THAND AS PERCENTAGE OF WB	COMBINED PERCENTAGE FINER THAND AS PERCENTAGE OF TOTAL SOIL SAMPLE

ANNEXURE 4/2

CONSISTENCY LIMITS-(ATTERBERG'S LIMIT)

[IS:2720 (PART-5)-1985] Reaffirmed 2010

Consistency denotes the degree of firmness of the soil which may be termed as soft, firm, stiff or hard. Atterberg divided the entire range from liquid to solid state into four stages;

The liquid state

The plastic state

The semi solid state

The solid state

The set of arbitrary limits known as Consistency limits of Atterberg's limits in terms of water content.

The Atterberg's limits are- (1) Liquid limit, (2) Plastic Limit, (3) Shrinkage limit.

UTILITY OF DETERMINATION OF ATERBERG'S LIMITS

They help in the classification of soil which determines its placement is various zones of the dam.

They give an approximate assessment of cohesion or inter molecular attraction.

They give an assessment of Shrinkage of the soil on drying.

LIQUID LIMIT

The liquid limit of a soil is the water content expressed as a percentage of the weight of the oven dry soil, at the boundary between liquid and plastic states of Consistency of soil. It is the minimum water content at which a part of soil cut by a groove of standard dimention, will flow together for a distance of 12mm under the impact of 25 below in a standard liquid limit apparatus.

Apparatus:

Burette, Casagrande Cup, Grooving, Tool, One Enameled Bowl, Spatula, Distilled Water, Porcelain Evaporating Dish, Oven, flat glass plate, palette knives, wash bottle or Beaker, containers-air tight and non-corrodible.

Soil Sample:

A sample weighing 120gm shall be taken from the thoroughly mixed portion of soil passing 425-micron IS sieve.

Procedure:

The liquid limit device should be clean, dry; and in good working order. The cup should fall freely and it should not have too much side play at its hinge. The grooving tool shall be inspected to ascertain its critical dimensions. Now the cup should be adjusted so that it falls through the height of 1 cm. when one revolution is given by means of handle.

About 120gm, of soil sample passing 425-micron IS sieve stated above shall be mixed thoroughly with distilled water in enameled bowl or on the glass plate to form a uniform paste. In the case of clayey soils the soil paste shall be left for sufficient time (24 hours) so as to ensure uniform distribution of moisture throughout the soil mass. The soil shall be placed into the cup, so that the cup of apparatus is filled half with thickness of 1 c.m. be made plane. By grooving tool, groove of proper dimension is formed along the diameter in the paste. The casagrande tool cuts a groove of size 2 mm wide at the bottom, 11mm wide at the top. Blows are then given at the rate of two blows per second so that the groove gets closed to the length of 12mm. Number of the blows given to close the groove for the length of 12mm are recorded. Little soil shall be taken in evaporating dish and weighed. The soil is removed from the cup and is mixed with the remaining soil in the enameled bowl little quantity of water is added. The paste is stirred with spatula for uniform distribution of water. This paste is again placed in the bowl of the apparatus. Again drops are given as stated above for closer of the groove. Numbers of drops are recorded with different moisture content and the soil is taken in small dishes for determination of moisture content. The dishes are kept in the electric oven.

The soil paste in these operations is of such consistency that the number of drops to close the groove are not less than 15 or more than 35.

Observations:

Observations are recorded in tabular form in APPENDIX IS; 2720 (Part-5)- 1985.

Calculations and Results:

A flow curve shall be plotted on a semi-logarithmic graph with water content as the ordinate and log of number of dros abscissa. The water content corresponding to 25 drops is taken as the liquid limit of the soil.

Precautions:

The soil shall not be oven dried before the commencement of the test. Distilled water shall be used.

PLASTIC LIMIT

The plastic limit of a soil is the water content expressed as a percentage of the weight of the oven dry soil, at the boundary between the plastic and semi-solid states of consistency of the soil. It is the minimum water content at which a soil will just begin to crumble when rolled into a thread approximately 3 mm in diameter.

Apparatus:

As for liquid limit test, and ground glass flat plate about 45 cm square or larger.

Soil Sample:

A sample weighing about 20 gm shall be taken from thoroughly mixed soil passing 425 micron IS sieve.

Procedure:

The soil sample shall be thoroughly mixed with little quantity of distilled water till the soil mass becomes plastic enough to be easily shaped into a ball of about 8 gm of plastic soil and rolled between fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rolling is done till the threads are of 3 mm diameter. The soil is then kneaded together to a uniform mass and rolled again. The process of rolling and kneading goes on till the thread crumbles at the thickness of 3 mm. The

whole test shall be repeated once more.

The crumbled soil threads are collected in the evaporating pan and are kept in the oven.

Observations:

Observations are recorded in tabular form in Appendix A. IS 2720 (Part-5)-1985

Results:

The moisture content is determined as above for at least three portions of the soil. The average of the results is the plastic limit of the soil.

Precautions:

Undue pressure which might result in mechanical breaking of the soil thread, should not be used.

The rate of rolling shall be between 80 and 9000 strokes/minute.

Reference:

IS 2720 (Part-5) : 1985

Staff:

1. One lab. Technician
2. One Helper
3. Two Tests per day

ANNEXURE 4/3

SHRINKAGE LIMIT

[IS 2720 (Part 6)-1972] Reaffirmed-2011

This is the maximum water content at which a reduction in water content will not cause an appreciable decrease in the volume of the soil mass. Below the Shrinkage limit, the soil is considered to be a soild. Shrinkage limit values together with other index values are useful in identifying expansive soils.

Apparatus:

Evaporating Dish: Two porcelain dishes, about 12 cm diameter with a pour out and flat bottom. The diameter of flat bottom, being not less than 55 mm or and enameled iron tray with pour out.

Spatula: Flexible, with the blade about 8 cm long and 2 cm wide.

Shrinkage Dish: Circular, porcelain or glass dish having a flat bottom and 45mm in diameter and 15mm height internally. The internal corner between the bottom and the vertical sides shall be rounded into a smooth concave curve.

Straight Edge: Steel straight edge, about 15 cm in length.

Glass Cup: 50 to 55 mm in diameter and 25mm in height, the top rim of which is ground smooth and level.

Glass Plate: Two, each 75x75mm , 3mm thick. One plate shall be of plain glass and the other shall have three metal prongs inert to mercury.

Oven: Thermostatically controlled to maintain the temperature between 105º and 110ºC, with interior of non-corroding material.

Sieves: 425 micron IS sieve.

Balance: Sensitive to 0.1 g and 0.01g.

Mercury: Clean, sufficient to fill the glass cup to overflowing.

Procedure:

Determine the volume of the dry soil pat by removing the pat from the Shrinkage dish and immersing it in the glass cup full of mercury in the following manner. Fill the glass cup to overflowing with mercury and remove the excess mercury by pressing the glass plate with the three prongs firmly over the top of the cup, collecting the excess mercury in a suitable container. Any mercury which may be adhering to the outside of the cup shall be carefully removed. The cup, filled with mercury shall be placed in a clean evaporating dish and the dry soil pat shall be placed on the surface of the mercury. Then carefully force the pat under the mercury by means of the glass plate firmly over the top of the cup. It is essential that no air be trapped under the soil pat. The displaced mercury being collected in evaporating dish and measured in a graduate glass and record the volume of the dry soil pat Vo.

The weight of the clean empty dish shall be determined and recorded. The capacity of the dish in cubic centimeters, which is also the volume of the wet soil pat, determined by measuring the volume of mercury held by the dish. Mercury shall be filled in the dish to overflowing and the excess removed by pressing a glass plate firmly over the top of dish and no air should be entrapped. The volume of mercury may then be measured by means of 25ml. glass graduate. This volume shall be recorded as the volume of the shrinkage dish, V.

Observations:

Project:

Name of work: Laboratory Sample No.

Project: Description of Soil Sample

- Shrinkage dish number
- Weight of empty shrinkage dish in gm
- Weight of shrinkage dish+wet soil pat (gm)
- Weight of shrinkage dish+dry soil pat (gm)
- Weight of oven dry soil pat (Wo) (in gm)
- Moisture content ofsoil pat (Wm) (%)
- Volume of wet soil pat in ml. (V)
- Volume of dry soil pat in ml. (Vo)
- Shrinkage limit = Wm $\left[\frac{V-Vo}{Wo}\right]x100$

Calculations:

1. **Moisture Content (W):** To Calculate the moisture content of wet soil pat as a percentage of the dry weight of the soil as below:

$$\text{Wm } \frac{W-Wo}{Wo} x100$$

Where: Wm = Moisture content of the soil pat.

W = Weight of wet soil pat, obtained by subtracting the weight of shrinkage dish from weight of the dish and wet soil pat.

Wo = Weight of oven dry soil pat, obtained by subtracting the weight of the shrinkage dish from the weight of the dish and dry soil pat.

2. Shrinkage Limit (Remoulded soil) (51-); to Calculate the shrinkage limit using the following formula.

$$\text{SL} = \text{Wm-} \left[\frac{V-Vo}{Wo}\right] x100$$

Where Wm=Moisture content of the wet soil pat in percent,

V = Volume of wet soil pat in ml.

Vo = Volume of oven dry soil pat in ml, and

Wo = Weight of oven dry soil pat in gm.

Precautions:

The test shall be repeated at least three times for each soil sample and the average of the results thus obtained reported. If any individual value varies from the average by more than $\pm$ 2 percent, it shall be discarded and the test repeated.

At the time of filling the shrinkage dish no air bubbles should remain in the soil paste.

It is essential that no air be trapped under the dry soil pat when measuring the volume of dry soil.

Staff:

One Research Assistant or Embankment Inspector

One Helper 2 tests per day

ANNEXURE 4/4

ENGINEERING TESTS FOR EARTH DAM DESIGN

COMPACTION OF SOILS (MOISTURE DENSITY RELATIONS)
IS: 2720 (Part-7) 1980 Reaffirmed 2002

Significance:

In the stability analysis of an earthen embankment the density of the soil and its Shear Strength play an important role. The until weight or density of the soil varies with the degree of compaction of the soil in the embankment. Stability of the embankment largely depends upon the compaction achieved, because compaction also improves its shear strength, bearing capacity, and bring about a lower permeability of the soil and decreases the tendency of the soil to settle under repeated loads.

The degree of compaction of a soil is characterized by its dry density. In embankment under construction it depends upon the moisture content, amount of compactive effort and the nature of the soil being compacted.

The moisture content at which the dry density of the soil is maximum is known as optimum moisture content (O.M.C.) To find out the soil moisture density relationship for a soil to be used for embankments for tank bunds, highways, run ways, railways etc. the soil is subjected to a compaction test. The test gives a practical and satisfactory method of field control on construction of earthen embankments.

Testing:

Two types of tests are needed, a standard laboratory compaction test and a field density test. The ratio of the field density to the standard laboratory density of a soil is termed the "Relative Compaction". In practice a fild density between 95% and 98% of standard density in the laboratory is specified. Both the tests are conducted as per standard procedure laid down in the relevant IS code IS 2720/part VII.

In the standard compaction test of soil, the compaction energy applied by the specified compaction rammer in a specified manner is considered to be equivalent to a compaction equipment used in the field.

Utility of Compaction Test or Moisture Density Relationship

(i) It helps in designing the dam section.

(ii) It helps in quality control of earth work where results of density achieved in the fill is compared with maximum dry density for assessing compaction efficiency.

(iii) It determines the quantity of water to be added to the material brought on the embankment before, rolling begins.

COMPACTION TEST (IS; 2720 (PART 7) 1980 Reaffiremed.2002
(USING LIGHT COMPACTION)

Introduction:

The test determines the relationship between moisture content and the dry density that can be achieved with the standard compactive effort. With the increase in moisture content, dry density goes on increasing and a stage comes when any further increases in moisture content leads to decrease in dry density. A plot of moisture contents as abscissa and dry density as ordinate is a parabola. Maxima of the prabola give the Maximum Dry Density (MDD) and the corresponding moisture content as the Optimum Moisture Content (OMC) with the standard compactive effort.

In other words, compaction is a process of reducing the Void ratio and bringing together the soil particles by the application of quick repeated load.

Apparatus:

Compaction cylinder with detachable collar and base plate having capacity 1000 cm^3 with internal diameter of 100 $\pm$ 0.1mm and height 127.3 $\pm$ 0.1mm

Rammer; Compaction Ramer of 50 dia, weight 2.6 kg. having vertical drop of 31 cm,

Measuring Cylinder,

Sample Extruder,

G.I. Tray with trowel, Spatula etc.

Oven

Balance one of capacity 10 kg sensitive to 1 gm and another of capacity

200g sensitive to 0.01g.

Evaporating dish,

Physical balance with weight box.

Sample for Test:

The air dried sample passing 80mm I.S. sieve shall be made to pass through 20mm and 4.75mm IS sieves, separating the fractions retained and passing these sieves. The percentage of each fractions shall be determined. The percentage of soil retained on 4.75mm IS Sieve and the percentage of soil retained on 20mm IS sieve shall be determined.

The ratio of fraction passing 20mm IS sieve and retained on 4.75mm IS Sieve to the soil passing 4.75mm IS sieve shall be determined. The material retained on and passing 4.75 mm IS sieve shall be mixed thoroughly in calculated proportion to obtain about 16 to 18 kg of soil. In the case of material passing 20mm IS sieve and retained as 4.75mm IS sieve is greater than 20%, the ratio of such material to the material passing 4.75mm IS sieve shall be maintained for each determination in a test. if the material retained on 4.75mm IS sieve is less than 20% the samples passing the 20mm IS sieve may be directly used.

About 16 Kg. of above prepared soil samples shall be taken and enough water shall be added to bring its moisture content to about 7% (sandy soils) and 10% (clayed soils) less than the estimated O.M.C. The processed soil is kept in an air tight tin for about 18 hours to ensure thorough mixing of water through soil.

Procedure:

The empty mould shall be cleaned dried and weighed to nearest 1 gram. The inside of the mould shall be greased lightly. Mould shall be attached to the based plate and collar shall be attached to the cylinder. About 5 Kg. soil (kf clayey) shall be taken in small tray and 30 cc of water is added to it. The soil is mixed thoroughly. Three equal parts of this soil shall be made. One part of the soil shall be placed in mould 25 blows equally distributed are given to this part of the soil. The surface of this compacted layer is made rough with spatula. Second part of the soil shall be placed in mould and again 25 blows are given. The same process shall be

repeated for third part, collar shall be removed, and the surface of the compacted soil shall be carefully levelled with the level of mould because volume of the soil shall be equal to the volume of cylinder. The weight of mould with soil shall be recorded; soil shall be taken out of the mould with the help of sample pusher.

Vertical slice from inner portion of the soil ejected out of the mould is taken in evaporating dish which is previously weighed. It shall be kept in the oven.

Add 30 cc of water more than added in the previous test to 5.0 kg of soil and same process shall be repeated Reading shall be recorded. This procedure shall be repeated for 5 times each using higher water content then the proceeding specimen. After the sample in the oven shall be dried its weight shall be recorded.

Observations:

Observation are recorded in a tabular form.

Calculations;

$$\text{Moisture Content } \% = \frac{\text{Weight of water X 100}}{\text{Weight of dry soil}}$$

$$\text{Wet Density} = \frac{\text{Weight of Moist compacted soil}}{\text{Volume of soil or Volume of mould}}$$

$$\text{Dry Density} = \frac{\text{Wet Density X 100}}{\text{100 + Moisture Content}}$$

A curve showing the relationship between moisture content and dry density shall be plotted. The maximum point of the curve corresponds to the maximum dry density and the corresponding water content shall be the optimum moisture content.

Precautions:

Before compaction thorough mixing of sample with water should be done because inadequate mixing and insufficient maturing period results in formation of modules which act like preces of aggregate which affects the test results.

ANNEXURE 4/5

SHEAR STRENGTH
(IS: 2720 part 11-1993) Reaffirmed 2011
IS: 2720 part 12-1981(Reaffirmed 2011

SHEAR STRENGTH

One of the important parameters to know properties of a soil, is its shear strength. Shear strength of a soil is the limiting resistance offered by the soil to the shearing forces. It is customary to measure it in two components Cohesion and Angle of Internal friction' and then evaluate it on the basis of Coulomb's equation given by French Engineer Coulomb.

$$S=C + ef \tan \theta$$

Where S is the shear strength of the soil, C is cohesion, θ is, the angle of internal friction and ef is the effective normal stress.

COHESION 'C'

It is produced by the actual bond which develops at the surfaces of contact of clay particles as a result of electro-chemical forces of attraction.

ANGLE OF INTERNAL FRICTION θ

Angle of internal friction θ is due to presence of friction between particles and is measure of the frictional component of Shear strength. Presence of water film decreases the frictional resistance while increase in the normal load increases it. Water behaves as a lubricant and assists the sliding forces while increase in normal load increases the surface area in contact at the plane of shear and thus increases the frictional resistance.

UTILITY OF RESULTS OF SHEAR TESTS

Shear test results help in:

- designing the dam section.
- assessing the bearing capacity of foundations.
- assessing the pore pressure likely to develop in a dam under different conditions.
- assessing stability of an existing dam when undisturbed soil samples from the dam are tested for shear.

TRIAXIAL SHEAR TEST
(IS: 2720 (PART 18-1971)

UNCONSOLIDATED UNDRAINED TEST WITHOUT MEASURING PORE PRESSURE (Q-TEST)

Purpose:

For the determination of the compressive strength of a specimen of saturated cohesive soil in the Triaxial shear machine under conditions in which the cell pressure is maintained constant and there is no change in the total water content of the specimen.

Equipments:

Triaxial Shear Testing Machine, Triaxial Cell, Lateral pressure assembly, pore pressure apparatus, constant volume mould sample extractor, sheath stretcher, rubber membrane, perspex discs, balance and oven, stop watch, vernier calliper, scale, knife, Grease or oil.

Procedure:

A specimen of size 37.5 mm diameter and 75mm long shall be prepared with the help of constant volume mould at required moisture content and density. In the case of undisturbed soil sample, the specimen shall be extracted from the 37.5 mm diameter steel sampling tube and specimen of 75mm length is prepared.

The specimen shall then mount in the triaxial cell on pedestal after placing perspex disc of 37.5mm diameter at the bottom and top of the specimen. The rubber membrane shall be placed around the specimen using the sheath stretcher and the membrane shall sealed by means of rubber rings. The cell shall be assembled in its place and completely filled with clean water. The cell containing the specimen shall be placed in the loading machine; the strain gauge and proving ring with stress gauge are set in a proper position with the cell for recording required observation.

The desired pressure shall be applied to the sample in the cell with the help of lateral pressure assembly by adjusting the height of the mercury pot.

The machine shall be started after adjusting Turrent setting lever at the desired rate of strain. The observation of strain and stress gauges are recorded simultaneously. The test shall be continued until the maximum value of the stress is reached or till an axial strain of 20 percent

is reached.

After completion of the operation the cell shall be drained and the specimen is taken out. In similar procedure two more specimens shall be tested with the increased values of two different lateral pressures and all observations shall be recorded in the proforma attached.

Calculations:

The corresponding shear stresses are worked out for all the 3 specimens tested as above, for plotting Mohr's circles on a graph. A common tangent to all the three circles is drawn. The point where the Tangent cuts the axis of the graph is taken as the value of cohesion (C) and the angle which the tangent line makes with the horizontal is taken as angle of friction (θ).

Staff:
Research Assistant One sample in 2 days
Helper

CONSOLIDATED UNDRAINED TEST WITH PORE PRESSURE MEASUREMENT (R-TESTS)
(IS:2720 part-12 1981) Reaffirmed 2011

Purpose;

For determination of shear strength parameters of soils from consolidated undrained triaxial compression test with measurement of pore water pressure.

Knowledge of shear strength parameters that is cohesion intercept and the angle of shearing resistance of saturated soil both in terms of total stress and effective stress obtained from triaxial compression shear tests conducted under consolidation undrained conditions with measurements of pore water pressure.

The test is essential for solving problems involving stability of earth embankments.

Equipments:

Triaxial shear testing machine, Triaxial Cell, Lateral pressure assembly, system to measure pore pressure, Constant volume mould, Sample Extractor, Sheath stretcher, rubber membrane, porous discs, balance and oven.

Procedure:

A specimen of size 37.5 mm diameters and 75mm length shall be prepared at saturation with

the help of constant volume mould. Filter paper strips shall be provided along the height of the specimen at its circumference to induce radial drainage. Filter paper discs of 37.5mm dia shall be placed at the bottom and top of the specimen and then porous stones of 37.5mm diameter are placed at the bottom and top of the specimen. The specimen shall then the mounted in the triaxial cell, rubber membrane shall be placed around the specimen and the rubber membrane sealed by means of rubber rings. The cell shall be assembled and filled with clean water. The cell shall be placed in the loading machine strain gauge and proving ring is set in proper position with the cell for recording observations.

The desired pressure shall be applied to the specimen in the cell with the help of lateral pressure assembly by adjusting the height of the mercury pot. The drainage valves of the cell shall be opened and the specimen shall be kept for consolidation for 24 hours.

After completion of consolidation the specimen shall be tested in a similar way but with different rate of stain (0.625 mm per minute). The readings of strain gauge, stress gauge and pore pressure measurements shall be recorded simultaneously. The test shall be continued until the maximum values of the stress shall reach or till an axial strain of 20 percent shall be reached.

Two more specimens shall be tested similarly with increased value of two different lateral pressure, and observations shall be recorded in the proforma attached.

Calculations:

As described above.

Staff:

Research Assistant

One helper One sample in six days.

DRAINED TEST ('S'-TEST)

Like R-test, natural and de-aired porous stone shall be used in this test and saturated specimen shall be consolidated in the same way. But here, unlike R-test the drainage valves shall be closed during testing i.e. drainage shall allowed during shearing of the specimen also and the valve connecting the cell to the pore-pressure apparatus shall be kept closed.

Readings of proving ring gauge and strain gauge shall be taken up to desired deformation at desired rate of strain. The tests shall be repeated on identical specimens at different lateral pressure. In R and S tests side strains of filter paper strips used to expedite the consolidation of saturated specimen. Rate of strain for 1.5" dia specimen.

NAME OF TEST	RATE STRAIN	TIME FOR SHEARING SAMPLE (20% STRAIN)
Q at O.M.C. & M.D.D. R test for impervious material.	0.02" min	30 minutes
	0.002"/min	5 hours
S. Test for pervious material	0.002"/min	6 hours

Precautions:

1. Pore pressure apparatus should be properly de-aired.
2. Pore pressure gauge should not be subjected to shear.
3. All valves should be leak proof.

APPENDIX B

(CLAUSE 5.4)

PROFORMA RECORD OF OBSERVATION OF CU TRIAXIAL

SHEAR TEST

Pre-Shear Data Sheet No.1

Project _____

Test No._____

Sample No. _____

Date _____

Soil identification_____

Tested by _____

Sample Measurements _____

Initial Water Content _____

Initial dia, Do _____

Can No. _____

Initial length, Lo v

Weight of can + Wet soil _____

Initial area, Ao _____

Weight of can + Dry soil _____

Initial volume, Vo _____

Weight of water

Initial weight _____

Weight of can _____

Weight of dry soil _____

Water content _____

Void Ratio _____

Specific Gravity_____

Effective Confining pressure_____

Time	Elapsed Time,t	Esqrt	Burette reading EDELTAV
Post-Consolidation Water Content _____ Post-Consolidation Void Ratio _____ CV_____			

Back Pressure

B-factor

Remarks:

PROFORMA FOR CU TRIAXIAL SHEAR TEST-SHEAR DATA SHEET NO.2 ACCORDING TO COMPENDIUM OF INDIAN STANDARDS ON SOIL ENGINEERING-PART 1

Project_____ Loading Frame No._____Cell No. _____Text No. _____
Sample No. _____Proving No. _____ Date _____
Soil Identification _____ Deformation Rate _____Tested by _____

Post-consolidation Length , L _____ Confirming Pressoure 62 _____
Post-consolidation Dia, D_____
Post-consolidation Area, A_____ Back Pressure_____Post-Shear Weight_____

Elapsed Time	Gauge U	Dial Gauge	Strain %	Proving Ring Dial	Δu	Axial Load	Area of Sample	6_1-6_2	6_3	6_1	6_1+6_3	$6_1/6_2$	A Factor			Post-Shear Water Content
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
		Proving Ring Suspended														Specimen Location
		proving Ring acted up by º Ar														Can No.
																Weight of Can+ Wet Soil
																Weight of Can + Dry Soil
																Weight of Water
																Weight of Can
																Weight of Dry Soil
																Swater Content

Post-Shear Length .....
Post-Shear Sample Shape.....

ANNEXURE 4/6

PERMEABILITY OF SOIL
(IS: 2720 (PART 17) 1986 Reaffirmed 2011)

Introduction:

Permeability is the ease or facility with which water percolates through soil. Darcy was first to study flow of water through soil and demonstrated that the rate of flow or discharge per unit time is proportional to the Hydraulic gradient.

$$q = K\ i\ A$$

Where:

q = Discharge per unit time

A = Cross sectional area of soil perpendicular to flow

i = Hydraulic gradient

K = Darcy's coefficient of permeability

Coefficient of permeability 'K' is defined as the superficial velocity of liquid under unit gradient.

Factors Affecting the Permeability

Grain size of soil

Void ratio of soil

Structural arrangement of soil

Entrapped air and other foreign matter

Absorbed water

Temperature/viscosity of water

Laboratory Determinations

It is determined in the laboratory with the help of permeability Apparatus. The size of the apparatus varies with the maximum size of soil particles. Following two methods are employed.

Constant head method for pervious soils,

Variable head method for impervious soils.

Field Permeability Determination:

This test gives three dimensions permeability. Following two methods are employed:

Pumping out test below water table,

Pumping in test above water table

Procedure:

Test procedure shall be as laid down in IS: 2720 part 17-1986 for laboratory determination of permeability IS: 5529 (part 1)- 1985 & IS: 5529 (Part 2). Code of practice for in situ permeability tests in over burden and in bed rock respectively.

Comparison of Laboratory Permeability and Field Permeability:

Whereas laboratory permeability is one dimensional, field permeability is three dimensional. There is no direct relationship between laboratory permeability and field permeability. Laboratory permeability is more realistic and reliable for engineering problems of construction.

Purpose:

Permeability results are useful in deciding the zone where a particular soil is to be used in a dam. Permeability of various soil groups and their placement is given in table-6 of IS 1498-1970. Permeability of casing soil shall be normally ten times of the permeability Hearting soil.

Permeability results help in working out the likely seepage through body of the dam and foundations and remedial measures, if the seepage is excessive. Permeability results help in assessing uplift pressure under a hydraulic structure. Permeability results help in finalizing

dam section.

PERMEABILITY TESTS
(Falling Head Method)

Equipments:

Permeameters, stand pipes and compaction assembly.

Procedure:

About 2.5 kg of soil sample shall be taken and a sample shall be prepared at optimum moisture content by adding water. The soil sample shall be compacted at maximum dry density as per standard compaction test in the permeameter. Both the ends of the permeameter shall be leveled, filter papers of size 4.0 inch diameter shall be placed at both ends and two porous stones shall also be placed at both ends of the permeameter. The permeameter shall be then assembled and connected to the stand pipe with the help of rubber tubing's.

Clean water shall be filled in the stand pipe and the connection valve of the permeameter shall be opened to allow the water to go inside the soil sample.

The readings of water level on stand pipe are recorded at regular intervals. The operation shall be continued for about a week so as to allow sufficient time for the saturation of entire soil sample.

After saturation of the sample, final readings of water head are taken for calculations.

Observations and Calculations:

Observations shall be recorded & permeability shall be calculated as follow:

RECORD OF OBSERVATION WITH EXAMPLE FOR CALCULATION OF PERMEABILITY BY FALLING HEAD METHOD

Project _____Test No. _____

Sample No. _____ Date _____

Soil Identification _____ Tested by _____

Diameter of Specimen (D) _____cm

Length of specimen (L) _____ cm

Area of specimen (A) _____ cm^2

Volume of specimen (V)=AL = _____cm^3

Area of stand-pipe (a) = _____ cm^2

C = 2.303 ---- = $\frac{aL}{A}cm$

A = Temperature of water, T = 34ºC

Sl.No.	Initial Time ti seconds	Final time tf seconds	Initial Head h1 (cm)	Final Head h2 (cm)	h1/h2	log 10h1 h2 $\frac{\log 10 h1/h2}{(tf-ti)}cm/s$	Kr =	Remarks
1	2	3	4	5	6	7	8	9

Weight of wet soil specimen after test Wt = _____g

Weight of dry soil specimen, Ws = _____g

Water content, W = $\frac{W_t - W_s}{W_s} x100$= _____percent

Specific gravity of specimen, Gs = _____

Void ratio, e = $\frac{VG_s - W_S}{W_S} x100$=_____

Degree of saturation, S = $\frac{GsW}{e}$=_____ percent

Permeability at 27ºC, k27 = $\frac{kTyT}{Y_{27}}$=_____ cm/s

Where μ T/μ 20 is the viscosity correction coefficient.

First the soil sample shall be saturated for 5 to 6 days. For the soil of low permeability the soil specimen shall be subjected to a gradually increasing vacuum with bottom outlet closed, so as to remove air from the soil voids. After complete saturation of the specimen both the top and bottom outlets of the permeameter shall be closed.

Staff:

E.I. or Research Assistant : 1

Skilled Helper : 1

Test Norms/ Periods for the completion of Test

One sample in 10 to 12 days depending on the type of sample.

IS: 2720 (Part 17(- 1986

RECORD OF OBSERVATION WITH EXAMPLE FOR CALCULATION OF PERMEABILITY BY CONSTANT HEAD METHOD

Project _____Test No. _____

Sample No. _____Date _____

Soil identification_____Tested by _____

Diameter of specimen (D) _____cm

Length of specimen (L) _____cm

Area of specimen (A) _____cm^2

Volume of specimen (V) _____cm^3

Head Loss h - H1-H2 =_____cm

Hydraulic Gradient i-h/L _____

Temperature of water T = _____^oC

Sl. No.	Quantity Q cm^3	Time, t Seconds	Permeability $KT\frac{Q}{Ait}$ cm/s	Remarks
1	2	3	4	5

Weight of wet soil specimen after test,Wt = _____g

Weight of dry soil specimen, Ws = _____g

Water content, W = $\frac{Wt-Ws}{Ws}x100$_____percent

Specific gravity of specimen, Gs = _____

Void ratio, e = $\frac{VGs-Ws}{Ws}x100$=_____

Degree of saturation, S = $\frac{GsW}{e}$=_____ percent

Permeability at 27ºC, k27 = $\frac{kTyT}{y27}$=_____ cm/s

DETERMINATION OF PERMEABILITY FOR UNDISTURBED SAMPLE

The undisturbed soil sample shall be trimmed in the shape of a cylinder of 4" dia 4.6" high. The excess length of the sample should be cut off and the specimen shall be placed centrally over the porous disc of the drainage base, fixed to the mould.

Further steps are same as in the case of test for a disturbed sample, as already described in the testing procedure, above.

The undisturbed sample in the core cutter can also be fitted with copper pipes. The core cutter shall be sealed in both sides with paraffin wax. The rubber cork having the diameter equal to the dia of the core cutter with a hole at the centre, shall be taken after removing the waste, it is placed at the top and bottom of the core cutter Rubber tube of the glass stand pipe, is fitted in the hole of cork which serves as inlet. A rubber tube shall be similarly attached at the bottom, to serve as the bottom outlet.

Procedure for Constant Head Test:

Soils of medium to high permeability shall be tested by constant head procedure. Soil specimen shall be subjected to a required constant head.

One or two days time shall be givento obtain full saturation of the sample, which can be checked if so desired as per the procedure given in the relevant IS Code 2720 9part 17): 1986. the specimen shall be connected through the top inlet to the constant head water reservoir. The bottom outlet shall be opened and when the steady state of flow has been established, the quantity of flow, for a convenient time interval, shall be collected and measured.

Alternatively, the inlet may be at the bottom and water may be collected from the outlet at the top.

The collection of the quantity of flow for the same time interval shall be repeated thrice.

Observations and Calculations:

Observations shall be recorded & permeability shall be calculated.

Precautions:

Coarse grained soils shall be tested under low hydraulic gradient to ensure laminar flow

conditions for the validity of Darcy's law.

Clean water or distilled water shall be used for the test.

It shall be ensured that no air shall be entrapped in the supply line to the permeameter, when the flow is started for the test, if there is air in the assembly it shall be got removed, before taking observations.

Temperature at the test be noted and the permeability be reported at the standard temperature of + 20ºC.

If the test temperature is different from +20ºC, the value of the coefficient of permeability K value is to be corrected for viscosity, viz., temperature and shall be reported as:

$$K20 = \frac{\mu T}{\mu 20}$$

ANNEXURE 4/7

SWELLING PRESSURE TEST
(IS: 2720 (Part-41) -1977) Reaffirmed 2011

Introduction:

Expansive soils are those which swell considerably on absorption of water from out side and shrink on removal of water. Although the phenomenon of Swelling and shrinkage is not uncommon with most of the soils (except sand and gravel), it is exhibited to a very marked degree only by certain clayey soils and hence, the term expansive soil is used only for such soils.

The capacity to swell of a soil depends upon the type and amount of clay minerals and the exchangeable bases. Out of the three major mineral groups montmorillonite, illite and kalinite, the montmorillonite clay minerals swell on coming in contact with water, where as the clay minerals of the other two groups do not swell or swell to a very less extent.

The volume changes associated with expansive soils are liable to cause considerable distress to structures involving their use or coming in contact with them.

Equipments:

1. One Loading Unit 5 Ton Capcity.
2. One spacer plate 4" dia x 1/2" thick
3. One flanged and plug 4" dia x 2" height.
4. Two porous stone 4" dia x 1/2" thick.
5. One proving ring 250 kg cap. with calibration chart.
6. One dial gauge 0.001" x 1" range.
7. One load transfer bar.
8. One steel ball.
9. One soaking tank, 10" dia x 8 1/2 high.

Staff:

Research Assistant of EI: 1

Procedure:

The samples shall be collected in core-cutters, so that in situ condition of the soil shall be maintained.

Core-cutter received from the site shall be opened with spatula and volume of the soil shall be measured and its weight shall be recorded along with the core-cutter. Sample shall be removed from the core cutter and shall be made to sundry and then completely dry in ovenat 105ºC for about an hour. Prior to this about 150 gms. of soil shall be taken out for N.M.C. (Normal Moisture Content) determination.

We density and moisture content shall be found out and the dry density of soil shall be calculated. From the dry density and volume of mould of swell pressure apparatus calculate the quantity of dry soil sample required for the test. in this weighed sample add 6 to 8% of water (less than shrinkage limit) to facilitate compaction. The mould shall be clamped to the base plate in the recess. On the base plate spacer platewise kept. Coller shall be attached to the mould. Part of the soil shall be put in the cylinder and with the help of steel bar it shall be tamped.

The same procedure should be adopted for whole of the weighed soil. After this the soil shall be compacted by using the apparatus provided for. Spacer shall be removed and boiled porous stones are kept with the filter papers beneath and above the sample.

Place the mould assembly with specimen centrally inside the soaking tank. Couple the perforated swell plate to the load transfer bar with the help of the springs and insert the steel ball in the recess between the lower end of the load transfer bar and the perforated swell plate. Place this assembly with the perforated swell plate aligned in the mould collar and screwed in the load transfer bar to the lower abutment of the providing ring with the dial gauge bracket firmly.

Apply an initial load of 4.0kg. (approximately 0.05 kg/cm^2) on the specimen and reset the load measuring dial and the strain dial to zero position. Submerge the specimen fully by pouring water in the soaking tank and maintain the water level in the tank always above the

perforated swell plate. No sooner the strain dial show some increase in volume, bring it back to zero by adjusting the load on the perforated swell plate with the help of the hand wheel. This sort of frequent adjustment needs shall be done only on the first day of soaking. Record the providing ring dial at total elapsed time of 15mins, 30 mins., 1 hour, 2 hours, 4 hours, 8 hours and thereafter every 24 hours until the swelling pressure becomes constant. Continue the test at least for 96 hours. If the dial indicates any swelling, compensate the swelling by increasing the load on the swell plate. This volume change compensation had to be done about 30 minutes before a reading is due on the 2^{nd}, 3^{rd} and 4^{th} day.

If the swelling of soil goes on even after 96 hours the test shall be continued until the swelling pressure becomes constant. The maximum reading shall be recorded.

Sample is removed from the machine, and some saturated soil from middle portion of the mould is removed from the sample and is kept in oven after weighing for determination of S.M.C.

Calculations:

From the calibration chart supplied by the manufacturer load applied correwxponding to the maximum reading is calculated. The difference between the final and initial dial readings of the proving ring gives total load in terms of division which when multiplied by the calibration factor gives the total load. This when divided by the cross-sectional area of the soil specimen gives the swell pressure expressed in kN/m^2 (kgf/cm^2).

$$\text{Swelling Pressure in } kN/m^2 \text{ } (kgf/cm^2) = \frac{\text{Load}}{\text{Area of Specimen}}$$

$$\frac{\text{Final Dial Reading} - \text{Initial Dial Reading}}{\text{Area of Specimen}} \times \text{Calibration factor of Proving Ring}$$

Result: Swell pressure is reported in kgf/cm^2

References:

C.B.I.P. technical Report No. 28 of 3/80Soil engineering by Alam Singh

Operating instructions by AIMIL (IS:2720 part-41-1997)

ANNEXURE 4/8

DETERMINATION OF TOTAL SOLUBLE SOLIDS IS: 2720 (PART-21) 1977 Reaffirmed in 1987

The presence of soluble solids in soil is one of the important aspects requiring examination as these soluble solids greatly influence the Engineering properties of the soil.

Apparatus:

Bottle shaker, Electric oven, chemical balance, Glass funnel, porcelain Dish, Flask, Measuring cylinder, Glass bottle, pipette, Desicator, thermometer and Filter paper No. 42.

Procedure:

Soil samples passing 2mm I.S. Sieve and dried in oven at a temperature 105ºC shall be prepared. Out of this sample, 10 gms. of soil shall be taken and transferred to 250ml. glass bottle and 100ml. distilled water is added to it. The bottle shall be placed in the bottle shaker and it shall than be shaken for at least 15 hours, continuously. After this, the sample shall be allowed to settle, the clear portion of water is filtered through filter paper No. 42. 50ml. of clear filtrate shall be taken in the porcelain dish and is kept for drying in the oven at 110ºC. The dish shall be then cooled at room temperature in a desicator and weighed to get the weight or residue.

Observations: Observation shall recorded as follow:

Name of Project		Details of sample:		
1.	Sample No.	1	2	3
2.	Weight of oven dried soil taken (W) in g			
3.	Volume of clear filtrate taken in ml.	50	50	50
4.	Porcelain dish No. or glass dish No.			
5.	Weight of dish + Residue after over drying in g.			
6.	Weight of dish in g.			

7.	Weight of Residure (W_1) (5-6) in g.			
8.	Percentage of soluble solids $2X\frac{W_1}{W}X100$			

Calculations:

The percentage of total soluble solids in the soil is then calculated on the basis of the soil taken for analysis.

Percentage of soluble solids = $2X\frac{W_1}{W}X100$

Where W=Wt. of oven dry sample in gms.

W_1 = Wt. of residue in gms.

ANNEXURE 4/9

DETERMINATION OF SPECIFIC GRAVITY IS: 2720 (Part 3/Sec 1): 1980 Reaffirmed 2011

Specific gravity of soils finds application in finding out the degree of saturation and unit weight of moist soils.

Apparatus:

Pycnometer, Balance, Oven, Thermometer, Sieve 4.75mm and 2mm, Desiccator, Evaporating Dishes.

Procedure:

About 1 kg. of soil sample passing through 4.75 mm IS Sieve and dried in an oven shall be prepared and out of this 400 gms of sample shall be taken for test the pycnometer shall be cleaned, dried and weighed. It shall again be filled with water and weighed. The soil sample shall be transferred to pycnometer and weighed. The pycnometer shall be then filled with distilled water up to the top and outside surface shall be cleaned. pycnometer shall be then weighed again.

Calculations:

Specific Granity= $\frac{W_3 - W_1}{(W_3 - W_1) + (W_2 - W_4)}$

Where W1 = Empty weight of dry pycnometer in gms.

W2 = Wt.of pycnometer filled with distilled water in gms.

W3 = Wt. of pycnometer with dry soil in gms.

W4 = Wt. of pycnometer with soil and distilled water in gms.

ANNEXURE 4/10

DETERMINATION OF THE FREE SWELL INDEX OF SOILS:

Reference: IS:2720 (Part 40)-1977

Theory:

Determination of free swell index of soil which helps to identify the potential of a soil to swell which might need further detailed investigation regarding swelling and swelling pressures under different field conditions.

Equipments:

IS Sieve 425 Micron, Two glass graduated cylinders 100 ml capacity (see IS: 878-1956 for specification of graduated measuring cylinder), glass rod, kerosene, distilled water.

Procedure:

Take two 10 gms soil specimens of oven dry soil passing through 425-micron IS sieve

(Note:- In the case of highly swelling soils, such as sodium bentonites, the sample size may be 5 gms or alternatively a cylinder of 250 ml capacity may be used) Each soil specimen shall be poured in each of the two glass graduated cylinders of 100 ml capacity. One cylinder shall then be filled with kerosene oil and the other with distilled water up-to the 100 ml (see note above) mark. After removal of entrapped air (by gentle shaking or stirring with a glass rod), the soils in both the cylinder shall be allowed to settle. Sufficient time (not less than 24 hours) shall be allowed for the soil sample to attain equilibriums state of volume without any further change in the volume of the soils. The final volume of soils in each of the cylinders shall be read out.

Calculations:

The level of the soil in the kerosene graduated cylinder shall be read as the original volume of the soil samples, kerosene being non-polar liquid does not cause swelling of the soil. The level of the soil in the distilled water cylinder shall be read as the free swell level. The free swell index of the soil shall be calculated as follows:-

Free swell index, % = V_s-V_kX100 / V_k

Where:

V_s- The volume of soil specimen read from the graduated cylinder containing distilled water.

V_k- The volume of soil specimen read from the graduated cylinder containing kerosene.

ANNEXURE 4/11

WATER CONTENT

The moisture (water content) of a soil sample can be determined by the calcium carbide method with the help of moisture tester. (Ref: Soil Mechanics and Foundation by Dr B.C. Punmia ,1982)

ANNEXURE 4/12

BEARING CAPACITY OF SOIL BY PLATE LOAD BEARING TEST

The load test on soils and the evaluation of bearing capacities & settlement can be determined by this method. This method assumes that down to the depth of influence of stresses the soil strata is reasonably uniform. This should be verified by boring or sounding (Ref. IS 1888-1992).

ANNEXURE-5

GOVERNMENT OF MADHYA PRADESH

WATER RESOURCES DEPARTMENT

O.K. CARD

FOR

LAYOUT OF DAM AND APPURTENANT WORKS

For use by construction Engineer

O.K. Card No. _____ Date_____

1.	Name of Work	:		
2.	Location_____	:	Across River/Nalla_____	
	Longitude	:	_____N	
	Latitutde	:	_____E	
	Name of Village	:		
3.	Dam Axis	:	_____Length Bearing	
4.	Curvature if any give details	:	:	
5.	Reference to GTS B.M.	:	Location	:
			Value	:
6.	Surveyed by S/E	:		
7.	Checked by A.E.	:		
	E.E.	:		
8.	Approved by E.E /	:		
	S.E.	:		

	S/E (Works)	A.E. (Works)	E.E. (Works)	S.E. (Works)
Note:	For Major Project	Approval to be given by	S.E.	ON Ground
	For Medium Project	-do-	E.E.	
	For Minor Project	-do-	A.E.	

ANNEXURE-6

GOVERNMENT OF MADHYA PRADESH

WATER RESOURCES DEPARTMENT

O.K. CARD

FOR

LAYOUT OF CANAL AND STRUCTURES

For use by construction Engineer

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location_____	:	R.D./CH._____To_____ Village_____
3.	Canal Alignment to be walked over by and approved by S.E.	:	
4.	Reference to GTS B.M.	:	Location : Value :
5.	Surveyed by S/E	:	
6.	Checked by A.E. or E.E.	: :	
7.	Approved by S.E. or E.E.	:	

	S/E (Works)	A.E. (Works)	E.E. (Works)	S.E. (Works)
Note:	For Major Project	Approval to be given by	S.E.	ON Ground
	For Medium Project	-do-	E.E.	
	For Minor Project	-do-	A.E.	

ANNEXURE-7

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR CONCRETE WORK IN FOUNDATION & PLINTH

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1. Name of Work :
2. Location of work :
   (i) Block No. :
   (ii) R.D./CH : _____to_____
   (iii) Offset : _____to_____
   (iv) Lift R.L. : _____to R.L._____
3. Name of agency :
4. Method of concrete mixing :
   (i) Hand Vol/wt :
   (ii) Mixer Vol/wt. :
   (iii) Batching plant Vol.Wt. :
5. Method of placing :
   (i) Dropping from top
   (ii) Dropping by bucket
   (iii) Hand placing
6. Method of consolidation :
   (i) Mech. vibrator
   (ii) Hand keeping by trowel
   (iii) Hand tamping by rod
7. (i) Grade of mix :
   (ii) Proportion (designed)
   (iii) Slump required
   (iv) Max size of aggregate required to be used
   (v) Designed strength..... kg/sq.cm.

8. Date and time (i) Starting.....

(ii) Finishing .....

Sig. S/E L/C (Construction) Sig. A.E. I/C. (Construction

S.No.	Date of Test	For use by Q.C. Personnel Location of Test				Cube No.	Mix Pre-portion of concrere	W/C ratio	F.M. of sand	Max. size of agregate	Unit wt. of Agg.	Remark
		Block	RD/CH	Off set	RL							
1	2	3	4	5	6	7	8	9	10	11	12	13

Remarks
(i) General Quality of material
(ii) Oversize/under size
(iii) Segregation/bleeding
(iv) Surface cleaning
(v) Workmanship
(vi) Others

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-8

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR CONCRETE WORK IN SUPER STRUCTURES

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1. Name of Work :
2. Location of work :
   (i) Block No. :
   (ii) R.D./CH : _____to_____
   (iii) Offset : _____to_____
   (iv) Lift R.L. : _____to R.L._____
3. Name of agency :
4. Method of concrete mixing :
   (i) Hand Vol/wt :
   (ii) Mixer Vol/wt. :
   (iii) Batching plant Vol.Wt. :
5. Method of placing :
   (i) Dropping from top
   (ii) Dropping by bucket
   (iii) Hand placing
6. Method of consolidation :
   (i) Mech. vibrator
   (ii) Hand keeping by trowel
   (iii) Hand tamping by rod
7. (i) Grade of mix :
   (ii) Proportion (designed)
   (iii) Slump required
   (iv) Max size of aggregate required to be used
   (v) Designed strength..... kg/sq.cm.

8. Date and time

(i) Starting.....

(ii) Finishing .....

Sig. S/E L/C (Construction) Sig. A.E. I/C. (Construction

S.No.	Date of Test	For use by Q.C. Personnel Location of Test				Cube No.	Mix Pre-portion of concrere	W/C ratio	F.M. of sand	Max. size of agreegate	Unit wt. of Agg.	Remark
		Block	RD/CH	Off set	RL							
1	2	3	4	5	6	7	8	9	10	11	12	13

Remarks (i) General Quality of material

(ii) Oversize/under size

(iii) Segregation/bleeding

(iv) Surface cleaning

(v) Workmanship

(vi) Others

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-9

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR MASONARY WORK IN FOUNDATION & PLINTH

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1.	Name of Work	:	
2.	Location of work	:	
	(i) Block No.	:	
	(ii) R.D./CH	:	_____to_____
	(iii) Offset	:	_____to_____
	(iv) Lift R.L.	:	_____to R.L._____
3.	Name of agency	:	
4.	Method of concrete mixing	:	
	(i) Hand Vol/wt	:	
	(ii) Mixer Vol/wt.	:	
	(iii) Batching plant Vol.Wt.	:	
5.	Proportion of mortar	:	
6.	Class of stones/bricks	:	
7.	Sand quarry	:	
8.	Stone quarry	:	
9.	Date and time	:	
	(i) Starting_____		
	(ii) Finishing_____		

Sig. S/E I/C (INCHARGE) Sig. A.E. (INCHARGE)

S.No.	Date	Location of Test				Briquette No.	For use by Q.C. Personnel			F.M. of sand	Remark
		Block	RD/CH	Off set	RL		W/C ratio	Slump	Pro Portion		
1	2	3	4	5	6	7	8	9	10	11	12

Bricks	(i)	Dimension	Boulders	1.	Size
	(ii)	Physical	stones	2.	Weight
	(iii)	Appearance		3.	Weathering
	(iv)	Others		4.	Others
	(v)	Weather worked			

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-10

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR MASONRY WORKING SUPER STRUCTURE

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1. Name of Work :
2. Location of work :
   (i) Block No. :
   (ii) R.D./CH : _____to_____
   (iii) Offset : _____to_____
   (iv) Lift R.L. : _____to R.L._____
3. Name of agency :
4. Method of concrete mixing :
   (i) Hand Vol/wt :
   (ii) Mixer Vol/wt. :
5. Proportion of mortar :
6. Class of stones/bricks :
7. Sand quarry :
8. Stone quarry :
9. Date and time :
   (i) Starting_____
   (ii) Finishing_____

Sig. S/E I/C (INCHARGE) Sig. A.E. (INCHARGE)

S.No.	Date	Location of Test				Briquette No.	For use by Q.C. Personnel			F.M. of sand	Remark
		Block	RD/CH	Off set	RL		W/C ratio	Slump	Pro Portion		
1	2	3	4	5	6	7	8	9	10	11	12

Bricks	(i)	Dimension	Boulders	1.	Size
	(ii)	Physical	stones	2.	Weight
	(iii)	Appearance		3.	Weathering
	(iv)	Others		4.	Others
	(v)	Weather worked			

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-11

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR EARTH WORK -MAJOR PROJECT

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1.	Name of Work	:	
2.	LOCATION OF WORK	:	
	(i) R.D./CH	:	_____to_____
	(ii) Offset	:	_____to_____
3.	Depth of filling	:	
	R.L. of the previous layer	:	
	R.L. of the present layer	:	
4.	Type of roller used_____ No. of passes_____	:	
5.	Surface preparation	:	
	(i) Stripping	:	
	(ii) Narrowing	:	
	(iii) Removal of vegetation	:	
	(iv) Watering	:	
6.	Date and time start of rolling	:	
7.	Date and time of completion	:	
8.	any other information or reference	:	

Sig. S/E I/C (INCHARGE) Sig. A.E. (INCHARGE)

S.No.	Particulars	(For use of Q/C Personnel) Result Remarks	(State short coming or O.K. for fresh layer)
1	2	3	4
1.	Date of test		
2.	Surface preparation		
3.	Field classification of soil		
4.	Borrow area grid No. _____ Pit No. _____		
5.	Location of Test (i) R.D./CH. (ii) Off set (iii) R.L. _____		
6.	Thickness of layer		
7.	Wet density or rolled fill		
8.	Moisture content rolled fill		
9.	Dry density of rolled fill		
10.	Laboratory date (i) OMC (ii) MDD.		
11.	Compaction efficiency		
12.	Trimming and finishing of side slopes		

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-12

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR EARTH WORK -MEDIUM PROJECT

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1.	Name of Work	:	
2.	LOCATION OF WORK	:	
	(i) R.D./CH	:	_____to_____
	(ii) Offset	:	_____to_____
3.	Depth of filling	:	
	R.L. of the previous layer	:	
	R.L. of the present layer	:	
4.	Type of roller used_____ No. of passes_____	:	
5.	Surface preparation	:	
	(i) Stripping	:	
	(ii) Narrowing	:	
	(iii) Removal of vegetation	:	
	(iv) Watering	:	
6.	Date and time start of rolling	:	
7.	Date and time of completion	:	
8.	Any other information or reference	:	

Sig. S/E I/C (INCHARGE CONSTN) Sig. A.E. (INCHARGE CONSTN)

S.No.	Particulars	(For use of Q/C Personnel)		(State short coming or O.K. for fresh layer)
		Result	Remarks	
1	2	3		4
1.	Date of test			
2.	Surface preparation			
3.	Field classification of soil			
4.	Borrow area grid No. _____ Pit No. _____			
5.	Location of Test (i) R.D./CH. (ii) Off set (iii) R.L. _____			
6.	Thickness of layer			
7.	Wet density or rolled fill			
8.	Moisture content rolled fill			
9.	Dry density of rolled fill			
10.	Laboratory date (i) OMC (ii) MDD.			
11.	Compaction efficiency			
12.	Trimming and finishing of side slopes			

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-13

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR EARTH WORK-MINOR PROJECT

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
	(ii) Off set	:	_____to_____
3.	Depth of Filling	:	
	R.L. of the previous layer	:	
	RL of the present layer	:	
4.	Type of roller used_____No. of Passes _____	:	
5.	Surface preparation	:	
	(i) Stripping	:	
	(ii) Narrowing	:	
	(iii) Removal of Vegetation	:	
	(iv) Watering	:	
6.	Date of time of start of rolling	:	
7.	Date of time of completion	:	
8.	Any other information or reference	:	

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)		
		Results	Remarks	(State short coming or O.K. for fresh layer)
1	2	3	4	

1. Date of test
2. Surface preparation
3. Field classification of soil
4. Borrow area grid No. _____ pit No. _____
5. Location of test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
6. Thickness of layer.
7. Wet density of rolled fill
8. Moisture content of rolled fill
9. Dry density of rolled fill
10. Laboratory data
    (i) OMC
    (ii) MDD
11. Compaction efficiency
12. Trimming and finishing of side slopes

Sig. of R.A. /E.IK. (Q.C.) A.R.O. (Q/C) R.O./ E.E. (Q/C)

ANNEXURE-14

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR EARTH WORK-MAIN CANAL & DISTRIBUTORY

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
3.	Depth of Filling	:	
	R.L. of the previous layer	:	
	RL of the present layer	:	
4.	Type of roller used_____No. of Passes _____	:	
5.	Surface preparation	:	
	(i) Stripping	:	
	(ii) Narrowing	:	
	(iii) Removal of Vegetation	:	
	(iv) Watering	:	
6.	Date of time of start of rolling	:	
7.	Date of time of completion	:	
8.	Any other information or reference	:	

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)		
		Results	Remarks	(State short coming or O.K. for fresh layer)
1	2	3	4	

1. Date of test
2. Surface preparation
3. Field classification of soil
4. Borrow area grid No. _____ pit No. _____
5. Location of test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
6. Thickness of layer.
7. Wet density of rolled fill
8. Moisture content of rolled fill
9. Dry density of rolled fill
10. Laboratory data
    (i) OMC
    (ii) MDD
11. Compaction efficiency
12. Trimming and finishing of side slopes

Sig. of R.A. /E.IK. (Q.C.) A.R.O. (Q/C) R.O./ E.E. (Q/C)

ANNEXURE-15

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR EARTH WORK-MINOR

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
3.	Depth of Filling	:	
	R.L. of the previous layer	:	
	RL of the present layer	:	
4.	Type of roller used_____No. of Passes _____	:	
5.	Surface preparation	:	
	(i) Stripping	:	
	(ii) Narrowing	:	
	(iii) Removal of Vegetation	:	
	(iv) Watering	:	
6.	Date of time of start of rolling	:	
7.	Date of time of completion	:	
8.	Any other information or reference	:	

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)		
		Results	Remarks	(State short coming or O.K. for fresh layer)
1	2	3	4	

1. Date of test
2. Surface preparation
3. Field classification of soil
4. Borrow area grid No. _____ pit No. _____
5. Location of test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
6. Thickness of layer.
7. Wet density of rolled fill
8. Moisture content of rolled fill
9. Dry density of rolled fill
10. Laboratory data
    (i) OMC
    (ii) MDD
11. Compaction efficiency
12. Trimming and finishing of side slopes

Sig. of R.A. /E.IK. (Q.C.) A.R.O. (Q/C) R.O./ E.E. (Q/C)

ANNEXURE-16

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD FOR FILTERS

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
	(ii) Offset		_____to _____
	In case of slope protection, give other details or reference _____,		
3.	Lift R.L. of base _____ (in case of slope protection give thickness only)	:	
4.	Mode of compaction _____	:	
5.	Type of material used	:	
	Sand/Gravel/Stone chips of metal____mm	:	
6.	Surface preparation _____	:	

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)	
		Results (sets of Observations)	Remarks (state short coming or O.K. for fresh layer)
1	2	3	4

1. Date of test :
2. Surface preparation :
3. Thickness of filter layer :
4. Location of test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
5. Wet density g/cm^3 :
6. Moisture content :
7. In situ dry density g/cm^3 :
8. Max. dry density g/cm^3 :
9. Min. dry density g/cm^3 :
10. Relative density % :

% Passing at	D-10,	D-15,	D-50,	D-60,	D-85
Base	BM	D15	D85	D50	D60
Filter	FM	D15	D15	D50	D10

I _____
II_____
III_____

Sig. of R.A. /E.IK. (Q.C.) A.R.O. (Q/C) R.O./ E.E. (Q/C)

ANNEXURE-17

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR BOULDER PITCHING ON UPSTREAM SLOPE OF EARTH DAM

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Name of agency	:	
3.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
	(ii) Offset	:	_____to _____
	(iii) R.L.	:	_____to _____
	(iv) Other details of slope	:	_____to _____
4.	Designed thickness of boulder pitching	:	
5.	Mode of placement	:	
	(i) Hand placing	:	_____
	(ii) Unloading from a dumper/bucket	:	_____
6.	Location of quarry	:	_____
7.	Wt. of boulders per carrier_____	:	
	Vol. per carrier		

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)	
		Results	Remarks (state short coming or O.K. for fresh layer)
1	2	3	4

1. Date of test :
2. Surface preparation any :
3. Thickness of boulder pitching:
4. Location of check test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
5. Weight of boulder :
6. Size of bolder (1xbxt or Vol.) :
7. Physical condition :

   Weathered/Flaky/Laminated/Cubical/Rectangular
8. Quality of stone :
   Sand stone/quartz/granite/shale/biotite etc.
9. Packing for removal of void from inside:
10. Surface finish :

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

ANNEXURE-18

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR BOULDER PITCHING IN BED OF RIVER/CANAL

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Name of agency	:	
3.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
	(ii) Offset	:	_____to _____
	(iii) R.L.	:	_____to _____
	(iv) Other details of slope	:	_____to _____
4.	Designed thickness of boulder pitching	:	
5.	Mode of placement	:	
	(i) Hand placing	:	_____
	(ii)Unloading from a dumper/bucket	:	_____
6.	Location of quarry	:	_____
7.	Wt. of boulders per carrier_____Vol. per carrier	:	

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)	
		Results	Remarks (state short coming or O.K. for fresh layer)
1	2	3	4

1. Date of test :
2. Surface preparation any :
3. Thickness of boulder pitching:
4. Location of check test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
5. Weight of boulder :
6. Size of bolder (1 x b x t or Vol.) :
7. Physical condition :

   Weathered/Flaky/Laminated/Cubical/Rectangular
8. Quality of stone :
   Sand stone/quartz/granite/shale/biotite etc.
9. Packing for removal of void from inside:
10. Surface finish :

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

ANNEXURE-19

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR BOULDER PITCHING AROUND THE ABUTMENT OR STRUCTURE

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Name of agency	:	
3.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
	(ii) Offset	:	_____to _____
	(iii) R.L.	:	_____to _____
	(iv) Other details of slope	:	_____to _____
4.	Designed thickness of boulder pitching	:	
5.	Mode of placement	:	
	(i) Hand placing	:	_____
	(ii)Unloading from a dumper/bucket	:	_____
6.	Location of quarry	:	_____
7.	Wt. of boulders per carrier_____	:	
	Vol. per carrier		

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)	
		Results	Remarks (state short coming or O.K. for fresh layer)
1	2	3	4

1. Date of test :
2. Surface preparation any :
3. Thickness of boulder pitching:
4. Location of check test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
5. Weight of boulder :
6. Size of bolder (1 x b x t or Vol.) :
7. Physical condition :

   Weathered/Flaky/Laminated/Cubical/Rectangular
8. Quality of stone :
   Sand stone/quartz/granite/shale/biotite etc.
9. Packing for removal of void from inside:
10. Surface finish :

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

ANNEXURE-20

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR ROCK TOE/BOULDER TOE/RIP RAP

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Name of agency	:	
3.	Location of Work	:	
	(i) R.D./CH.	:	_____to _____
	(ii) Offset	:	_____to _____
	(iii) R.L.	:	_____to _____
	(iv) Other details of slope	:	_____to _____
4.	Designed thickness of boulder pitching	:	
5.	Mode of placement	:	
	(i) Hand placing	:	_____
	(ii)Unloading from a dumper/bucket	:	_____
6.	Location of quarry	:	_____
7.	Wt. of boulders per carrier_____	:	
	Vol. per carrier		

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

S.No.	Particulars	(For use of Q/C personnel)	
		Results	Remarks (state short coming or O.K. for fresh layer)
1	2	3	4

1. Date of test :
2. Surface preparation any :
3. Thickness of boulder pitching:
4. Location of check test
   (i) R.D./CH
   (ii) Off set
   (iii) R.L. _____
5. Weight of boulder :
6. Size of bolder (1 x b x t or Vol.) :
7. Physical condition :

   Weathered/Flaky/Laminated/Cubical/Rectangular
8. Quality of stone :
   Sand stone/quartz/granite/shale/biotite etc.
9. Packing for removal of void from inside:
10. Surface finish :

Sig. S/E INCHARGE (CONSTN.) Sig. A.E. INCHARGE (CONSTN.)

ANNEXURE-21

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR FOUNDATION OF EARTH DAM

For Use by Construction Engineers.

O.K. Card No. _____Date_____Shift_____

1.	Name of Work	:	
2.	Location of work	:	R.D./CH. _____to_____
3.	Depth of C.O.T./P.T.	:	_____metres.
4.	Top width C.O.T./P.G.	:	_____metres.
5.	Bottom width C.O.T./P.T.	:	_____metres.
6.	Side slopes of C.O.T./P.T.	:	_____Hor. to ____vertical
7.	Foundation strata on which C.O.T./P.T. is resting	:	_____
8.	Permeability test results	:	_____
9.	Layout of C.O.T./P.T.	:	_____
	Approved by S.E. For	:	_____
	Major and Medium project & by E.E. For Minor	:	_____
	Project-when? (give date)	:	_____
10.	Foundation inspection done and approved by Geologist for Major and Medium projects when? (give date)	:	_____
11.	Whether inspected by C.E. when ? (give date)	:	_____

Sig. OF GEOLOGIST SIG. OF E.E. (WORK) Sig. OF S.E. (WORKS)

ANNEXURE-22

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOUNDATION OF MASONRY DAM

For Use by Construction Engineers.

O.K. Card No. _____Date_____ Shift_____

1.	Name of Work	:	
2.	Location of work	:	
	R.D./CH.	:	_____to_____
	Block No.	:	_____to_____
	Offset	:	_____to_____
3.	Depth of foundation	:	_____metres.
4.	Top width	:	_____metres.
5.	Bottom width	:	_____metres.
6.	Foundation strata on which resting	:	_____
7.	Permeability test results	:	_____
8.	Layout of approved by S.E. for Major and Medium projects and by E.E. For Minor projects when? (give date)	:	_____
9.	Foundation inspection done and approved by Geologist for Major and Medium projects when? (give date)	:	_____
10.	Whether inspected by C.E. when ? (give date)	:	_____

Sig. OF GEOLOGIST SIG. OF E.E. (WORK) Sig. OF S.E. (WORKS)

ANNEXURE-23

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOUNDATION OF STRUCTURE OF HEAD WORKS VIZ, HEAD SLUICE, WASTE WEIR, CHUTE FALL, PIW, ETC.,

For Use by Construction Engineers.

O.K. Card No. _____Date_____ Shift_____

1.	Name of Work	:	
2.	Location of work	:	
3.	Depth of foundation	:	_____metres.
4.	Top width	:	_____metres.
5.	Bottom width	:	_____metres.
6.	Foundation strata on which resting	:	_____
7.	Permeability test results	:	_____
8.	Layout of approved by S.E./E.E. for Major and Medium/minor works when? (give date)	:	_____
9.	Whether inspection and approved by Geologist for Major and Medium projects when? (give date)	:	_____
10.	Whether inspected by C.E. when ? (give date)	:	_____

Sig. OF GEOLOGIST SIG. OF E.E. (WORK) Sig. OF S.E. (WORKS)

ANNEXURE-24

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOUNDATION OF STRUCTURE OF CANALS

For Use by Construction Engineers.

O.K. Card No. _____Date_____ Shift_____

1.	Name of Work	:	
2.	Name of Local nalla/stream	:	
3.	Location	:	
	R.D./CH _____of_____		Canal/Dist/Minor
4.	Depth of foundation	:	_____metres.
5.	Top width of foundation	:	_____metres.
6.	Bottom width of foundation	:	_____metres.
7.	Strata of foundation on which resting	:	_____
8.	Layout of approved by S.E./E.E. for Major structures on main canal/ structures on Dist. & minors.	:	_____
9.	Whether inspection and approved by Geologist when? (give date)	:	_____
10.	Whether inspected by S.E. when ? (give date)	:	_____

Sig. OF GEOLOGIST SIG. OF A.E. (WORK) Sig. OF E.E. (WORKS)

ANNEXURE-25

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
GATES AND VALVES

For Use by Construction Engineers.

O.K. Card No. _____ Date_____

1.	Name of Work	:
2.	Location of works	:
3.	Type of gate/valve	:
4.	Manufactured & supplied by	:
5.	Size of gate/valve	:
6.	Inspected by SE E/M and approved by him for all Major projects and by E.E. E/M for all Medium Pro9jects when? (give date)	:
7.	Whether inspected by C.E. E/M when? (give date)	:
8.	Whether inspected by CE (works) when? (give date)	

Sig. of A.E. (E/M) Sig. of E.E. (E/M) Sig. of S.E.(E/M)

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS) Sig. of S.E.(WORKS)

ANNEXURE-26

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
INSTRUMENTATION OF MASONRY DAM

For Use by Construction Engineers.

O.K. Card No. _____ Date_____

1. Name of Work :
2. Name and location of instruments shown below :

Sl.No.	Name of Instrument	Type of Instrument	Number	Location in Dam	Offset from Axis of Dam	Level of Lift RL	Remark

3. Date of Installation :
4. By whom supplied ? (name and address of Manufacturer) :
5. Whether inspected by AE/EE/ SE when? (give date) :
6. Whether inspected by CE when? (give date) :
7. Whether inspected by AE/EE/SE (Q.C.) & approved: :

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS) Sig. of S.E.(WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.) Sig. of S.E.(Q.C.)

ANNEXURE-27

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
INSTRUMENTATION OF EARTH DAM

For Use by Construction Engineers.

O.K. Card No. _____ Date_____

1. Name of Work :
2. Name and location of instruments shown below :

Sl.No.	Name of Instrument	Type of Instrument	Number	Location in Dam	Offset from Axis of Dam	Level of Lift RL	Remark

3. Date of Installation :
4. By whom supplied ? (name and address of Manufacturer) :
5. Whether inspected by AE/EE/ SE when? (give date) :
6. Whether inspected by CE when? (give date) :
7. Whether inspected by AE/EE/SE (Q.C.) & approved: :

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS) Sig. of S.E.(WORKS)

ANNEXURE-28

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
TURFING OF EARTH DAM ON U/S.

For Use by Construction Engineers.

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____
	Level of lift RL	:	_____
3.	Type of doob used	:	
4.	Material approved by EE (WORKS)	:	
5.	When inspected by AE/EE Q.C. (give date)	:	

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

ANNEXURE-29

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
TURFING ON CANAL BANKS

For Use by Construction Engineers.

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____
3.	Type of doob used	:	
4.	Material approved by EE (WORKS)	:	
5.	When inspected by AE/EE Q.C. (give date)	:	

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

ANNEXURE-30

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
LINING IN MAIN CANALS/DISTRIBUTORIES

For Use by Construction Engineers & Q.C. Staff

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____
3.	Type lining being done	:	
4.	Thickness CNS layer used	:	_____Cm.
5.	Thickness of lining used	:	_____ Cm.
6.	L.D.P.E. film type and thickness	:	

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

ANNEXURE-31

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

O.K. CARD
FOR
LINING OF MINORS

For Use by Construction Engineers

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____minor
3.	Type of lining used	:	
4.	Thickness CNS layer used	:	_____Cm.
5.	Thickness of lining	:	_____ Cm.
6.	L.D.P.E. film type and thickness	:	

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

ANNEXURE-32

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

O.K. CARD
FOR
LINING IN FIELD CHANNELS & WATER COURSES

For Use by Construction Engineers & Q.C. Staff

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____
3.	Type of lining	:	
4.	Thickness of lining	:	_____Cm.
5.	Thickness of CNS Layer	:	_____ Cm.
6.	L.D.P.E. film type and thickness	:	

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

ANNEXURE-33

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
_____PROJECT,_____

O.K. CARD

FOR PRE-STRESSED CONCRETE WORK

For use by construction Engineers

O.K. Card No. _____ Date_____ Shift_____

1. Name of Work :
2. Location of work :
   (i) Block No. :
   (ii) R.D./CH : _____to_____
   (iii) Offset : _____to_____
   (iv) Lift R.L. : _____to R.L._____
3. Name of agency :
4. Method of concrete mixing :
   (i) Hand Vol/wt :
   (ii) Mixer Vol/wt. :
   (iii) Batching plant Vol.Wt. :
5. Method of placing :
   (i) Dropping from top
   (ii) Dropping by bucket
   (iii) Hand placing
6. Method of consolidation :
   (i) Mech. vibrator
   (ii) Hand keeping by trowel
   (iii) Hand tamping by rod
7. (i) Grade of mix :
   (ii) Proportion (designed)
   (iii) Slump required
   (iv) Max size of aggregate required to be used
   (v) Designed strength..... kg/sq.cm.

8. Date and time (i) Starting.....

(ii) Finishing .....

Sig. S/E L/C (Construction) Sig. A.E. I/C. (Construction

S.No.	Date of Test	For use by Q.C. Personnel Location of Test				Cube No.	Mix Pre-portion of concrere	W/C ratio	F.M. of sand	Max. size of agregate	Unit wt. of Agg.	Remark
		Block	RD/CH	Off set	RL							
1	2	3	4	5	6	7	8	9	10	11	12	13

Remarks
(i) General Quality of material
(ii) Oversize/under size
(iii) Segregation/bleeding
(iv) Surface cleaning
(v) Workmanship
(vi) Others

Sig. R.A./E.I. (Q/C) A.R.O. (Q/C.) R.O. (Q./C.

ANNEXURE-34

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
REINFORCEMENT STEEL

For Use by Construction Engineers.

O.K. Card No. _____ Date_____

1.	Name of Work	:
2.	Location of works	:
3.	Type of Reinforcement steel bars	:
4.	Manufactured & supplied by	:
5.	Size of reinforcement steel bars	:
6	Ultimate Tensile Strength	
7	Yeild Stress	
8	Elongation Value	
9	Value of Bend Test (Ductility)	
10	Mass per meter (run) kg	
11.	Inspected by SE E/M and approved by him for all Major projects and by E.E. E/M for all Medium Projects when? (give date)	:
12.	Whether inspected by C.E. E/M when? (give date)	:
13.	Whether inspected by CE (works) when? (give date)	

Sig. of A.E. (E/M) Sig. of E.E. (E/M) Sig. of S.E.(E/M)

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS) Sig. of S.E.(WORKS)

ANNEXURE-35

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
LOW DENSITY POLYTHENE FILM

For Use by Construction Engineers & Q.C. Staff

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____canal/Disty.
3	L.D.P.E. film type		
4	Manufactured & supplied by		
5	Density of film		
6	Thickness of film		
7	Yeild Tolerance of film		
8	Tensile Strength of film		
9	Type of lining being done	:	
10	Thickness CNS layer used	:	_____Cm.
11	Thickness of lining used	:	_____ Cm.

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

ANNEXURE-36

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

_____PROJECT_____
O.K. CARD
FOR
MANUFACTURED TILES

For Use by Construction Engineers & Q.C. Staff

O.K. Card No. _____ Date_____

1.	Name of Work	:	
2.	Location of work	:	
	RD/CH	:	_____to_____canal/Disty.
3	Type of manufactured tiles		
4	Manufacturer & supplied by		
5	Flexural Strength of tiles		
6	Thickness of tiles		
7	Type of lining being done	:	
8	Thickness CNS layer used	:	_____Cm.
9	Thickness of lining used	:	_____ Cm.

Sig. of A.E. (WORKS) Sig. of E.E. (WORKS)

Sig. of A.E. (Q.C.) Sig. of E.E. (Q.C.)

REFERENCES BOOKS & CODES

ANNEXURE-37

LIST OF IS CODES

S.NO.	IS NO.	SUBJECT
1.	460 - 1978	Test Sieves
2.	460 (Pt.I)1978	Wire Cloth test sieves (Second revision)
3.	460 (Pt.II)1978	Perforated plate test sieves (second revision)
4.	460 (Pt.III)1978	Method of examination of test sieves (Second Revision)
5.	456 - 1978	Code of practice for plain and Reinforced concrete (in corporating amendment No.1).
6.	516 - 1959	Methods of test for strength of concrete (with amendment NO.1)
7.	650 - 1966	Standard sand for testing of cement (first revision) (with. amendment No.1) (Reaffirmed 1980).
8.	1121	Methods of test for determination of strength properties of natural building stones.
9.	1121 - (Pt.I) 1974	Compressive strength (first revision) (with amendment No: 1)
10.	1121 (Pt.IV) 1974	Shear strength (First revision).
11.	1122-1974	Methods of test for determination of true specific gravity of natural building stones (first revision).
12.	1124-1974	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones (first revision).
13.	1125-1974	Method of test for determination of weathering of natural building stones (first revision).
14.	1126-1974	Method of test for determination of durability of natural building stones (first revision).
15.	1199-1959	Methods of sampling and analysis of concrete.
16.	1498-1970	Classification and identification of soils for general engineering purposes (first revision)
17.	1727-1967	Methods of test for pozzolanic materials (first revision)
18.	1888-1971	Method of load test on soils (first revision)

19.	2386	Methods of test for aggregates for concrete.
20.	2386 (Pt.I) 1963	Particle size and shape.
21.	2386 (Pt.II) 1963	Estimate of deleterious materials and organic impurities.
22.	2386 (Pt.III) 1963	Specific gravity, density, voids, absorption and bulking.
23.	2386 (Pt.IV) 1963	Mechanical properties (with amendment No.1).
24.	2386 (Pt.V) 1963	Soundness
25.	2386 (Pt.VI) 1963	Measuring mortar making properties of fine aggregate.
26.	2386 (Pt.VII) 1963	Alkali aggregate reactivity.
27.	2430-1969	Methods for sampling of aggregate for concrete.
28.	2720	Methods of test for soils
29.	2720 (Pt.I) 1972	Preparation of dry soils samples for various tests (first revision) with amendment No.1).
30.	2720 (Pt.II) 1972	Determination of water content (second revision).
31.	2720 (Pt.III) 1972	Determination of specific gravity.
32.	2720 (Pt.III/Sec.1) 1980	Section 1-Fine grained soils (first revision)
33.	2720 (Pt.III/Sec.2) 1980	Section 2-Fine, medium and coarse grained soils (first revision)
34.	2720 (Pt.IV)1975	Grain size analysis (first revision)
35.	2720 (Pt.V)1970	Determination of liquid and plastic limits (first revision) (reaffirmed 1978)
36.	2720 (Pt.VI)1972	Determination of Shrinkage factors (first revision)
37.	2720 (Pt.VII)1980	Determination of water content, dry density relation using light compaction (second revision).
38.	2720 (Pt.VIII)1974	Determination of water ,content, dry density, relation. using heavy compaction (first revision) (with amendment No.1)
39.	2720 (Pt.IX)1971	Determination of dry density, moisture content relation by constant weight or soil method (with amendment No.1) (reaffirmed 1978).
40.	2720 (Pt.X)1973	Determination of unconfined compressive strength

		(first revision).
41.	2720 (Pt.XI)1971	Determination of the shear strength parameters of a specimen tested in unconsolidated untrained trial compression without the measurement of pore water pressure (with amendment Nos. 1 and 2), (Reaffirmed 1978) .
42.	2720 (Pt.XII)1975	" Determination of shear strength parameters of soil from consolidated undrained trixial compression test with measurement of pore water pressure.
43.	2720 (Pt.XIII)1972	Direct shear test (first revision).
44.	2720 (Pt.XV)1965	Determination of consolidation properties (with amendment Nos. 1 and 2)
45.	2720 (Pt.XVI)1979	Laboratory determination of C.B.R (first revision).
46.	2720 (Pt.XVII)1966	Laboratory determination of permeability (with amendment No.1).
47.	2720 (Pt.XXI)1977	Determination of total soluble soilds (first revision).
48.	2720 (Pt.XXIII)1976	Determination of Calcium Carbonate (first revision).
49.	2720 (Pt.XXVI)1973	Determination of pH values (first revision).
50.	2720 (Pt.XXIX)1975	Determination of dry density of soils in-place by the core cutter method (first revision).
51.	2720 (Pt.XL)1977	Determination of free swell index of soils.
52.	2720 (Pt.XLI)1977	Measurement of swelling pressure of soils.
53.	2809-1972	Glossary of terms and symbols relating to soil Engineering (first revision.)
54.	3085-1965	Methods of test for permeability of cement mortar and Concrete (Reaffirmed 1980).
55.	3495 (Pt.I to IV) 1976	Methods of test of burnt clay building bricks (second revision) (with amendment No.1)
56.	4031-1968	Methods of physical tests for hydraulic cement (Reaffirmed 1980).
57.	4032-1968	Methods of chemical analysis of hydraulic cement (Reaffirmed 1980) .

58.	4434-1978	Code of practice for in-situ vane ~ear test for soils (first revision).
59.	4464-1967	Code of practice for presentation of drilling information and core description in foundation investigation.
60.	4464-4967	Method for subsurface sounding for soils.
61.	4968(Pt.II) 1976	Dynamic method using cone and bentonite slurry (first revision) (with amendment No.1).
62.	4968(Pt.III) 1976	Static cone penetration test (first revision).
63.	5513-1976	Vicat apparatus (first revision).
64.	5514-1969	Apparatus used in. Lechatelier's test.
65.	5529	Code of practice for in-situ permeability test
66.	5529 (Pt.I)1969	Test in over-burden
67.	5529 (Pt.II)1973	Test in bedrock
68.	6632 (Pt.I to X)1973	Methods of test for building limes.
69.	6632 (Pt.III)1973	Determination of residue on slaking of quicklime.
70.	6632 (Pt.IV)1973	Determination of fineness of hydrated lime
71.	6632 (Pt.V)1973	Determination of volume yield of quick lime
72.	6632 (Pt.VII)1973	Determination of compressive and transverse strength.
73.	6632 (Pt.VIII)1973	Determination of workability
74.	6632 (Pt.IX)1973	Determination of soundness
75.	6632 (Pt.X)1973	Determination of popping and pitting of hydrated lime
76.	7292-1974	Code of practice for in-situ determination of rock properties by flate jack.
77.	7320-1974	Concrete slump test apparatus.
78.	7746-1975	Code of practice for in-situ shear test on rock (with amendment No.1)
79.	8763-1978	Guide for undisturbed sampling of sands.
80.	8764-1978	Method of determination of point load strength index of rock
81.	8764-1978	Method of making curing and determining compressive strength of accelerated cured concrete specimens.

82.	9143-1979	Method for the determination of unconfinded compressive strength of rock material.
83.	9179-1979	Method for preparation of rock specimen for laboratory testing.
84.	9221-1979	Method of determination of modulus of elasticity and poission's of rock materials in Uniaxial compression.
85.	9259-1979	Liquid limit apparatus for soils (with amendment No.1).
86.	9376-1979	Apparatus for measuring aggregate crushing valve and ten percent fines valve.
87.	9377-1979	Apparatus for aggregate impact value.
88.	9399-1979	Apparatus for flexural testing of concrete.
89.	9459-1980	Apparatus for uses in measurement of length change of hardened cement paste, mortar and concrete.
90.	9669-1980	CRB Moulds and its accessories.
91.	10050-1981	Slake durability index of rocks, method for determination.
92.	10740-1982	Compaction mould assembly for light and heavy compaction test for soils.
93.	2508 – 1984	Specification for Low Density Polyethylene Film
94.	10646 :1991	Canal Linings – Cement Concrete Tiles -Specification
95.	432 (Part 1) -1932	Specification for mild steel and medium Tensile Steel bars and hard- Drawn steel wire for concrete reinforcement.
96.	1608: 2005	Metallic Materials: Tensile Temperature at ambient temp.
97.	1786 :2008	High Strength deformed steel bars and sires for concrete reinforcement
98.	3600 (P-3)1989	Transverse Tensile Test
99.	1599: 1985	Method for Bend test
100.	2329: 2005	Method of Bend tests metallic Tubes

ANNEXURE-38

REFERENCE BOOKS

S.NO.	BOOKS	AUTHOR
1.	Principles of soil Mechanics	Ronald F. Scott.
2.	Soil Mechanics in Engineering practice	KERL Terzagi
3.	Soil Chemical Analysis	M.L. Jackson
4.	Soil Survey Manual	Oxford
5.	Physical properties of soil	Means & Pockher
6.	The A.B.C. of soils	Jacob S. Jaffe
7.	Measurement of soil properties in the Triaxial Test.	Bishop & Henkit
8.	The nature and properties of soils	Buckman & Brady
9.	The nature and properties of soils	Brady
10.	Fundamentals of soil Mechanics	Tyler
11.	Introductory soil	C. Beyger
12.	Soil Mechanics	Jumikas
13.	The Mechanics of Engineering soils	
14.	Soil Testing for Engineers	
15.	Elastic solution for soil and Rock Mechanics	Poabes Davis
16.	Soil Mechanics	T.W. Lambe
17.	Earth Manual	USBR
18.	Soil Mechanics & foundation Engineering	H.P. Oza
19.	Soil Engineering Theory and Practice	Alam Singh
20.	Standards for testing soil	CBIP Pub No. 42.
21.	Application and Properties of Fibre Reinforced Concrete, A Research Article in Journal of Engineering Research and Applications ISSN :2248-9622, Vol.4, Issue 5(version 1), May 2014, PP 123-131	Amit Rai and Dr Y.P.Joshi

ANNEXURE-39

LIST OF SPECIFICATIONS

Section-II	Chapter-34 to 39	Electrical Works and other connected Items		
Section-II	Chapter-41	Drilling of Tube wells.		
		Volume-V		
Section-I	Chapter-30	Water supply		
Section-II	Chapter-31	Sewerage and Drainage		
Section-III	Chapter-32	Sanitary Fittings		
Section-IV	Chapter-33	Miscellaneous Items of Water and Sanitary Fittings.		

ANNEXURE-40

LIST OF TECHNICAL CIRCULARS ISSUED BY BODHI BHOPAL DESIGN SERIES

T.C. NO.	REFERENCE NO.	SUBJECT
1.	Memo No. 2247/BODHI/R&C/20 Dated 15.11.85	Issue of New Series of TCS from Bureau of Design (BODHI) Design Series No. 1, "Check List of data required for design of Earth Dam"
2.	-do-	-do- Design Series No.1 "Check list of data required for design of Masonry Dam.
3.	-do-	-do- Design series No. 3 "Check list of design cases of cross drainage works."
4.	Memo No. 2246/BODHI/P&H/13/ Y85 Dated 15.11.85	Design Series No. 4 "Estimate of yields at various dependabilities at Projects Site".
5.	Memo No. 474/BODHI/20/R&C/ Dated 3.3.86	Design Series No. 5 "Provision of U/S Concrete membrane in Masonry dam section".
6.	Memo No. 933/BODHI/R&C/ dated 24.4.86	Safety of dam review of spillway capacity.
7.	------	Drainage below lining.
8.	Memo No. 1047/BODHI/R&C/20/85 Dated 5.5.85	Protection of U/s slope for Reservoir embankment.
9.	Memo No.2010/BODHI/ED/D&H/20/86 dt. 86	Down stream slope protections of reservoir embankment.
10.	Memo No. 1266/BODHI/R&C/EVA/ 11/87	"Crest width of Earth/Rock fill Dams"
11.	2507/BOHI/R&C/EVA/11/87 Dated 11.7.87	Core in Earth Dam
12.	2617/BOHI/R&C/EVA/11/87 Dated 18.8.87	Provision of Berms
	Revised 2509/BOHI/R&C/EVA/11/87 Dated 11.7.87	Revised TC No.9

13.	Memo No. 886/BOHI/R&C/ED/36/88 Dated 3.3.88	Shrinkage/ Settlement allowance in Earth Rock fill dam
14.	2477/BOHI/R&C/EVA/11/87 Dated 8.7.88	Bending/ Stripping/ Ploughing and furrowing for canal
15.	Memo No. 101/BOHI/R&C/TC/11/88 Dated 12.12.88	Transmission losses system efficiencies
16.	103/BOHI/R&C/TC/11/88 Dated 12.12.88	Type sections for minor water courses and field channels
17.	105/BOHI/R&C/TC/11/88 Dated 12.8.88	Canals in expansive soils identification and Treatment
18.	113/BOHI/R&C/TC/11/88 Dated 21.8.89	Joining of Material Gravity Dam and appurtenant works.
19.	115/BOHI/R&C/TC/11/88 Dated 16.6.89	Free Board in Canals
20.	117/BOHI/R&C/TC/11/88 Dated 14.8.89	Necessity and type of drainage arrangement behind lining
21.	119/BOHI/R&C/TC/11/88 Dated 14.6.90	Estimation of design flood for small and medium catchments
22.	121/BOHI/R&C/TC/11/88 Dated 24.8.89	Free board requirement in embankment dams for small and medium catchments.
23.	123/BOHI/R&C/TC/11/88 Dated	Compressive strength of Masonry Mortarsize of specimen for testing.
24.	203/BOHI/R&C/TC/11/89 Dated 12.4.90	Anchoring and splicing of reinforcing bars
25.	205/BOHI/R&C/TC/11/89 Dated 20.6.90	Estimation of crop water requirement and irrigation water requirement.
26.	207/BOHI/R&C/TC/11/89 Dated 28.5.90	Structure on water cources field channel (guide lines)
27.	209/BOHI/R&C/TC/11/89 Dated 20.8.90	Under sepage control measure for earth and rock fill dam
28.	211/BOHI/R&C/TC/11/88 Dated 17.9.90	Guidelines for selection of spillways and energy dissipation.
29.	213/BOHI/R&C/TC/11/89 For E-in-C	Top width of dam

	19.11.90	
30.	215/BOHI/R&C/TC/11/91 Dated 29.4.91	Guidelines for design and construction of stop dam.

INVESTIGATION SERIES

T.C. NO.	REFERENCE NO.	SUBJECT
1.	Memo No. 739/BODHI/R&C/Dated 31.3.86	Survey estimate
2.	Memo No. 740/BODHI/R&C/Dated 31.3.86	Issue of new series of TC from Bureau of design/ Investigation series TC No.2 Revised Estimate.
3.	Memo No. 11/BODHI/R&C/TC/11/88 Dated 31.2.88	Sedimentation surveys of Reservoirs.

CONSTRUCTION SERIES

T.C. NO.	REFERENCE NO.	SUBJECT
1.	1621/BODHI/R&C/20/85 Dated 16.7.86	Construction series TC No.1 sitting of canal section on steeply sloping side long ground
2.	2865/BODHI/R&C/EVA/11/88 Dated 8.8.88	Safety during construction special precautions to be taken while doing deep excavation.
3.	107/BODHI/R&C/TC/11/88 Dated 31.12.88	Guidelines for use of Plastics (LDPE Film) for lining of canals.
4.	TC No.57 memo no. 3484002/BODHI/Specification TC/Dated 23.10.2013	Testing of core specimen from Hardened concrete
5.	TC No. 23, memo no. 123/BODHI/R &C/TC/11/88 Dated 31.08.1989	Compressive strength of concrete and mortar cubes

OPERATION AND MAINTENANCE SERIES

T.C. NO.	REFERENCE NO.	SUBJECT
1.	Memo No. 723/BODHI/R&C/20/ Dated 29.3.86	Operation and maintenance TC No. 1 "Repair of Concrete"
2.	Memo No. 912/BODHI/20/R&C/	Maintenance series No. 1 special care needed

	Dated 21.4.86	with regard to unobstructed out fall for CD work on Canal"
3.	Memo No. 109/BODHI/R&C/TC/11/ 88 Dated 31.12.88	Annual/ Periodical inspection of Irrigation Works (Head Works)

TESTING AND RESEARCH SERIES

T.C. NO.	**REFERENCE NO.**	**SUBJECT**
1.	Memo No. 718/BODHI/R&C/20/86 Dated 29.3.86	Testing and Research TC No. 1 "Guide lines for measurements, testing and Analysis of seepage from Masonry and concrete dams.

ANNEXURE-41

GOVERNMENT OF MADHYA PRADESH

WATER RESOURCES DEPARTMENT

Proforma to be used by Q.C. Staff

S.No.	Proforma	Reference	Remarks
1.	Details of Field /Laboratory Tests and References to Indian Standards	Annexure 1	
2.	Frequencies of various Tests for Earth work	Annexure 2-A	
3.	Frequencies of Tests to be conducted for concrete/Mortar	Annexure 2-B	
4.	Quality Control laboratories	Annexure 2-C	
5.	Testing of water	Annexure 3/1	
6.	Testing of fine Aggregate	Annexure 3/2	
7.	Testing of coarse Aggregate	Annexure 3/3	
8.	Testing of cement	Annexure 3/4	
9.	Testing of pozzolana	Annexure 3/5	
10.	Testing of Concrete	Annexure 3/6	
11.	Testing of Natural Building Stone	Annexure 3/7	
12.	Testing of Bricks	Annexure 3/8	
13.	Testing of LDPE Film	Annexure 3/9	
14.	Testing of Flexural Strength of manufacture tiles	Annexure 3/10	
15.	Testing of Reinforment steel	Annexure 3/11	
16.	Grain Size analysis	Annexure 4/1	
17.	Atterbergs limit (Liquid & plastic)	Annexure 4/2	
18.	Shrinkage limit	Annexure 4/3	
19.	Compaction Test	Annexure 4/4	
20.	Tri-axial Shear Test	Annexure 4/5	
21.	Permeability test	Annexure 4/6	
22.	Swelling Pressure test	Annexure 4/7	
23.	Total Soluble Solid	Annexure 4/8	

24.	Specific Gravity	Annexure 4/9
25.	Free Swell of Soil	Annexure 4/10
26.	Water content of soil	Annexure 4/11
27.	Bearing Capacity of Soil By Plate Load Bearing Test	Annexure 4/12
28.	Lay out of Dam and Appurtenant work	Annexure 5
29.	Lay out of canal and structure	Annexure 6
30.	O.K. Card for concrete work in foundation and plinth	Annexure 7
31.	O.K. card for Masonry work in superstructure.	Annexure 8
32.	O.K. card for Masonry work in foundation and plinth	Annexure 9
33.	O.K. Card for Masonry work in superstructure.	Annexure 10
34.	O.K. Card for E/Work-Major Project	Annexure 11
35.	O.K. Card for E/work-Medium Project	Annexure 12
36.	O.K. Card for E/Work-Minor Project	Annexure 13
37.	O.K. Card for E/Work-Main Canal/Distributory	Annexure 14
38.	O.K. Card for E/Work-Minors	Annexure 15
39.	O.K. Card for Filters	Annexure 16
40.	O.K. Card for boulder pitching on U/Slop of E/Dam	Annexure 17
41.	O.K. Card for Boulder pitching in bed of river/ canal	Annexure 18
42.	O.K. Card for boulder pitching Around the abutment of structure	Annexure 19
43.	O.K. Card For Rock Toe/B-toe/Rip-Rap	Annexure 20
44.	O.K. Card For Foundation of E/Dam	Annexure 21
45.	O.K. Card For Foundation of Masonry Dam	Annexure 22
46.	O.K. Card for Foundation of Structure of H/Works	Annexure 23
47.	O.K. Card for Foundation of Structure of Canal	Annexure 24
48.	O.K. Card for Gates and valves	Annexure 25
49.	O.K. Card for Instrumentation of Masonry dam	Annexure 26
50.	O.K. Card for Instrumentation of Earth Dam	Annexure 27
51.	O.K. Card for Turfing on Earth Dam	Annexure 28

80.	Test Brick/tiles	Appendix XIV
81.	Weekly progress report on E/Dam/Canal	Appendix XV
82.	Weekly Concrete/Masonry	Appendix XVI
83.	Borrow areas operation pass	Appendix XVII
84.	Determination of Field Moisture & density	Appendix XVIII
85.	Determination of compaction efficiency	Appendix XIX
86.	Okays given by Quality Control Unit	Appendix XX
87.	Types of Fibre Reinforce Concrete	Appendix XXI

ANNEXURE-42

GOVERNMENT OF MADHYA PRADESH

WATER RESOURCES DEPARTMENT

Proforma to be used by Construction (work) Staff

S.No.	Proforma	Reference	Remarks
1.	Field and Laboratory Tests and Reference to I.S.	Annexure 1	
2.	Frequencies of various tests on E/Work, concrete and M/Works.	Annexure 2	
3.	O.K. Card for layout of dam axis	Annexure 5	
4.	O.K. For layout of canals	Annexure 6	
5.	O.K. Card for CC work in foundation	Annexure 7	
6.	O.K. For C.C. in Superstructure	Annexure 8	
7.	O.K. For M/Work in foundation	Annexure 9	
8.	O.K. For M/Work in superstructure	Annexure 10	
9.	O.K. For E/Work in Major Project	Annexure 11	
10.	O.K. For E/Work in Medium Project	Annexure 12	
11.	O.K. For E/Work in Minor project	Annexure 13	
12.	O.K. For E/work in Main canal Disty.	Annexure 14	
13.	O.K. For E/Work in Minors	Annexure 15	
14.	O.K. For Filters	Annexure 16	
15.	O.K. For Boulder pitching on u/s E/Work	Annexure 17	
16.	O.K. For B/Pitching in bed of river/canal	Annexure 18	
17.	O.K. For B/Pitching Around abutment of structure	Annexure 19	
18.	O.K. For rock Toe/Boulder toe/Rip-Rap	Annexure 20	
19.	O.K. For Foundation of E/Dam	Annexure 21	
20.	O.K. For Card for CC work in M/Dam	Annexure 22	
21.	O.K. For Structure of H/Works	Annexure 23	
22.	O.K. For of canals	Annexure 24	
23.	O.K. For Gates and Valves	Annexure 25	
24.	O.K. For Instrumentation of M/dam	Annexure 26	

25.	O.K. For Instrumentation of E/Dam	Annexure 27
26.	O.K. For Turfing on E/Dam	Annexure 28
27.	O.K. For Turfing on Canal banks	Annexure 29
28.	O.K. For Lining in main canal/distributory	Annexure 30
29.	O.K. For Minors	Annexure 31
30.	O.K. For Lining in Field channels/water courses	Annexure 32
31.	O.K. Card for Pre- Stressed concrete	Annexure 33
32.	O.K. Card for Reinforcement Steel	Annexure 34
33.	O.K. Card for Low Density Polythene Film	Annexure 35
34.	O.K. Card for Manufactured Tiles	Annexure 36
35.	List of I.S. Codes	Annexure 37
36.	List of For Reference books	Annexure 38
37.	List of For Specifications	Annexure 39
38.	List of Technical circulars	Annexure 40
39.	List of proforma to used by workstaff	Annexure 41
40.	List of Proforma to used by construction (work)staff	Annexure 42
41.	DO's & DONTS	Annexure 43

ANNEXURE-43

DO'S & DON'TS FOR INSPECTION & SUPERVISORY STAFF

I. EXCAVATION

1. Do not start excavation unless the original ground levels are recorded in M.B. and area to receive excavated materials ready to receive the same.

2. Do Not drill the holes (for blasting) more than 2/3 the depth of the proposed excavation and the spacing of the holes should be generally 1.5 to 2 times the depth.

3. Do Not permit blasting within 15 M. of any structure

4. Do Not permit persons and machinery within 150 M. of the area of blasting

5. Do not allow over excavation. See that the rock beyond the lines required IS preserved in sound condition.

6. Do check whether the foundations of the important structures are taken at least 1 M. into sound rock.

7. Do not try to keep the area free of water before loo1cing for the source of water. Prevent leaks at the source.

8. Do insist on stocking the excavated material beyond the lines of excavation allowing sufficient space for trolley lines, dewatering and other machines.

9. Do insist on stocking the excavated material in sparate areas with reference to the nature of materials.

10. Do insist on maintaining a complete and accurate record of drilling operations.

11. Do not forget to get there presentative samples of foundation rock tested.

II. DIVERSION OF RIVER:

1. Hydrographs of the river should be carefully studied and the work on the dam should be planned and divided in such a way as to adhere to the schedule of construction with minimum amount of expenditure on coffer dams and closure operations.

2. Don't keep the difference in levels of adjacent blocks, over which the river-flow is to be diverted, more than 5 M. Where .the difference in levels is more than 5 M. the masonry may be suitably stepped off at the ends.

3. The spillway bucket should be constructed before raising the masonry of the spilway block to such heights that damage the toe of the dam and treatment done to the foundation rock of the bucket

III. GROUTING:

1. Don't forget that a grout pump is a very powerful hydraulic jack that can seriously damage engineering structures if not used with caution.

2. Don't pump water into a hole longer than necessary. There is no advantage in needlessly pumping water into a free hole.

3. Don't think that there is one optimum water cement ratio for every hole. It changes as the hole approaches completion, generally increasing.

4. Don't attempt to reduce the water cement ratio too rapidly, you may plug the hole:

5. Don't pump thin grout into a hole that will thick grout readily.

6. Don't put too much emphasis on static or standing pressure alone. Grout that is slightly too thick, if pumped slowly will close almost any hole.

7. Don't be too willing to holes completed because the suddenly build up pressure, wash them out with a blow pipe if you believe that holes have been clogged.

8. Don't vary the pump speed needlessly, stopping unnecessarily or pumping at less than the normal pumping speed, if there are leaks.

9. Don't fall to inject the grout at all times at the maximum, allowable pressure or at such pressure as can be sustained. Throughout the grouting, rock which lies above the natural ground water table will absorb moisture from the grout causing it to thicken and slowly clog the bed rock seams and crevices. Remember also, that leaks or an appreciable amount of grout should be caulked as soon as possible after they develop.

10. Don't be too hasty about deciding that hole is tight. Force water so long as there

is any perceptible picking up in the pump speed at normal pumping pressure. Many apparently tight holes loosen up and take grout freely after a minutes under pressure.

11. Don't judge the efficiency of grout operations solely on the number of sacks of cement injected. Look for leaks.

12. Grout should be continuous. Don't fluctuate the pressure rapidly.

13. Don't fall to see that the grouting equipment is cleaned thoroughly as the loose grout scales will plug the seams in the rock.

IV. MASONRY

1. Don't prepare the final foundation surface earlier than a week.

2. Do clean the old masonary surface prior to starting masonary by wire brushes and washing. Old joints need chipping if not wet sand blasting.

3. Don't permit dry stones and insist on wetting the stones.

4. Do maintain the proper mixing time.

5. Don't place mortar which bleeds excessively.

6. Don't leave mortar in the mixers at the end of the job. Thoroughly wa~ and clean the mixer drum and hopper before stoppage of work.

7. Do insist usage of labels for different proportions, of mortars to be' used from the same mixer platform.

8. Do insist on bond stones for face.-work and also on breaking of joints by a distance equal to half the height of the course.

9. Don't permit rubble weighing less than 40 kg.

10. Don't permit under-pinning after a stone is laid as it tends to lift the stone and leave air pockets.

11. Don't allow chips in the intervening space between stones before filling in mortar and shaking it, to a full depth, to a thick quacky mass.

12. Don't allow to insert flat chips at top, drive them all endwise.

13. Don't permit fresh masonary to be disturbed by traffic or clean up gang until it attains sufficient strength.

14. Do insist on removal of all laitance: excess mortar, etc. after the mortar has set finally.

15. Insist on keeping the surfaces continuously moist and curing should be done at least for 28 days.

16. Don't forget to leave construction joints 2 M wide 0.6M. deep, throughout the length of the blocks in the surface of the lower section of masonry in case of long stoppage of work.

17. Insist on raking of the joints before the mortar becomes too hard. Don't permit pointing earlier than a week after construction of masonary.

V CONCRETE:

1. Do see that the sloping rock is stepped or benched for level bearing.

2. Use rich cement slurry over the previously poured concreted before commencement of the fresh concrete over it. Mortar of prescribed proportion should be used wherever possible.

3. Do avoid water beyond just workability.

4. Do allow for bulkage of sand when batching is done by volume.

5. Inspect and see that forms are to be in line and levels before concreting.

6. Before commencement of concreting, do check whether all the materials in required quantities are received at site.

7. Don't re-tamper the concreting.

8. Do empty the mixer completely before commencing a new batch.

9. Do insist on revolving of drum during charging of water into the drum.

10. Dont' mix concrete containing air-entraining agent on route.

11. Do insist on removal of accumulated water at site to be concreted.

12. Do avoid segregation and avoid also re-handling, if possible.

13. Do avoid construction joints if possible, except as detailed in plan.

14. Do avoid over-vibration, but vibrate thoroughly and continue little longer till all the water and air come out.

15. Do clean hardened concrete whenever concreting is resumed at a construction on joints, wet the surface and spread a thin layer of mortar over it.

16. Do check and remove laitance when concrete reached required level. If laitance is excessive, do cut down water in the mix or over working of concrete.

17. Do not place the next lift of concrete in less than 72 hours.

18. Do have a check on placing or dowels, keys, water-stops and other construction details as shown on drawings.

19. Do keep a record of volume of concrete placed and batches wasted.

20. Do check actual amount of cement used in concrete laid each day as a check on the quantity of concrete placed and accuracy of batching.

21. Dokeep a record of embedded parts in the structures.

22. Do keep a record of reinforcement steel actually placed.

23. Do insist on putting plums wherever specified.

24. Do insist on cleaning of form-work and oiling the same before concreting is started.

25. Do insist on removal of hardened concrete from the inner faces of mixer and conveying equipment at the end of each shift.

26. Do insist on continuous curing of concrete for the period specified.

27. Don't allow old construction joints.

28. Do protect reinforcing steel from rust, bending or distortion and keep in free from oil

or grease.

29. Do protect cement from moisture.

30. Prior to commencement of concrete, do check up whether the reinforcement is as per drawings or not.

31. Do insist on removal of rejected materials from site.

32. Do maintain complete and accurate daily reports and records.

VI LABORATORY

1. Do see that the sample of construction materials are tested well in advance whenever there is a change.

2. Do not fail to check the slump, unit, weight and percent of air entrained of the concrete mix.

3. Do check the consistency at least 3 times per shift.

4. Do not vary approved mix designs without authority. The design shall be modified whenever there is change in quality of materials.

5. Determine the moisture content and absorption of aggregates when batching be weight and make necessary correction in water content.

6. Do keep check on W/C ratio; as specified.

7. Do keep a check of the measuring devices used at mortar concrete mixers.

8. Do keep a complete record of all concreting operations.

9. a minimum of their test specimens shall be made for each 120 cubic meter of each class of concrete for a given age. There shall be at least three test specimen for each day of concreting even if only a few cubic meters of the particular class of concrete is manufactured in a day.

10. Do not fail to report the results of tests regularly.

APPENDIX-I

EMBANKMENT TEST SECTION

An embankment test section shall be constructed he fore embankment construction to determine optimum practicable moisture content and number of roller passes required to compact the material to the required density, When an appreciable change in material occurs, as may be indicated by an increase in density, test sections shall be made during construction.

The procedure for construction of an embankment test section is as follows:

a) Select a location on the embankment where uninterrupted placing operations are being performed. This area 15 m by 30 m (about 50 feet by 100 feet) shall be carefully marked and referred so that its limits will be easily recognised. In order to expedite the determination of moisture content to be used, more than one test section may be established on the embankment at the same time.

b) During construction of the test section which will most probably continue for several shifts, a complete record of the procedure shall be kept. This record shall include the number of layers placed, the spread thickness of each layer, the moisture content at which the materials were rolled, the designation (No.1; NO.2 etc.) of the rollers used, the condition of the rollers, (clean or dirty) the action of the materials being rolled (such as wavy under the rollers, the amount of penetration of the roller teeth after different numbers of roller trips etc.) and the borrow pit location from which the materials taken.

c) Check the rollers to make certain that they meet all the requirements of the specifications.

d) Determine the required spread thickness of layer that will compact to the specified thickness after rolling the specified number of times and maintain this thickness as long as number of roller passes is kept the same.

e) Using the available data from borrow pit investigation of the materials to be used in the test section, the optimum moisture content as determined by laboratory tests will be known and 3 percent less than this moisture content shall be used in the first 3 or 4 layers rolled.

f) After 3 or 4 layers have been placed at 3 percent less than the laboratory optimum

moisture content, field density tests shall be made throughout the section. These tests shall be made for at least each 93 sq. meters (1000 sq. feet) of test section area, and shall be so distributed over the area that they will detect the effects of different compaction conditions encountered during construction. For example if the test section is located near an abutment, certain parts of the area will receive more compaction from track travel than others; hence some tests shall be made in the portion compacted only by the rollers and so reported.

g) the next step is to compact another 3 or 4 layers at a moisture content slightly higher (1 percent or 2 percent) than the moisture content previously used, maintaining the same roller, thickness of layer, and number of roller passes as in above. Field density tests are again made over the test section.

h) If the resulting field dry densities (of material passing the No. 4 sieve) from 9g) above show an increase with increase of moisture, then increase the moisture again by another 1 percent or 2 percent and repeat the test. if an increase in moisture results in a decrease in field density then place the next layers slightly dry of the original moisture content used and repeat the test. This procedure is nothing more than developing on the embankment a moisture density relation or compaction curve for a certain roller, thickness of layer and a given number of roller trips. If special studies during investigation have indicated that the material being tested shall be placed within certain moisture limits, or if the moisture limits to be used have been specified, the procedure outlined above shall include tests at these moisture contents or at moisture contents both greater and smaller than the specified limits.

i) The roller compaction curve is no compared with the standard laboratory compaction curve. If the field density of materials passing the No. 4 sieve (from the roller curve) is greater than the standard compaction density, at the specified moisture content, the test section shall be continued, decreasing the number of roller trips while maintaining the specific desirable moisture content until the most economical compactive effort is determined. When the roller trips are decreased, the required spread thickness of layer that will compact to the specified thickness of compacted material shall be reckoned.

APPENDIX-II

FILTER

Where indicated in the drawing filter blanket or seepage drains shall be laid on the base under the downstream portion of the earth embankment. The number of layers in the filter blanket or seepage drains and thickness of each layer shall be as specified in the drawings.

Material- The filter material shall be clean, sound and well graded sand and gravel or screened rock fragments. The gradation of each filter layer shall meet the following requirements with respect to the material to be protected and also with respect of adjacent filter layers.

i) $\frac{\text{d 15 of the filter}}{\text{d 15 of the base material}} = 5 \text{ to } 40$

Provided the filter does not contain more than 5 percent of material finer than 0.07 mm (Sieve No. 200)

ii) $\frac{\text{d 15 of the filter}}{\text{d 85 of the base material}} = 5 \text{ or less}$

iii) The grain size curve of the filter shall be roughly paralleled to that of the base material.

In the above, d15 is the size at which 15 percent of the total soil particles are smaller, the percentage being by weight as determined by mechanical analysis.

The d85 size is that at which 85 percent of the total soil particles are smaller. If more than one filter layer is required, the same criteria are followed. The finer filter is considered as the base material for selection of the gradation of the coarser filter. In addition to the limits, ratio established, for adequate filter design the 73 mm particle size shall be the maximum utilized in a filter to minimize segregation and bridging of large particles during placement of filter materials.

The requirements for grading of the filter shall be established by the field laboratory on the basis of mechanical analysis of advancement materials. Mechanical analysis shall be performed on samples, which have been compacted by the methods equivalent to compaction

by rollers so that individual particles of decomposed rock are broken down to their final condition in the embankment.

The following gradation is tentatively established but is subject to modifications after further laboratory tests:

a) For filter material in contact with foundation of earth fill materials.	Well graded coarse sand and gravel passing 12mm (1/2" screen)
b) For middle layer of filter blanket and for layers in contact with rock fill.	Coarse gravel passing 75mm (3" screens) and retained on 12mm (1/2" screen)

No particle of decomposed rock shall be permitted in the filter. No debris, wood, vegetable matter or other deleterious material shall be permitted in the filter.

APPENDIX-III

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
PROJECT

Test results of Post-checking of Rolled fill of _____dam/canal embankment at RD_____for compaction efficiency by Central Laboratory.

S.No.	Date of Sampling	Laboratory Sample No.	Location			Fill embankment	
			Ch. RL	Offset	RL	MC %	Dry Density kg/cm3

CONTD.

Proctor's OMC %	Compaction MDD Kg/cm3	Comp. eff. % (C.E.)	% Deviation in		Test not performed as per frequency (Dam daily) (canal twice weekly)
			M.C.	C.E.	
9	10	11	12	13	14

Remarks (s.p. of Imp)
(15)

Note:- (1) % deviation in (O.M.C.- Embankment M.C. x 100)

$$MC = \frac{\text{(O.M.C.- Embankment M.C. x 100)}}{\text{O.M.C.}} \times 100$$

(2) $$\%\text{ deviation in C.E.} = \frac{\text{(Prescribed C.E. - C.E. Attained)}}{\text{Prescribed Comp. off}}$$

Negative sign shows x results on higher side which is desirable for (2) : but undesirable for (1)

A.R.O.
CENTRAL LAB

R.O./E.E.
CENTRAL LAB

No. _____/

Date _____

Forwarded to the E.E., S.D.O., R.A., S/E (Q/C) for necessary action.

A.R.O./R.O./A.E.
CENTRAL LAB

APPENDIX-IV

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT
PROJECT

Test results of Post-checking of Rolled fill of _____dams at RD_____for permeability by Central Laboratory.

S.No.	Date of Sampling	Laboratory Sample No.	Location			Roll filled dry density kg/cm3
			Ch.	Offset	RL	
1	2	3	4	5	6	7

CONTD.

%MC OF the fill	Permeability of U/D Samples(n/yr)	Test not performed as per frequency (dam every alternate day)	remarks
8	9	10	11

No. _____/ Date _____

Forwarded to the E.E., S.D.O., R.A., S/E (Q/C) for necessary action.

A.R.O./R.O./A.E.
CENTRAL LAB

APPENDIX-V

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

Test results of soil samples of Borrow area/embankment at RD_____ Ref. _____(if any) Central Laboratory, _____.

S. No.	Lab Sample No.	Location Borrow Pit No. or RL/ Ch. Off	Natu MC %	Natu dry sensity Kg/m3	Sp. gr.	Total gravel IS: No. 480	Grain sizeanalysis [IS 2720 (part 4)]		
							Sand 2.02 mm %	Silt 0.02 0.002 mm %	Clay 0.002 mm%
1	2	3	4	5	6	7	8	9	10

A.R.O.
CENTRAL LAB_____

No. _____ Date_____

Copy is forwarded to the E.E., S.D.O. R.A. SE(Q/C)

A.R.O.
CENTRAL LAB_____

APPENDIX-VI

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

Test results of sand samples conducted at central Laboratory/field laboratory.

Location: Quarry/Stack_____Reference

Sieve openings in mm

0.15 0.30 1.20 2.40 4.80

0.60

100						
90		Note: If No. 120 is 20% or less 240				
80		1 dv may be increased to 20%				
70 %						
60 Re						
50 tai		Recommended Limits				
40 n						
30 ed						
20						
10		IDEAL	SAND	SAMPLE		
0						

15 30 60 120 240 480

(Adopted from USBR Concrete manual)

Sample No.	Particulars	I.S. 480	Sieve 240	Nos. 120	60	30	15	F.M.	Sp. gr.	St. dt.	Bul King	Remark
	Indv. % Retained Cum % Retained Indv. % Retained Cum % Retained											

Tested by
L.T./R.A.

Checked/Supervised
A.R.O.

Signature
R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

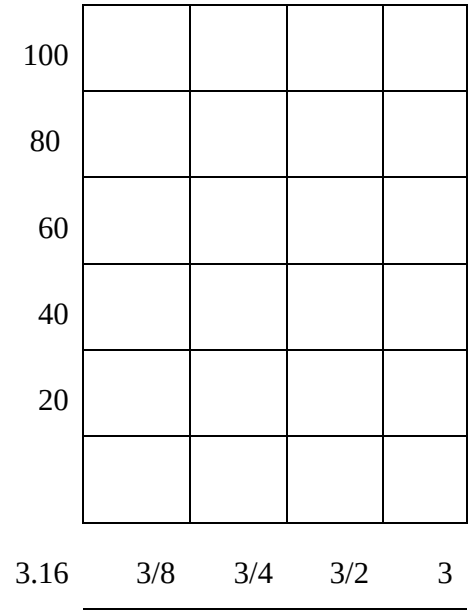
A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-VII

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

Test results of coarse aggregates (3" and below/conducted at Central Laboratory/Field Laboratory _____

Location Quarry Stack Reference



Class of aggregates: (As per IS Specifications)
a) Hand broken/crushed/singles
b) Granite/quartzite/sand stone

ANALYSIS

Sample No.	Particulars	sieve sizes in inches --- 3" 3/3" 3/4" 3/8" 3/16"	Allowance Limits	Result	Remarks
	% retained	(i) Over size > 15% (ii) Soundness (>12%(with Na_2SO_4 (>18% with Mg SO_4)			

Sample No.	Particulars	sieve sizes in inches ---------- 3" 3/3" 3/4" 3/8" 3/16"	Allowance Limits	Result	Remarks
	Cumulative % retained Cumulative %retained	(iii) Absorption (>1%) (iv) Abrasion (>50%) (v) Impact value (<45%) (vi) Sp.gr. (<2.86) (vii) Crushing (<45%) value (viii) Flakiness (<10%)			

Tested by
L.T./R.A.

Checked/Supervised
A.R.O.

Signature
R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-VIII

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

Test results of coarse aggregates (3/4" and below) conducted at Central Laboratory/Field Laboratory _____

Location: Quarry/Field Laboratory _____

Location	Quarry Stack	Reference	
Cum % Passing	100		
	80		
	60		
	40		
	20		
	0		
		3/16	3/8	3/6

Sieve opening in inches
(As per I.S. Specification)

Class of aggregates: a) Hand broken/crushed/singles
(As per IS Specifications) b) Granite/quartzite/sand stone

ANALYSIS

Sample No.	Particulars	Sieve	Size	Inches	Allowable Limits	Results	Remarks
		3/4"	3/8"	3/16"			
					(i) Oversize (>15%) (ii) Soundness (>12%) with Na_2SO) (>15%) with Mg SO_4 (iii) Absorption (>1%) (iv) Abrasion (>50%) (v) Impact value (>45%) (vi) Sp.gr. (>2.6%) (vii) Crushing (>45%) value		
	Cumulative retained						
	Cumulative passing				(viii) Flakiness (>10%)		

Tested by
L.T./R.A.

Checked/Supervised
A.R.O.

Signature
R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-IX

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT:

Test results of coarse aggregates (1/2" and below) conducted at Central Laboratory/Field Laboratory _____

Location: Quarry/Field Laboratory _____

Location	Quarry Stack		Reference
Cum % Passing	100		
	80		
	60		
	40		
	20		
	0		
		3/8	3/4	3/2

Sieve opening in inches
(As per I.S. Specification)

Class of aggregates: a) Hand broken/crushed/singles
(As per IS Specifications) b) Granite/quartzite/sand stone

ANALYSIS

Sample No.	Particulars	Sieve	Size	Inches	Allowable Limits	Results	Remarks
		3/4"	3/8"	3/16"			
	% retained				(i) Oversize (>15%) (ii) Soundness (>12%) with Na_2SO_4) (>15%) with Mg SO_4 (iii) Absorption (>1%) (iv) Abrasion (>50%) (v) Impact value (>45%) (vi) Sp.gr. (>2.6%) (vii) Crushing (>45%) value		
	Cumulative passing				(viii) Flakiness (>10%)		

Tested by
L.T./R.A.

Checked/Supervised
A.R.O.

Signature
R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-X

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT:

Test results of cement sample, test conducted at Central Laboratory

Name of godown/name of work site_____for use in structure_____

Manufactured at _____

Factory_____Ref. _____

Sl. No.	Sample No.	Lab No.	Physical tests Setting time Initial Final (Minutes)		Specific Surface	Tensile Strength test		Le-chat test	Imp. Constituents properties	Remarks
						Briq kg/cm2	cube kg/cm2			
1	2	3	4	5	6	7	8	9	10	11
									1.C_2S% 2.C_3S% 3. C_3A% 4. C_4AF% 5. $CaSO_4$% 6. Free Line 7. MgO% 8. Ignition loss 9. Heat of hydration	

Tested by
L.T./R.A.

Checked/Supervised
A.R.O.

Signature
R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

Abbreviations

COMPOUND	**FORMULA**	**ABBREVIATIONS**
Tricalcium silicate,	3 CaO, SiO_2	C_3S
Dicalcium silicate,	2 CaO, SiO_2	C_2S
Tricalcium Aluminate	3 Ca-Al_2 O_3	C_3A
Tetra calcium alumino ferrote	4CaO, Al_2 O_3, Fe_2O_3	C_4AF
Calcium sulphate	$CaSO_4$	$CaSO_4$
Magnesium Oxide	MgO	MgO

APPENDIX-XI

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT:

Test results of boulder sample conducted at Central Laboratory

Location: Quarry/Stack _____ Ref.

For use in _____work at _____

Sl.No.	Sample Ref	Lab. No.	Wt. of Individual Piece inKg (75kg.)	Size 1xbxh (10"to4"	Absorption (1%)	Sp.gr. <	Soundness 12% (with Na_2SO_4
1	2	3	4	5	6	7	8

CONTD:

Acid reaction with conc. HC 1%	Abrasion	Visual weather construction	General including	Remarks suitability
9	10	11	12	13

Checked/Supervised

A.R.O.
CENTRAL LAB

Signature

R/O./E.E.
CENTRAL LAB/FIELD LAB

No.

Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-XII

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT:

Test results of water sample conducted at Central Laboratory _____

Location: River/Reservoir/Storage_____Ref._____

For use in concreting/Mortar/Curing/Other_____Purpose in _____ structure at _____

S. No.	Sample lab No.	Chemical test						Physical Test				Remark
		pH	Cl	SO_3	Acidity	Alkalinity	hardness	Total Suspended Solids (TSS)	Volatile and Fixed Residue	Turbidity	Total Solids	
1	2	3	4	5	6	7		8	9	10		11

Tested by Checked/Supervised Signature

L.T./R.A. A.R.O. R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-XIII

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT:

Test results of common bricks/tile samples conducted at Central

Laboratory_____

Location: _____ Ref. _____

For use in _____ at _____

Sample mark of ref. _____lab No. _____

Properties of bricks I.S. 3102-1965 & IS 3367-1975	Permissible limits			Tiles	Observation	Remarks
	Class I	Class II	Class III			
1	2	3	4	5	6	7
1. Colour	Uniform	Uniform	Non-Uniform	Uniform		
2. Burnt Character	Well burnt	Over burnt	Under burnt	Well burnt		
3. Shape	Uniform faces	Slightly distorted	Distorted	Uniform faces		
4. Edges	Sharp straight & right angled	Fine compact	Non- uniform	Sharp straight & right angled		
5. Texture after	Fine uniform compact	Fine compact	Non- uniform	Fine uniform compact		
6. Sound when struck	Ringing	Ringing of dull	dull	Ringing		
7. Effore scence	Very slight	Very Slight	Slight	Very Slight		
8. tolerance on diamension (19x9x9cms) (19x9x4 cms)	1 to 3%	3 to 8%	8%	3%		

Properties of bricks I.S. 3102-1965 & IS 3367-1975	Permissible limits			Tiles	Observation	Remarks
	Class I	Class II	Class III			
1	2	3	4	5	6	7
9. Compressive strength kg/cm^2	70	70	35	105 for class I & 75 for class II		
10. Water Absorption	20%	20%	25%	(15 to 20%)		

Tested by Checked/Supervised Signature

L.T./R.A. A.R.O. R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB.

APPENDIX-XIV

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT :

COMPRESSIVE STRENGTH TEST OF CONCRETE/ MORTAR

Test results of hardened concrete/mortar conducted at Central Lab. _____

Location: _____ Ref. _____

Location of sample				Concrete /mortar specimen No.	Date of Casting	Grade of % Concrete/ Mortar	Water Cement Ratio	Date of Testing	Weight of Cube/Mortar
Block	Ch.	Off. set	Rl						
1	2	3	4	5	6	7	8	9	10

	7 Days Test Results		28 Days Test Results		% Strength with respect to 28 days strength	Remarks
Test Results Load in Tones	Compressive Strength in kg/cm^2	Average of Comp. Strength kg/cm^2	Compressive Strength in kg/cm^2	Average of Comp. Strength kg/cm^2		
11	12	13	14	15	16	17

Tested by — Checked/Supervised — Signature

L.T./R.A. — A.R.O. — R/O./E.E.
Central lab/Field Lab

No. Dated _____

Forwarded to E.E., SDO, RA, S/E (Q.C.) For necessary action

A.R.O./R.O./E.E.
CENTRAL LAB

APPENDIX-XV

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT:

Weekly progress report on earth dam/Canal work for the unit No. for

RD_____ to _____

ending on_____

S. No.	Location of strips rolled achieved	Mode of compaction	Elevation attained till the previous week	Depth of filling done during week	Elevation attained this week	Final elevation to be attained	Compaction Max.	Efficiency Min.
1	2	3	4	5	6	7	8	9

1. RD _____ to _____
2. Offset_____ to _____
3. _____ to _____
4. _____ to _____
5. _____ to _____
6. _____ to _____
7. _____ to _____
8. _____ to _____
9. _____ to _____
10. _____ to _____

CONTD:

No. of O.K. cards issued during the week	No. of field moisture density tests for as pertaining compaction efficiency
10	11

11. No. of cases in which desired CE was not attained.

12. No. of cases where proper rectifications was made.

13. No. of cases where rectifications are still required to be made.

14. No. of cases with locations where rectifications could not be made during the week.

15. Total No. of O.K. Cards issued during the week.

16. Remarks.

No. Dated _____

Submitted to E.E., SDO, RA, S/E (Q.C.) for information and necessary action.

A.R.O. (Q.C.) Unit No. _____

APPENDIX-XVI

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT :

Weekly progress report of dam/Canal Concrete and masonry works for the unit. No. _____from RD _____ to _____ ending on _____

S.No.	Proper location	Tests performed during the week						
		No. of concrete cubes cast	No. of mortar cube/ briquitte cast	Sand Grading & F.M.	Test Bulkage	Coarse aggregate		Sp.Gr.
						Grading	Water Absorption	
1	2	4	3	5	6	7	8	9

Any other test	No. of concrete cubes cast	Tests performed during the week							Remarks
		No. of mortar cube/ briquitte	Sand grading & FM	Test Bulkage	Coarse Grading	age Water absorption test	Sp. gr.	Any other	
10	11	12	13	14	15	16	17	18	19

A.R.O.
L.C. Q/C. Unit No. _____
R.D.

No. Dated _____

Submitted to E.E., SDO, RA, S/E (Q.C.) for information and necessary action.

A.R.O. (Q.C.) Unit No. _____

APPENDIX-XVII

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT :

BORROW AREA OPERATION PASS S.L. ON _____ (SOIL/SAND/ BOULDER)

1. DATE_____
2. NAME OF WORK
3. LOCATION OF BORROW AREA (I) GRID NO. _____
   (II) PIT NO. _____
   (III) SITUATION _____
   (IV) QUARRY REF. (FOR SAND AND BOULDER_____
4. DETAILS OF VISUAL CLASSIFICATION _____
5. AVERAGE MOISTURE CONTENT (FOR SOIL AND SAND) _____
6. INTENDED TO BE USED FOR (PLACE AND WORK)
7. DEPTH OF CUTING (FOR SOIL AND WORK)
8. WEIGHT AND SIZE OF BOULDER
9. REMARKS (GENERAL CONDITION OF BORROW MATERIAL) _____

SIGNATURE OF Q/C PERSONNEL

_____

APPENDIX-XVIII

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT :

Determination of field moisture and dry density of compacted earth fill of _____ DAM/ CANAL between R.D._____ TO _____Unit, wt. of core cutter (Wc) _____ Volume of core cutter (v) _____located at RD _____ off set _____

1.	Date	:
2.	O.K. Card No.	:
3.	Sample No.	:
4.	Wt. of core cutter + soil in gms. (WS)	:
5.	Wt. of wet soil in gms. (Ws-Wc)	:
6.	Wet density $\frac{Ws-Wc}{V}$	:
	(a) g/cc	
7.	Moisture container No. & Wt.	:
8.	Wt. of container + wet of soil in g.	:
9.	Wt. of container + dry soil in g.	:
	Wt. wet soil	:
10.	Wt. of dry soil in g. (d)	
11.	Wt. of moisture in g. (m) (8-9)	:
12.	%age moisture content (m.c.) = $\frac{mx100}{d}$	:
13.	Dry density (d) in (i) g/cc	:

APPENDIX-XIX

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

PROJECT :

Determination of compaction efficiency of compacted earth fill of dam/canal between RD_____Unit.

Date	O.K. Card No.	Sample No.	Location of Sample RD Offset RD	Field Classification	Earth Fill Zone
1	2	3	4	5	6

CONTD:

Embankment Data			Laboratory Data			Compaction efficiency	Remarks
Wet density kg/m^3	Dry density	M.C.	%	OMC	MDD		
7			8			9	10

APPENDIX-XX

GOVERNMENT OF MADHYA PRADESH
WATER RESOURCES DEPARTMENT

OKAYS GIVEN BY QUALITY CONTROL UNIT

S.No.	Particulars of OK given	OK Card No.	Date	By whom given							Remark
				RA	AE	EE	SE	AE	EE	SE	
				EI	ARO	RO	QC	Field	Field	Field	
1	2	3	4	5	6	7	8	9	10	11	12

In col. No. 2 : As per annexure 7 to 32 details should be given.

In col. No. 3 : As per annexure 7 to 32 No. should tally.

In col. No. 4 : As per annexure 7 to 32 date should tally

APPENDIX-XXI

Fiber Reinforced Concrete:

A fiber is a small discrete reinforcing material produced from various materials like steel, Plastics, glass, carbon and natural materials in various shapes and size.
The plain concrete fails suddenly when the deflection corresponding to the ultimate flexural strength is exceeded , on the other hand fiber-reinforced concrete continue to sustain considerable loads even at deflections considerably in excess of the fractures deflection of the plain concrete.

1. **Steel Fiber Reinforced Concrete:** Steel fiber reinforces concrete is a composite material which is made up from cement concrete mix and steel fibers as a reinforcing. The steel fibers, which are uniformly distributed in the cementations mix. This mix, have various voume fractions, geometries, orientations and material properties. It has been shown in the research that fibers with low volume fractions (<1%) , in fiber reinforced concrete, have an insignificant effect on both the compressive and tensile strength.
   The types of steel fibers are defined by ASTM A820:-
   - Type I: cold-drawn wire
   - Type II: cut sheet
   - Type III: melt –extracted
   - Type IV: mill cut
   - Type V : modified cold –drawn wire

   Generally Steel fiber reinforced concrete (SFRC) is very ductile and particularly well suited for structures which are required to exhibit:-
   - High fatigue strength resistance to impact, blast and shock loads
   - Shrinkage control of concrete
   - Tensile strength, very high flexural, shear
   - Erosion and abrasion resistance to splitting
   - Temperature resistance, high thermal
   - Earth quack resistance

   The degree of improvement gained in any specific property exhibited by SFRC is dependent on a number of factors that included: -
   - Concrete mix and its age
   - Steel fiber content, volume fraction
   - Fiber geometry, its aspects ratio (length to diameter ratio) and bond characteristics volume fractions.

2. **Glass Fiber Reinforced Concrete:** Glass fiber-reinforced concrete is (GFRC) basically a concrete composition which is composed of material like cement, sand, water and admixtures, in which short length discrete glass fibers are dispersed. Inclusion of these fibers in these composite resulting improved tensile strength and impact strength of the material. GFRC has been used for a period of 30 years in several construction elements but at that time it was not so popular, mainly in non-structural ones, like facing panels (about 80 % of the GRC production) , used in piping for sanitations network systems , decorative non-recoverable formwork, and other products.

At the beginning age of the GFRC development, one of the most considerable problems was the durability of the glass fiber, which becomes more brittle with time, due to the alkalinity of the cement mortar. After some research , significant improvements have been made, and presently , the problems is practically solved with the new types of alkali- resistant (AR resistance) glass fibers and with mortar additives that prevent the processes that lead to the embrittlement of GFRC.

3. **Polymer Fiber Reinforced Concrete:** Civil structures made of steel reinforced concrete normally suffer from corrosion of the steel by the salt, which results in the failure of those structures. Constant maintenance and repairing is needed to enhance the life cycle of those civil structures.
   There are many ways to minimize the failure of the concrete structures made of steel reinforce concrete. The custom approach is to adhesively bond polymer fiber composites onto the structure. This also helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite, but this method add another layer, which is prone to degradation. This fiber –polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As results, the adhesive bond strength is reduced, which results in th de-lamination of the composites.
   A uniform distribution of fibers throughout the concrete improves the homogeneity o the concrete matrix. It also facilitates reduced water absorption, greater impact resistance, enhanced flexural strength and tensile strength of concrete. the use of polymer fibers with concrete has been recognize by the Bureau of Indian Standards (BIS) and Indian Road congress and is included in the following standards documents;-
   - IS 456:2000 Amendment No. 7 ,2007
   - IRC: 44-2008- Cement concrete Mix Design for pavements with fibers
   - IRC:SP:76:2008 –Guidelines for ultra-thin white topping with fibers vision: 2021 by Ministry of Surface Transport, New Delhi

   Polymer Fiber Reinforced concrete has been approved by National bodies like:-
   - Central Public Works Department(CPWD)
   - Airport Authority of India
   - Military Engineering Services
   - Defense Airfields
   - NF/Southern Railways
   - ISRO, Banglore

4. **Natural Fiber Reinforced Concrete:** The first use of fibers in reinforced concrete has been dated to 1870's. Since then' researchers around the world have been interested in improving the tensile properties of concrete by adding, iron and other wastes.
   Local interest has been demonstrated through research work performed. In addition to industrial fibers, natural organic minerals fibers have been also investigated in reinforced concrete. Wood, sisal, jute, bamboo, coconut, asbestos and rock-wool, are examples that have been used and investigated.

5. **Synthetic Fibers:** Synthetic fibers are no substitute for primary reinforcement in concrete because they add little or no strength. But structural reinforcement doesn't provide its benefits until concrete hardens. That's why some contractors add synthetic fiber to concrete as secondary. Unlike structural reinforcement, synthetic fibers

provide benefits while concrete are still plastic. They also enhance some of the properties of hardened concrete.

Synthetic Fibers Types : The number of synthetic fiber has grown in recent years, the primary types of synthetic fibers commercially available in the India are polypropylene, polyester and nylon. Through the fibers within each type come in various lengths, thickness, and geometries, synthetic fibers provide similar benefits when used as secondary concrete reinforcement.

- Polypropylene: The synthetic fibers available in the United States, polypropylene is the most widely used in ready mixed concrete. Polypropylene fibers are hydrophobic , so they don't absorb water and have no effect on concrete mixing water requirements. They come as monofilaments.
- Polyester: Through not as widely used as polypropylene fibers are offered by several manufacturers. The fiber bundles come only in monofilaments form in lengths from 0.75 to 2 inches.
- Nylon: Like polyester fibers, nylon fibers come only in monofilaments form. What primarily distinguishes them from polypropylene and polyester fibers is their hydrophilic nature. Nylon fiber manufacturers also report that their fibers have highest aspects ratios (ratio of length and diameter) than those made of polypropylene .Therefore; they can be added in smaller dosages to produce the same reinforcing effects .usually no more than 1 pound per cubic yard is needed.