Government of Nepal

Ministry of Physical Infrastructure and Transport

Department of Roads

Bridge Branch

Guideline for Quality Management for Concrete Bridges

2018

Forward

Quality means excellence. It is thus a philosophy rather than a mere attribute. The difference between two objects is judged by their qualities. We set some standards which determine the level of acceptability. Nowadays, application of quality management is not only becoming popular but also mandatory in construction industry.

Just knowing some quality control methods or procedures will not do any good. We must have to adopt and implement the quality control methods and tools that are available to us. The concept and its practice must be tuned in harmoniously.

Quality assurance in construction activities guides the use of correct structural design, specifications and proper materials ensuring that the quality of workmanship by the contractor /sub-contractor is achieved and finally maintaining the structure after construction is complete through periodic assessments for maintenance and repairs. Quality control has to be imposed by the contractor whereas quality assurance is carried out by a separate third party agency engaged by the owner, or owner itslelf.

The contribution of Er. Prabhat Kumar Jha, Senior Divisional Engineer, Bridge Branch for preparation of the "Guideline for Quality Management for Concrete Bridges-2018"; is highly appreciated. The suggestions and experience shared by peer review team ,engineers and experts has been incorporated.

The guideline is compiled version of to Standard Specifications for Road and Bridge Works,2073 of DOR, IRC SP 047:1998 Guidelines on Quality Systems for Road Bridges, and all other relevant IRC and IS codes.

I hope the guideline will lead the Department of Roads to achieve higher level of quality for Concrete Bridge Construction.

Thank You

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Er. Rabindra Nath Shrestha
Director General
Department of Roads

Acknowledgement

The Quality Management Guideline for Concrete Bridges has been prepared with reference to Standard Specifications for Road and Bridge Works, 2073 of Department of Roads, IRC SP 047:1998 Guidelines on Quality Systems for Road Bridges, and all other relevant IRC and IS codes.

The Guideline has covered the Material Selection, Steel Placement, Concrete Production and Placing and Post-Tensioning Activities including Typical Proformae. It is believed that the Guideline will boost the quality management during the construction of bridges under Department of Roads.

The effort and dedication of Er.Prabhat Kumar Jha, Senior Divisional Engineer of the Bridge Branch; is highly appreciable. Bridge Branch is obliged to the SDE. Shiv Raj Adhakari, SDE. Binod Sapkota and Er. Krishna Bahadur Kuwar, who had done the peer review of the Guideline and had recommended for approval. The support of Mr. Bishnu Shrestha, World Bank Consultant, is also acknowledged by the Department.

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Er. Arjun Jung Thapa
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References :

1. **IRC SP 047:1998 Guidelines on Quality Systems for Road Bridges**
2. **IRC 18:2000 Design Criteria for Prestressed Concrete Road Bridges(Post Tensioned Concrete)**
3. **IS 1343 (1980): Code of Practice for Prestressed Concrete**
4. **IRC 21:2000 Standard Specifications and Code of Practice for Road Bridges**
5. **IS 1786 (2008): High strength deformed steel bars and wires for concrete reinforcement**
6. **IS 383 (1970): Specification for Coarse and Fine Aggregates From Natural Sources For Concrete**
7. **IS 9103 (1999): Specification for Concrete Admixtures**
8. **IS 14268 (1995): Uncoated stress relieved low relaxation seven-ply strand for prestressed concrete**
9. **Standard Specifications for Road and Bridge Works 2073**
10. **Notes of DOR PSC Superstructure Standard Drawing**

C1. Material Requirement

C1.1 Cement

Type of Cement

1a. Ordinary Portland cement 33 Grade (Confirming to IS 269-2015)

1b. Ordinary Portland cement 43 Grade (Confirming to IS 269-2015)

1c. High Strength Ordinary Portland cement 53 Grade (Confirming to IS 269-2015)

2. Portland Pozzolana cement (Confirming to IS 1489-Part-I)

4. Low Heat Portland cement (Confirming to IS 12600)

5. Rapid hardening Portland cement (Confirming to IS 8041)

Note :(1) Use of Portland Pozzolana Cement may be permitted only in Plain Concrete members.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level not less than 30 cm and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation with min gap of 500 mm from outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. Stack of cement bags shall not exceed 8 bags in height. Different types of cement in bags shall be clearly distinguished by visible marking and shall be stored in separate stacks.

Cement form broken bags shall not be used in the works. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weather proof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement for any one structure shall be from the same source as far as possible.

All cement used in the works shall be tested by the manufacturer. The manufacturer shall provide the results of tests as given in Table 1.1 for each supply and for the last six months of his production.

Each set of tests carried out by the manufacturer on samples taken from cement which is subsequently to site shall relate to no more than one day's output of each cement plant.

Cement which is stored on site for longer than one month shall be tested in such laboratory for every 200 tons or part thereof and at monthly intervals thereafter.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and the cement used in the works and shall provide the Engineer with two copies thereof.

Cement type selection and its content :

i. High strength Ordinary Portland Cement 53 Grade, conforming to IS: 12269 or 43 Grade conforming to IS: 8112, capable of achieving the required design concrete Strength and Durability, shall be used.

ii. Cement shall be obtained from approved Manufacturers only.

iii. Cement content in the Concrete Mix:

- for PRESTRESSED CONCRETE: not less than 400 kg/m^3 AND not more than 500 kg/m^3.
- for REINFORCED CONCRETE: not less than 350 kg/m^3 AND not more than 450 kg/m^3.

Table 1.1. Physical Requirement for OPC

SN	Characteristic	Requirement			Method of Testing
		OPC 33	OPC43	OPC53	
i.	Fineness, Sqm/Kg (Min.)	225	225	225	IS 4031-Part 2
ii.	Soundness (Le-Chatelier Method),mm, (Max.)	10	10	10	IS 4031-Part 3
iii.	Setting time:				IS 4031-Part 5
	Initial,min,(Min.)	30	30	30	
	Final,min,(Min.)	600	600	600	
iv.	Compressive Strength,MPa				IS 4031-Part 6
	a)72±1 hr,Min	16	23	27	
	b)168±2 hr,Min	22	33	37	
	c)672±4 hr,Min	33	43	53	
	Max.	48	58	-	

Note : 1. In the event of cement failing to comply the soundness specified in the above 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 75mm at a relative humadity of 50-80# for a total period of 7 days. The expansion of cement so aerated shall not more than 5mm.

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 sec. of completion of the mixing period, expressed as %, 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 confirm to the value given in the above table.

3. The samples shall be taken within 3 weeks of the delivery and all the tests shall be commenced within 1 week of sample.

4. Cement may be rejected, if it dose not comply with any of the requirements of above table.

C1.2 Aggregate

Aggregates are inert granular materials such as sand, gravel or crushed stone. These are either naturally occurring or obtained by crushing rocks, boulder or stone. Depending on the dimensions of the granules, aggregates are classified as fine (sand) and course (gravel or crushed stone).

Coarse aggregates

Coarse aggregates are particles greater than 4.75mm, but generally range between 10mm to 40mm in diameter. These are either uncrushed natural gravel or crushed stone produced from crusher plant or combination of natural gravel and crushed stone.

Fine aggregates

Fine aggregate are basically sands from the land or the river source. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve.

Table 1.2 Limits of deleterious materials

SN	Deleterious Substance	Fine Aggregate % by Wt., max.		Fine Aggregate % by Wt., max.		Method of Test
		Uncrushed	Crushed	Uncrushed	Crushed	
i.	Coal and lignite	1	1	1	1	IS 2386 part II
ii.	Clay Lumps	1	1	1	1	IS 2386 part II
iii.	Material finer than 0.075mm IS Sieve	3	15	3	3	IS 2386 part I
iv.	Soft Fragments	-	-	3	-	IS 2386 part II
v.	Shale	1	-	-	-	IS 2386 part II
vi.	Total % of all Deleterious material (i. to v)	5	2	5	5	

Sampling : As per IS 2430

Table 1.3 Grading Requirement

S.N	IS sieve Designation	Percentage Passing for Single Sized Coarse Aggregate of nominal Size				Percentage Passing for Graded Coarse Aggregate of Nominal Size			Fine aggregate
		40 mm	20 mm	12.5mm	10 mm	40 mm	20 mm	12.5mm	4.75mm down
i)	80 mm					100			
ii)	63 mm	100							
iii)	40 mm	85-100	100			90-100	100		
iv)	20 mm	0-20	85-100			30-70	90-100	100	
v)	16 mm			100					
vi)	12.5 mm			85-100	100			90-100	
vii)	10 mm	0-5	0-20	0-45	85-100	10-35	25-35	40-85	100
viii)	4.75 mm		0-5	0-10		0-5	0-10	0-10	90-100
ix)	2.36 mm								75-100
x)	1.18 mm								55-90
xi)	0.60 mm								35-59
xii)	0.30 mm								8-30
xiii)	0.15 mm								0-10

Table 1.3 Physical Characteristic Requirement confirming IS: 383 (2016)

SN	Physical Characteristic	Permissible Values	Method of Testing
i.	Toughness/Strength : Aggregate Abrasion Value/LAA Aggregate Crushing Value Aggregate Impact Value	<30%(for wearing course) <35% for Concrete grade at/above M30 <45% for Concrete grade less than M30 <30% In case the aggregate crushing value exceeds 30 percent then the test for 'ten percent fines' should be conducted and the minimum load for the ten percent fines should be 50 kN <30% (for wearing course)	IS 2386 Part 4

SN	Physical Characteristic	Permissible Values	Method of Testing
		<35% for Concrete grade at/above M30 <45% for Concrete grade less than M30	
ii.	Durability: Soundness either: Sodium Sulphate or Magnesium Sulphate	10%(FA) 12%(CA) 15%(FA) 18%(CA)	IS 2386 Part 5
iii.	Flakiness Index	<15% for Concrete grade at/above M30 <25% for Concrete grade less than M30	IS 2386 Part 1
iv.	Water Absorption	<2%	IS 2386 Part 3

For Bridge Components

i. Maximum size of Coarse Aggregate used shall be 20mm.

ii. In zones of congestion in the structural sections like End Block of PSC Girder, if absolutely necessary, 12 mm. down sized Coarse Aggregates may be used (but the Mix shall then be re-designed to suit).

Acceptance Testing

The Contractor shall deliver to the Engineer samples containing *not less than 50 kg of any aggregate* which he/she proposed to use in the works and shall supply such further samples as the Engineer may require. All the materials shall be accepted if the results of not less than three consecutive sets of test.

Compliance Testing/Process Control Testing

The Contractor shall carry out routine testing of aggregate for compliance with the quality requirement during the period that concrete is being produced for the works. Frequency test shall be as follows:

Table 1.4 Frequency of Aggregate Test

Aggregate Type	Frequency
Fine aggregate	1 set (3 nos) test for each 10 to 50 cum and additional test for each 50 cum of concrete
Coarse Aggregate	1 set (3 nos) test for each 25 to 125 cum and additional test for each 125 cum

If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Engineer.

Delivery and Storage of Aggregate

Aggregate shall be delivered to site in clean and suitable vehicles. Different type or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that the contamination of aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregate shall be arranged in such a way that drying out in hot weather is prevented in order to avoid fluctuations in water content. Storage of fine aggregates shall be arranged in such way that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

C1.3 Water

Water for concrete and for its curing shall be of potable quality and presence of any salts, sugars and pollutants like chlorides, sulphates, algae, etc., shall be well within the limits specified in table 1.5.

The average 28 days compressive strength of at least three 150mm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average stenght of 3 similar concrete cubes prepared with distilled water.

Table 1.5 Water Quality Requirement

SN	Impurities	Permissible limits, Max.	Method of Testing
i.	Organic	200 mg/l	IS 3025 Part 18
ii.	Inorganic	3000 mg/l	IS 3025 Part 18
iii.	Sulphate (SO_3)	400 mg/l	IS 3025 Part 24
iv.	Chloride (Cl)	500 mg/l	IS 3025 Part 32
v.	Suspended Matter	2000 mg/l	IS 3025 Part 17
vi.	PH Value	Not < 6 <5ml of 0.02 N NaOH required to neutralize 100ml water sample (Phenolphthalein as indicator)	IS 3025 Part 22

C1.4 Additives

To suitably improve workability and increase initial setting time of concrete and cement grout, Admixtures conforming to IS: 9103, and ASTM C–494 Type F water-reducing, high range admixtures, shall be permitted in appropriate dosages, subject to their satisfactory proven use.

Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he/she proposes to add it in the mix. The information provided shall include:

(i) The typical dosage, the method of dosing, and the detrimental effects of an excess or deficiency in the dosage.

(ii) The chemical names of the main active ingredients in the admixture.

(iii) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.

(iv) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so the extent to which it does so.

(v) Details of previous uses of the admixture in Nepal.

The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

Types of Admixtures:

a) Accelerating Admixture

b) Retarding Admixture

c) Water Reducing Admixture

d) Air-entraining Admixture

e) Super-plasticizing Admixture

f) Anti-washout Admixture

Compatibility of the admixtures with the cement and any other pozzolan or hydraulic addition shall be ensured by for avoiding the following problems.

(i) Requirement of large dosage of superplasticizer for achieving the desired workability.

(ii) Excessive retardation of setting

(iii) Excessive entrainment of large bubbles

(iv) Unusually rapid stiffening of concrete

(v) Rapid loss of slump

(vi) Excessive segregation and bleeding

Table 1.6 Physical Requirement for Additives

S.N.	Requirements	Accele-rating Admixture	Retarding Admixture	Water Reducing Admixture	Air-Entraining Admixture	Superplasticizing Admixture (for Water-Reduced Concrete Mix)	
1	2	3	4	5	6	7	8
i)	Water content, percent of control sample, Max	_	_	95		80	80
ii)	Slump	_	_	_	_	Not more than 15mm below that of the control mix concrete	
iii)	Time of setting, allowable deviation from control sample hours:						
	Initial						
	Max	-3	+3	± 1	_	_	+4
	Min	-1	+1	_	_	+1.5	+1
	Final						
	Max	-2	+3	± 1	_	+1.5	± 3
	Min	-1	+1	_	_	_	_
iv)	Compressive strenght, percent of control sample, Min						
	1 day	_	_	_	_	140	_
	3 days	125	90	110	90	125	125
	7 days	100	90	110	90	125	125
	28 days	100	90	100	90	100	100
	6 months	90	90	100	90	100	100
	1 year	90	90	100	90	100	100
v)	Flexural Strength percent of control sample, Min						
	3 days	110	90	100	90	110	110
	7 days	100	90	100	90	100	100
	28 days	90	90	100	90	100	100
vi)	Length change, perent of increase over control sample, Max						
	28 days	0.010	0.010	0.010	0.010	0.010	0.010
	6 months	0.010	0.010	0.010	0.010	0.010	0.010
	1 year	0.010	0.010	0.010	0.010	0.010	0.010
vii	Bleeding, percent increase over control sample, Max	5	5	5	5	5	5
viii	Loss of workability	_	_	_	_	At 45 min the slump shall be not less than that of control mix concrete at 15 min	At 2 h, the slump shall be not less than that of control mix concrete at 15 min
ix	Air content (%) Max, over control	–	–	–	–	1.5	1.5

Anti-washout admixture

Anti-washout admixture (also, viscosity improving admixture) of concrete for underwater concreting is produced as a viscosity modifying admixture to enhance the rheological properties of cement paste. It mainly composed of microbial polysaccharides for example gum or polysaccharide derivatives for instance hydroxyethyl cellulose and hydroxypropyl methyl cellulose.

It is demonstrated that, the Anti-washout admixture is substantially influential in enhancing the cohesiveness of concrete that is poured underwater and in danger of washout or segregation due to surrounding water.

The amount of Antiwashout admixture which is required to be added to concrete mixture is specified based on required flowability, depth of the underwater placement, horizontal flow distance, water to cementitious materials ratio and the quantity of cementitious materials to be utilized.

Figure 1.1 Without or With(right) Anti-washout Admixture

Classification of Anti-Washout Concrete Admixtures

It can be divided into the following classes:

Class-A Anti-Washout Admixtures

Water soluble synthetic and natural organic admixture which improve the viscosity of the mixing water. The ranges of this class applied are between 0.2 to 0.5% solid by mass of cement.

Anti-washout admixtures containing cellulose ether, pregelatinized starches, carageenans, polyacrylamides, polyethylene oxides, alignates, carboxyvinyl polymers, and polyvinyl alcohol are examples of the Class A.

Class-B Anti-Washout Concrete Admixtures

It is organic flocculants which can dissolve in water and absorbed by cement particles, and consequently it enhances viscosity by increasing attractions between cement particles.

The dosage is between 0.01 and 0.10% solid by mass of cement. Examples of Class B are Styrene copolymers with carboxyl groups, synthetic polyelectrolytes, and natural gums.

Class-C Anti-Washout Concrete Admixtures

It is emulsions of different organic material that not only improve attractions between particles but also provide extremely fine particles in the cement paste. The amount of Class C anti-washout admixture that is usually added it ranges from 0.10 to 1.50% solid by mass of cement.

Paraffin-wax emulsions that are unstable in the aqueous cement phase, acrylic emulsions, and aqueous clay dispersions are examples of Class C anti-washout admixture.

Class-D Anti-Washout Concrete Admixtures

These are large surface area inorganic materials which rise mixture capacity to retain water. The dosage range employed is 1-25% solid by mass of cement. Examples include bentonites, pyrogenic silicas, silica fume, milled asbestos, and other fibrous materials.

Class-E Anti-Washout Concrete Admixtures

It is inorganic materials which provide extra fine particles to the mortar pastes. The mount of the Class E that is added is between 1 to 25% solid by mass of cement.

Fly ash, hydrated lime, kaolin, diatomaceous earth, other raw or calcined pozzolanic materials, and various rock dusts are examples of Class E Antiwashout admixture.

Compliance

For compliance with this specification, test concrete in which admixture is used for conformance with the in Table 1.7.

Table 1.7. Physical Requirements[A]

Requirement	Limits
Slump Loss, % of control at 30 minutes	50
Strength, min % of Control	
3 days	90
7 days	90
28 days	90

[A]The values in the table include allowance for normal variation in test results. The object of the 90% strength requirementis to require a level of performance comparable to that of the reference concrete. The effects of antiwashout admixture on time of setting is not a requirement, but the user should be aware that some brands of admixtures retard this property. If this is critical to the work that this be controlled, then this needs to be controlled by creating a job-specific requirement.

Note : Effect of Superplasticizers on the Properties of Hardened Concrete

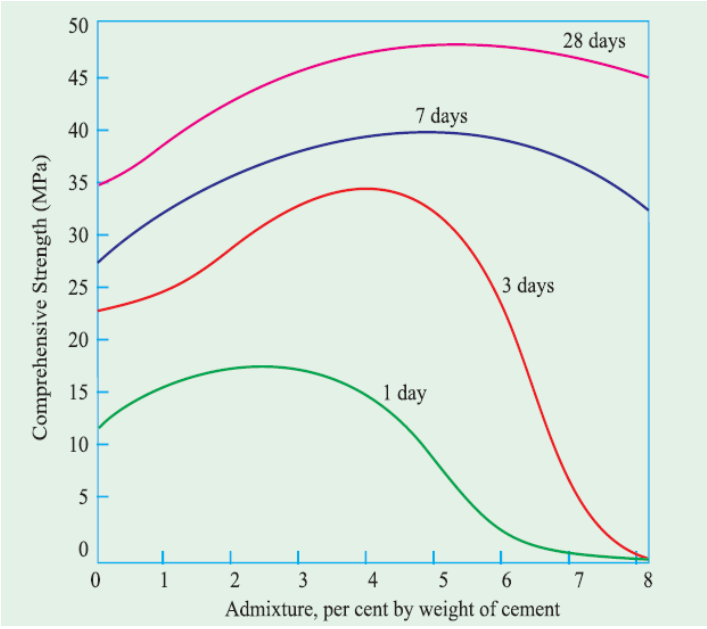


Figure 1.2 : Effect of Admixture Dose

Plasticizers or superplasticizers do not participate in any chemical reactions with cement or blending material used in concrete. Their actions are only physical in fluidizing the mix, made even with low water content. Their fludifying action lasts only as long as the mix is in plastic condition. Once the effect of adsorbed layer is lost, the hydration process continues normally. *It can be categorically said that the use of right quality of plasticizers or superplasticizers when used in usual small dose (say up to 3% by weight of cement) there is no bad effect on the properties of hardened concrete*. Only in case

of bad quality lignosulphonate based plasticizer is used, it may result in air-entrainment, which reduces the strength of concrete. Since plasticizers and superplasticizers improve the workability, compactability and facilitate reduction in w/c ratio, and thereby increase the strength of concrete, it contributes to the alround improvement in the properties of hardened concrete.

As a matter of fact, it is the use of superplasticizers, which is a pragmatic step to improve alround properties of hardened concrete. The use of superplasticizer has become an unavoidable material in the modern High Performance Concrete (HPC).

It has been mentioned earlier that all plasticizers and superplasticizers exhibit certain retarding properties. These retarding properties do not make significant difference when the dosage is normal (say upto 3%). The strength parameter is not reduced beyond one day. Bu when plasticizers are used in higher dose, the strength development will be greatly affected in respect of one day and even three days strength. However, seven day strength and beyond, there will not be any reduction in strength. The typical strength development of lignosulphonate type water reducing admixture is shown in Fig. figure 1.2

At the same w/c ratio, naphthalene based or melamine based superplasticizers do not considerably modify the drying shrinkage of concrete. At the same consistency, they sometime reduce drying shrinkage appreciably.

The total creep is higher when concrete contains naphthalene sulphonates, at high w/c ratio (0.64). On the contrary, when w/c ratio is low, the difference in creep between samples with and without plasticizers are insignificant.

Impermeability plays a primary role on the durability of concrete and since this depends on w/c ratio, superplasticizers should exert a favourable effect. Superplasticizers, owing to the reduction in w/c ratio, reduce the penetration of chlorides and sulphate into the concrete and, therefore, improve their resistance to the de-icing effect of salt or sea water. For the same reason, the resistance to sulphate attack is also improved.

Suffice it to say that the use of plasticizer or superplasticizer, could lead to the reduction in w/c ratio, without affecting the workability and thereby concrete becomes stronger. Therefore, it will contribute to the alround improvement of hardened properties of concrete.

C1.5 Reinforcement

Fe 415, Fe 500 and above deformed bar with characteristic strength f_y 415 MPa,500 MPa and above respectively, where characteristic strength f_y shall be taken as the minimum value of 0.2% proof stress or yield stress.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. The reinforcement bar bent and fixed in position shall be free from rust orscales, chloride contamination and other corrosion products. Where cleaning of corroded, effective method of cleaning such as sand blasting shall be adopted.

All reinforcement shall be delivered to site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Reinforcement shall be stored at least 150 mm above the ground on clean area free of mud and dirt and sorted out according to category, quality and diameter.

Table 1.8 Chemical Composition (IS 1786:2008)

Constituent	*Percent, Maximum*								
	Fe 415	Fe 415D	Fe 415S	Fe 500	Fe 500D	Fe 500S	Fe 550	Fe 550D	Fe 600
Carbon	0.30	0.25	0.25	0.30	0.25	0.25	0.30	0.25	0.30
Sulphur	0.060	0.045	0.045	0.055	0.040	0.040	0.055	0.040	0.040
Phosphorus	0.060	0.045	0.045	0.055	0.040	0.040	0.050	0.040	0.040
Sulphur and phosphorus	0.110	0.085	0.085	0.105	0.075	0.075	0.100	0.075	0.075

For guaranteed weldability, the Carbon Equivalent should be less than 0.42.

Table 1.9 Mechanical Properties of High Strength Deformed Bars (IS 1786:2008)

S.N.	Property	Fe 415	Fe 415D	Fe 415S	Fe 500	Fe 500D	Fe 500S	Fe 550	Fe 550D	Fe 600
1	2	3	4	5	6	7	8	9	10	11
i)	0.2 percent proof stress/ yield stress, Min, N/mm^2	415	415	415	500.0	500.0	500.0	550.0	550.0	600.0
ii)	0.2 percent proof stress/ yield stress, Max, N/mm^2	–	–	540.0	–	–	625.0	–	–	–
iii)	TS/YS ratio[1)], N/mm2	≥ 1.10, but TS not less than 485.0 N/mm^2	≥ 1.12, but TS not less than 500.0 N/mm^2	1.25	≥ 1.08, but TS not less than 548.0 N/mm^2	≥ 1.10, but TS not less than 565.0 N/mm^2	1.25	≥ 1.06, but TS not less than 585.0 N/mm^2	≥ 1.08, but TS not less than 600.0 N/mm^2	≥ 1.06, but TS not less than 660N/mm^2
iv)	Elongation, percent, min. on gauge length 5.65√A, where A is the cross-sectional area of the test piece	14.5	18.0	20.0	12.0	16.0	18.0	10.0	14.5	10.0
v)	Total elongation at maximum force, percent, Min, on gauge length 5.65√A, where A is the cross-sectional area of the test piece [2)]	–	5	10	–	5	8	–	5	–

1) TS/YS ratio refers to ratio of tensile strnght to the 0.2 percent proof stress or yield stress of the test piece

2) Test, wherever specified by the purchaser.

Table 1.10 Nominal Cross-section Area and Mass (IS 1786:2008)

SN	Nominal Dia.,mm	Cross-Section Area,mm2	Mass per meter
i)	*4*	12.6	0.099
ii)	5	19.6	0.154
iii)	6	28.3	0.222
iv)	8	50.3	0.395
v)	10	78.6	0.617
vi)	12	113.1	0.888
vii)	16	201.2	1.58
viii)	20	314.3	2.47
ix)	25	491.1	3.85
x)	28	615.8	4.83
xi)	32	804.6	6.31
xii)	36	1018.3	7.99
xiii)	40	1257.2	9.86
xiv)	45	1591.1	12.49
xv)	50	1964.4	15.42
Tolerance			
SN	**Nominal Size,mm**	**Tolerance on Nominal Mass, %**	
i.	Upto 10mm	-8	
ii.	10mm to 16mm	-6	
iii.	Over 16mm	-4	

Testing frequency :

- For 1-25 bundles lot 3 rod (one from each bundle) from randomly selected 3 bundles.
- For 26-65 bundles lot 4 rod (one from each bundle) from randomly selected 4 bundles
- For 66-180 bundles lot 5 rod (one from each bundle) from randomly selected 5 bundles
- For 181- 300 bundles lot 7 rod (one from each bundle) from randomly selected 7 bundles
- For > 300 bundles lot 10 rod (one from each bundle) from randomly selected 10 bundles

C1.6 Prestresssing Steel

The prestressing steel shall be IS:14268:1995" Uncoated stress relieved low relaxation seven ply strand for prestressed concrete" as per Table1.11.

Table 1.11 Physical Properties of Prestressing Strands

Class	Nominal Dia. of Strand, mm	Nominal Area of Strand,mm^2	Nominal Mass of Strand, Kg/m	Min. Breaking Strength of Strand,KN	0.2% Proof Load(90% of Breaking Strength),KN
I	9.5	51.6 ± 0.40	0.405	89.0	80.1
	11.1	69.7 ± 0.40	0.548	120.1	108.1
	12.7	92.9 ± 0.40	0.730	160.1	144.1
	15.2	139.4 ± 0.40	1.094	240.2	216.2
II	9.5	54.8 + 0.66 / -0.15	0.432	102.3	92.1
	11.1	74.2 + 0.66 / -0.15	0.582	137.9	124.1
	12.7	98.7 + 0.66 / -0.15	0.775	183.7	165.3
	15.2	140.0 + 0.66 / -0.15	1.102	260.7	234.6
Minimum % elongation = 3.5% of minimum gauge length of 600mm					
Relaxation loss % = 2.5 % max., at 70% of specified MBS after 1000hr or, 1.8 % max., at 70% of specified MBS after 100hr.					

CLASS : The strand shall be either Class I or Class II depending on the breaking strength of the strand given in Table 1.11.

Strand : The seven wires strand shall have a centre wire at least 1.5 % greater in diameter than the surrounding wires enclosed tightly by six helically placed outer wires with a uniform length of lay of at least 12 times but not more than 16 times of the nominal diameter of the strand. The wire in the strand shall be so formed that they shall not fly out of position when the strand is cut without seizing.

Data in respect of modulus of elasticity, relaxation loss at 1000 hrs., minimum ultimate tensile strength, stress-strain curve etc. shal1 necessarily be obtained from manufacturers.

Test samples of sufficient length to permit the tests for breaking load, 0.2 percent proof load and elongation shall be cut from one end of a coil selected at random from a group of every 5 numbers of coils. The test piece shall not be detached from the coil or length of strand, except in' the presence of purchaser or his authored representative. Should 10 percent or more of the selected coils fail to fulfil the requirement of this standard, the parcel from which they were taken shall be deemed not to comply with this standard.

Prestressing steel shall be subjected to acceptance tests prior to actual use on the works (guidance may be taken from BS:4447). The modulus of elasticity value, as per acceptance tests, shall conform to the design value which shall be within a range not more than 5 per cent between the maximum and minimum.

C1.7 Sheathing Ducts

The sheathing ducts shall be either in mild steel or in HDPE. They shall be in as long lengths as practical from handling and transportation considerations without getting damaged.

C1.7.1 MS sheathing ducts

Unless otherwise specified, the material shah be Cold Rolled Cold Annealed (CRCA) Mild Steel intended for mechanical treatment and surface refining but not for quench hardening or tempering. The material shall be clean and free from rust and normally of bright metal finish.

The thickness of metal sheathing shall not be less than 0.3 mm, 0.4 mm and 0.5 mm for sheathing ducts having internal diameter upto 50 mm, 75 mm and 90 mm respectively. For bigger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier.

Table1.12 Details of Ducts

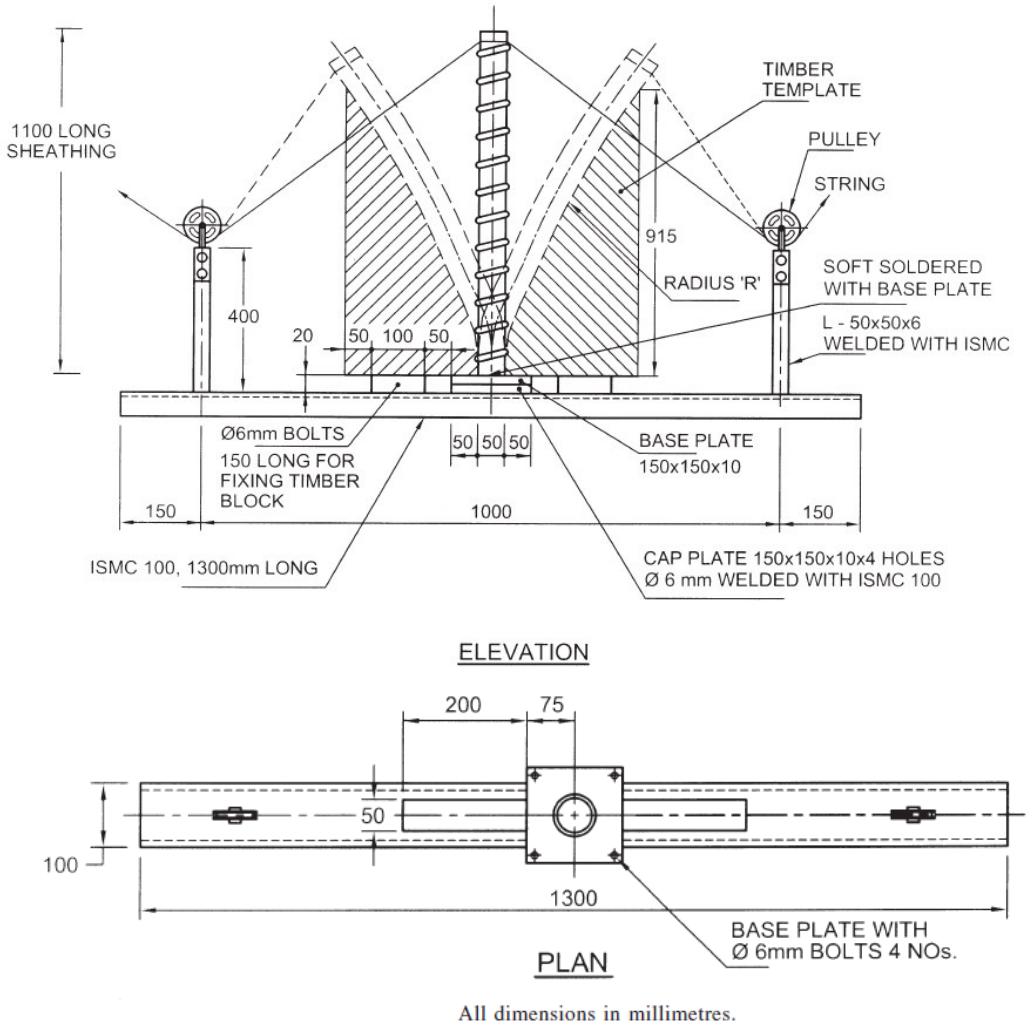
No. of Strands/Dia. in mm	Diameter of Duct in mm		Thickness of MS Sheathing in mm	Thickness of HDPE duct in mm
	Metallic	HDPE		
6/13	50	50	0.3	2.0
122/13	75	75	0.4	2.5
19/13	85	85	0.4	2.5
27/13	100	100	0.5	3.0
12/15	85	85	0.4	2.5
19/15	100	100	0.5	3.0
27/15	125	130	0.5	4.0

The sheathing shall conform to the requirements specified *below* and a test certificate shall be furnished by the manufacturer.

TESTS ON SHEATHING DUCTS (Ref. IRC 18:2000)

All tests specified below shall be carried out on the same sample in the order given below. At least 3 samples for one lot of supply (not exceeding 7000 metre length) shall be tested.

Workability Test : A test sample 1100 mm long is soldered to a fixed base plate with a soft solder (Figure1.2). The sample is then bent to a radius of 1800 mm alternately on either side to complete 3 cycles. Thereafter, the sealing joints will be visually inspected to verify that no failure or opening has taken place.



All dimensions in millimetres.

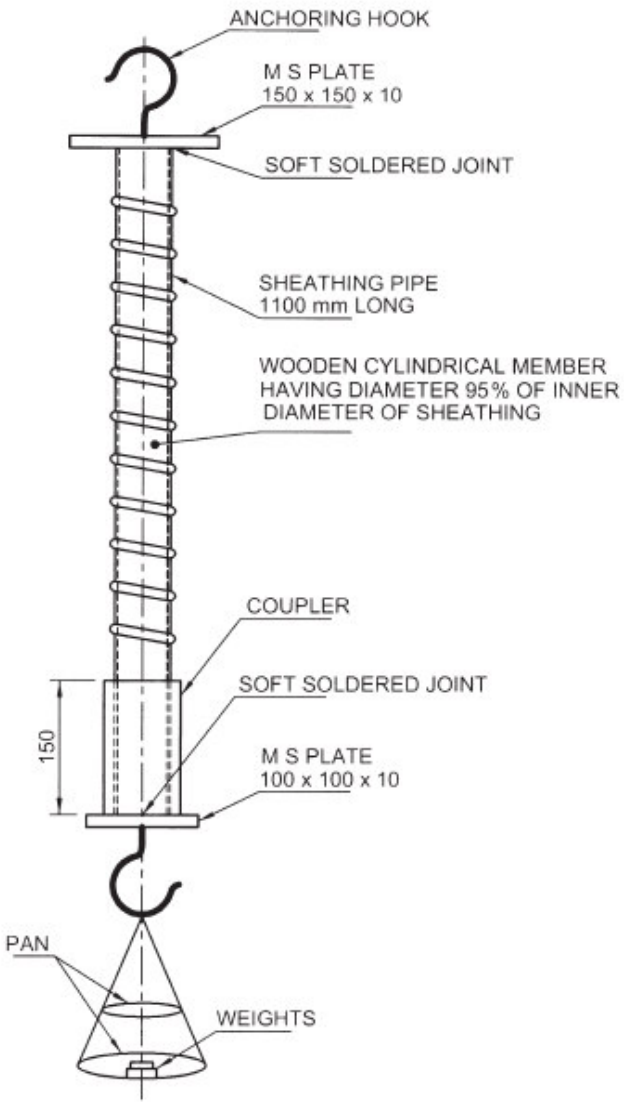
Figure 1.2 Workability Test

Transverse Load Rating Test : The test ensures that stiffness of the sheathing is sufficient to prevent permanent distortion during site handling. The sample is considered acceptable if the permanent deformation is less than 5 per cent.

Tension Load Test : The test specimen is subjected to a tensile load. The hollow core is filled with a wooden circular piece having a diameter of 95 per cent of the inner dia of the sample to ensure circular profile during test loading, Figure 1.3

Diameter of Sheath mm	*Load* N
25 to 35	250
More than 35 up to 45	400
More than 45 up to 55	500
More than 55 up to 65	600
More than 65 up to 75	700
More than 75 up to 85	800
More than 85 up to 90	1 000

A coupler is screwed on and the sample loaded in increments, till specified load. If no deformation of the joints nor slippage of couplers is noticed, the test shall be considered satisfactory:



All dimensions in millimetres.

Figure 1.3 Tension Load Test

Water Loss Test : The sample is acceptable if the water loss does not exceed 1.5 per cent of the volume.

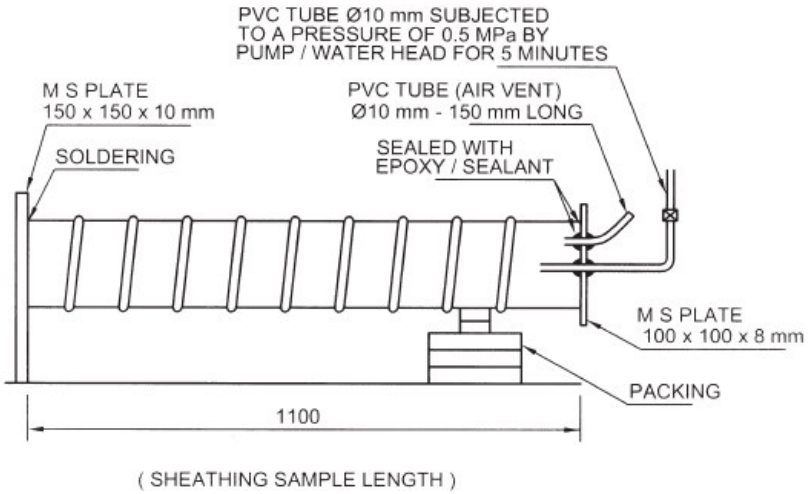


Figure 1.4 Test For Water Loss Study

C1.7.2 Corrugated HDPE sheathing ducts

Unless otherwise specified, the material for the ducts shall be high-density polyethylene with more than 2 per cent carbon black to provide resistance to ultraviolet degradation and shall have the following properties :

Specific Density	:	0.954 g/cm3 at 23°C
Yield Stress	:	18.0 N/mm^2
Tensile Strength	:	21.0 N/mm^2
Shore Hardness D-3 sec. value	:	60
-15 sec. value	:	58
Notch impact strength at 23°C	:	10 kJ/m^2
-40°C	:	4 kJ/m^2
Coefficient of Thermal Expansion for 20°C - 80°C	:	1.50 x 10^{-4} kJ/m^2

The thickness of the wall shall be 2.3 ± 0.3 mm as manufactured and 1.5 mm after loss in the compression test, for duct size upto 160 mm OD.

The sheathing ducts shall be of the spiral corrugated type. The ducts shall be corrugated on both sides. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers.

Where sheathing duct joints are unavoidable, such joints shall be made cement slurry tight by the use of corrugated threaded sleeve couplers which can be tightly screwed on to the outer side of the sheathing ducts. A heat-shrink coupler could also be used if suitable.

Typical details of a sleeve coupler is shown in **Figure 1.5.** The length of the coupler should not be less than 150 mm but should be increased upto 200 mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using **the** sheath making machine with the next higher size of die set.

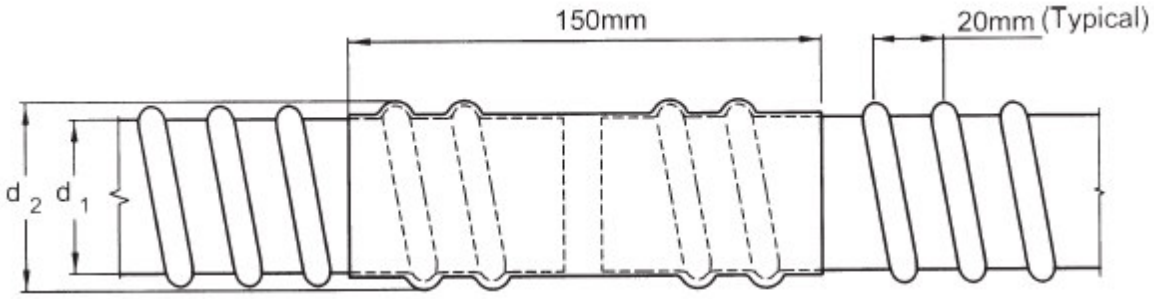


Figure 1.5 Typical details of a sleeve coupler

The heat-shrink coupler **Figure 1.6** is supplied in the form of bandage rolls which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after heating the bandage material shrinks on to the sheathing duct and ensures formation of a leak proof joint, without the need for extra taping or support in the form of corrugated sleeve couplers. The heating is effected by means of a soft gas flame.

These ducts shall be joined by adopting any one or more of the following methods, as convenient to suit the individual requirements of the location, subject to the satisfactory pressure tests, before adoption.

- Screwed together with male and female threads.
- Joining with thick walled HDPE shrink couplers with glue. This can also be used for connection with trumpet, etc.
- Welding with electrofusion couplers.

The joints shall be able to withstand an internal pressure of 0.5 bar for 5 minutes.

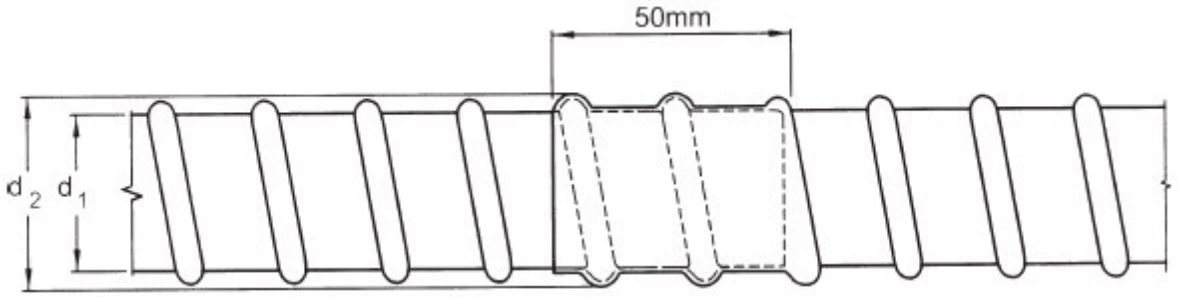


Figure 1.6 Typical details heat-shrink coupler

The ducts shall transmit full tendon strength from the tendon to the surrounding concrete over a length not greater than 40 duct diameters.

TESTS ON CORRUGATED HDPE SHEATHING DUCTS (Ref. IRC 18:2000)

The additional acceptance tests (besides the above mentioned tests for MS Duct) for the prestressing systems employing corrugated HDPE ducts shall cover the following two tests:

Bond Test : To establish satisfactory bond characteristics between the tendon and concrete, in the ultimate condition. The failure capacity of the bond shall be at least equal to the anchorage efficiency or 0.95 of failure capacity of the tendon. At least 3 nos. of tests shall be carried out to ascertain the adequacy of the duct.

Compression Test for The Loss of Wall Thickness : To establish the wear and tear of the sheathing material and the rigidity of the duct surface against indentation and abrasion under concentrated line loading from the tendon constitutents. The residual thickness of the duct shall not be less than 1.5 mm.

C.1.7 Anchorage and Jack

Anchorage of cables in the top deck surface shall not be permitted. All anchorages shall be properly sealed after prestressing and grouting operations. All wires/strands in one cable should be stressed simultaneously by using multi-stressing jack.

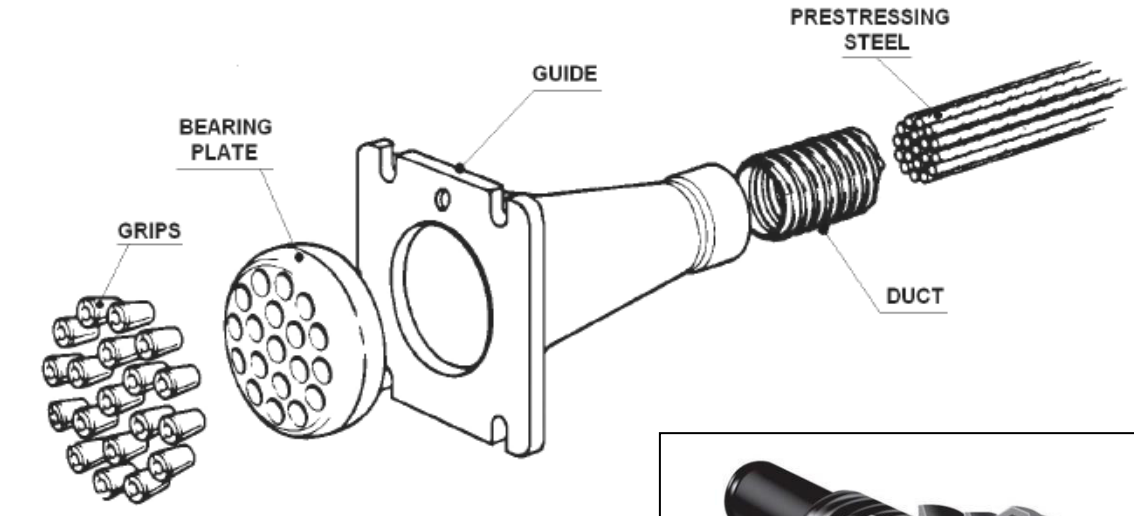
Pre-stressing accessories like jacks, anchorages, wedges, block plates, etc. shall be procured from authorised manufacturers only. Anchorages shall conform to "Recommendations for acceptance and application of pre-stressing systems" published by FIB. The pre-stressing accessories shall be subjected to an acceptance test prior to their actual use on the work. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

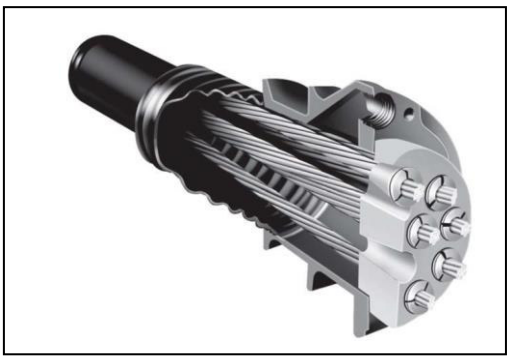
Swages of pre-stressing stand and button-heads of pre-stressing wire, whereprovided shall develop a strength of at least 95 per cent of the specified breaking load of the strand or wire as the case may be. Where swaging/button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

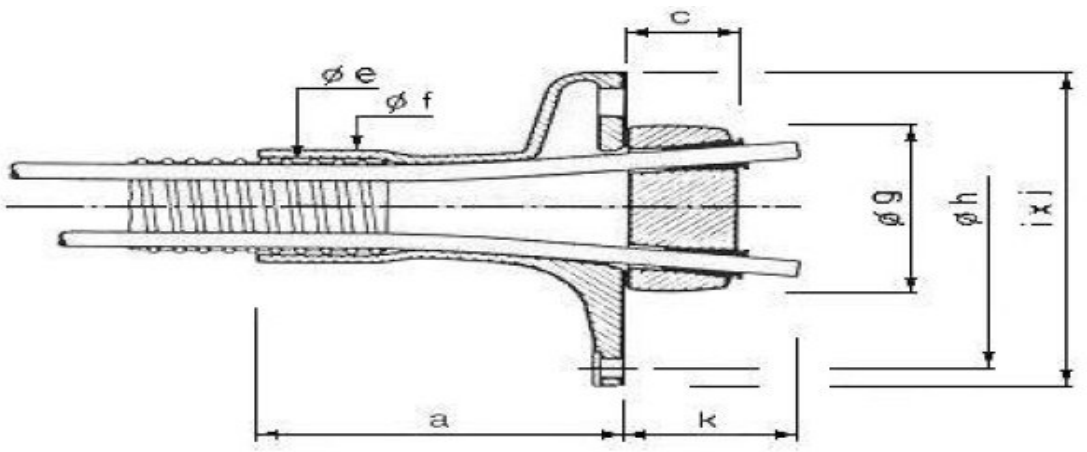
Un- tensioned Steel reinforcements, around anchorages shall conform to the details of pre-stressing system and as shown on the drawing.

Example of Freyssinet post tensioning Anchorage and Jack :K-Type



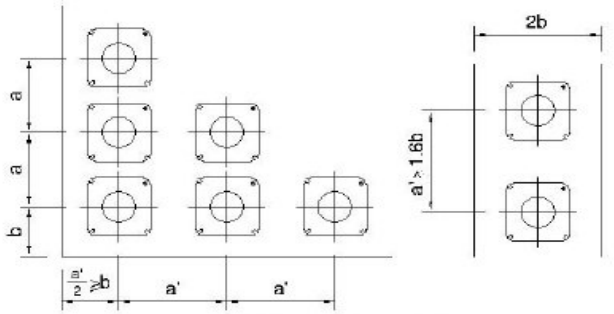
PRESTRESSING ANCHORAGES



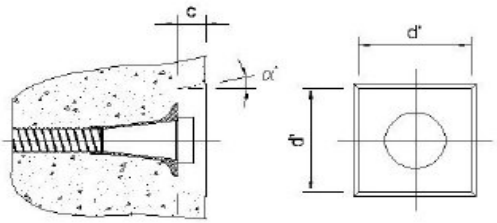


ANCHORAGE TYPE		a	c	e	f	Ø g	Ø h	i	j	k
4 K 13	-	104	45	45	56	85	158	147	147	75
7 K 13	4 K 15	103	50	62	72	120	184	160	160	85
12 K 13	7 K 15	180	55	84	100	140	254	220	235	90
19 K 13	12 K 15	190	60	95	105	160	190	244	244	95
27 K 13	19 K 15	270	70	127	136	200	234	275	293	105
37 K 13	27 K 15	395	78	171	190	252	425	365	365	115
-	37 K 15	467	85	178	206	270	495	425	425	125

ANCHORAGE SPACING & EDGE DISTANCE



ANCHORAGE CENTERS & EDGE CLEARANCES

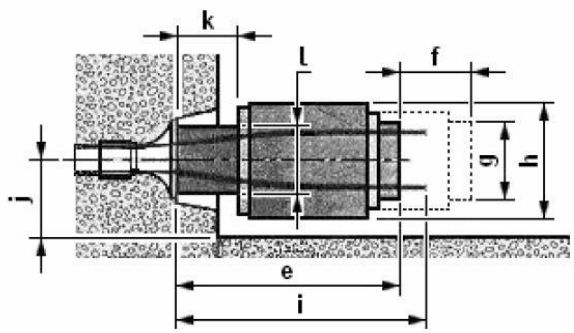


RECESS DIMENSIONS

CONC. CUBE STRENGTH in N/mm.²

ANCHORAGE TYPE	TENDON FORCE kN	BASE SQUARE OF GUIDE mm. x mm.	M30		M35		M40		M45		M50		M55		M60		RECESS DIMENSIONS			
			a	b	a	b	a	b	a	b	a	b	a	b	a	b	c	d'	Jack	α°
4K13	734.8	147 X 147	200	150	185	135	170	120	170	120	170	120	170	120	170	120	100	205	K100	10
4K15	1042.8	160 X 160	220	170	200	150	180	130	180	130	180	130	180	130	180	130	110	220	K100	10
7K13	1285.9		220	170	200	150	180	130	180	130	180	130	180	130	180	130	110	270	K200	10
7K15	1824.9	220 X 220	280	220	260	200	240	180	240	180	240	180	240	180	240	180	120	270	K200	10
12K13	2204.4		280	220	260	200	240	180	240	180	240	180	240	180	240	180	120	300	K350	10
12K15	3128.4	244 X 244	325	250	300	230	290	210	270	185	270	185	270	185	270	185	125	300	K350	10
19K13	3490.3		325	250	300	230	290	210	270	185	270	185	270	185	270	185	125	350	K500	10
19K15	4953.3	275 X 292.5	430	320	400	280	360	250	320	220	320	220	320	220	320	220	125	350	K500	10
27K13	4959.9		430	320	400	280	360	250	320	220	320	220	320	220	320	220	125	500	K700	10
37K13	6796.9	365 X 365	520	400	490	360	460	330	430	300	400	270	400	270	400	270	145	500	K700	30
27K15	7038.9		520	400	490	360	460	330	430	300	400	270	400	270	400	270	145	500	K700	30
37K15	9645.9	425 X 425	580	440	560	400	540	380	500	350	460	320	460	320	460	320	160	600	K1000	30

Jack:



JACK TYPE	ANCHORAGE TYPE		e	f	g	h	i	j	k	l
K 100	4 K 13	-	635	200	185	275	785	190	126	192
	7 K 13	4 K 15	635	200	185	275	785	190	126	192
K 200	7 K 13	4 K 15	720	200	220	350	875	230	228	274
	12 K 13	7 K 15	726	200	220	350	875	230	231	274
K 350	12 K 13	7 K 15	820	250	267	440	970	270	235	324
	19 K 13	12 K 15	820	250	267	440	970	270	230	324
K 500	19 K 13	12 K 15	940	250	267	515	1090	310	230	410
	27 K 13	19 K 15	933	250	267	515	1090	310	222	410
K 700	27 K 13	19 K 15	881	260	350	610	1030	360	142	478
	37 K 13	27 K 15	973	260	350	610	1125	360	104	478
K 1000	37 K 13	27 K 15	1062	220	400	710	1220	410	268	535
	55 K 13	37 K 15	1171	220	400	710	1320	410	279	535

C1.8 Recommended Practice for Storages and Handling of Prestressjng Material

1. All prestressing steel, sheathing, anchorages and sleeves or couplings shall be protected during transportation, handling and storage. For wires upto 5 mm dia, coils of about 1.5 m dia, and for wires above 5 mm dia, coils of about 2 m dia without breaks and joints shall be obtained from the manufacturer.

2. Materials shall be stored in accordance with the provisions contained in relevant specifications. All efforts shall be made to store the materials in proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space shall also permit easy inspection, removal and re-storage of the materials.

3. The prestressing steel, sheathing and other accessories shall be stored under cover and protected from rain or damp ground. These shall also be protected from the ambient atmosphere if it is likely to be aggressive. All prestressing steel shall be provided with temporary protection during storage such as coating of soluble oils, silica gel or vapour phase inhibiting materials of proven specifications.

4. Storage at site shall be kept to the absolute minimum. All materials even though stored in approved go downs shall be subjected to acceptance test prior to their immediate use.

C2.1 Non-Prestressing Steel Placement

All non-presressing steel shall confirm as per Table 1.7 and 1.8.The sampling and frequency of testing shall be as described in section C1.5 .All reinforcement not complying with the Specification shall be removed from site.

Unless otherwise shown on the Drawing, bending and cutting shall comply with IS: 2052.

C2.1.1 Bends and Hooks Forming End Anchorages

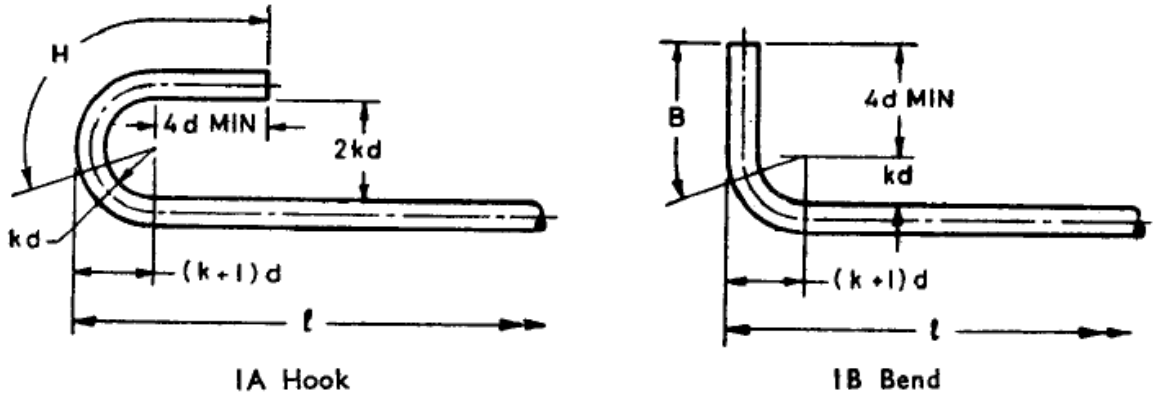


Figure 2.1 : Hook and Bend Details

Unless otherwise indicated in the schedule, a semicircular hook or a bend forming an anchorage to a bar shall be bent with an internal radius in accordance with Fig. 1A and Fig. 1B, respectively. The hook and allowances shall be in accordance with Table 2.1.

Table 2.1 Hook and Bend Allowances

Nominal Size of Bar,mm	Hook :Cold Worked Steel Bars,mm	Bend :Cold Worked Steel Bars,mm
10	130	75
12	155	75
16	210	95
20	260	120
22	285	130
25	325	150
28	365	170
32	415	190
36	470	215
40	520	240
45	585	270
50	650	300

Binders, Stirrups, Links and the Like - In the case of binders, stirrups, links, etc, the straight portion beyond end of the curve at the end shall be not less than eight times the nominal size of the bar.

C2.1.2 Curved Bars

Bars specified to be formed to radii exceeding those given in Table 2.2 need not be bent, but the required curvature may be obtained during placing.

C2.1.3 Bending and Cutting Tolerances

Bars shall be bent in accordance with the appropriate dimensions shown in the schedule. Where an overall or an internal dimension of the bent bar is specified, the tolerance, unless otherwise stated, shall be as in Table 2.3

Any excess in length of bar supplied over the total of the lengths of the various portions of the bar between bends, including the specified tolerances or not, shall be taken up in the end anchorages, or in

the portion of the bar which shall be indicated on the schedule. The cutting lengths shall be specified to the next greater whole 25mm of the sum of the bending dimensions and allowance.

Table 2.2 Bars Bent to A Radius

Nomina Size of Bar, mm	Critical Radius,m
10	3.5
12	5
16	8
20	12
22	18
25	24
28	34
32	40

Table 2.3 Permissible Bending and Cutting Tolarances

Bar	Dimensions		Tolerance	
	Over, cm	Up to and Including,cm	Plus,mm	Minus,mm
For Bend Bars	-	75	3	5
	75	150	5	10
	150	250	6	15
	250	-	7	25
For Straight Bars	All lengths		25	25

The cutting tolerance for bars to be bent shall be the tolerance given for straight bars, To allow for this cutting tolerance when dimensioning bent bars, at least one dimension shall not be specified.

C2.1.4 Fixing Reinforcement

The economy of reinforced concrete design will be fully realized only when the reinforcements are maintained at their designed positions at all times. The important factors in fixing the reinforcement are precision and convenience.

Reinforcement shall be thoroughly cleaned. All dirt, scale, loose rust, oil and other contaminants shall be removed before placing it in position. If the reinforcement is contaminated with concrete form previous operation, it shall be cleaned before concreting in that section.

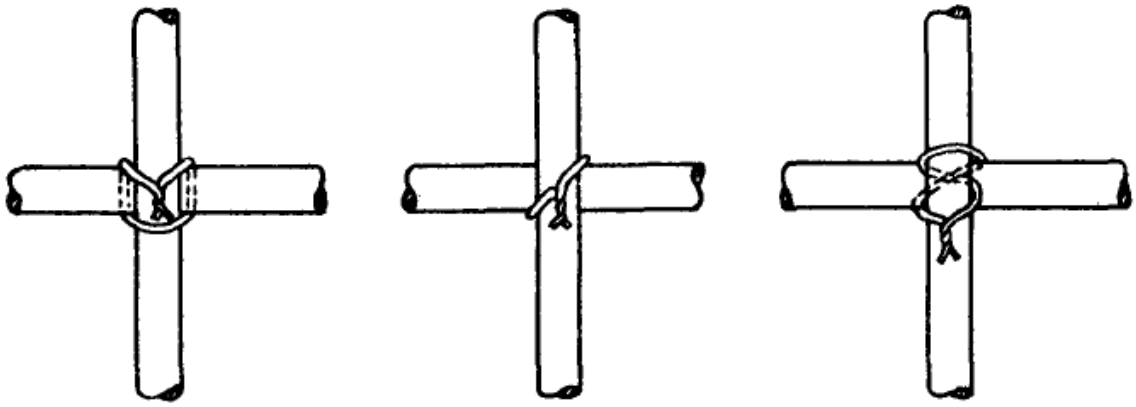
Reinforcement shall be placed in position as given on the detailed design drawing fixing of reinforcement and concreting, the position of the reinforcement shall be checked prior to concreting.

Minimum lap-length of reinforcement bars shall be 50-65d where d is the dia. of the smaller diameter bar to be lapped (unless otherwise specified). Not more than 50 percent of reinforcement crossing a section shall be lapped at that location. All laps in reinforcement shall be properly staggered and minimum distance between the laps shall be 1.33 times the lap length.

The precautions shall be taken to prevent displacement of reinforcement during shuttering and concreting.

Tying of Reinforcement Bars - Bars crossing each other, where required, shall be secured by binding wire (annealed) of size not less than 0.90mm and conforming to IS: 280-1962 Specification for Mild Steel Wire (Revised), in such a manner that they will not slip over each other at the time of fixing and concreting.

Every compression bar shall be tied at least in two perpendicular directions. Stirrups may be staggered, provided it is ensured that the corresponding stirrups form a uniform pattern in elevation.



a. b. c.

Figure 2.2 Three methods of trying reinforcement bars

Three methods of tying reinforcement bars are illustrated in Fig. 2.2 of the three methods, the method illustrated in Fig. 2.2 should be preferred to method given in Fig. 2.2b, and that given in Fig. 2.2.b to the one given in Fig. 2.2.c.

Cover Block

Cover blocks, which are generally of cement mortar, shall be used to ensure the required cover for reinforcement. Cover blocks are generally square of rectangular in plan with or without binding wire embedded in them which will be tied to the reinforcement at the time of placing. Rings with suitable hole at the centre may also be used.

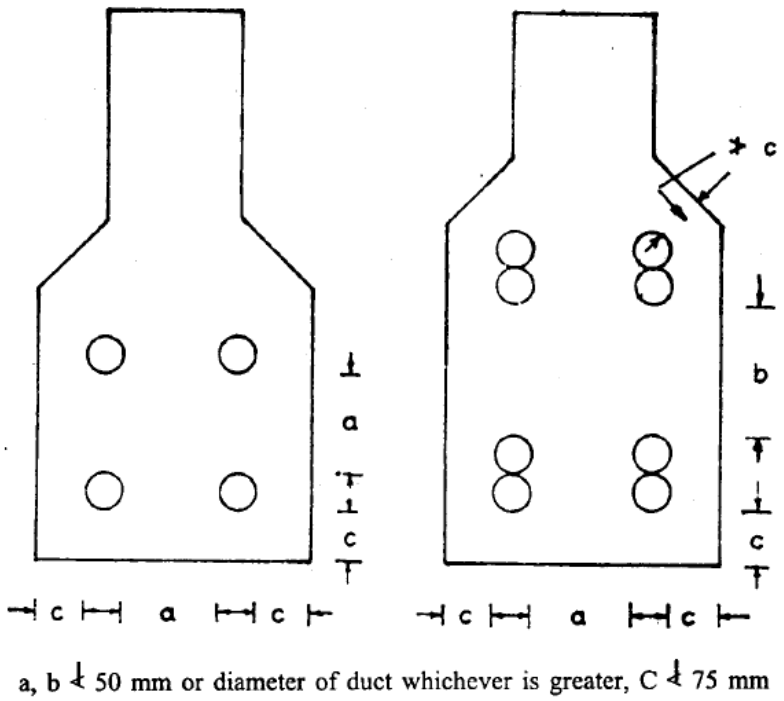
The mortar or concrete used for the cover blocks or rings shall not be leaner than the mortar or concrete in which they will be embedded.

To provide necessary cover for reinforcement at any section, only single cover blocks shall be used.

C2.2 Prestressing Steel Placement

C.2.2.1 Cover and Spacing of Prestressing Steel

Wherever prestressing cable is nearest to concrete surface, the minimum clear cover measured from outside of sheathing, shall be 75 mm.



a, b ≮ 50 mm or diameter of duct whichever is greater, C ≮ 75 mm

Figure 2.3 Cable Cover

A minimum clear distance of 50 mm or diameter of the duct, whichever is greater, shall be maintained between individual cables when grouping of cables is not involved.

Grouping of cables shall be avoided to the extent possible. If unavoidable, only vertical grouping of cables, upto 2 cables may be permitted as shown in Fig. 2.3. The minimum clear spacing between groups shall be diameter of the duct or 50 mm, whichever is greater.

Individual cables or ducts of grouped cables shall be deflected or draped in the end portions of members. The clear spacing between cables or ducts in the end one metre of the members as specified in figure 2.3 shall be maintained.

The placement of cables or ducts and the order of stressing and grouting shall be so arranged that the prestressing steel, when tensioned and grouted, does not adversely affect the adjoining ducts.

All cables shall be threaded by threading machine or any contrivance into preformed ducts. Wherever two stage prestressing is contemplated, a dummy core shall be provided in the preformed ducts of the second stage cables, which shall be pulled out after the first stage prestressing and grouting is over. Thereafter, the cables for the second stage shall be threaded into the preformed ducts. Where prestressing in more than two stages is contemplated, the above procedure shall be followed for subsequent stage cables also.

Stressing of cable/part of cable to avoid shrinkage cracks shall not be treated as a stage.

C.2.2.2 Splay of Cables in Plan and Minimum Radius of Cables In Elevation

The splay of cables in plan, for bringing them from their position in the bottom flange at mid-span into the web towards the supports shall not be more than 1 in 6. The points of splay shall be suitably staggered on both sides of the longitudinal centre line of the web of the girder. The minimum radius of curvature, spacing and cover for curved cables shall be specified to ensure that bursting of the side cover both perpendicular to the plane of curvature and in the plane of curvature of the ducts does not take place.

C.2.2.3 Emergency Cables/Strands

Besides the design requirements, additional cables/strands shall be symmetrically placed in the structure so as to be capable of generating prestressing force of about 4 per cent of the total design prestressing force in the structure. Only those cables which are required to make up the deficiency shall be stressed and the remainder pulled out and the duct hole shall be grouted.

C.2.2.4 Others

- Cut lengths out of the long mono-strand, each length being equal to actual length of the concerned cable required between its stressing Jacks plus additional lengths beyond the Jacks to enable gripping the strands adequately by the Wedges of the Jacks.
- Bunch together designed monostrands into a 'multistrand' holding them together by binding wire tightened around the bunch at about 1.0 m intervals.
- Insert these cables in to their respective Sheathing Ducts which are already placed to the required profile in the already concreted deck.
- All Prestressing Cables shall be laid to smooth profiles using the specified profile ordinates given in the attached Prestressing Drawing. Short 12 mm dia. cross-bars shall be spot welded to the stirrup legs at approximately 2 m centers along the length of cables to give the necessary profile to the cables.
- At the time of installation of Cable-Sheathing (HDPE Ducts), the sheathing materials shall be examined for any possible punctures/cuts/etc. and the same shall be sealed with waterproof tape. The number of joints should be kept to the minimum, and each joint adequately sealed against the

possibility of any ingress of any material and mortar. Joints in adjacent ducts should be staggered by at least 300 mm. Adequate concrete shield should exist between the adjacent ducts to prevent any accidental flow of grout from one duct to the other and the ducts shall be strictly maintained in their correct alignment and profile during the placing of concrete.

- Prestressing tendons may be gripped by wedges, yokes, double cones or any other approved type of gripping devices. The prestressing wires may be gripped singly or in groups. Gripping devices shall be such that in a tensile test, the wire or wires fixed by them would break before failure of the grip itself.
- Prior to concreting the Deck, INSERT 80 mm ID Plain HDPE Ducts into the 90 mm ID Corrugated HDPE Ducts (which have already been placed to the required cable profiles), protruding them suitably beyond the cable–Anchorages.
- After concreting of the Deck is over, REMOVE these 80 mm ID Plain HDPE Ducts AND quickly blow oil-free compressed air through the emptied 90 mm ID Corrugated HDPE Ducts in order to flush them clean. Stand-by flushing equipment, capable of developing a pumping pressure of 20 Kg/cm2 (2 MPa) and a sufficient capacity to flush out any blockages due to any accidental partial grout leaks in ducts, shall be kept available at site.
- The 19-stranded multistrands may now be inserted in to their respective 90 mm ID corrugated HDPE Ducts already placed inside the Concreted Deck.
- Prestressing tendons shall never be heated or exposed to flame or to welding. Protruding Ends of tensioned strands of Grouted Cables, protruding beyond anchorages, shall only be saw-cut, not flame-cut. Recesses at anchorages (in the girder–ends) shall be filled and sealed with non shrink cement mortar after the protruding strand–ends of tensioned, anchored and grouted cables are cut to suit.
- Prior to placing the shuttering, the Contractor should demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and, if the prestressing reinforcement has been placed, that the Cable–steel is free and not bonded in the duct.
-

C4.1 Post- Tensioning

Prestressing steel may be tensioned by means of hydraulic or mechanical jacks. Devices attached to the tensioning apparatus for measuring the applied force shall be such that they do not introduce errors exceeding 5 percent. *Jacking Force normally should not exceed 76.5% of the Breaking Load.*

Before commencement of prestressing, it should be ensured that all the Cables/Ducts are free of any clogs and that the structure–members are free to accommodate the horizontal and vertical movements due to application of prestress, and that there is enough space for the movement of the jack piston.

Prestressing cables shall be protected against any unacceptable rusting, damage due to 'pitting', and any greasing. The strands must be thoroughly cleaned with petrol at locations where Stressing Jacks and Wedges have to grip them.

Each Cable shall be stressed from both its ends simultaneously, equally and gradually, and the extensions recorded at each suitable increment of Jacking Force. Any slack in the prestressing tendon shall first be taken up by applying a small initial tension. The initial tension required to remove slackness shall be taken as the starting point for measuring elongation. Further increase of tension shall be carried out in suitable steps and corresponding elongations noted. The 'force-elongation' relationship shall be recorded in tabular and/or graphical form. The magnitude of initial effective elongation corresponding to initial tension applied to remove slackness shall be obtained from the recorded and linearized portion of measured tension elongation relationship and added to the measured elongation to give the total elongation.

Alternatively, the same correction can be carried out graphically as shown in Fig. 4.1.

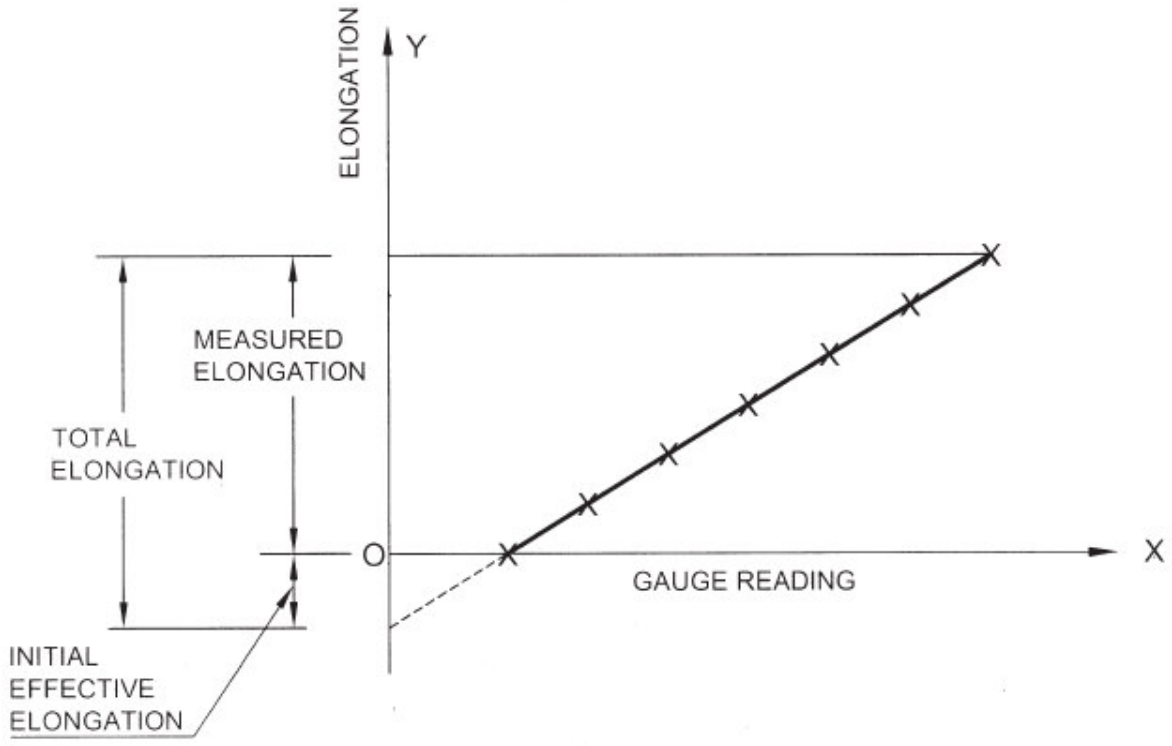


Figure 4.1 Determination of Actual Elongation

In practice, the force and elongation of tendon may not exactly match with the expected values given in stressing schedule. In such cases either the force (or the elongation) will be achieved first and the other value lag behind. In such cases the force (or elongation) shall be further increased, but not exceeding 5 percent of the design value till the elongation (or force), which had lagged behind reaches the design value*. If, even after reaching 5 percent extra value of the force (or elongation), the other lagged quantity does not reach the design value, reference should be made to the designer for review and corrective action.*

When two or more prestressing wires or strands are to be tensioned simultaneously by the same tensioning apparatus, care shall be taken to ensure that all such tendons are of the same length from grip to grip.

The placement of tendons and the order of stressing and grouting shall be so arranged that the prestressing steel, when tensioned and grouted, does not adversely affect the adjoining ducts.

The Cable Elongations at their Jacking-Points, mentioned in the drawing, are based on the assumption that the Modulus of Elasticity of Cable-steel, Es_d, (generally 1.95 × 105 MPa (i.e. 1.988 × 106 kg/cm2)). However, if Es_d of the actually supplied Cable-steel at site is slightly different, then the required Elongations at each end shall be re-worked out at site by multiplying the specified values by the ratio of (assumed Es_d / actual Es), and these shall then be the 'correct' specified extentions.

Tensioning of Prestressing Cables:

Normally, the specified required extensions shall be achieved at the specified Jacking Forces at stressing ends.

Check the correct functioning of the jack, pump and leads.

The difference between calculated and observed tension and elongated during pre-stressing operations shall be regulated as follows:

a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5 kg/sq. cm. until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

c) If the elongation at 1.05 times the specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this lack of discrepancy:

(i) De- tension the cable. Slide it in its duct to check that it is not blocked by mortar which has through holes in the sheath. Re- tension the cable if free.

(ii) Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory.

If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at jacking end. Extensions should also be checked 24 hours after anchoring the cables to guard against the possibility of 'slow slipping', if any. If the average observed 'slow slip' at anchorages of a cable exceeds 3mm, the matter should be reported to the Designer for any further instructions.

All cables which satisfy the above provisions shall be grouted, taking care that the cables not yet stressed do not get accidentally blocked due any internal grout leak.

The number of stages of pre-stressing and grouting shall be reduced to a minimum, 2 in the case of simply supported girders.

The Sequence of Stressing of Cables shall be as indicated in the attached relevant Prestressing Drawing and the prestressing shall be accomplished accordingly. First Stage Cables i.e. PS-I cables shall be stressed in their indicated sequence when the last cubic meter of concrete in the deck-slab has attained a work's cube crushing compressive strength of at least 40 N/mm^2 and is more than 10 days old (after the day of its casting).

Cables of PS-II shall be stressed in their indicated sequence when concrete in the deck slab has attained a works cube crushing compressive strength of higher of least 45N/mm^2 or designed concrete strength and is at least 28 days old (after the day of its casting).

After completion of stressing and anchoring a cable, the Jack Force shall be released in such a way so as to avoid shock to the anchorage and the cable.

A complete record of pre-stressing operations along with elongation and jack pressure data shall be maintained in the approved format.

An appropriately experienced Technical representative of the Supplier of Prestressing system shall carry out and supervise all Prestressing and Grouting Operations at site and ensure, monitor and certify their correctness.

C4.2 Grouting the Ducts of Successfully Tensioned Cables

The purpose of grouting is to provide permanent protection to the post-tensioned steel against corrosion and to develop bond between the prestressing steel and the surrounding structural concrete. The grout ensures encasement of steel in an alkaline environment for corrosion protection and by filling the duct space, it prevents water collection and freezing.

Prestressing steel shall be bonded by the Grout to the concrete by filling the void space between the duct and the tendon with cement grout.

In cold and frosty weather, injection should be postponed unless special precautions are taken. If frost is likely to occur within 48 hours after injection, heat must be applied to the member and maintained for at least 48 hours after injection so that the temperature of the grout does not fall below 5°C. Prior to commencement of grout, care must be taken to ensure that the duct is completely free of frost/ice by flushing with warm water, but not with steam.

When the ambient temperature during the day is likely to exceed 40°C, grouting should be done in the early morning or late evening hours.

When the cables are threaded after concreting, the duct must be temporarily protected during concreting by inserting a stiff rod or a rigid PVC pipe or any other suitable method.

During concreting, care shall be taken to ensure that the sheathing is not damaged. Needle vibrators shall be used with extreme care by well experienced staff only, to ensure the above requirements.

It is a good practice to move the cables in both directions during the concreting operations. This can easily be done by light hammering the ends of the wires/strands during concreting. It is also advisable that 3 to 4 hours after concreting the cable should be moved both ways through a distance of about 20 cms. With such movement, any leakage of mortar which has taken place in spite of all precautions, loses bond with the cables, thus reducing the chance of blockages. This operation can also be done by fixing prestressing jacks at one end pulling the entire cable and then repeating the operation by fixing the jack at the other end.

The cables to be grouted should be separated by as much distance as possible.

In case of stage prestressing, cables tensioned in the first stage should not remain ungrouted till all cables are stressed. It is a good practice, while grouting any duct in stage prestressing, to keep all the remaining ducts filled up with water containing 1% lime or by running water through such ducts till the grout has set. After grouting the particular cable, the water in the other cables should be drained and removed with compressed air to prevent corrosion.

End faces where anchorages are located are vulnerable points of entry of water. They have to be necessarily protected with an effective barrier. Recesses should be packed with mortar concrete and should preferably be painted with water proof paint.

For this purpose each cable shall normally be Grouted within 5 days of completion of its successful tensioning unless specific requirements require delaying it till certain other cables are first successfully stressed. Grouting shall be carried out as early as possible but not later than 2 weeks of stressing a tendon.

The Grout shall consist of Ordinary Portland Cement, Water, and an Expansive Admixture(approved by the Engineer. All grout shall pass through a screen with 2 mm maximum clear openings prior to being introduced into the grout–pump. No admixtures containing chlorides and nitrates shall be used.

The Grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed colloidal grout. The water content shall not be more than 24 litres per 50 kg sack of cement. Retempering of grout shall not be permitted. Grout shall be continuously kept agitated until it is pumped in.

Grouting Equipment shall be furnished with a pressure gauge having a full-scale reading of upto 20 Kg/cm2 (2 MPa) and it shall be capable of grouting at a pressure of at least 10 Kg/cm2 (1 MPa).

If the expansive Admixture (other than Aluminium compound) is used to expand the Grout, it shall be added strictly as per Manufacturer's instructions. The ducts shall be completely filled, from the low end, with grout, under NOT MORE THAN 7 kg/cm^2 pressure. Grout shall be pumped through the duct and continuously wasted at the outlet until no visible slugs of water or air are seen. All vents shall then be closed, and the grouting pressure at the injection–end raised to 10 kg/cm^2 and held for a minimum of 10 seconds before closing the hole in the cable–anchorage at the injection–end.

If some delays in Grouting are unavoidable (e.g. due to sequence of construction planned), temporary protection against corrosion shall be provided by ventilating the Ducts with dry/hot air, since any humid conditions contribute considerably to acceleration of corrosion of cable–steel.

Reference to IRC SP 047: Guidelines on Quality Systems for Road Bridges

TYPICAL PROFORMAE

Note:

Typical proformae which have been adopted on some of the work sites are attached to give an idea of the structure of these proformae. These are indicative and may be modified, augmented or supplemented according to the needs of a particular work. The proformae are divided into categories :

Category A: Planning Proformae

Category B: Inspection Proformae

Category C: Surveillance Proformae

Category D: Proformae for Registers and Records

Category E: Proformae for Procedural Guidelines of QA System

Proforma "A4"

TEST FREQUENCY SCHEDULE

Specified Material: **Specification:** **IS (Relevant)**

Consignment Identification Number	Specified Test	Performance standard	Performing agency	QA Agency	Frequency of Performance	Frequency of Assurance	Frequency of Audit
	a) Chemical Properties b) Physical Properties c) Special Requirement (As Specified)						

Proforma 'B1'

DATA SHEET FOR SIEVE ANALYSIS - AGGREGATE

SAMPLE NO.	DATE OF SAMPLING
QUANTITY OF AGGREGATE :	METHOD OF TEST
SOURCE :	DATE OF TESTING
TO BE USED IN STRUCTURE :	SAMPLING & TESTING BY
	WEIGHT OF SAMPLE

IS SIEVE NO.	MASS RETAINED	CUMULATIVE MASS RETAINED	% CUMULATIVE RETAINED	ACCEPTABLE LIMIT

REMARKS

Note :

Plot a Grain Size Distribution Curve

Signed
Date

For Contractor
Name

Signed
Date

For Department
Name

Proforma 'B-2'

FORMWORK INSPECTION CHECK LIST

LOCATION DATED:

CONTRACTORS' INSPECTION REQUEST NO YES NO N.A.

CONTRACTORS' DRG OR SKETCH NO.

1. Formwork design/drawing/sketch approved including de-shuttering arrangements
2. Trial panel approved (if required)
3. Formwork alignment correct
4. Formwork levels correct, including screeds
5. Formwork dimensions correct
6. Formwork member spacing correct
7. Formwork member material quality acceptable
8. Falsework member sizes correct
9. Falsework member spacing correct
10. Falsework member material quality acceptable
11. Gaps between primary & secondary members closed/wedged.
12. Face boarding/Plywood/Metal thickness correct
13. Joints between panels closed (no gaps)
14. Joints between panels flush (no steps/lips)
15. Panel flatness acceptable
16. Gaps between secondary members and face panels closed
17. Tie rod material and sizes correct
18. Tie road spacing correct
19. Tie rods tight, face cones flush
20. Spacers between shutter surface tightly fitting
21. Box outs, cast-in items, ducts

fixed correct, securely. Contd..

22. Prestressing sheathing & vents, alignments & spacing of supports acceptable

23. Empty sheathing secured against floatation

24. Prestressing anchorage positions & fixing acceptable

25. Chamfers/fillets sizes, straightness, fixing acceptable

26. Formwork clean

27. Formwork release oil material approved.

28. Formwork release oil applied correctly.

29. Construction joint preparation satisfactory

30. Contraction/expansion joint preparation satisfactory

31. Safe access constructed

32. Adequate work space provided for labour, equipment

33. Shutter vibrators (if required) location & fixing arrangements approved

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Inspected by: Name Signed Date

(for Contractor)

Approved by: Name Signed Date

(for Department)

Proforma 'B-3'

REINFORCEMENT INSPECTION CHECKLIST

LOCATION DATED:

	YES	NO	N.A.
CONTRACTORS INSPECTION REQUEST NO.			
REF DRG NO.			
1. Working drawing checked and approved			
2. Latest revision being used			
3. Bar schedules approved			
4. Reinforcing steel material approved			
5. Bar bending & cutting satisfactory			
6. Corrosion treatment of bars, if required, satisfactory			
7. Bar sizes correct			
8. Bar spacing correct			
9. Bar lap lengths correct			
10. Bar laps at correct locations			
11. Bar tied as specified			
12. Bar assembly rigid and adequately supported (including spacers/chair supports).			
13. Cover to bottom bars correct			
14. Cover to side bars correct			
15. Cover to top bars correct			
16. Cover blocks approved including fixing			

Inspected by: (for Contractor)	Name	Signed	Date
Approved by: (for Department)	Name	Signed	Date

Proforma 'B-4'

INSPECTION CHECK LIST BEFORE APPROVAL TO CONCRETE

LOCATION: DATED:

CONTRACTORS' INSPECTION REQUEST NO. YES/NO Check
N.A INITIAL

1. Method statement approved
2. Batching plant mixers in working order (separate dispenser for admixture, if required, available)
3. Standby batcher in working order
4. Water, sand, coarse aggregate, cement, admixture approved.
5. Water, sand, coarse aggregate, admixture, cement stock sufficient.
6. Concrete conveying arrangement (including transit mixers) available in working condition and of sufficient capacity
7. Formwork approved
8. Reinforcement approved
9. Prestressing sheathing approved
10. Concreting equipment in working order
11. Standby crane, vibrators present
12. Tremie in working order (for under water work)
13. Concrete gang present, including carpenter, steel fixer, mechanics and electricians
14. Access provided
15. Safety arrangements adequate
16. Lighting provided
17. Communications between various points provided

18. Arrangements for arranging suspension/ stoppage of concrete provided

19. Curing arrangements made

20. Laboratory notified

Inspected by: (for Contractor)	Name	Signed	Date
Approved by: (for Department)	Name	Signed	Date

Proforma 'B-5'

PROFORMA FOR CONCRETE DELIVERY AND POUR RECORD

1. CONCRETE BATCHING DELIVERY TICKET NO.

Location of Pour :	Date
Concrete Grade :	Mix. Temp.
W/C Ratio	Slump
Cement Contents	No. of Cubes Taken
Max. Aggregate size	
Admixutre (Type & Dosage)	
Batching Started, Hrs. :	Batching Finished, Hrs.
Quantity Batched, Cu.m. :	
TRUCK ARRIVED ON SITE	Truck No.
Slump Test Result (S)	Hrs.
Discharge Started	Mm at Hrs
Placement Completed :	Hrs
No. of Sitecubes Taken :	Hrs
Place Where Cubes Taken	Hrs
Placement Temperature of Concrete :	
Ambient Temp.	
Weather Condition :	

Inspected by: (for Contractor)	Name	Signed	Date
Approved by: (for Department)	Name	Signed	Date

Proforma 'B-6'

POST CONCRETING INSPECTION

Note: Post concreting inspection shall be carried at various stages such as after stripping of side shuttering, each stage of prestressing, decentering and/or as per designers stipulation.

Location :
Date of pour :

Stage of Inspection :
Date of Inspection :

Specified Class :

	Observation	Type of Remark S orNS*	S or NS
1	Position/Dimensions of the member	Alignment Levels Dimensions	S or NS S or NS S or NS
2.	Surface Defects (honey combing/ sand streaks/air bubbles/cold joints)	No defects Minor defects Major defects	(Note type and extent of defect)
3.	Class of Finish	S or NS	
4.	Cracks	No cracks Cracks Nature of cracks	Date first observed
5.	Any other Defect		
6.	Non conformance report no.	Report No./ Not Applicable	

Remarks :

In case of NS report in item (1) to (5), it should be examined by competent authority before approval or non approval. If required, a separate non-conformance report (including sketches, photographs etc.) shall be prepared for further action.

*S - Satisfactory, NS = Not satisfactory

Inspected by: (for Contractor)	Name	Signed	Date
Inspected by: (for Department)	Name	Signed	Date
Approval/ Non Approval by: (for Department)	Name	Signed	Date

Proforma 'C-1'

MATERIAL QUALITY SURVEILLANCE FORM

CONTRACTOR			CONTRACT NO.	
MANUFACTURER	SUPPLIER	SOURCE	PURCHASE ORDER	INSPECTING AGENCY
INSPECTED AT	INSPECTION CERTIFICATE	DELIVERY CHALLAN	DISTIN-GUISHING MARK	DATE OF MFR./ SUPPLY
SHIPPING, STORAGE & OTHER REMARKS		(Satisfactory/ No Satisfactory)		DATE OF MFR./ SUPPLY

TEST RECORD

S.No.	Test	Method of Test	Acceptance Limits & Units	Obtained Value	Remarks

(Appropriate Tests)

Remarks :

Inspected by: (for QA Team) Name Signed Date

In Presence of: (for Contractor) Name Signed Date

Proforma 'C-2'

PRODUCTS QUALITY SURVEILLANCE FORM

NAME OF PRODUCT :

Contractor | Contract to

Manufacturer/Supplier/Source | Purchase Order | Inspecting Agency

Inspection Certificate | Delivery Challan | Distinguishing Mark | Date of Manufacture/Supply

Drawing Nos. | Tender Specification Clause

Shipping, Storage & Other Remarks

S. No.	Test	Method of Test	Acceptance Range	Obtained Value	Remarks

Inspected by: (for QA Team) | Name | Signed | Date

In Presence of: (for Contractor) | Name | Signed | Date

Proforma 'C-3'

SURVEILLANCE FORM FOR PRE-CONCRETING OPERATIONS

CONTRACTOR		CONTRACT NO.
ELEMENTS OF STRUCTURE	IDENTIFICATION NO	LOCATION

SURVEILLANCE OBSERVATIONS

WORK DESCRIPTION

1. Line, Level and Dimension as per Drg.
2. Availability of adequate approved material
3. Placing of Reinforcement (Including supports/spacers etc.)
4. Form works and Scaffolding as per Drawing
5. Box outs/embedded parts, if any
6. Cleaning of forms
7. Arrangements of Plant and Equipment
8. Walkway for Pouring and Inspections
9. Safety Arrangements
10. Curing Arrangement

Inspected by: (for QA Team)	Name	Signed	Date
In Presence of: (for Contractor)	Name	Signed	Date

Proforma 'C-4*

QUALITY SURVEILLANCE FORM WORKMANSHIP OF CONCRETE

CONTRACTOR		CONTRACT NO.
ELEMENTS OF STRUCTURE	IDENTIFICATION NO.	LOCATION

SURVEILLANCE OBSERVATIONS

The following items should be observed during concrete pour by the OA Surveillance Team.

1. Mixing of Concrete

— Check the concrete class and the respective mix design already approved.
— Check the condition of the aggregates to be used.
— Check the weighing and water dispensing methods adopted during the mixing.
— Check that the mixer machine has been cleaned properly.
— Check that the required mixing time is allowed.

2. Transportation/Conveyance (as Specified, but generally to cover following):

— Check if the equipment is in proper working order.
— Check if the specified methods are being followed.
— Check if the stipulated time limits are observed.
— Check if the non-conforming wet concrete is being rejected and disposed off.

3. Placing of Concrete

Check that :

— The concrete is not segregated during pour. The height of dropping is controlled.
— The concrete is poured in layers.
— The vibrators are being applied systematically to compact uniformly and adequately, avoiding over vibration.
— The concrete is not being pulled or pushed. Pouring is being done close to the final position.
— The cold joints are not allowed to be developed.
— The under water concrete is being poured only by tremies or pipeline.
— The forms are not getting displaced or deformed during the concrete pour and vibrating.
— No cement slurry is getting lost. Suitable number of carpenters are present to watch and repair formwork during the pour, if required.
— The concrete is poured within the allowable time limits from the time of batching.
— The concrete cubes are taken as required.
— The curing arrangements are satisfactory.
— The equipment is in working condition.

— ' The equipment is cleaned properly.

— The quality of wet concrete is as per specifications, (slump, homogenous mix etc.

— Continuous supply of concrete is assured.

Inspected by: (for QA Team)	Name	Signed	Date
In Presence of: (for Contractor)	Name	Signed	Date

Proforma 'D-1'

PARTICULARS OF WORK

Name of Work ……

Name of Conctractor ……

Address of Contractor ……

Contract agreement No. ……

Contract Amount ……

Applicable Schedule of Rates ……

Period of Completion ……

Date of Work Order ……

Stipulated Date of Completion ……

Actual Date of Starting of Work ……

Extensions ……

(1) ……
(2)……..

INCUMBANCY

Sr. No.	Designation*	Name	Period	
			From	To

* Departmental officers' designations covering all officers having execution responsibilities for the project.

Proforma 'D-3'

REGISTER OF DRAWINGS

Name of work :
Name of Contractor :

1.Receipt of Drawings

Sr. No.	Drawing No./ Date	Revision No	Brief Title	Issued By/ Source	Date of Receipt	No of Copies	Status of Drgs	Further Action	Signature and Date

2.Issue of Drawings

Sr. No.	Drawing No./ Date	Revision No	Brief Title	Sr. No of Receipt Register	Issued To	No of Copies	Status of Drgs	Drawing Supersedes Drg. No (If any)	Signature

Proforma 'D-3'

CEMENT REGISTER

1 . Weekly Receipt Issue (For week from……. to…….)

Name of Work :-

Name of Contractor

Closing Balance at the Site of Work from

previous week…… bags.

Date	Quantity Received	Qnty. Used Bags/MT	Purpose	Closing balance at the end of day (bags/MT)
	Bags / MT Source			
Total				

For Contractor

Name :

Signed:

Date:

For Engineer

Name :

Signed:

Date :

CONSUMPTION OF CEMENT ON DIFFERENT ITEMS OF WORKS, (THEROTICAL AND ACTUAL)

Name of Work :
Name of Contractor:

(A) Weekly records of items of Works

Sr. No.	Item of Work	Quantity of work done during the week

(B) Abstract for the Week Ending ……. (Indicate Cement Consumption)

Sr. No.	Item of Work	Quantity of work done		Rate of Cement per Unit (bags/MT)	Cement required to be consumed theoretically (bags/MT)	Actual Cement consumed (bags/MT)
		Quantity	Unit			

For Contractor

Name :

Signed:

Date:

For Engineer

Name :

Signed:

Date :

Proforma 'D-5'

RECORDS OF CALIBRATION OF EQUIPMENT

Name of Work :

Name of Contractor :

ITEM	DATE CALIBRATED & PERSON CERTIFYING (FOR VENDOR OR CONTRACTOR)	*DATE OF NEXT CALIBRATION	DATE OF INSPECTION & PERSON APPROVING (FOR DEPARTMENT)	RESULT OF INSPECTIONS

* Frequency of caliberation for different equipment to be specified in advance.

Proforma 'D-6'

DAILY PROGRESS REPORT

Name of Work :

Name of Contractor :

Date	Activity Location	Item of Work	Weather Condition	Special Problems/ Difficulties	Remarks	Signature with date	
						Recorded	Checked

For Contractor

Name :

Signed:

Date:

For Engineer

Name :

Signed:

Date :

Proforma 'D-7'

REGISTER OF INSPECTION NOTES

Name of Work :

Name of Contractor :

Name of inspection Note	No and date under which recceived	Reviewed by	Signature	No & Date of Compliance submitted	Reviewed by	Signature	Remarks

Proforma 'D-8'

REGISTER OF OBSERVATION MEMOS ISSUED FROM THE QUALITY CONTROL CELL

Name of Work :

Name of Contractor :

Year	Observation Memo No	No and Date under which it is received	Reviewed By	Signature	No and date of compliance submitted	Reviewed By	Signature	Remarks

Proforma 'D-9'

RECORD OF PRESTRESSING WORKS

1 Name of Work :
2 Name of Contractor :
3 Span Length
4 Span No
5 Name and no of component
6 Date of Casting
(Indicate average cube strength
at 7 days and 28 days as per design)
7 Gauge Pressure not to exceed …….

Date of Pre stressing	No of Cable/ Wire or pairs of wires	Side……..				
		Gauge Reading	Initial Extension in mm	Locking Pressure	Slip Observed in mm	Final Extension in mm
1	2	3(i)	3(ii)	3(iii)	3(iv)	3(v)

Gauge Reading	Side……				Total Final Extension in mm	Calculated extension in mm for an initial pull per cable/wire/pair of wire
	Initial Extension in mm	Locking Pressure	Slip Observed in mm	Final Extension in mm		
4 (i)	4 (ii)	4 (iii)	4 (iv)	4 (v)	5	6

Theoretical Extension required in mm	Loss or gain in extension in mm	Progressive loss or gain of extension in mm	Slip observed in any , after 10 days	Remarks	Signature		
					AE	EE	Contractor
7	8	9	10	11	12(i)	12 (ii)	12 (iii)

For Contractor
Name :
Signed:
Date:

For Engineer
Name :
Signed:
Date :

Proforma 'D-10'

GROUTING RECORDS

Name of the Work

Cable* No. '

Name of Contractor :
Span No. :
Date of Cable installation :
Type of Cement: OPC/IISOPC
Week & Year of Manufacture
of OPC/IISOPC :
W/C Ratio :

Date of Grouting

Name & Amount of admixture
used, if any :

Temp:	Mixing Water ----------	Grout ----------	
Time:	Start ----------	Finish ----------	
Equipment:	Grout mixer ----------	Grout Pump ----------	
Cable Duct:	Diameter ----------	Length ----------	
Volume of grout in litres ----------		Regrouting ----------	
Grouting pressure			
Cement consumption: Theoretical ----------		Actual	

Pre-Grouting Checks :				
Free of blockage:	inlet:	Yes/No	Outlet	Yes/No
	Vents:	Yes/No	Cable Duct :	Yes/No
Leakage observed:		Yes/No	Sealed :	Yes/No

If cable duct blocked: Remedial Measures ----------

Grouting Observations:

Passage of grout through vents	Yes/No
Passage of grout through outlet	Yes/No
Any equipment failure	
Post grouting checks	…….
Probbing by stiffwire	……
Remarks	……..
Signatures of officers present during grouting:	

For Contractor
Name :
Signed:
Date:

For Engineer
Name :
Signed:
Date :

Proforma 'D-11'

PERFORMA FOR RESULT ANALYSIS (CEMENT)

Name of Work :
Name of Contractor :

Type of Cement: Grade of Cement

Sr. No	Consignment No./ Date	Sample Ref. No./ Date	Result of Chemical Test C3A, etc	Result of Physical Test (Fitness, Strength etc)	Result of Special Test , If Any
			Provide Separate Column for each test		
No of Samples					
Mean					
Standard Deviation					
Range					
Remarks :					

For Contractor
Name :
Signed:
Date:

For Engineer
Name :
Signed:
Date :

Proforma 'D-11'

PROFORMA FOR RESULT ANALYSIS (CONCRETE)

Concrete Grade :
Name of Contractor :

Slump Test:
28 Days Strength:

Notes:For every Grade of concrete, separate analysis proforma should be used, Separate analysis proforma should be used with every change in mix-design.

Sr . No .	Sample Ref. No.	Structural element	Wet concrete properties		Hardened concrete Properties Strength at Age in days		
			Temp	Slump	3 Days	7 Days	28 Days
				Provide separate	column for each test		
No.of samples Mean Standard Deviation Range Comments							

For contractor
Name
Signed Date

For Engineer
Name
Signed Date

GUIDELINES FOR NON-CONFORMING WORKS

1. GENERAL

In broad terms, for the Quality Assurance of the finished work it is necessary for the materials and workmanship to conform with the Contract requirements. Ideally, non-conforming work shall be rejected.

The Statement above is true in general terms but special difficulties arise in the case of concrete, where the non-conformance may only be known after 28 days cube results become available, in which period work has progressed further. In some of the situations, acceptance after repair/review for adequacy is feasible. Therefore, separate procedures are laid out for some of the non-conforming situations. In case the item does not meet the requirements after such repair/review, the non-conforming item should be rejected.

2. CONCRETE WORKS

The primary means by which Quality Assurance shall be achieved is by the procedures described in relevant material qualification and workmanship method statements. The non-conforming concrete items shall be further reviewed, as given below :

2.1 Non-conformance Other than Strength or Finish

In the event that any requirement other than strength and standard of finish is not met then the following procedure shall be followed:

1 . The Contractor shall be notified without delay verbally and in writing by the following means:

a) Return of the Request for Inspection Form signed "not approved" with the reasons for rejection stated

b) Issue of a Site Instruction or Site Works Order or letter stating the facts and confirming that the works are not approved.

2. Approval to carry out concreting of a similar nature shall be withheld.

3. The Contractor shall be asked for his proposals to rectify the non-compliance which may involve re-submission of materials, new trial mixes, revised method statement.

4. The acceptance or reiection of any unapproved concrete work shall be referred to the Engineer.

5. When satisfied with the measures taken to ensure future compliance the Engineer shall confirm approval to continue concrete for permanent works.

2.2. Non-Conformance with Strength Requirements

1 . The Specification for concrete recognises the statistical possibility of cube failures and thus limits of means, standard deviation, minimum values of strength are specified. The rejection criteria is set out in the agreement.

2. In the event of cube failures outside the provision of the Contract then the non-compliance procedures described in the specification shall be followed :

a) Approval of concreting of similar works shall be withheld.

b) All aspects of concreting shall be reviewed.

c) The cause of failure shall be identified and measures taken to remedy the problem.

3. Various repair/rectification procedures for commonly arising/non-conformance, are specified in contract. The contractor shall furnish his exact proposals for rectification under consideration.

4. The fact of non-conformance and the proposed rectification procedure is conveyed to the engineer/design organisation of owner (or design consultant) for review and opinion about :

i) Acceptability of measure proposed by the contractor, if any.

ii) Further non-destructive testing, if any,

iii) Acceptability in case strength is achieved at a later age (e.g. 90 days)

iv) Acceptability at the level of strength achieved for the stress levels in concerned members

v) Acceptance of repair/rectification/strengthening measures with modifications, if required, or rejection.

5. Rejection in case the item does not pass modified acceptance limits after repairs.

Non-Conformance with Finish Requirements

1. Where the required finish is non attained then the non-conformance procedure for repair/rectification, as described in the Specification shall be followed.

2. In addition the following procedures shall be followed:

a) Approval of similar form work shall be withheld.

b) All aspects of formwork shall be reviewed.

c) The cause of poor finish shall be identified.

3. Revised specifications/instructions to avoid further recurrence of non-conformance shall be issued.

RECORDS

1. It is mandatory that all instances of work outside the Specification are recorded in writing, and conveyed to the Contractor. This ensures that :

a) The Contractor is irrefutably informed.

b) A record of non-compliance is built up to give a general guide to the Contractor's performance.

2. The records of repair/rectification, retesting, inspection and acceptance shall be kept as part of 'as-built' documentation.

3. Record of all references to designers for concessions/rectification and approval given by them shall be kept.

4. Record of compliance to the modifications in procedures, testing, etc., if any shall be kept.