

No. NHIII/P/18/78

*Dated the 18th December, 1978*

To

All Chief Engineers/Addl. Chief Engineers of States/Union Territories-Public Works Departments dealing with Roads

Sub : Some guidelines for ensuring safety to men and materials during the construction of bridges-Special Precautions for Prestressed Concrete Structures

Bridge construction, right from the foundation stage upto its final completion, involves numerous operations, and constitutes one of the most difficult tasks in civil engineering jobs. Its execution calls for a very careful planning and handling by really competent and experienced technical personnel to avoid any mishaps leading to injury to workmen, loss of life or damage to structural components, with a consequent severe set back to the progress of work, lot of public criticism, prolonged enquiries and so on. A thorough knowledge of safety precautions is a must for ensuring a smooth progress and successful completion of the job.

2. Keeping the above requirements in view, a number of circulars have been issued by the Ministry in the past, some of which are now listed in Annexure I, for ready reference. The I.R.C. publication embodying the M.O.T. Specifications for Road and Bridge Works also covers some of the safety measures required to be taken on bridge works. In addition, a list containing various standards on safety measures published by the Indian Standards Institution from time to time, is furnished in Annexure II. The State Chief Engineers dealing with

road bridges are requested to bring the same to the notice of their field staff for information, guidance, and strict compliance. Some of the States might have already issued more comprehensive and detailed instructions on this subject. If so, they are requested to kindly furnish to this Ministry copies of such instructions, to facilitate the pooling of information and for disseminating the same amongst the other States.

3. Barring a few cases of departmental execution, normally most of the bridge works are got executed through contractors, and the departmental site engineer, while confining his supervisions to compliance with the working drawings made available to him, is generally prone to pay less attention to the mode of execution, the equipment used and the procedure followed by the contractor, either due to ignorance or a tendency to shift the responsibility to the contractor for successful completion of the job, particularly on major projects handled by big contracting firms (though the contracting firms are no doubt fully responsible for all sizes of jobs). Sometimes, the site engineer is blissfully ignorant of the various prestressing operations, the jack pressures and elongations etc., which are left to be taken care of by the firm's site engineers. If such things go unchecked, even major firms can commit very big blunders, such as concreting a prestressed beam without vibrators, carrying out launching operations without ensuring proper safety precautions etc., all of which may lead to very serious disasters. There is, therefore, an urgent need to train and educate the departmental staff properly through detailed circulars, detailed instructions furnished on all the working drawings, and a liberal supply of codes and books for their guidance. The field man must know what to look for and control. Proper detailing on drawings is even more important than designs.

4. While stressing the importance of compliance with the various previous circulars/codes/specifications mentioned in para 2 above, a few guidelines to be followed for ensuring safety in the construction of prestressed concrete bridge components are now furnished in Annexure III. The State Chief Engineers may, if desired, enhance or elaborate the same, before circulating amongst all the departmental officials.

*Enclosures to letter No.NH III P/18/78 dt. 18.12.78*

#### **ANNEXURE I**

#### **LIST OF CIRCULARS ALREADY ISSUED BY THE MINISTRY OF SHIPPING & TRANSPORT (Roads Wing) ON SAFETY IN CONSTRUCTION**

- (1) NHV—11 (6)/73 dated 19.11.74 "Ensuring Safety of Bridge Structures—Guidelines for Engineers."
- (2) Deleted Refer to IRC : 87-1984
- (3) NHIII—23 (123)/72 dated 20.3.76 "Regulation of traffic on National Highways (i) in the event of flood breach or damage due to certain other reasons or (ii) when widening/reconstruction of any existing C.D. structure is in progress or construction of a new structure on an existing section."
- (4) PL-67 (3)/77 dated 8.3.1977 "Instructions regarding stacking of constructional material on bridge decks during construction."

#### **ANNEXURE II**

#### **LIST OF INDIAN STANDARDS ON SAFETY IN CONSTRUCTION**

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|-----|--------------------------|---------------------------------------------------------------------------|
| 1.  | IS : 3696 (Part I)—1966  | Safety code for Scaffolds and Ladders:<br>Part I—Scaffolds                |
| 2.  | IS : 3696 (Part II)—1966 | Safety Code for Scaffolds and Ladders:<br>Part II—Ladders                 |
| 3.  | IS : 3764-1966           | Safety Code for Excavation Work                                           |
| 4.  | IS : 4081-1967           | Safety Code for Blasting and Drilling Operations                          |
| 5.  | IS : 4130-1975           | Safety Code for Demolition of Buildings (First Revision)                  |
| 6.  | IS : 4138-1967           | Safety Code for Working in Compressed Air                                 |
| 7.  | IS : 4756-1968           | Safety Code for Tunneling Work                                            |
| 8.  | IS : 4912-1968           | Safety Requirements for Floors and Wall Openings : Railing and Toe Boards |
| 9.  | IS : 5121-               | Safety Code for Piling and Other Deep Foundations                         |
| 10. | IS : 5916-1970           | Safety Code for Constructions Involving use of Hot Bituminous Materials   |
| 11. | IS : 7293-1974           | Safety Code for Working with Construction Machinery                       |
| 12. | IS : 7969-1975           | Safety Code for Storage and Handling of Building Materials                |

#### **ANNEXURE III**

#### **GUIDELINES FOR SAFETY IN CONSTRUCTION OF PRESTRESSED CONCRETE BRIDGES**

##### **1 Introduction**

The art of prestressed concrete construction is a specialised job, requiring a high order of workmanship, quality materials and equipment. The constructional operations involve sophisticated techniques which have a relatively high potential of hazards if they are not well planned and all safety measures not undertaken. Numerous cases have come to notice where constructional lapses have resulted

in serious failures resulting not only in loss of materials and equipment but also human life. Whereas, the entire construction programme for the successful completion of the work is the sole responsibility of the contracting firm, it is also incumbent on the departmental staff to be fully conversant with all the operations to oversee the procedures to ensure that no accidents occur at site which may ultimately cause not only loss of materials and at times human lives but also delay the progress of the work. In order to ensure that all prestressed concrete works are carried out with the utmost care conforming to prescribed specifications and adopting foolproof techniques, some broad guidelines have been evolved for guidance of the field engineers. Mere compliance with these guidelines will not, however, absolve the contractor of the entire responsibility for a successful and safe completion of the work.

## **2. General**

2.1. It shall be ensured that the general safety precautions as applicable to any civil engineering construction relating to false work, centering, shuttering, excavation, protection against floods, rain, etc., shall be adequately taken care of.

2.2. Complete and detailed working drawings for carrying out the temporary and permanent works shall be available at site.

2.3. All works shall be carried out in accordance with the prescribed specifications and strict quality control to meet the specified standards.

2.4. Any change in the construction programme not reflected in the design while seeking approval, shall be examined *denovo* for ensuring the safety of the structure.

2.5. All works shall be executed under the direct supervision of competent engineering departmental officers, as well as contractor's site engineers.

3. To ensure safety of all form works, necessary guidance may be had from item No. 2 of Annexure I, and clause 1500 of Ministry of Shipping & Transport (Roads Wing) Specifications for Road and Bridge Works, for concrete jobs. In addition, casting bed required for precast P.S.C. beams, or centering for cast-in-situ P.S.C. beams need special attention. The end supports of casting beds for precast beam should be capable of supporting full beam weight when prestressed. The centering for in-situ work should be sturdy enough to withstand the heavy vibrations during compaction.

## **4. Prestressing for structures :**

4.1. The design of prestressed concrete structures should not only satisfy the various loading conditions during service but also cater to the various constructional loads and forces that would come into play during the different stages of construction leading to the completion of the work.

4.2. All aspects relating to materials, (viz. prestressing tendons, sheaths, anchorages, grout) tensioning equipment, tensioning procedure, grouting, etc., shall conform to the provisions contained in section 1800\* of the Ministry of Shipping & Transport (Roads Wing) Specifications for Road and Bridge Works, and the approved drawings for the project.

\* Clause 1807 regarding grouting is being revised to conform to Ministry's circular No. NH VI-50 (3)/83 dated 2nd Nov, 1983.

### **4.3 Special precautions to ensure safety during construction :**

While planning the various constructional operations involved in the execution of prestressed concrete works utmost and careful attention must be paid to the following requirements to ensure safety.

#### **4.3.1. Stressing schedule :**

Prestressing involves the application of very high forces and high pressures in the hydraulic pipelines and jacking devices and calls for appropriate precautions to prevent accidents. For this purpose, the following should be given special attention :

- (i) The various procedures laid down in the stressing schedule shall be strictly adhered to;
- (ii) The sequence of stressing individual tendons at various stages as specified in the stressing schedule shall be strictly followed;
- (iii) The concrete strengths as specified in the designs for prestressing at various stages shall be ensured by checking the test cubes;
- (iv) In cases where pre-loading has been specified by the designer before prestressing is resorted to, the same shall be ensured;
- (v) The removal of formwork/scaffolding shall strictly follow the indications given in the stressing operations;
- (vi) All precast members shall be designed to withstand all stresses likely to occur in the member during handling, placing and assembly, and subsequent prestressing, to ensure the stability and safety of all members; and
- (vii) The stressing operations should be carried out by experienced personnel under a competent supervisor.

#### **4.3.2. Stressing equipment :**

All temporary strengthening devices, handling appliances (lifting equipments viz. cranes, jacks, pullies, hoists, etc), temporary supports shall be designed to withstand safely all the effects due to loads and forces coming into play during the various constructional operations. In addition, the following checks shall be made before the equipments are actually used on the work :

- (i) The stressing equipment shall be thoroughly checked to satisfy the manufacturer's instructions for operations and the same shall be strictly followed.
- (ii) The pressure gauge of the pump shall be checked and shall be calibrated where necessary.
- (iii) A proper arrangement for handling the jack shall be made to avoid any mishap. For example : A small jack can be handled manually but for a large jack some suitable mechanical device will need to be made.
- (iv) It is desirable that all working personnel wear gloves when handling prestressing tendons.
- (v) Temporary suspension of any other construction operations shall be made which might warrant a workman to stand directly behind the jack during stressing.

- (vi) Utmost care shall be taken when handling coils of high tensile wire or strand, as this may whip back if not securely bound.
- (vii) Wedges and the inside surfaces of anchorages shall be cleaned so that the wedges are free to move inside without hindrance.

#### 4.3.3. Stressing Operation :

- (i) Stressing shall be carried out as per manufacturer's instruction manual.
- (ii) During stressing standing behind the jack as well as behind the preblocked anchorage being stressed from the other end shall be forbidden.
- (iii) Side ejection of the jack can be caused by poor concrete in the anchorage zone or by insufficient corner or edge reinforcement, which shall be avoided.
- (iv) Sudden dewedging or a broken wire in a cable can cause ejection of the jack and wedges and shall be avoided.
- (v) Handrail arrangement must be provided if working personnel are likely to fall when jumping clear of the jack, as may happen in the case of bridge decks constructed by the cantilever technique.
- (vi) Workmen must not be allowed to become casual just because they have stressed hundreds of tendons successfully before.
- (vii) Hydraulic hoses shall be examined regularly as a matter of necessity and, likewise, oil in the pump shall be examined regularly.
- (viii) Hydraulic pressure pipes shall be checked for flaws or bubbles after each stressing operation.
- (ix) Double-check the wedges or grips for fixing of tendons to the prestressing jack.
- (x) Tension the tendons to a low initial stress and then recheck the positioning of wedges or grips as also of the jack.
- (xi) The jack shall not be hit with a hammer to adjust its alignment when the load is on.
- (xii) A competent person shall always be available at the non-jacking end to check on anchorages during stressing, if one end stressing is adopted.
- (xiii) Detensioning shall be done gradually.

#### 4.3.4. Launching the precast girders :

The operation of launching precast prestressed concrete girders is basically a specialised art which varies from one system to another, depending upon site conditions, facilities available with the contractors, etc., and as such it is difficult to offer specific guidelines in this regard. It shall, however, be ensured that the launching beams and trusses and all connected structural members are structurally safe during the various launching operations.

It is also necessary that the prestressed girder and the supporting system is duly designed for loads and forces likely to come into play during the various operations connected with launching viz. lifting, side shifting, transporting, launching in position, etc.

All launching operations shall be avoided during high winds.

#### 4.3.5. Handling and erection :

Where a precasting technique is used for construction, all lifting operations, all temporary situations shall be analysed in advance to ensure safety. The following shall also be considered during handling and erection operations :

- (i) The aim of the precaster shall be to devise a system requiring minimum amount of handling of a precast unit from the casting bed to its final location.
- (ii) Before handling, it shall be checked that the concrete has gained sufficient strength to resist handling stresses, particularly when accelerated curing techniques are used.
- (iii) A check shall be made to ensure that the pressure developed below the erection equipment base does not exceed the permissible bearing pressure of the soil.
- (iv) In case of erection of bridge elements, with a launching truss, the stability of the approach embankment shall be checked for the safe movement of the launching truss.
- (v) If shifting of the precast units is done by mounting on trolleys, then their stability against toppling over shall be checked.
- (vi) In case of deep girders, the top flange of the girders shall be stiffened adequately, if necessary, to prevent buckling during erection.
- (vii) Adequate hairpin mesh shall be provided over the area of support during erection to prevent bursting cracks developing in the concrete.
- (viii) Lifting of the girders (and similarly at the time of lowering) shall be done gradually at both ends and with equal increments aiming to keep the girder horizontal.
- (ix) Sometimes, the precast unit is required to be supported temporarily before placing it on bearings. In such cases, the adequacy of the device providing such support shall be checked.
- (x) The stability of all temporary works shall be ensured.
- (xi) If jacking or any temporary support is provided under the end diaphragm of the structure, then the structural adequacy of the end diaphragm shall be ensured to cater for the reaction developing during jacking operation.
- (xii) It shall be ensured that jibs and booms of cranes do not come into contact with overhead electric transmission lines.
- (xiii) Only one person shall signal to the operator of the lifting appliance at the time of hoisting/lowering.
- (xiv) No mobile lifting appliance shall be used on a sloping surface until adequate precautions are taken to ensure stability of the equipment.

- (xv) Mobile cranes shall not be operated while being parked on loose earth or slushy area.
- (vi) If a chain or rope of a lifting machinery has a knot in any of its part, then this shall not be used for lifting until the knot is removed.
- (xvii) All chains, ropes and lifting gears shall be checked and tested by a competent person at regular time intervals.
- (xviii) When mobile lifting equipment is not in operation, the boom must be lowered to the horizontal position and tied securely in place to prevent accidental drop.
- (xix) No person shall be present under a load which is suspended by a lifting equipment.
- (xx) Hoisting machines used to lift a load shall be such that the load to be lifted falls within their working capacity and not overloaded.
- (xxi) Pulleys used for hoisting loads shall be examined at regular intervals to see if any undue wear has taken place.
- (xxii) Correct lifting equipment shall be used to avoid uncalled for torque and eccentric loading on all components.

#### **4.4.6. Other precautions :**

- (i) Fencing arrangement shall be provided in accessible area at the back of the jack so that no passers by can appear suddenly behind the jack. Also warning sign board shall be put up, as a safe guard for stressing operations.
- (ii) It shall be ensured that adequate precautions are taken to restrain any possible skewing or lifting of the stressing equipment during tensioning or release.
- (iii) No prestressing steel shall be permitted to be used for earthing electrical equipment of any kind.
- (iv) All equipments must be kept thoroughly clean and in a workmanlike condition (as badly maintained equipment always gives rise to trouble and consequently is dangerous).
- (v) After stressing, the wires or strands behind the anchorages shall be cut off preferably with a disc cutting tool or a cropper or a snapping off tool.
- (vi) A clear eyeshield shall be worn by workmen during grouting operations.
- (vii) Before grouting, all ducts shall be checked to see that none are blocked.
- (viii) If possible, only threaded connectors shall be used between grout nozzles and grouting points (A sudden spurt of grout under pressure can cause severe injury, especially to eyes).
- (ix) One should not peer into duct bleeders to see if grout is coming through. Grout may jam temporarily and as pressure is applied, may spurt suddenly from the bleeders, or the far end of the duct, causing serious injury.
- (x) When grouting over railways or public roads or other public places, precautions shall be taken to see that escaping grout does not cause a hazard to traffic below.