5.3 PRESTRESSING REINFORCEMENT

5.3.1 Description

5.3.1.1 General

This work shall consist of the furnishing and placing, pretensioning or post tensioning of bars, strands or wires as specified on the Drawings and these Specifications.

5.3.1.2 Definitions

Post tensioning is defined as any method of prestressing concrete in which the tensioned reinforcement is tensioned after the concrete is placed.

Pretensioning is defined as any method of prestressing concrete in which the tensioned reinforcement is tensioned before the concrete is placed.

Prestressing reinforcement is defined as any reinforcement to which prestress is applied by post tensioning or pretensioning.

Non-prestressing reinforcement ("ordinary reinforcement" or only "reinforcement") is defined as any reinforcement to which no prestressing tension is applied externally.

5.3.2 Materials

5.3.2.1 Tendons for Post Tensioning Systems

Prestressing steel shall be Stress-Relieved Wire according to AASHTO M 204, Stress-Relieved Strand according to AASHTO M 203 or High-Strength Steel bar according to ASTM A 722.

The Contractor may propose any other internationally acknowledged prestressing steel subject to approval of the Engineer. Detailed drawings showing the tendon arrangement and calculations shall be submitted, which verify that the proposed tendons introduce into bridge structures the prestressing effect equivalent to the original design shown on the Drawings.

No tendons shall be used in the construction before testing has been carried out and approved by the Engineer.

5.3.2.2 Anchorage Assemblies

The end anchorages (stressing anchorages and dead end anchorages) shall be especially designed for the actual type of tendon and must have been used on other similar work and thus have demonstrated proper functioning and durability for this purpose.

Allowance shall be made to test anchorages to destruction. The anchorages shall be capable of fixing the prestressing steel at a load of not less than 95% of the specified minimum tensile strength of the prestressing steel.

The manufacturer shall submit appropriate test certificates from an approved testing laboratory.

Information on all details of the design and the steel quality of the anchorages shall be submitted to the Engineer.
5.3.2.3 Sheathing

All sheathing shall be of the metallic corrugated type, galvanized and fully mortar tight. The sheathings shall be strong enough to maintain their shape under such forces as may be expected to act on them.

All information on proposed sheathings shall be submitted by the Contractor to the Engineer for his approval.

5.3.3 Construction Methods

5.3.3.1 General

The Contractor shall provide a technician skilled in the use of the actual system of prestressing to supervise the work to the satisfaction of the Engineer.

The Contractor shall provide all equipment necessary for the construction and the prestressing. Prestressing shall be done with approved jacking equipment. If hydraulic jacks are used they shall be equipped with accurate reading pressure gauges. The combination of jack and gauge shall be calibrated and a graph or table showing the calibration shall be furnished to the Engineer. Should other types of jacks be used, calibrated proving rings or other devices shall be furnished to accurately establish jacking forces.

If alternative systems are adopted, the Contractor shall submit, for the approval of the Engineer, drawings and calculations which show the arrangements of tendons, anchorage assemblies, etc. and verify that the prestress occurring at every section is equal to that produced by the system originally used in the design.

A) Pre-Tensioning Systems

Prestressing strand and wire to precast piles shall be seven wire strand and wire in accordance with ASTM A 416-74.

Prestressing tendons can be directly substituted by other types of equivalent strength tendons conforming to JIS G 3109-1971, BS 3617-1971 and BS 2691-1969.

B) Certificates

Manufacturer’s test certificate for breaking strength shall be obtained for each delivered coil or bundle and a stress/strain diagram shall be obtained for every fifth coil or bundle.

Each coil or bundle of prestressing steel shall be delivered with charge No. and markings to allow identification of the corresponding tests carried out.

Copies of the manufacturer’s dated test certificates of his Routine Testing shall be submitted to the Engineer for his approval.

C) Tests

Tests in addition to those to be carried out by the manufacturer as specified herein will be required.

Supervised by the Engineer, the Contractor shall cut out samples (approximately 1.0m long) for each 25 tons of steel, or as directed by the Engineer. The breaking load,
0.2% proof load and elongation tests shall be carried out according to ASTM A 370, by an approved independent testing laboratory.

Expenses incurred in connection with cutting out, transport and testing of the samples shall be borne by the Contractor.

No tendons shall be used in the construction before the testing has been carried out and approved by the Engineer.

5.3.3.2 Storage of Materials

Coils and bundles of prestressing steel shall be stored flat on a floor raised off the ground and under full cover from the weather. They shall be protected from damage, oil, corrosion or any deleterious matter, and shall not be opened until required. Before being fabricated into prestressing tendons the strands or bars shall be cleaned of loose rust and any deleterious matter, and inspected by the Engineer for approval. Prestressing steel reinforcement which shows signs of pitting or has any surface defects such as splits, roughness or necking is not to be used, and any lengths of wire or strand so affected shall be cut off and rejected.

Corrugated sheathing is to be delivered to the site coiled on to large diameter wooden drums, securely fastened and protected from damage. They shall be stored on site under cover from the weather, and shall be protected from rusting, damage, oil or any other deleterious matter and shall be clean and free from all such matter before being used in the Works.

5.3.3.3 Manufacture of Tendons

Prestressing cables shall be prepared on site from coils of wires or strands. Tendons, which consist of a number of high tensile steel strands, shall be formed in a manner approved by the Engineer. In estimating the length of all cables, extra allowance must be made for applying either one or two tensioning jacks.

Sheathing shall be carefully examined prior to use and any damaged lengths shall be cut away and rejected.

Suitable spacers shall be provided, if required, to hold the strands or bars in correct position in the sheathings to ensure that there is sufficient space around each wire or cable to allow proper grouting.

Joints in corrugated sheathing shall be formed by the use of couplers and/or by wrapping the joints with tape. They shall be so designed as to prevent the ingress of concrete or other material during casting. All joints in sheathing shall be approved by the Engineer.

5.3.3.4 Placing Tendons and Sheathing

Tendons shall be carefully handled so as to avoid sharp bends or kinks. The sheathing and/or the tendon shall be rigidly supported in the exact positions as shown on the Drawings so that no movement can take place during casting of elements to be prestressed.

The tendons shall be placed with the following tolerances:

Vertical ± 10 mm, horizontal ± 20 mm.

The tendons shall be supported by special supporting arrangements as proposed by the Contractor and approved by the Engineer. If the sheathing is supported by
reinforcement bars, they shall be plain round bars of mild steel. The supports shall be placed at adequate centres to ensure the tendons in all positions are placed along the prescribed curve. Care must be taken to prevent the supports from penetrating into the sheathings and if necessary special means must be used.

5.3.3.5 Placing Anchorages

Anchor cones, blocks and plates shall be positioned and maintained during concreting so that the centreline of the duct passes axially through the anchorage assembly.

All bearing surfaces of the anchorage shall be clean prior to concreting and tensioning. The anchorage itself shall be adequately protected against corrosion following the completion of the final stressing operation.

5.3.3.6 Jacks for Prestressing

All jacks used for prestressing shall be of the type applicable to the system adopted.

The accuracy of all load measuring equipment shall be checked to the satisfaction of the Engineer at the start of work each day it is to be used and whenever the equipment is moved to a different jack.

5.3.3.7 Post-tensioning Procedure

1) Prior to construction work, the Contractor shall submit a table which shows the tensioning order of all tendons to be tensioned at each construction stage, pressure of hydraulic jacks or pumps, anchor pull-in and elongation of each tendon. This proposed post-tensioning procedure is subject to approval by the Engineer.

The Contractor shall carry out tensioning tests on a few tendons designated by the Engineer, and the results shall be taken into consideration for the table preparation. The result of the tensioning work for each tendon shall be submitted in a form designated by the Engineer.

2) Tensioning shall be carried out only in the presence of the Engineer unless permission in writing has been obtained to the contrary.

3) Immediately before tensioning, the Contractor shall prove that all tendons are free to move between jacking joints and that members are free to accommodate the horizontal and vertical movements due to the application of prestress.

4) Unless otherwise described in the Contract, concrete shall not be stressed until it has reached at least the age at which two test cylinders taken from it attain the specified transfer strength. The test cylinders shall be made and tested in accordance with Section 5.1.2.4. The Contractor shall cast sufficient additional cylinders to demonstrate that the required strength of the concrete at transfer has been reached.

5) Where members consist of jointed elements, the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member.

6) The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Engineer.
7) The Contractor shall add to the forces described in the Contract an allowance for anchorage friction and jack losses. The total forces and calculated extensions shall be agreed with the Engineer before stressing is commenced.

8) Immediately after anchoring, the stresses in the prestressing tendons shall not exceed 70% of their specified characteristic loads. During stressing the value shall not exceed 80%.

9) The tendons shall be stressed at a gradual and steady rate. The forces in the tendons shall be obtained from readings on two load cells or pressure gauges incorporated in the equipment. The extensions of the tendons under agreed total forces shall be within 5% of the agreed calculated extensions.

If the required elongation cannot be reached, the jacking force may be increased to 80% of the specified characteristic load of the tension. If the difference between the measured and calculated elongation is more than 10%, however, no further tensioning shall be made until the calculations and the equipment is checked.

10) When stressing tendons with stressing anchorage at both ends, the pull-in at the ends remote from the jack shall be accurately measured and the appropriate allowances made in the measured extensions at the jack ends.

11) When the prestressing has been applied to the satisfaction of the Engineer, the tendons shall be anchored. The jack pressures shall then be released in such a way as to avoid shocks to the anchorages or tendons.

12) If the pull-in of the tendons at completion of anchoring is greater than agreed by the Engineer, the loads shall be released at a gradual and steady rate and tensioning carried out afresh.

13) The Contractor shall keep full records of all tensioning operations including the measured extensions, pressure gauge or load cell readings and the amount of pull-in at each anchorage. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

14) The men employed shall be experienced in this class of work. Every precaution shall be taken to ensure the safety of the workmen during the tensioning period.

5.3.3.8 Grouting

Grouting shall be carried out as specified in Section 5.1.3.17.

5.3.3.9 Finishing off Tendons

After grouting, the ends of the anchorages and any projecting ends of cut-off tendons shall be covered by concrete or special mortar mix.

5.3.3.10 Pre-Tensioning

The specified force shall be maintained by the use of fixing devices at the ends of the tensioning steel during concreting and curing until the concrete has attained the specified strength or other strength approved by the Engineer. The tensioning steel shall then be released gradually and uniformly.

All details and function of the “prestressing bed” shall be approved by the Engineer.

The amount of tensioning shall be as shown on the Drawings or as instructed by the Engineer.
The amount of jacking force and the elongation shall be measured on each strand wire or bar in a way approved by the Engineer.

Test specimens manufactured and cured in accordance with Section 5.1.2.4 may be requested for the verification of the concrete strength before releasing the tensioning steel.

5.3.4 Measurement

The quantity to be measured shall be the theoretical weight in metric tons of the prestressing steel as shown on the Drawings without sheathings, anchorages etc., and measured between the outer faces of the anchorage blocks.

5.3.5 Payment

The work measured as provided above shall include all works as specified including provision of sheathings, anchorages, couplers, spirals, supports for the tendons, tensioning, grouting and finishing works.

Pay item shall be:

5/3/1 Prestressing Wire or Strand as detailed on the Drawings and as stated in the Bill of Quantities. Tonne