Health & Safety Executive

Guidance Note GS 49 from the Health and Safety Executive

Pre-stressed concrete

General Series 49 (March 1991)

These Guidance Notes are published under five subject headings: Medical, Environmental Hygiene, Chemical Safety, Plant and Machinery and General.

INTRODUCTION

1 Concrete is a versatile material which can be used in many different forms. These include mass concrete fill, concrete with various types of steel reinforcement which carry the tensile stresses and pre-stressed concrete where only predominantly compressive stresses are present throughout its life.

2 Concrete is strong in compression but will crack under a relatively small tensile force. Pre-stressing is used to impart an initial compressive force into the concrete section so that at the full design load either the concrete retains some compressive stress or only a very small tensile stress is attained. Although other materials can be pre-stressed, only the pre-stressing of concrete is considered in this Guidance Note.

3 Information on concrete pre-stressing is also published by the Concrete Society (Ref 1) and CIRIA (Ref 2). This Guidance Note is intended to be read in conjunction with these documents and to draw particular attention to the hazards of the actual stressing activity or from release of an end anchorage or failure of a tendon.

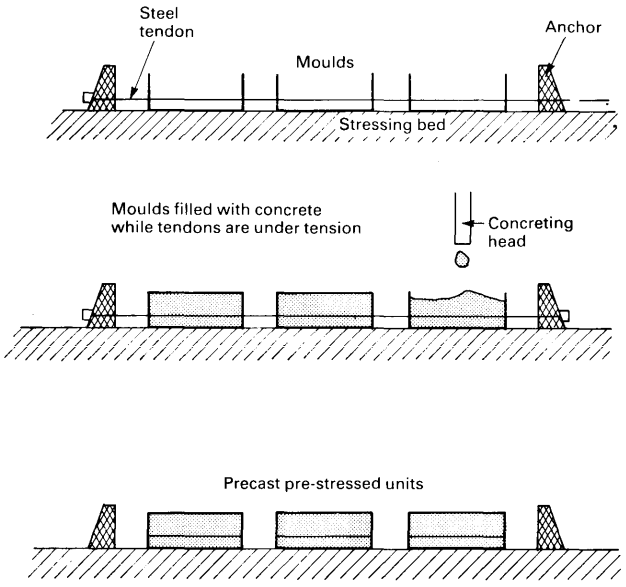

Fig 1 Pre-tensioning (factory system)

4 This Guidance Note does not cover the demolition or breaking up of stressed concrete products.

STRESSING

5 There are two different methods of pre-stressing concrete:

(a) Pre-tensioning. This system is normally used for factory production. The steel tendons are tensioned and held in position while concrete is cast into moulds around the tendons. Once the concrete has set and achieved a certain strength, the tensile force is released and the stressing load is transferred to the concrete (Figures 1 and 2).

(b) Post-tensioning. This system is normally used for site production. A precast concrete unit or concrete structure which has achieved sufficient strength for handling, transporting and positioning is stressed by tendons inserted into ducts in the concrete. The tendons are then stressed and by transferring the load into the concrete by means of the end bearings the concrete is compressed. There are a number of systems in use, which vary in their details (Figures 3-5).

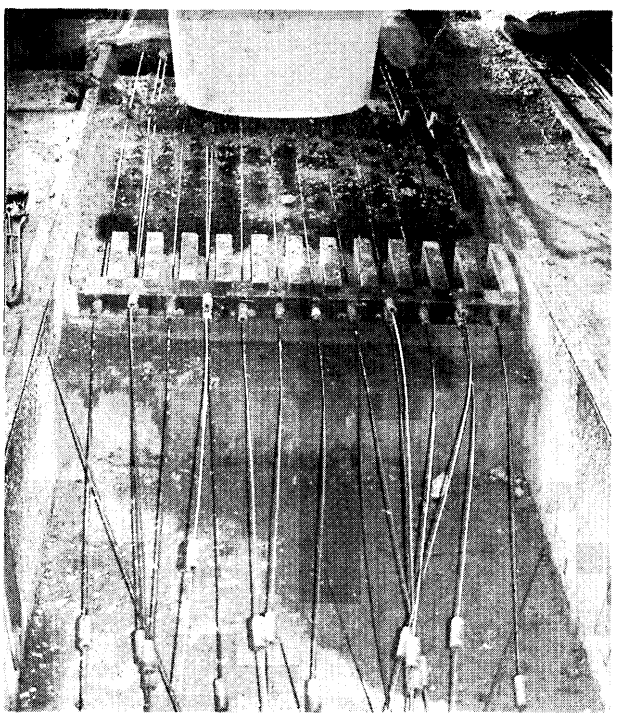

Fig 2 Stressed tendons being concreted

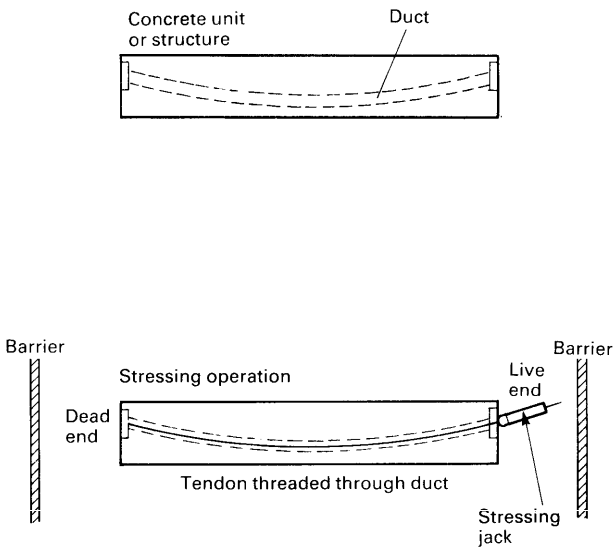

Fig 3 Post-tensioning

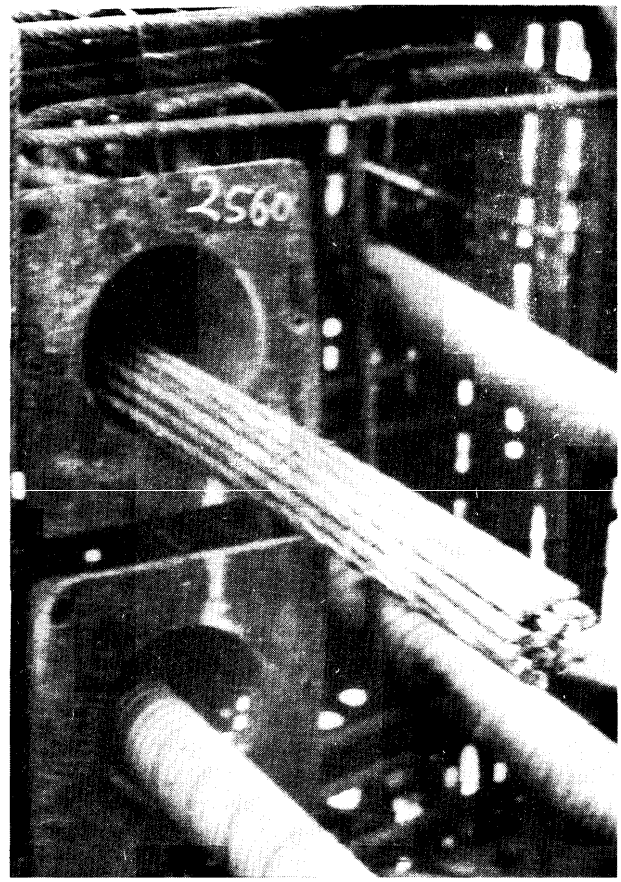

Fig 4 Steel end anchorages and stranded cable before stressing

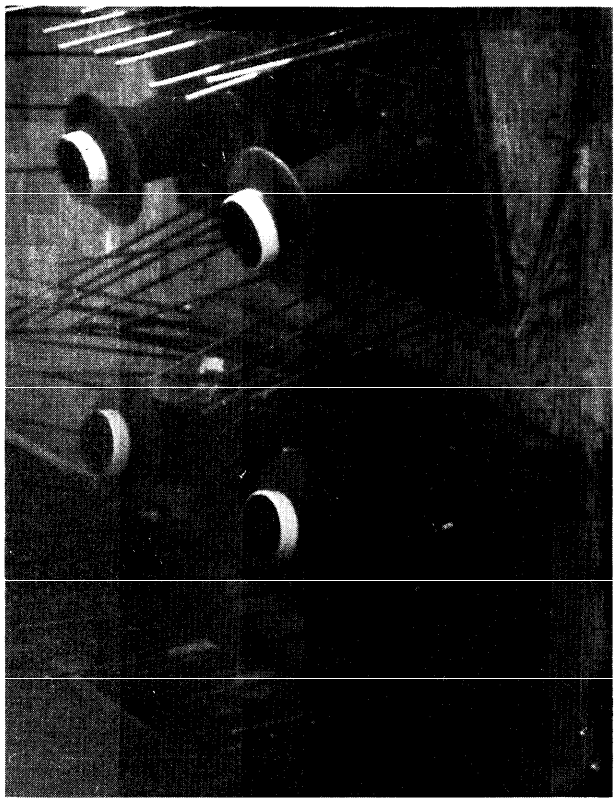

Fig 5 End anchorages after concreting

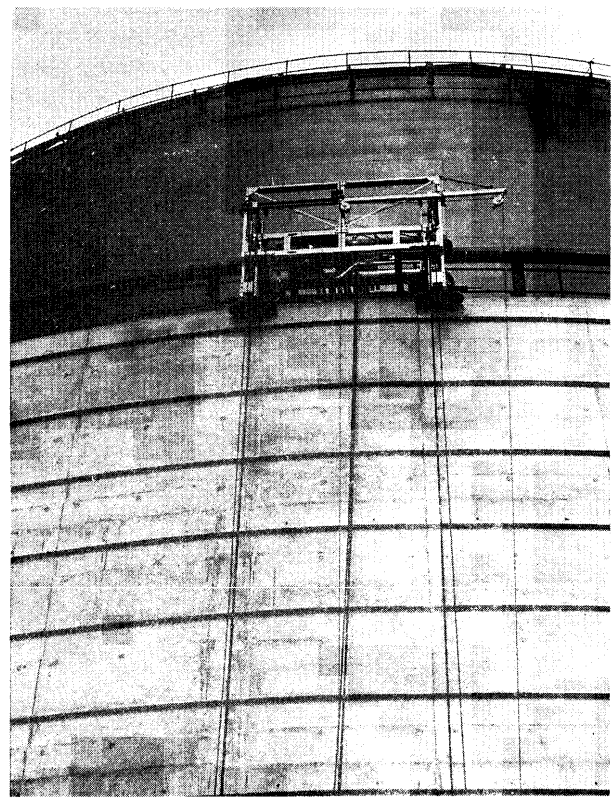

Fig 6 Stressed circular tank

6 It is possible for post-tensioning to be carried out in stages as the working load increases. A mixture of both forms of stressing is also used as well as a mixture of reinforced concrete and pre-stressed concrete.

7 Tendons of high tensile steel can consist of single wires from 2 mm and upwards in diameter, stranded cable which may have from 4 to 27 wires in each cable or special high tensile steel bars from 12 mm to 50 mm in diameter. The force used to extend the tendons may be of any magnitude from 4 kN to 10000 kN and once tensioned, the force in the tendon is held by means of the particular end fixing or the bonding of the concrete.

8 Pre-tensioning wires, because they are encased in set concrete, are held in position by surface bonding and the natural tendency for the diameter of the wire to increase once the initial tensile force is released. Immediately this happens the stressing force is reduced, followed by a more prolonged reduction due to creep in the system. This may reduce the tensile force by up to 35°/0 over a period of time. Nevertheless, in spite of the reduction from the initial force used in stressing there can be quite high residual forces within a concrete unit.

9 Depending on the engineering design, tendons are sometimes sheathed to prevent bonding with the concrete and more recently greased and plastics-coated strand has been used for the same purpose.

Factory production

10 Production is normally limited to small-section floor beams or slab units up to 1.2 m in width. Poles to carry power lines or lighting units can also be manufactured. The stressing bed can be up to *250* m long, but normally the total length will be divided into smaller units by the use of steel end plates. At one end a fixed stressing head is embedded in the floor and at the other there is an hydraulic jacking head. Tendons are usually parallel to one another and at a constant position within the concrete section unless deflected tendons, which are not now very common, are used.

11 An alternative method of stressing tendons up to 5 mm diameter is by the use of a winch connected to each tendon, the required tension being predetermined by means of a load cell within the tensioning system.

12 The tendons are stressed to a predetermined amount and, while they are under tension, the concrete is cast within the moulds around the tendons. The concrete is left to harden and normally demoulding is done the following day when the concrete has attained sufficient strength to carry the compressive load. The jacking load is released and the steel tendons are cut at each end of each unit. The units are then lifted and stored. By positioning the majority of tendons in the bottom of the unit, the induced compression can be used to bow the unit upwards, effectively precambering it.

Site production

13 Precast concrete units may be manufactured off site and transported to site or they may be made in a casting yard within the site complex. Ducts are cast into the units and the tendons are threaded through them. The tendons are stressed by hydraulic jack against the end fixings and the strands, wires or bars locked off at one or both ends, usually by means of wedges forced home by a secondary part of the main stressing jack.

14 Ducts can be either straight or curved and may be shorter than the length of the unit as the tendons can terminate at a buried dead end. Tendons can be extended by couplers or may be overlapped to achieve continuity. It is essential when using multiple wires or strands that the position of one wire in relation to another is checked as the action of threading them through the duct can result in wires becoming misplaced.

15 When stressing has been completed, the excess tendon must be cut off. Because excess heat can soften the tendon and lead to an explosive failure, cutting must be by disc cutter at a defined minimum distance from the end fixing. The duct is usually cement grouted to prevent corrosion of the tendon. The pressure of the grouting process must not be allowed to exceed the recommended figure as too high a pressure can cause premature setting of the grout and lead to inadequate filling of the duct. The tendon may then corrode and loss of stressing may result. Careful control of grouting between air release holes is essential.

END ANCHORAGES

16 Whether the tendons are single wires, multiple strands or large diameter bars the integrity of the system is dependent on the anchorages at both ends. Once the tendon is stressed, the forces are retained by maintaining the residual tension in the tendon by end grips and wedges or special nuts bearing against an end plate or a concrete anchorage block.

17 For stressing circular tanks special opposing connectors and anchorages can be used (Figure 6). Similar end anchorages to those mentioned in paragraph 16 are possible but in this case the tendons are stressed against vertical ribs of concrete at suitable intervals around the tank.

SAFE SYSTEMS OF WORK

18 It is essential that all personnel are trained and experienced in the work to be carried out and that there is a competent supervisor. People not directly involved in the stressing operation should be excluded from the work area. Before work is started a system of work should be prepared stating the general procedures to be followed, the necessary stressing force and the calculated extensions or tensions to be used as well as how records are to be maintained.

19 Materials should be stored properly in the dry and should be free from damage and heavy rust. Materials should be checked against test certificates and records kept of usage. Strands, bars and wires should all be checked for physical damage, kinks, heavy rust or pitted

surfaces and must be discarded if any defects are found. Poor grips and wedges or insufficiently indented wires may lead to slipping failure under load.

20 Routine servicing of the mechanical gear should be carried out in accordance with the manufacturer's instructions. Regular checks of the load calibration of the hydraulic jack against the pressure should be made at three-monthly intervals.

21 In the factory stressing bed system the permanent anchors should be examined every six months for signs of fatigue or distress. Welds should be checked by any appropriate means to ensure their integrity. Daily visual inspections should be made of anchors and other equipment.

22 All reusable items such as wedges and grips should be cleaned and stored in a dry, clean atmosphere in clearly labelled containers. Hydraulic hoses and jacks should be stored properly.

23 In factories the use of a standard tendon and length of bed will result in known extensions and loads. Systems of work and protection of the people carrying out stressing will be part of normal activity. Nevertheless, because they are so routine it is possible to become careless and it is essential that other people are not allowed to be present or near the bed while stressing is in operation. Clear warnings should be displayed during operation and barriers erected around anchorages.

24 For long beds the use of intermediate saddles over the stressing beds is advised to contain tendons in case of failure. An alternative means of dealing with a possible tendon failure is by using heaps of hessian placed over the stressing bed. In the event of a failure the broken wire becomes entangled in the hessian.

25 On site it is necessary to provide end barriers high enough and strong enough to ensure that, in the event of a failure during stressing, wedges, end plates or anchors cannot fly off beyond the boundaries of the operation. The space between the end of the unit and the barrier must be no larger than is needed to accommodate the jacking system and the people involved. Materials that can be used for barriers include timber railway sleepers, earth or sandbags. No welding should be carried out on or anywhere near any pre-stressed concrete or its components.

OPERATIONAL SAFETY

26 Before stressing check that the hydraulic hoses have no kinks, connections are tight, there are no leaks and there is sufficient hydraulic oil.

27 All personnel should be kept clear from behind the line of the jack and should be wearing gloves, hard hats, goggles and boots.

28 At the point of maximum force jacking should be stopped and the elongation of the tendon measured and checked against the required dimension. No elongation beyond that stated in the system of work should be carried out without authorisation from the designer.

29 Given that barriers and notices have been provided and are used in accordance with paragraph 25, stressing may proceed during normal working hours. Approach by anyone not involved should be prevented. Care should be exercised at all times by those carrying out the stressing.

30 If stressing is to be carried out at height, similar provisions as regards operation and safety barriers must be made. Provisions for access must be in accordance with the Construction (Working Places) Regulations 1966 (Ref 3).

REFERENCES

1 Cl RIA Report 106- ***Post-tensioning systems for concrete in the UK 1940-1985,*** ISBN O 860172376. Available from CIRIA, 6 Storey's Gate, London SW1 P 3AU

2 Concrete Society data sheets: ***Safety precautions for pre-stressing operations.*** Available from the Concrete Society, Terminal House, Grosvenor Gardens, London SW1 W OAJ

3 ***The Construction (Working Places) Regulations 1966,*** S1 1966 **No** 94, HMSO.

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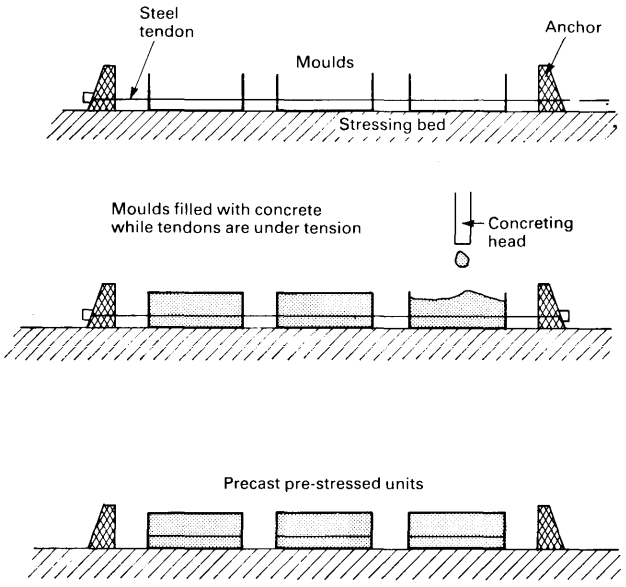

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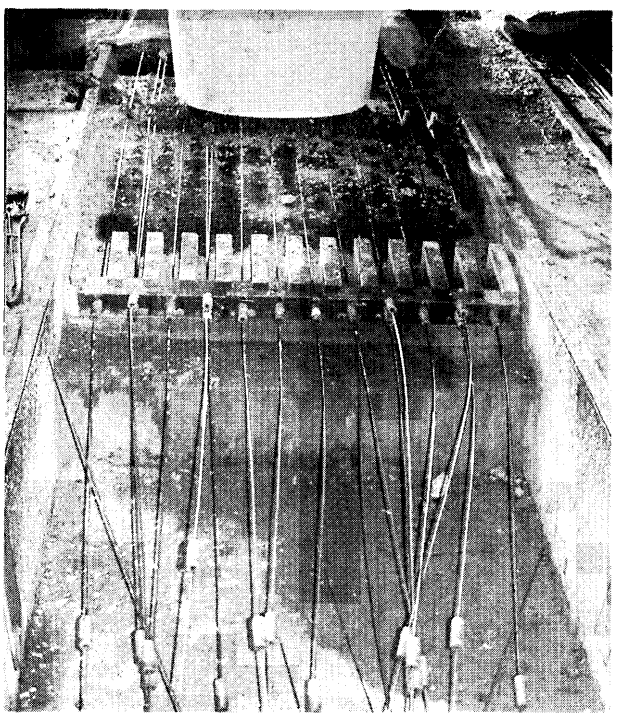


Fig 2 Stressed tendons being concreted

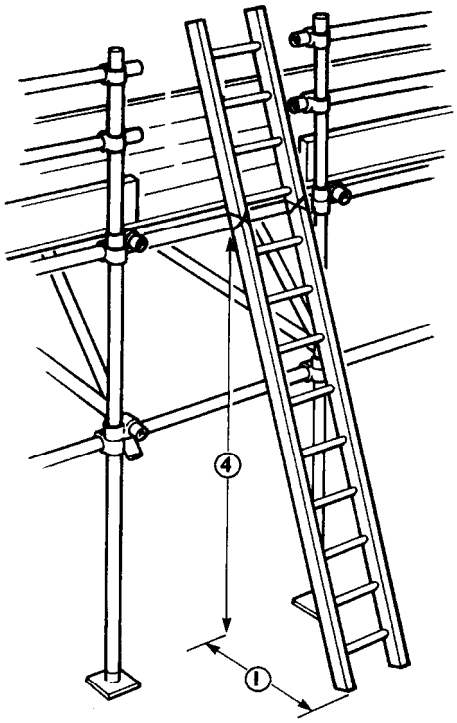
- Avoid overloading the scaffold. Make sure it is designed to take the loads put on it. Store materials so the load is spread evenly.

Scaffold inspection

- **Scaffolds must be inspected by a 'competent person' usually at least every seven days. Any faults found must be put right.**
- **Before contractors allow their workers to use someone else's scaffold they must make sure it is safe.**

For more information on inspection and reports, read CIS 47.

Ladders



Ladders should be correctly angled one out for every four up.

- Ladders should be in good condition and examined regularly for defects.
- They should be secured so they cannot slip, usually by tying them at the top.
- Access ladders should extend about 1 m above the working platform. This provides a handhold for people getting on and off.
- Avoid overreaching: if you are working from a ladder, make sure it is long enough and positioned to reach the work safely.
- Do not climb or work off a ladder unless you can hold onto it.

Stepladders and trestles

- Do not use the top platform of a stepladder unless it is designed with special handholds.
- **Trestle platforms and stepladders must not be used as a workplace above 2 m in height unless proper edge protection is provided.**

Legal requirements

Health and Safety at Work etc Act 1974

Management of Health and Safety at Work Regulations 1992

Provision and Use of Work Equipment Regulations 1992

Construction (Health, Safety and Welfare) Regulations 1996

References and further information

BS 5973:1993 *Code of practice for access and working scaffolds and special scaffold structures in steel*

Tower scaffolds CIS 1 O(rev) HSE Books 1997

Construction site health and safety checklist CIS 17 (rev) HSE Books 1994

Inspections and reports CIS 47 HSE Books 1997

Health and safety in construction HSG 150 HSE Books 1996 ISBN 0 7176 1143 4

Protecting the public: Your next move HSG151 HSE Books 1997 ISBN 0 7176 1148 5

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This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

The leaflet includes mandatory requirements under the Construction (Health, Safety and Welfare) Regulations 1996. These are shown in bold type.

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