Construction Measurement III
SBQ3314

Precast Pre stressed Concrete Works

Dr. Sarajul Fikri Mohamed

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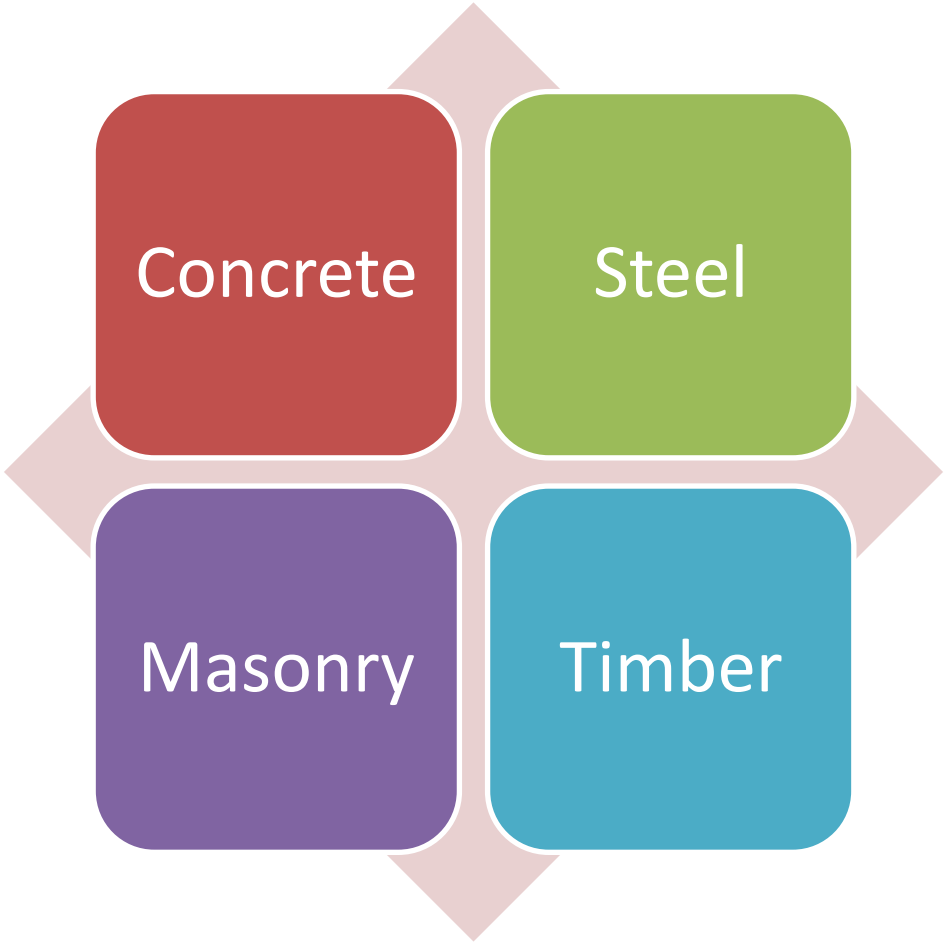
Pre stressed concrete in bridgeworks

Types of Material : BRIDGEWORKS



System Structure : BRIDGEWORKS

i Simply Supported

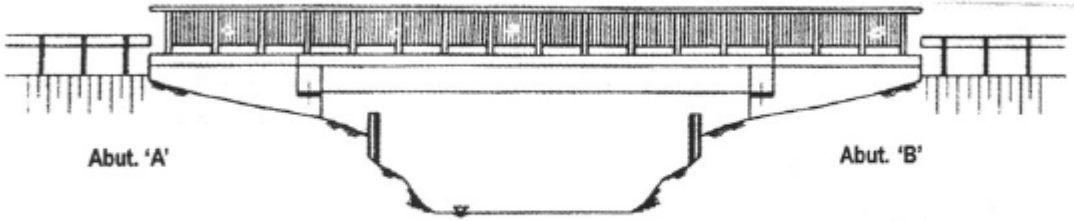


Fig. 1.1 - Simply Supported (SG)

ii Continuous

Fig. 1.2 - Continuous Span (CG)

iii Cantilever

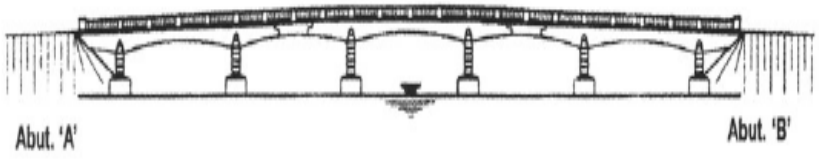


Fig. 1.3 - Cantilever with Suspended Span (CT)

v Truss

vi Frame

Fig. 1.5 - Arch Bridge (AR)

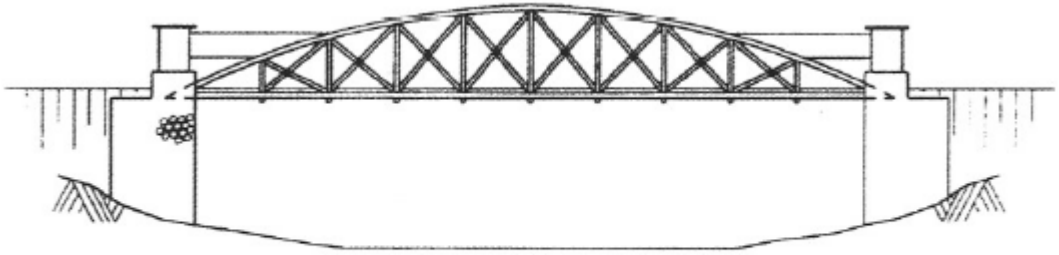


Fig. 1.6 - Truss Bridge (TR)

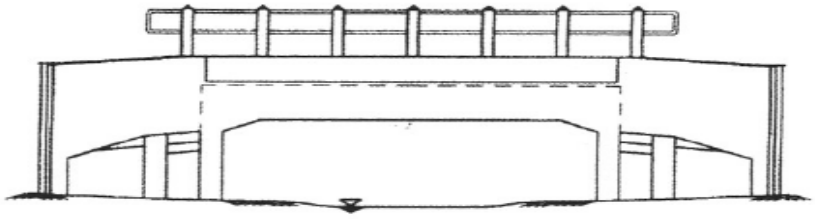


Fig. 1.4 - Frame (FR)

System Structure : BRIDGEWORKS

vii Cable Stayed

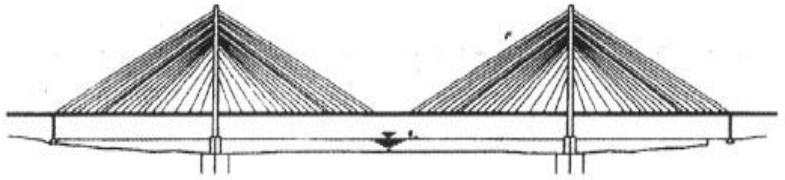


Fig. 1.8 - Cabled Stayed Bridge (CS)

viii Suspension

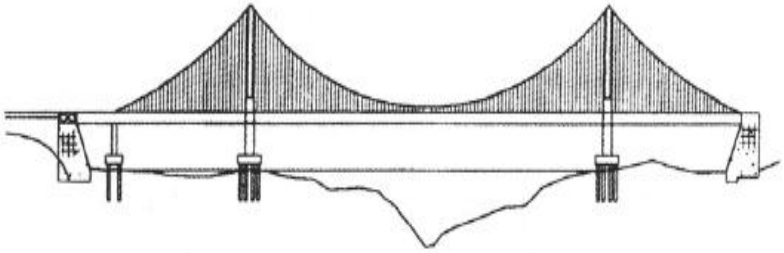


Fig. 1.7 - Suspension Bridge (SP)

ix Culvert

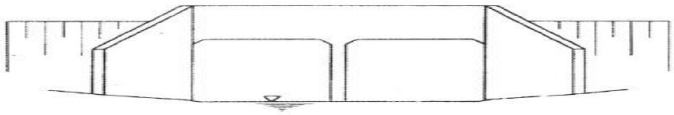


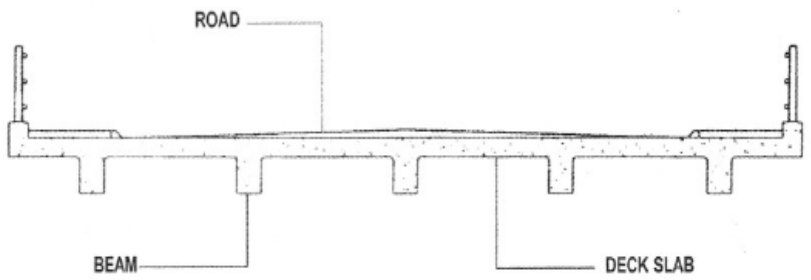
Fig. 1.9a - Box Culvert (BC)

Fig. 1.9b - Pipe Culvert (PC)

Deck types : BRIDGEWORKS

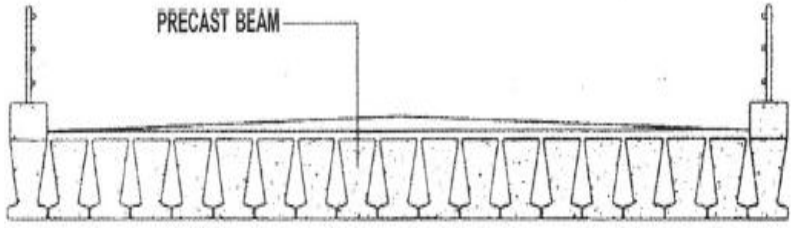
i Reinforced concrete beam

1. Reinforced Concrete Beam (Fig. 1.10) (RCB)



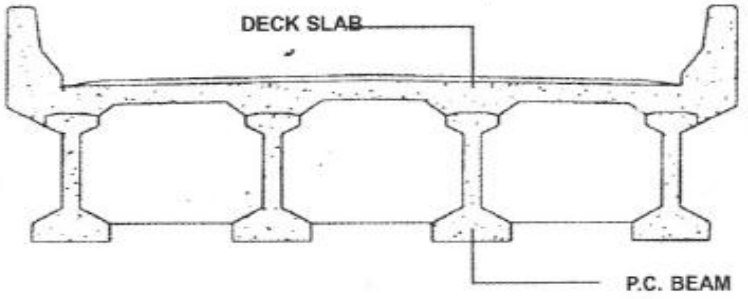
ii Precast reinforced concrete beam

2. Precast Reinforced Concrete beam (Fig. 1.11) (PRCB)



iii Prestressed concrete beam

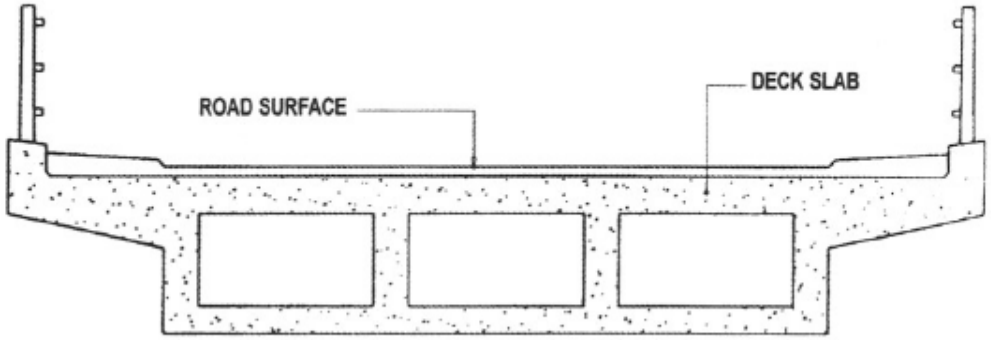
3. Prestressed Concrete I-Beam (Fig. 1.12) (PCB)



Deck Types : BRIDGEWORKS

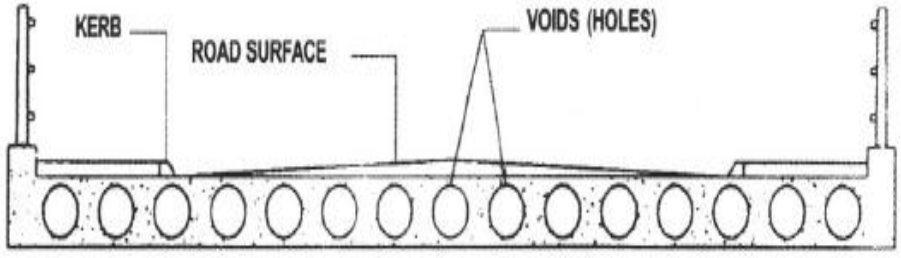
iv Concrete Box Girder

7. Concrete Box Girder (Fig. 1.16) (CBG)



v Voided Concrete Slab

6. Voided Concrete Slab (Fig. 1.15) (VCS)



3D-VIEW OF BRIDGE COMPONENTS

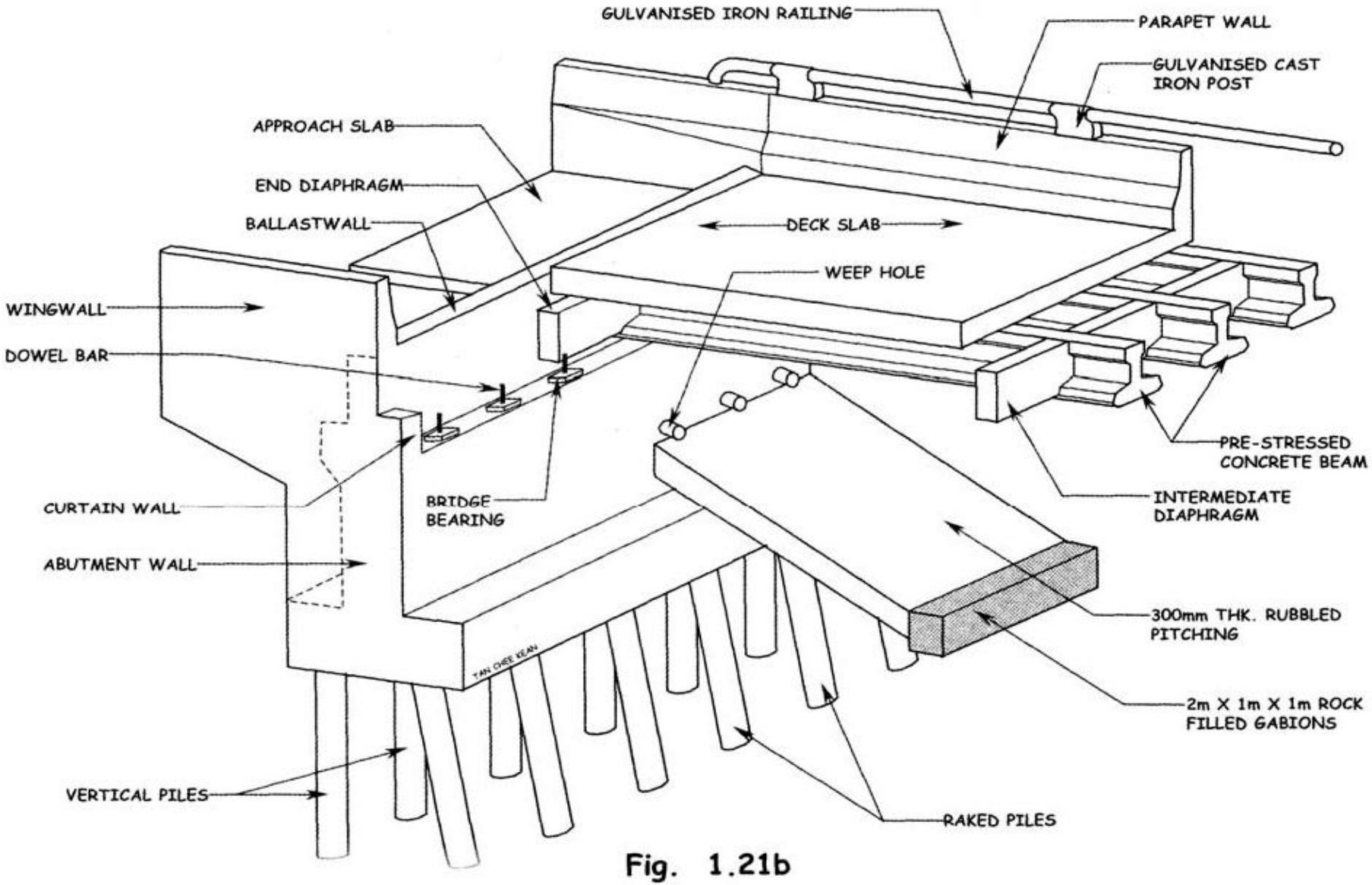


Fig. 1.21b

Pre-cast & Pre-stressed Concrete : COMPONENTS

1. Precast concrete beam
2. Ducting
3. Vents
4. Tendons
5. Anchorages
6. Filling to anchorage pockets
7. Construction joint
8. Temporary support

Pre-cast & Pre-stressed Concrete : PRE-CAST CONCRETE BEAM

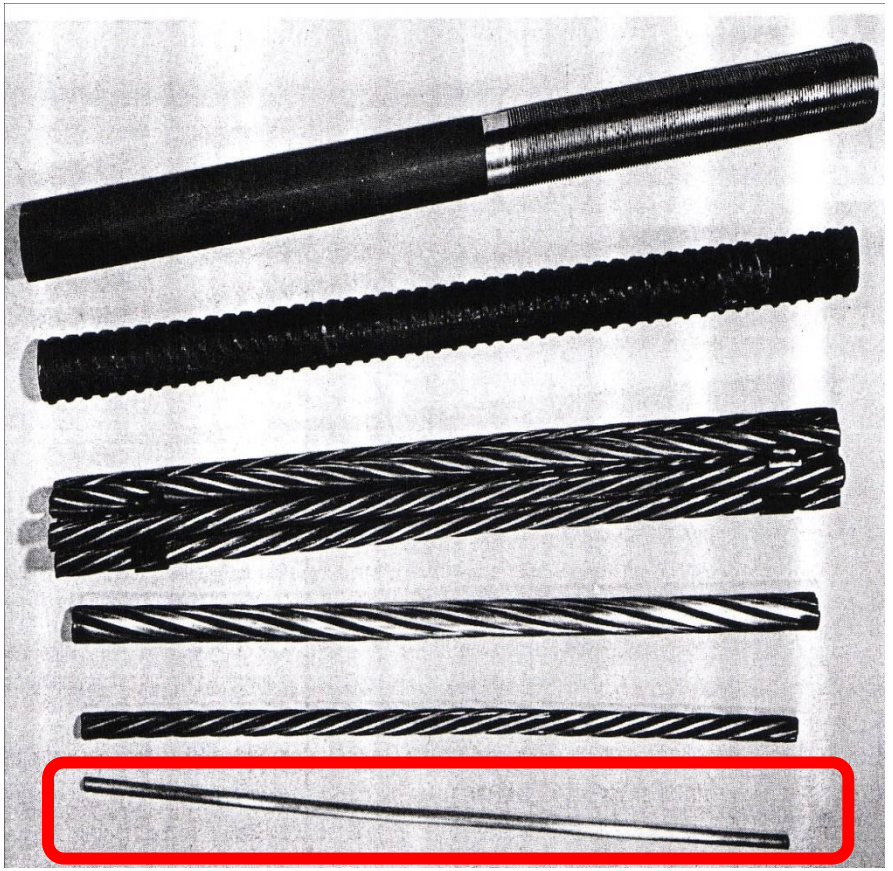
- Prestressed concrete beams includes: cast in situ or pre cast, beams or box girders, simply supported or cable stayed.
- Two main types which include:
- PRE-TENSIONING
  - The tendon is stressed by jacking against an anchor frame before the concrete is placed.
- POST-TENSIONING
  - The tendon is pulled and stretched using a jack and the resulting force is transferred directly on the hardened concrete through the tender anchor.

Cast in situ beam for construction of a bridge

Pre cast concrete beam from factory transported to site

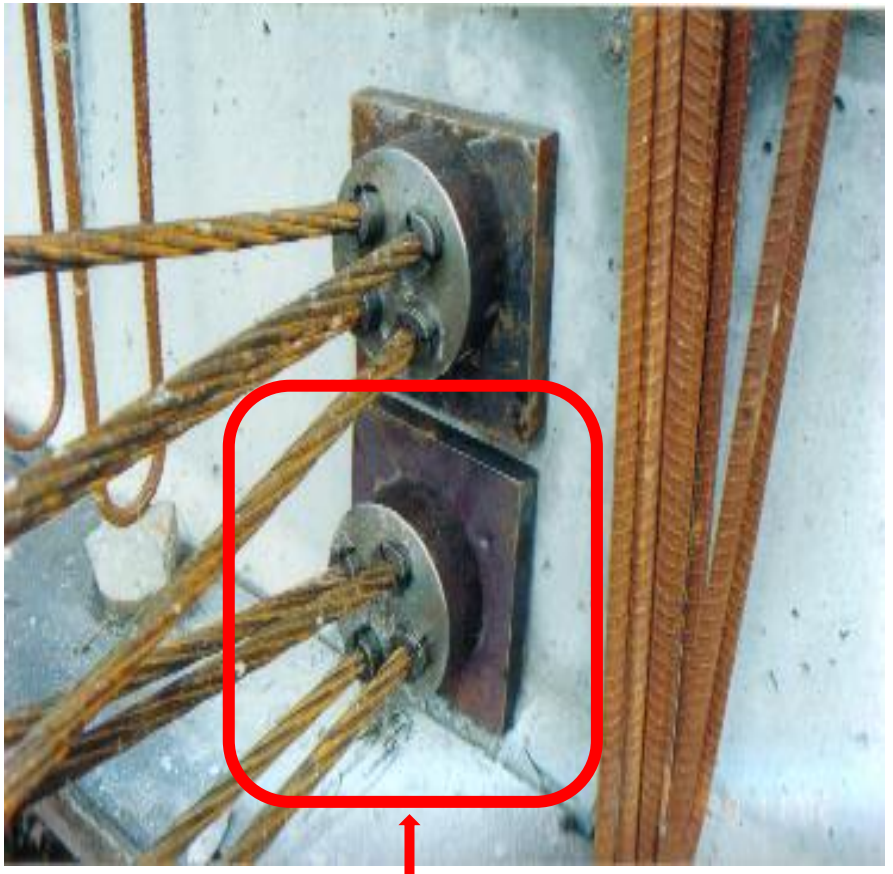
Pre-cast & Pre-stressed Concrete : WIRES

- Individual wires are used in pre-tensioned beams but have become less common in favour of strand; which has better bond characteristics.
- Wire diameters are typically between 5mm to 7mm, with a minimum tensile strength of between 1570 and 1860 N/mm2 carrying forces up to 45kN.

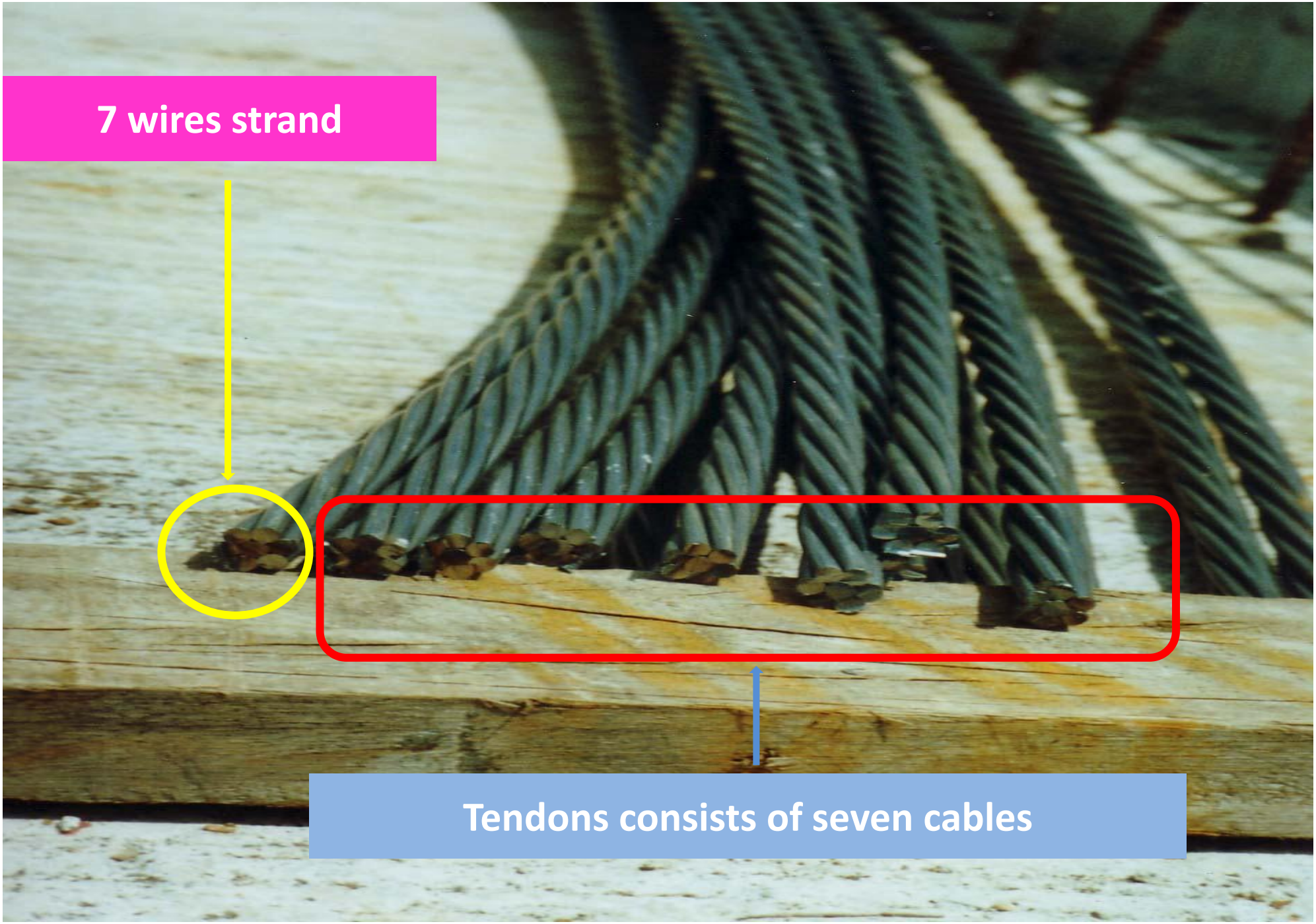


Pre-cast & Pre-stressed Concrete : STRANDS AND TENDONS

- The common pre-stressing is 7 wire strand; made up of individual cold-drawn wires with six outer wires twisted around an inner core wire
- For post tensioning, 13mm or 15mm diameter, 7 wire strand is used, either singly for pre-tensioning or in bundles to form multi strand tendons.
- The common post-tensioned tendon sizes utilize 7, 12, 19 or 27 strands.

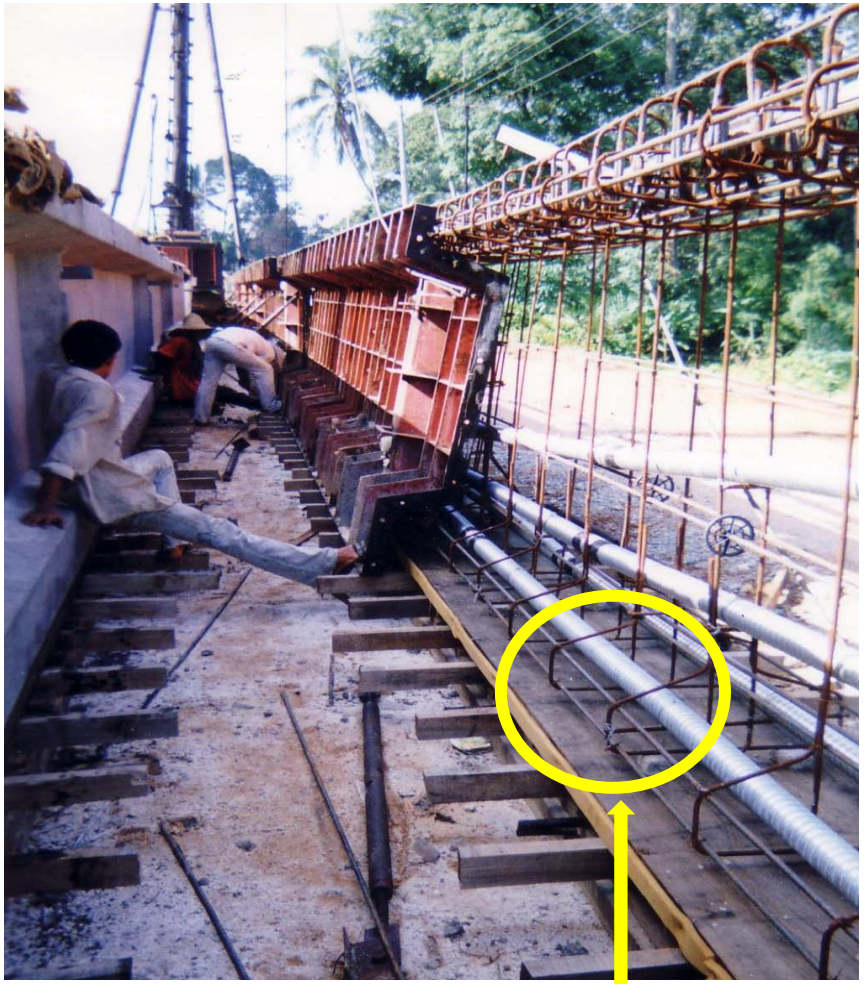


Multi strand tendon live-end anchor


7 wires strand
Tendons consists of seven cables

Pre-cast & Pre-stressed Concrete : DUCTING

- A duct is used to form a void through the concrete into which the tendon is placed.
- Ducts are made from corrugated steel covered by BS EN523 (1997) with a wall thickness of 0.25mm
- Meanwhile, corrugated plastic ducts also cal be used with a wall thickness of 2.5mm to 3.0mm thickness.
- External tendons are usually placed inside high-density polyethylene (HDPE) ducts.



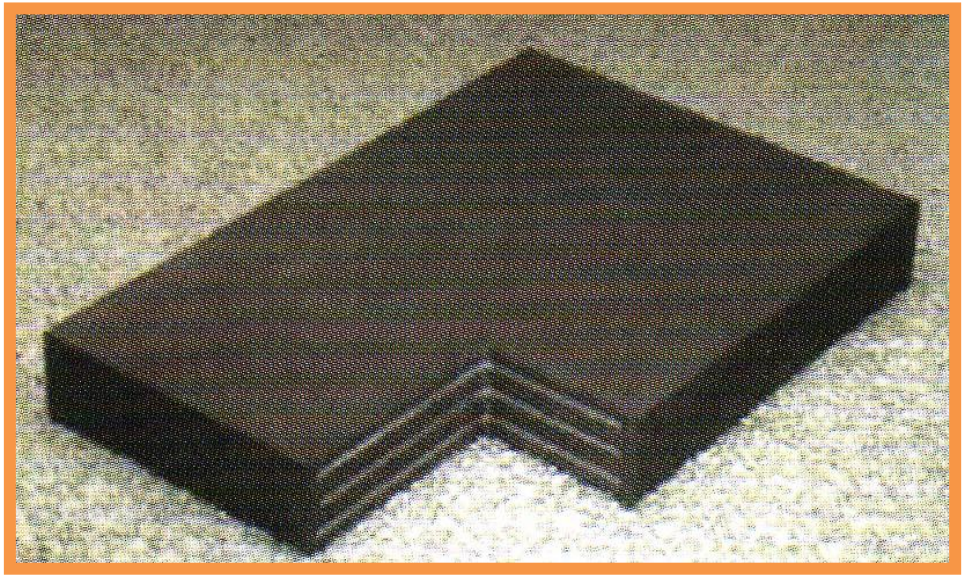
Steel duct

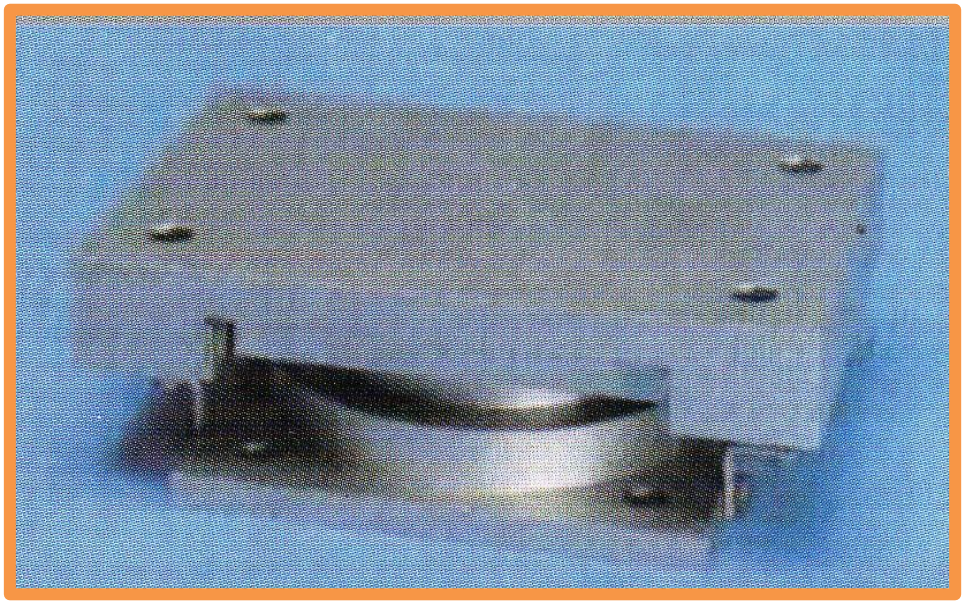
Pre-cast & Pre-stressed Concrete : ANCHORAGES

- For pre-tensioned strands the anchorage is by bond and friction of the bare strand cast into concrete
- For post-tensioned tendons, anchorage is achieve by using anchor blocks or an encased dead-end anchor.
- Stressing of multi-strand tendons is undertaken using jacks placed over the anchorage and tendon. The jack grips each strand and pulls the tendon until the required force is generated.

Multi strand tendon live-end anchor

Pre-cast & Pre-stressed Concrete : ANCHORAGES : BEARING PLATE





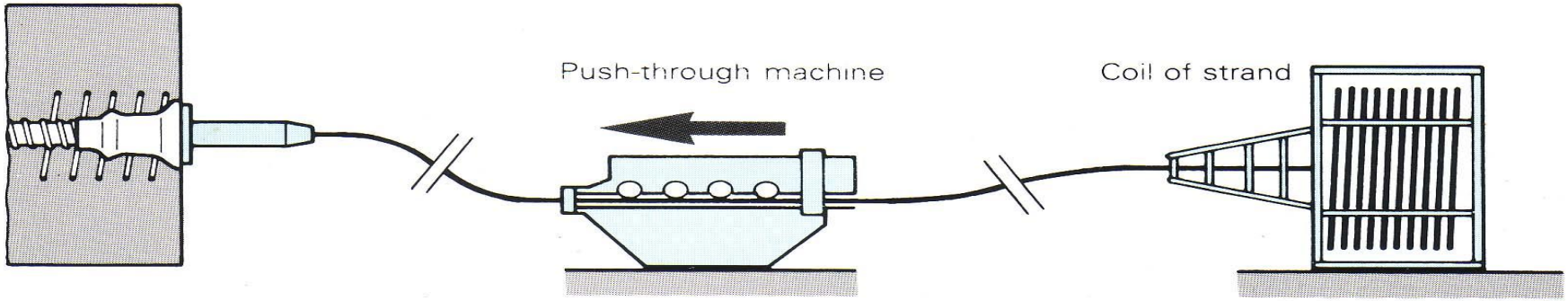
Pre-cast & Pre-stressed Concrete : EQUIPMENT FOR PLACING TENDONS

- For larger and longer multi-strand tendons, special equipment is needed to position the strand.
- In a multi-strand tendon, the strands are positioned by either pushing or pulling the strand into place.
- The push-through method involves pushing individual strands into the duct one at a time until the number is in position.
- The pull-through method is strands are first cut to length and bundled into a complete tendon at one end of the duct. A steel pulling rope is thread through the duct and connected to a winch at one.

The push-through method

Pushed-through

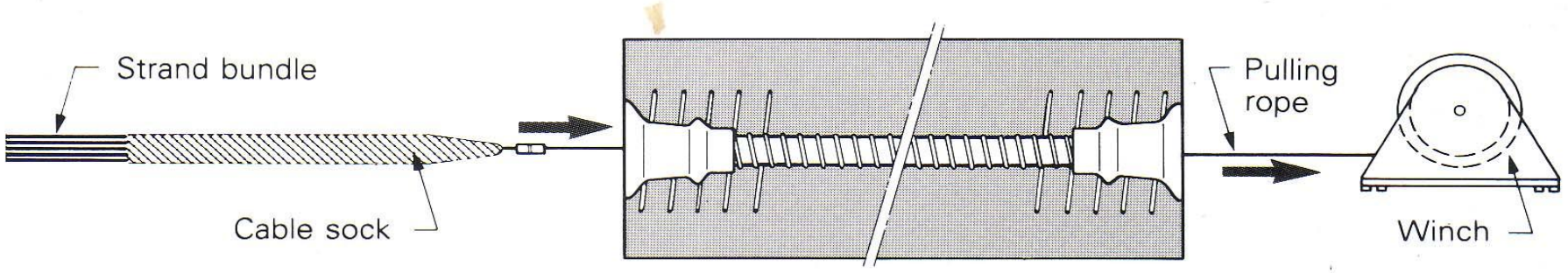
In the ***push-through method*** developed by VSL, the strands are pulled from the coil and pushed into the duct. Pushing-through may be carried out either before or after concreting.



The pull-through method

Pulled-through

In the ***pull-through method,*** the entire strand bundle is pulled through the duct after concreting.



Pre-cast & Pre-stressed Concrete : THE PUSH THROUGH METHOD

Placing of empty ducts

Pushing-through of strand

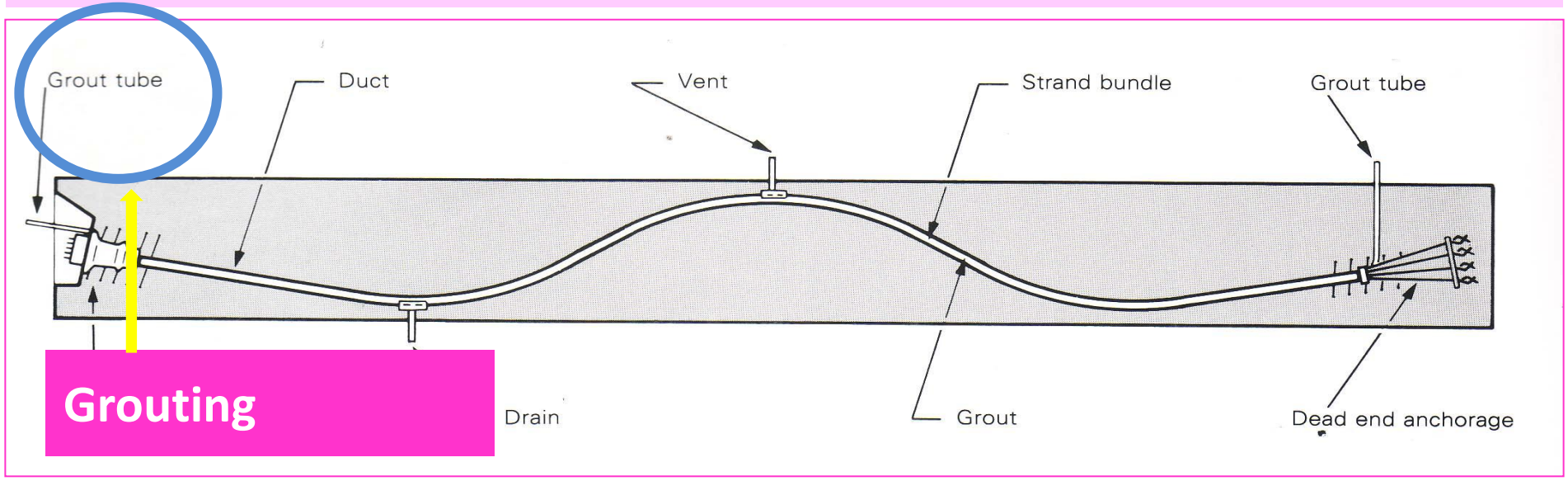
Pre-cast & Pre-stressed Concrete : STRESSING JACKS

- The jacks are hydraulically operated with oil pumped into the piston to apply load to the tendon.
- The larger jacks can generate a pulling force in excess of 1200 tonnes. The same jacks are also used to de-stress tendons.
- For de-stressing, special tools are used to move the jack back and to give access to the anchor wedge or nut allowing them to be loosened or removed.

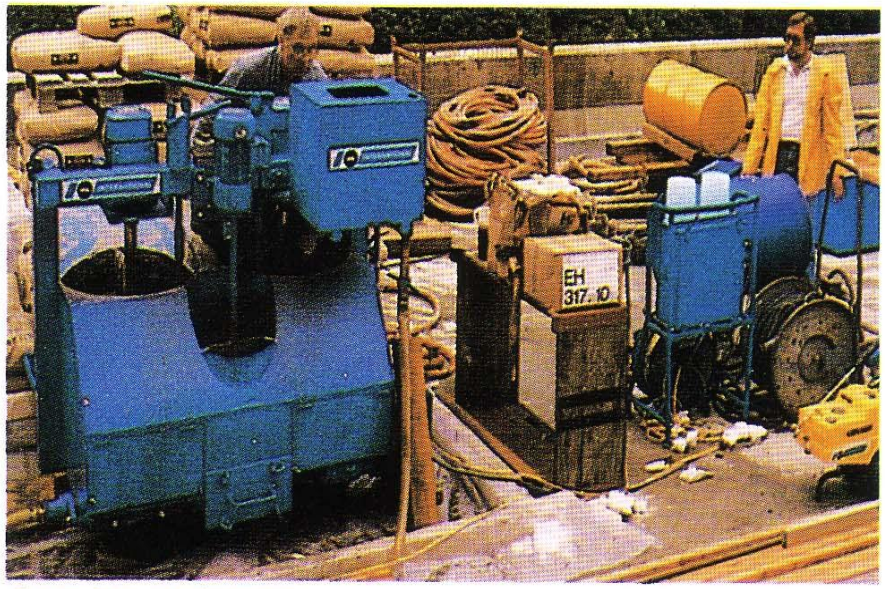
Stressing jack

Pre-cast & Pre-stressed Concrete : GROUTING AND VENTS

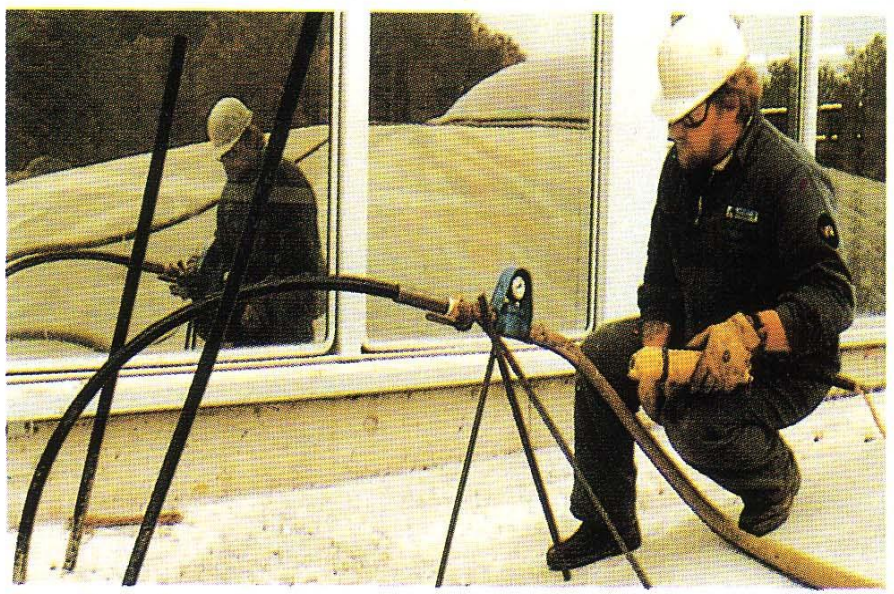
- Grouting mixing on site and these are used to mix the cement, water and any admixtures required to give a homogeneous grout.
- The post-tensioning system have a large hole in the bearing plate to allow the grout to be pumped in via the anchorage cap.
- Inlet tubes are needed to allow the grout to be pumped into the duct and should have a minimum internal diameter of 25mm.
- A grout pump combined with the mixing pans takes the fluids grout from the pans and pushed it into the duct via the inlet.
- All grouting equipment should be duplicated on site to ensure that back-up is always available in case of breakdowns.



Pre-cast & Pre-stressed Concrete : GROUTING AND VENTS



Grouting equipment

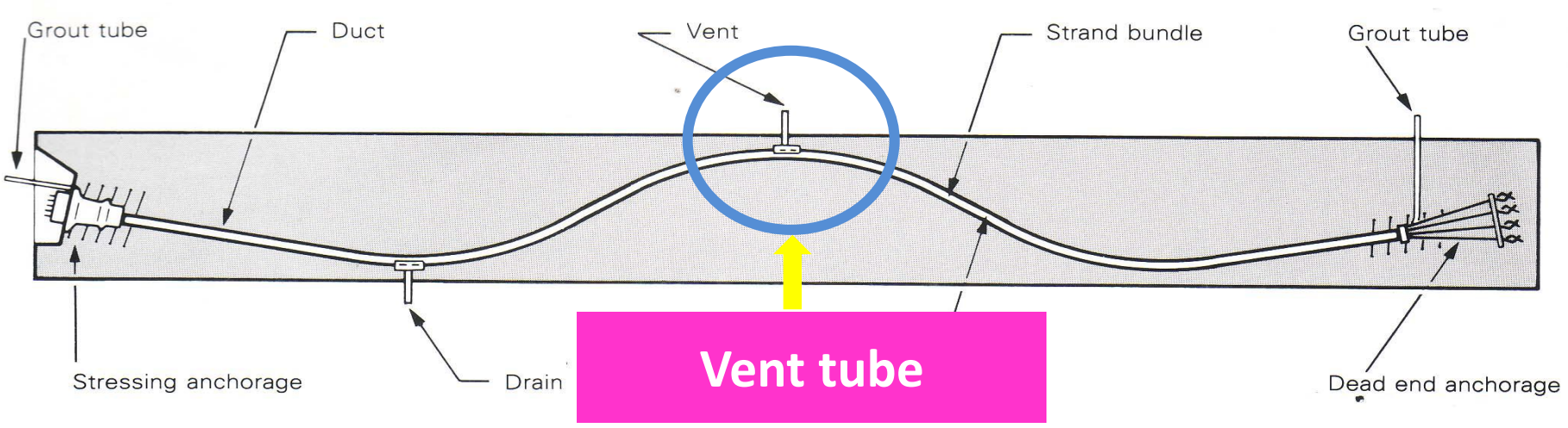


Grouting of tendon

- Grouting equipment includes mixer and pump in one unit.
- Grouting is usually carried out as soon as possible after stressing.

Pre-cast & Pre-stressed Concrete : GROUTING AND VENT

- Outlet tubes are required to vent off the air and to ensure the ducts are full of grout.
- Vents are provided at each low point, both to drain out any standing water and to draw off any trapped air.
- A vent is provided at the ‘far’ end of the duct to ensure that the duct is filled along its full length.
- Vents should be provided at regular intervals along ducts with long ‘flat’ profiles to remove trapped air that can occur as the grout runs along the bottom of the duct. The maximum vent spacing is less than 15m.



SMM2 measurement rules

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

SECTION F

Related Clauses : PRE-CAST & PRE-STRESSED CONCRETE

Clause	Description
F.34	Generally (Prestressed concrete work)
F.41-45	Contractor-designed construction
F.26	Generally (Composite construction)
F.35	In-situ concrete members
F.1-7	Generally (In-situ concrete)
F.36	Reinforcement to in-situ concrete members
F.8-9	Reinforcement
F.37	Formwork to in-situ concrete members
F.10-16	Formwork
F.38	Precast concrete units
F.17	Generally (Precast concrete)
F.21	Standard or purpose-made units
F.23	Temporary supports
F.39	Ducts, grooves and pockets
F.40	Prestressed tendons

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

F.34 GENERALLY

- Concrete members classified as prestressed concrete works where a stress is artificially induced in the concrete by means of tendons tensioned working load are applied.

- Prestressed concrete work and its reinforcement and associated formwork shall be given under an appropriate heading.

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

F.34 GENERALLY

- Work required to be designed by the Contractor shall be given in accordance with clauses F.41-45.

- Work of composite construction shall be given in accordance with clause F.26

Pre-stressed concrete beams deliver to site

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

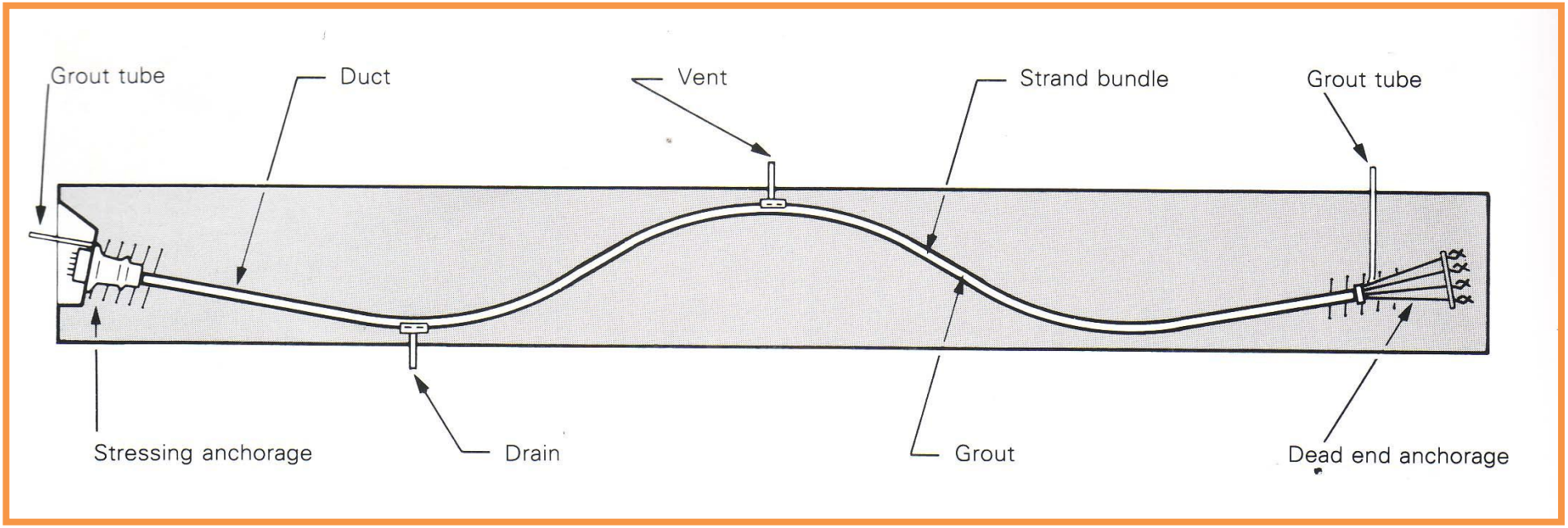
PRESTRESSED CONCRETE WORK

F.34 Generally

- A brief description of the prestressed work stating the method of tensioning shall be given.

- Location drawings showing the prestressing arrangements shall be provided except where stress is to be applied over the full length of a concrete member by means of continuous tendons running between the ends of the member.

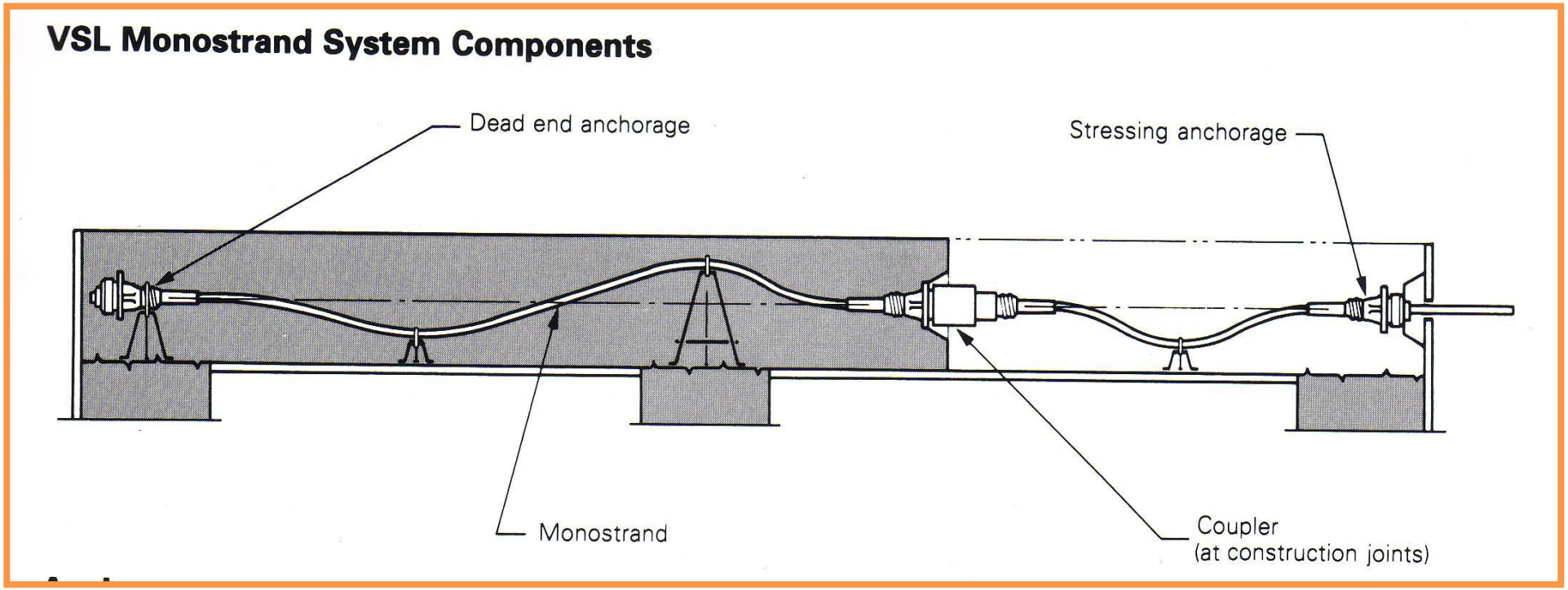
VSL Multistrand System Components : PRE-CAST & PRE-STRESSED CONCRETE



- Standardized tendon units with up to 55 strands of 13mm (0.5”) or 15mm (0.6”) diameter.
- Ducts of steel or polythelene
- Grouting with cements mortar or other materials.
- Simultaneous stressing of all strands in a tendon but individual locking of each at the anchorage.
- Stressing in any number of steps.

VSL Monostrand System : PRE-CAST & PRE-STRESSED CONCRETE

A brief description of the pre-stressed work



Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK

F.34 GENERALLY

Except in the case of standard or stock-pattern members particulars of the following shall be given:

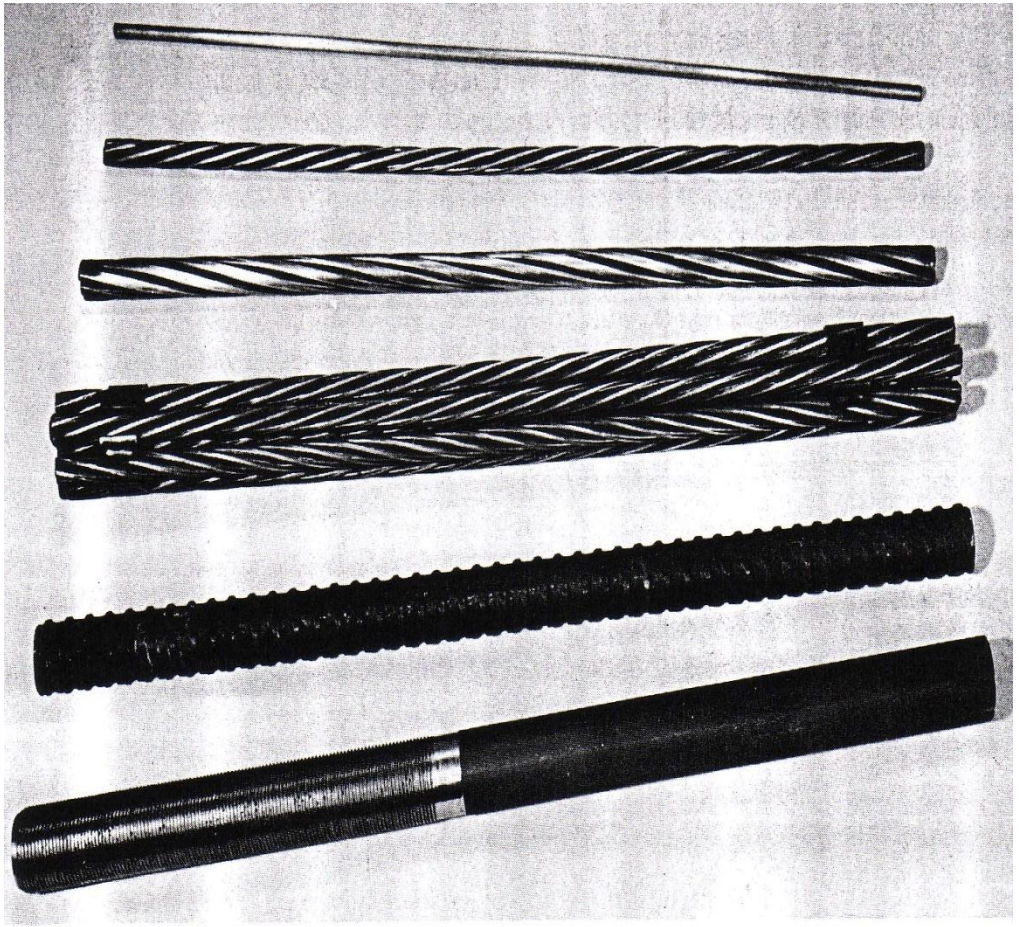
a. Materials of which the wires are composed, their diameters and details of any preparatory treatment.
b. Numbers of wires to be tensioned simultaneously.
c. Amount of tension to be applied to the wires.
d. Strength of concrete required at transfer of stress.
e. Tests.
f. Cutting off and treating the ends of wires.

Heading and Description : PRE-CAST CONCRETE BEAM

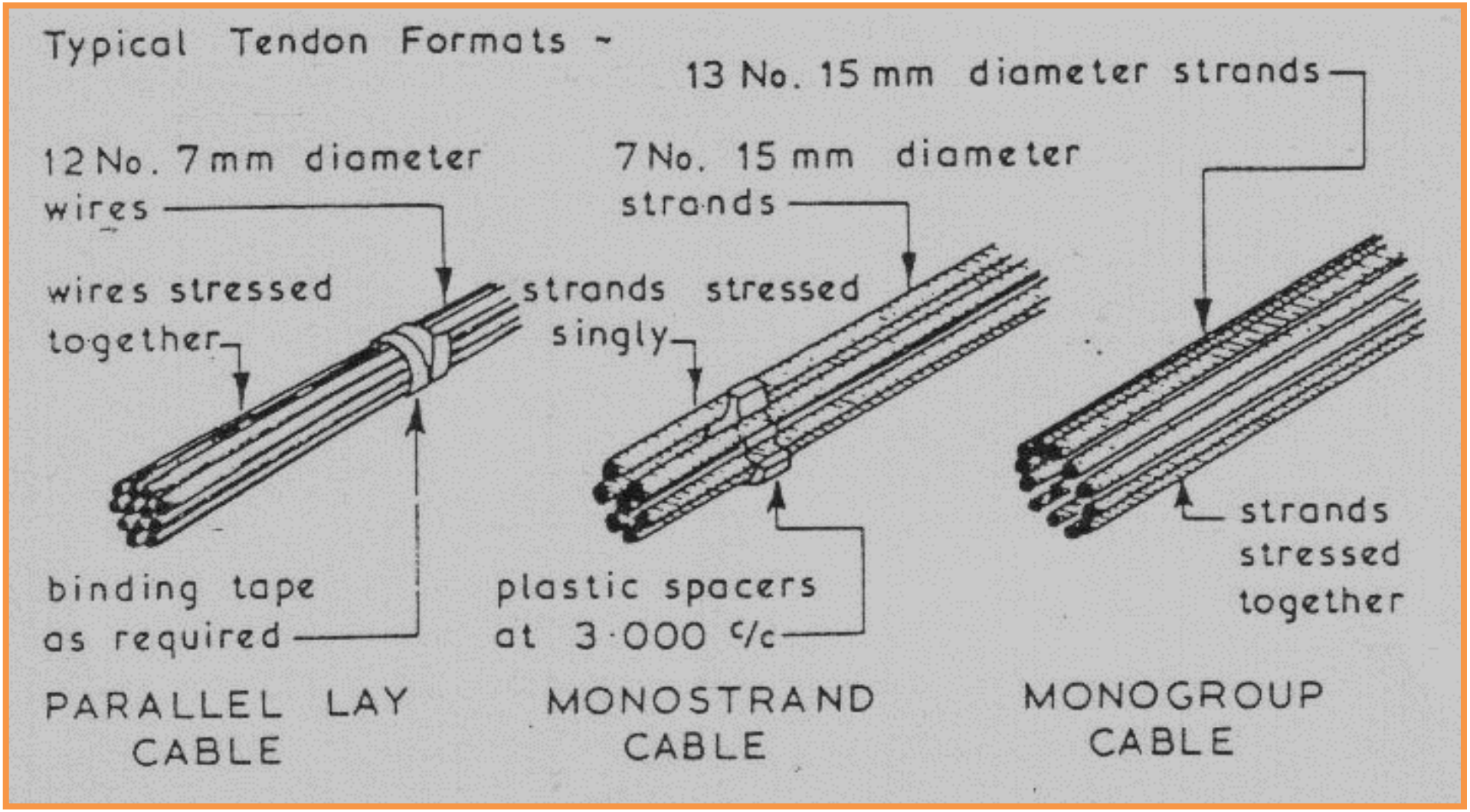
Description	Unit
Precast Concrete Beam 18000 mm long pre-cast beam, Grade 45 with approved type of reinforcement to engineer's details with minimum 23 days concrete works cube strength shall be 50N/mm3 minimum cube strength at transfer shall be 40N/mm3 including 7-wire super strands with low relaxation in accordance with ASTMA4160 – 82 per strands	No

Types of Tendon : PRE-CAST & PRE-STRESSED CONCRETE

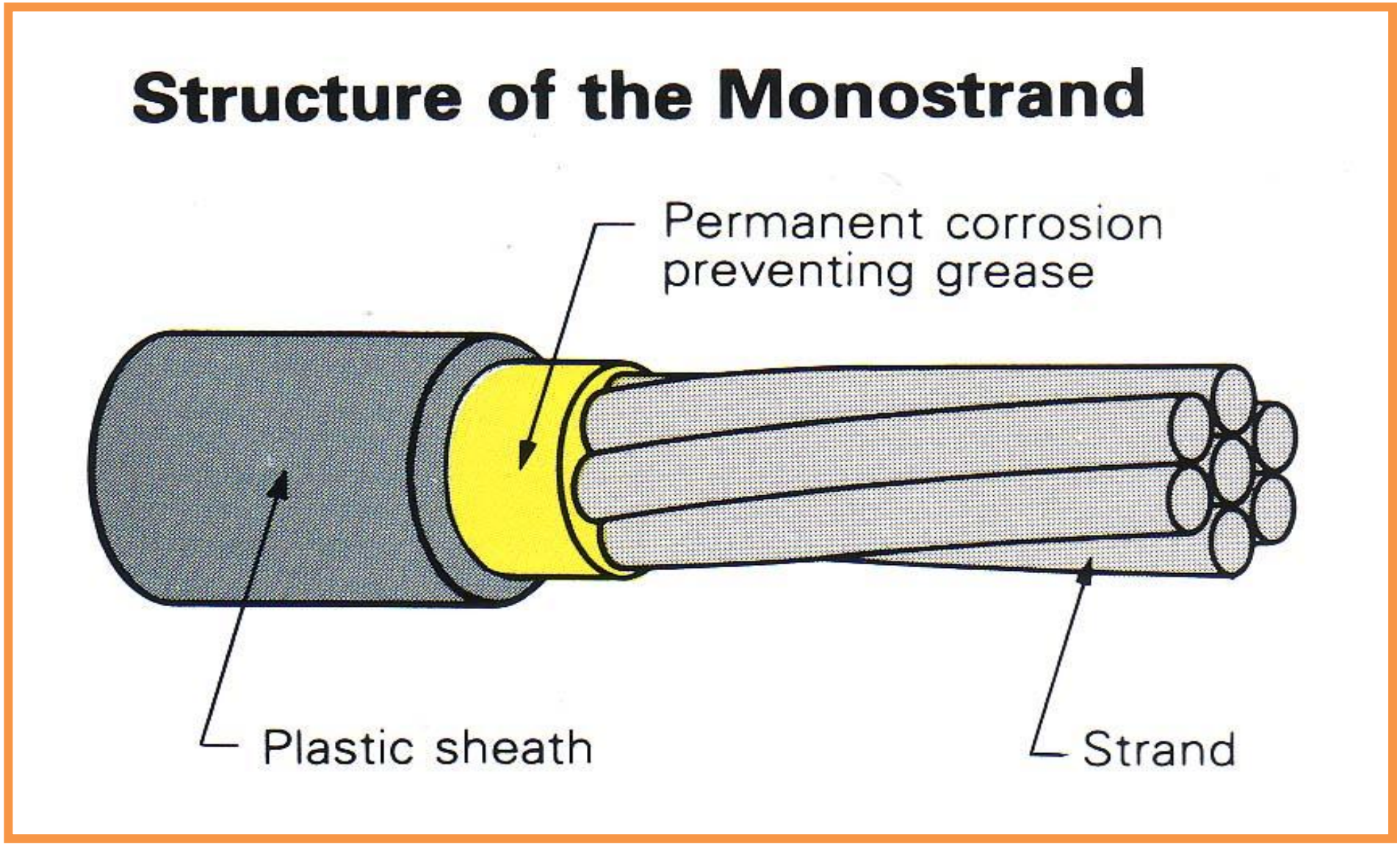
1. Wire
2. Standard strand
3. Drawn strand
4. Cable of seven strands
5. Dividing bar
6. Macalloy bar



Typical Tendon Format : PRE-CAST & PRE-STRESSED CONCRETE



Structure of Monostrand : PRE-CAST & PRE-STRESSED CONCRETE



Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK

F.34 GENERALLY

Where tendons are tensioned after the concrete is cast (post-tensioned) particulars of the following shall be given:

a. The type of jack used.

b. Details of anchorages and anchorage fittings.

C. Whether tensioning is carried out from one or both ends of tendons.

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK
F.35 IN-SITU CONCRETE MEMBERS

- In-situ concrete member shall be given in accordance with clauses F.1-7.
- Members not cast in a continuous length shall be so described stating the number and average length of separately cast section.
- Construction joints between section shall be enumerated -NO

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK
F.36 REINFORCEMENT TO IN-SITU CONCRETE MEMBERS

- Reinforcement shall be given in accordance with clauses F.8-9.

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK
F.37 FORMWORK TO IN-SITU CONCRETE MEMBERS

- Formwork shall be given in accordance with clauses F.10-16 subject to the following ;

a) Additional requirement for supporting formwork shall be described.

b) Formwork to pre-tensioned and post-tensioned work shall each be so described.

c) Temporary restraints required for tensioning of items for formwork.

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK
F.37 FORMWORK TO IN-SITU CONCRETE MEMBERS

- Formwork for *'anchorage pockets'* shall be enumerated - NO (stating the size and shape)

- Formwork for temporary construction joints shall be enumerated - NO (stating the section profile of the abutting units)

Anchorage Pockets : PRE-CAST & PRE-STRESSED CONCRETE

Measurement rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK
F.38 PRECAST CONCRETE UNITS

- Item description for precast concrete members which are assembled from sections cast separately shall state whether the sections are assembled before or after erection.

- Construction joint between adjacent units shall be enumerated.

- Temporary supports for precast units are self-supporting only after tensioning shall be enumerated stating the area of support required and its height where this exceeds 3.50m.

Typical Pre-cast Beam and Floor Deck Section : PRE-CAST & PRE-STRESSED CONCRETE

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

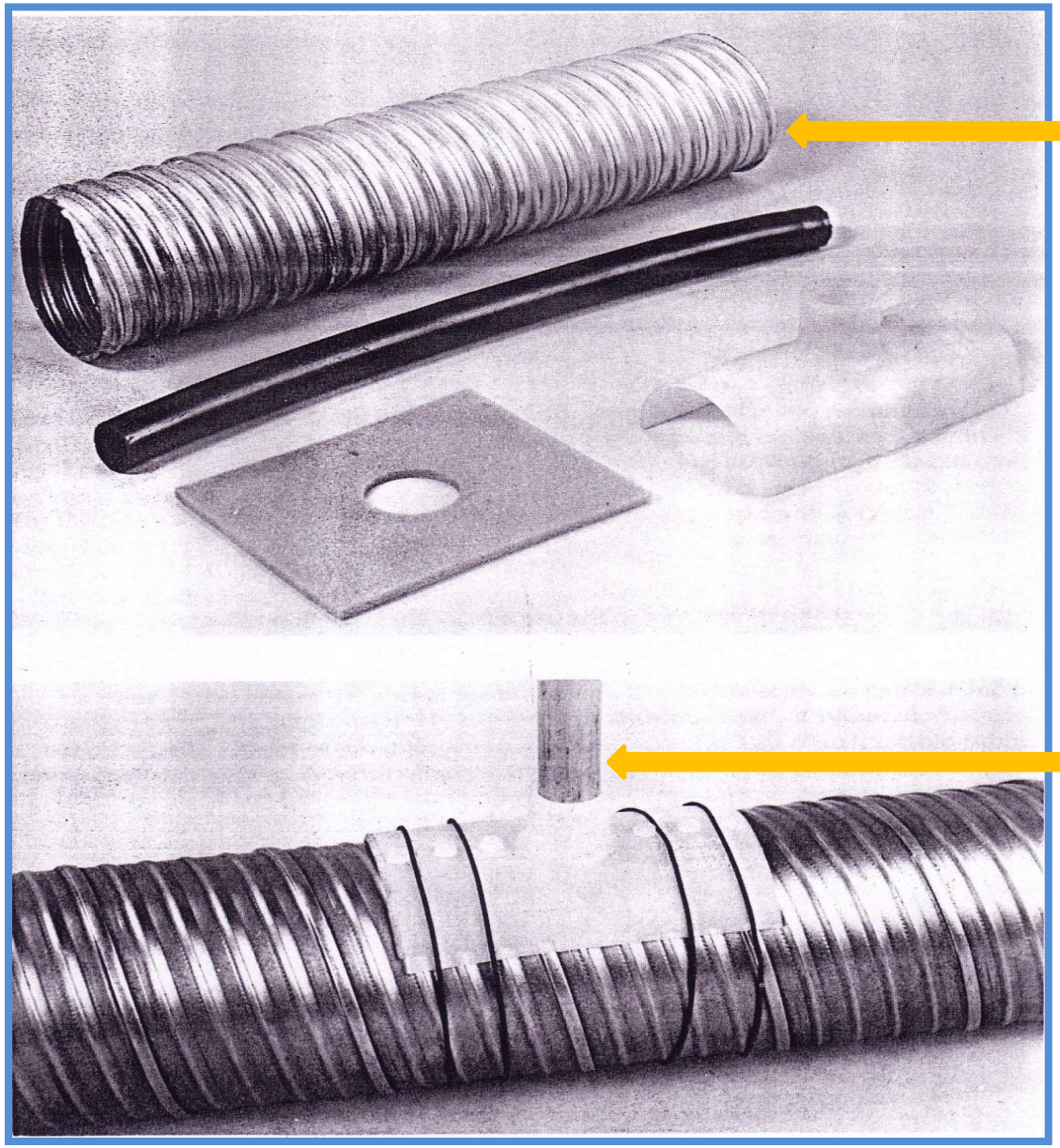
PRESTRESSED CONCRETE WORK

F.39 DUCTS, GROOVES AND POCKETS

- Ducts and grooves for post-tensioned prestressing tendons shall be given in metres (M) stating the number and size.

- Particular of the following shall be given: sleeves or sheathing, temporary supports & mix of grout.

Grouting Duct and Vent : PRE-CAST & PRE-STRESSED CONCRETE



Steel duct

Vent tube

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK

F.39 DUCTS, GROOVES AND POCKETS

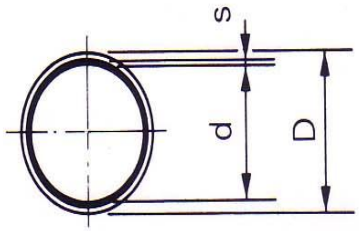
- Ducts and grooves over 6.00m long shall be so described stating the length in stages of 3.00m.

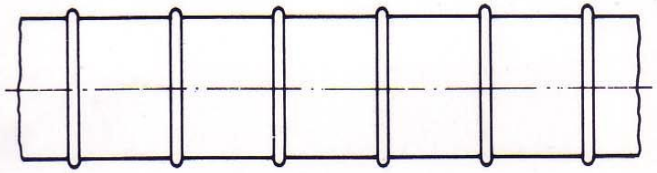
- Curved ducts shall be described separately.

Heading and Description : DUCTS AND GROOVE

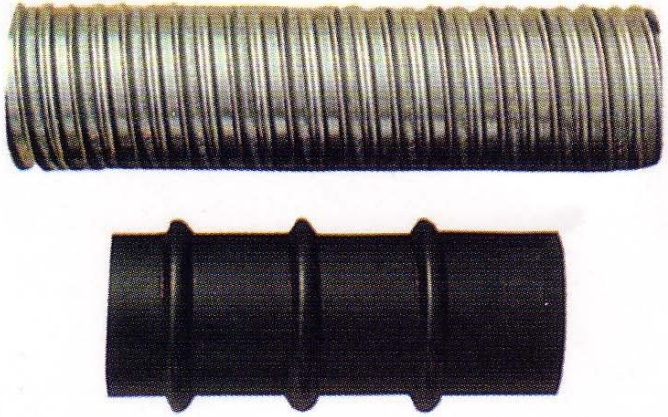
Description	Unit
Ducts and Groove ____ mm thick _____ mm diameter metal sheeting including temporary supports required, filling in with cement and sand grouting (1:3) in the formation of the curved duct exceeding 3.00m but not exceeding 6.00m.	m

Dimensions of Polyethylene Ducts PT-PLUS™





Strand type 13 mm (0.5")	Strand type 15 mm (0.6")	Dimensions of duct (mm)		
Tendon unit	Tendon unit	d	D	s
5-12	6-7	59	73	2
5-19	6-12	76	91	2.5
5-31	6-19/6-22	100	116	3
Other units on request				



Steel and polyethylene ducts

PT-PLUS™ system

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK

F39.3 DUCTS, GROOVES AND POCKETS- VENTS

- Vents shall be enumerated. NO

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK

F.39.4 FILLING OF ANCHORAGE POCKETS

- Filling of anchorage pockets shall be enumerated (NO) stating the finish of any exposed surface.

Filling of anchorage pockets shall be enumerated (NO)

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

PRESTRESSED CONCRETE WORK

F.40 PRESTRESSED TENDONS

- Prestressed tendons shall be enumerated (NO) stating their length, number of wires, ultimate strength and size of wires, type of core and sheathing.
- The lengths of pre-tensioned tendons shall be measured to the surfaces of the concrete members.
- Description shall state whether tendons are pre-tensioned or post-tensioned members.

Pre-stressed tendons shall be enumerated (NO)

Measurement Rules : PRE-CAST & PRE-STRESSED CONCRETE

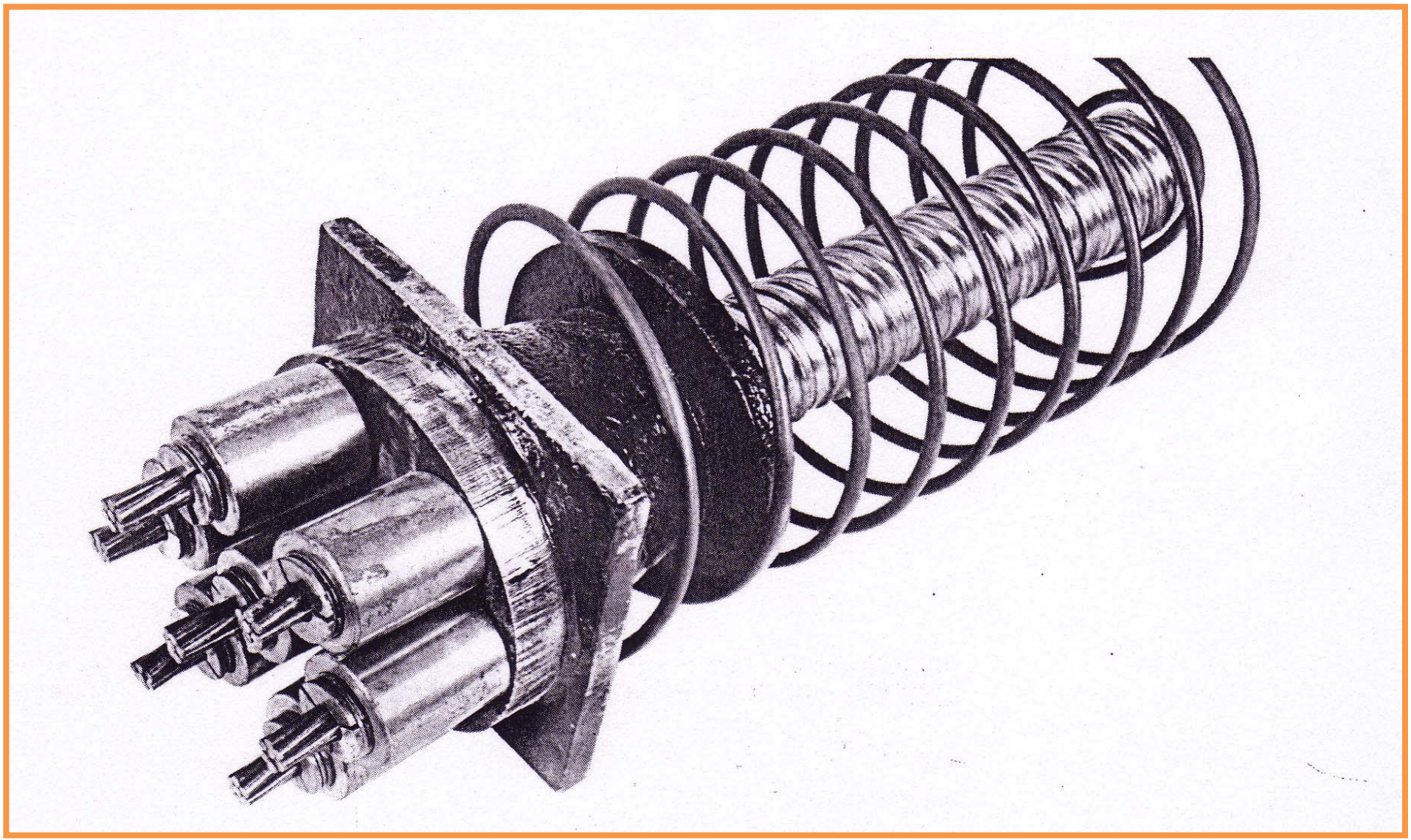
PRESTRESSED CONCRETE WORK
F.40.2 ANCHORAGES

- Anchorages shall be enumerated (NO) stating their components

Measurement rules : PRE-CAST & PRE-STRESSED CONCRETE

Anchorages shall be enumerated (NO)

SCD Seven Strand Anchorages : ANCHORAGE



Taking off list

Taking Off List : PRE-CAST & PRE-STRESSED CONCRETE

1	General	Item
2	Precast Concrete System : beam, floor, etc	No
3	Reinforcement (insitu)	kg
4	Formwork for anchorage pocket	No
5	Ducting	M
6	Vents	No
7	Tendons	No
8	Anchorages	No
9	Filling to anchorage pockets	No
10	Construction joint	No
11	Temporary support	No

Heading and description

Heading and Description : PRE-CAST CONCRETE BEAM

Description	Unit
Precast Concrete Beam 18000 mm long pre-cast beam, Grade 45 with approved type of reinforcement to engineer's details with minimum 23 days concrete works cube strength shall be 50N/mm3 minimum cube strength at transfer shall be 40N/mm3 including 7-wire super strands with low relaxation in accordance with ASTMA4160 – 82 per strands	No

Heading and Description : DUCTS AND GROOVE

Description	Unit
Ducts and Groove ____ mm thick _____ mm diameter metal sheeting including temporary supports required, filling in with cement and sand grouting (1:3) in the formation of the curved duct exceeding 3.00m but not exceeding 6.00m.	m

Heading and Description : TENDONS

Description	Unit
Tendons ___ mm long tendons cable conduit of 12 strands per cable, each strands consist of 7-wires super low relaxation, ___ mm diameter stressed with minimum of 188 kN per strand.	No

Heading and Description : TENDONS

Description	Unit
Anchorages Monostrand anchorage including wedges, forge steel anchorage block with 12 Nos of holes for strand, bearing plate cast into end of member including socket for steel duct.	No

Heading and Description : FILLING TO ANCHORAGE POCKETS

Description	Unit
Filling to Anchorage Pockets Filling into stressing and anchorage pockets with extreme size mm x mm including finished with emulsion paint on all exposed surfaces.	No

Heading and description : TENDONS

Description	Unit	Qty	Note
<u>Precast Prestressed Concrete Beam</u> <u>Tendons</u> Post tension tendons at a length of 19.70 m with minimum 127mm diameter 7 wire super low relaxation strands with a minimum UTS of 125 psi per strand Ditto, at a length of 19.71m, ditto, 124 psi per strand Ditto, at a length of 21.78m, ditto, 133 psi per strand	No	6	F.40.1- Prestressed tendons shall be enumerated stating their length, number of wires, ultimate strenght and size of wires, type of sheeting

Heading and Description : FILLING ANCHORAGE POCKETS

Description	Unit	Qty	Note
Precast Prestressed Concrete Beam Filling anchorage pocket Filling into stressing and anchorage pocket to level of beam ends with approved concrete grout strength	No	6	F.39.4 - Filling of anchorage pockets shall be enumerated stating the finish of any exposed surface

Heading and description : VENTS

Description	Unit	Qty	Note
Precast Prestressed Concrete Beam Vent Forming 250 mm diameter vent at 5 m centres at side of the beam including finished on every exposed upon completion	No	6	F39.3 - Vents shall be enumerated.

Heading and Description : ANCHORAGE

Description	Unit	Qty	Note
<u>Precast Prestressed Concrete Beam</u> <u>Anchorage</u> Anchorage of both ends of the beam according to manufactures instructions	No	6	F.40.2 - Anchorage shall be enumerated stating their components