Prestressed Concrete Design (SAB 4323)

End Block Design

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Introduction

- In post-tensioned construction, the prestressing force is transferred to the concrete through relatively small anchorage plates behind the anchorage by bearing. This results in a very high concrete bearing stress behind the anchorage plate.
- Failure of anchorage zone is perhaps the most common cause of problems arising during construction.
- Such failures are difficult and expensive to repair and might require replacement of the entire member

Introduction

- Anchorage zones failure due to uncontrolled cracking or splitting of the concrete from insufficient transverse reinforcement.
- Bearing failures immediately behind the anchorage plate are also common and may be caused by inadequate dimensions of bearing plates or poor quality of concrete

End Block

End Block

End Block

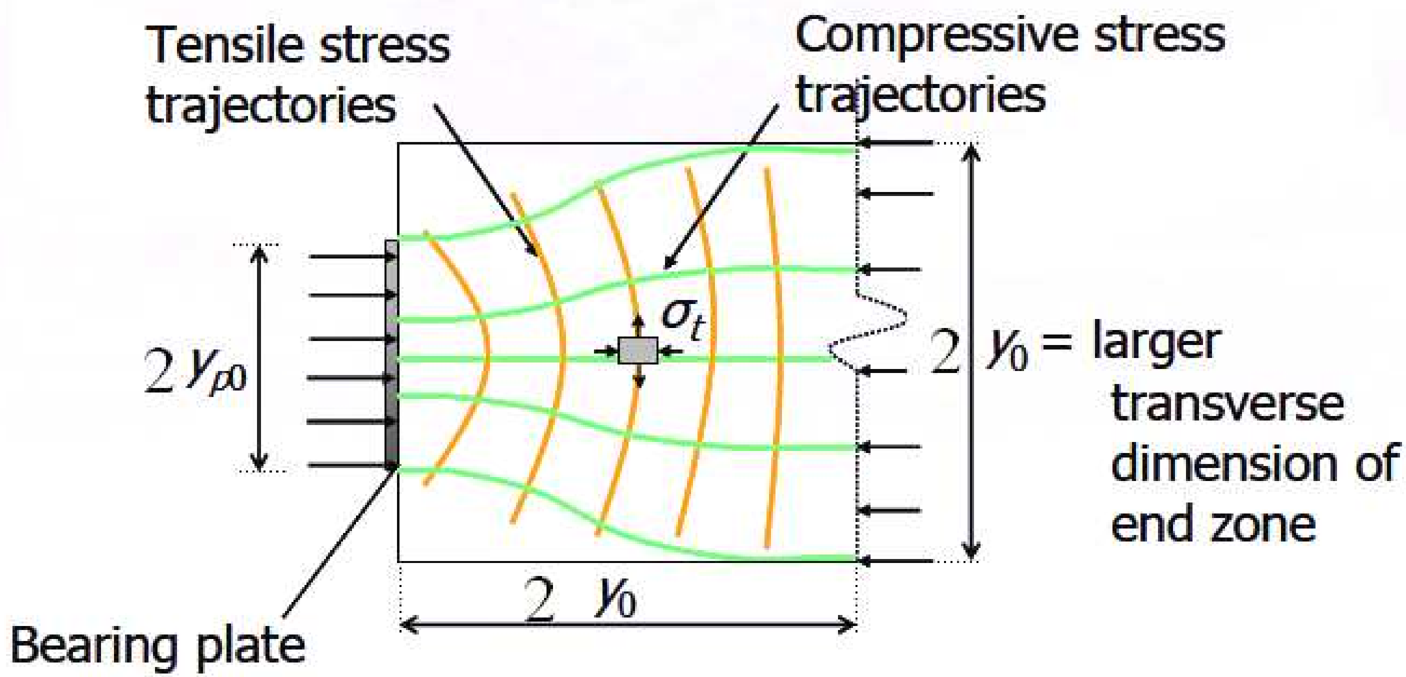
Stress Distribution

- The prestressing force in a tendon is applied through the anchorages as a concentrated force
- By St Venant's principle, the stress distribution in a member is reasonably uniform away from the anchorage, but in the region of the anchorage itself (D–Region) the stress distribution within the concrete is complex

Stress Distribution

- The most significant effect for design is that the tensile stresses are set up transverse to the axis of the member, tending to split this concrete apart (Refer to figures on the following slides)
- Reinforcement must be provided to contain these tensile stresses

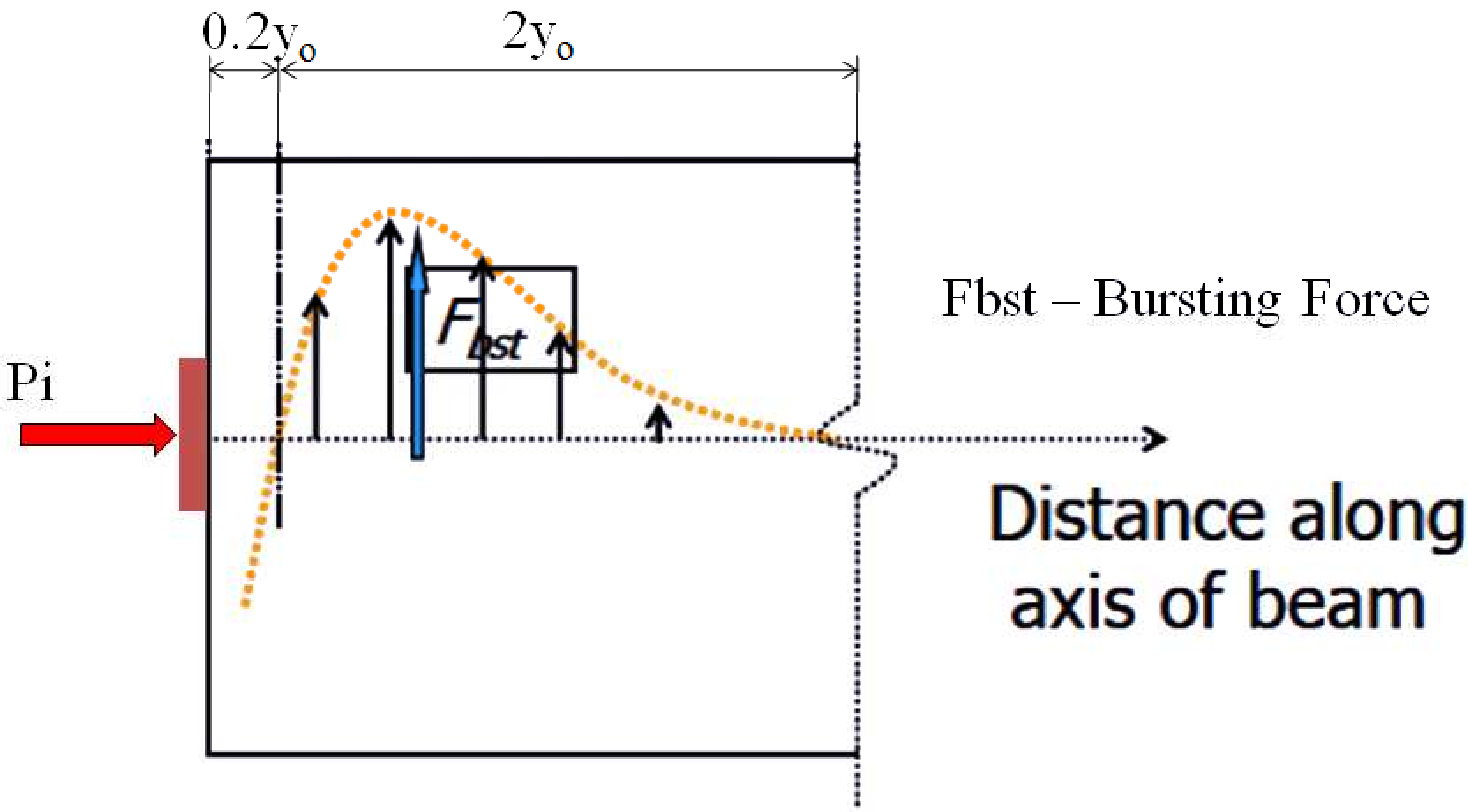
Stress Distribution



y_o is half the side of the end block;

y_{po} is half the side of the loaded area;

Stress Distribution



Stress Distribution

- It is sufficiently accurate to consider the resultant of these stresses, Fbst
- At SLS, Fbst is assumed to act in a region extending from $0.2y_o$ to $2y_o$
- The value of Fbst as a proportion of Pi may be found from Table 4.7 BS 8110 as shown below

Table 4.7 — Design bursting tensile forces in end blocks

y_{po}/y_o	0.2	0.3	0.4	0.5	0.6	0.7
F_{bst}/P_o	0.23	0.23	0.20	0.17	0.14	0.11

The above relationship can be defined by the following equation:

$\text{Fbst} = \text{Pi}\,(0.32 - 0.3y_{po}/y_o)$

with $y_{po}/y_o \le 0.3$, Fbst/Pi = 0.23; $y_{po}/y_o \ge 0.7$, Fbst/Pi = 0.11

Design for Bursting Force

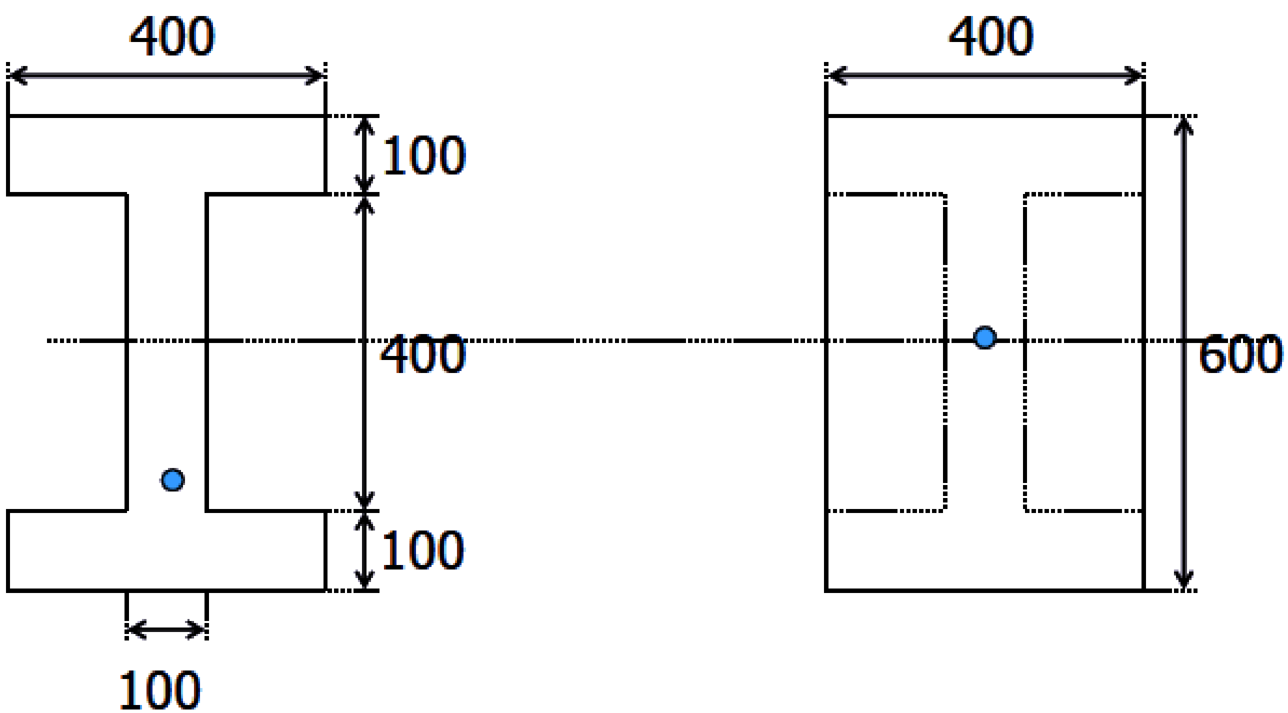
- For post-tensioned members which are grouted after tensioning, the maximum force applied to the member is the initial jacking force, Pi and the design is based on SLS
- The bursting force is resisted by reinforcement in the form of spirals or closed links, uniformly distributed throughout the end block (from $0.2y_o$ to $2y_o$) and with a stress of 200 N/mm^2

Design for Bursting Force

- For post-tensioned members with unbonded tendons, area of reinforcement is design at ULS given by Fbst / 0.87fy, where Fbst is obtained from Table 4.7 BS 8110
- Where an end block contains several anchorages, it should be divided into a series of symmetrically loaded prisms and then each prism treated as a separate end block. Additional reinforcement should be provided around the whole group of anchorages to maintain overall equilibrium

Example 9-1

Design the end block reinforcement for the following bonded post-tensioned beam. A prestressing force of 1055 kN is applied by a single tendon. Take e = 0 at supports.



Section beyond end zone

Section at end zone

Solution

Try the size of bearing plate = 200 mm x 300 mm

In the vertical direction,

y_{po} = 300/2 = 150 mm; y_o = 600/2 = 300 mm ; $y_{po}/y_o = 0.5 > 0.3$

Fbst = 1055 (0.32 – 0.3 (150/300)) = 179.35 kN

In the horizontal direction,

y_{po} = 200/2 = 100 mm; y_o = 400/2 = 200 mm ; $y_{po}/y_o = 0.5 >0.3$

Fbst = 1055 (0.32 – 0.3 (100/200)) = 179.35 kN

As = 179.35 x 1000 / 200 = 896.75 mm^2

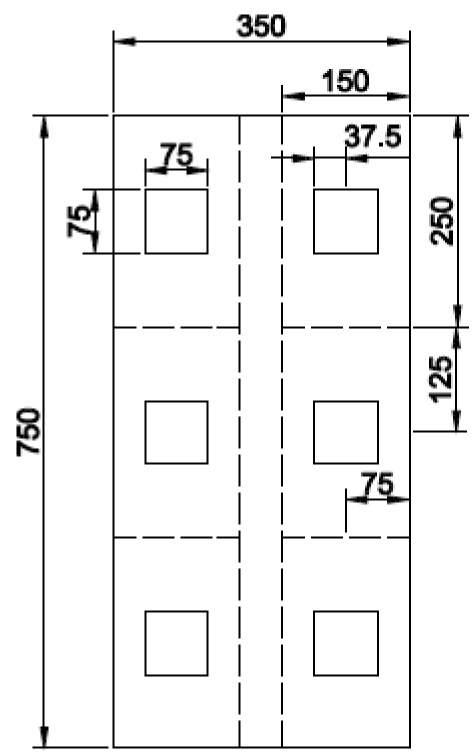
Use T12 - 2 legs, As = 113 mm^2;

No of links = 896.75/113 = 7.9, use 8

Provide 8 T12 through a distance of 600 mm ($2y_o$)

Example 9-2

The beam end shown below has six anchorages with 75 mm sq bearing plates and a jacking force of 500 kN applied to each. Determine the reinforcement required to contain the bursting forces if fy = 460 N/mm^2.



Solution

Individual Prism (150 mm x 250 mm)

In the vertical direction,

y_{po} = 75/2 = 37.5 mm; y_o = 250/2 = 125 mm ; y_{po}/y_o = 0.3 = 0.3

Fbst = 500 (0.32 – 0.3 (37.5/125)) = 115 kN

In the horizontal direction,

y_{po} = 75/2 = 32.5 mm; y_o = 150/2 = 75 mm ; y_{po}/y_o = 0.43 > 0.3

Fbst = 500 (0.32 – 0.3 (37.5/75)) = 85 kN

Max Fbst = 115 kN

As = 115 x 1000 / 200 = 575 mm^2

Use T10 – 2 leg, As = 157 mm sq; No of links = 575/157 = 3.7, use 4

Provide 4 T10 through a distance of 250 mm ($2y_o$)

Solution

Overall Prism (350 mm x 750 mm)

Equivalent $2y_{po}$ = $(6 \times 75 \times 75)^{1/2}$ = 184 mm

In the horizontal direction,

y_{po} = 184/2 = 92 mm; y_o = 350/2 = 175 mm ; y_{po}/y_o = 0.53>0.3

Fbst = 6 x 500 (0.32 – 0.3 (92/175)) = 486 kN

In the vertical direction,

y_{po} = 184/2 = 92 mm; y_o = 750/2 = 375 mm ; y_{po}/y_o = 0.25 < 0.3

Fbst = 6 x 500 x 0.23 = 690 kN

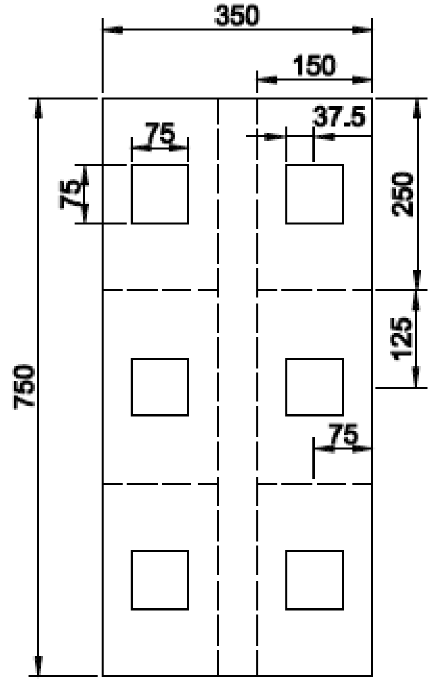
Max Fbst = 690 kN

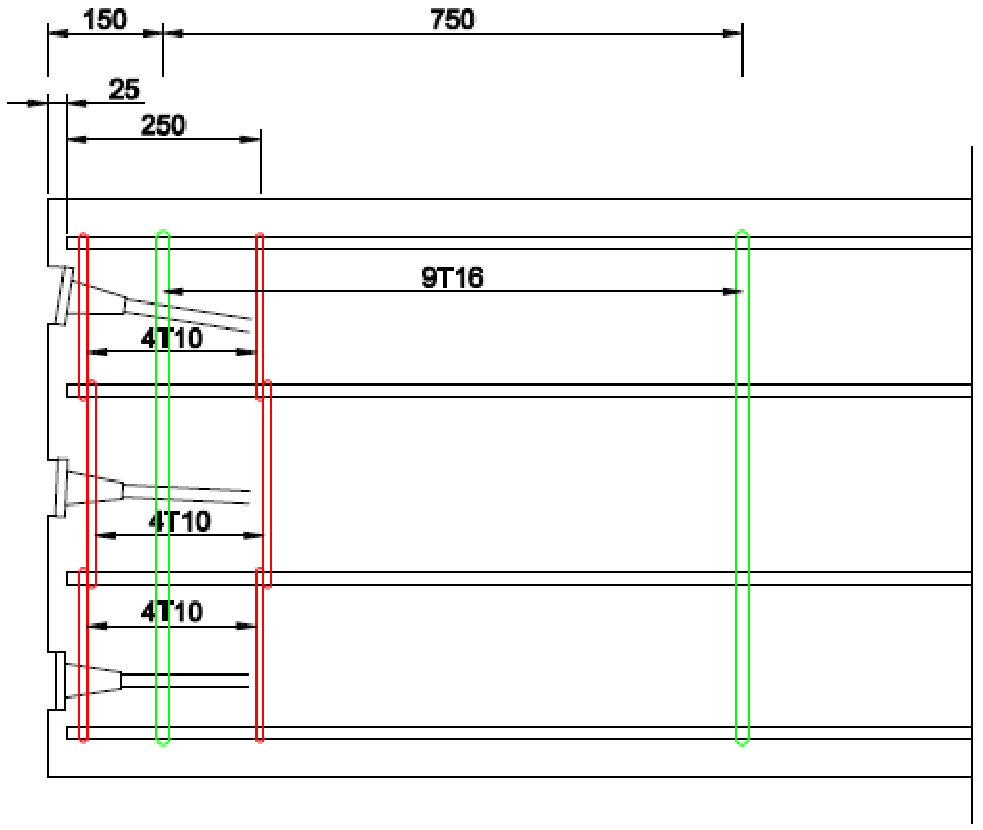
As = 690 x 1000 / 200 = 3450 mm^2

Use T16 – 2 leg, As = 402 mm^2; No of links = 3450/402 = 8.5, use 9

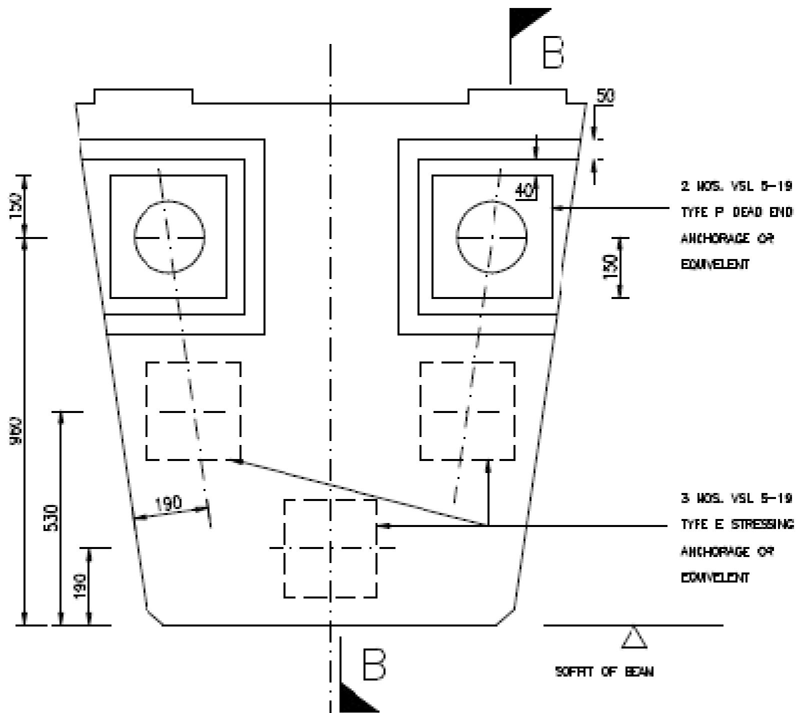
Provide 9T16 through a distance of 750 mm ($2y_o$)

Detailing of Reinforcement

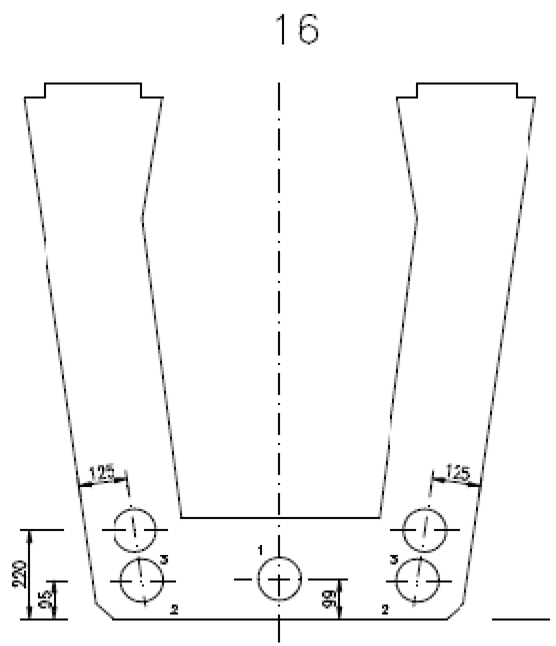




Detailing Examples



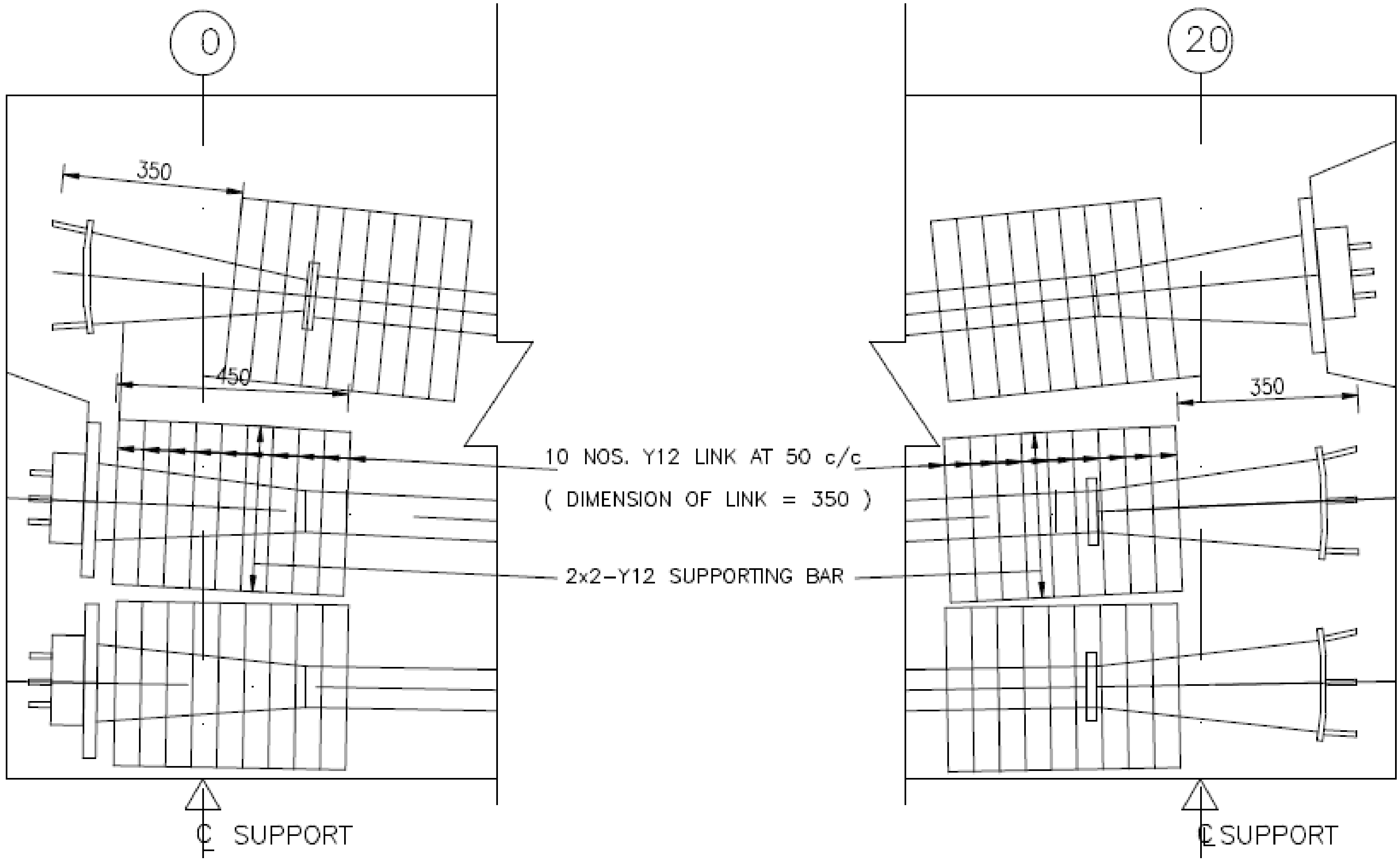
DETAIL OF RIGHT END BLOCK



ARRANGEMENT OF CABLE AT POINT

SCALE 1 : 10

Detailing Examples



END BLOCK REINFORRCEMENT FOR DEAD AND STRESSING END

Detailing Examples