DEPARTMENT OF CIVIL ENGINEERING

IIT DELHI

PILE CAP DESIGN

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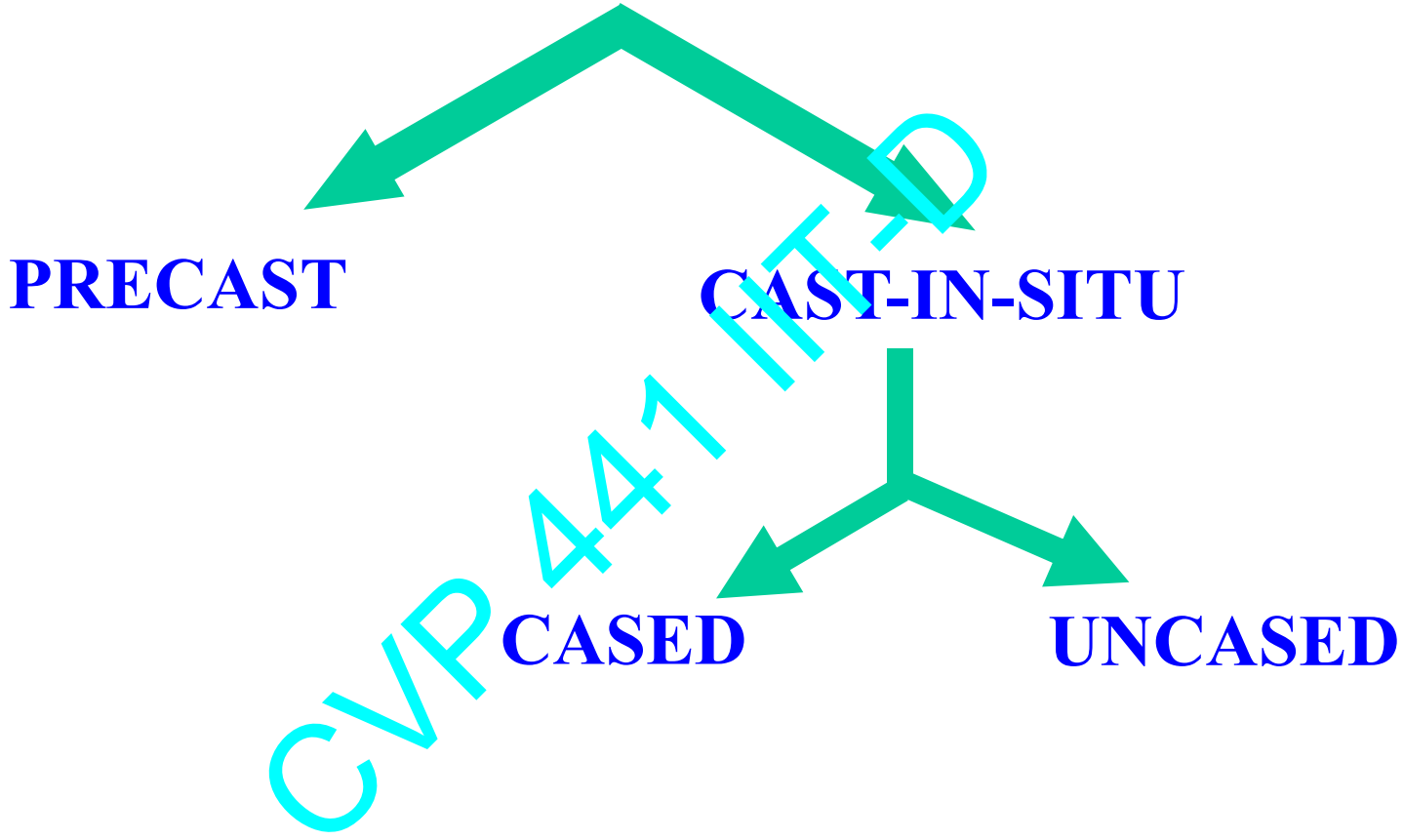
PILES



WHEN PILES SHOULD BE USED??

Soil is too weak

Predominantly lateral loads

High possibility of uplift

Under marine environment

The structural engineer should choose foundation type in consultation with the Geotechnical Engineer.

INPUTS FROM SOIL REPORT

Pile type, diameter and length

Load capacity in compression

Load capacity in uplift

Lateral load capacity

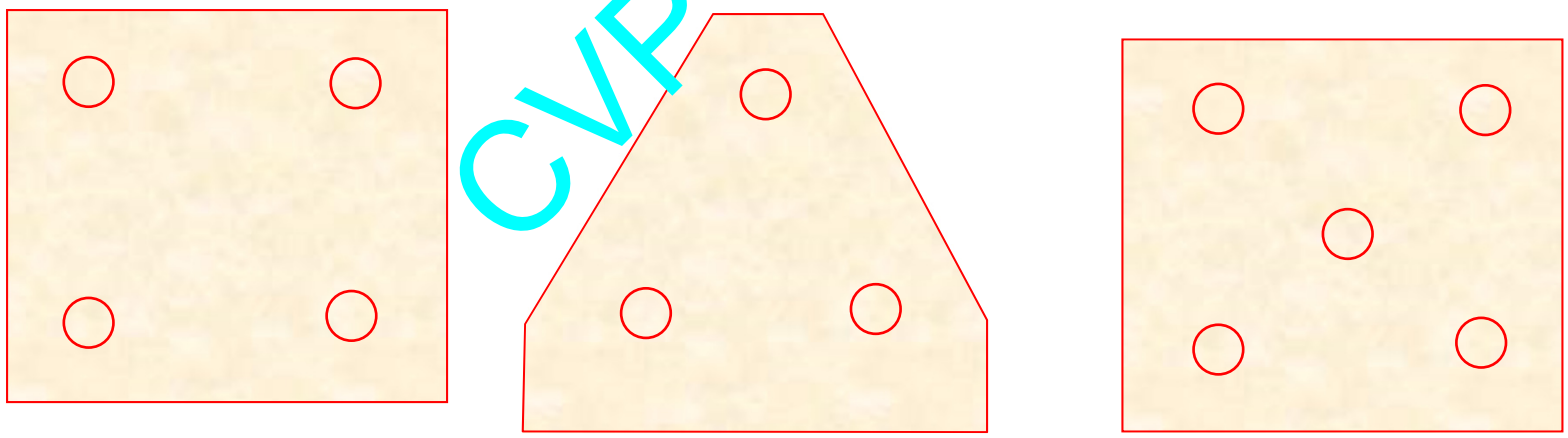
In addition, good Geotechnical Engineers generally provide pile reinforcement. Otherwise, they should provide details of lateral load analysis.

DESIGN OF PILE FOUNDATION SYSTEM

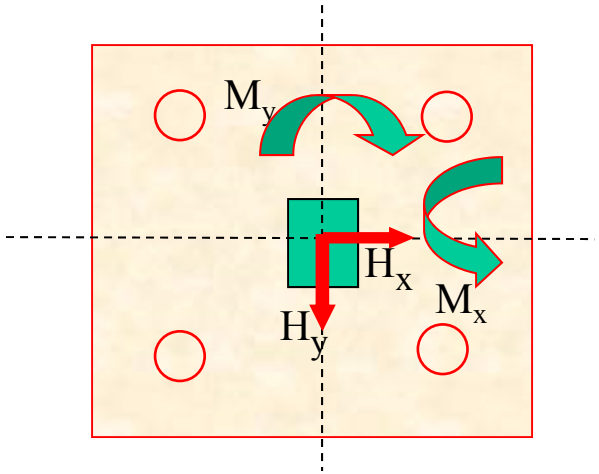
(1) Number and layout of piles (pile layout)

Will depend on the load and moments at the base of the columns.

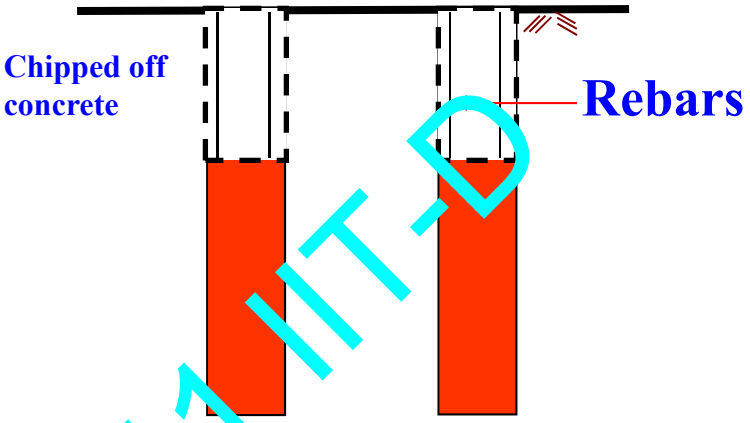
(2) Design of pile caps



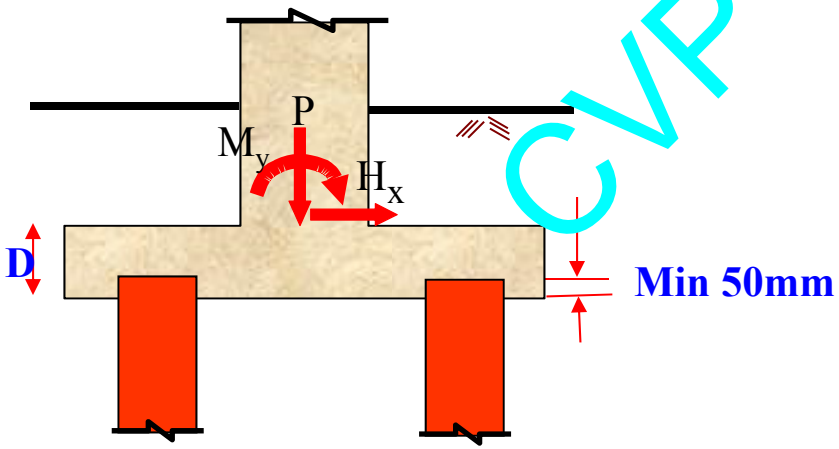
NUMBER AND LAYOUT OF PILES



PLAN



ELEVATION



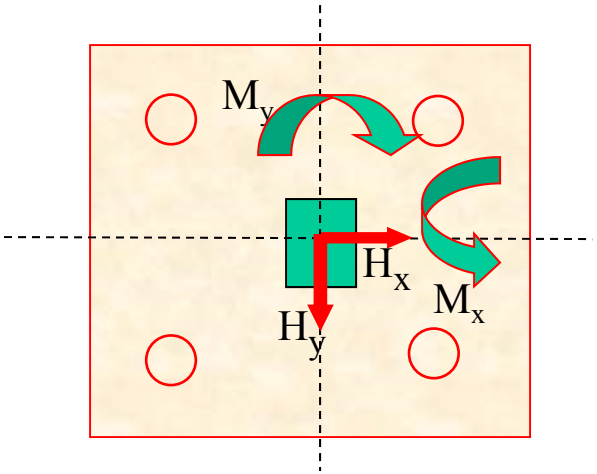
Loads and moments must be calculated at the base of the pile cap

$P_t = P + \text{Overburden}$

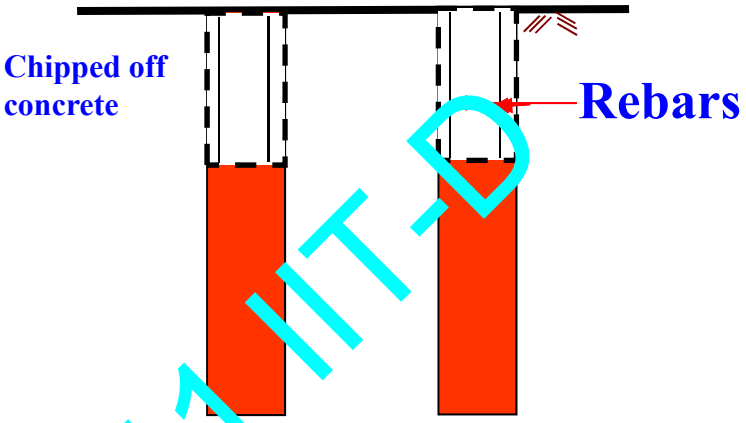
$M_{xt} = M_x + H_y * D$

$M_{yt} = M_y + H_x * D$

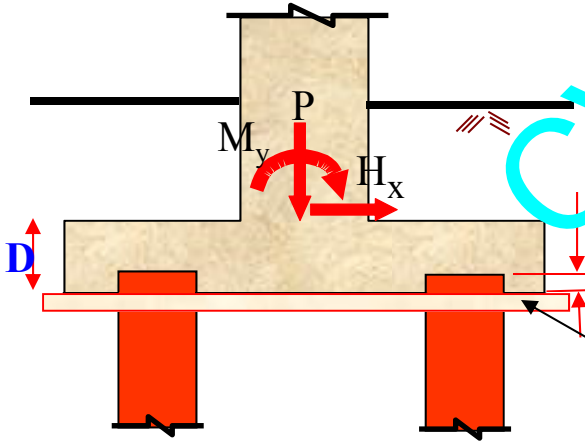
NUMBER AND LAYOUT OF PILES



PLAN



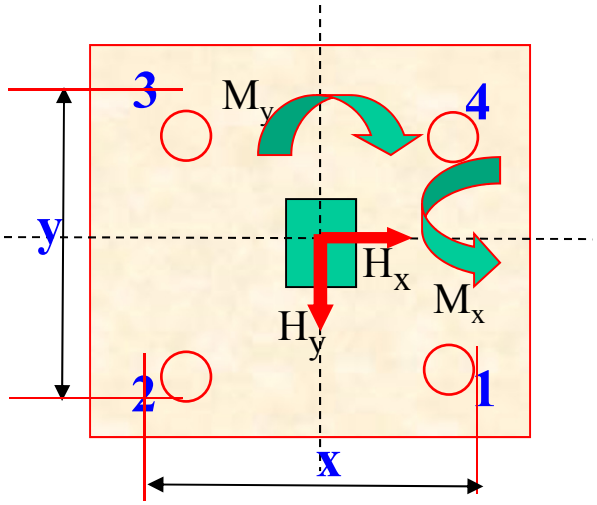
ELEVATION



Min 50mm

Min 75mm thick levelling course
(1:5:10 lean concrete)

NUMBER AND LAYOUT OF PILES



Pile forces

$F_1 = (P_t /4)+ (M_{xt}/2y)+ (M_{yt}/2x)$

(Compression)

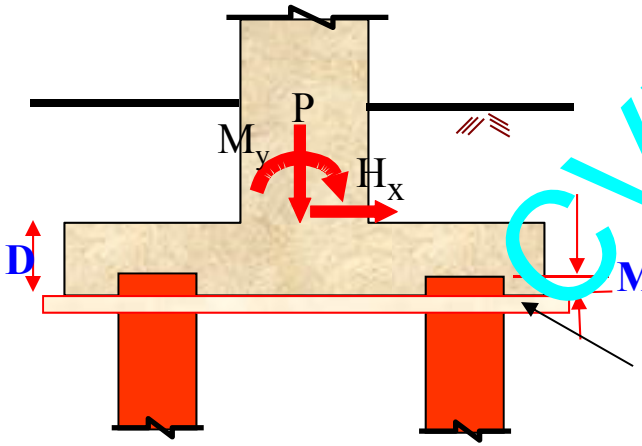
$F_3 = (P_t /4)- (M_{xt}/2y)- (M_{yt}/2x)$

Could be negative i.e uplift

Lateral force = sqrt (Hx^2+Hy^2)/4

Must make sure that

Max compressive force	<=	Pile capacity in compression
Max uplift force	<=	Pile capacity in uplift
Max lateral force	<=	Lateral load capacity



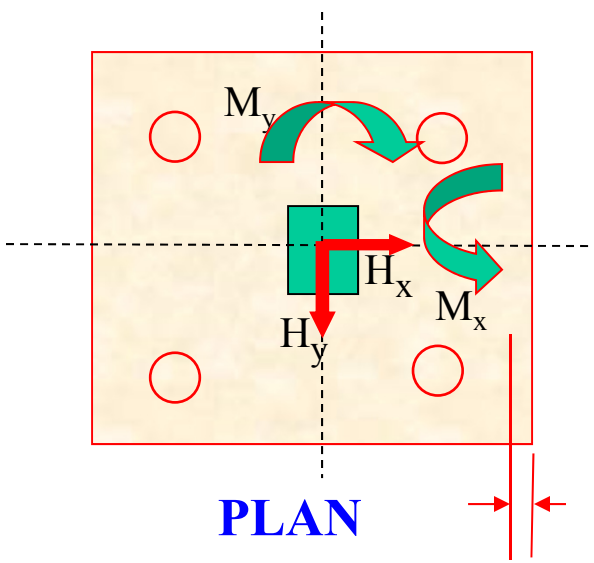
If unsafe

Increase x or y or number of piles

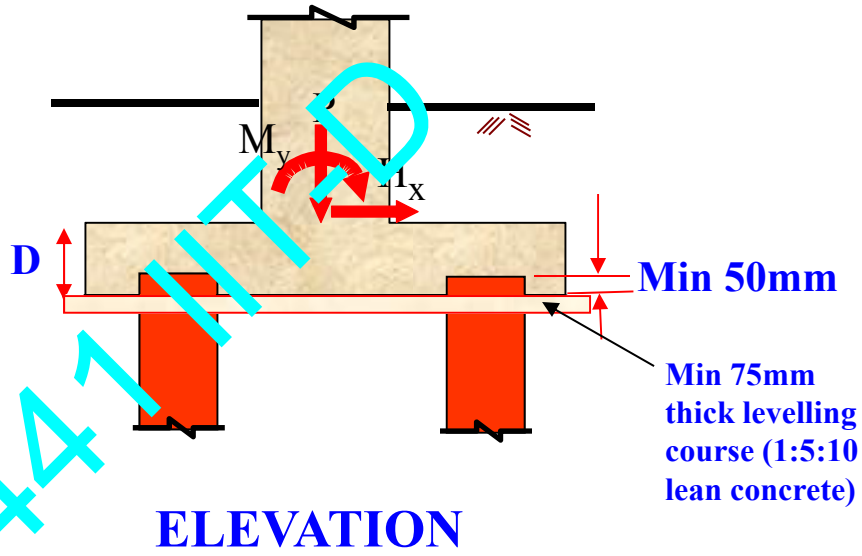
If oversafe

Reduce number of piles

NUMBER AND LAYOUT OF PILES



PLAN



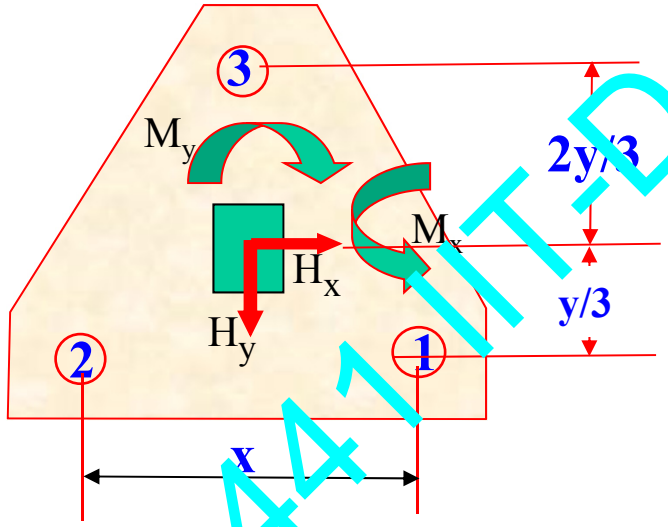
ELEVATION

Clear overhang = 100mm

Preferably 150mm (Sinha, 2005)

Min D should be 500mm

NUMBER AND LAYOUT OF PILES



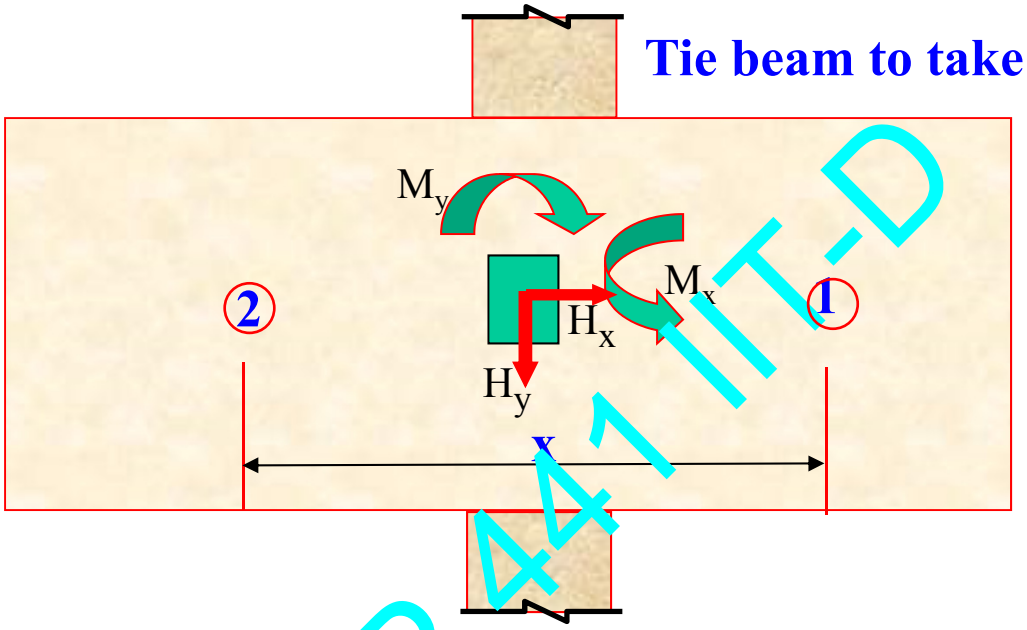
Pile forces

$F_1 = (P_t/3) + (M_{xt}/2y) + (M_{yt}/x)$ (Compression)

$F_2 = (P_t/3) + (M_{xt}/2y) - (M_{yt}/x)$ (Compression/ Uplift)

$F_3 = (P_t/3) - (M_{xt}/y)$ (Compression/ Uplift)

NUMBER AND LAYOUT OF PILES



Pile forces

$F_1 = (P_t /2) + (M_{yt}/x)$ (Compression)

$F_2 = (P_t /2) - (M_{yt}/x)$ (Compression/ Uplift)

In general, for an array of n number of piles:

$$F_i = (P_t / n) \pm (M_{xt} y / \sum y^2) \pm (M_{yt} x / \sum x^2)$$

MINIMUM SPACING OF PILES

(IS 2911 Part 1, sec 2: 1979)

Friction piles	3 * Pile diameter
End bearing piles through compressible strata	2.5 * Pile diameter
End bearing piles through compressible strata and resting on stiff clays	3.5 * Pile diameter or 1050mm (whichever is more)

It is always advisable to send the pile layout drawing to the Geotechnical engineer before approving for construction

STRUCTURAL DESIGN

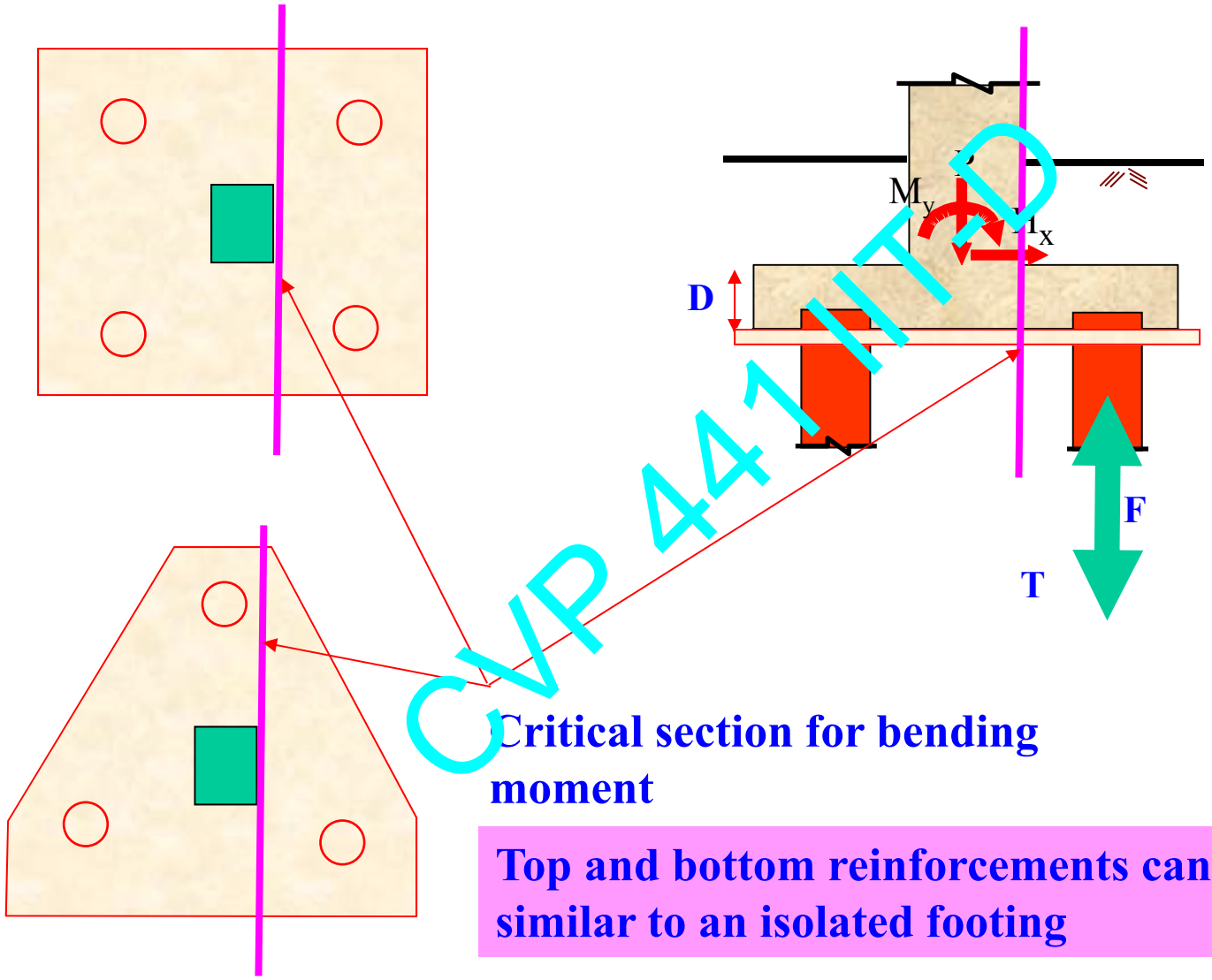
OF PILE CAPS

Design for bending

Check for one-way shear

Check for two-way/ punching shear

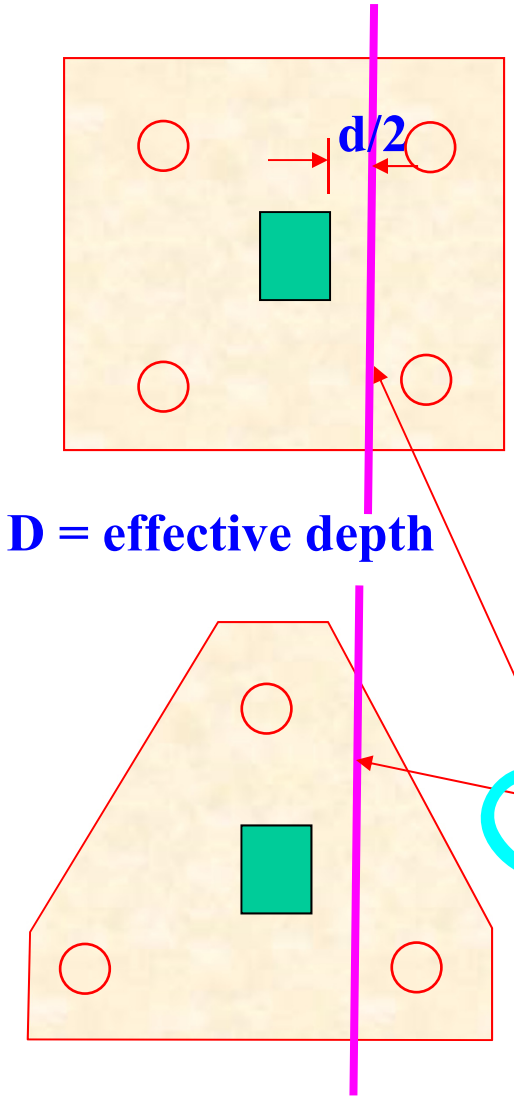
DESIGN FOR BENDING

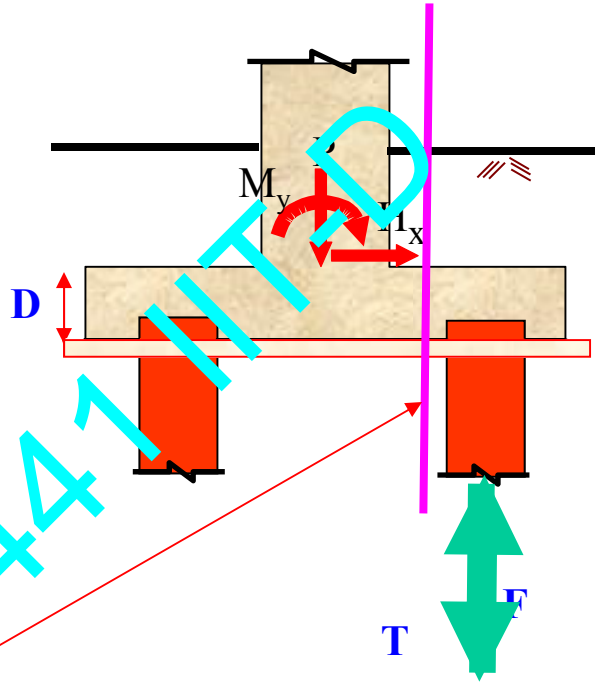


Critical section for bending moment

Top and bottom reinforcements can be found similar to an isolated footing

CHECK FOR ONE WAY SHEAR





Critical section for one way shear

Face of col. In case of tension

Safety against one way shear can be found similar to an isolated footing

34.2.4 *Shear and Bond*

34.2.4.1 The shear strength of footings is governed by the more severe of the following two conditions:

a) The footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width; the critical section for this condition shall be assumed as a vertical section located from the face of the column, pedestal or wall at a distance equal to the effective depth of footing for footings on piles.

b) Two-way action of the footing, with potential diagonal cracking along the surface of truncated cone or pyramid around the concentrated load; in this case, the footing shall be designed for shear in accordance with appropriate provisions specified in **31.6**.

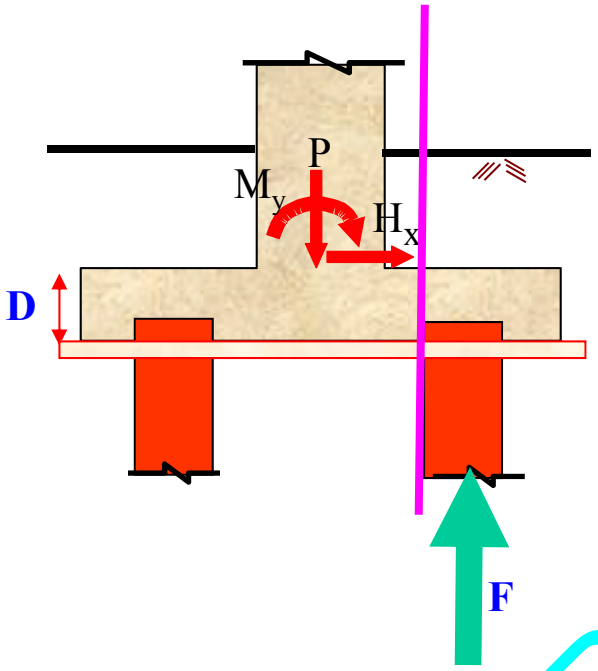
34.2.4.2 In computing the external shear or any section

in case of footings on soil and at a distance equal to half the effective depth

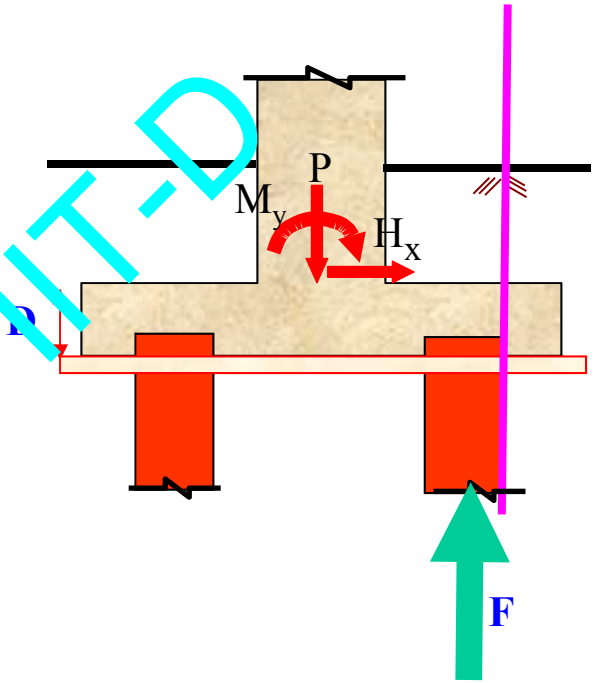
34.4

The

CHECK FOR ONE WAY SHEAR



This pile will make full contribution in shear

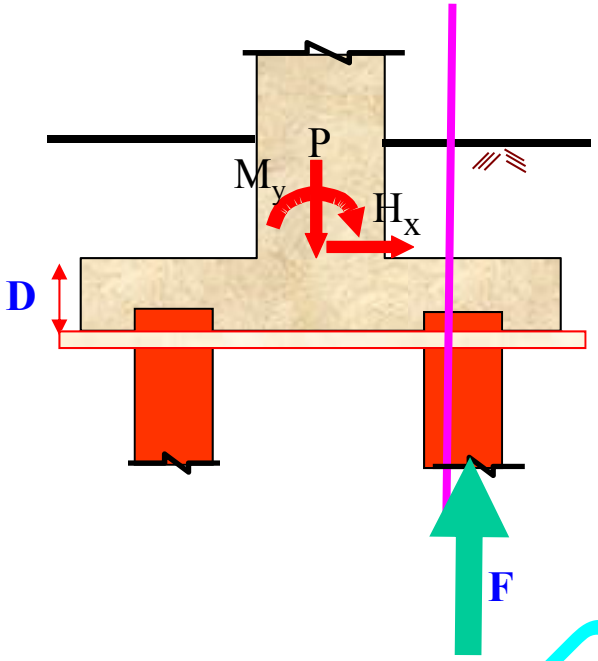


This pile will make no contribution in shear

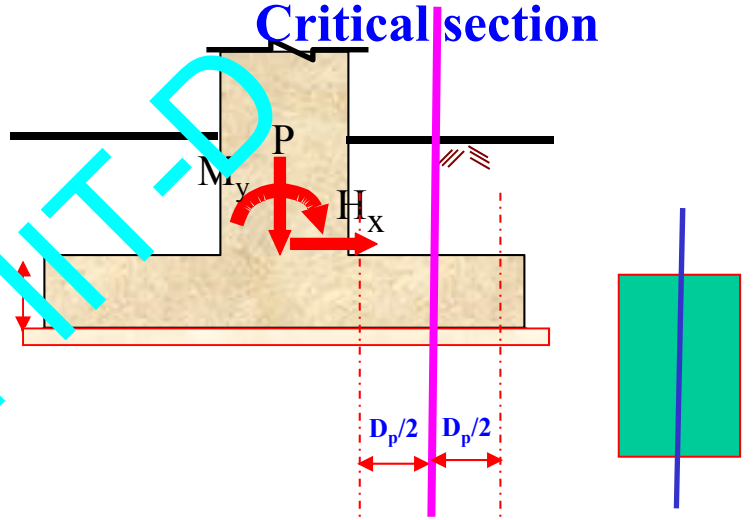
CONTRIBUTION OF A PILE FOR ONE WAY SHEAR (IS 456)

34.2.4.2 In computing the external shear or any section through a footing supported on piles, the entire reaction from any pile of diameter D_p whose centre is located $D_p/2$ or more outside the section shall be assumed as producing shear on the section; the reaction from any pile whose centre is located $D_p/2$ or more inside the section shall be assumed as producing no shear on the section. For intermediate positions of the pile centre, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straight line interpolation between full value at $D_p/2$ outside the section and zero value at $D_p/2$ inside the section.

CHECK FOR ONE WAY SHEAR



This pile will make partial contribution in shear

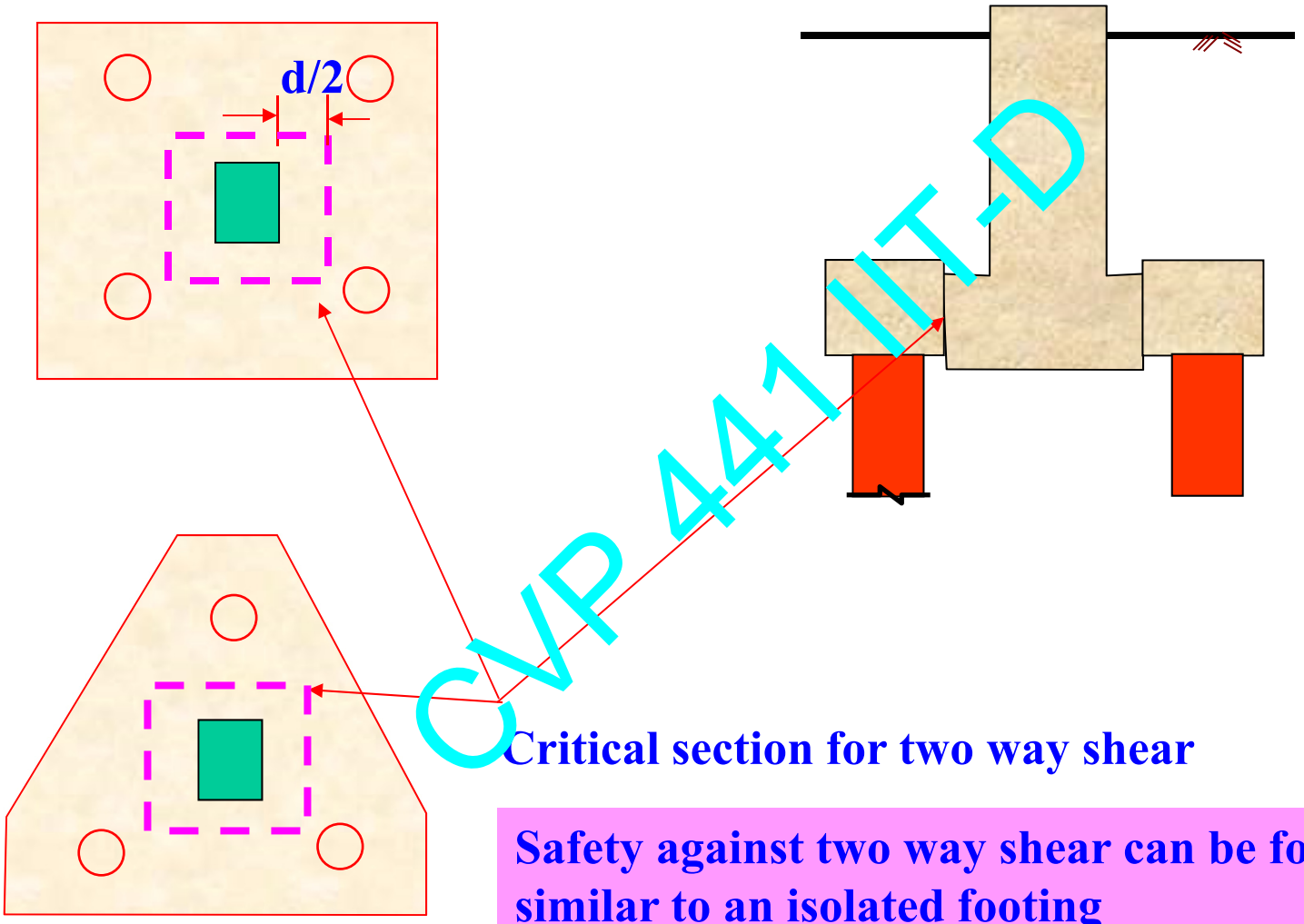


Zero contribution if pile centre here

Full contribution if pile centre here

Linear interpolation if in between

CHECK FOR TWO WAY SHEAR



Critical section for two way shear

Safety against two way shear can be found similar to an isolated footing

REINFORCEMENT DETAILING (SP 34)

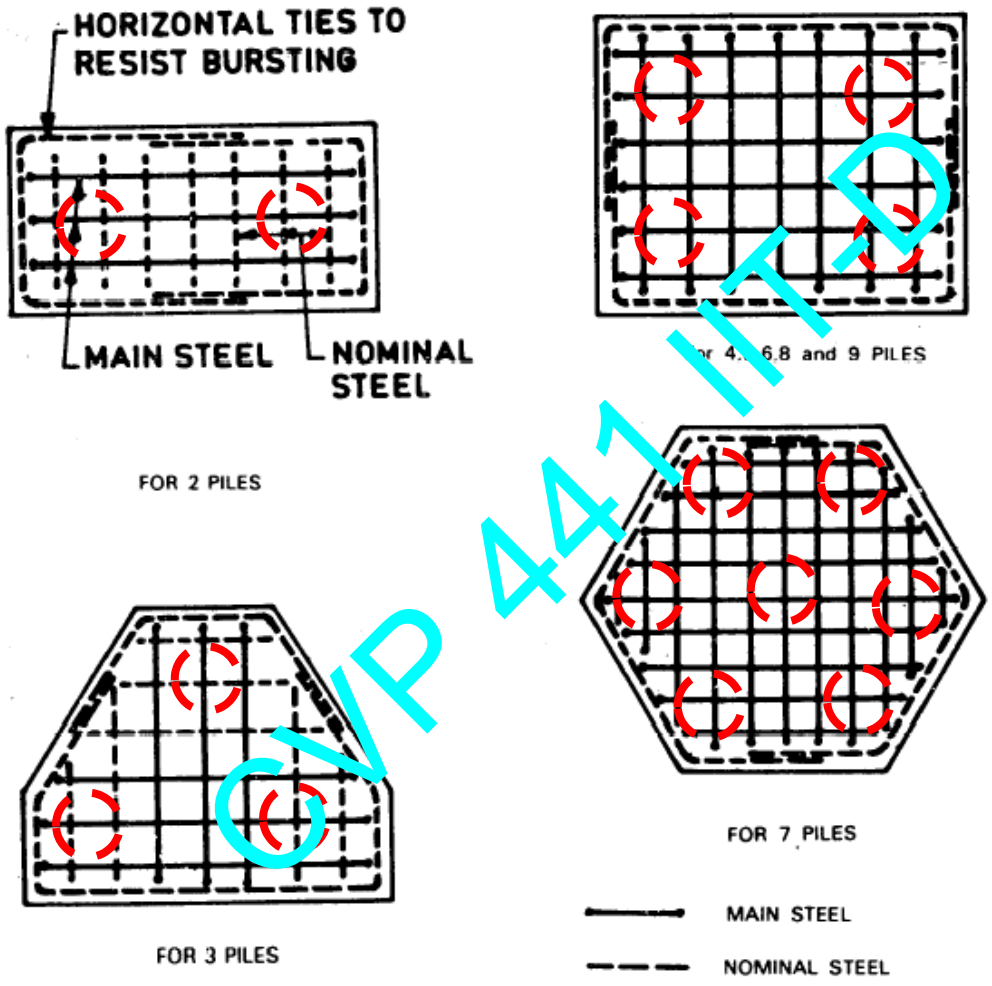


FIG. 6.10 GENERALLY ADOPTED CONFIGURATION FOR PILE CAPS (ALONG WITH PLAN ARRANGEMENT OF REINFORCEMENT)

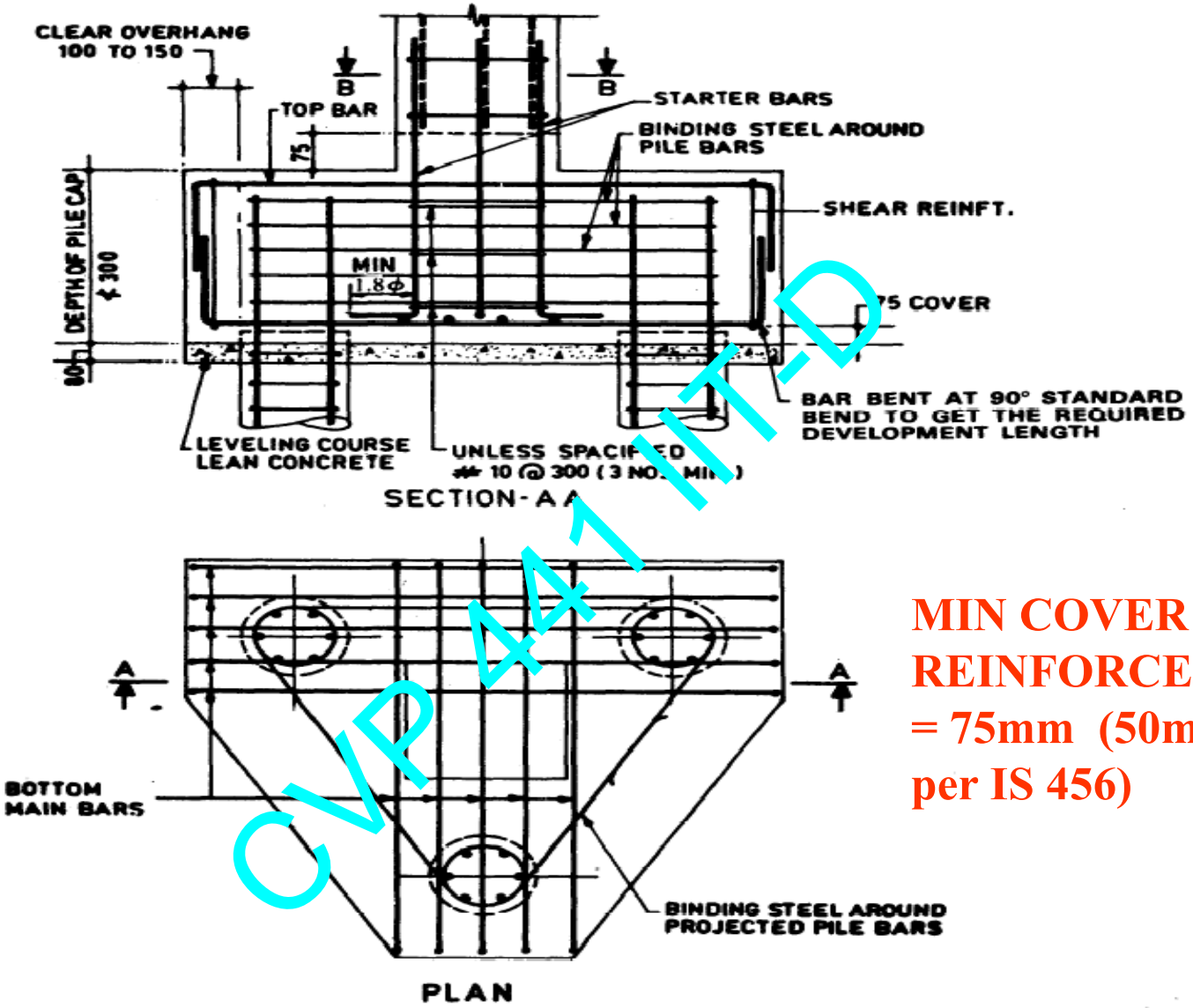


FIG. 6.12 TYPICAL DETAILS OF A 3-PILE CAP

MIN COVER TO REINFORCEMENT = 75mm (50mm as per IS 456)

REINFORCEMENT DETAILING (SP 34)