Universitatea Politehnica Timişoara
Facultatea de Construcţii
Departamentul de Căi de Comunicație Terestre, Fundații și Cadastru

FOUNDATIONS

- CURS 10 -

Design of shallow foundations

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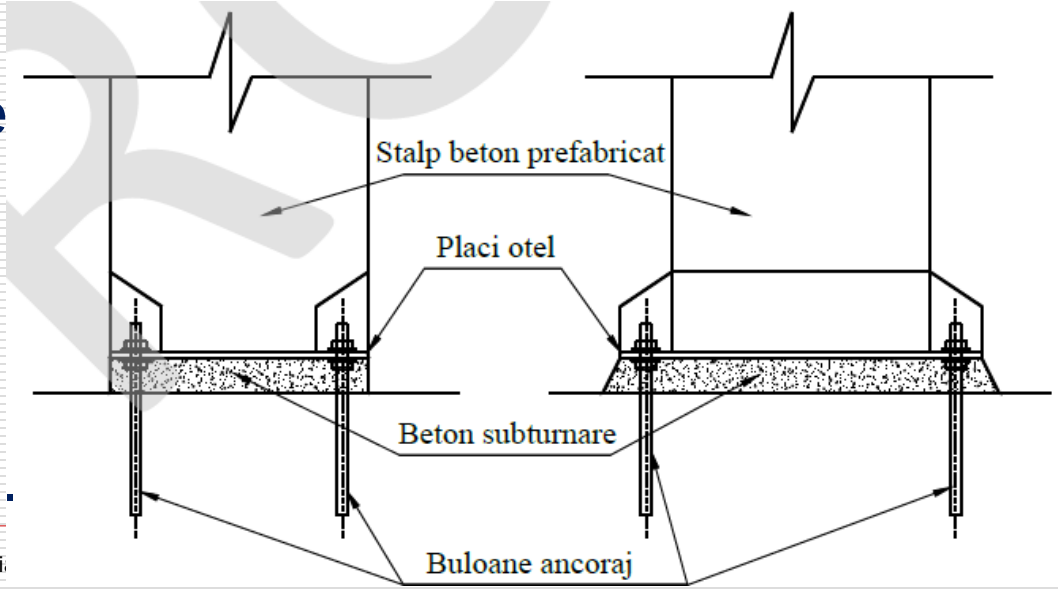
CHAPTER VI – SHALLOW FOUNDATIONS

§ 6.8 Design of foundation for precast concrete columns

- The **Foundations for precast concrete columns** must assure the transfer of stresses from precast columns to the base.
- In this case column reinforcement is not extended in the base.
- The fixing (clamping) is assured by other means:
  - steel base-plate and anchoring bolts;
  - sleeve foundation.

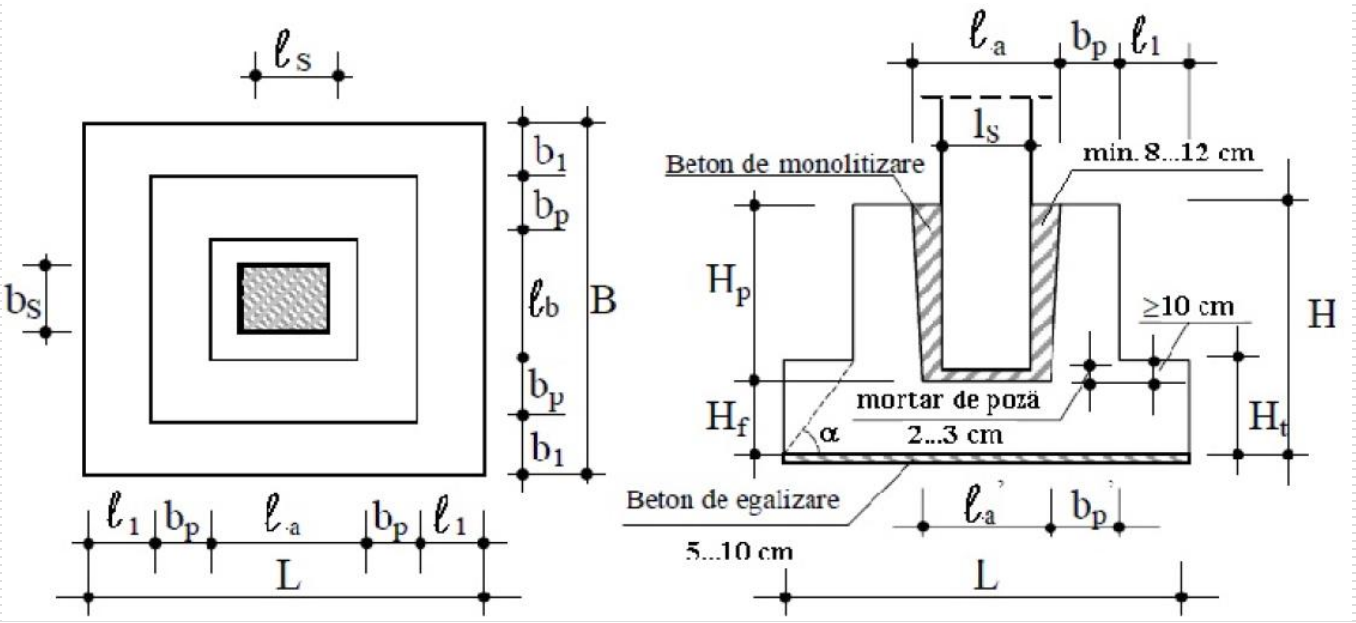
Foundation for precast concrete columns with steel base-plate and anchoring bolts.

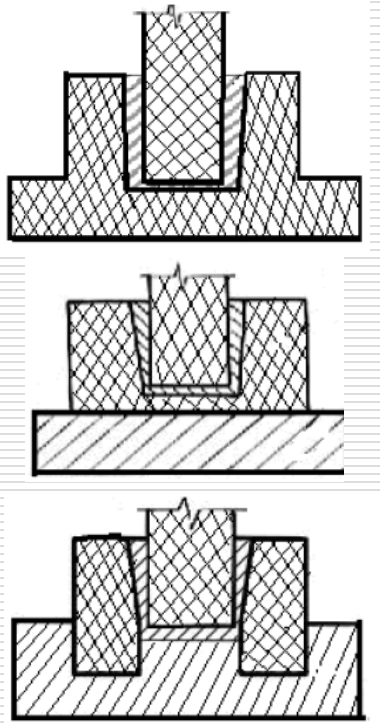
- This type of foundation are generally designed following the rules of elastic foundations.
- Special conditions should be met for the contact between the concrete (and reinforcement) column and the steel base plate.



§ 6.8 Design of foundation for precast concrete columns - Sleeve foundations -

- The **Sleeve foundations** could be realized by concrete casting on site or as precast foundations.
- The sleeve must have a hole for accommodating the concrete column (concrete dimensions + tolerances).
- The fixing (clamping) is assured by casting concrete of high resistance.



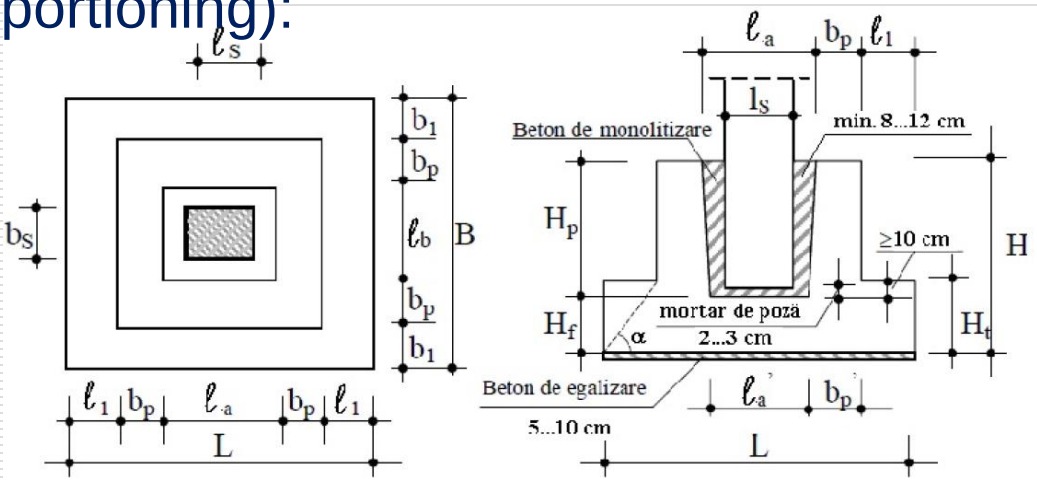


Sleeve foundation

Precast options

§ 6.8 Design of foundation for precast concrete columns - Sleeve foundations -

- Geometrical requirements (proportioning):
- The height of the sleeve H_p results from:
  - The minimum anchoring of reinforcement (l_{bd}+*100mm*) where l_{bd} is the anchoring length of column reinforcement;

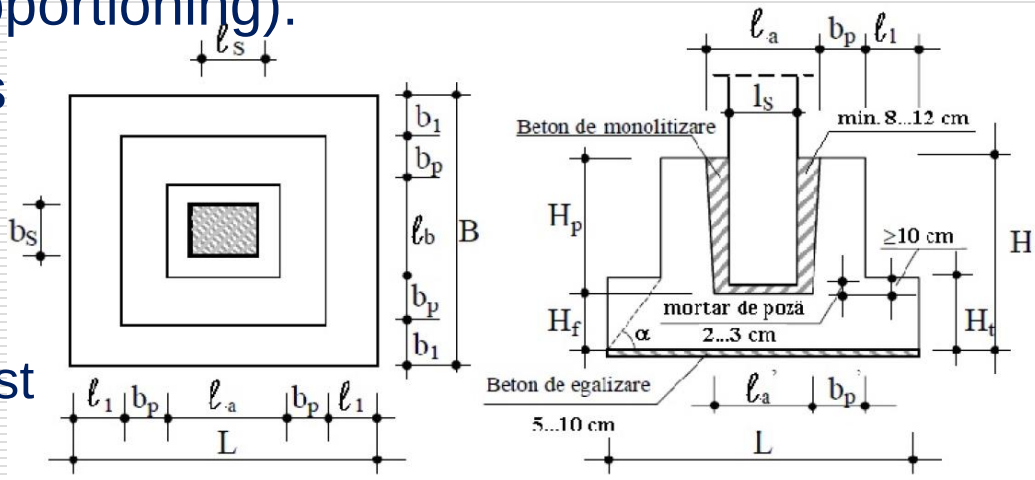


- $H_p \geq 1.2\, l_s$ (l_s is the larger dimension of the column cross-section);
- $H_p \geq 500\ mm$ for multi-storey buildings;
- $H_p \geq H_s/8$ for single-story buildings with H_s (column height) smaller than 10m.

- The thickness of the sole (H_f) results from punching checking of the column in two situations:
  - Construction stage condition: the axial load is equal to the column weight multiplied by a dynamic coefficient of 1.5 ($H_{f,min}$=*250mm*);
  - In final stage, to column loads, depending on sleeve face indentation.

§ 6.8 Design of foundation for precast concrete columns - Sleeve foundations -

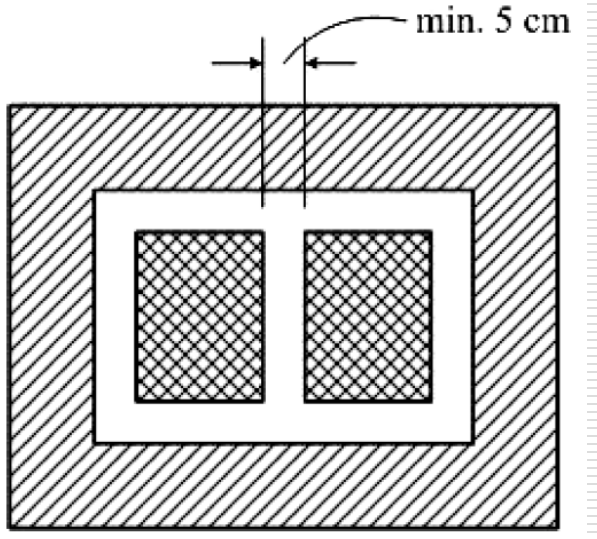
- Geometrical requirements (proportioning):
- The minimum sleeve thickness b_p results from:
  - min 200mm for cast concrete columns;
  - min 150 mm for concrete precast columns;
  - $b_p \geq l_s/3$



Obs: Usually the casting concrete class (min C16/20) is greater than the concrete class of the sleeve foundation (min C12/15).

The outer surfaces of the column and the inner surface of the foundation should be clean and wet prior concreting.

There are situations when the sleeve foundation will accommodate two columns. A minimum joint distance between columns should be assured (see the figure).



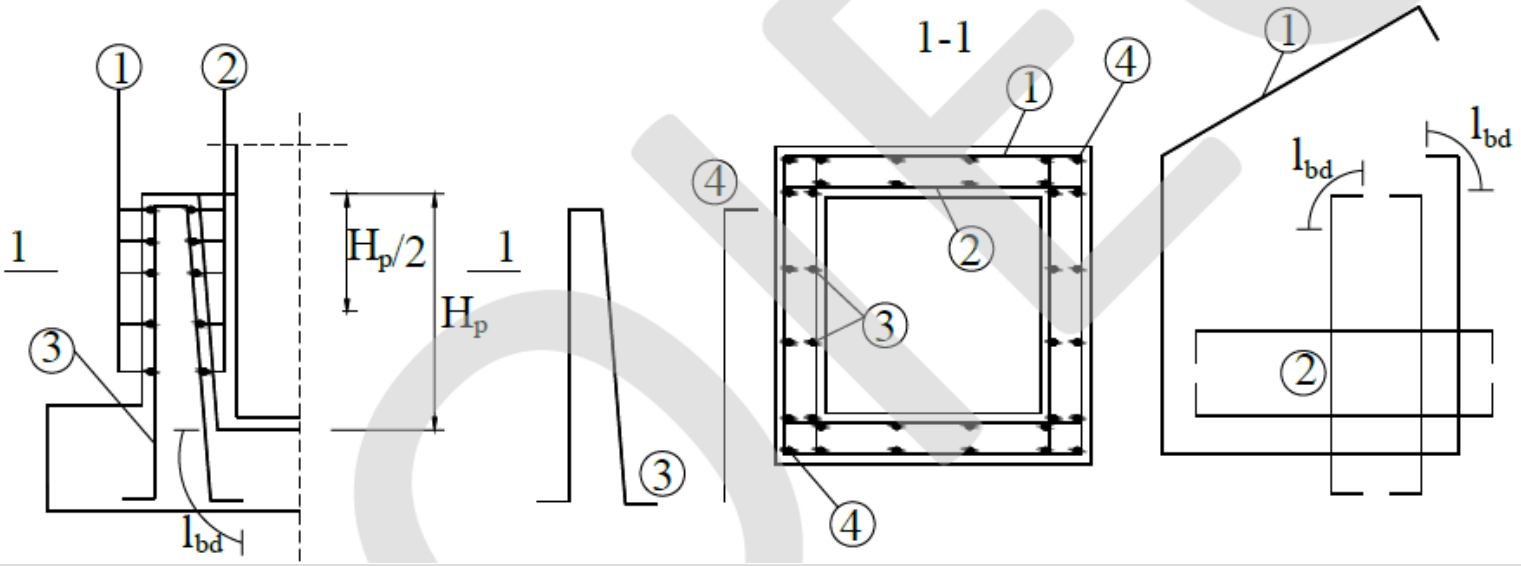
§ 6.8 Design of foundation for precast concrete columns - Sleeve foundations -

- Foundation reinforcement:
- **Sleeve reinforcement** (as in below figure):

Results from the design to lateral forces induced by column.

The horizontal reinforcement is superposed or made as stirrups.

Vertical reinforcement is anchored in the sole. The horizontal sole reinforcement passes through the vertical sole reinforcement.

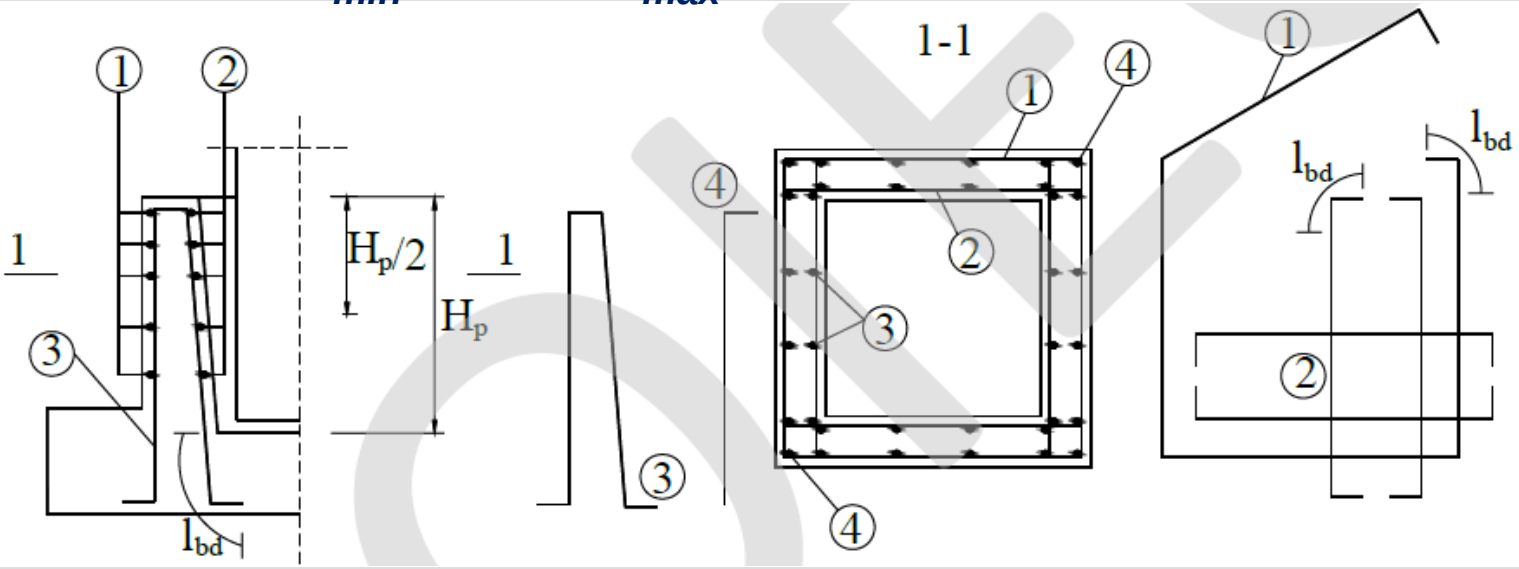


§ 6.8 Design of foundation for precast concrete columns - Sleeve foundations -

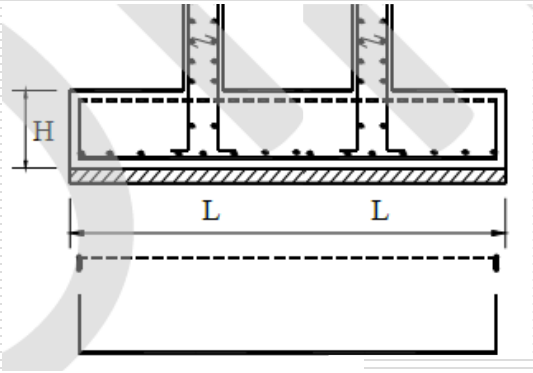
- Foundation reinforcement:
- **Sleeve reinforcement** (as in below figure):

Minimum requirements:

- p_{min}**=0.1%** on each face, horizontal and vertical;
- horizontal reinforcement: Φ_{min}**=10mm** (8mm in the bottom half of the sleeve), minimum **2x3 horizontal rebars,** in the upper half d_{max}**=200mm**.
- vertical reinforcement: Φ_{min}**=8mm,** d_{max}**=200mm**.



§ 6.8 Design of foundation for precast concrete columns - Sleeve foundations -



- Foundation reinforcement:
- **Sole reinforcement** (similar to concrete block foundations):

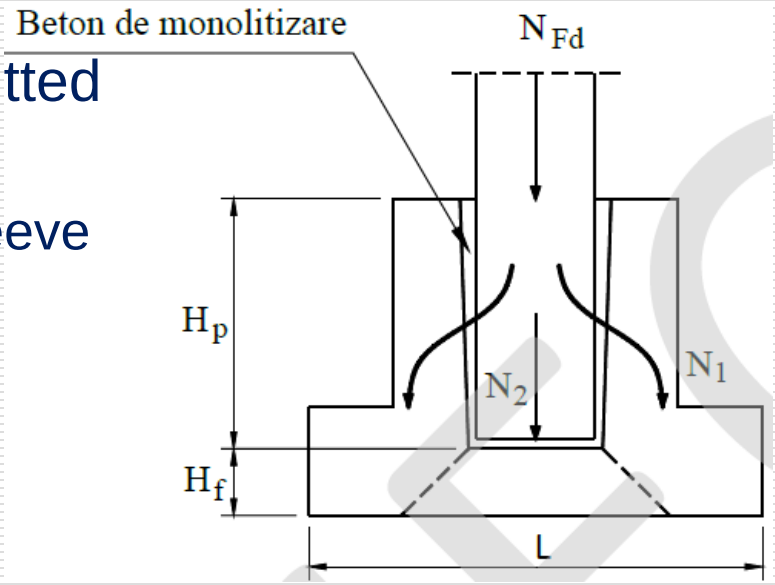
Results from the design to bending moment of the foundation.

Minimum requirements: p_{min}=0.1%, Φ_{min}=10mm, d_{min}=100mm, d_{max}=250mm, anchoring hooks of minimum height (*d*).

- **Concreting** of precast columns to the foundation block:

- The dimensions of the column hole are bigger than the column cross-section with **50-75mm** at the sole and **85-120mm** at top sleeve;
- The cast concrete has a minimum strength equal to the concrete strength in the column. Maximum size of the aggregates is 16mm;
- For centering the column different devices are used.

§ 6.8 Design of foundation for precast concrete columns - Sleeve design-



- **The axial load in the column** is transmitted to the ground through two components:
  - by friction through fixing concrete and sleeve walls (N_1);
  - by direct contact on the sole (N_2).

$$N_{Fd} = N_1 + N_2$$

With: $N_1 = As \cdot \gamma_{bt} \cdot f_{ctd}$

Where: f_{ctd} is the design tensile resistance of concrete;

A_s - is the lateral area of the column on H_p: $A_s = (2ls + 2bs)H_p$

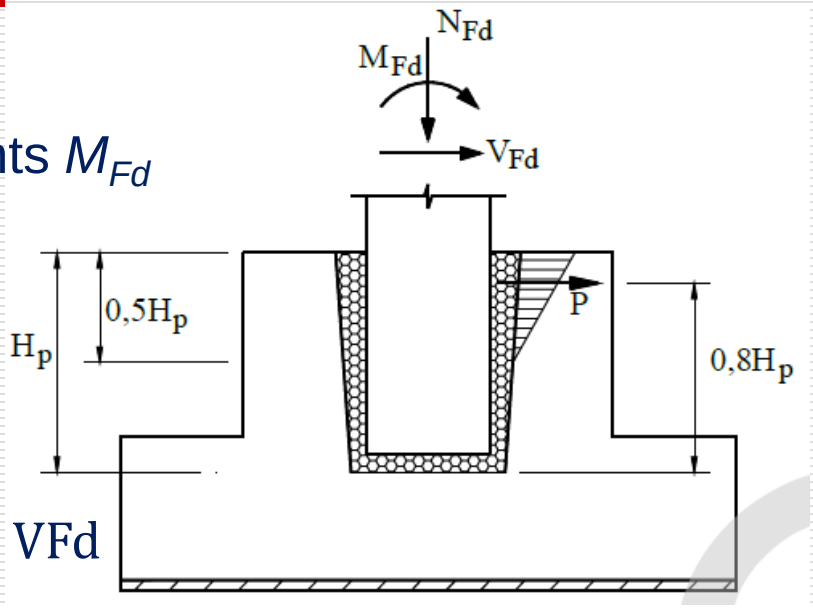
γ_{bt} - is the working conditions coefficient (γ_{bt} =*0.30* for constructions without dynamic loads, γ_{bt} =*0* for constructions with dynamic loads).

The force $N_2 = N_{Fd} - N_1$ is used for punching checking of the sole.

It is recommended that H_f is taken so that the N_2 will be transmitted only through sole concrete.

§ 6.8 Design of foundation for precast concrete columns - Sleeve design-

- **Horizontal loads in the sleeve walls**:
  - are due to the action of bending moments M_{Fd} and shear forces V_{Fd};
  - the pressure in the upper half of the sleeve is balanced by the opposite pressure on the other bottom half;
  - the resultant pressure is: $P = \frac{1.25 M_{Fd}}{H_p} + VFd$



The pressure *P* generates bending in frontal walls and tension in longitudinal walls. The tension in the longitudinal walls is given by: $N_p=P/2$

The **sleeve walls are designed to centric tension** to the force N_p. The resulting reinforcement (A_{sh}) will be disposed horizontally on the first half of the walls, on H_p height, symmetrically .

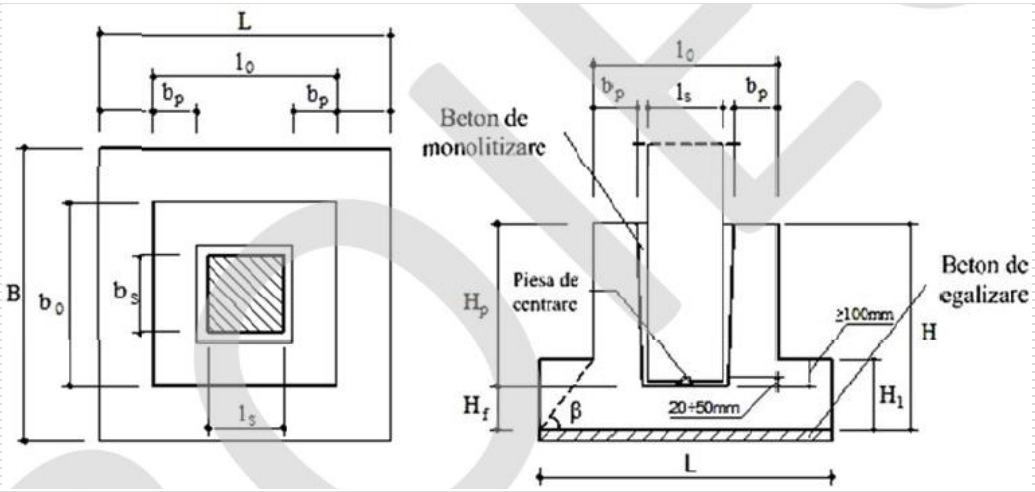
Obs: Generally the bending moments in frontal walls are small and could be neglected.

§ 6.8 Design of foundation for precast concrete columns - Sleeve design-

- **Check of eccentric compression at sleeve base**:
  - the cross-section is l_0, b_0;
  - the wall thickness is b'_p;
  - the forces acting on the cross-section are:

$$N = N_2$$

$$M = MFd + V_{Fd} \cdot H_p$$



The resulting reinforcement (A_{sv}) will be disposed vertically distributed on the dimensions of the walls.

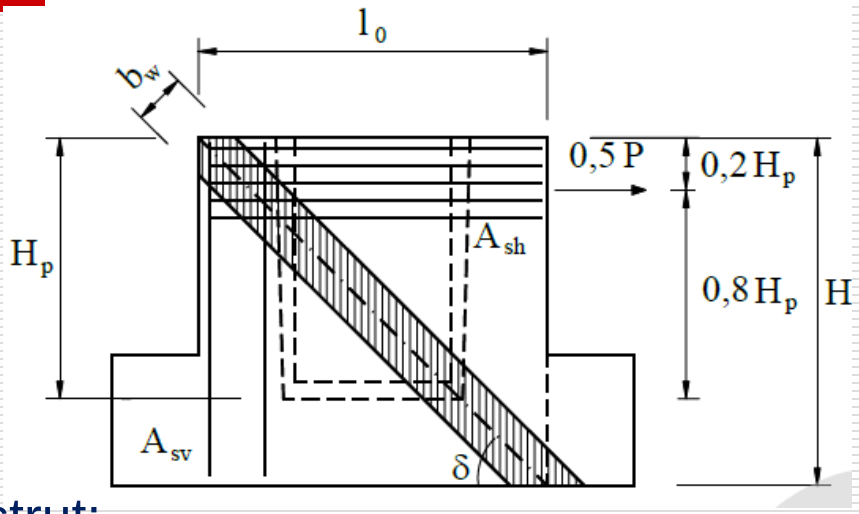
- **Check lateral wall to shear**:
  - is made considering the force P/2;
  - the checking considers the reinforcement A_{sh}.

§ 6.8 Design of foundation for precast concrete columns - Sleeve design-

Design of wall thickness:

- The thickness results from the condition that the strut formed from the projection of N_p force on this direction:

$$C_w = \frac{P}{2} \cdot \frac{1}{\cos\delta} \leq C_{w,Rd} = b_w \cdot b_p \cdot \sigma_{Rd,max}$$



Where: b_w is the width of the compressed strut;

b_p - is the width of the wall:

$\sigma_{Rd,max}$ - is the maximum stress in concrete $\sigma_{Rd,max} = 0.75 \cdot \upsilon \cdot f_{cd}$

with: $\upsilon = 1 - \frac{f_{ck}}{250}$; $b_w = (l_{bh} - \frac{b_p}{2} + c) \sin\delta + (l_{bv} - \frac{H_p}{5} + c) \cos\delta$ $\tan\delta = \frac{H}{l_0}$

l_{bh} and l_{bv} are the anchoring lengths of the horizontal and vertical reinforcements respectively;

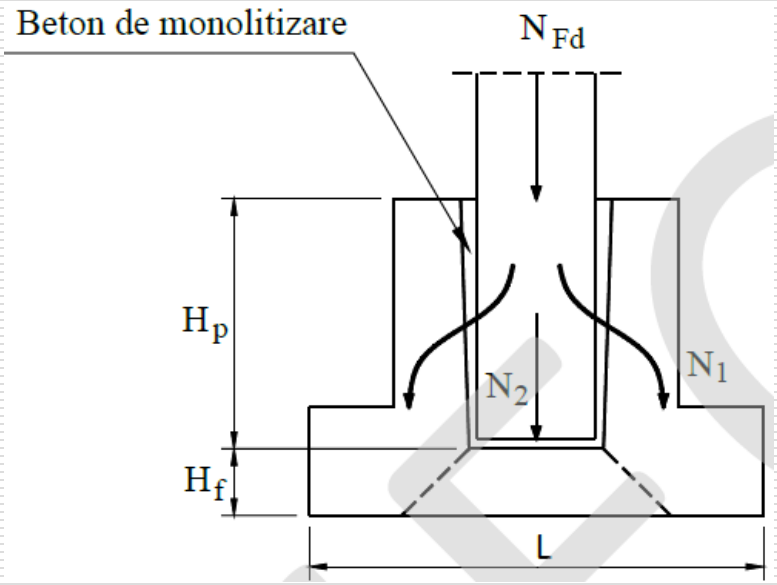
c - is the concrete cover

§ 6.8 Design of foundation for precast concrete columns - Sole design-

- **Design of sole to punching**:
  - Is done considering the force N_2
  - The design is performed as in the case of concrete block foundations

Condition for not disposing transversal reinforcement against punching:

$$\nu_{Fd} \le \nu_{Rd,c} = 0{,}12k \cdot (100\rho_1 \cdot f_{ck})^{1/3}$$



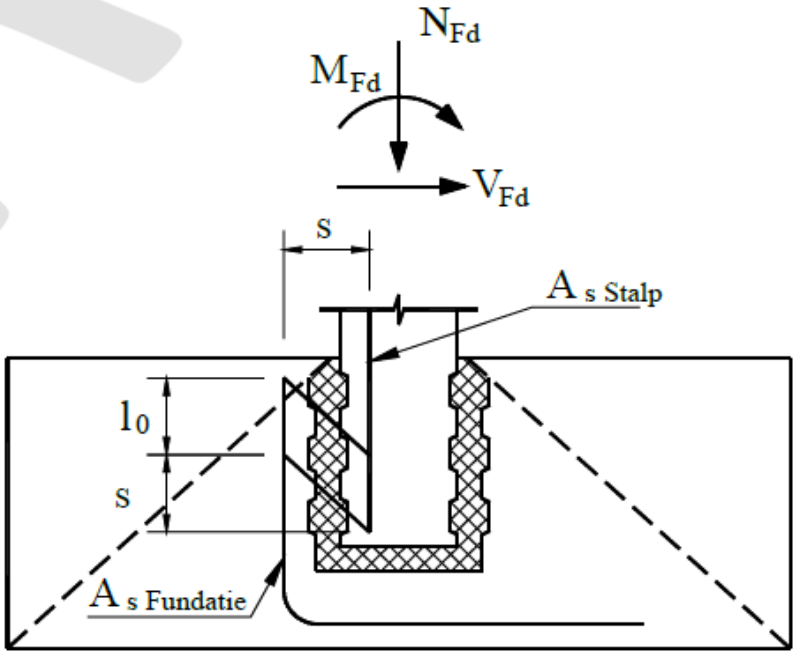
- **Design of sole to bending and shear force**:
  - Is done considering the geological pressure in minimum sections;
  - The applied loads are: $N = N_2$

$$M = MFd + V_{Fd} \cdot H_p$$

  - Is recommended to respect the condition $H_t \ge H_f + 100mm$.

§ 6.8 Design of foundation for precast concrete columns - Use of sleeves with indentations -

- **Use of sleeves with indentations**:
  - The sleeves have from casting walls with indentations in order to improve the connection between the column and the sleeve;
  - In this case is considered that the column is totally clumped in the foundation block.



- The design to punching is considering the transfer of forces from the top of the foundation block.
- Other type of checks are done as in case of smooth wall sleeves.