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A219

3.1 TYPE OF REINFORCEMENTS

3.2 EXAMPLES OF REINFORCEMENT

3.3 PROPERTIES OF REINFORCEMENTS

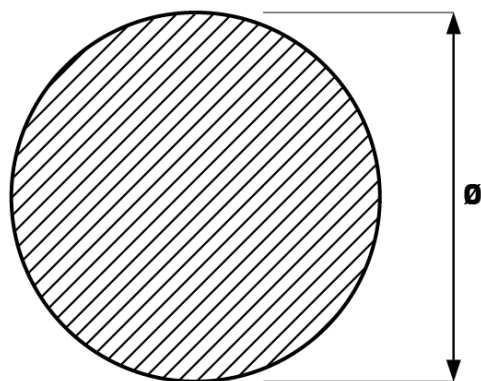
Type of reinforcements / Tipuri de armături

Reinforcements are disposed in zones where load produce tension!

Type of reinforcements:

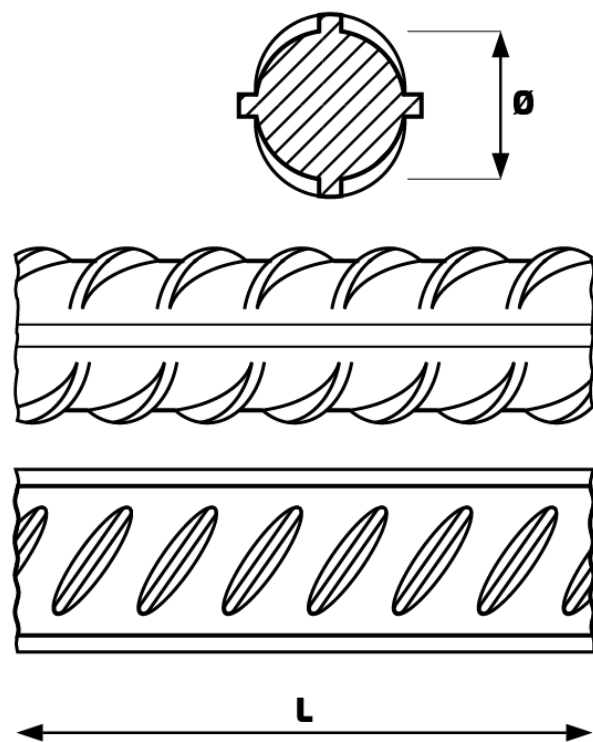
- 1) **FLEXIBLE REINFORCEMENT** → bars with circular cross section
- 2) **RIGID REINFORCEMENT** → welded or hot rolled profiles
- 3) **DISPERSED REINFORCEMENT** → different types of short fibers or textiles
- 4) **REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES**

Type of reinforcements / Tipuri de armături

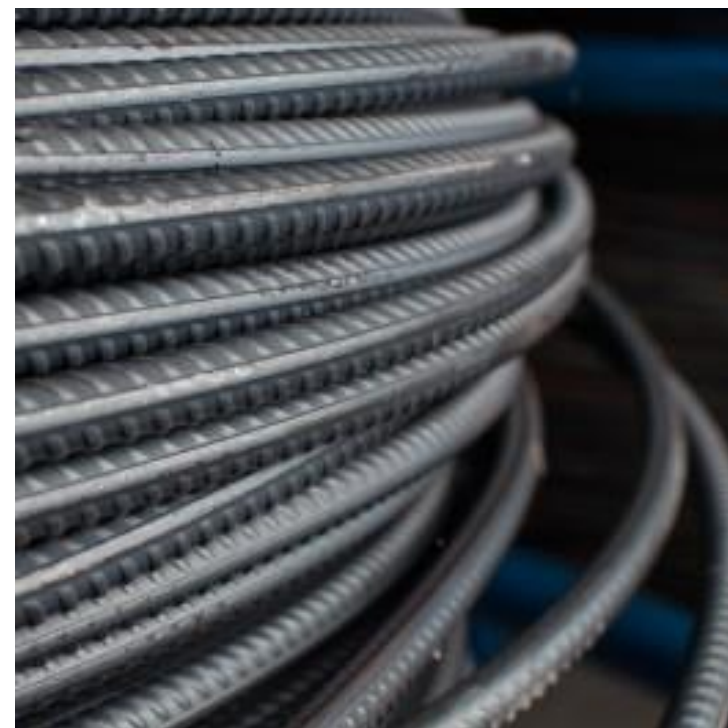
1) FLEXIBLE REINFORCEMENT → bars with circular cross section**OB 37****(Oțel Beton _ rezistența la rupere)**

Type of reinforcements / Tipuri de armături

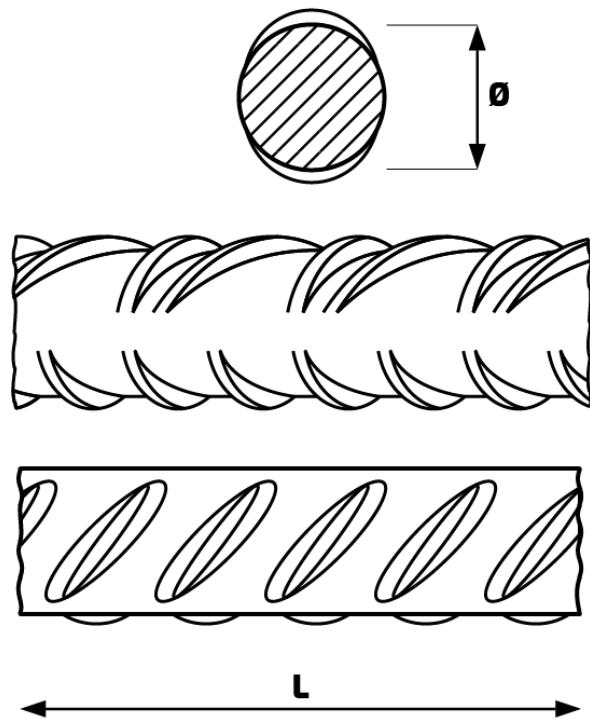
1) FLEXIBLE REINFORCEMENT → bars with circular cross section

**PC 52**

(Oțel cu profil periodic (P) laminat la cald (C)
_rezistența la rupere



Type of reinforcements / Tipuri de armături

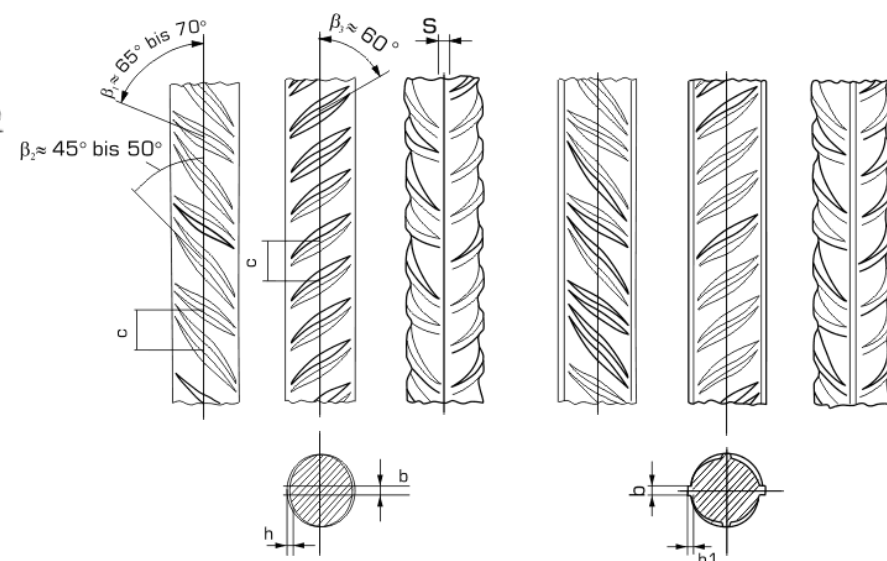
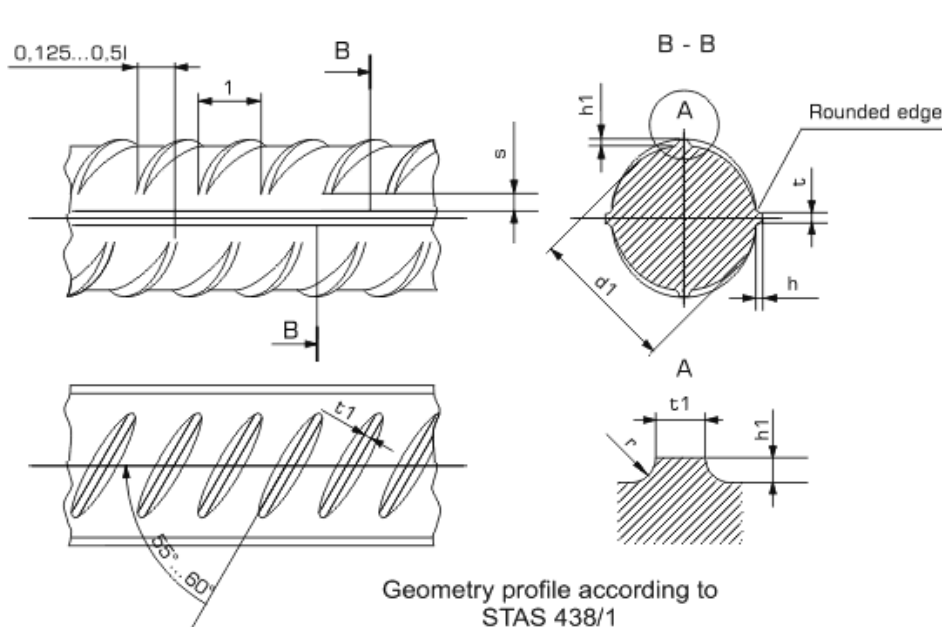
1) FLEXIBLE REINFORCEMENT → bars with circular cross section

BST500
(Betonstabstahl)



Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section



Geometry profile according to DIN 488 (Without longitudinal nerve)

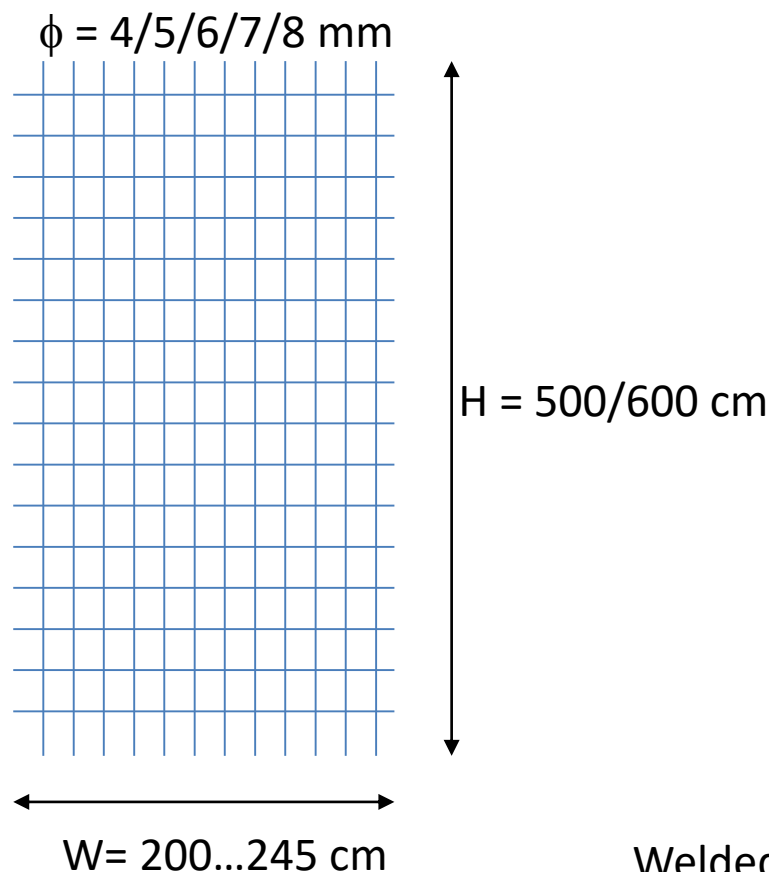
Geometry profile according to DIN 488 (With longitudinal nerve)

PC52



OTHER TYPES

Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

Welded wire fabrics –
Plase sudate SPPB (Sârmă cu Profil Periodic pentru Beton)

Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

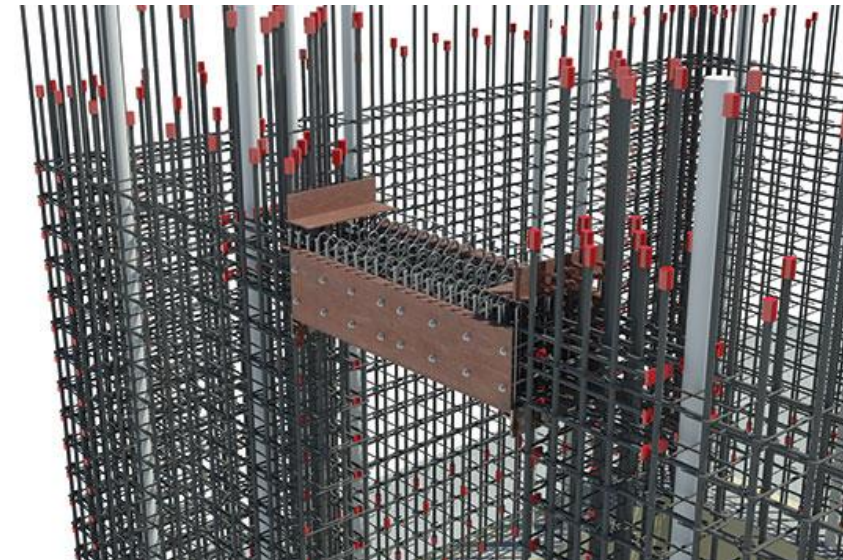
Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

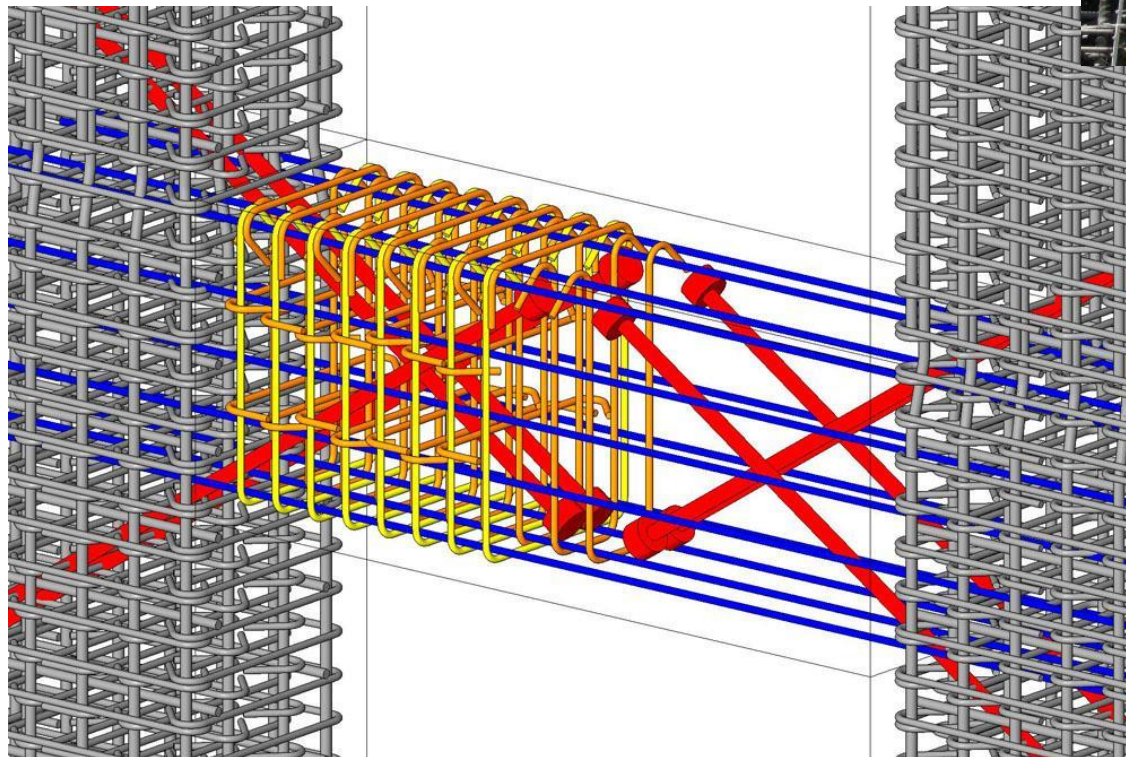
Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

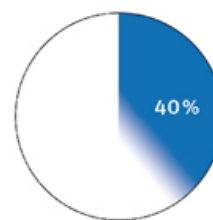
Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

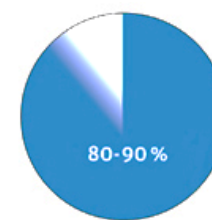
Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

Type of reinforcements / Tipuri de armături

1) FLEXIBLE REINFORCEMENT → bars with circular cross section

up to 40 % material savings



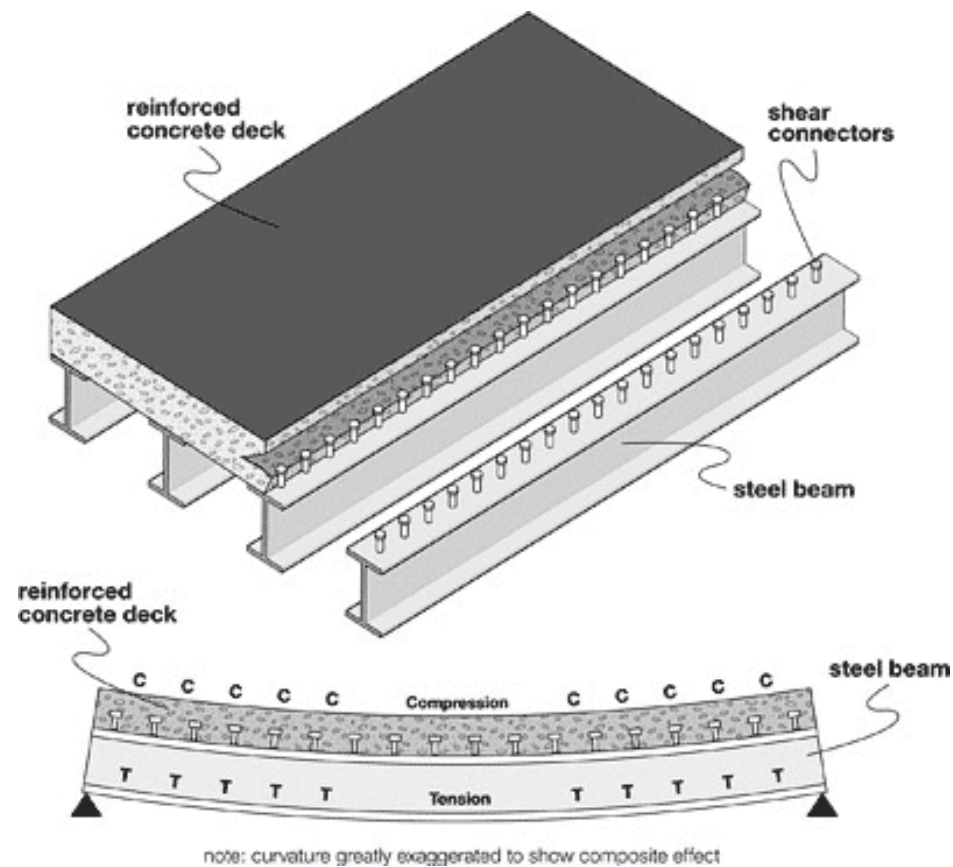
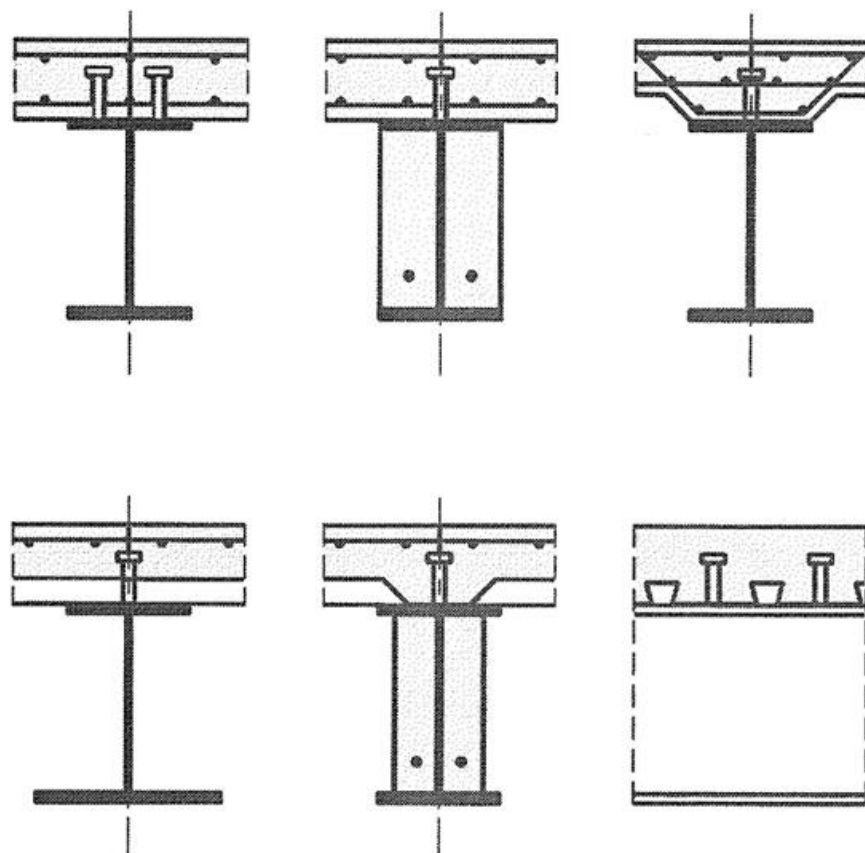
80-90 % savings in laying time

bamtec.com

Type of reinforcements / Tipuri de armături

2) RIGID REINFORCEMENT → welded or hot rolled profiles

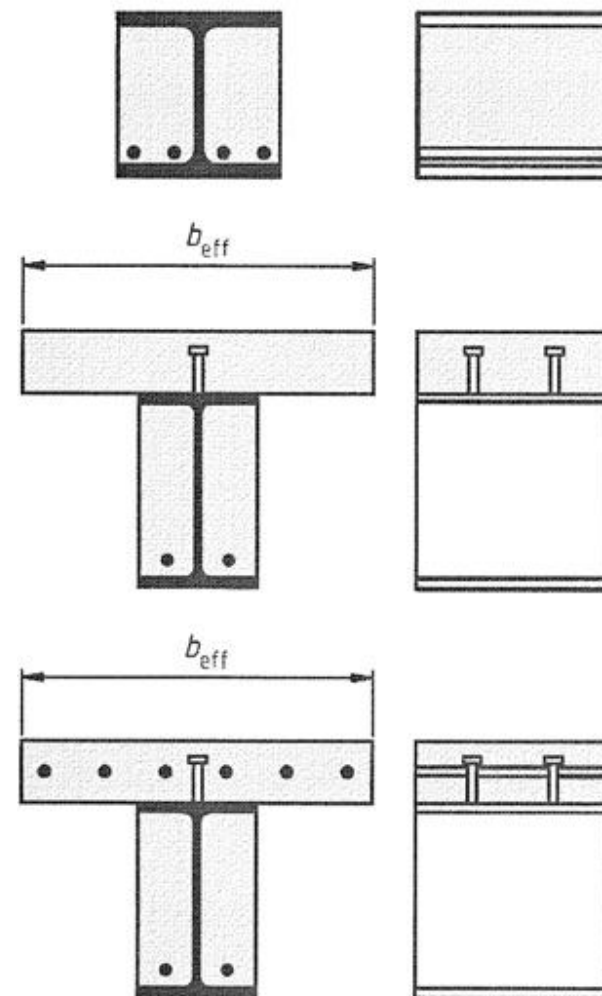
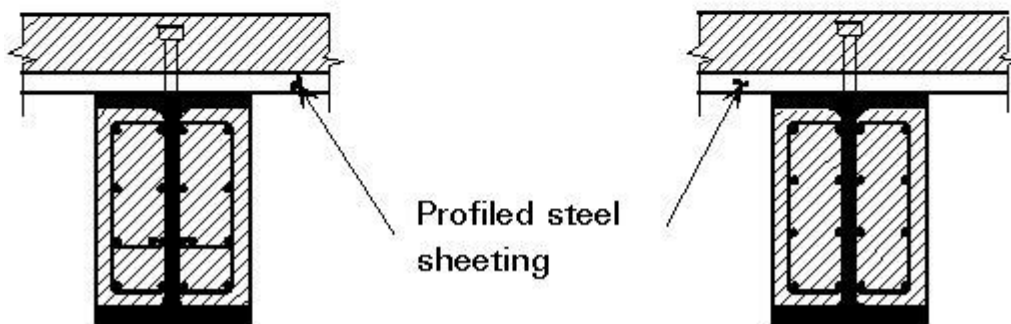
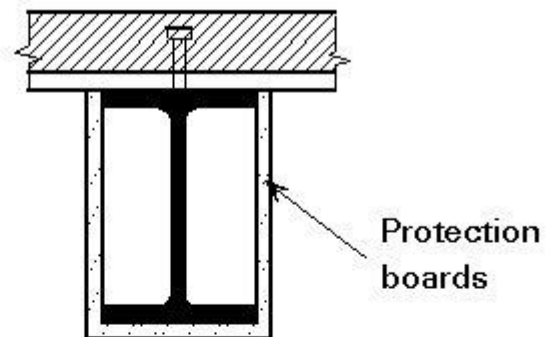
BEAMS



Type of reinforcements / Tipuri de armături

2) RIGID REINFORCEMENT → welded or hot rolled profiles

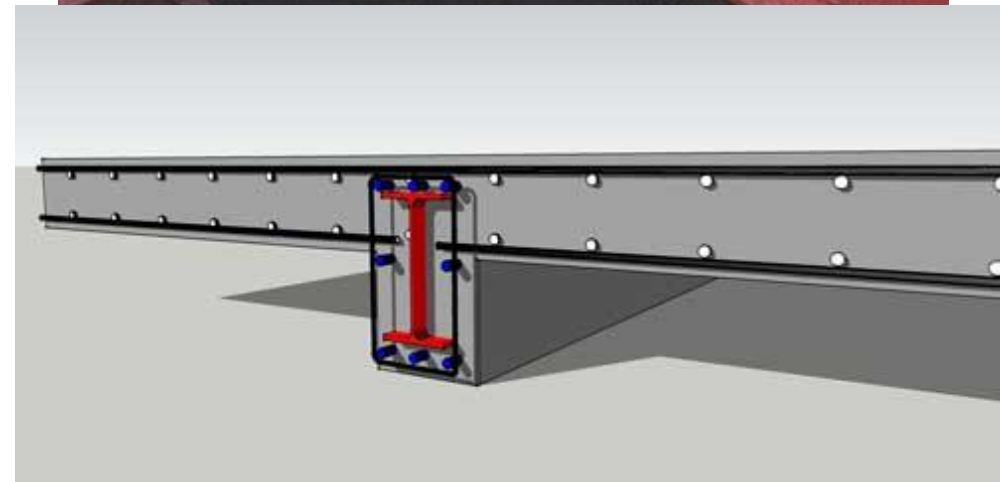
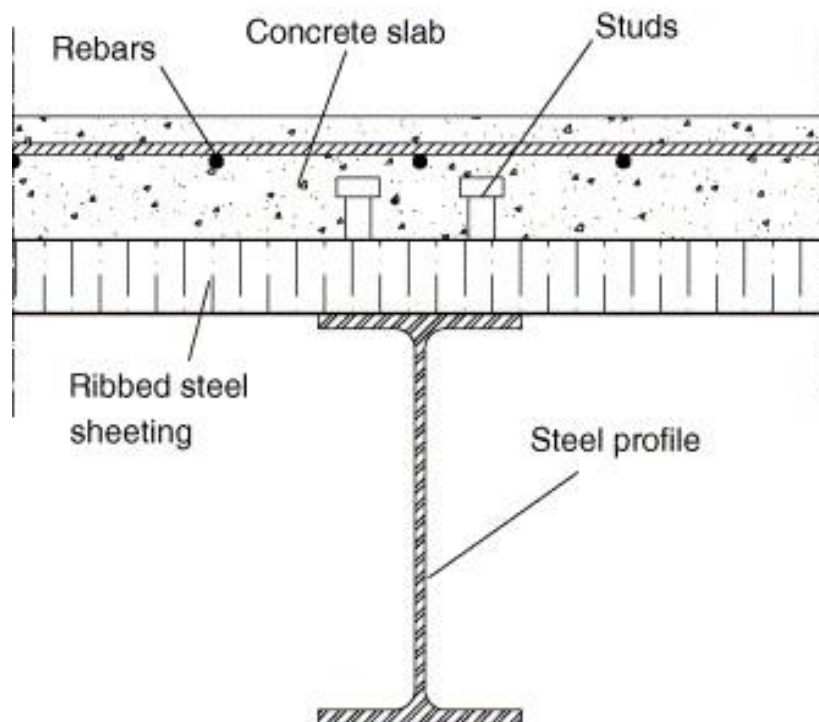
BEAMS



Type of reinforcements / Tipuri de armături

2) RIGID REINFORCEMENT → welded or hot rolled profiles

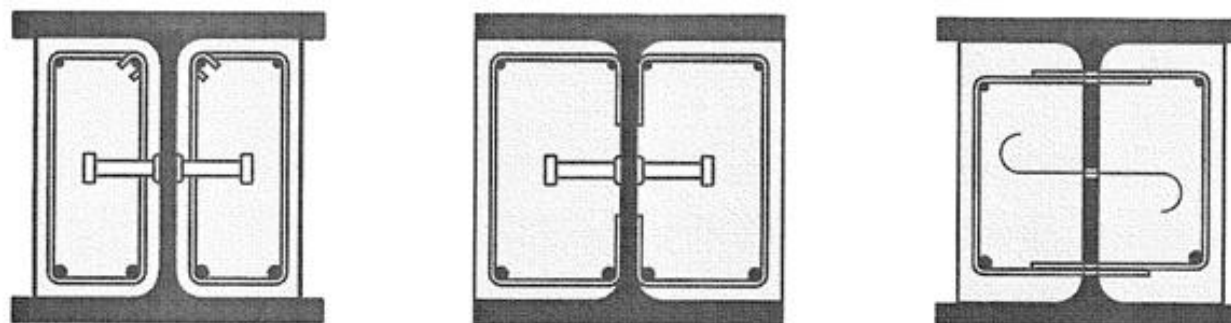
BEAMS



Type of reinforcements / Tipuri de armături

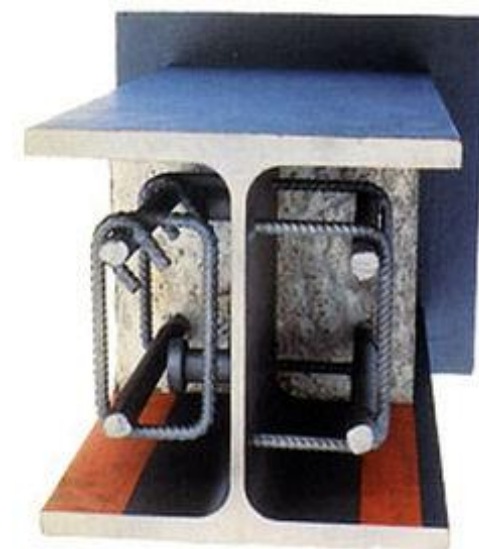
2) RIGID REINFORCEMENT → welded or hot rolled profiles

BEAMS



Key

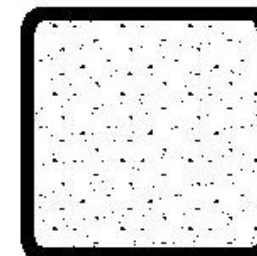
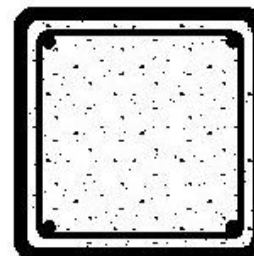
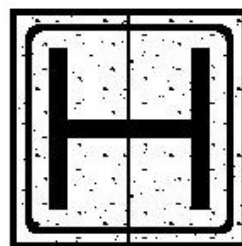
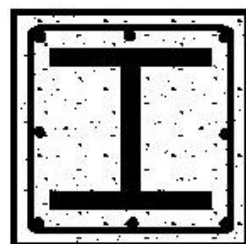
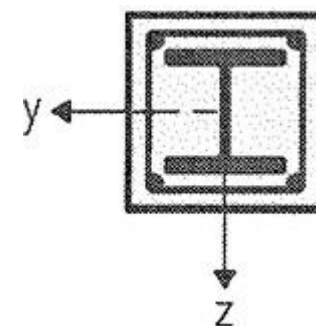
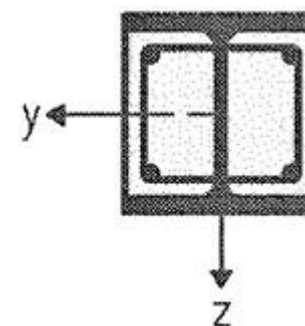
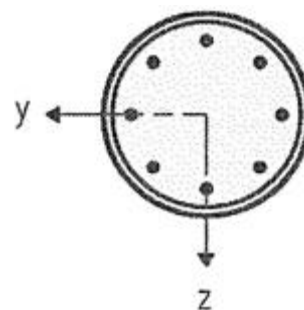
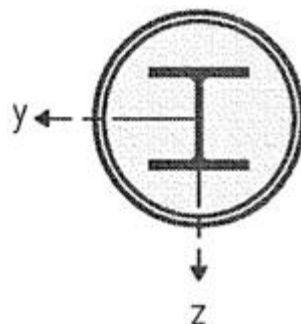
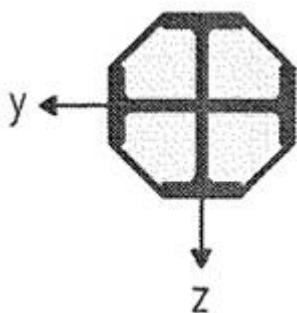
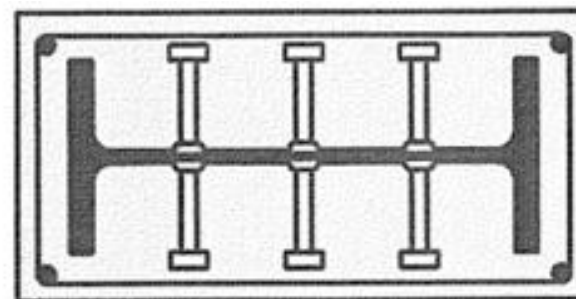
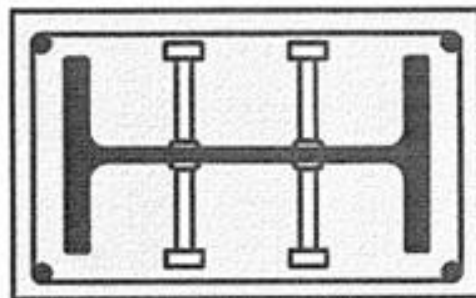
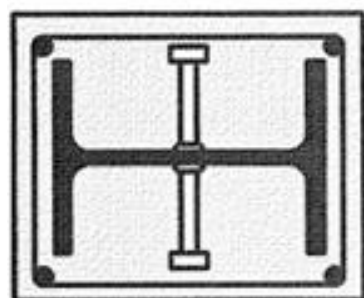
- 1 closed stirrups
- 2 open stirrups welded to the web
- 3 stirrups through the web



Type of reinforcements / Tipuri de armături

2) RIGID REINFORCEMENT → welded or hot rolled profiles

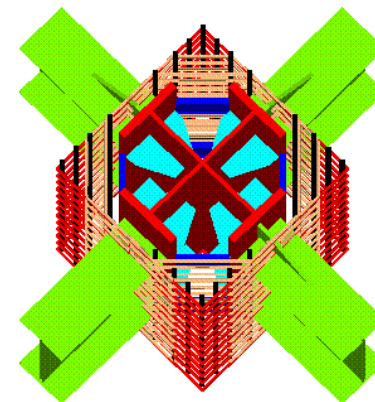
COLUMNS



Type of reinforcements / Tipuri de armături

2) RIGID REINFORCEMENT → welded or hot rolled profiles

COLUMNS

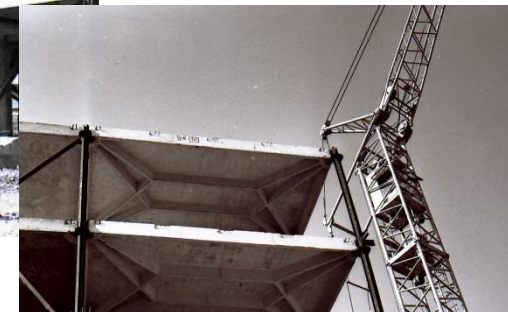
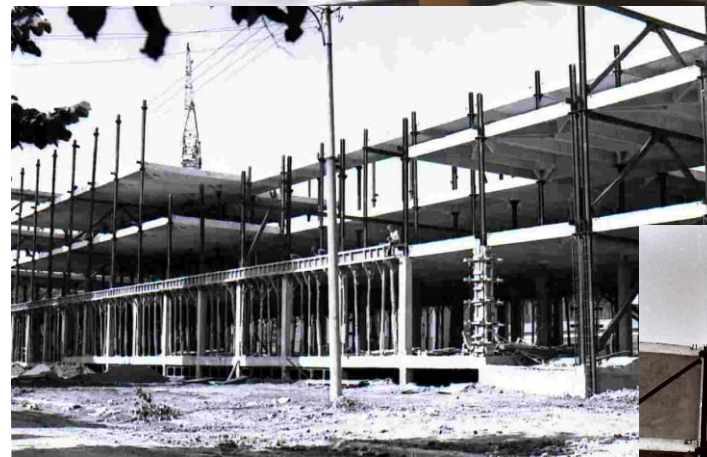


Type of reinforcements / Tipuri de armături

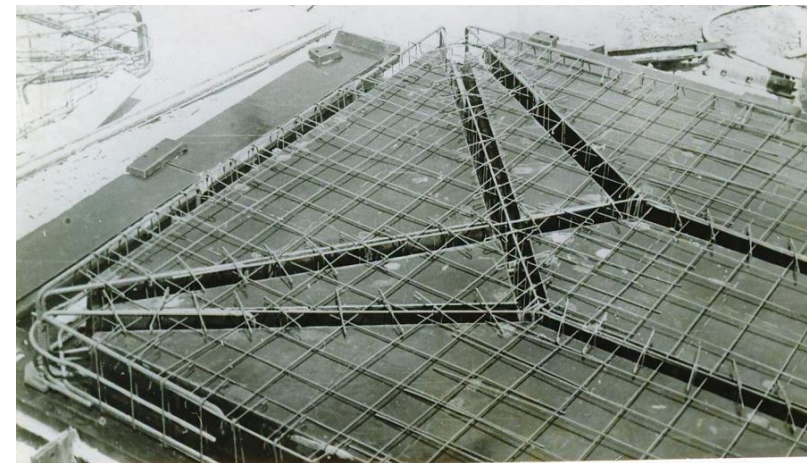
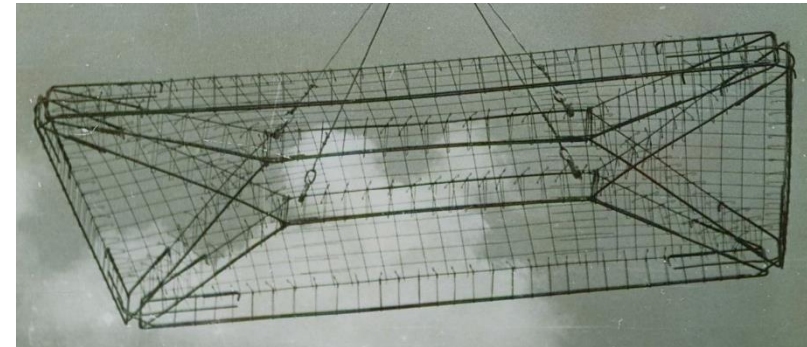
2) RIGID REINFORCEMENT

→ welded or hot rolled profiles

COLUMNS



Type of reinforcements / Tipuri de armături

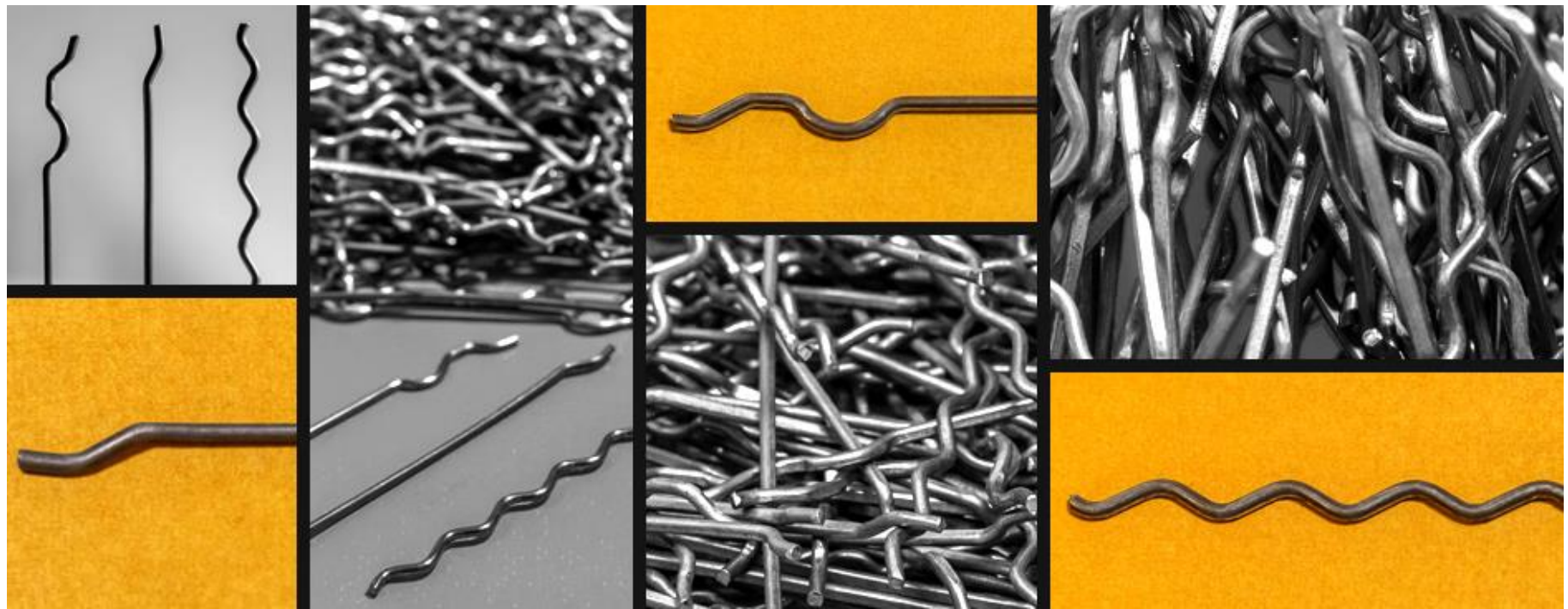
2) RIGID REINFORCEMENT → welded or hot rolled profiles**COLUMNS**

Type of reinforcements / Tipuri de armături

3) DISPERSED REINFORCEMENT → different types of SHORT fibers



Type of reinforcements / Tipuri de armături

3) DISPERSED REINFORCEMENT → different types of SHORT fibers

3) DISPERSED REINFORCEMENT → different types of SHORT fibers

Polypropylene fibers improves:

- concrete mix cohesion
- workability and pump ability
- freeze-thaw strength
- fire resistance
- impact strength
- shrinkage

Steel fibers

increase:

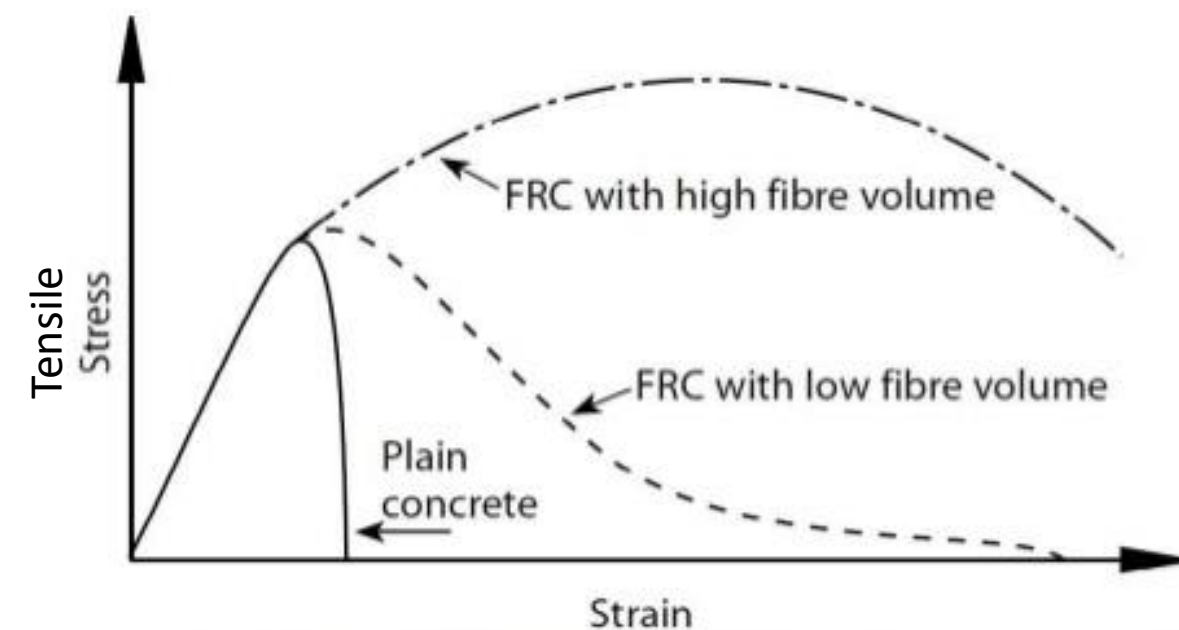
- structural strength
- ductility
- impact and abrasion strength
- freeze-thaw strength

reduces:

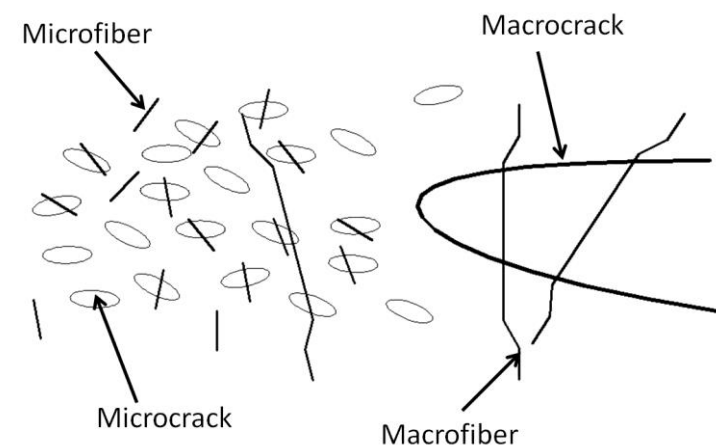
- quantity of the necessary reinf.
- crack width (control the width), thus increasing the durability

Type of reinforcements / Tipuri de armături

3) DISPERSED REINFORCEMENT → different types of SHORT fibers

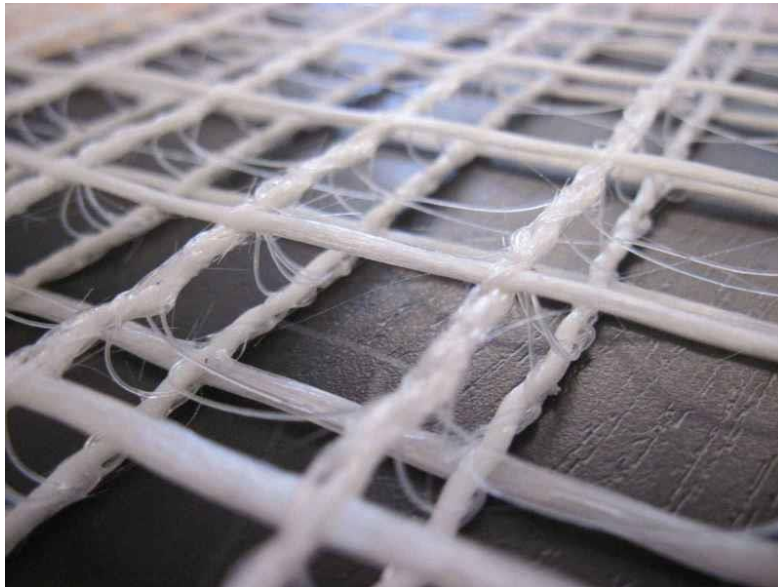


Reference: Cement & Concrete Institute
<http://www.cnci.org.za>

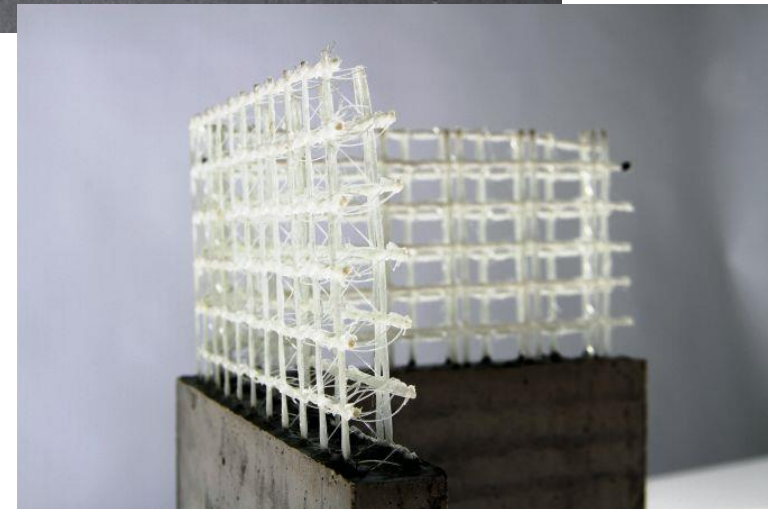
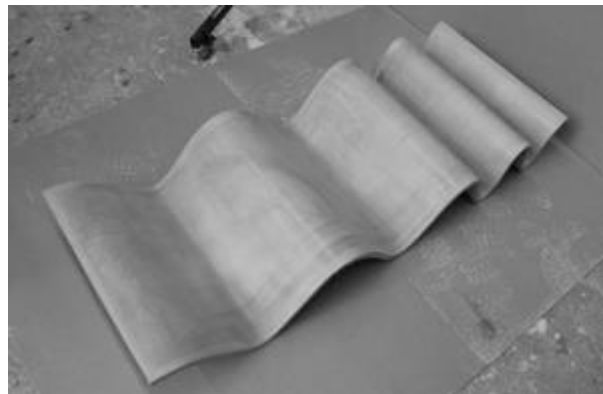
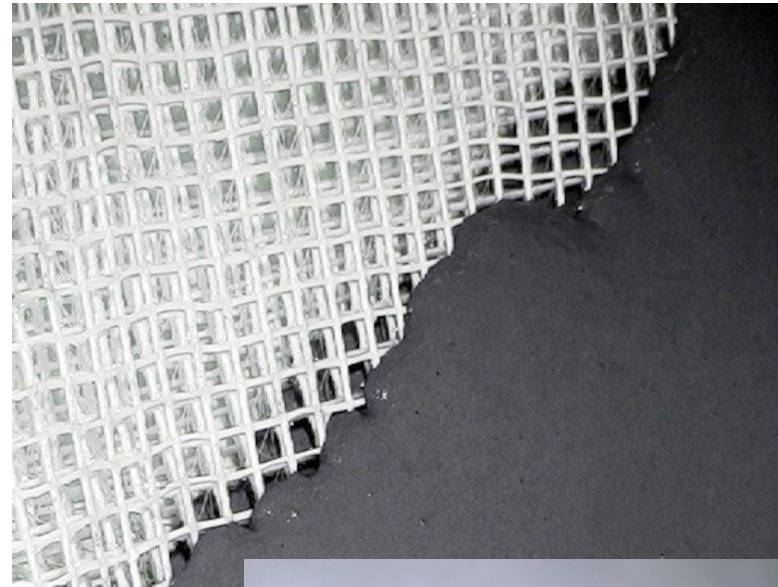


Type of reinforcements / Tipuri de armături

3) DISPERSED REINFORCEMENT → different types of TEXTILES

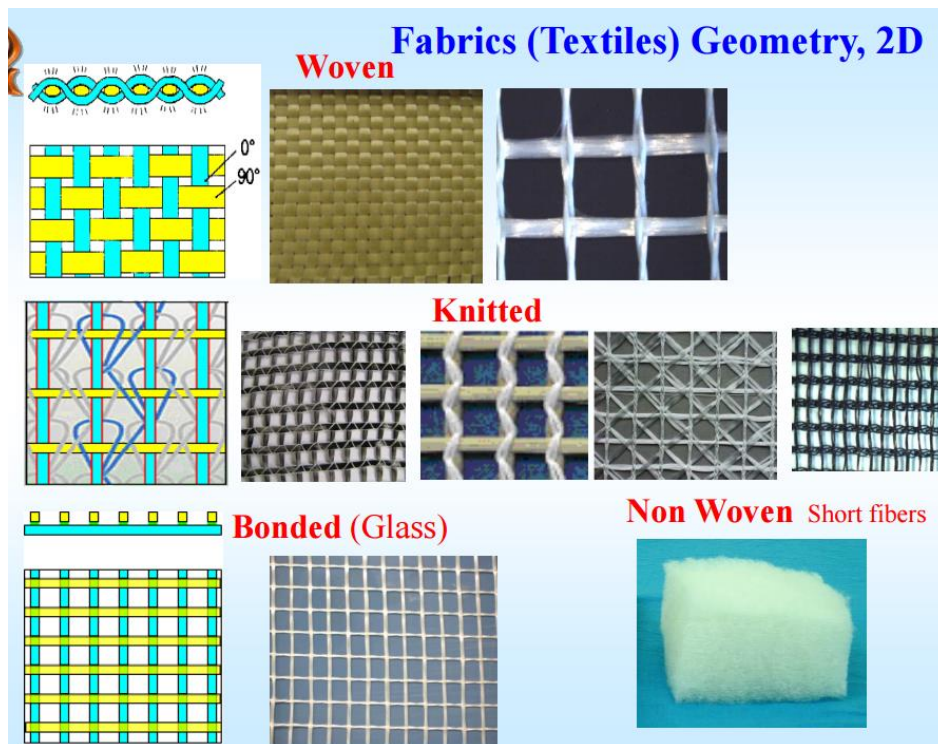


3D biaxial textile reinforcement

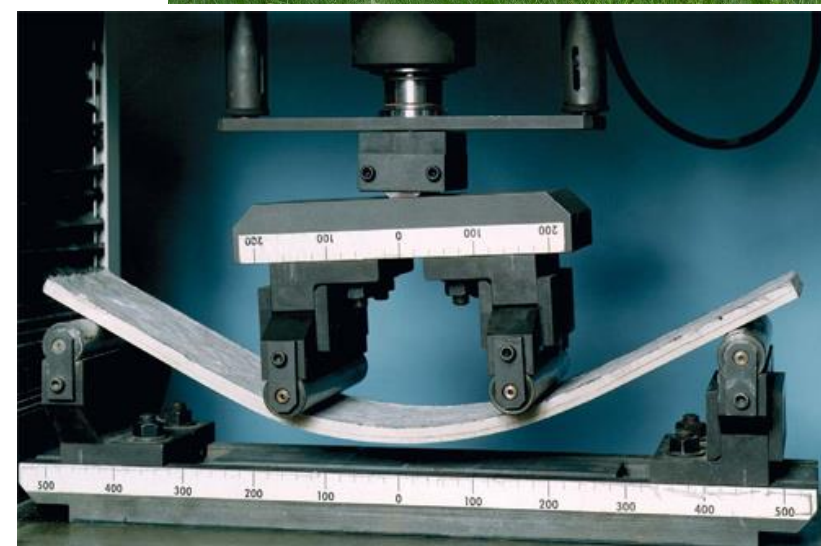


Type of reinforcements / Tipuri de armături

3) DISPERSED REINFORCEMENT → different types of TEXTILES

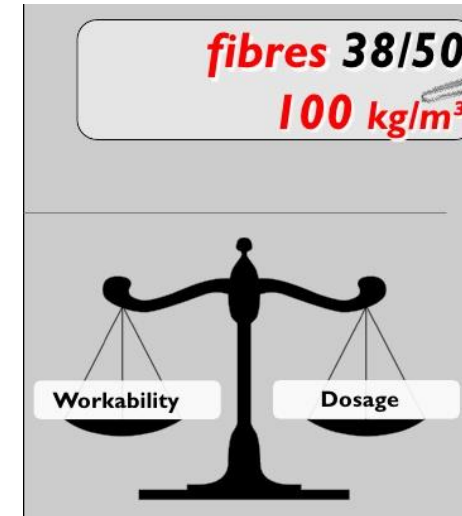


(Alva Peled)



Type of reinforcements / Tipuri de armături

3) DISPERSED REINFORCEMENT → different types of TEXTILES



4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES

Advantages of use of FRP composites in constructions

- High ultimate strength ($>4000 \text{ N/mm}^2$)
- Low weight ($\sim 1000 \div 2000 \text{ daN/m}^3$)
- Durability
- Low maintenance cost
- Versatility of systems
- High impact strength

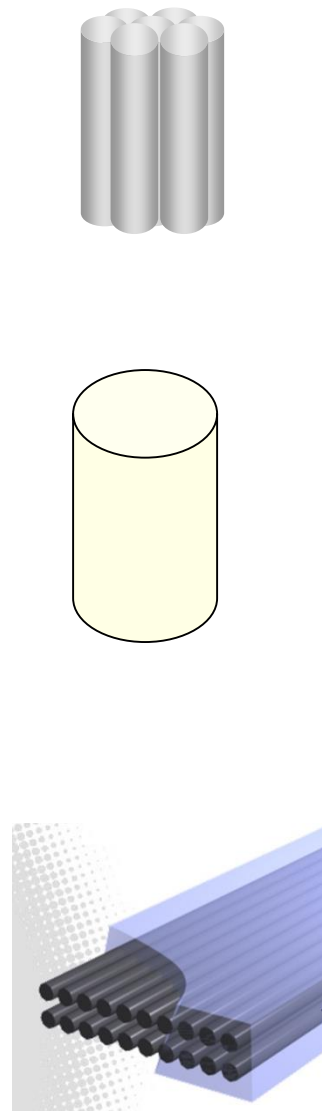
4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES

Domains of use

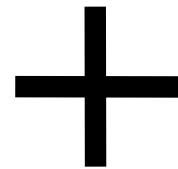
- Reinforced concrete exposed to salts
- Maritime structures
- Structural elements exposed to corrosive agents
- Application with needs of electromagnetic transparency or low thermally and electrically conductivity
- Weight sensitive structures

Type of reinforcements / Tipuri de armături

4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES



FIBRE

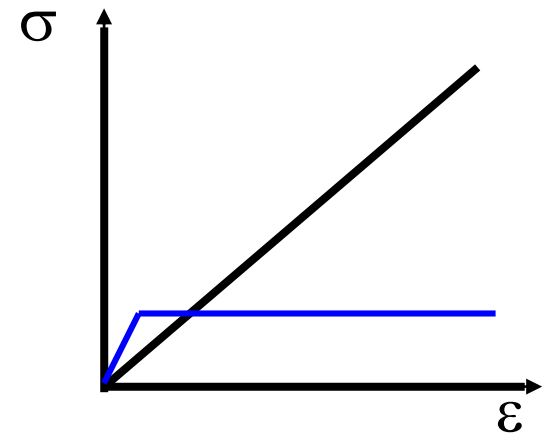


MATRIX



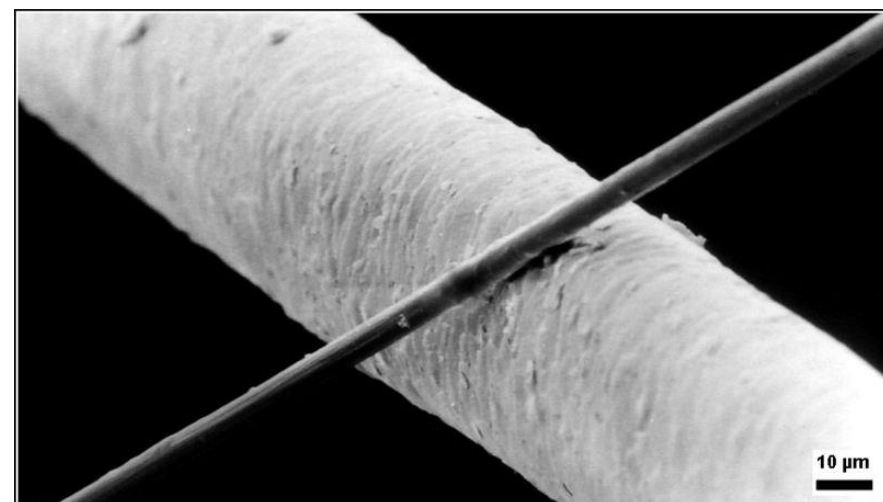
FRP COMPOSITE

- graphite (carbon)
 - glass
 - aramid
 - basalt
 - hybrid
-
- thermoplastic
 - thermorigide



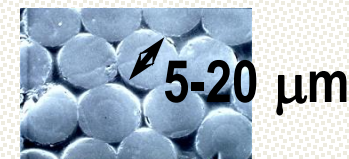
Type of reinforcements / Tipuri de armături

4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES



CROSS SECTION

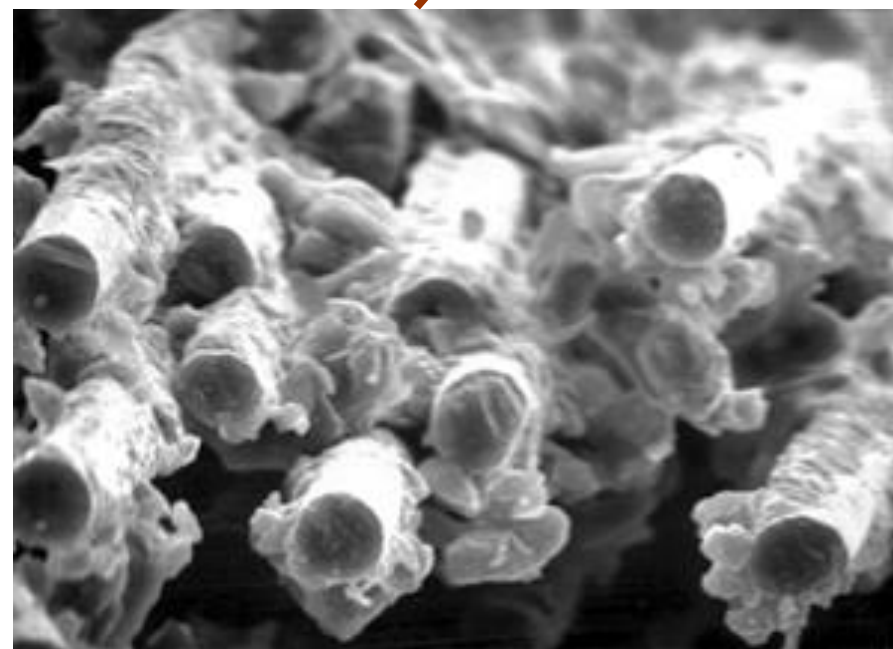
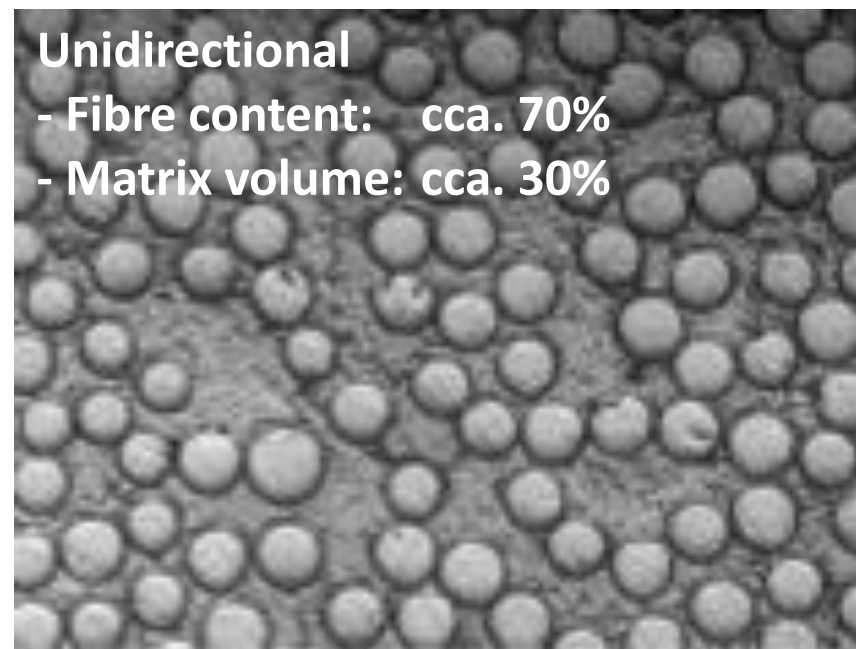
Ratio >10:1



HAIR DIAMETER
~ 200 nm

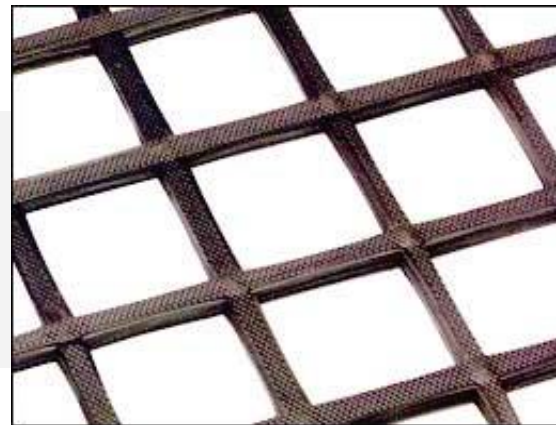
Unidirectional

- Fibre content: cca. 70%
- Matrix volume: cca. 30%



Type of reinforcements / Tipuri de armături

4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES

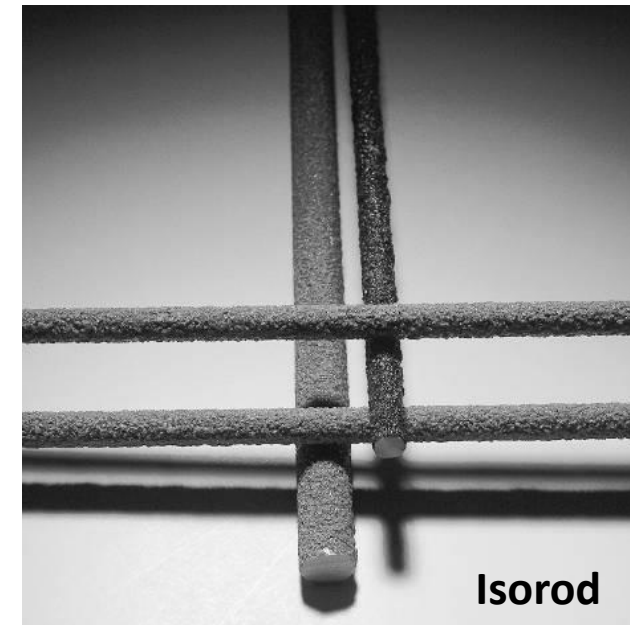


NEFMAC grid

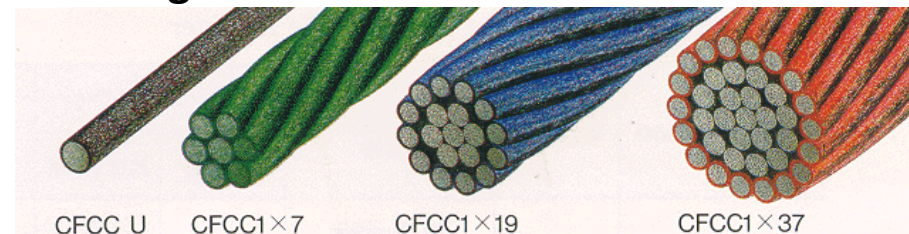


C-Bar reinforcement

Technora rebars and strands



Isorod



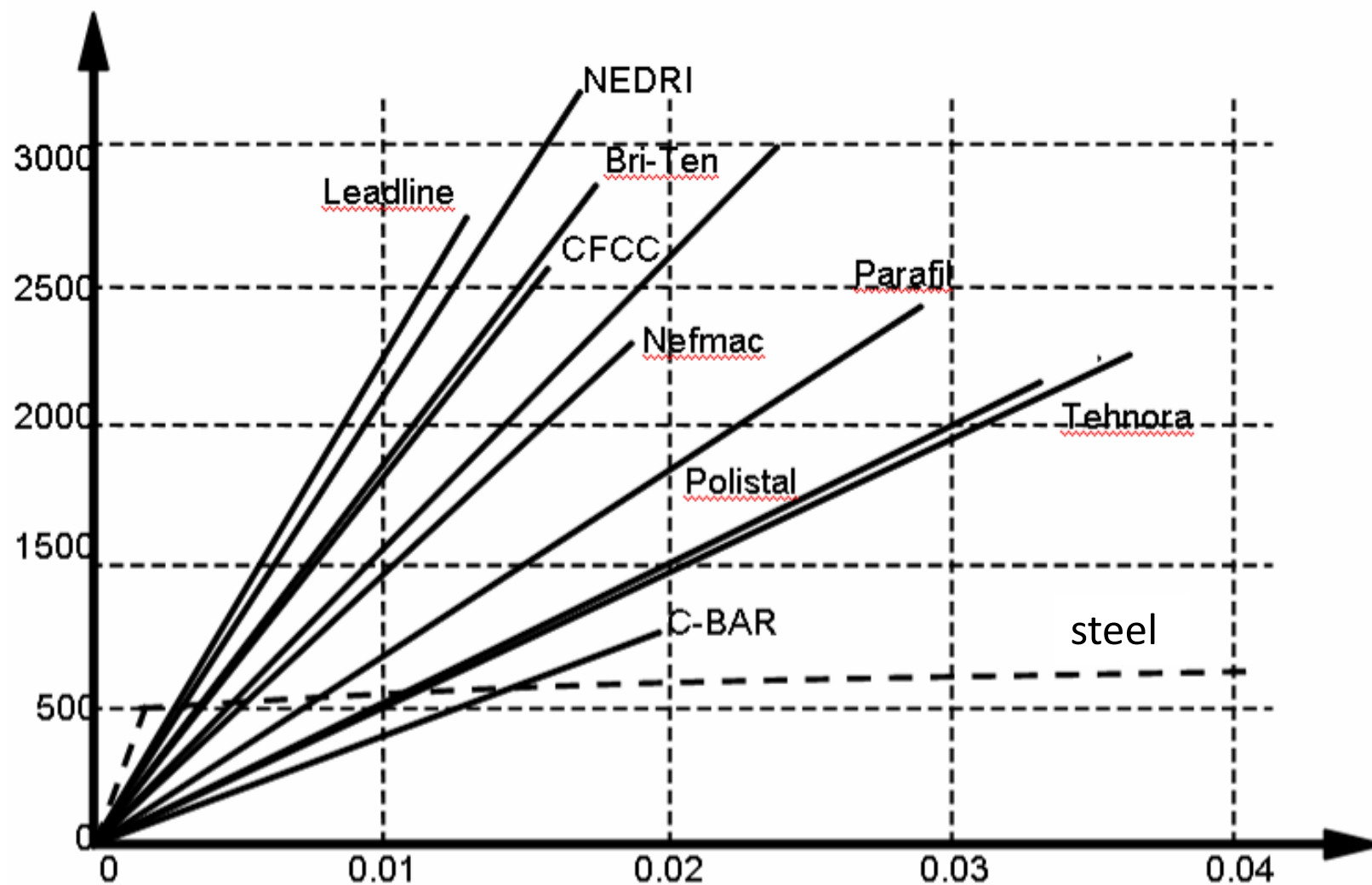
CFCC strands



CRT

Type of reinforcements / Tipuri de armături

4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES



Type of reinforcements / Tipuri de armături

| MATERIALS | Tensile strength [N/mm ²] | Modulus of elasticity [N/mm ²] | Density [kg/m ³] | Strain at failure [%] | |
|---------------------|--|---|---------------------------------|--------------------------|------------|
| GLASS FIBER | E | 1900 ÷ 3000 | 70000 | 1200 ÷ 2600 | 3.0 ÷ 4.5 |
| | S | 3500 ÷ 4800 | 85000 ÷ 90000 | | 4.5 ÷ 5.5 |
| ARAMID FIBER | | | | | |
| Low modulus | 3500 ÷ 4100 | 70000 ÷ 80000 | 1200 ÷ 1700 | | |
| High modulus | 3500 ÷ 4000 | 115000 ÷ 130000 | | | 2.5 ÷ 3.5 |
| CARBON FIBER | | | | | |
| High strength | 3500 ÷ 4800 | 215000 ÷ 235000 | | | 1.4 ÷ 2.0 |
| Ultra high strength | 3500 ÷ 6000 | 215000 ÷ 235000 | 1500 ÷ 1900 | | 1.5 ÷ 2.3 |
| High modulus | 2500 ÷ 3100 | 350000 ÷ 500000 | | | 0.5 ÷ 0.9 |
| Ultra high modulus | 2100 ÷ 2400 | 500000 ÷ 700000 | | | 0.2 ÷ 0.4 |
| Basalt fibers | 4800 | 89000 | 2700 | | 3.15 |
| Resin (Matrix) | 80 ÷ 100 | 30000 ÷ 40000 | 900 ÷ 1700 | | 0.5 ÷ 5 |
| GFRP | 770 ÷ 1670 | 38500 ÷ 155000 | 1800 ÷ 2100 | | 0.45 ÷ 2.2 |
| AFRP | 1500 ÷ 3000 | 50000 ÷ 130000 | 13 | | 2.4 ÷ 3.6 |
| CFRP | 1300 ÷ 2800 | 165000 ÷ 400000 | 1600 | | 0.45 ÷ 1.7 |
| CONCRETE | 1 ÷ 3 | 21000 ÷ 50000 | 2300 ÷ 2500 | | 0.015 |
| STEEL REINFORCEMENT | 350 ÷ 550 | 210000 | 7800 | | (0.2) 25 |
| PRESTRESSING REINF. | 1200 ÷ 1800 | 210000 | 7800 | | NA |

Type of reinforcements / Tipuri de armături

4) REINFORCEMENT FROM FIBER REINFORCED POLYMER COMPOSITES



3.1 TYPE OF REINFORCEMENTS

3.2 EXAMPLES OF REINFORCEMENT

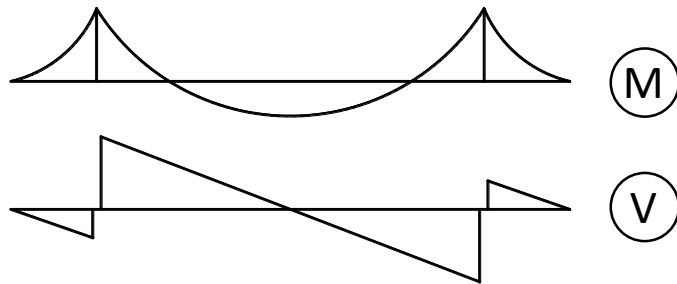
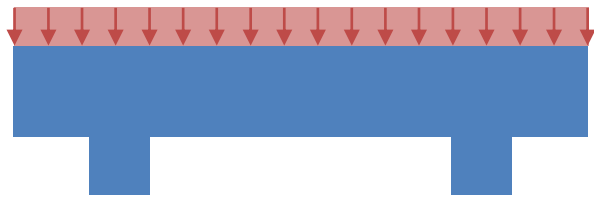
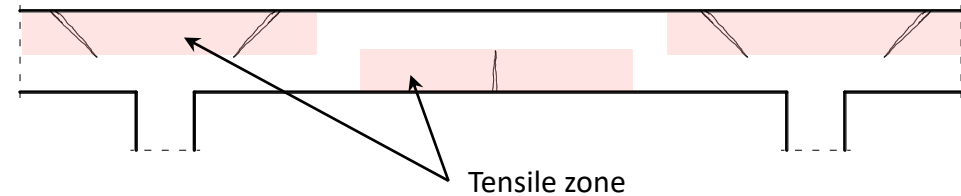
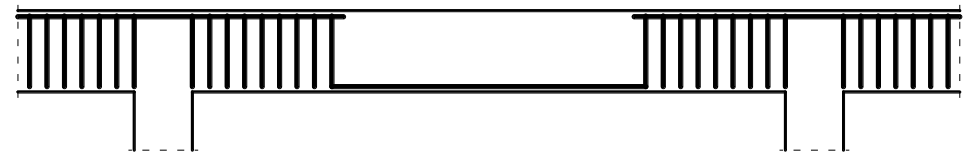
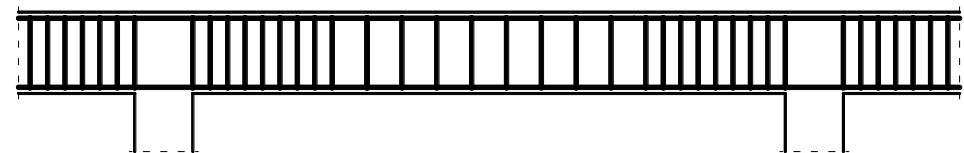
3.3 PROPERTIES OF REINFORCEMENTS

Samples of element reinforcement / Exemple de armări

ROLE OF REINFORCEMENTS:

A) Primary reinforcements → from dimensioning calculations

- Longitudinal – rebars – $M+N$, T
- Transversal – stirrups – V , T

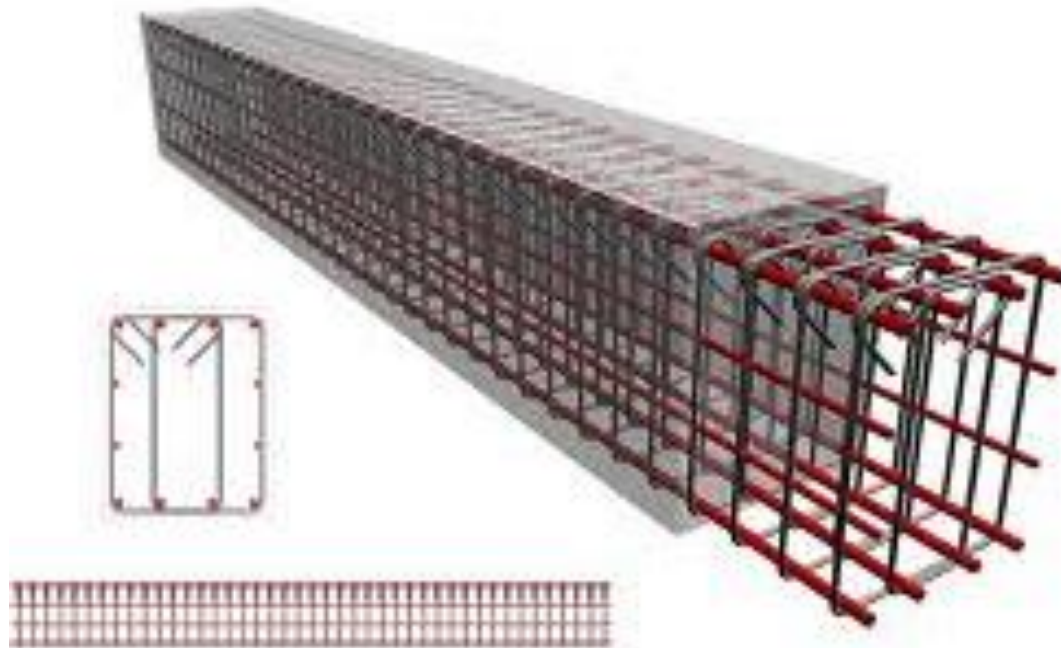
*Cracking of a beam**Necessary reinforcement – theory**Reinforcement disposal – practice*

Samples of element reinforcement / Exemple de armări

ROLE OF REINFORCEMENTS:

A) Primary reinforcements → from dimensioning calculations

- Longitudinal – rebars – $M+N$, T
- Transversal – stirrups – V , T

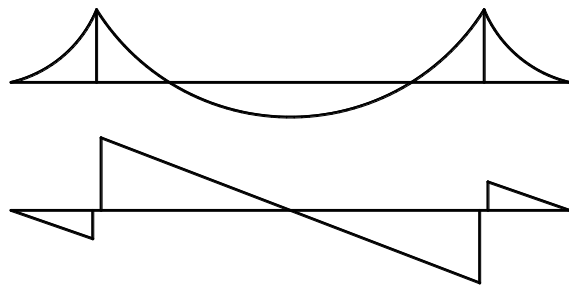
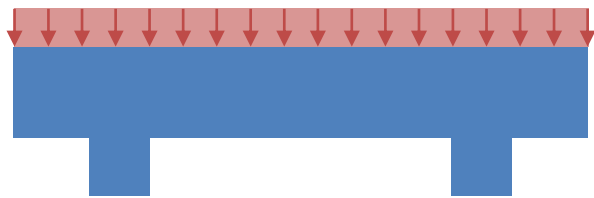


Samples of element reinforcement / Exemple de armări

ROLE OF REINFORCEMENTS:

B) Secondary reinforcement → for assembly and stability at casting

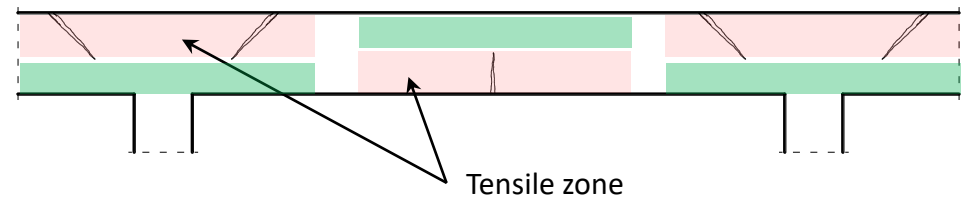
- disposed without calculus, from prescriptions



(M)

(V)

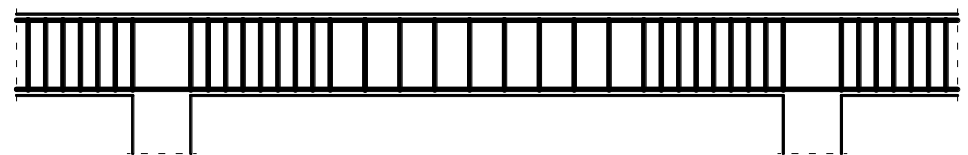
Cracking of a beam



Necessary reinforcement – theory



Reinforcement disposal – practice



Samples of element reinforcement / Exemple de armări

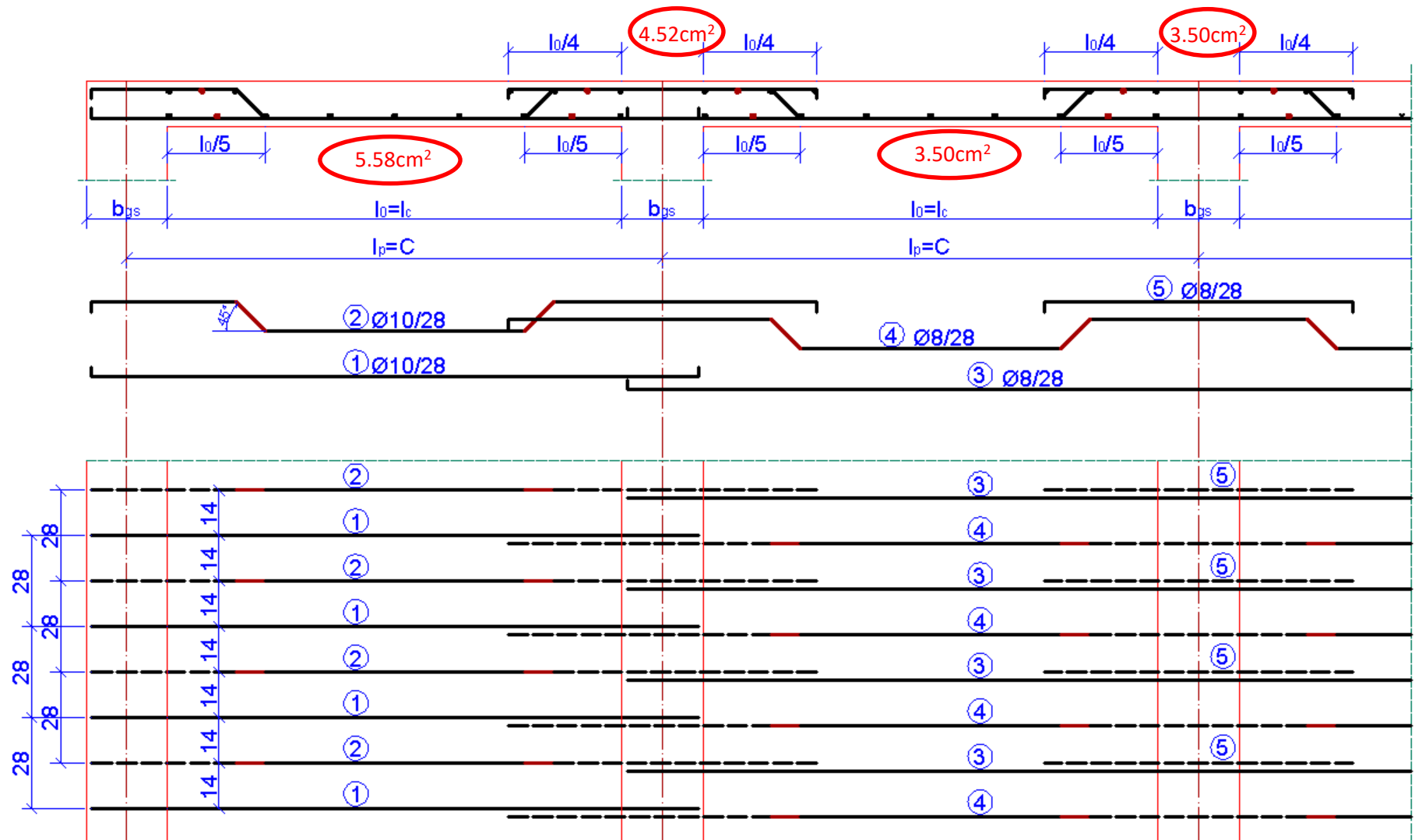
ROLE OF REINFORCEMENTS:

B) Secondary reinforcement → for assembly and stability at casting

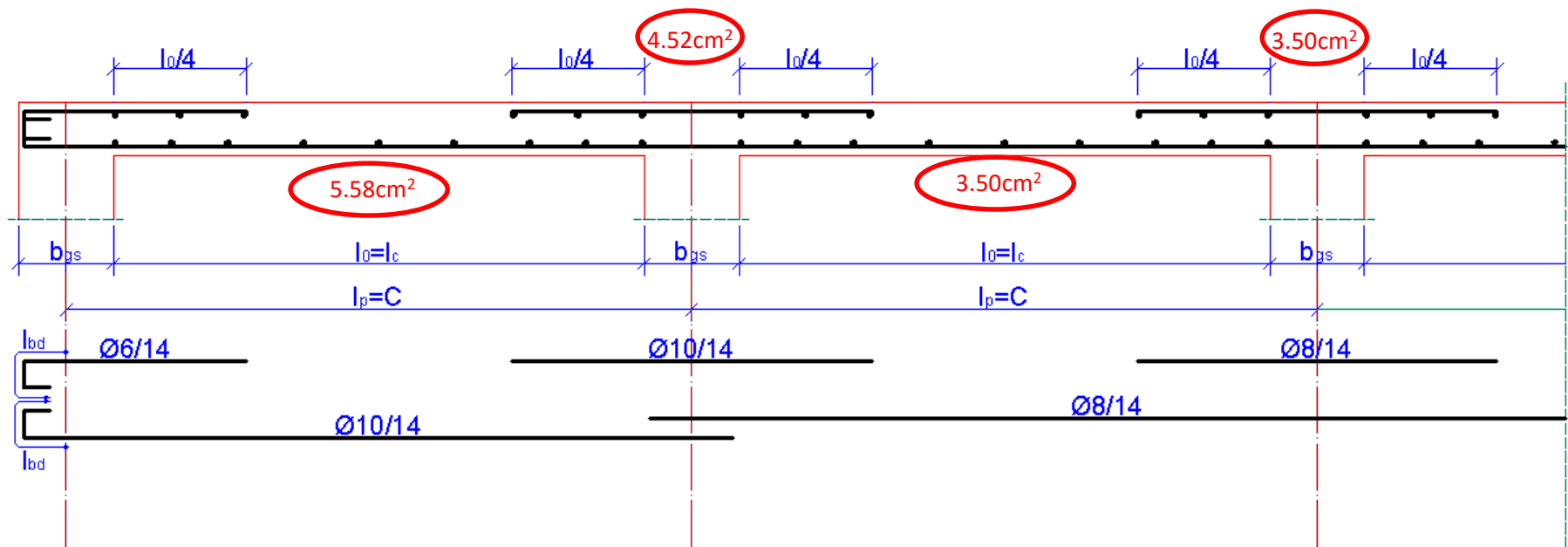
- disposed without calculus, from prescriptions



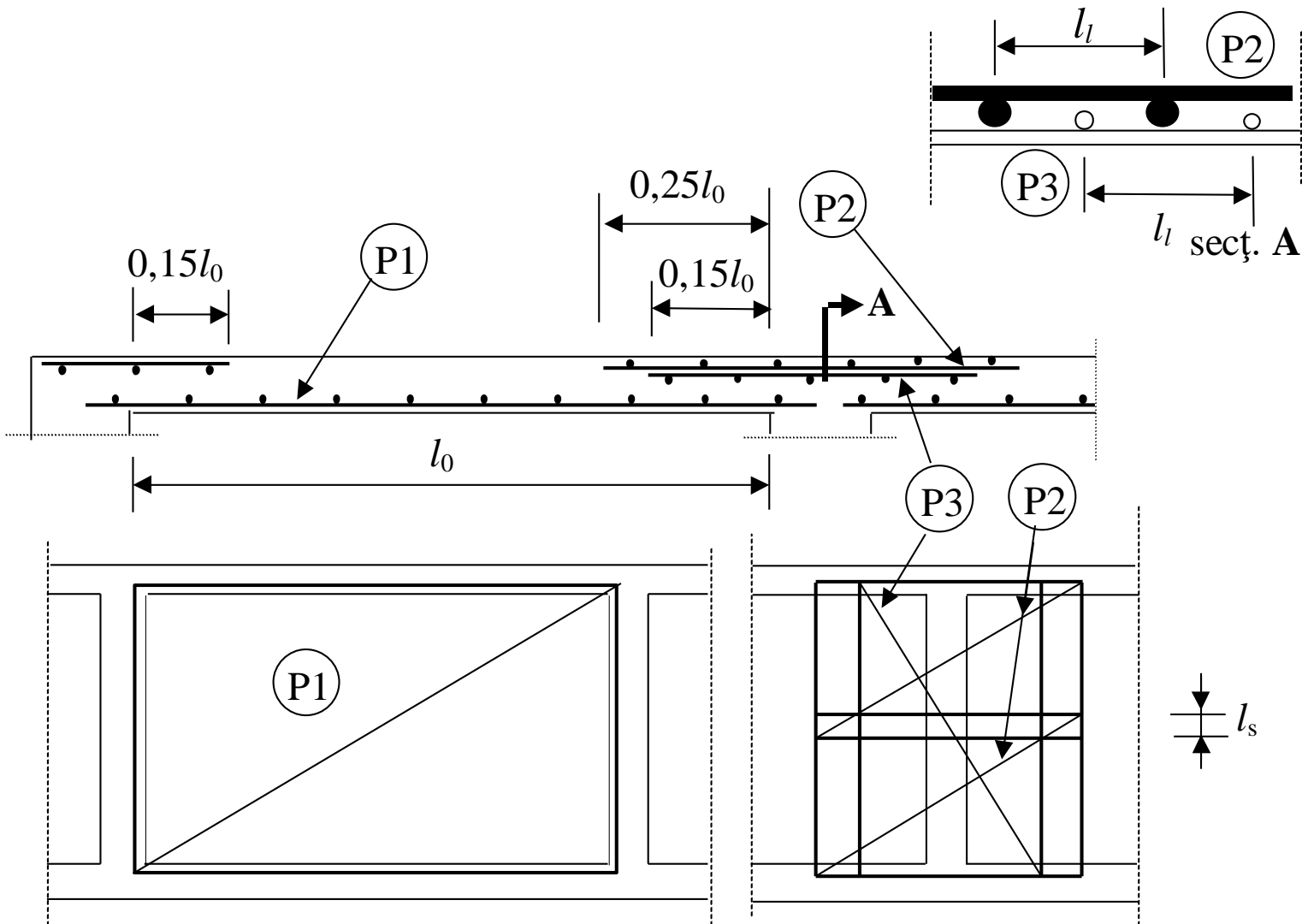
Samples of element reinforcement / Exemple de armări

Slab reinforcements → with bent bars

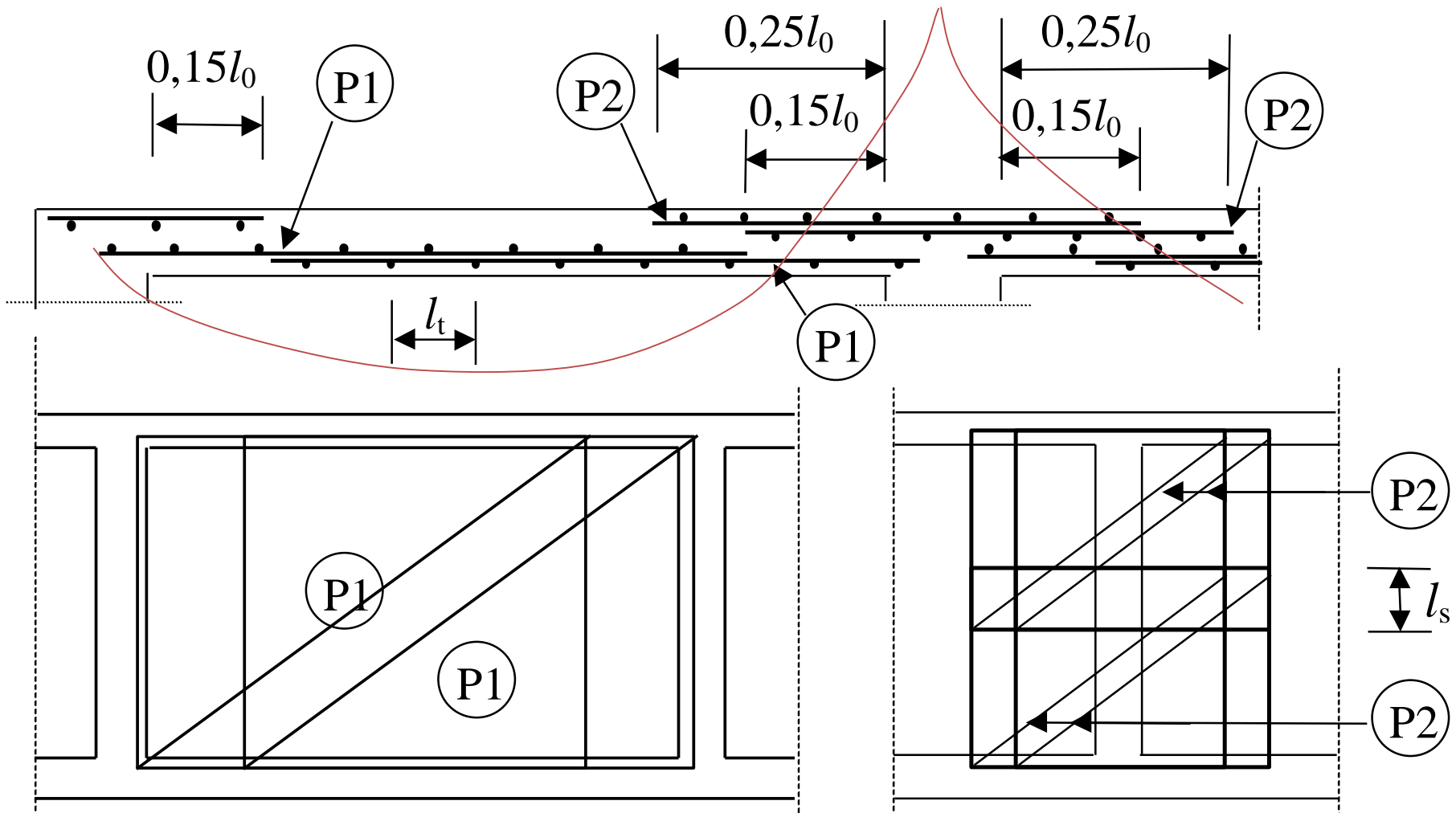
Samples of element reinforcement / Exemple de armări

Slab reinforcements → with **strait** bars

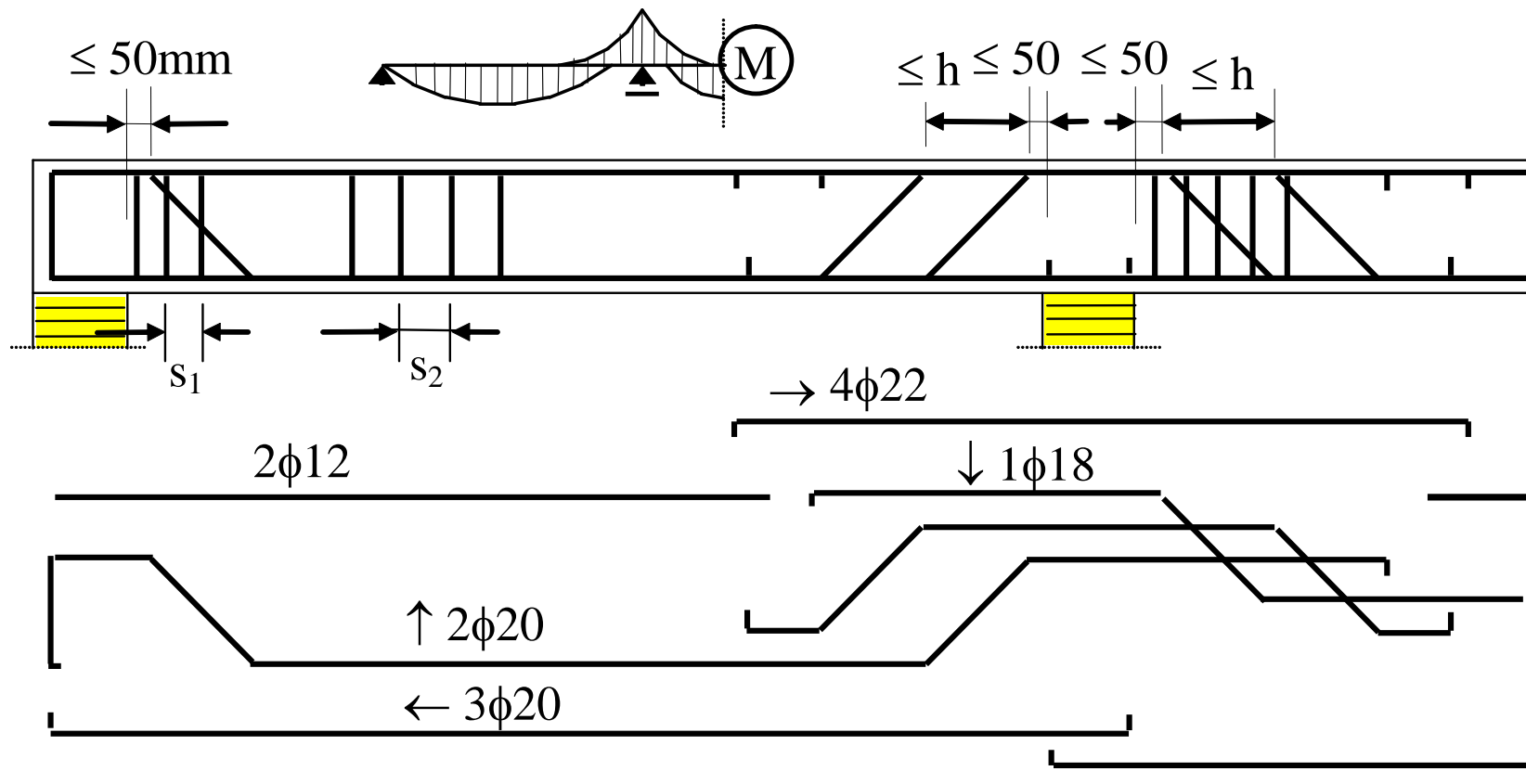
Samples of element reinforcement / Exemple de armări

Slab reinforcements → with welded fabrics

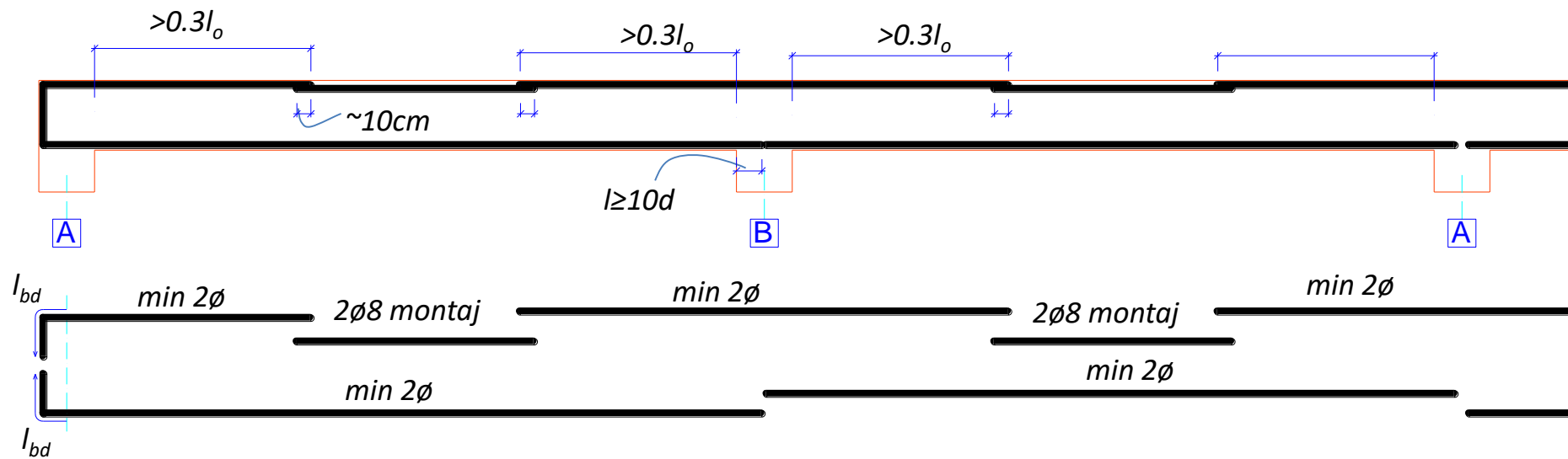
Samples of element reinforcement / Exemple de armări

Slab reinforcements → with welded fabrics

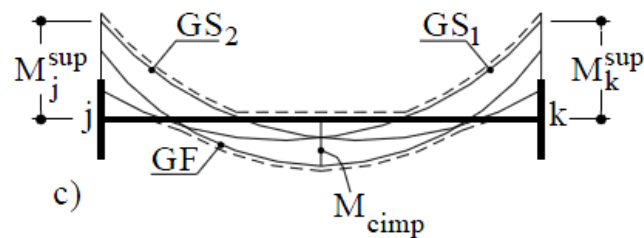
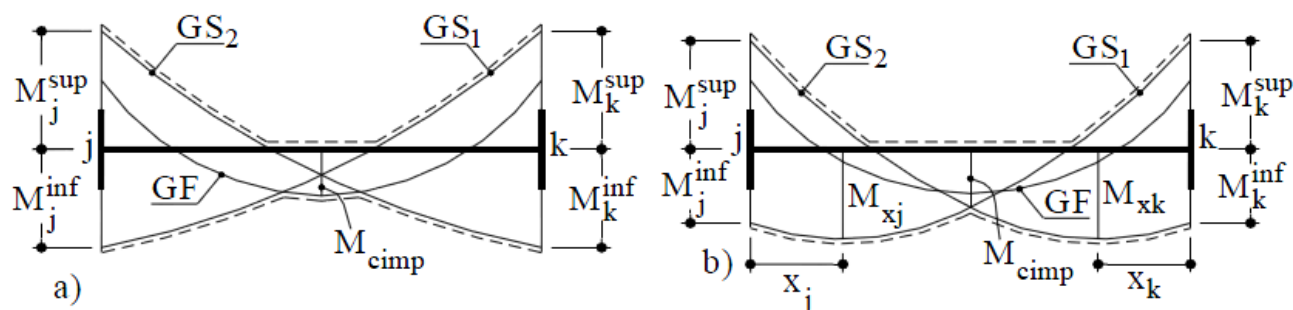
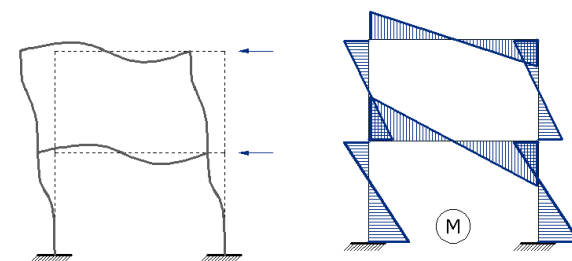
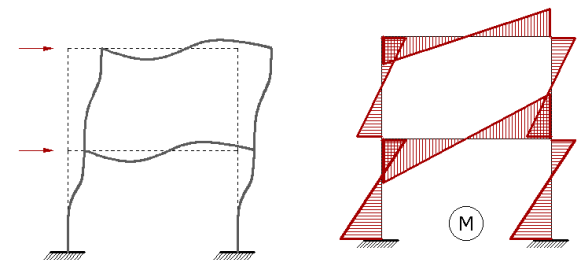
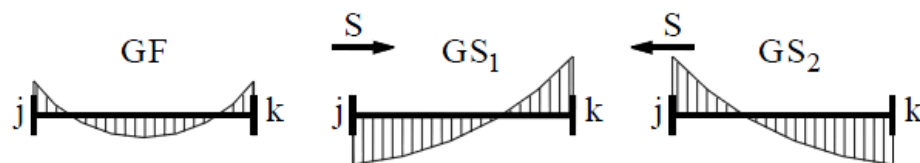
Samples of element reinforcement / Exemple de armări

Girder reinforcement → bent bars

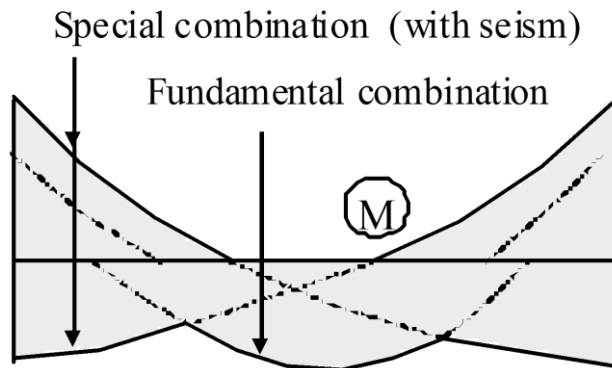
Samples of element reinforcement / Exemple de armări

Secondary beams reinforcement → strait bars

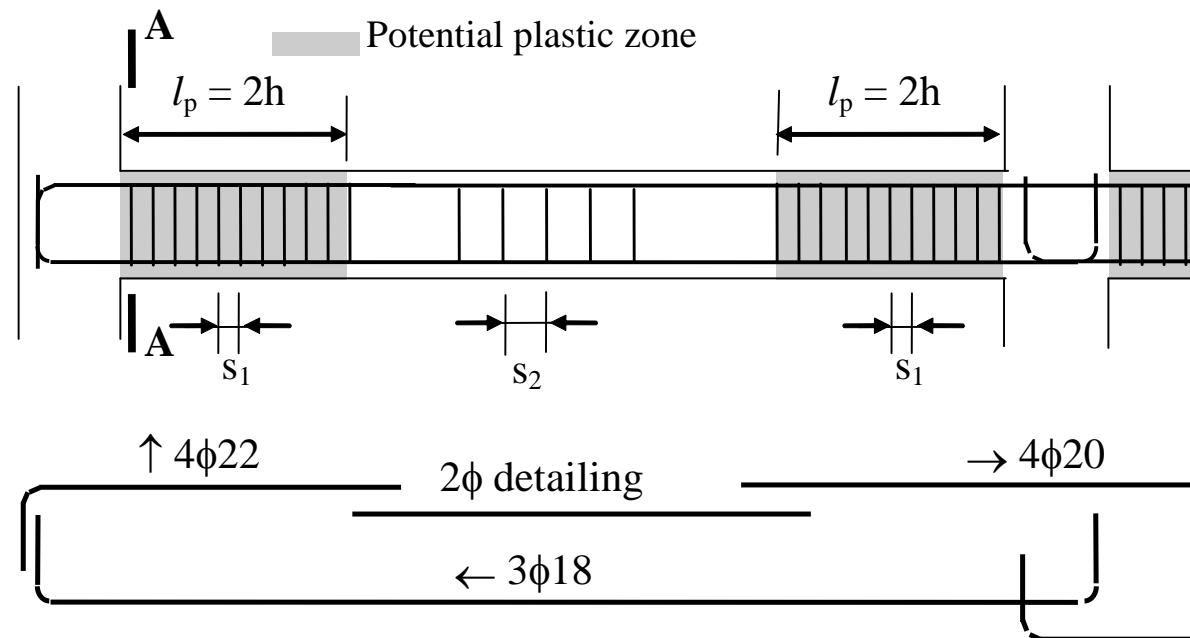
Samples of element reinforcement / Exemple de armări

Beam reinforcement → in seismic zones

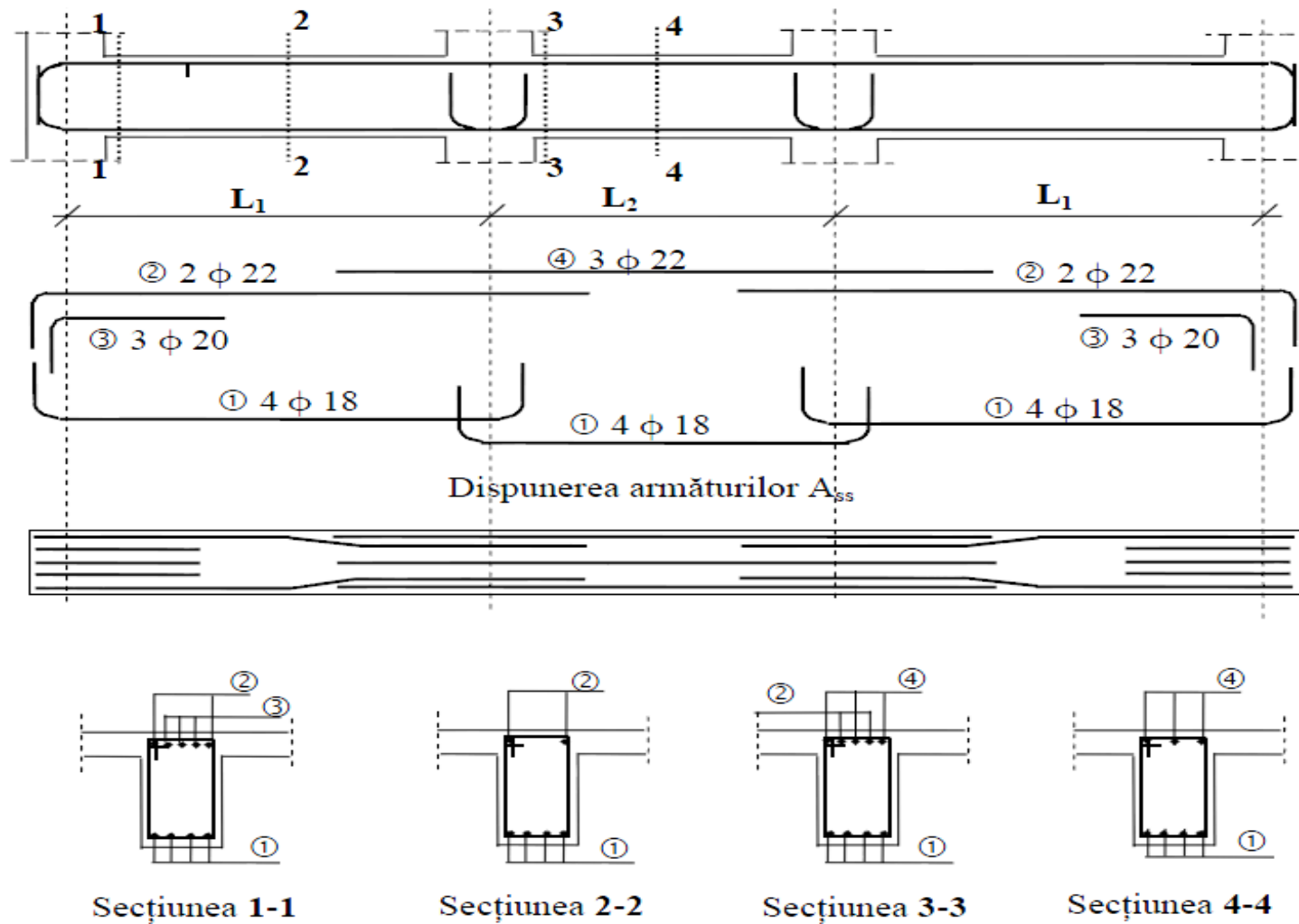
Samples of element reinforcement / Exemple de armări

Beam reinforcement → in seismic zones

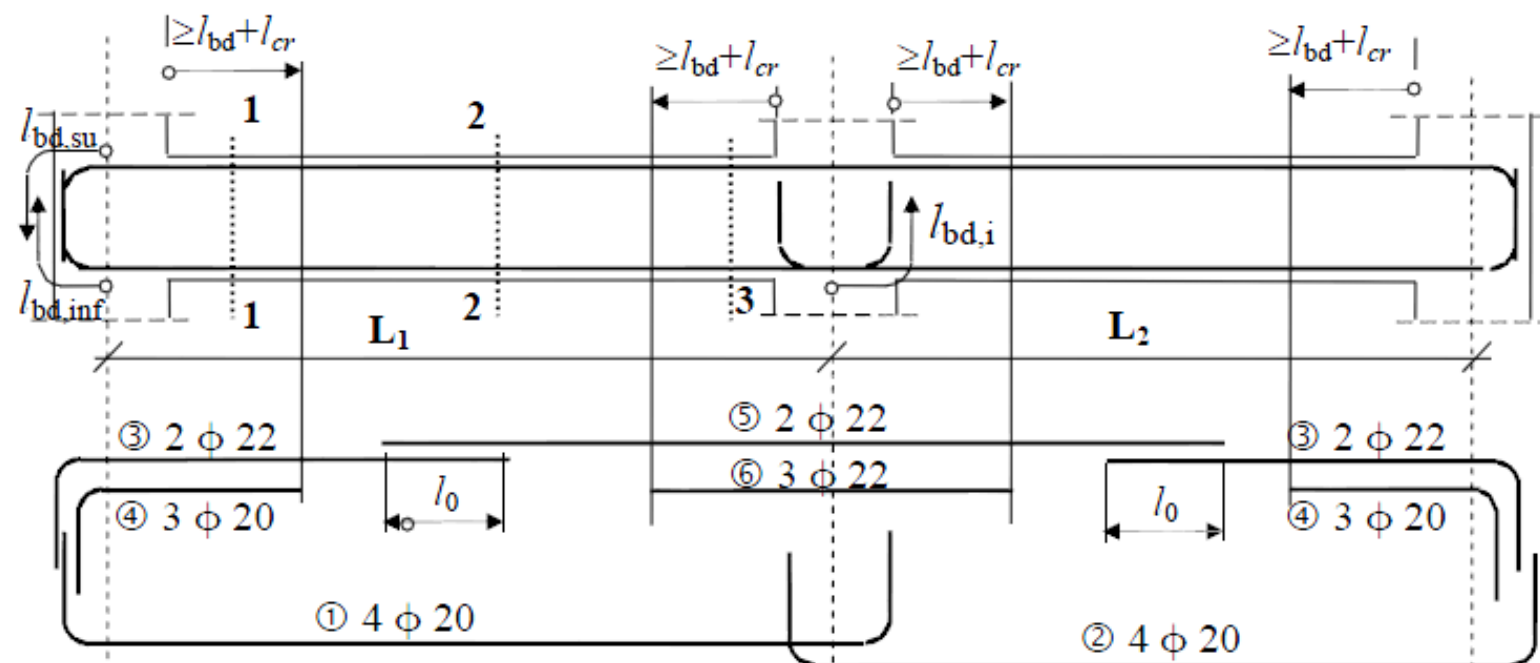
Envelope curve of the bending moments



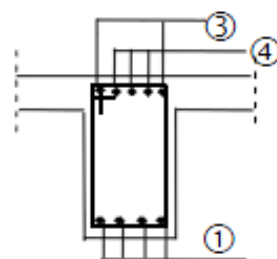
Samples of element reinforcement / Exemple de armări

Beam reinforcement → in seismic zones

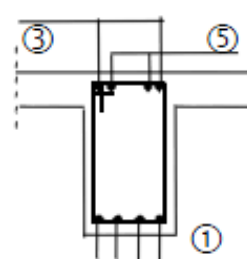
Samples of element reinforcement / Exemple de armări

Beam reinforcement → in seismic zones

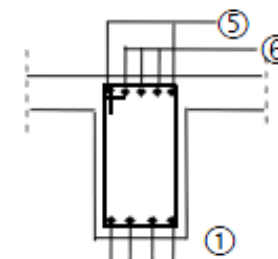
l_0 – lungimea de suprapunere



Secțiunea 1-1

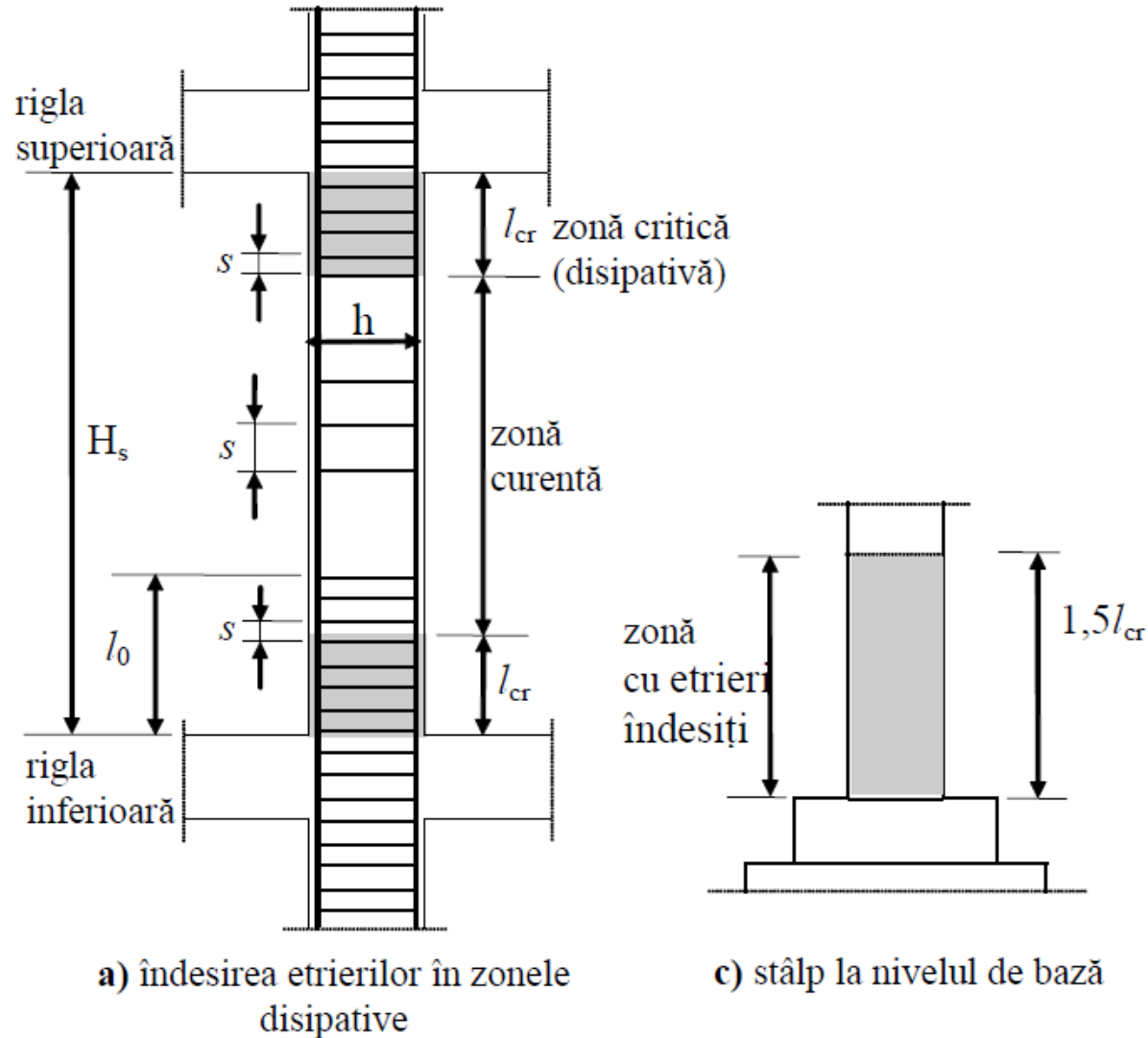


Secțiunea 2-2

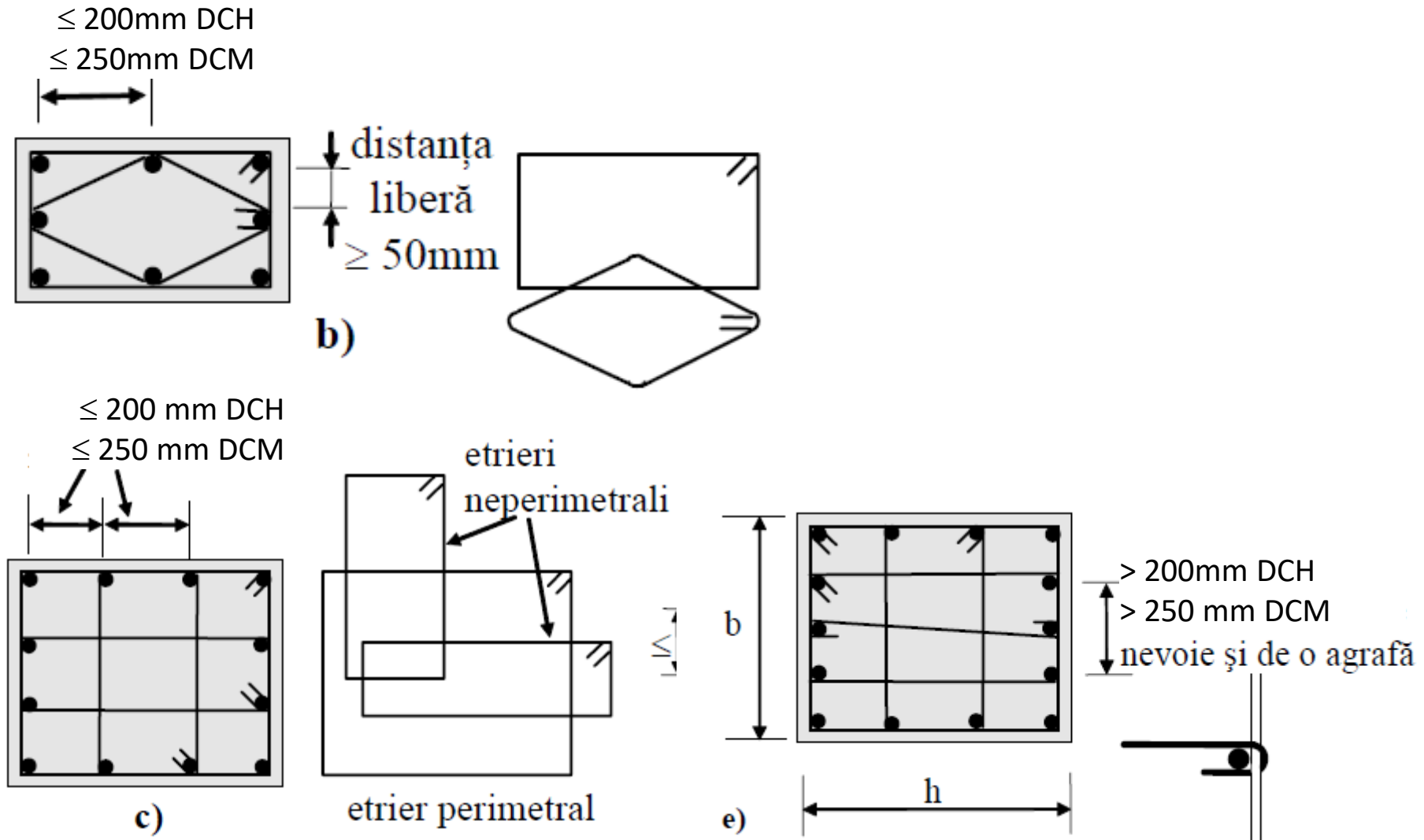


Secțiunea 3-3

Samples of element reinforcement / Exemple de armări

Column reinforcement → in seismic zones

Samples of element reinforcement / Exemple de armări

Column reinforcement → in seismic zones

3.1 TYPE OF REINFORCEMENTS

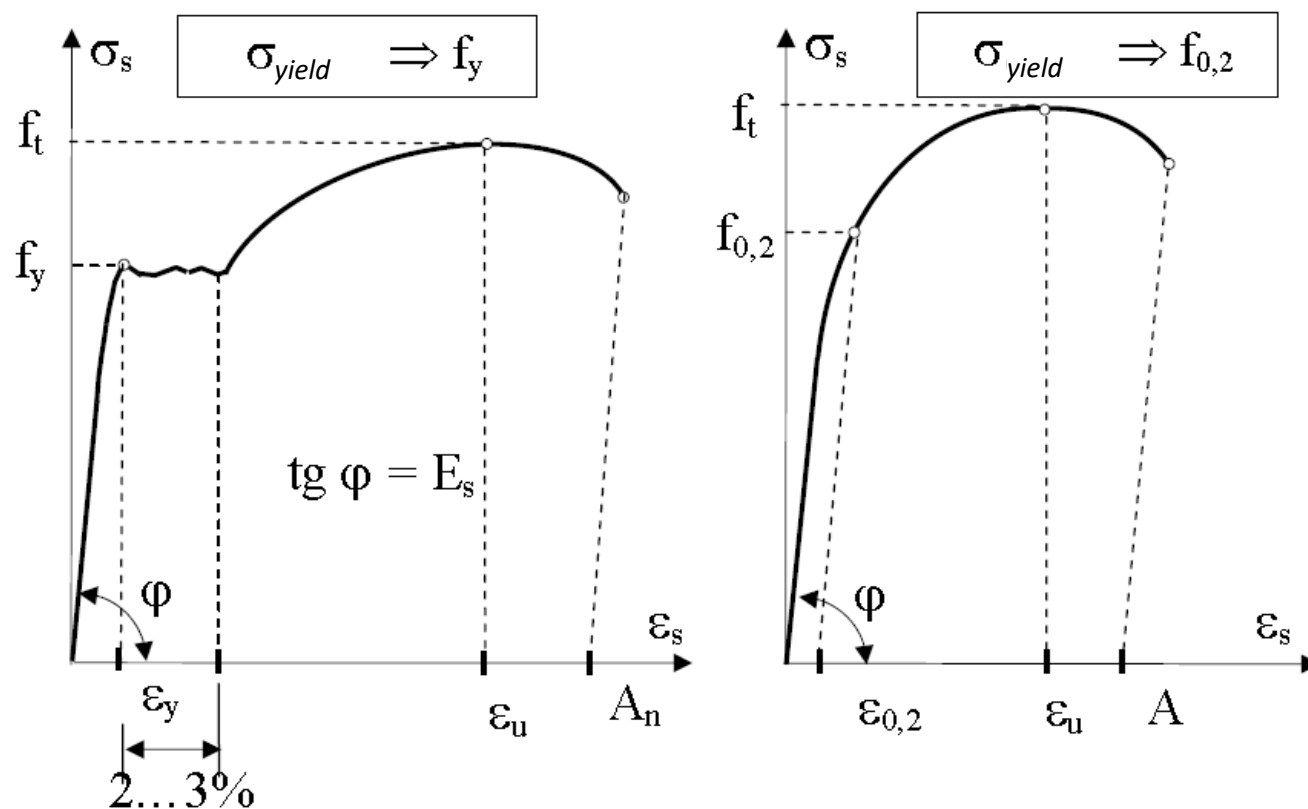
3.2 EXAMPLES OF REINFORCEMENT

3.3 PROPERTIES OF REINFORCEMENTS

Properties of the reinforcement / Proprietățile armăturilor

Behaviour under short term static loads

– characteristic curve of steel
 → tensile test



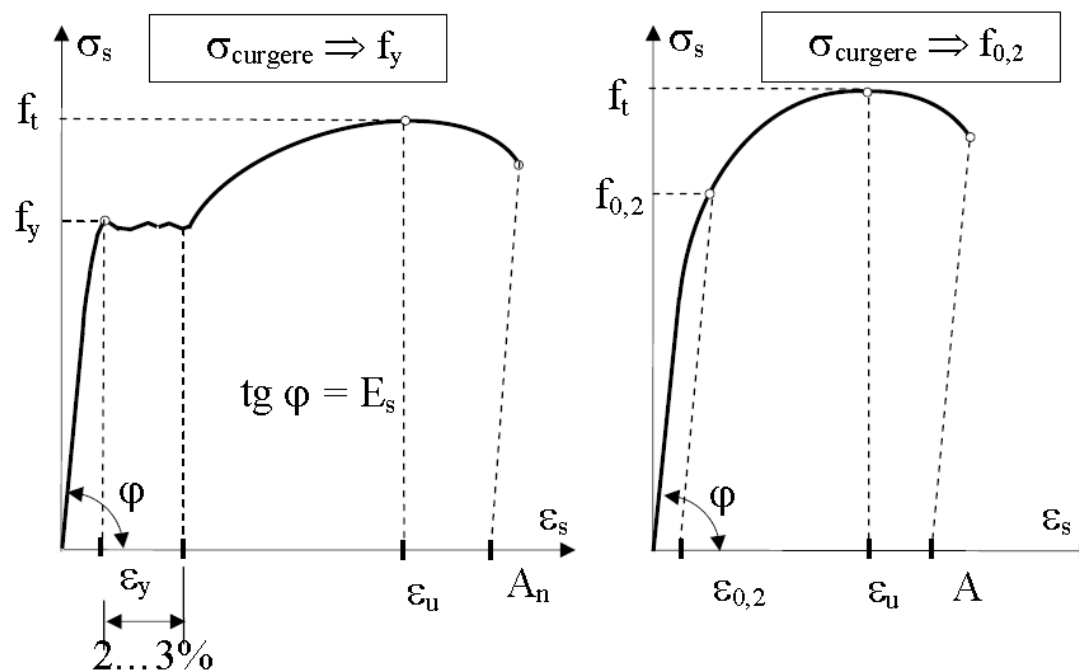
a) Steel with yield limit

b) Steel without yield limit

Properties of the reinforcement / Proprietățile armăturilor

Behaviour under short term static loads

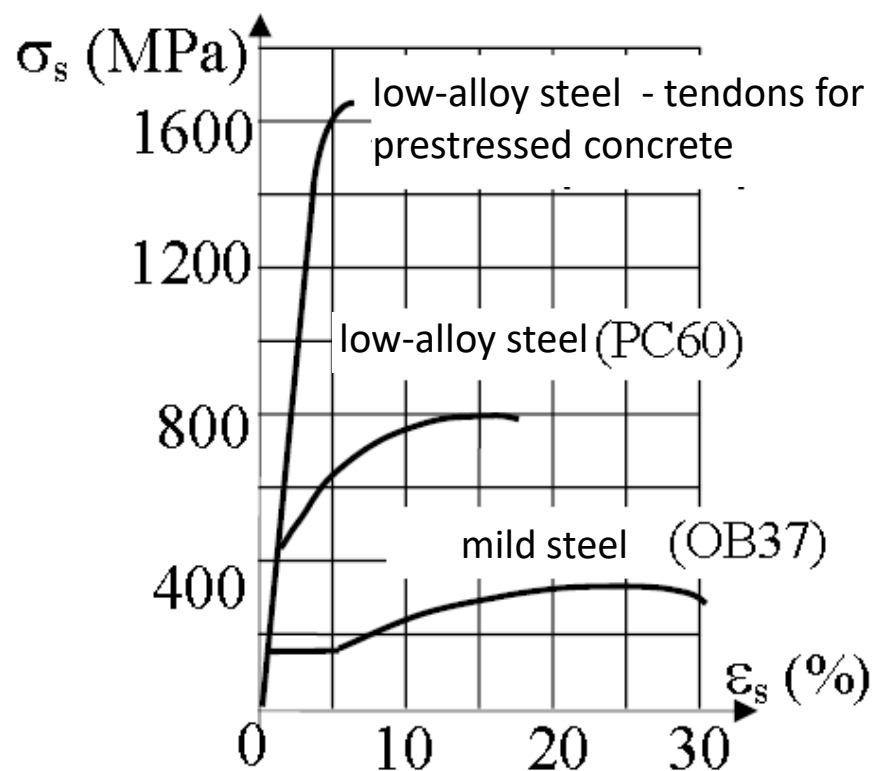
- f_{yk} - Characteristic yield strength of reinforcement (R_e)
- f_t - Tensile strength of reinforcement (R_m)
- $f_{0,2k}$ - Characteristic 0,2% proof-stress of reinforcement ($R_{0,2}$) (conventional)
- ε_{uk} - Characteristic strain of reinforcement at maximum load (A_{gt})
- A_n - Elongation after rupture (plastic deformation)



Properties of the reinforcement / Proprietățile armăturilor

- **Mild steel** has a low carbon content of about 0.2%:
 - elastic behavior until the apparent yield limit f_y
 - pronounced plastic behavior by the presence of the yielding plateau.
- **Low-alloy Steel** has a higher carbon content and other alloying elements:
 - Increases tensile strength, f_t
 - Reduced yielding plateau or disappearance
 - Reduction of the elongation to the maximum force, or the one measured after failure
 - Plastic behavior is indicated by reaching the conventional yielding limit, $f_{0,2}$
- **Reinforcement for reinforced concrete** → Mild steel and low-alloy steel with a carbon content of less than 0,3%
- **Reinforcement for prestressed concrete** → low-alloy steel with a carbon content of 0,6...0,9%, Manganese 0,3...0,7% and a maximum of 0,035% phosphorus and sulfur.

Properties of the reinforcement / Proprietățile armăturilor



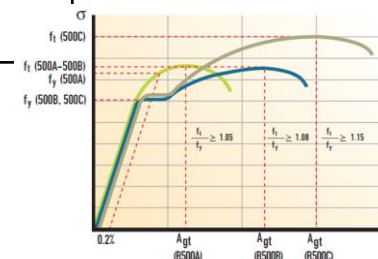
Properties of the reinforcement / Proprietățile armăturilor

Caracteristici mecanice ale unor armături laminate la cald

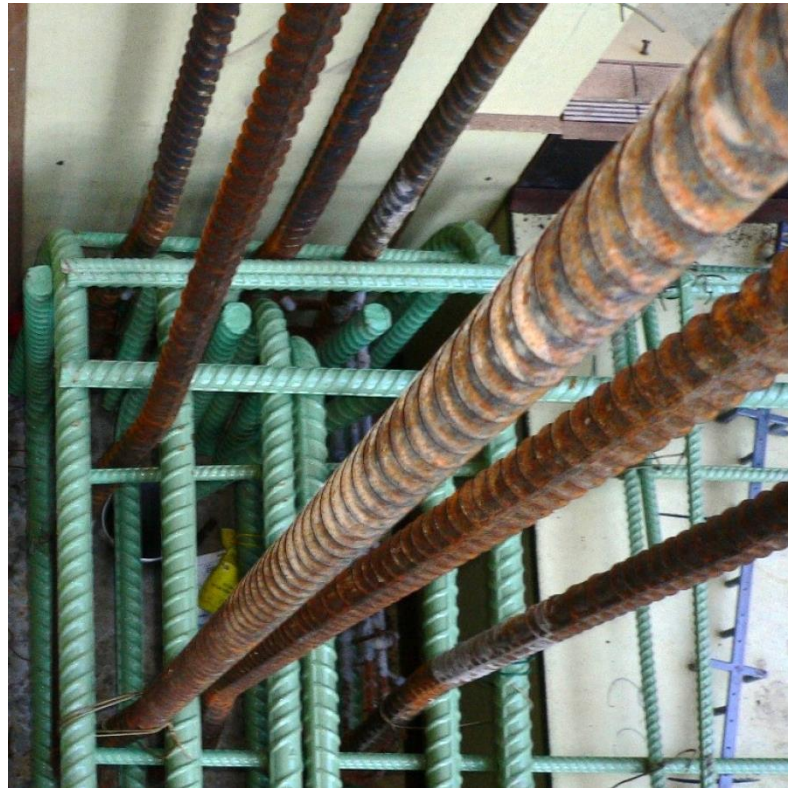
| Commercial denomination | Equivalent denomination | Nominal diameter (mm) | Minimal characteristic values | |
|-------------------------|-------------------------|-----------------------|-------------------------------|---------------------------------|
| | | | Yielding limit f_{yk} [Mpa] | Tensile strength f_{tk} [Mpa] |
| OB37 | 6...12 | 255 | 360 | 25 |
| | 14...40 | 235 | | |
| PC52 | 6...14 | 355 | 510 | 20 |
| | 16...28 | 345 | | |
| | 32...40 | 335 | | |
| B500B | 5...50 | 500 | 630 | > 9.0% |
| STNB | 3...10 | 400...510 | 510...610 | 6...8 |
| SPPB | 4...12 | 460 | 510 | |

- Modulus of elasticity $E_s = 200\ 000 - 210\ 000\ \text{N/mm}^2$

- Volumic mass = $7850\ \text{kg/m}^3$



THANK YOU FOR YOUR ATTENTION!



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