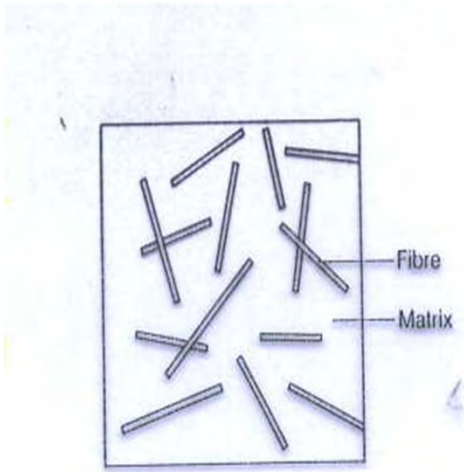
Applications of Fiber Reinforced Polymers in Structural Engineering

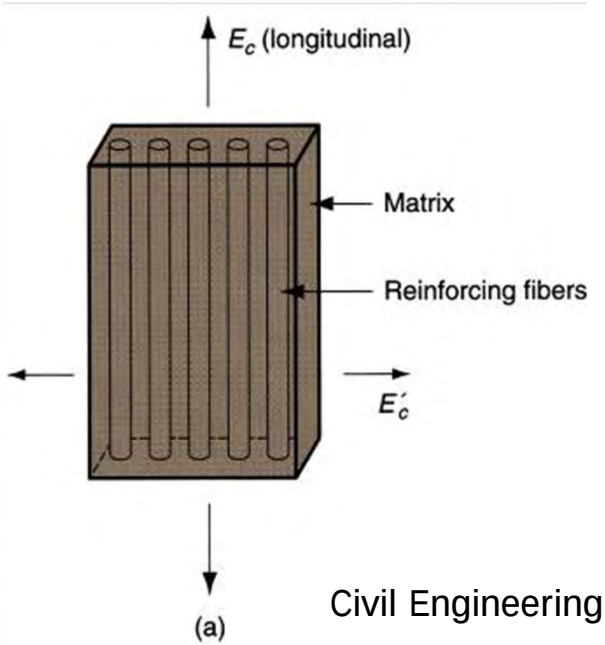
Civil Engineering Division – Enppi

Definition

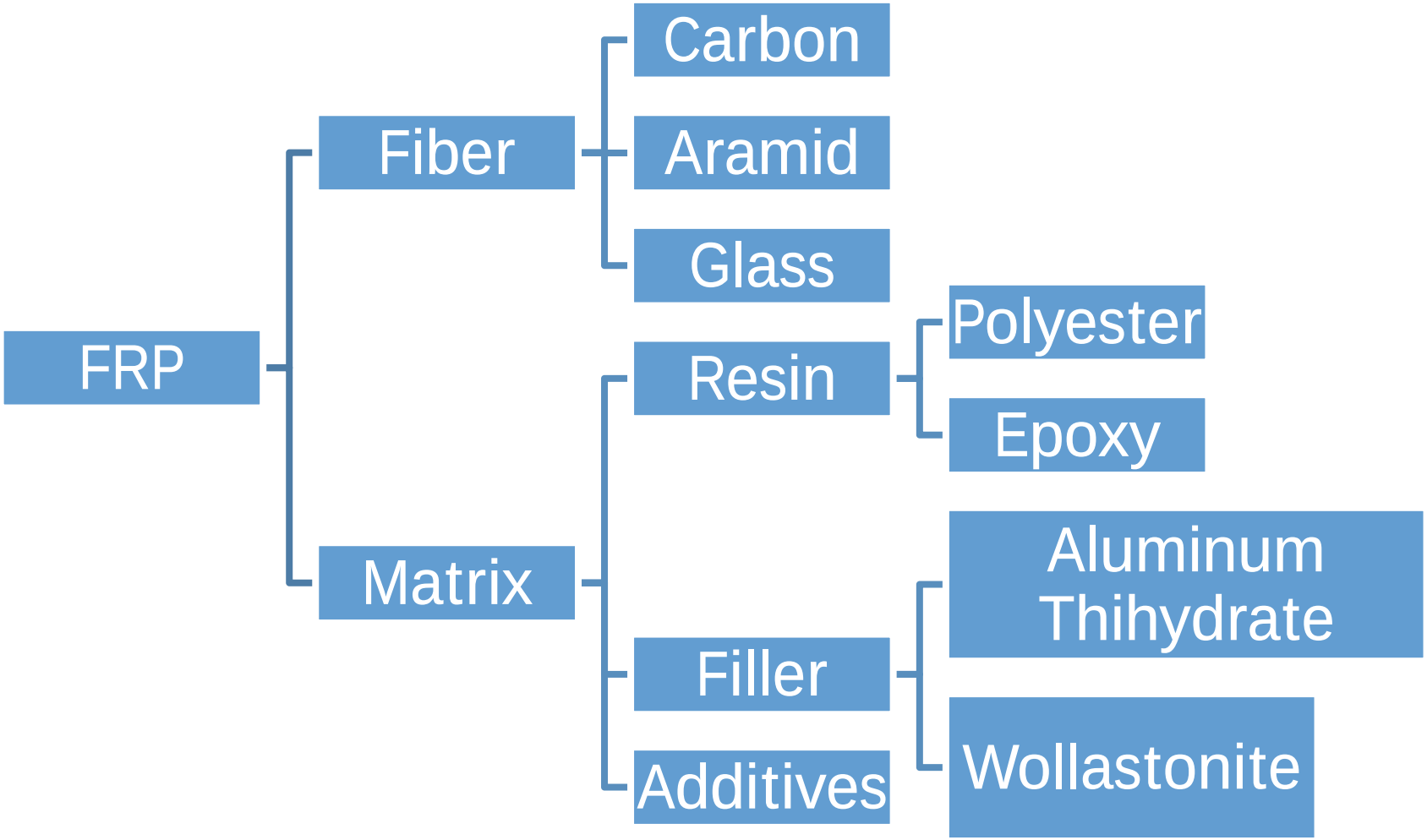
Fiber Reinforced Polymer (FRP) Composites are defined as:

"A matrix of polymeric material that is reinforced by fibers or other reinforcing material"





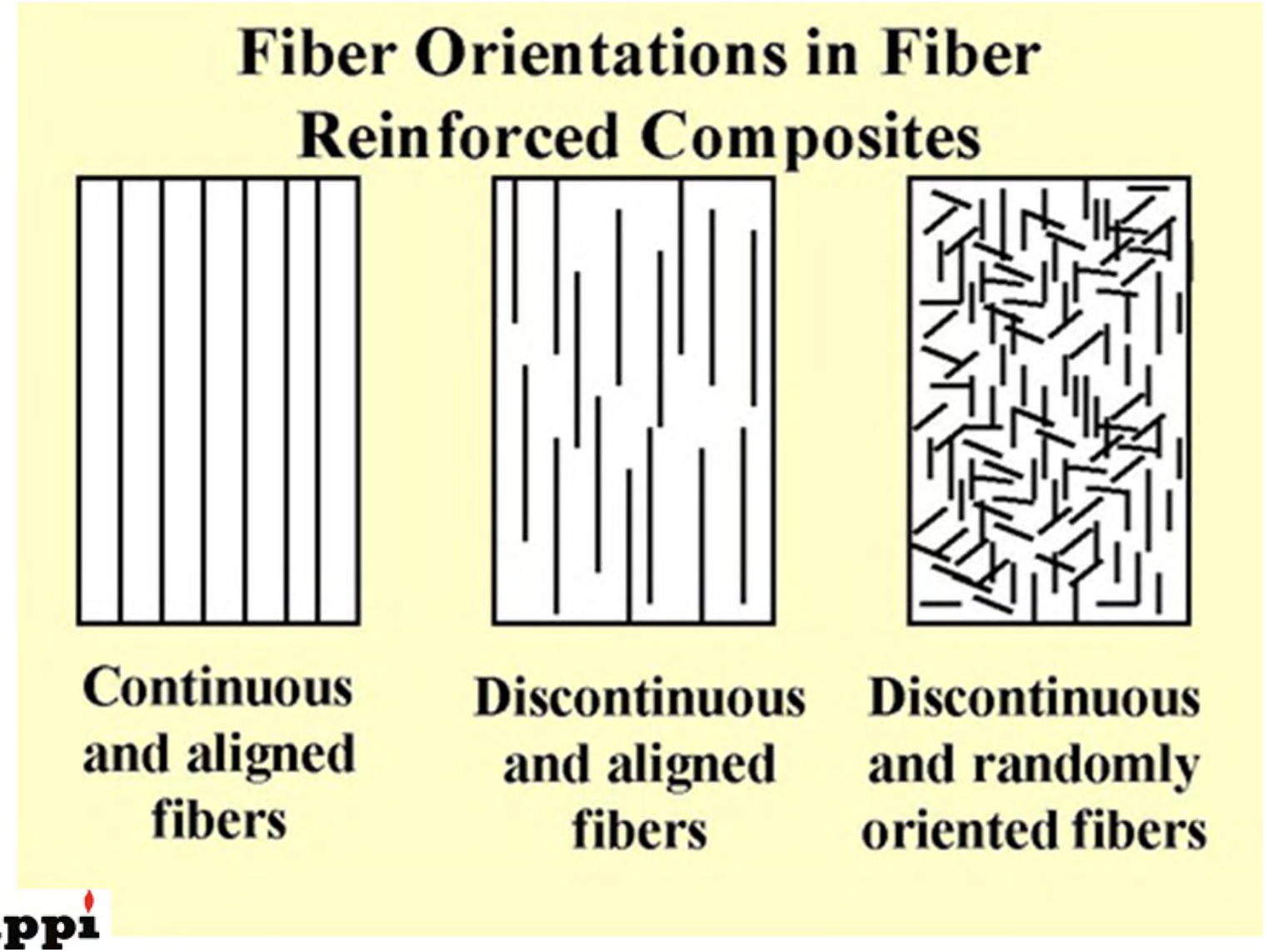
Definition


FRP
Fiber
Carbon
Aramid
Glass
Matrix
Resin
Polyester
Epoxy
Filler
Aluminum Thihydrate
Wollastonite
Additives

Types of Fiber

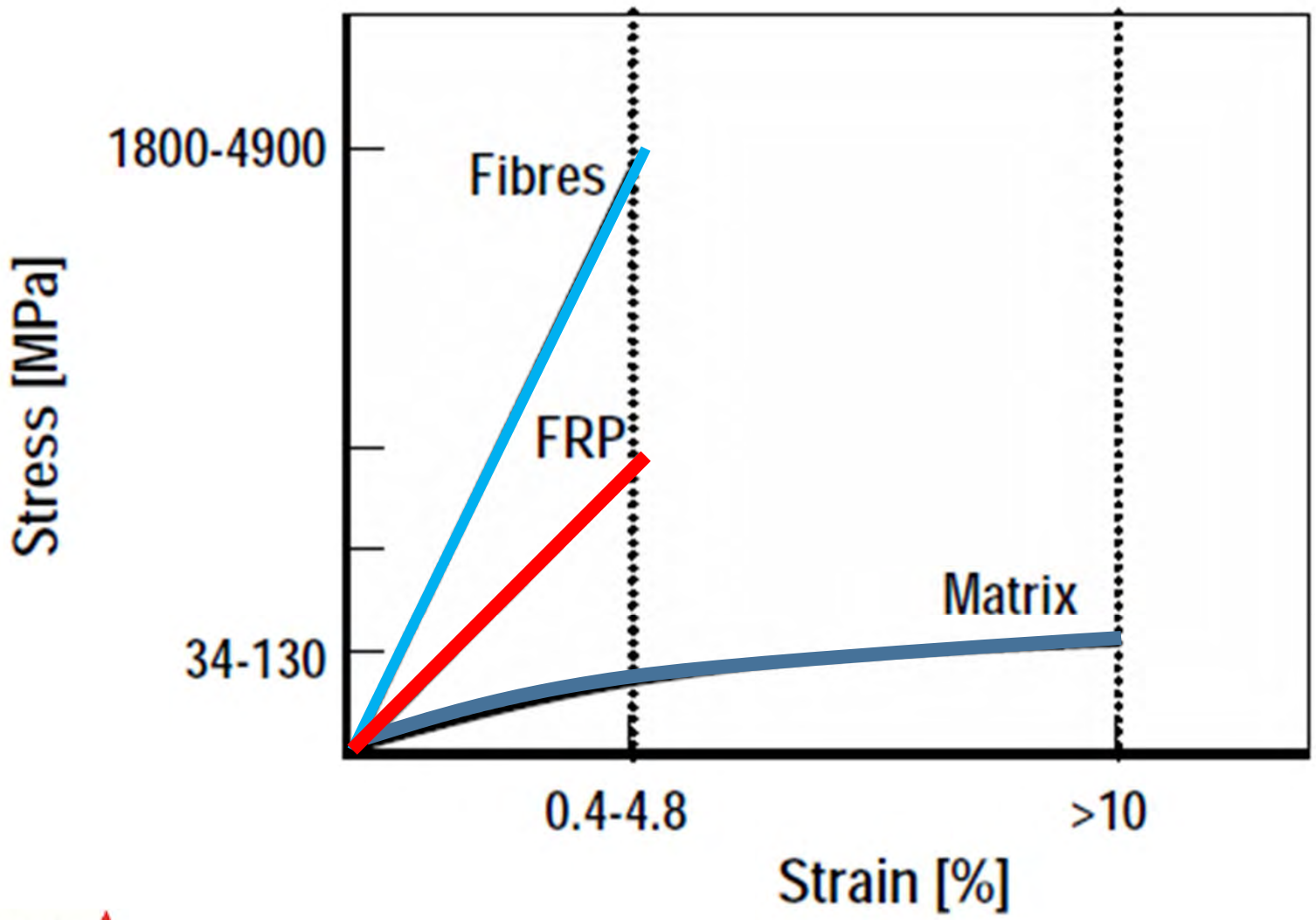
Property	Carbon	Aramid	Glass
Strength	**Excellent**	Good	Low
Ductility	low	Good	**Excellent**
Weight	**Light**	Medium	Heavy
Electric Resistance	Low	Good	**Excellent**
Price	**Expensive**	Moderate	Affordable

Fiber Orientation

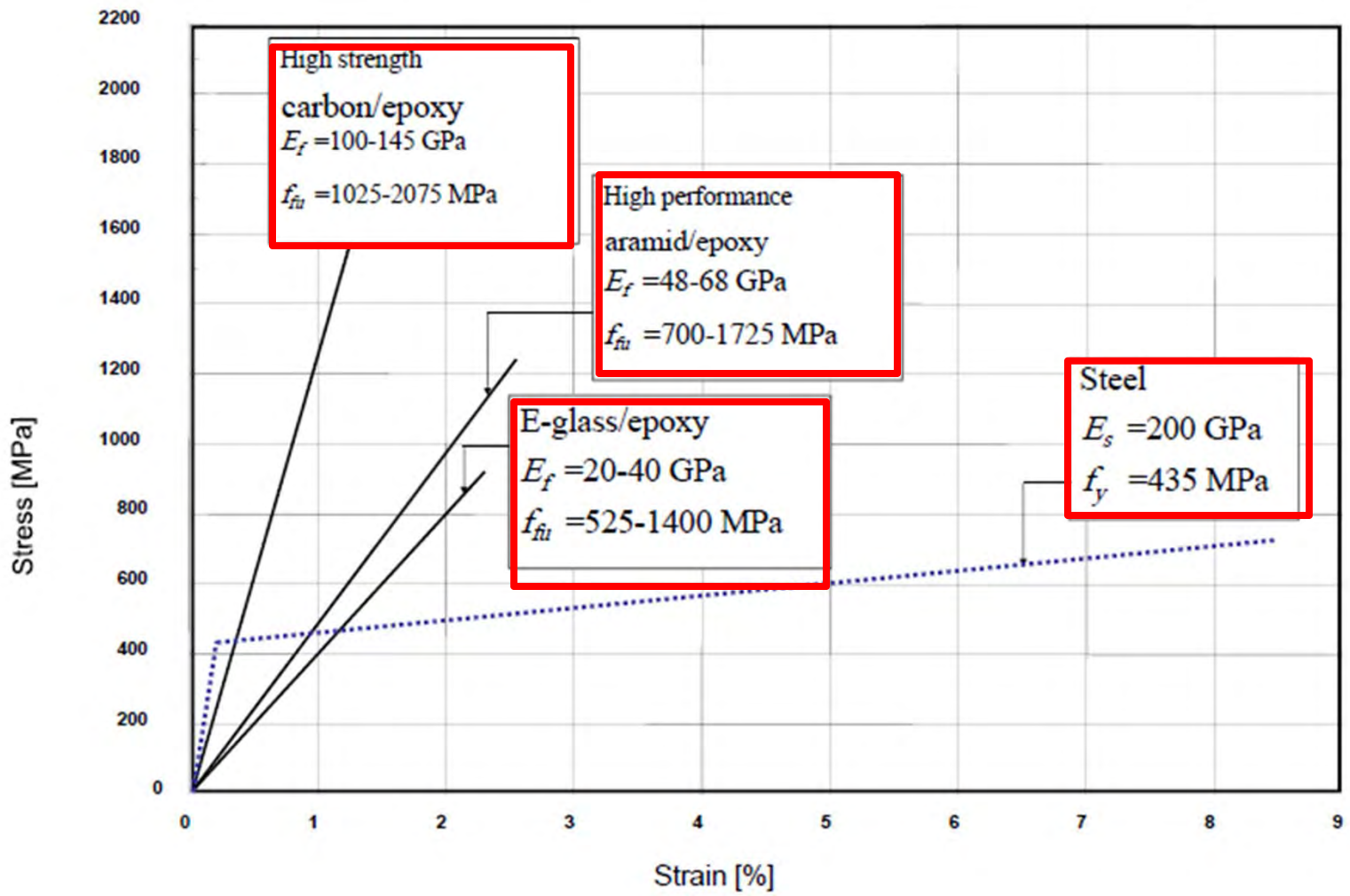


Enppi

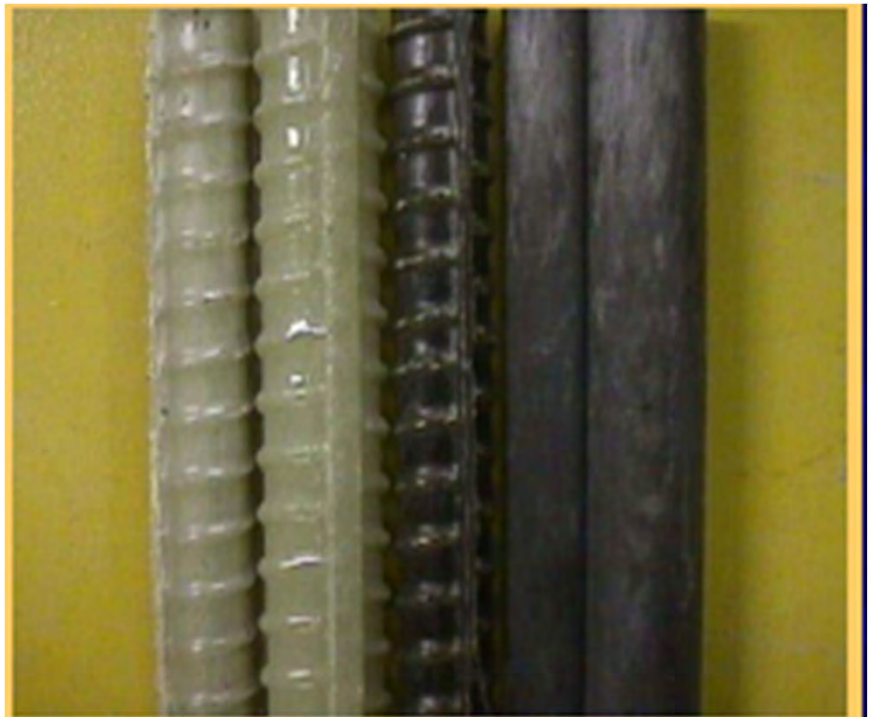
Mechanical Properties



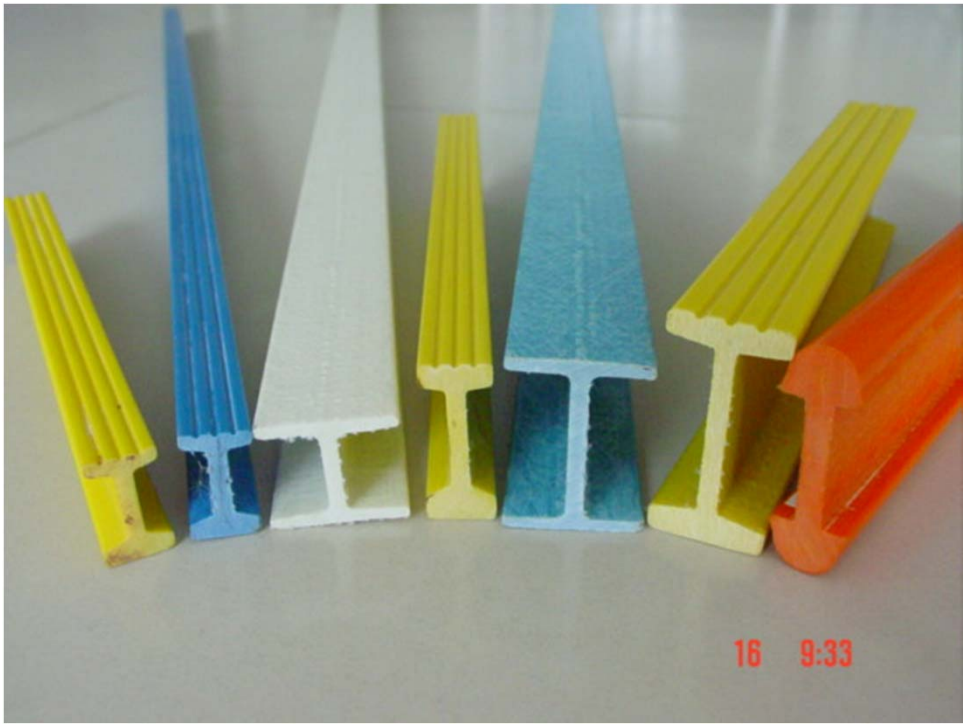
FRP VS Steel


High strength
carbon/epoxy
E_f =100-145 GPa
f_{fu} =1025-2075 MPa
High performance
aramid/epoxy
E_f =48-68 GPa
f_{fu} =700-1725 MPa
E-glass/epoxy
E_f =20-40 GPa
f_{fu} =525-1400 MPa
Steel
E_s =200 GPa
f_y =435 MPa
Stress [MPa]
Strain [%]
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
0
1
2
3
4
5
6
7
8
9

FRP Products

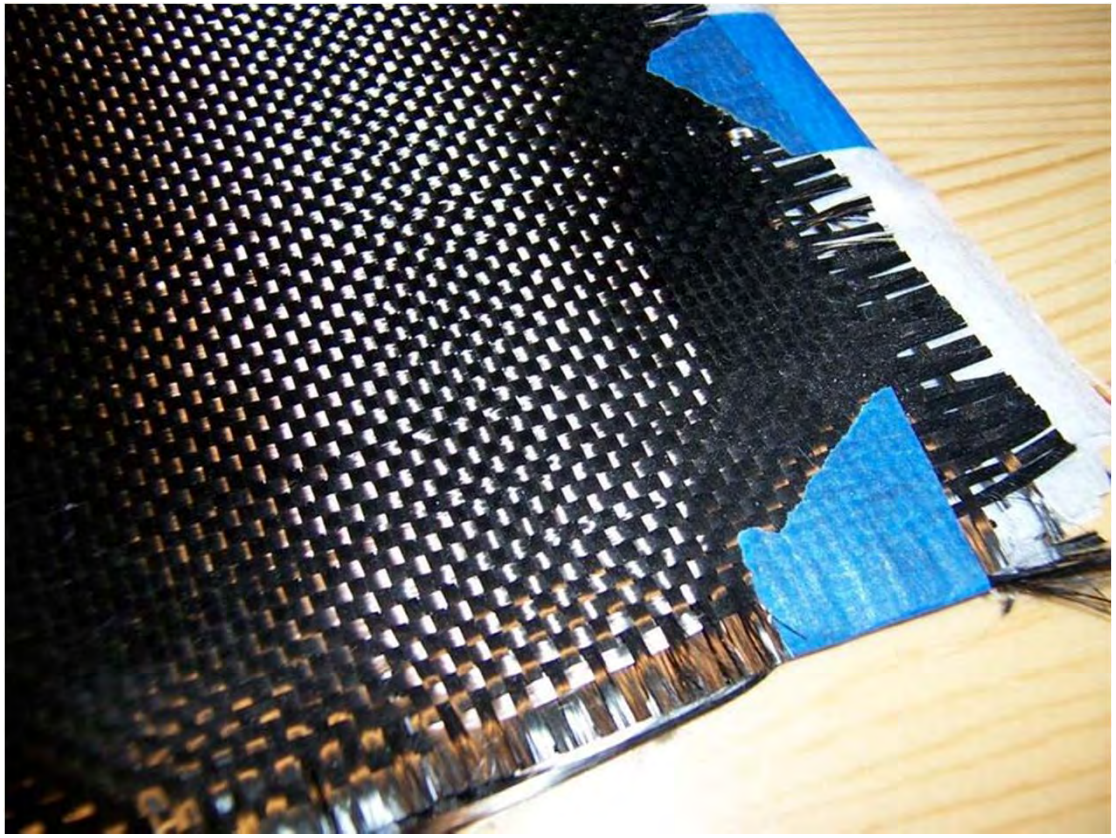


FRP Rods



FRP Rolled Sections

FRP Products (cont'd)

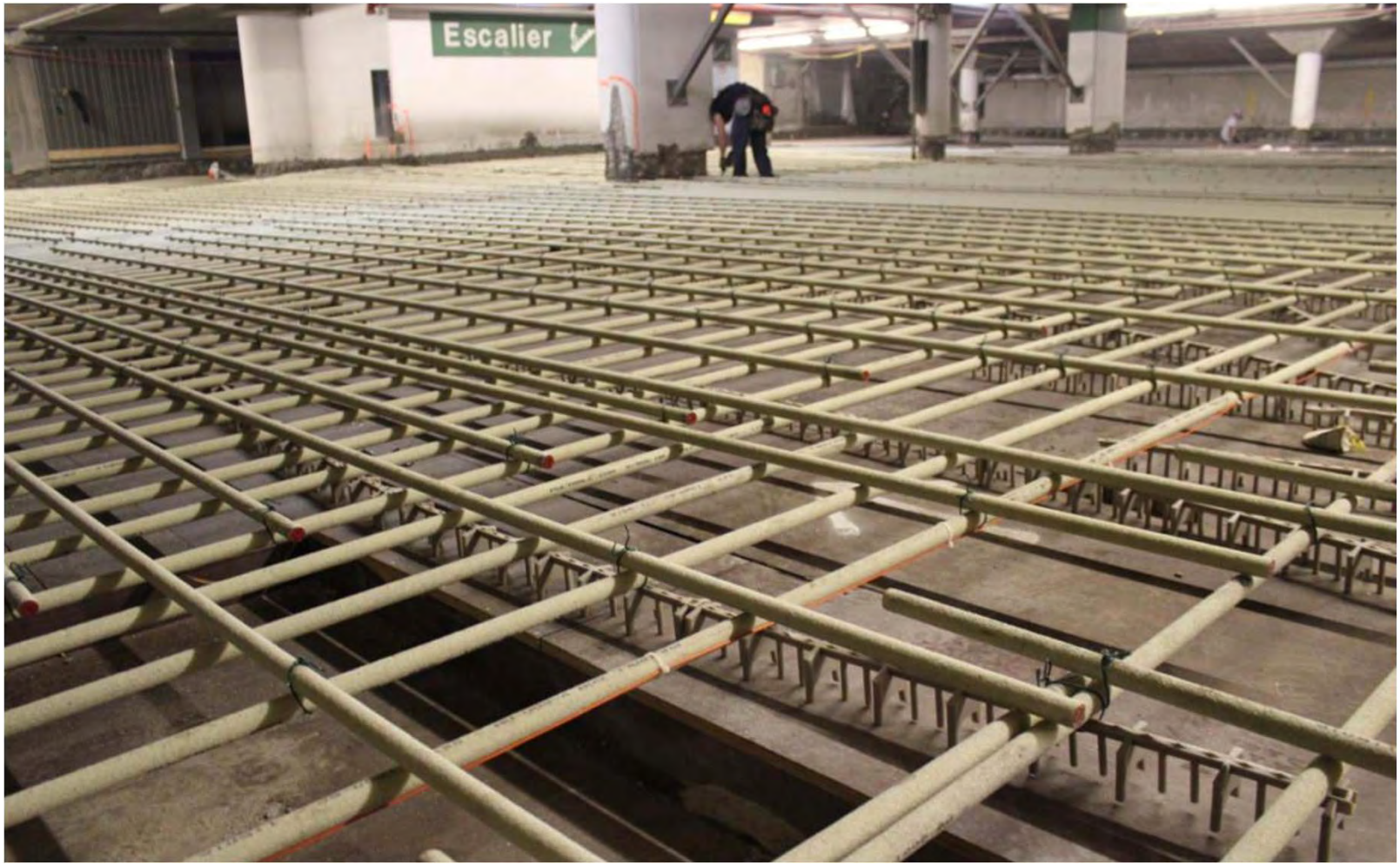


FRP Sheets

FRP Laminates

FRP Applications in Structural Eng.

1- Concrete Slab Reinforced with FRP Rods



FRP Applications in Structural Eng.

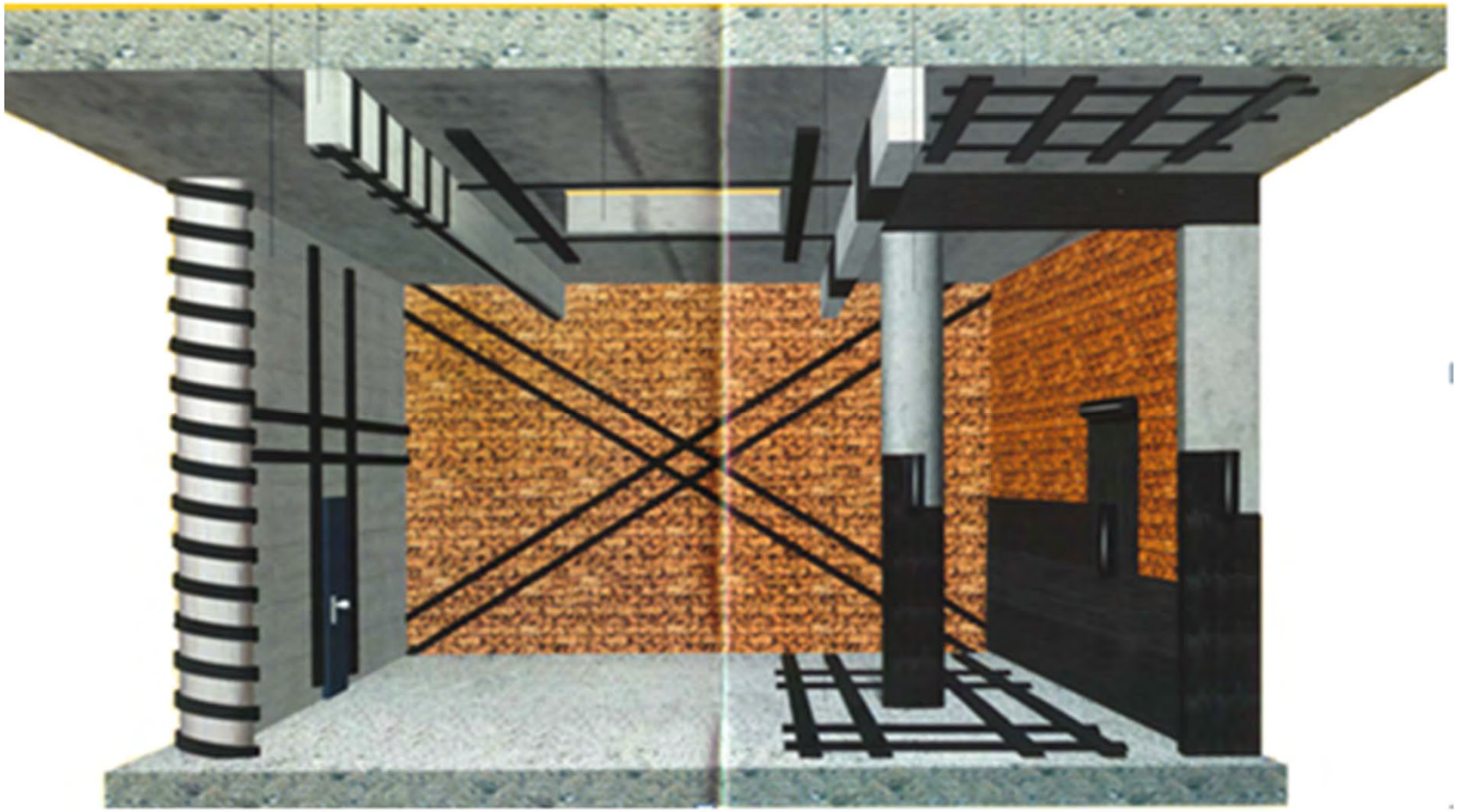
2-FRP Rolled Sections

FRP Applications in Structural Eng.

3-FRP Grating

FRP Applications in Structural Eng.

4- Strengthening

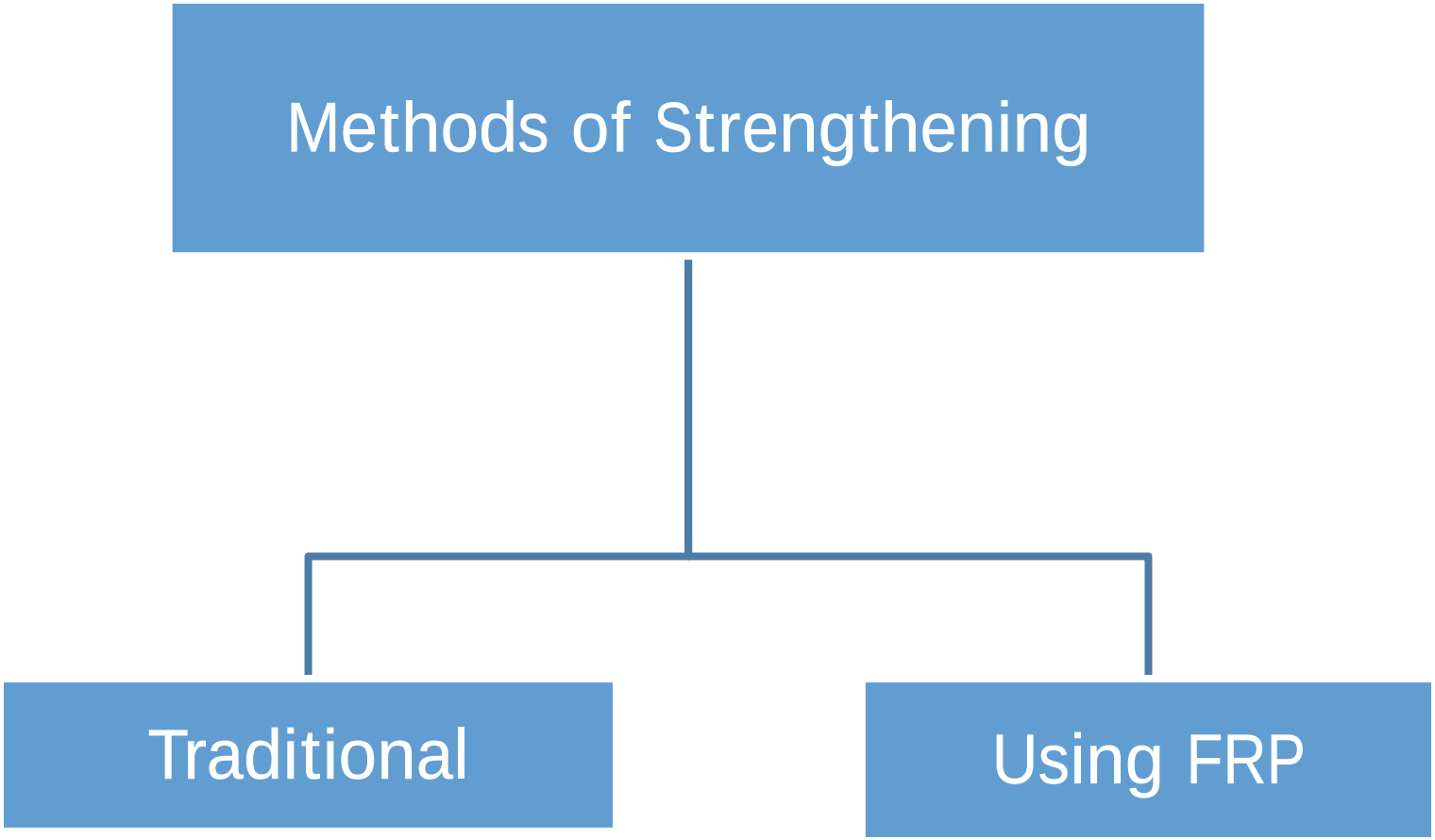


Strengthening using FRP

Why Strengthening?

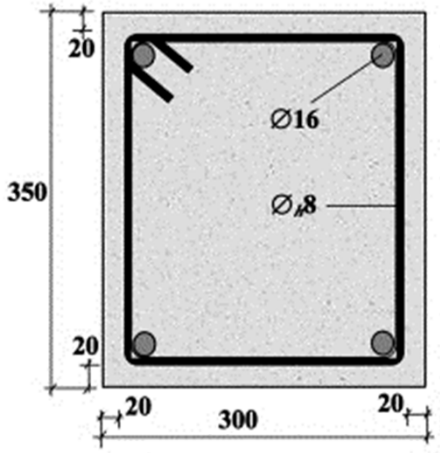
- To Change buildings function.
- Error in construction or design of member.
- To replace corroded reinforcement.
- To improve seismic resistance.
- Reinforcement around openings through floor slabs & walls.

Strengthening using FRP

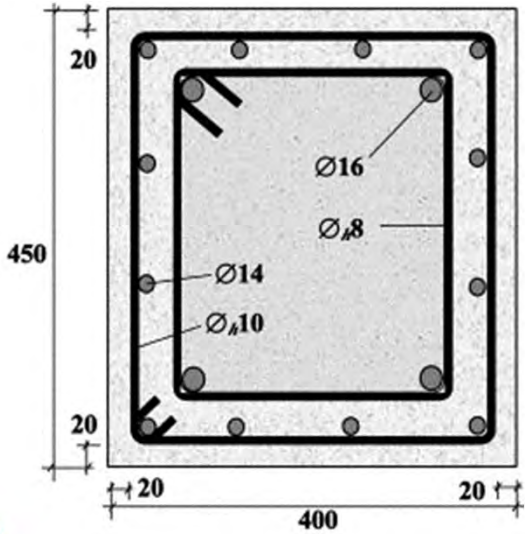


Traditional Strengthening Method

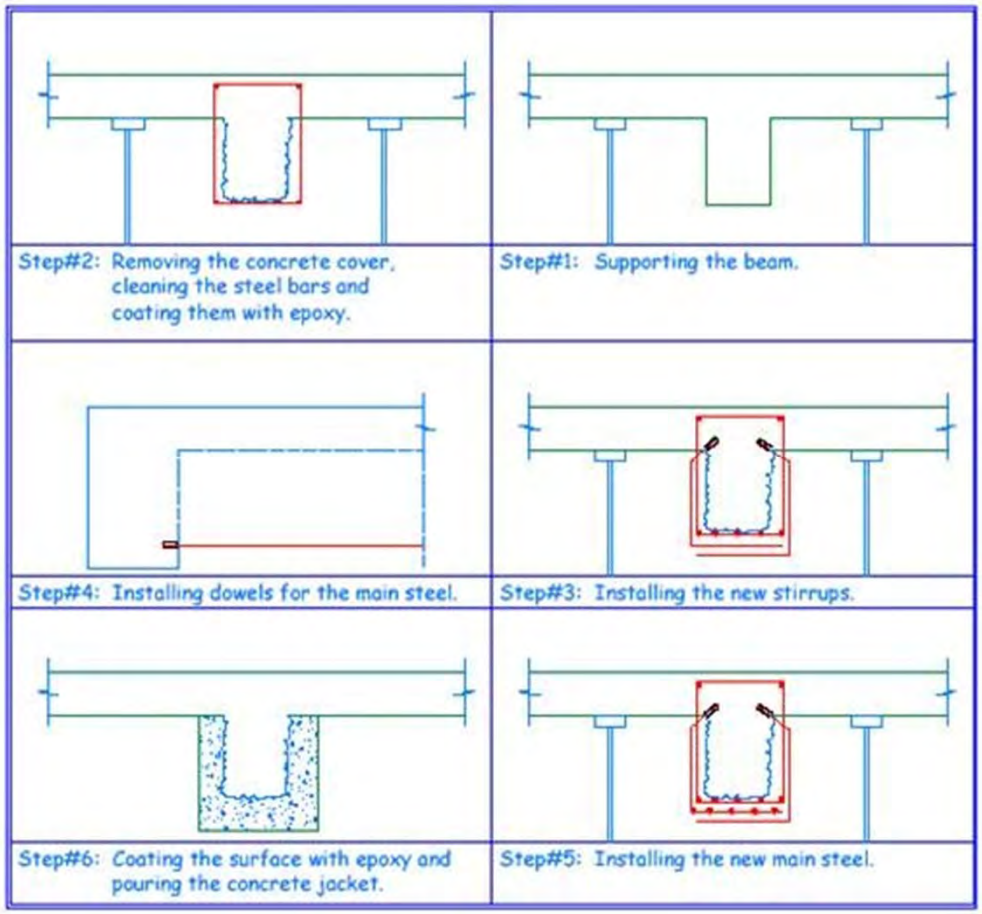
Traditional Strengthening Method



Initial Section



Repaired Section with Jacket



Enppi

Civil Engineering Division

Strengthening Using FRP

- ✓ The speed and ease of installation

Strengthening Using FRP

- ✓ The speed and ease of installation (cont'd)

Strengthening Using FRP

- ✓ The ease of Shape Fitting

Strengthening Using FRP

✓ Fiber composite material are available in very long lengths.

Strengthening Using FRP

- ✓ The use of FRP does not increase the dimensions of the members.

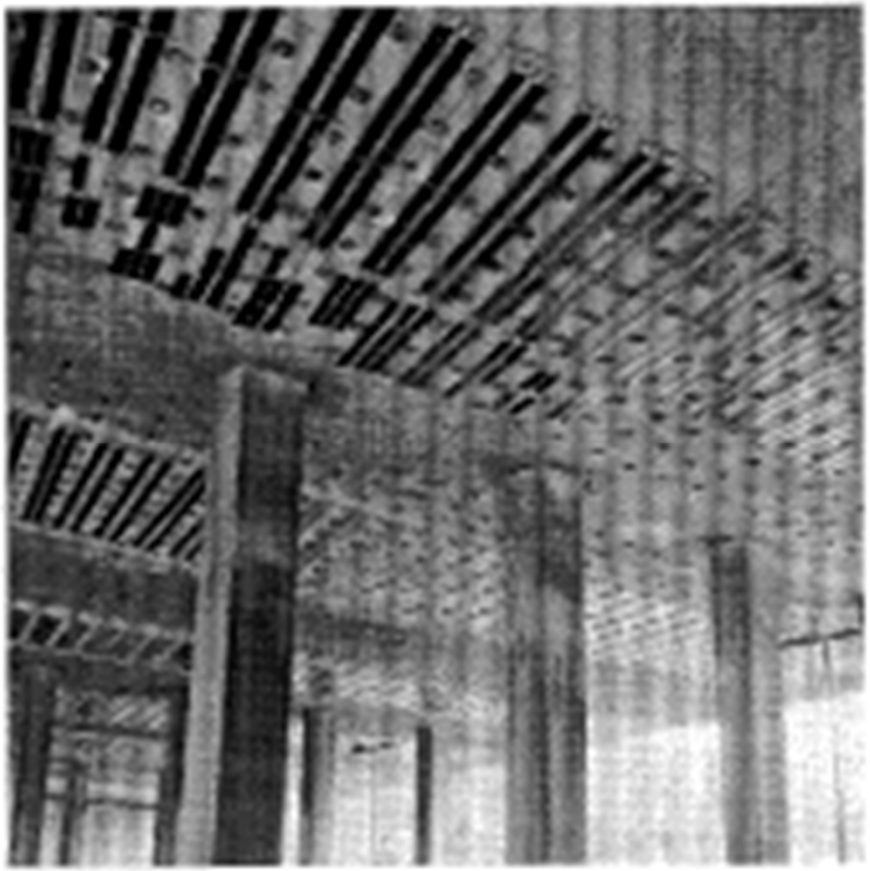
Strengthening Using FRP

RC- beam Flexure strengthening

The strength were <u>increased by 40%.</u>

Strengthening Using FRP

Flat Slab Strengthened in +ve Flexure Moment



Strengthening Using FRP

Highway RC – bridge slab

The ultimate Strength increased by 20%.

Strengthening Using FRP

Flat Slab in –ve Flexure Moment (cont'd)

Strengthening Using FRP

The ultimate beam capacity for strengthened beams increased by 30%.

Strengthening Using FRP

Using Inclined FRP Sheets

Strengthening Using FRP

Column Wrapping with FRP

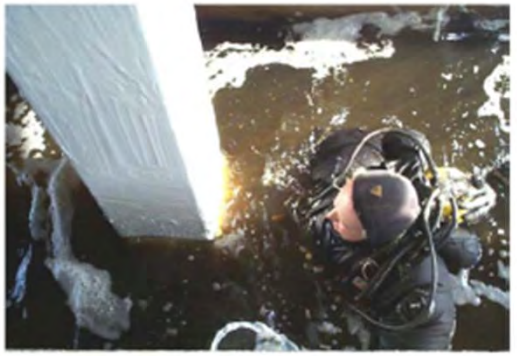
To enhance concrete strength and deformation permission.

Strengthening Using FRP

Bridge Column Strengthening

Strengthening Using FRP

Off shore Column Strengthening

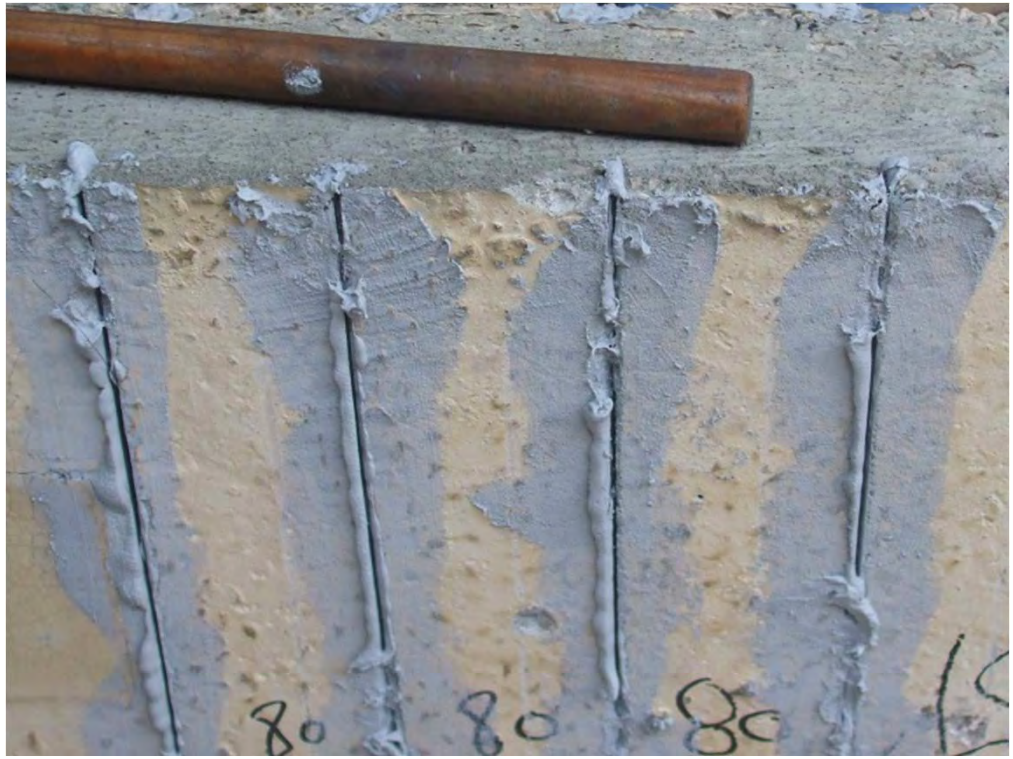


Strengthening Using FRP

Strengthening Using NSM Technique

Strengthening Using FRP

Strengthening Using NSM Technique (cont'd)



Codes for Strengthening with FRP

Egyptian code

ACI 440-2R-08

American Concrete Institute®
Advancing concrete knowledge

Applications of FRP in Egypt

Central Bank- slab Strengthening due to increase of loading

Applications of FRP in Egypt

Smart Village- Slab Strengthening

Applications of FRP in Egypt

El-Ahly Bank - Wrapping System for Columns

Applications of FRP in Egypt

Nile Ritz Carlton Hotel

Advanced Strengthening Method

FRP in Summary:-

1- High Stiffness to weight ratio (Carbon, Aramid, Glass).
2- High Strength (Carbon, Aramid, Glass).
3- Corrosion Resistance.
4- Energy Absorption on impact (Aramid, Carbon, Glass).
5- Cost (Glass, Aramid, Carbon).
6- Weight (Carbon, Aramid , Glass).
7- Moisture Resistance (Glass, Aramid , Carbon).

Thank You