



FAWCHEM

Anchorage Improvement in CFRP Structural Strengthening

Prepared By: Khiam Sarwar C.E.O
Prepared For: ICRI Fall Convention
Dated: 09-11-2018

Email: ceo@fawchem.com | fawchem@gmail.com
Website: www.fawchem.com

Description

CFRP (**Carbon Fiber Reinforced Polymer**) materials are widely used for strengthening of RCC Members like Columns, Beams, Slabs, Foundations, Shear Walls, Silos etc. as External Strengthening System. Anchorage Capacity of CFRP materials can be improved by the following two techniques.

- 1- Using Epoxy Adhesive of Different Densities.
- 2- Increasing Anchorage Depth of Epoxy Adhesive

1. Using Epoxy Adhesives of Different Densities

Epoxy Adhesives are used for fixing of CFRP Laminates to Concrete, and as Saturating Resins for Carbon Fiber Fabrics to Concrete and as a fixing material for NSM (Near Surface Mounted) CFRP Bars to Concrete. For every case mentioned above, the Epoxy Resins mostly used have density ranging 1.08 kg/Lit - 1.65 kg/Lit. But for one case normally Density is not varied which leads to lesser efficiency.

After grinding or Sandblasting the concrete surface its Roughness factor is increased. But, adhesive of higher density may not penetrate into Micro pores of roughened concrete surface, which may lead to cavitation and inhibit bonding. So if we use Epoxy adhesive of lesser density e.g. 1.08 kg/Lit as Primer then the surface can absorb Epoxy Adhesive and Enrich the bonding bridge at interface of Concrete and Epoxy adhesive for fixing of CFRP. Hence Anchorage/Slip Resistance of Overall CFRP Strengthening System is improved.

2. Increasing Anchorage Depth of Epoxy Adhesives

The CFRP Strengthening System is entirely based upon bond strength of Epoxy Adhesives. Sometimes the concrete surface Shear strength is lesser than expected and can cause CFRP De-Lamination. If we develop holes of nominal depth in concrete cover and fill with same Epoxy Adhesive which we use for CFRP Laminate bonding or use CFRP Anchor Pins we can increase the Anchorage Capacity of Strengthening System. By increasing Anchorage Capacity we can use the unused load bearing reserve of CFRP Tensile Strength and can manage to use lesser CFRP materials to strengthen the buildings.

Light House

Structural repair
and strengthening



Before treatment



After treatment



Complete Refurbishment



Before treatment



After treatment

Jetty Structure



Damaged



Repaired



Shear Strengthening



Flexural Strengthening



Finished

Bridge Strengthening



Bridge Strengthening

Flexural Strengthening

Positive Side



Negative Side



Bridge Strengthening



Pre Stressed CFRP

High Rise Buildings



High Rise Buildings



Column Strengthening

Slab Strengthening



Institutional Structures



Column Strengthening



Cement Silo

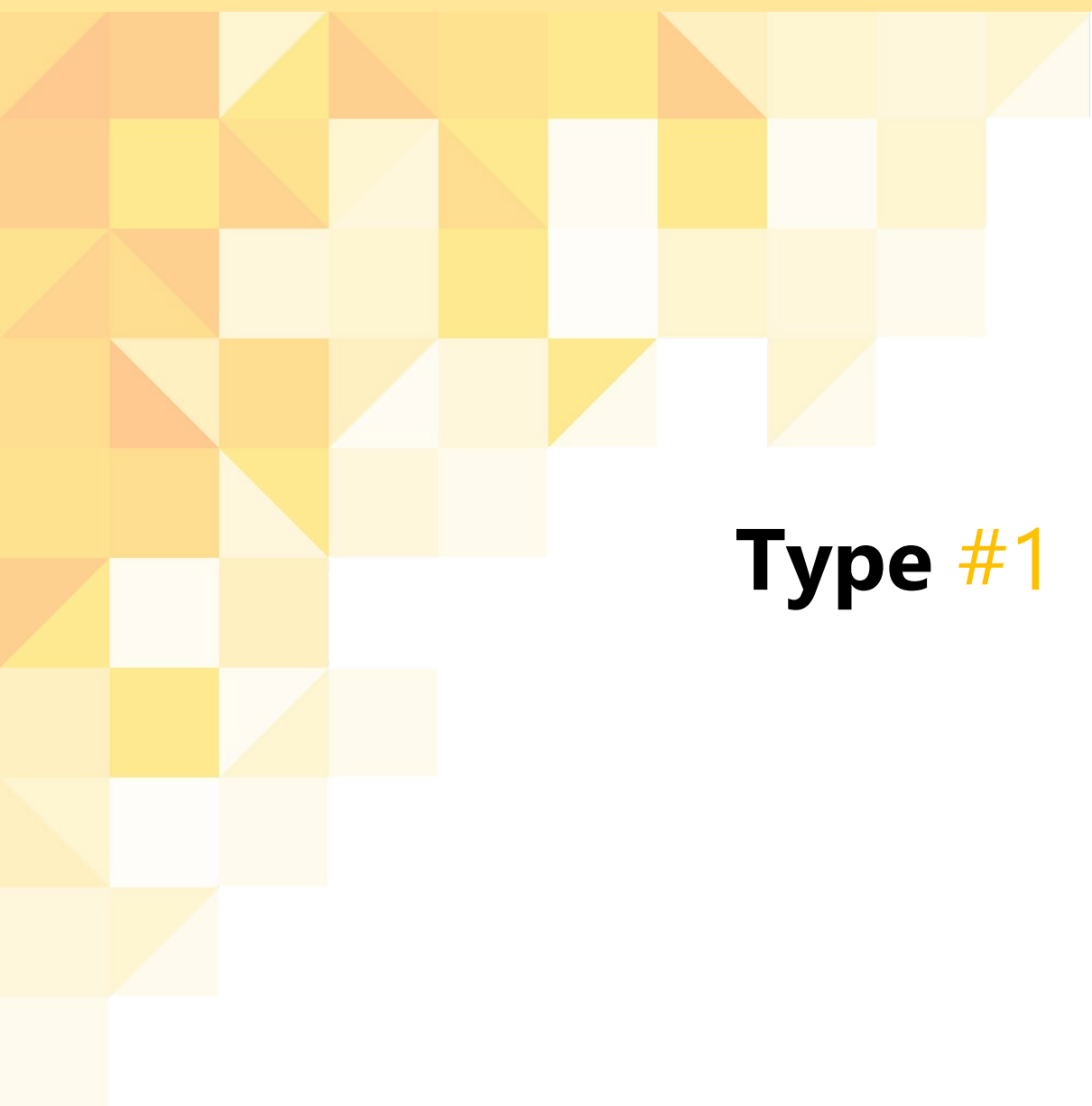
Industrial Strengthening



**Beams and Slabs
Strengthening**

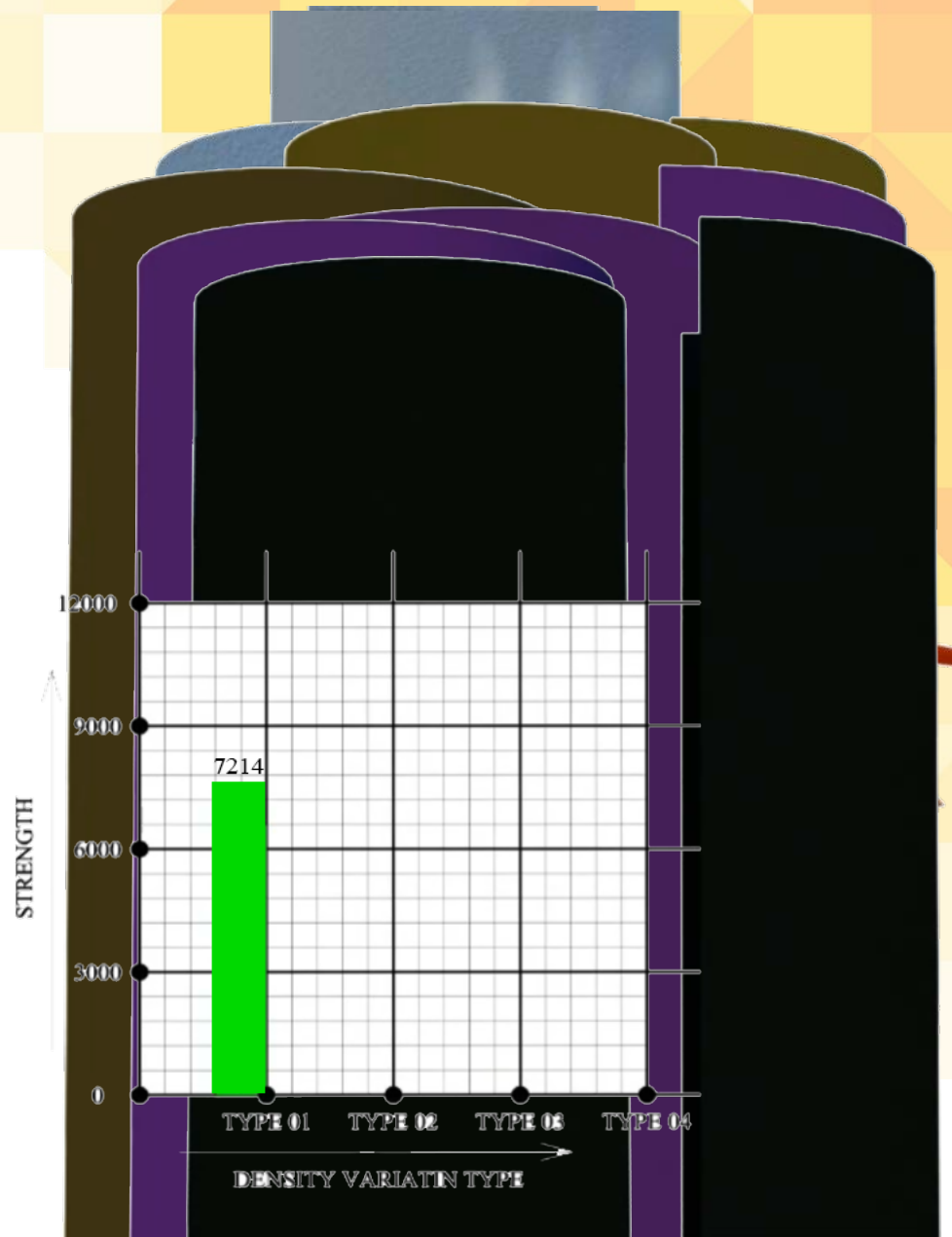
1. Using Epoxy Adhesives of Different Densities

Our Density Variation in this case lies between 1.08 kg/Lit – 1.30 kg/Lit



Type #1

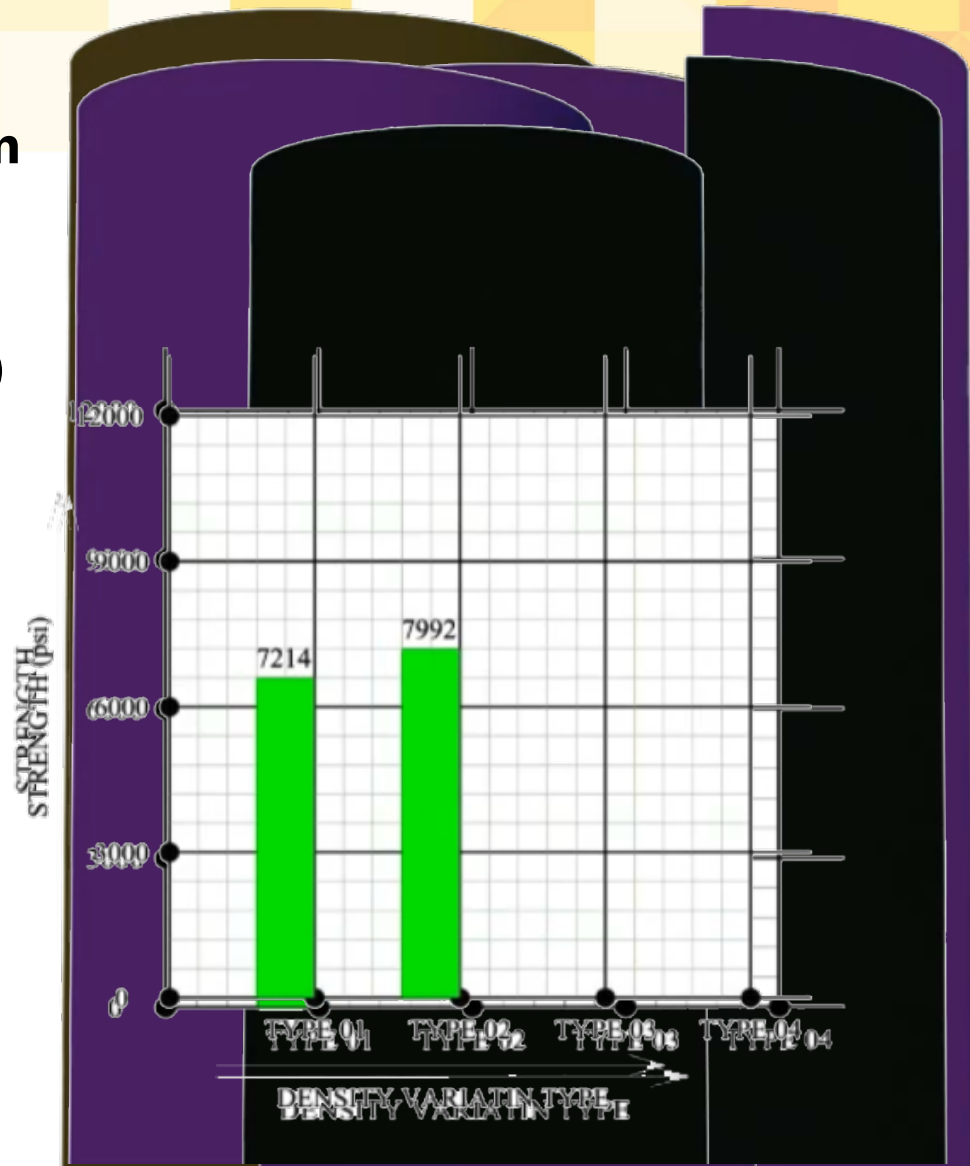
- 1- Grinding / Sandblasting
- 2- Cleaning
- 3- Epoxy Primer (1.08 Kg/lit)
- 4- Epoxy Adhesive + Saturator (1.16 Kg/lit)
- 5- Carbon fibre application fabric (Unidirectional)
- 6- Allowed to cure
- 7- Crushed (7214 psi)





Type #2

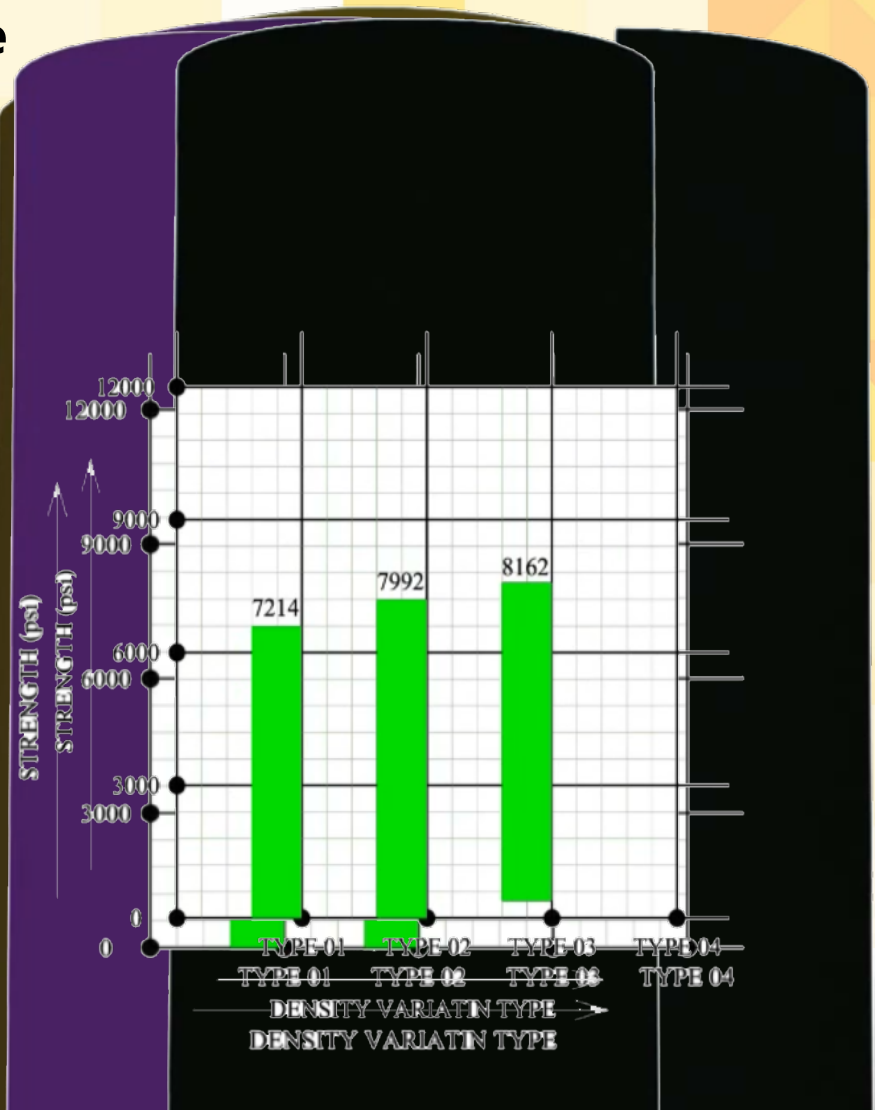
- 1- Primer (1.08 Kg/lit)
- 2- Adhesive + Saturator (1.16 Kg/lit)
- 3- Carbon Fibre Fabric 300 Gsm
- 4- Curing 30 C
- 5- Crushing Strength (7992psi)





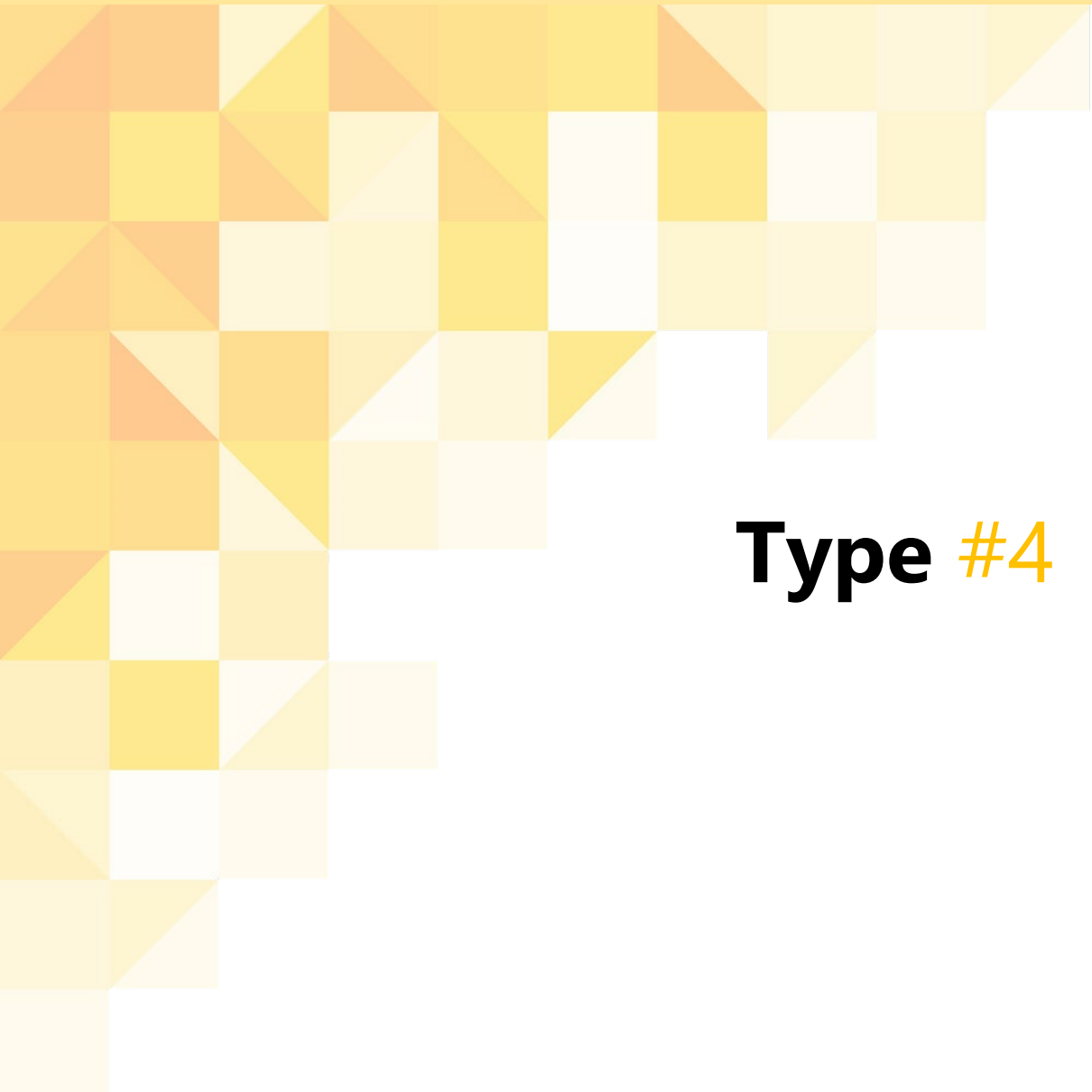
Type #3

- 1- Epoxy Primer (1.08 Kg/lit)
- 2- Epoxy Adhesive (1.3 Kg/lit)
- 3- Epoxy Saturator For Carbon Fibre (1.16 Kg/lit)
- 4- Allow to Cure
- 5- Crushing Strength (8162 psi)



2. Increasing Anchorage Depth of Epoxy Adhesives

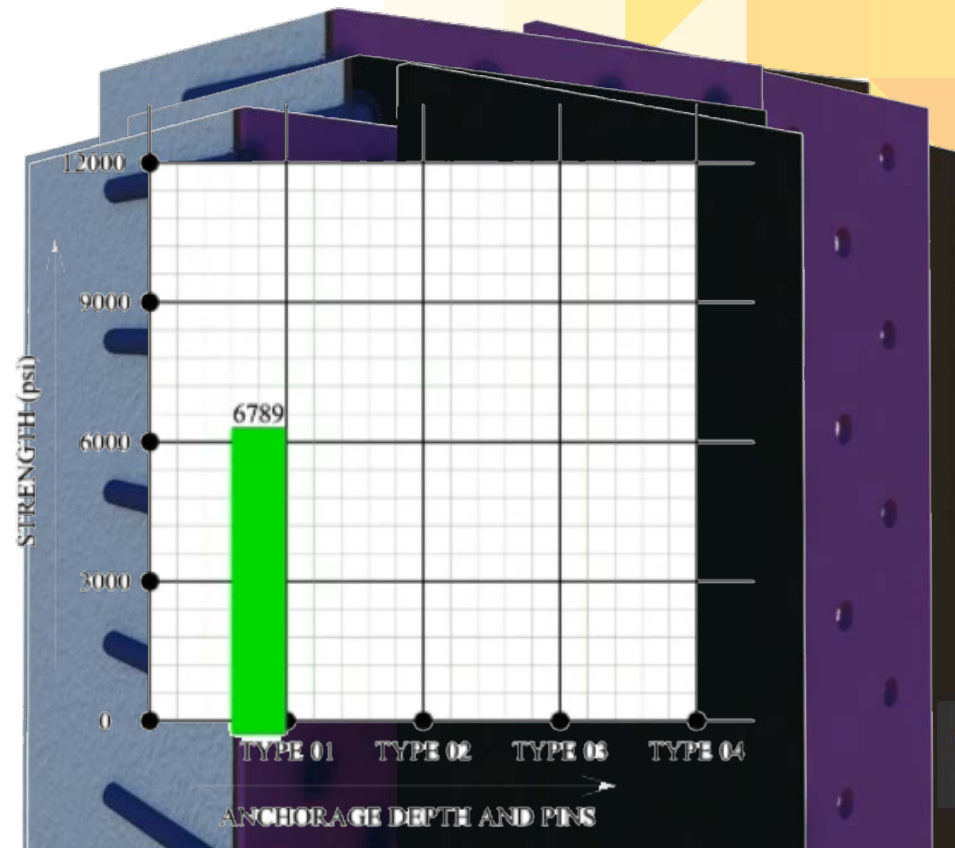
The CFRP Strengthening System is entirely based upon bond strength of Epoxy Adhesives. Sometimes the concrete surface Shear strength is lesser than expected and can cause CFRP De-Lamination. If we develop holes of nominal depth in concrete cover and fill with same Epoxy Adhesive which we use for CFRP Laminate bonding, we can increase the Anchorage Capacity of Strengthening System. By increasing Anchorage Capacity we can use the unused load bearing reserve of CFRP Tensile Strength and can manage to use lesser CFRP materials to strengthen the buildings.

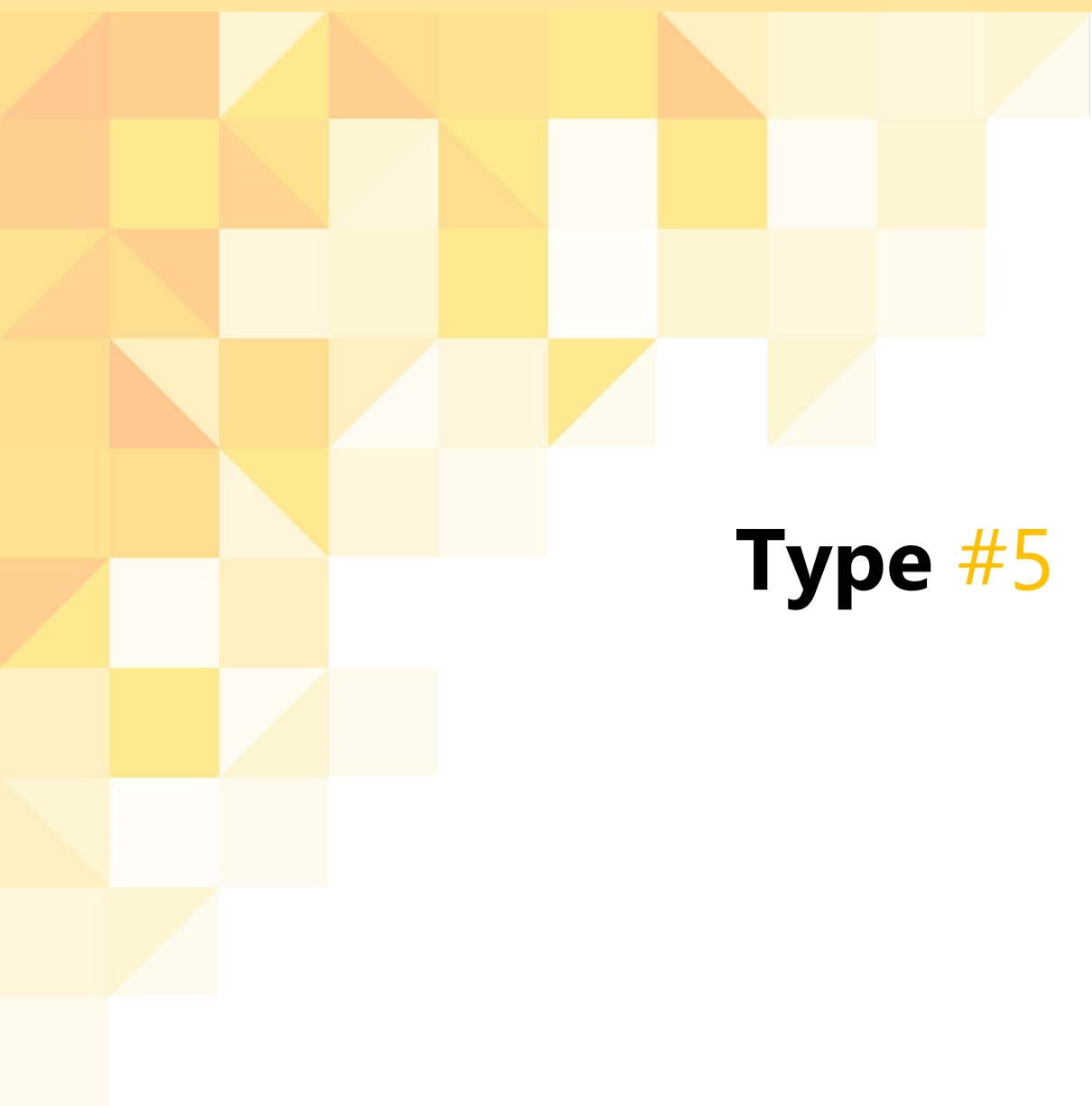


Type #4

Increasing Anchorage Depth

- 1- Drilling the concrete
- 2- Filling the holes with adhesive (1.3kg/lit)
- 3- Epoxy Primer (1.08Kg/lit)
- 4- Epoxy Adhesive (1.3Kg/lit)
- 5- Carbon Fibre Application
- 6- Curing 07 days
- 7- Crushing (6789psi)

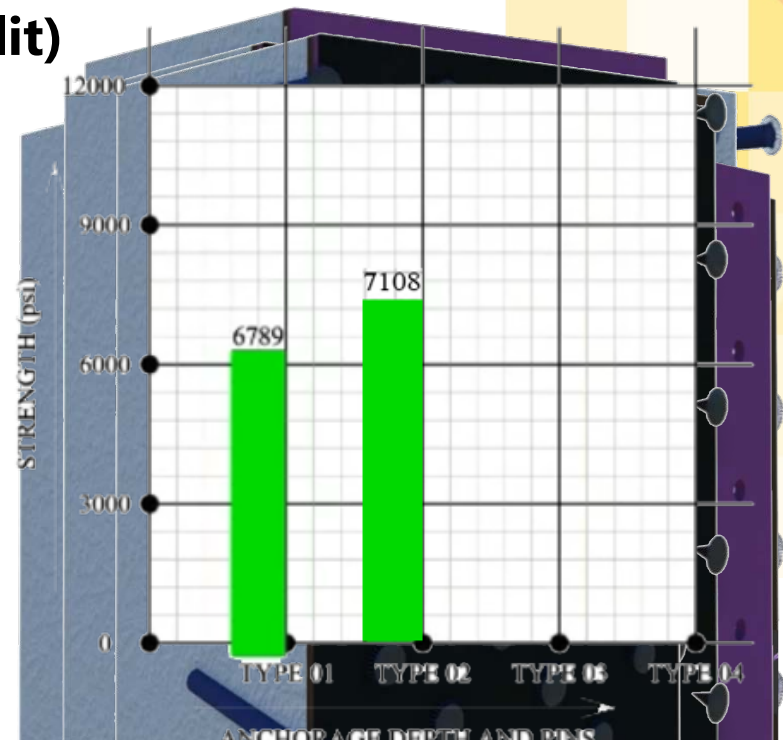


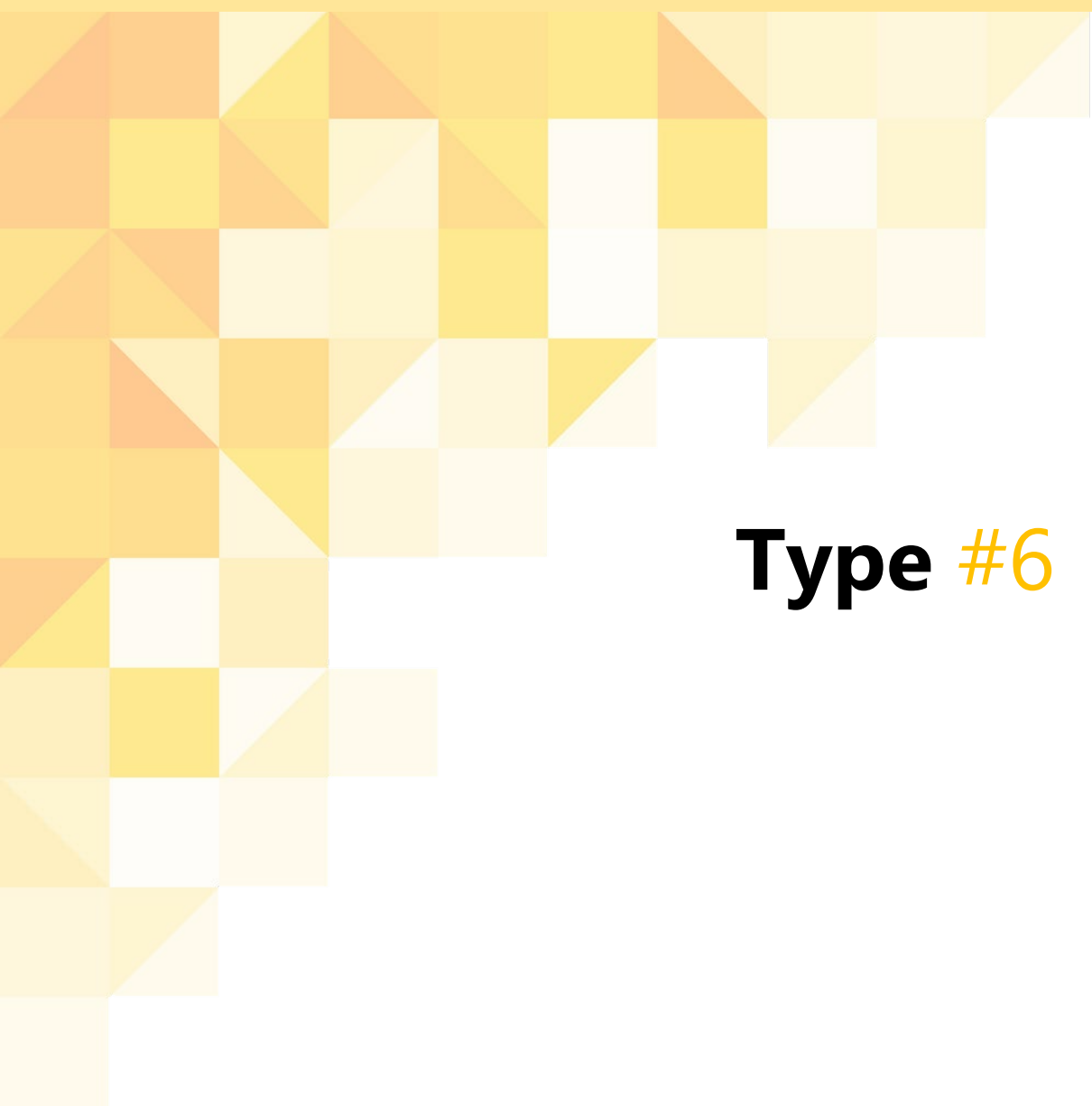


Type #5

Increasing Anchorage Depth + Application of CFRP PIN

- 1- Drilling the concrete
- 2- Filling the holes with adhesive (1.3kg/lit)
- 3- Epoxy Primer (1.08 Kg/lit)
- 4- Epoxy Adhesive Saturation (1.3 Kg/lit)
- 5- Carbon Fibre Application
- 6- Fixing CFRP Pins in wet condition
- 7- Curing
- 8- Crushing (7108 psi)

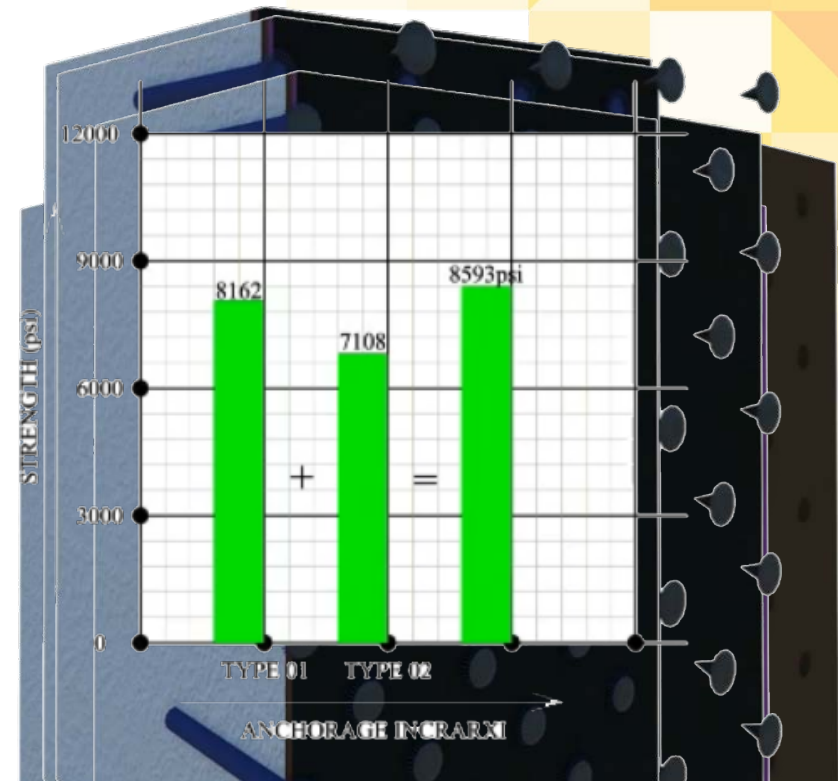




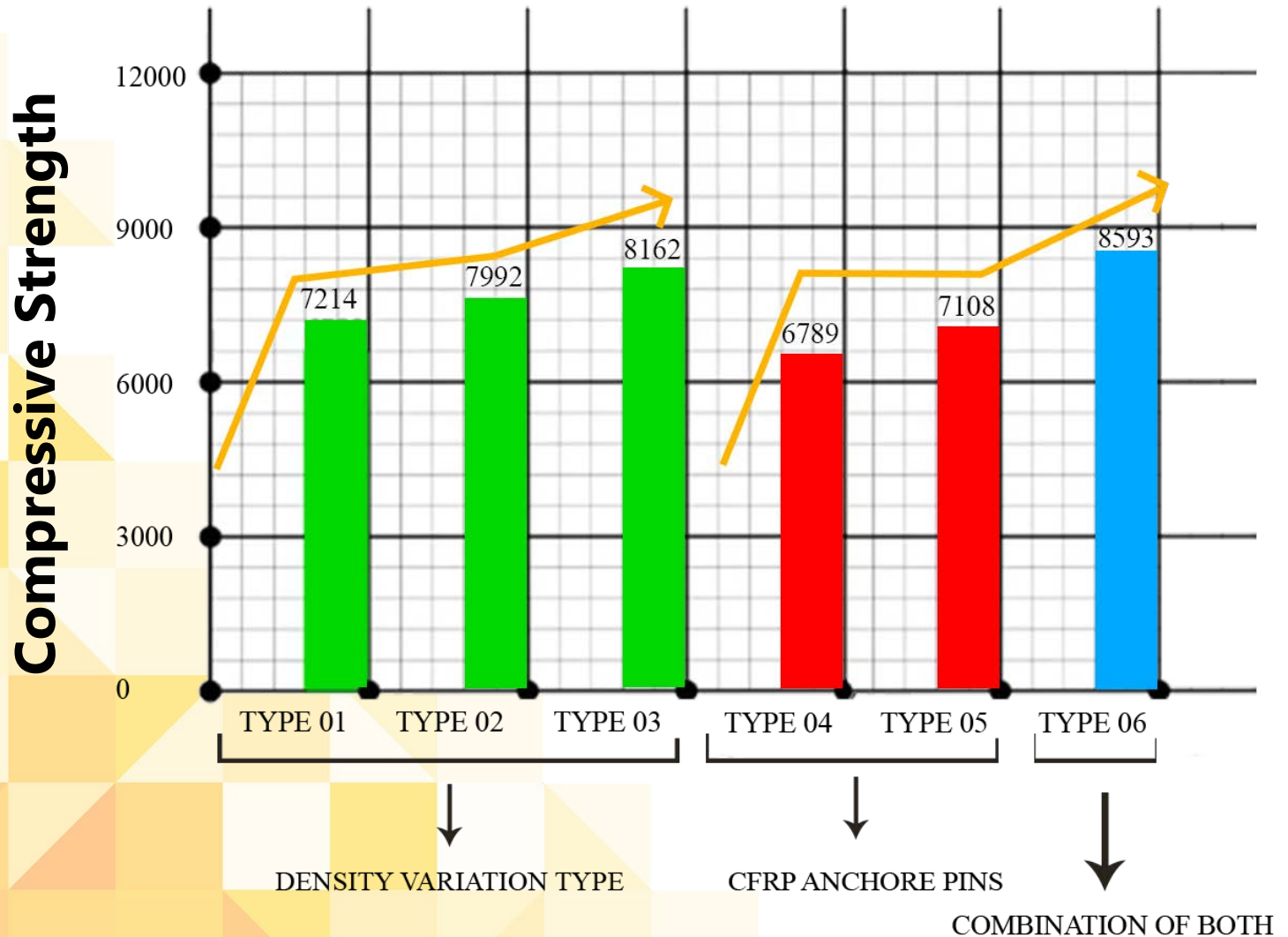
Type #6

Combination Of Variable Density & CFRP Anchor Pins

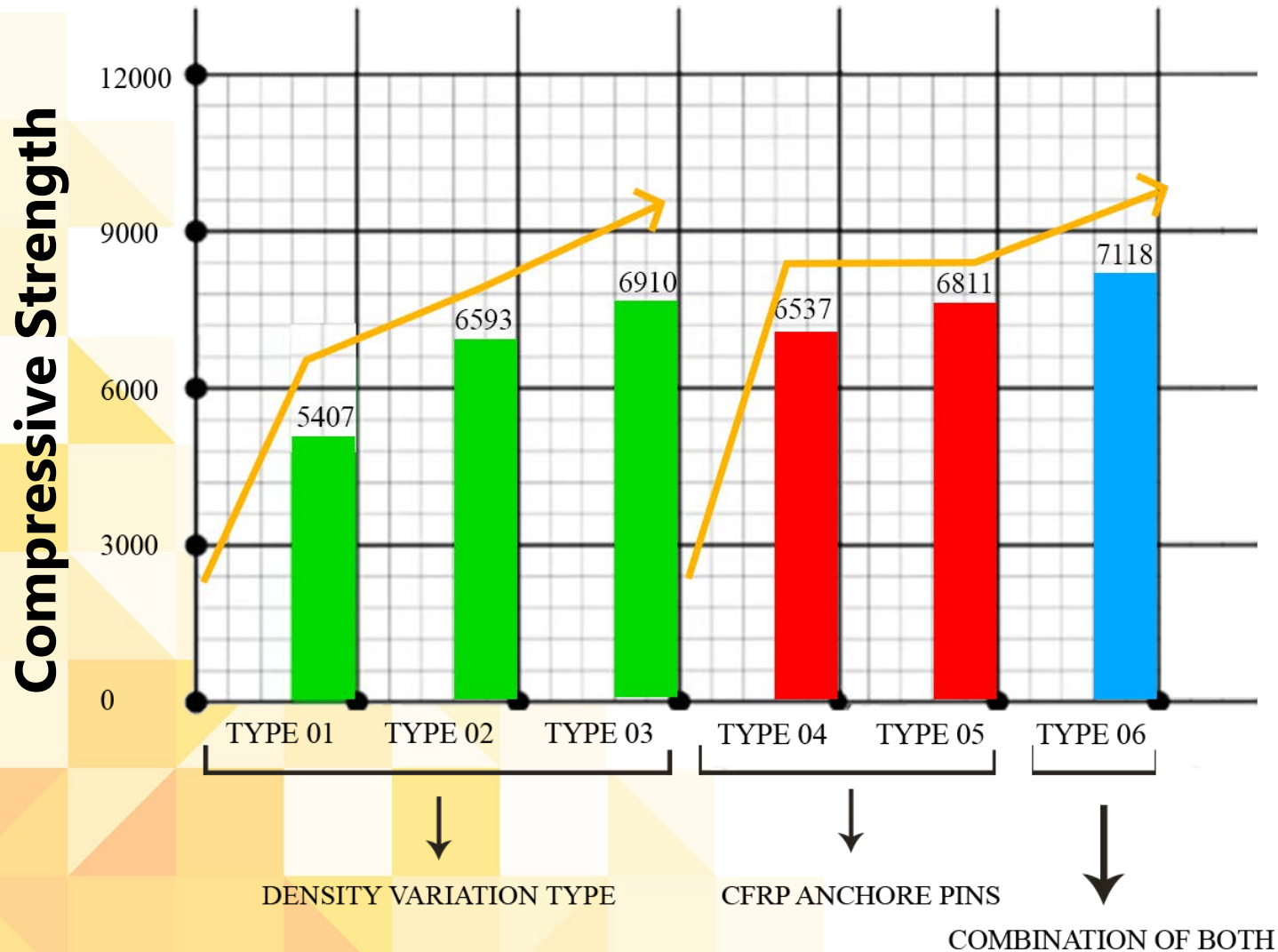
- 1- Drilling the holes
- 2- Filling the holes with epoxy (1.3kg/lit)
- 3- Epoxy Primer (1.08 Kg/lit)
- 4- Epoxy Adhesive (1.3 Kg/lit)
- 5- Carbon Fibre Application
- 6- Fixing CFRP Pins in wet condition
- 7- Curing
- 8- Crushing (8593psi)



Un strengthened Concrete | 4000 PSI



Un strengthened Concrete | 2500 PSI



Conclusion

The Anchorage capacity of CFRP Laminates and Amalgamates can be improved either by using Epoxy Adhesives of variable densities or by increasing Anchorage Depth of Epoxy Adhesives or by combination of both.

Merits

- 1- Lesser CFRP materials required for strengthening
- 2- Lesser time consumed for strengthening works of a building
- 3- Minimal weight added to the structure.
- 4- Cost of Refurbishment / Re-strengthening projects can be reduced.
- 5- Structures with low concrete strengths i.e. >2500 psi can also be Strengthened.
- 6- Building codes for CFRP Strengthening can be revised.

Demerits

- 1- Additional Cost of Epoxy Adhesives can be applied.
- 2- Accuracy of Drilling is required so expertise are important

Thank You!

The logo for FAWCHEM, featuring a stylized icon of a person or figure to the left of the word "FAWCHEM" in a bold, yellow, sans-serif font, all contained within a dark blue rectangular box with a yellow border.



**INTERNATIONAL
CONCRETE REPAIR
INSTITUTE**