

Rehabilitation and Retrofitting of Transportation Structures



constructive solutions



Vijay Kulkarni
Product Segment Manager- Grouts, Repairs & Protective Coatings

Concrete Deterioration



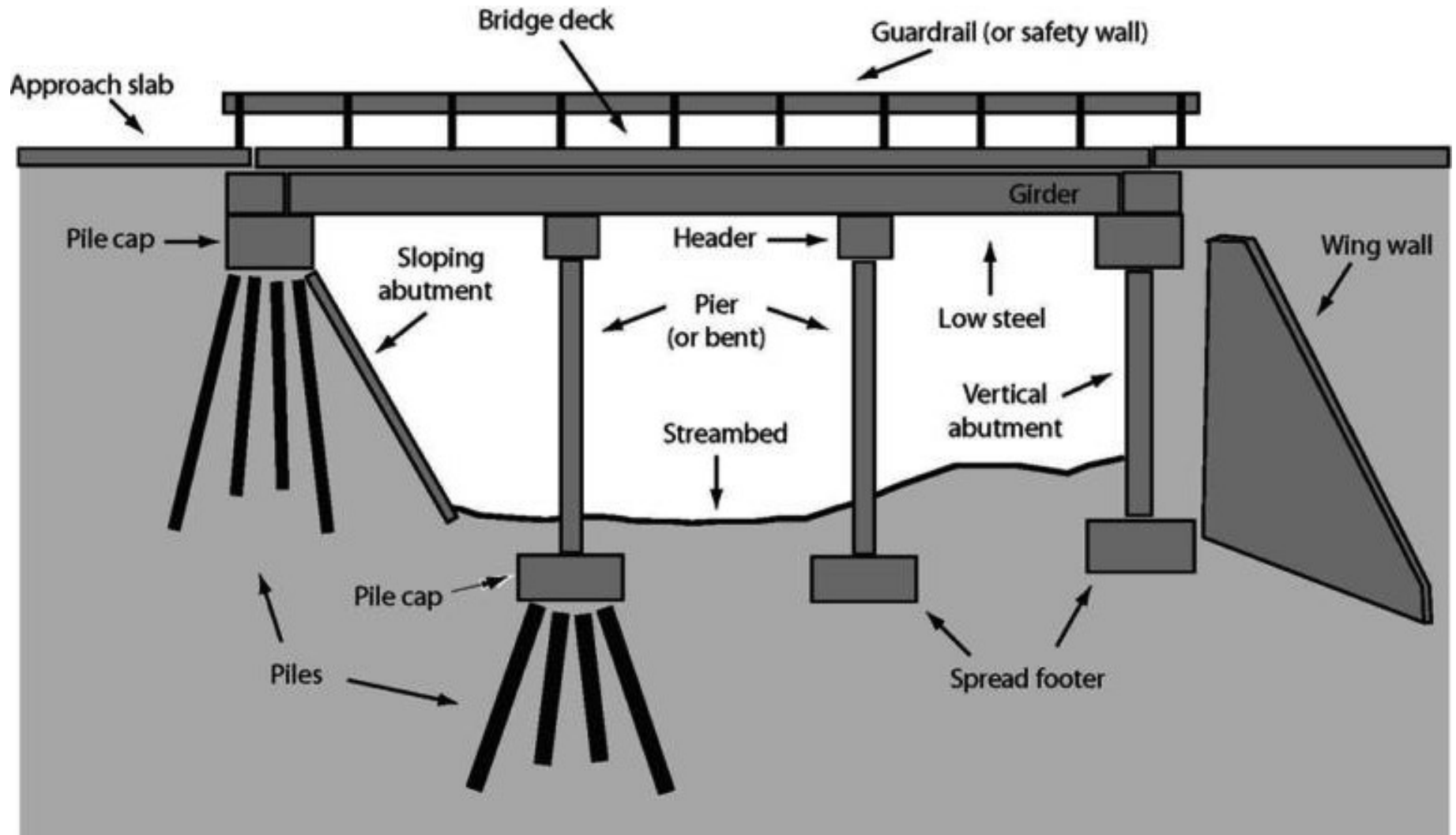
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Concrete deteriorate or fail to perform due to

- Faulty design mix Low strength, honeycombing , cracks, erosion due to abrasion etc.
- Faulty structure design – Structure failure, cracks, collapse
- Poor construction practice – Honeycombs, pinholes,etc
- Abuse of structures – Mechanical damages
- Chemical – Carbonation, chloride, Sulphate attack, AAR, leading to spalling
- Water leakages in underground structures



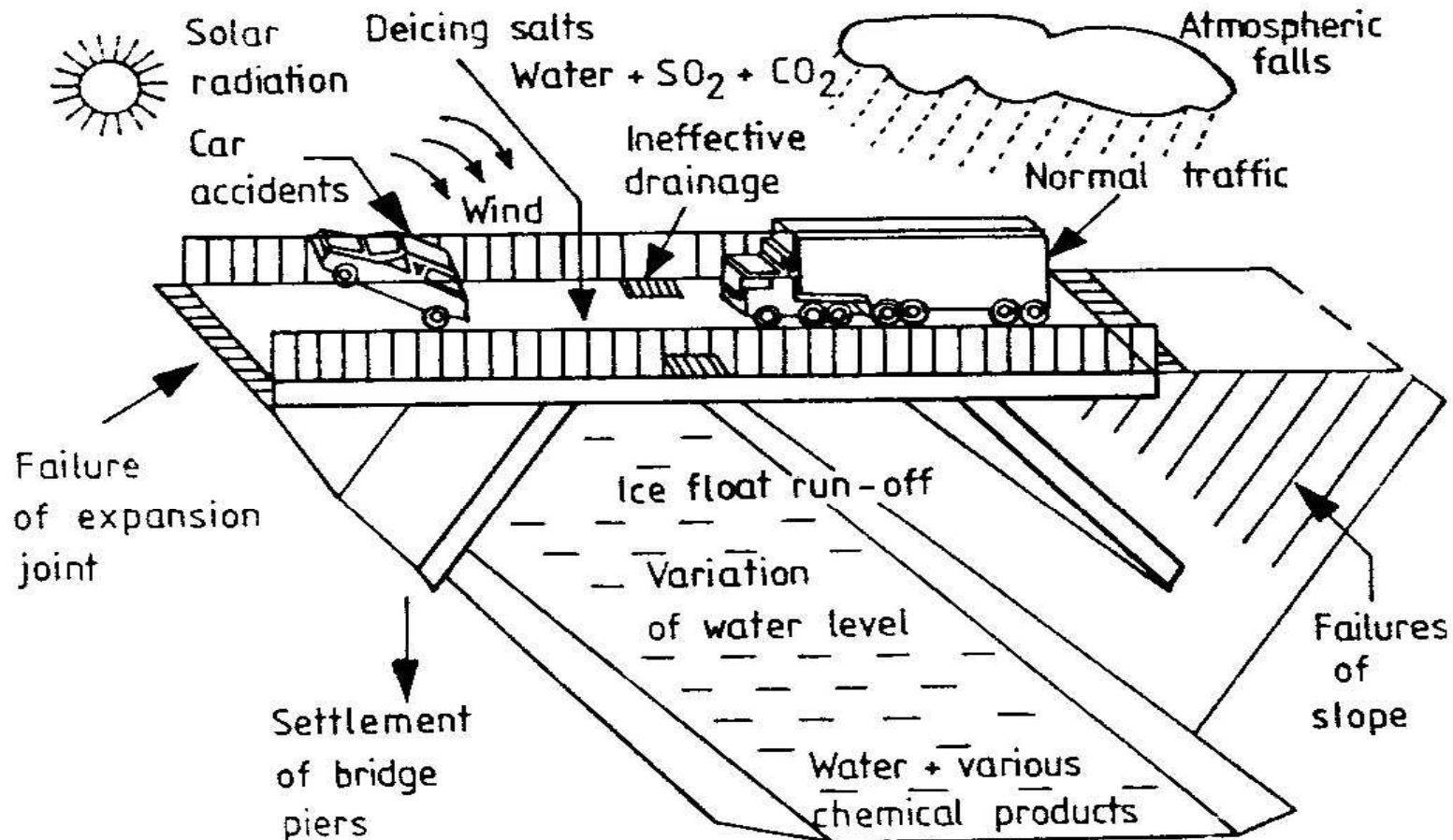
Components of Bridges



The most important factors acting on bridges during their service



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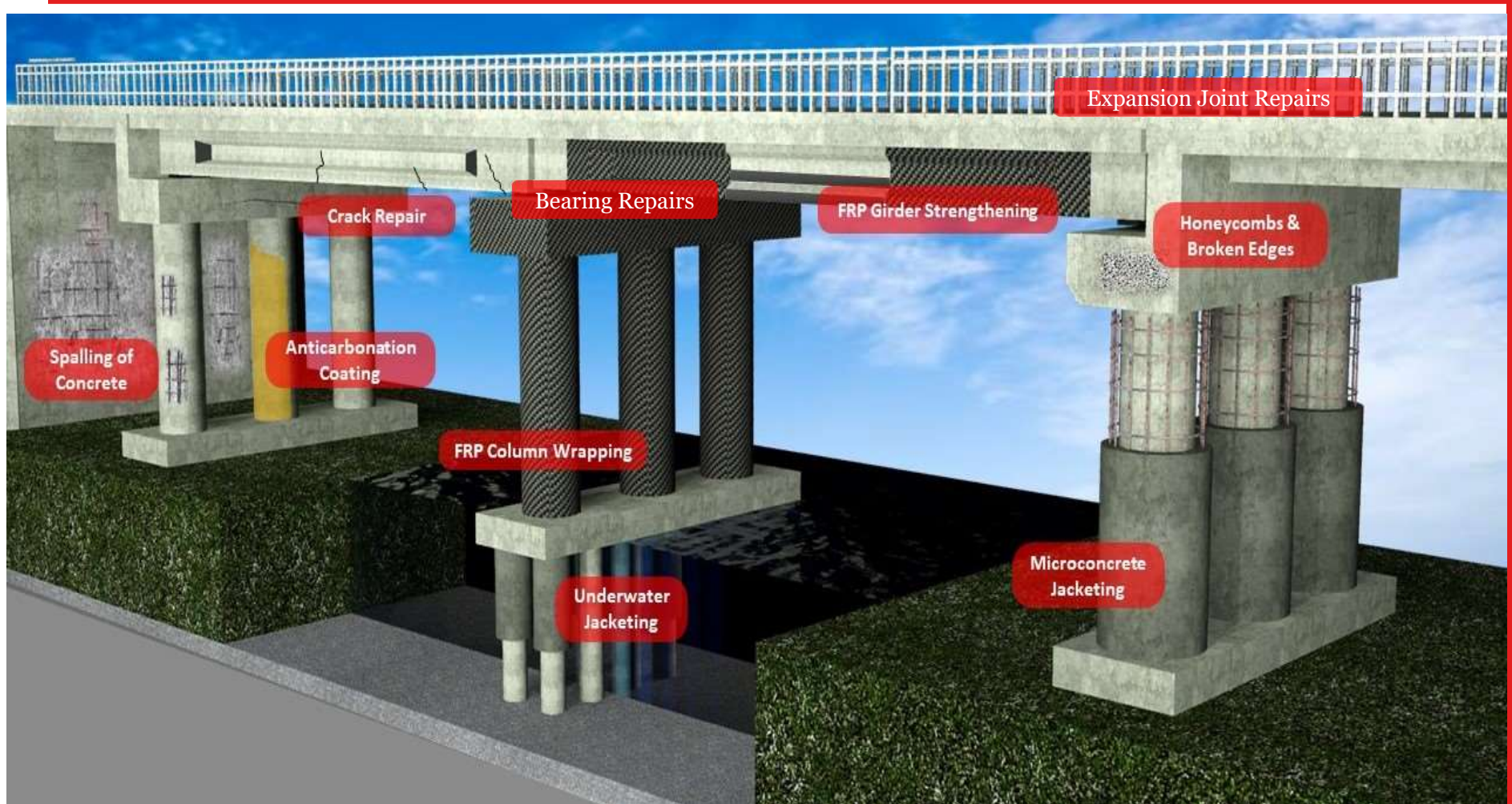


Factors acting on bridges during their service.

Common Defects in RCC Bridges



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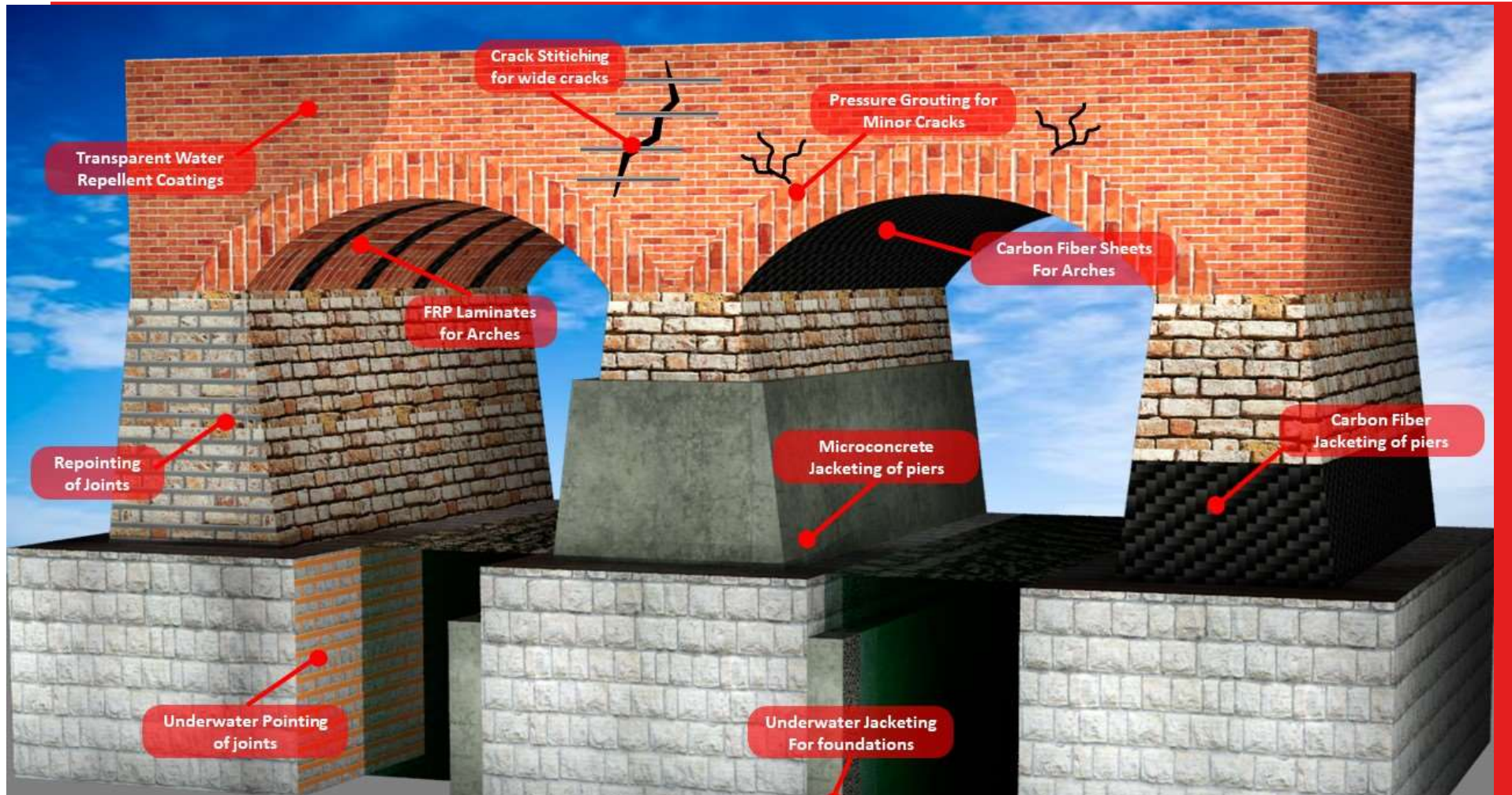


Common Defects in RCC Bridges

Common Defects in Masonry Bridges



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Common Defects in Masonry Bridges

Typical NDT Tests Conducted on concrete



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1. Ultrasonic Pulse Velocity – Soundness of concrete
 - Direct method
 - Indirect method
2. Rebound Hammer Test – Hardness of concrete
3. Core Cut – In Situ Compressive Strength
4. Phenolphthalein Test – Carbonation of Concrete
5. Half Cell Potential – Corrosion Level in concrete
6. Wenner Probe Method – Resistivity of concrete



Key Terms



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1. Repair - means to mend, to put into good shape or working order again, to recondition, to renovate, to restore and to correct.



2. Replacement - means to substitute, to change and to exchange. Some elements of bridge structures, mostly equipment elements, are usually replaced, e.g., expansion joints, bearings, barriers, etc.



3. Rehabilitation - means to restore, to make suitable, to put back in good condition, to re-establish on a firm, sound basis, to bring back to full use, to reinstate, to renew and to revive.



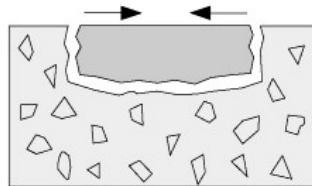
4. Retrofit/ Strengthening - means to increase load-carrying capacity by adding more material, additional components (e.g., carbon and glass fiber wrapping and laminates).



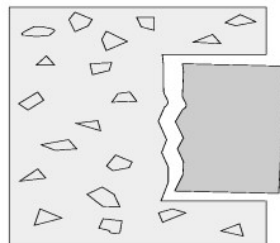
Repair materials

Properties required for repair materials.

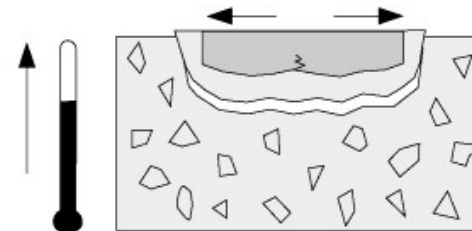
- Shrinkage compensation.



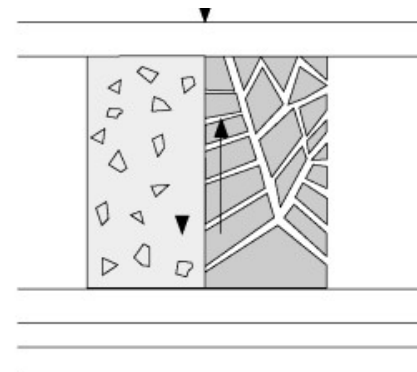
- Good bond strength with existing substrate.



- Compatible Coefficient of thermal expansion with parent substrate.



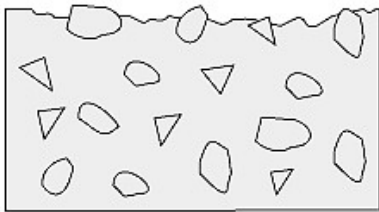
- Compatible or Higher Mechanical Properties than host substrate



Repair materials

Properties required for repair materials.

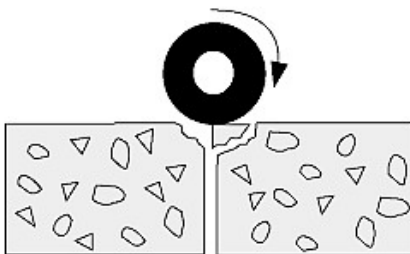
- Low Permeability & Effective Cover to protect steel.



- High Abrasion Resistance.



- Resistance to edge spalling i.e high tensile and bond strengths

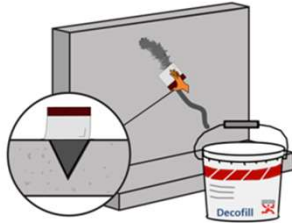


- Quick Turn around time i.e Rapid Strength Gain.

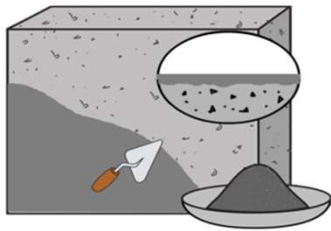


Repair/ Restoration Methods

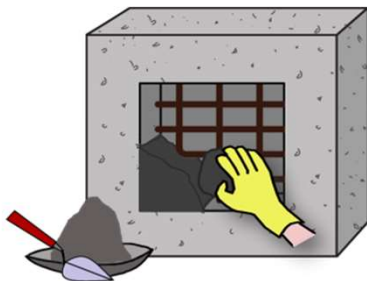
- **Crack Fillers & Sealers**



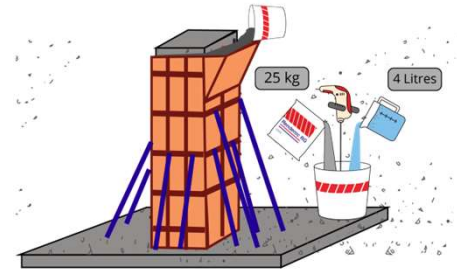
- **Fair Coat & Plugging Mortars**



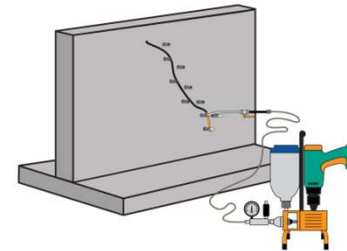
- **Repair Mortars**



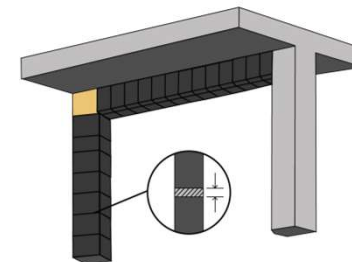
- **Microconcrete Jacketing**



- **Injection Grouting**



- **FRP Strengthening**



Application techniques

Depends on the size of the repair

- Multiple, small repairs (less than 0.5 sqm)
 - ▶ Hand patch repair mortars
- Medium sized repairs, difficult access, heavy steel reinforcement
 - ▶ Pourable micro-concrete
- Large repair areas
 - ▶ Spray



Typical Defects Observed

Following are the typical defects occurred in either old or new structures:

- Plaster Cracks
- Structural Cracks
- Water Leaking Cracks
- Construction Joints/ Non Structural Cracks
- Honeycombs
- Spalling
- Pinholes/ Blow Holes



Following are structural strengthening requirements

- RCC Beam/Column Jacketing
- FRP Fiber Wrapping Systems
- CFRP Laminates – Slab Strengthening

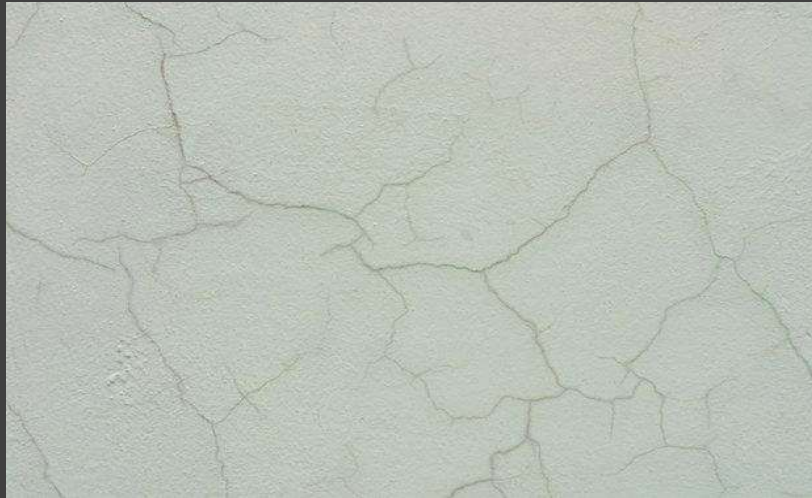


Fosroc Repair & Rehabilitation Offerings



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Non Structural Cracks in Concrete



Non structural cracks are cracks which do not hamper the structural integrity of the structure but affects the aesthetics of structure. For example,. Shrinkage cracks in concrete occur due to change in moisture of concrete. Concrete and mortar are porous in their structure in the form of inter-molecular space. They expand when they absorb the moisture and shrink when they dry. This is the main cause of concrete shrinkage cracks on drying.

Fosroc's Constructive Solution :

Cebex 100- Single component expansive grout additive

Uses & Advantages:

- Gaseous expansion system compensates for plastic shrinkage and settlement in properly designed cementitious grout.
- Reduced water/cement ratio mixes in the grout mix ensures low permeability and long term durability in service.
- Gives grout high fluidity with low water/cement ratio, thus making placement or injection of the grout easy.
- No metallic iron content to corrode and cause staining or deterioration due to rust expansion in the grout.
- Composition allows high early strength development in grouts, without the use of chlorides.

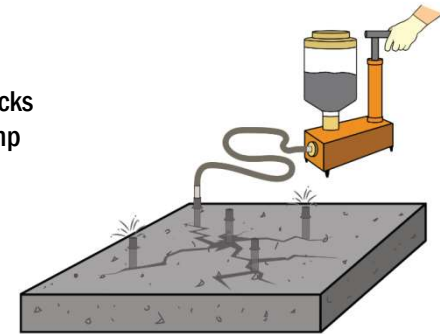
Packaging: Cebex 100 is supplied in 225g packs.

Application Pictionary – Cebex 100

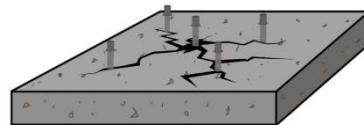
1. Drill the holes on the cracks



4. Inject the grout into the cracks using pressure grouting pump



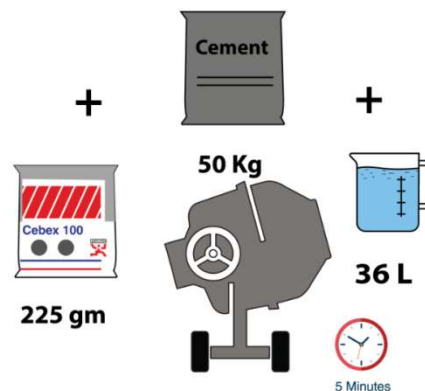
2. Fix the pvc nozzles for pressure grouting



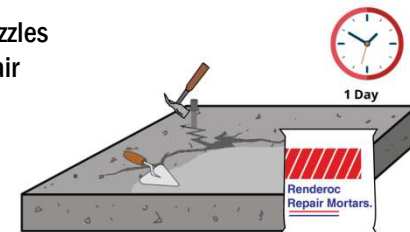
5. The grouted portion is densified



3. Mix cement, water and cebex 100 at specified ratio for 5 minutes



6. After 24 hours remove nozzles and make good with repair mortars



Fosroc Repair & Rehabilitation Offerings



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Structural Cracks in Concrete



Structural Cracks are cracks which hampers the structural integrity of the structures and are mostly caused due to following factors:

- Corrosion of Rebars
- Poor Construction Practices
- Sub Soil Settlement
- Over loading/Impact/ Blast Loadings
- Natural Calamities
- Etc

Fosroc's Constructive Solution :

Conbextra EP10 - Two component low viscous high strength epoxy injection grouting material

Uses & Advantages:

- Free Flow and chemical resistant.
- Excellent durability - high compressive, flexural and tensile strengths ensure a long working life.
- Cost effective - high early strength gain promotes minimum downtime and early commissioning.
- Excellent in service performance - non-shrink capability ensures full surface to surface contact.

Packaging: Conbextra EP10 is available in 1 Litre Pack

Application Pictionary – Conbextra EP10/EP10(M)



constructive solutions

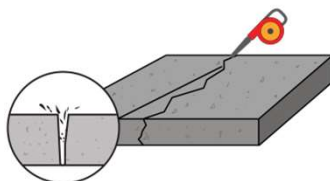
1. Structural Crack on concrete



2. Cut open the cracks to form V groove.



3. Remove all dust and loosely laid particles using a blower.



4. Place the injection packers at relevant spacing using epoxy sealing putties



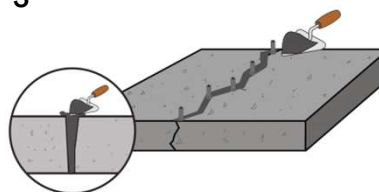
5. Mix Nitomortar S – Base & Hardener components



6. Add the aggregates and continue mixing to get a homogeneous mix



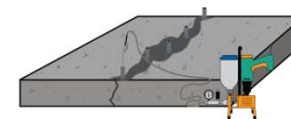
7. Seal the cracks using Nitomortar S



8. Mix the base and hardener components of Conbextra EP10.



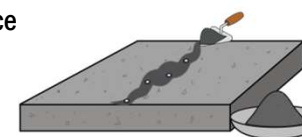
9. Pump the mixed resin into the cracks.



10. After resin hardens, remove the ports



11. Finish the surface using Nitomortar S



Conbextra EP10 Low viscous, High strength epoxy injection used for repairing structural cracks on pier caps at bangalore metro (BMRCL)



Before



After



Fosroc Repair & Rehabilitation Offerings



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Honeycombs



Honey combs are exposed aggregates which are formed on concrete surface due to

- Improper compaction of concrete during placing
- Excess Water in mix
- Leaky Shuttering
- Improper Mix ,etc

Fosroc's Constructive Solution :

Renderoc S2 - Shrinkage controlled, polymer modified, fibre reinforced cementitious repair mortar

Uses & Advantages:

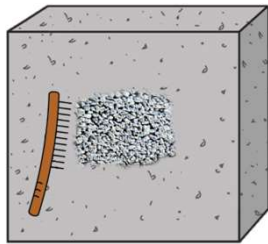
- High strength
- Can be applied by hand, like conventional mortars
- Extremely low permeability provides maximum protection against carbon dioxide and chlorides
- Excellent bond to the concrete substrate
- Shrinkage compensated
- No site batching required, supplied in pre-weighed prepacked condition
- Only addition of water at site

Packaging: 25 kg powder bag

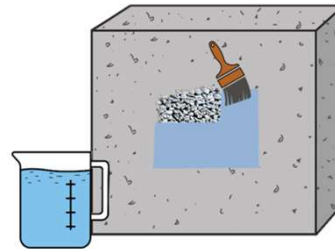
Application Pictionary – Renderoc S2



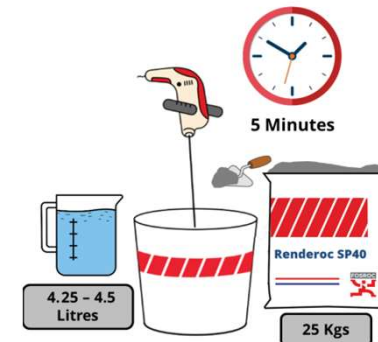
constructive solutions



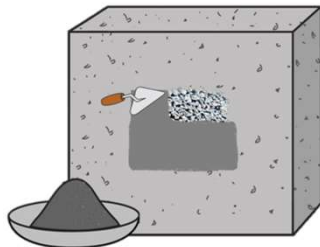
1. Clean the honeycombing using wire brushing



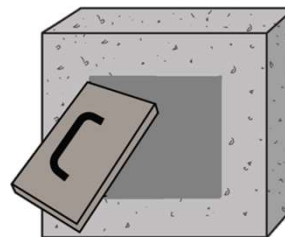
2. Prewet the surface using water



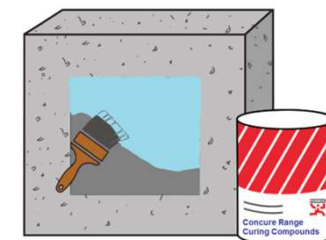
3. Mix Water and Renderoc SP40 Powder component using a paddles mixer and continue mixing till homogeneous mix.



4. Apply the repair mortar using trowel and press it on to surface



5. Finish the surface using a straight edge, wooden float or damp sponge



6. Cure the repair mortar using Concre WB or Nitobond AR or by using water

Fosroc Repair & Rehabilitation Offerings



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Pinholes / Blowholes



Pin holes and blow holes are small undulations and voids formed on concrete surfaces due to

- Inefficient use of mold releasing agents
- Excessive Vibration/ Less Vibration

Fosroc's Constructive Solution :

Renderoc FC - Single component polymer modified cementitious fairing coat

Uses & Advantages:

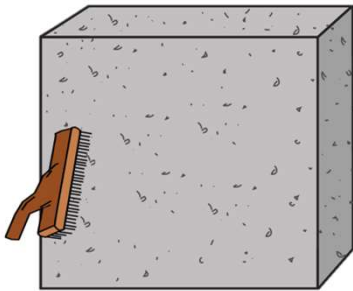
- Filling pinholes in concrete surfaces.
- General reprofiling over large areas, up to 3 mm depth
- Cost effective - no independent primer necessary
- Time saving - curing not necessary
- High performance - excellent bond to the substrate

Packaging: 5 & 15 kg powder bag

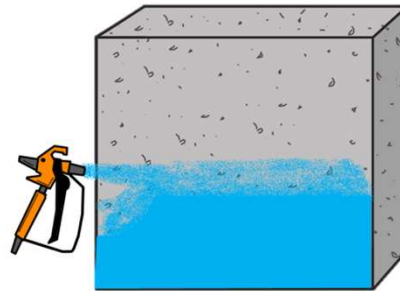
Application Pictionary – Renderoc FC



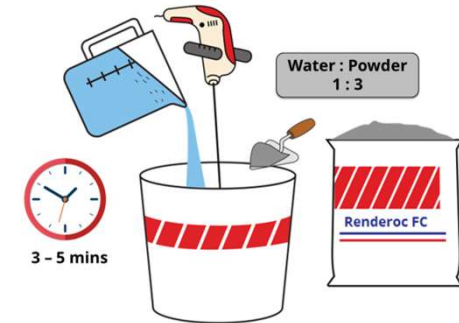
constructive solutions



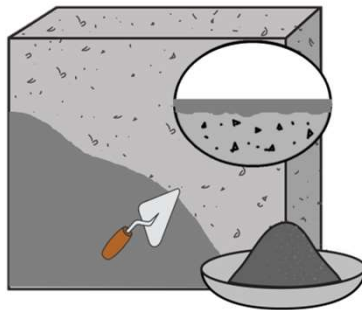
1. Wire brushing to remove all dust and loose particles



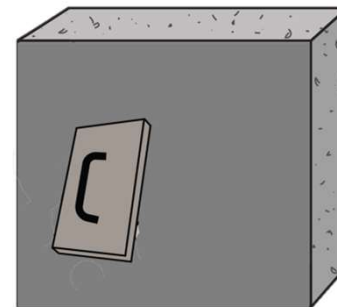
2. Pre wet the surface with water



3. Mix Renderoc FC powder and water in specified ratio and mix using a paddle mixer



4. Apply the mixed material over the undulations and blow holes using a trowel



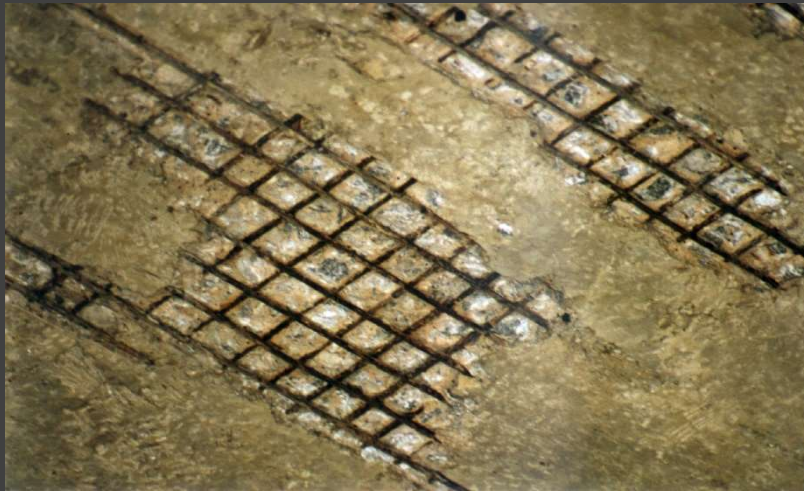
5. Finish the surface using a steel/plastic float

Fosroc Repair & Rehabilitation Offerings



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Spalling of Concrete



Spalling is a process in which concrete delaminates from the host due to several reasons such as, Reinforcement corrosion, carbonation, chlorination in which, steel expands in volume due to rust and puts pressure on concrete leading cracks and finally delamination of concrete.



Fosroc's Constructive Solution :

Renderoc HS XTRA – Dual Shrinkage Compensated, Structural grade polymer modified two component high strength ready to use repair mortar

Uses & Advantages:

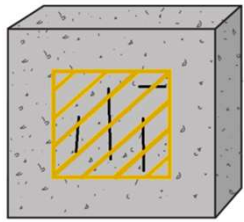
- High strength
- Can be applied by hand, like conventional mortars
- Extremely low permeability provides maximum protection against carbon dioxide and chlorides
- Excellent bond to the concrete substrate
- Shrinkage compensated
- No site batching required, supplied in pre-weighted prepacked condition
- Contains no chlorides.

Packaging: 25 kg powder

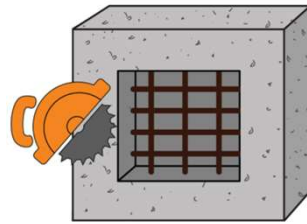
Application Pictionary – Renderoc HS XTRA



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1. Mark out the area to be repaired with sharp edges to prevent feather edges



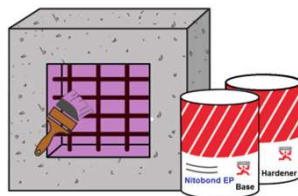
2. Chip out the unsound concrete to expose the reinforcements



3. Apply Reebaklens RR on rusted steel and allow it to react for 16 to 24 hours and remove all the rust and clean using wire brush



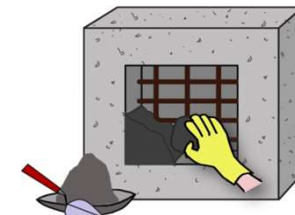
4. Apply Nitozinc Primer, an anti corrosive coating on the exposed reinforcements



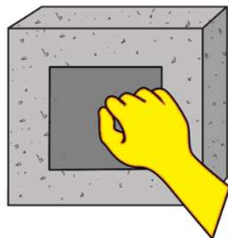
5. Apply bonding agent Nitobond EP on to concrete surfaces



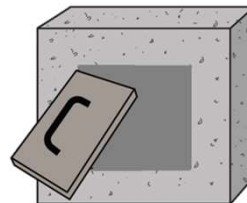
6. Mix Water and Renderoc HS Xtra as per specified ratio homogeneously



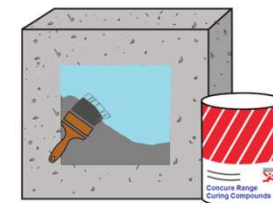
7. Apply the repair mortar using gloved hand or trowel and press it on to surface



8. Completely press the repair mortar on to the patch



9. Finish the surface using a straight edge, wooden float or damp sponge



10. Cure the repair mortar using Concure WB or Nitobond AR or by using water

Fosroc **Renderoc HS Xtra** High Strength, Non Shrink, Hand Applied Repair mortar used for rectifying large honeycombs in a commercial building rehabilitation project in Bangalore.



Before



After

Renderoc HS Xtra – Repair Mortar

- Dual Shrinkage Compensation – Dimensional Stability
- Fiber Reinforced
- High Strength
- Polymer Modified
- Single Component Cementitious System

Drying Shrinkage	<300 microns
Permeability	<5mm
Compressive Strength	>70 Mpa
Flexural Strength	>9 Mpa
Water Absorption	<2%

Renderoc S2 Structural Grade Repair Mortar being used at Indian Railways for repair of bridges across Annigere to Binkadakatti section in Karnataka.



Before



After



Renderoc S2 Structural Grade Repair Mortar being used at Indian Railways for repair of bridges across Annigere to Binkadakatti section in Karnataka.



Before



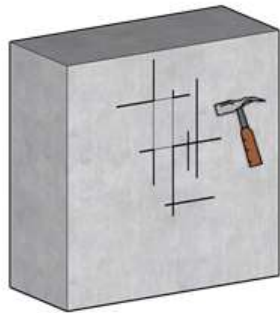
After



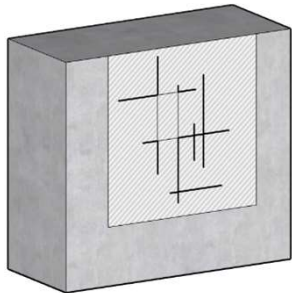
Renderoc SP40 / DS40 – Spray Application



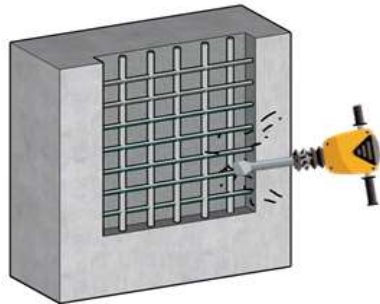
constructive solutions



1. Identify all the spalled and hollow areas by hammer sounding

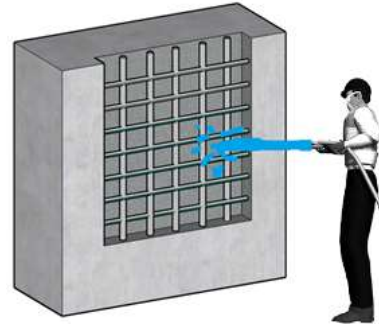


2. Mark out the areas in proper geometric shape to prevent feather edging

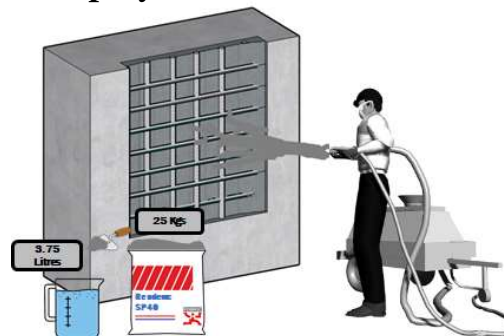


3. Remove all loose concrete by jack hammering/ other methods

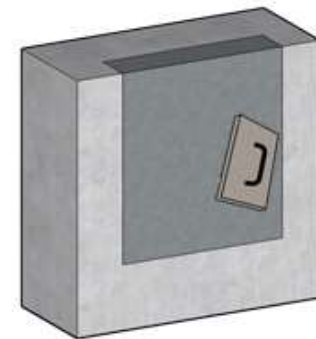
4. Clean the substrate by water jet to remove all dust and laintenance



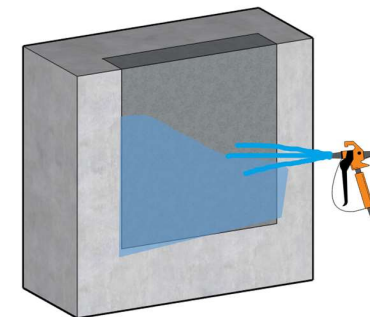
5. Mix **Renderoc SP40** powder and water in specified ratios in mixer and spray it on substrate



6. Float the finished surface with wooden float to give proper texture



7. Cure the repaired area with water or curing compounds



Fosroc **Renderoc DS40 & SP40** Dry and Wet spray mortars used for reinstatement of corroded span of Berth at ESSAR, Vizag



Fosroc Repair & Rehabilitation Offerings



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Microconcrete - Jacketing



Jacketing is a technique used to increase dimensions of existing RCC elements such as beams, columns, or to reinstate deteriorated RCC elements using microconcrete along with anchors, bonding agents, anticorrosive coatings, & watertight formwork in order to carry additional designed loads anticipated on the structure.

Fosroc's Constructive Solution :

Renderoc RG Series – High Strength non-shrink, cementitious micro-concrete

Uses & Advantages:

- Gaseous expansion system compensates for shrinkage
- Can be pumped or poured into restricted locations.
- Pre-bagged to overcome site-batched variations.
- Rapid strength gain to facilitate early reinstatement.
- High ultimate strengths and low permeability.
- Contains no chloride admixture.

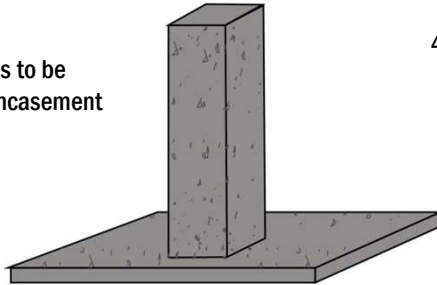
Packaging: Renderoc RG SPL is supplied in 25kg bags

Application Pictionary – Renderoc RG Series

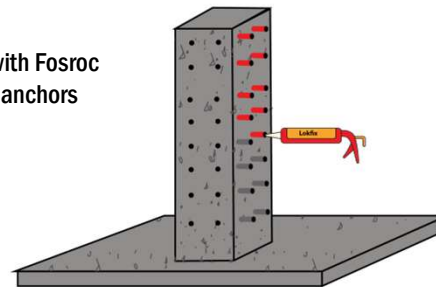


constructive solutions

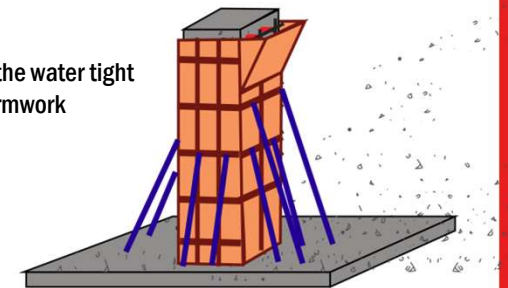
1.RCC Columns to be strengthened by encasement



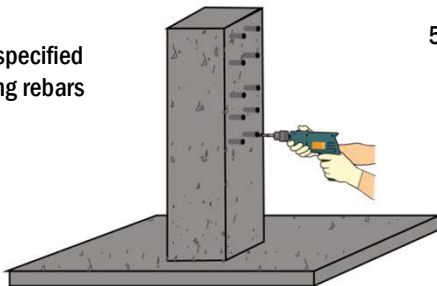
4.Fill the holes with Fosroc Lokfix E range anchors



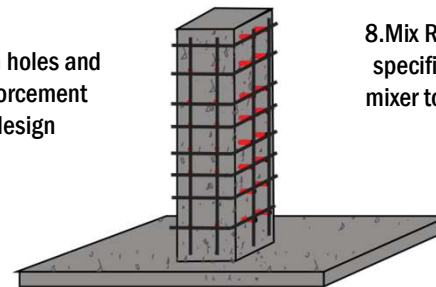
7.Set up the water tight formwork



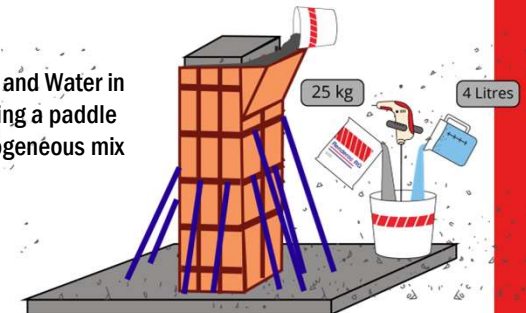
2.Drill holes at specified intervals for fixing rebars



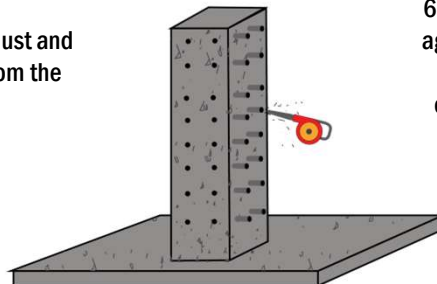
5.Fix the rebars in holes and set up new reinforcement cage as per design



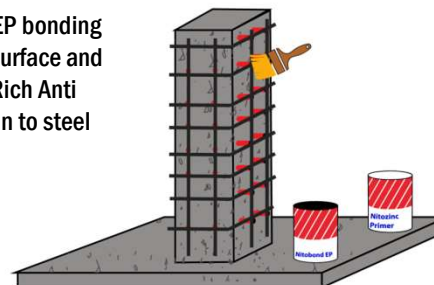
8.Mix Renderoc RG and Water in specified ratios using a paddle mixer to get a homogeneous mix



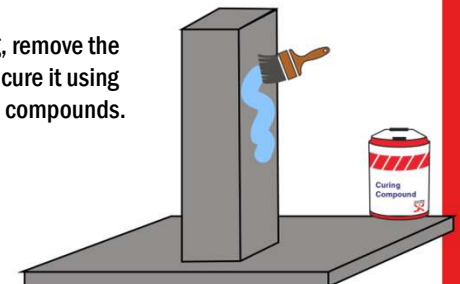
3.Remove all the dust and loose particles from the holes



6.Apply Nitobond EP bonding agent to concrete surface and Nitozinc – Zinc Rich Anti corrosive primer on to steel surface



9.After setting, remove the formwork and cure it using water or curing compounds.



South Western Railways - Bangalore



constructive solutions



Pondicherry NH - Bridge- **Renderoc RG** High Strength Microconcrete used for jacketing of deck slabs of the bridges



PT Slab – End Block Repairs with Conbextra EP300



constructive solutions



Bridge Bearing Repairs – Conbextra EP75 , BMRCL



constructive solutions



Fosroc **Nitowrap** FRP Structural Strengthening Systems



Why Strengthen?

■ Increase the loading :

- ▶ Require additional levels to a building
- ▶ require additional ability to take live load (traffic)
- ▶ Change of building use
- ▶ Wind loading

■ Loss of Reinforcement:

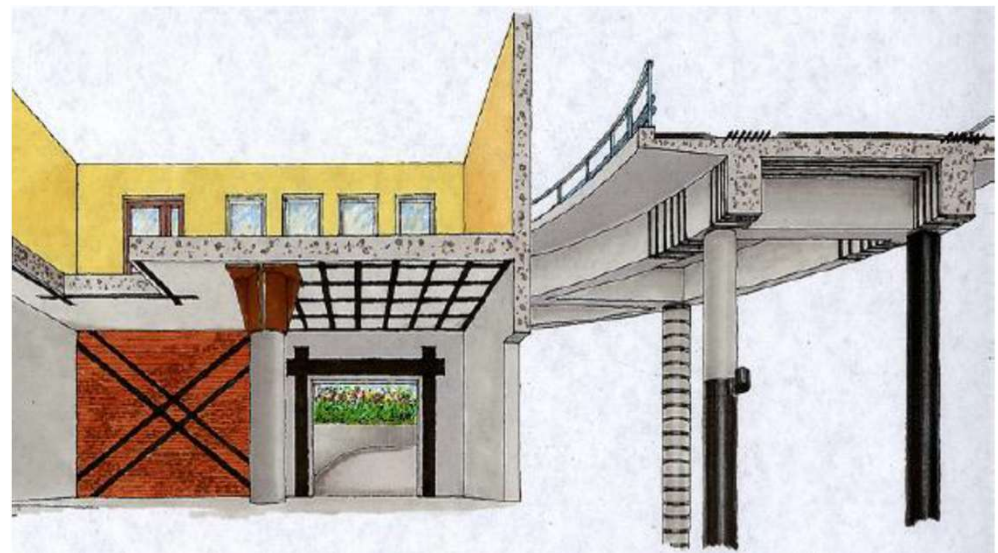
- ▶ Cut holes and openings in slab
- ▶ Fire
- ▶ Corrosion
- ▶ Mechanical Damage
- ▶ Loss of pre-stress force
- ▶ Remove columns/supporting walls

■ Change to design code

- ▶ Building changes use
- ▶ Requirements of safety factors
- ▶ Seismic codes
- ▶ Blast protection

■ Construction Defects

- ▶ Inadequate design
- ▶ Poor quality construction



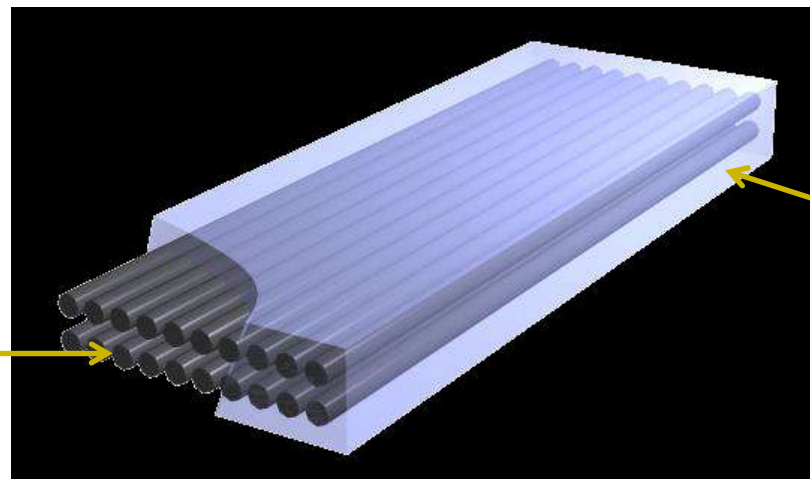
Fiber Reinforced Polymers



constructive solutions



Fiber
Reinforcement



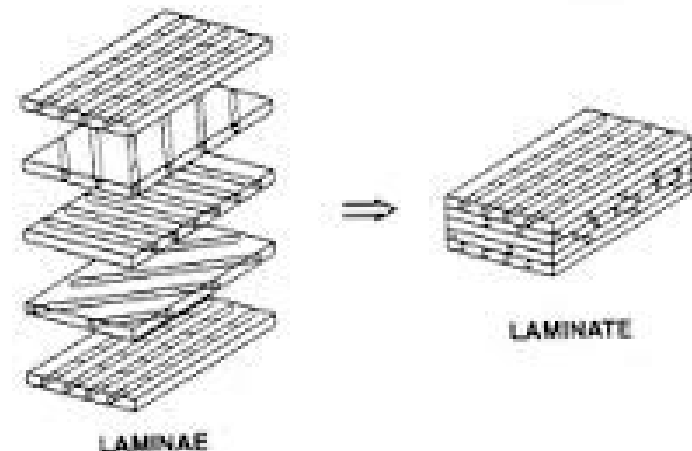
Polymer
(Resin)

- Primary function:

“To carry load along the length of the fibre, provides strength and or stiffness in one direction”

- **Fibers** can be oriented to provide properties in directions of primary loads

- **Resins** : To transfer stresses across the fibres.



Common FRP Constituent Materials



constructive solutions

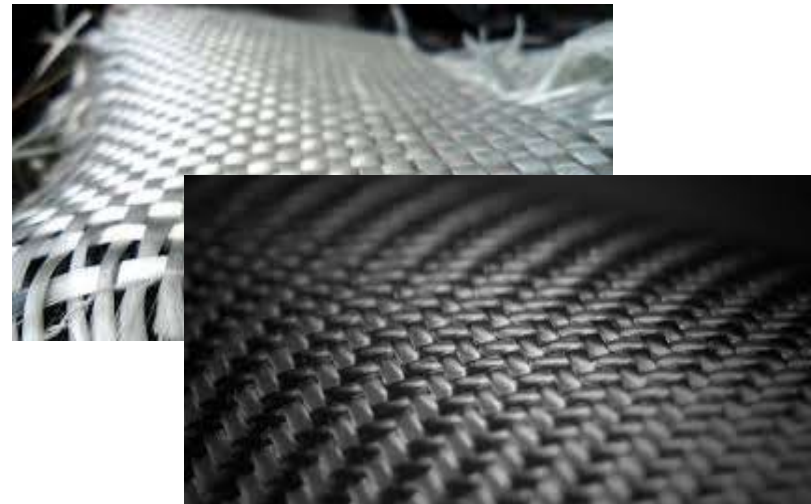
Resins

- Epoxy
- Vinylester
- Polyester



Fibres

- Carbon
- E-glass
- Aramid



Carbon Fibers



constructive solutions



- Very high strength and stiffness
- Low ultimate strain
- Low CTE
- Thermally stable up to 3500°F (1927 °C)
- Low impact resistance
- Excellent moisture and chemical resistance
- Sensitive to galvanic corrosion
- Highly conductive

Glass Fibers



constructive solutions



- High Strength
- Low Stiffness
- CTE similar to steel and concrete
- Soften at temperatures over 1500°F (816°C)
- Low resistance to sustained and cyclic loads
- Sensitive to alkalinity and moisture
- Highly insulative

Aramid Fibers



constructive solutions

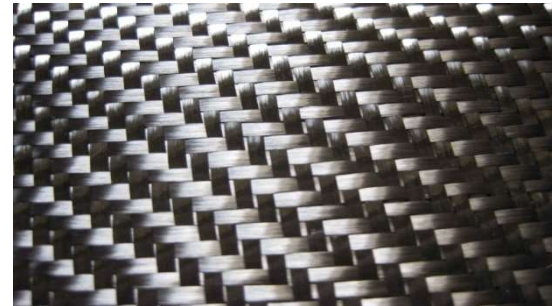


- High Strength
- Usable temperature range:
 $\pm 350^{\circ}\text{F}$ (177°C)
- Excellent impact resistance
- Sensitive to UV exposure
- Resistant to chemical attack
- Fibers swell with exposure to moisture
- Low Conductivity

Uni-directional Fibers



Bi-directional Fibers



FRP Strengthening Systems



Nitowrap CWS

Carbon Fiber Fabric

GSMs – 200 to 900

**Formerly called
Nitowrap EPCF**



Nitoplate CPS

Carbon Laminate

Thickness – 1.2 & 1.4 mm
**Formerly called Nitowrap
CFP**



Nitowrap GW

Glass Fiber Fabric

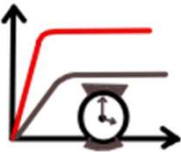
GSMs – 450 & 900

**Formerly called
Nitowrap EPGF**

FRP – Carbon vs Glass Fibers



constructive solutions

Condition	Carbon	Glass	Remarks
 Alkaline and Acidic			Coastal Environment/ Industrial
 Impact Tolerance			Blast mitigation / Seismic Retrofitting
 Thermal Expansion			
 Creep & Fatigue			Bridges
 Electrical Conductivity			Server-rooms, Pharma, etc

*Thumb Rule

Structural Strengthening – Carbon Fiber & Glass Fiber Wrapping



constructive solutions



Wrapping is a method of confining RCC elements such as beams or columns using high strength FRP (carbon/glass) fibers to increase load carrying capacity of existing RCC members for additional designed loads.

Fosroc's Constructive Solution :

Nitowrap CWS – Carbon Fiber Fabric & Nitowrap GW – Glass Fiber Fabric

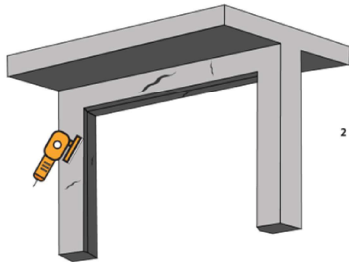
High performance high strength, carbon and glass fiber system for structural strengthening for strengthening columns, beams and slabs of load bearing structures

Uses & Advantages:

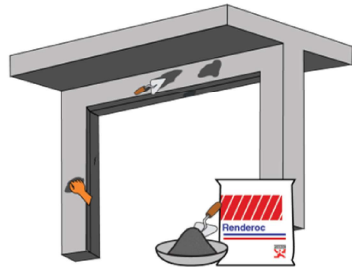
- Very high strength to thickness or weight ratio
- Increased load carrying capacity and better resistance to seismic forces and deflection.
- Chemical resistant - excellent resistance to acids and alkalis
- Thin sections - Can be effectively used in space constrained areas
- Creep & Fatigue resistance - Ideal for conditions of sustained loading and repeated loading.
- Flexible- Can be applied on any shape or contour of substrate

Packaging: Available in variants ranging from 200GSM to 920GSM and supplied in 50 or 100m rolls (kindly refer datasheet)

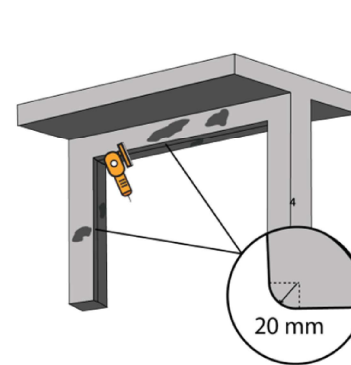
1.Surface Grinding to remove all dust and loose particles



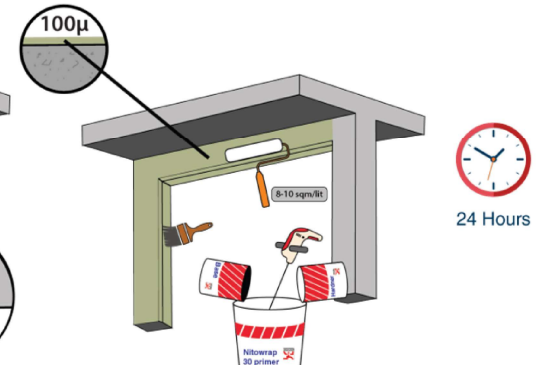
2.Repair all the cracks and undulations using appropriate repairs mortars in Fosroc Range



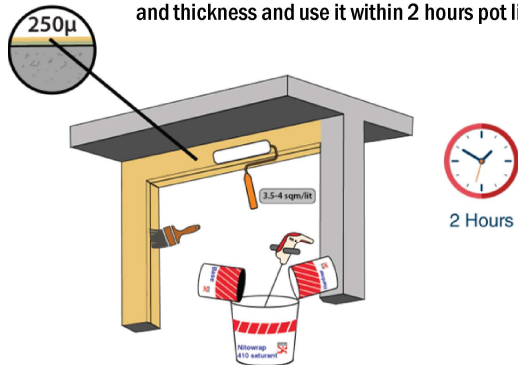
3.Rounding of the edges to minimum of 20mm to avoid stress concentrations



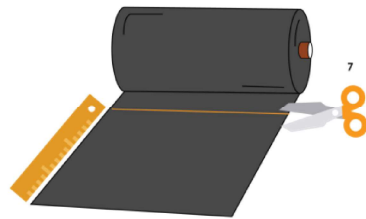
4.Mix the components of Nitowrap 30 primer using paddle mixer and apply on to prepared surface at specified coverage and thickness and allow it dry for 24 hours.



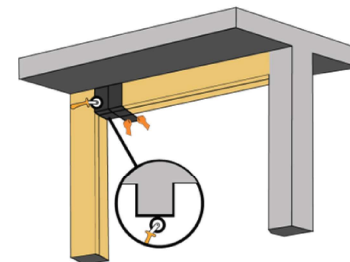
5.Mix the components of Nitowrap 410 saturant and apply it on to primed surface at specified coverage and thickness and use it within 2 hours pot life



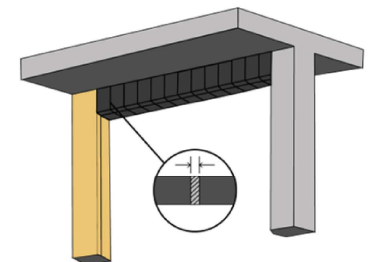
6.Cut Nitowrap EP(CF) – carbon fiber / Nitowrap EP(GF) – glass fiber sheets to required lengths



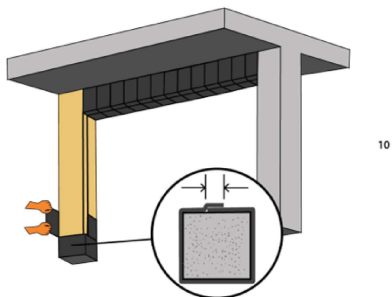
7.Apply the sheets on to saturant by pressing using hand within the open life of saturant and use roller to remove all air entrapped



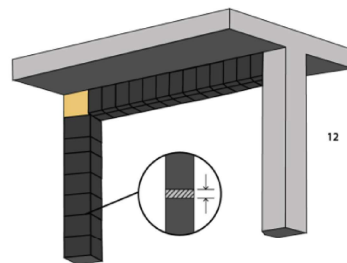
8.Subsequently apply the fabric sheets by overlapping as per design



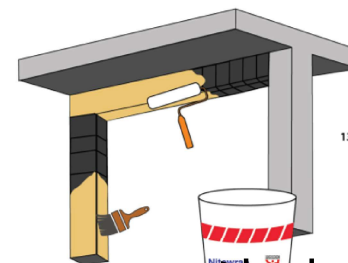
9.Follow the same procedure as above for columns and overlap as per design



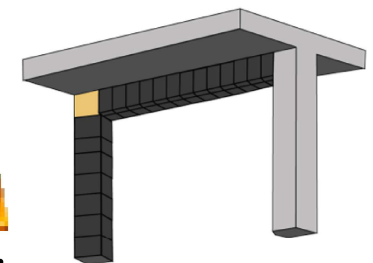
10.For the further layers of wrapping, again apply saturant on fabric and continue the process



11.Apply second layer of Nitowrap 410 saturant at specified thickness and coverage over the carbon/ glass fabric



12.Continue the process as per design



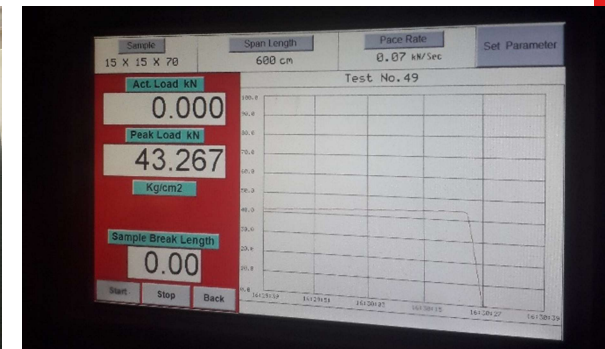
Flexural Test of Concrete Beams



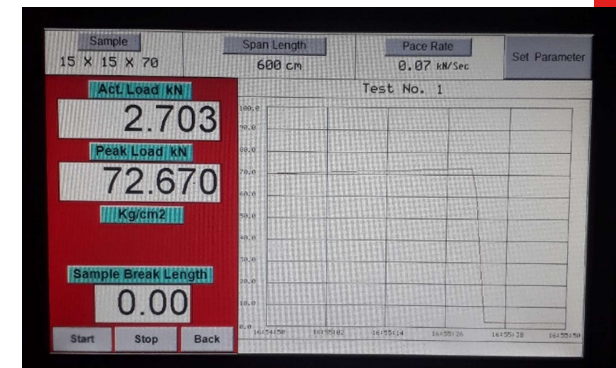
constructive solutions



Control Beam



Beam reinforced with 2 Laminates on soffit



% Enhancement = 67 %

Experimental Setup:

Two concrete cylinders of same batch were casted. One of the cylinder was control specimen and the other cylinder was wrapped with **1 Layer-200 GSM** carbon fiber system – **Nitowrap CWS200**



Parameter	Control Specimen	FRP Wrapped Specimen
Diameter (mm)	150	
Height (mm)	300	
Ultimate Load (kN)	998	1500
Compressive Strength (Mpa)	56.47	84.88
% Enhancement over control	50%	

Fosroc **Renderoc RG** Non shrink, Microconcrete & **Dekguard S** Anticarbonation Coating used for rehabilitation of conveyor belt bridge at SCCL Coal Mines



Fosroc **Nitowrap CWS 200** High Performance Carbon Fiber Composites System (Formerly known as Nitowrap EPCF 200) being used for structural strengthening of Railway Bridge Piers



Before



After



Assam PWD – Bridge Strengthening

Background: Old bridge – retrofitting needed for new loading conditions

Fosroc Support : Specification Support

Consultant: Assam PWD

Scope : Nitowrap CWS 200 Fabric



DMRC – FRP Strengthening, Delhi



constructive solutions

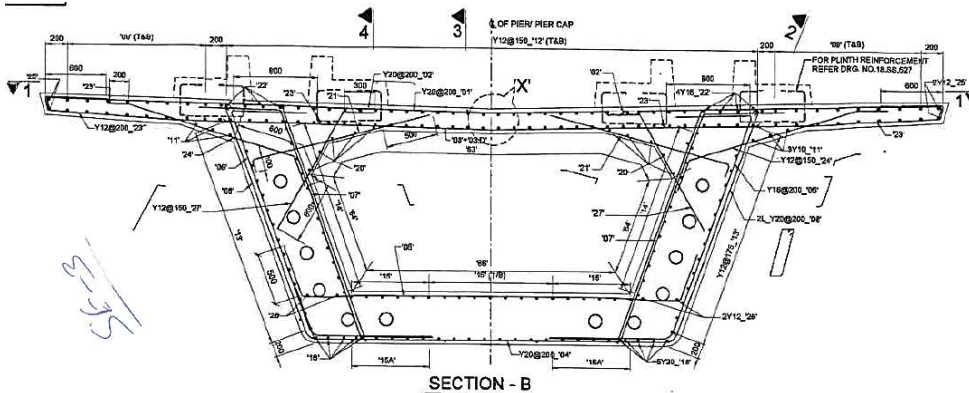
Scenario:

Loss of strength on Precast Segments of DMRC due to fire incident

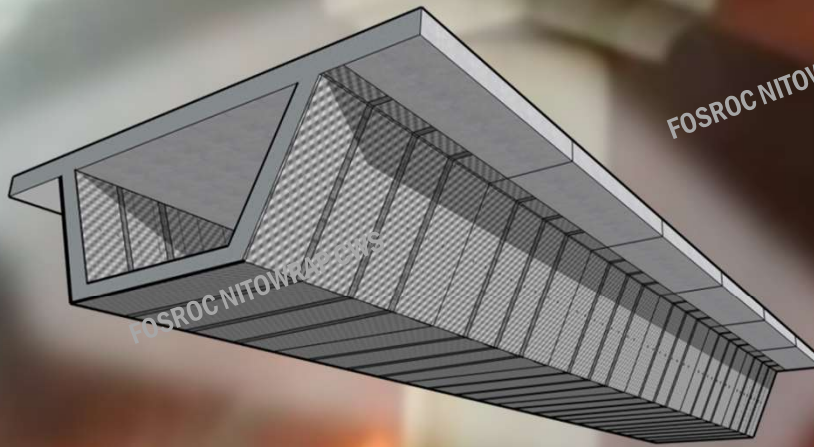
- Existing Shear Reinforcement : 2300 mm²
- Required Shear Reinforcement : 3000mm²
- Deficiency : **700mm²**
- Shear Capacity Deficiency : **3076 kN**



Data Provided for Design:



DMRC -Fosroc **Nitowrap CWS** used for shear strengthening of precast girders of a bridge to improve the shear strength of the fire damaged segments



DMRC – FRP Strengthening, Delhi



constructive solutions



Fosroc **Nitowrap CWS** used for structural rigidity enhancement and corrosion protection of steel truss fabricated to strengthen the connecting bridge at NTPC Simhadri



Before



After



Repair and Rehabilitation of Bridges – Veeranam Project

Nitowrap GW – Glass Fiber FRP Systems used for strengthening if girders



Pressure grouting in progress



Application of Nitowrap System to soffit of Girders

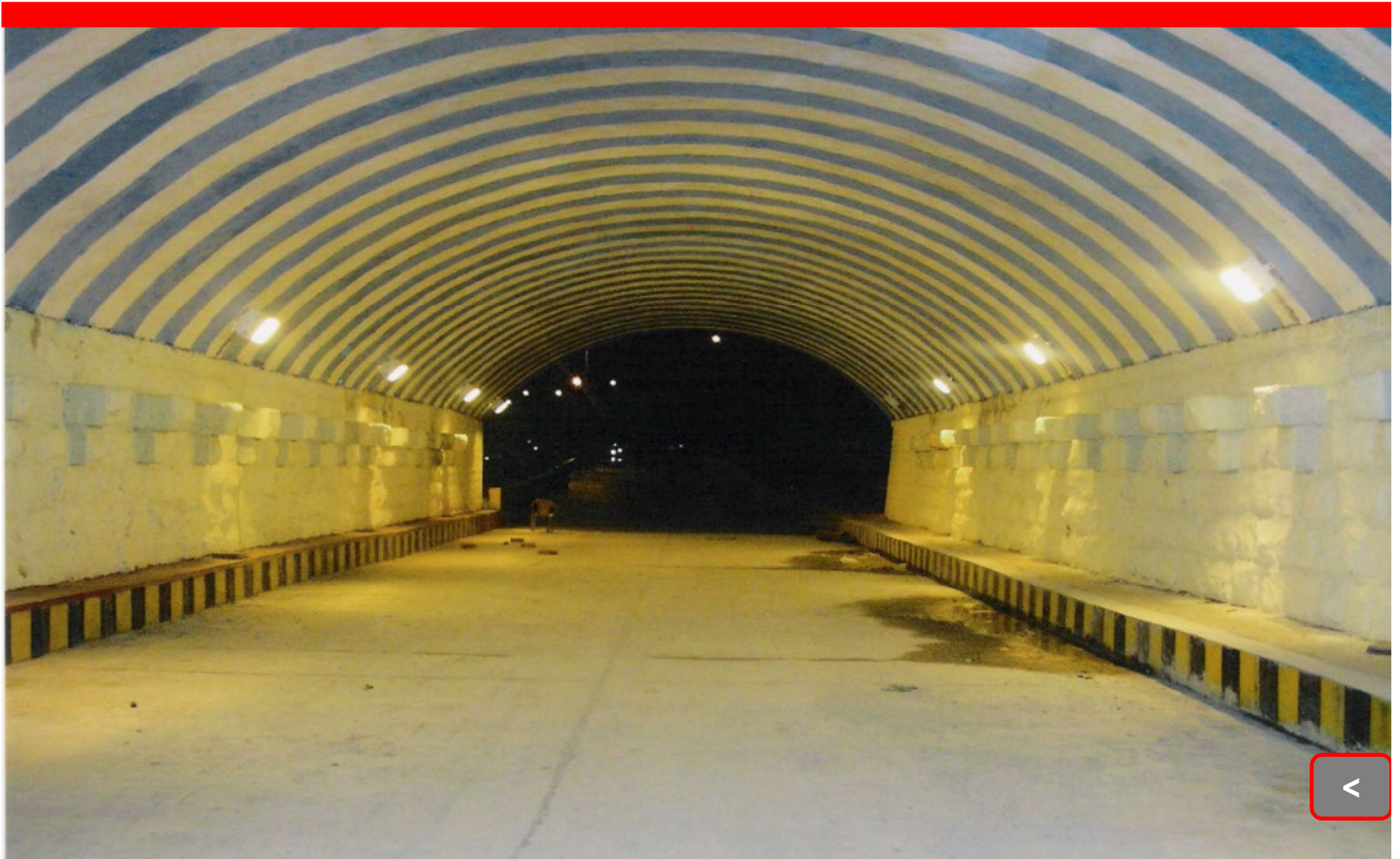
Strengthening of Masonry Arch Bridge with
Nitowrap CW – Carbon Fiber FRP Systems



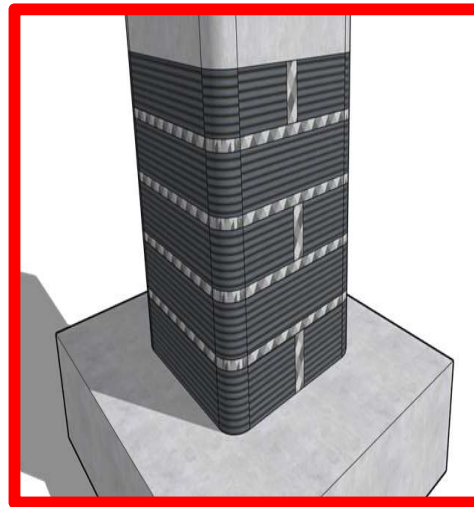
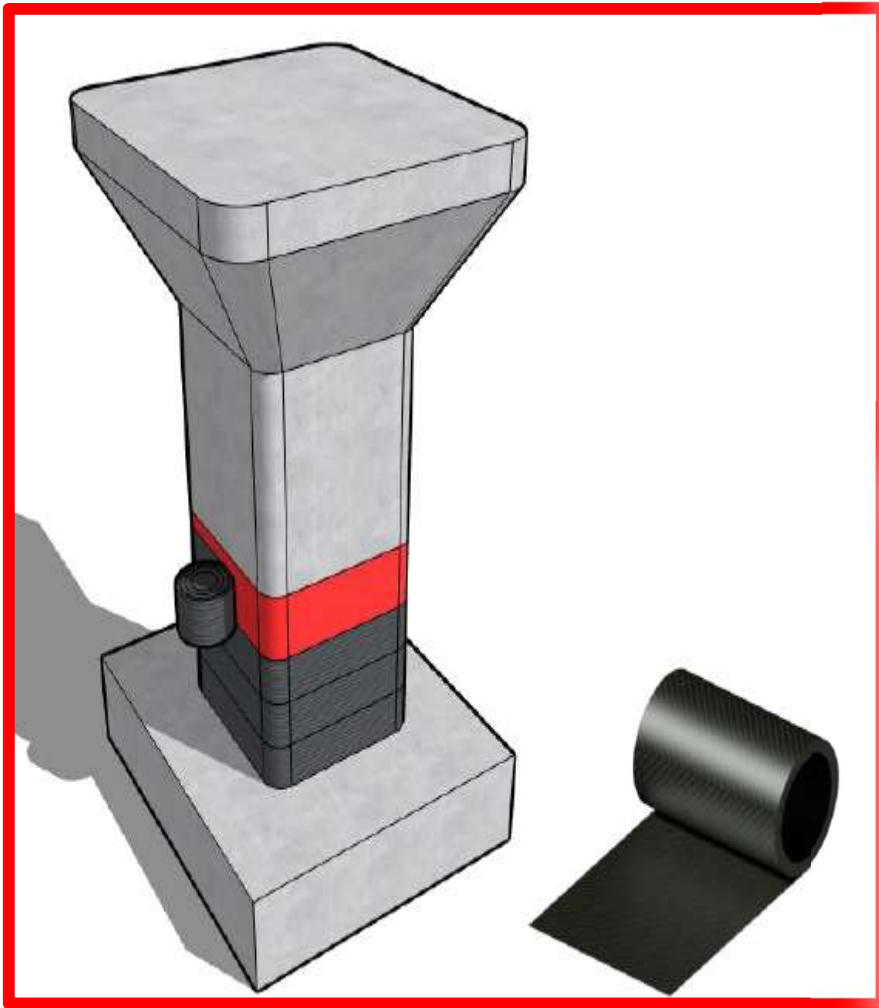
Strengthening of Masonry Arch Bridge with **Nitowrap CW – Carbon Fiber** FRP Systems



Strengthening of Masonry Arch Bridge with
Nitowrap CW – Carbon Fiber FRP Systems



Dhola Sadiya Bridge, Assam – **Nitowrap CWS 600** used for seismic retrofitting of RCC piers to accommodate seismic forces in the region.





FRP Strengthening of Pier Bearing Pedastals of BMRCL

Structural Strengthening – Carbon Fiber Laminates



constructive solutions



FRP laminates are high strength carbon fiber laminates which are externally bonded to existing RCC members such as slabs, in order to increase load carrying capacity, flexural strength, etc as per designed additional loads.

Fosroc's Constructive Solution :

Nitoplate CPS - High performance, high strength, corrosion resistant pultruded Carbon fibre plates

Uses & Advantages:

- Very high strength to thickness or weight ratio
- Increased load carrying capacity and better resistance to seismic forces and deflection.
- Chemical resistant - excellent resistance to acids and alkalis
- Thin sections - Can be effectively used in space constrained areas
- Primer not required - reduced downtime
- Easy to install, time & labour saving

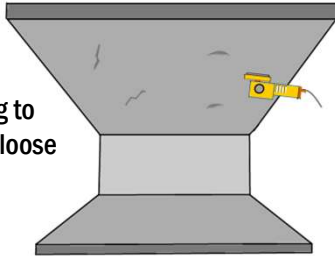
Packaging: Available in 1.2 & 1.4mm thickness and 100 or 200m rolls

Application Pictionary – Nitoplate CPS

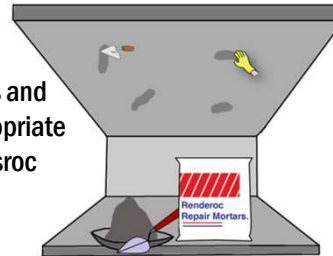


constructive solutions

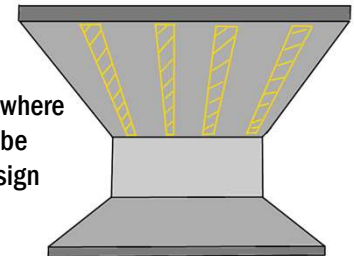
1. Surface Grinding to remove all dust and loose particles



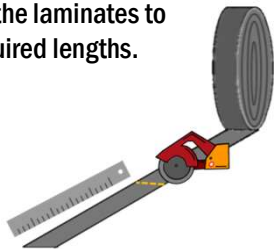
2. Repair all the cracks and undulations using appropriate repairs mortars in Fosroc Range



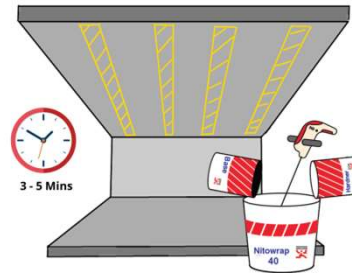
3. Mark out the area where laminates are to be applied as per design



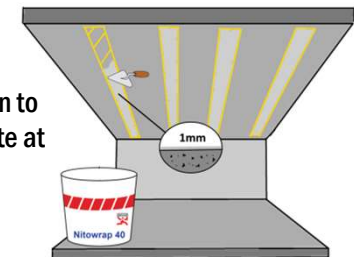
4. Cut the laminates to required lengths.



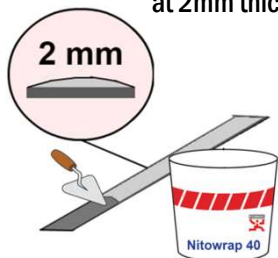
5. Mix components of Nitowrap 40 epoxy adhesive for 3 to 5 minutes using a paddle mixer



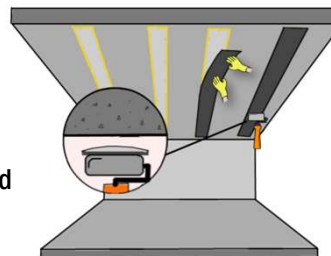
6. Apply the adhesive on to marked area of substrate at 1mm thickness



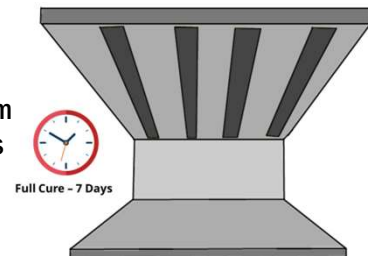
7. Apply adhesive on the laminate at 2mm thickness tapered towards ends



8. Apply the laminates on to substrate by hands and use roller to remove any entrapped air



9. Allow the system to cure for 7 days



Haraman Railways- Jeddah – **Nitowrap FRP** Systems used for flecural strengthening of deficient bridge girders and limit the deflection



U wraps at support



FRP Fabric – U Wrap





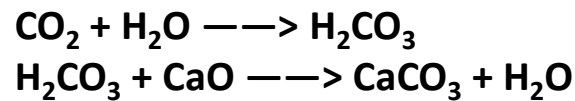
Anti Carbonation Coatings



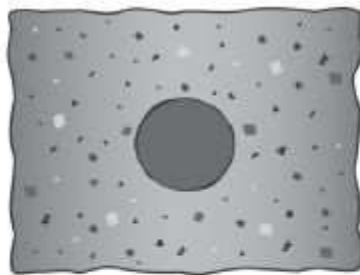
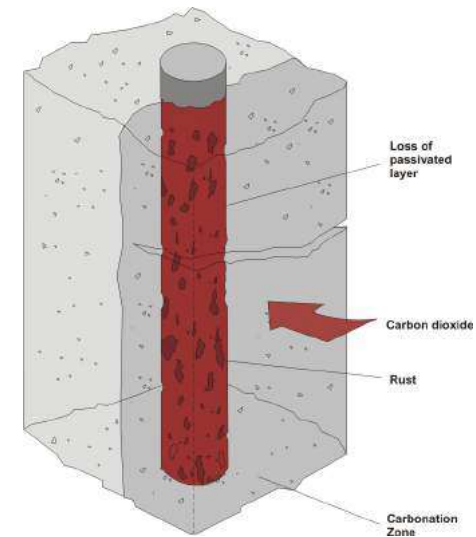
Need for Anti Carbonation Protective Coating



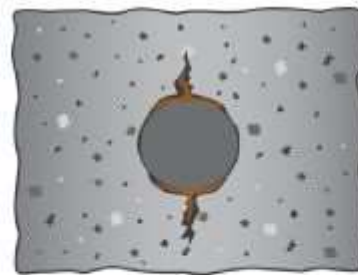
constructive solutions



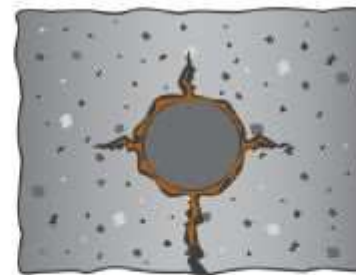
- Normal air contains 0.04% of CO_2
- Higher Concentration in urban and Industrial areas
- Alkalinity of concrete reduces to less than pH 8
- Passivity layer on steel lost when alkalinity lost
- **Corrosion commences !!**



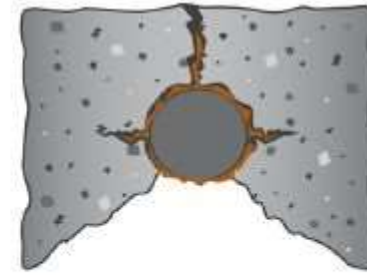
BEFORE CORROSION.



BUILD-UP OF
CORROSION PRODUCTS.



FURTHER CORROSION.
SURFACE CRACKS.
STAINS.



EVENTUAL SPALLING.
CORRODED BAR.
EXPOSED.

Factors affecting Carbonation

- Rate of Carbonation depends on following factors:

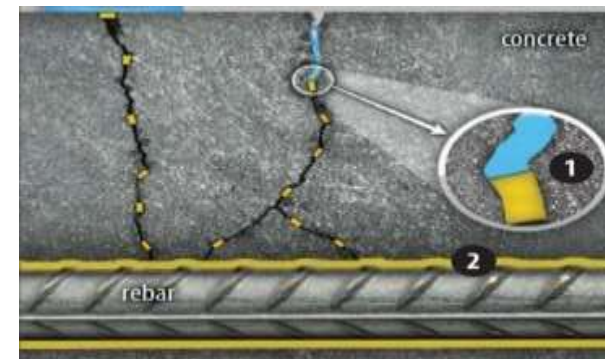
Relative Humidity



Grade of Concrete



Permeability



Depth of cover



Time



Factors affecting Carbonation

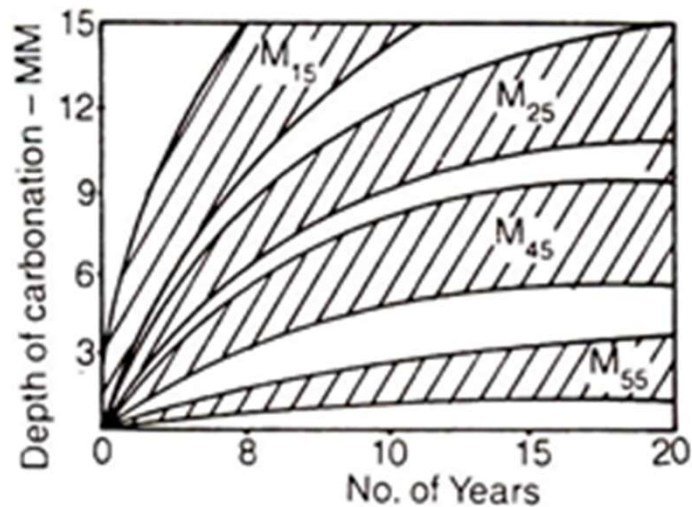


Fig. 17.4. Relation between depth of carbonation & strength of concrete

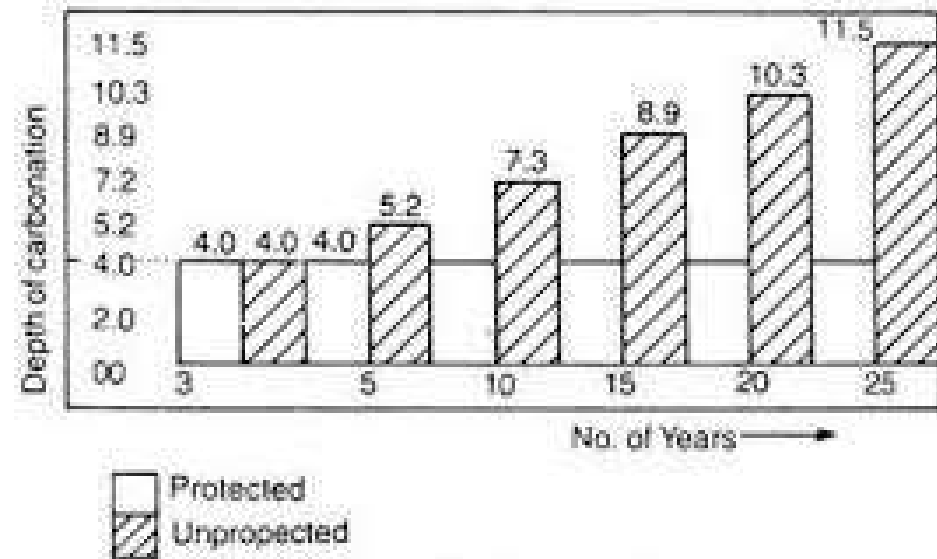


Fig. 17.5. Depth of carbonation of protected and unprotected concrete

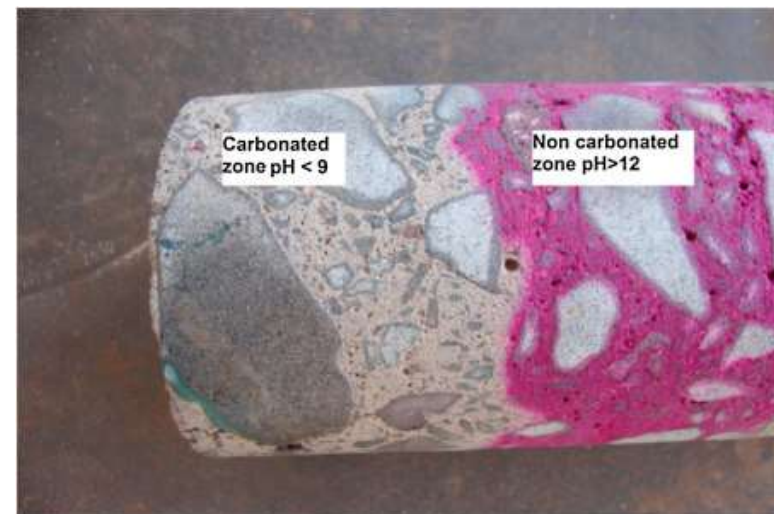
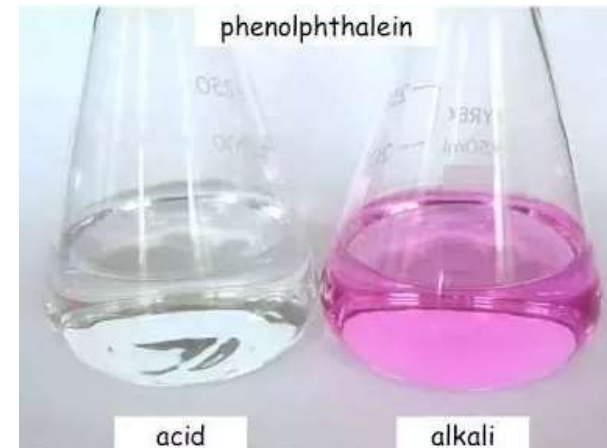
Detecting Carbonation



constructive solutions

Concrete sampling is done through core cutting machines and treated with phenolphthalein solution

- Purple Color indicates – **Not affected**
- No Colour Change - **Carbonated**



Combined Carbonation & Chlorination affected concrete



constructive solutions



Combined Carbonation and Chloride Attack



constructive solutions

FOSROC DEKGUARD E 2000

High Performance Protective Coating System for Bridges



Dekguard E 2000



constructive solutions

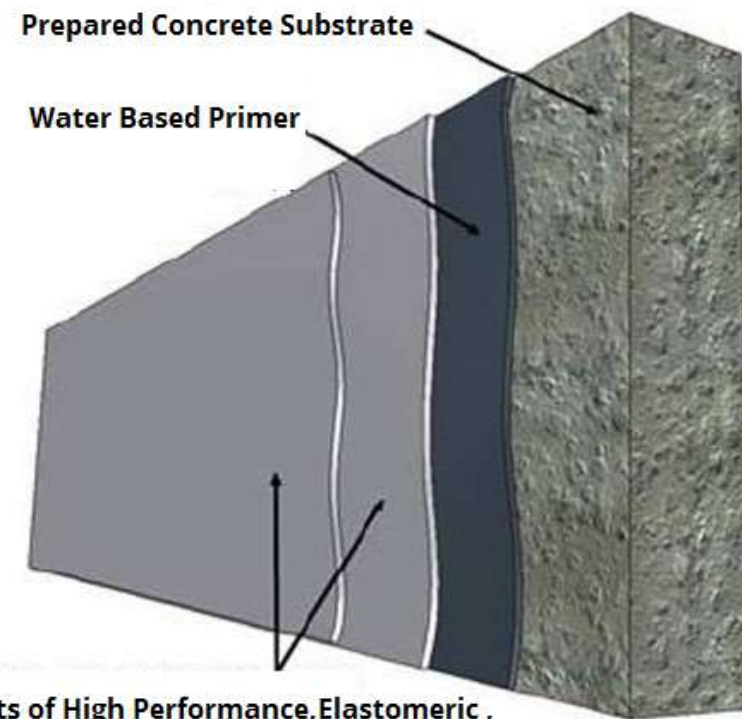
Fosroc Dekguard E 2000 is a water based acrylic , elastomeric, chloride and carbonation resistant, protective cum decorative coating for exposed RCC structures

Dekguard E 2000 consists of a single component penetrative silane siloxane based primer or water based primer to be applied in a single coat and a water based acrylic top coat to be applied in 2 coats at 200 to 300 microns

Dekguard Primer/ Dekguard WB

Dekguard E 2000 : Top coat

Coverage – 5 sqm/liter/coat

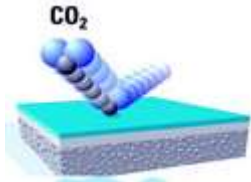


Two Coats of High Performance, Elastomeric , Waterbased, Anti-Carbonation Coating at 200 to 300 microns dry film thickness

Dekguard E 2000 product features

The following are the salient features of Dekguard E 2000

- **High performance** - comprehensive barrier against carbon-di-oxide, chlorides, rain water ingress , etc
- **Crack accommodation** - withstands substrate cracking up to 2 mm and cyclic movement up to 1 mm.
- **Extremely durable** - maintains elastomeric performance, with high recovery, even after long term UV weathering.
- **Breathable** - water vapour can escape from the structure.
- **Water based coating** – Eco friendly
- **Ease of Use** - Single Component , No mixing



Carbon Dioxide Diffusion Resistance

It can be defined as the ability of the coating to resist the ingress of carbon dioxide and to stop the carbonation of the concrete.

The R-value used in the design of coating system is to prevent the carbonation front reaching the steel reinforcement in a 60 year life cycle.

Equivalent thickness of air (R)

Specification Requirement :

Value of R must be greater than 240 m

Equivalent thickness of concrete (S_c)

Specification Requirement :

Value of S_c must be greater than 0.5 m

Standard Code - Taywood Method

CARBON DIOXIDE DIFFUSION RESISTANCE

Table 1

Coating System Name	Dekguard E2000
TC Specimen No.	145717B
D_{CO_2} (cm ² s ⁻¹)	1.92×10^{-07}
μ -value	7.75×10^{05}
R (m)	240
Sc (cm)	60
Mean Dry Film Thickness (μm)	309
Date of Test	02.09.10

Crack Bridging

It can be defined as **ability of a coating to accommodate expansions and contractions in structures and seal/bridge over the cracks** arising in concrete elements due to many factors such as thermal stresses, dynamic, fatigue loads, etc and thereby preventing ingress of CO₂, chlorides, sulphates, water and other harmful elements.



Specification Requirement :

Crack Bridging greater than 2mm static cracks and 1mm cyclic moments .

Standard Code –ASTM C 836-Modified



Crack Bridging Test on Dekguard E2000

Tensile Strength & Elongation

Elongation is property which imparts elasticity to coating which is also related to crack bridging ability. Higher the elongation, better is the crack accommodation capacity. Elongation also depends on the thickness of coating.

Specification Requirement :
Tensile Strength = 3MPa
Elongation greater than 200%

Standard Code –ASTM D 412



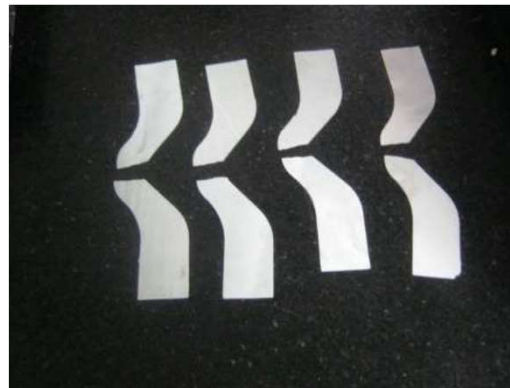
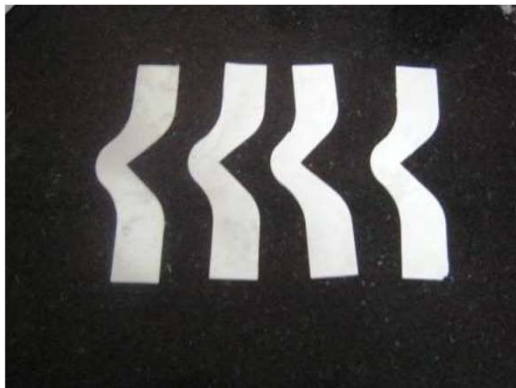
Test Specimen Before & After Testing

Tear Strength

Tear strength is the measure of how much tensile stress can the material withstand in a specific case, i.e. when a tear has been introduced in the material,

Specification Requirement :
Tear Strength equal to 12 N/mm

Standard Code –ASTM D 624



UV Resistance



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UV Resistance is ability of a coating to remain stable when exposed to sunlight without becoming brittle and losing physical and chemical properties or fading of any pigments and discoloration. It is one of the critical property of an external applied coating system.

Specification Requirement :
Greater than 500 Hours No sign of yellowing, chalking & discoloration.

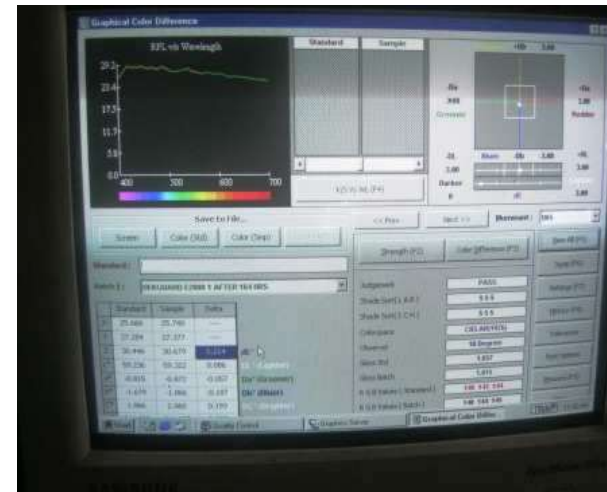
Standard Code –ASTM D 4587, Condition E Cycle 1 from ASTM G154



Sampling of coating



QUV – 8hrs UV, 4hr condensation



Zero colouration in spectrometer

Solar Reflective Index

Solar reflectivity or reflectance is the ability of a material to reflect solar energy from its surface back into the atmosphere

Specification Requirement :

Solar Reflective Index > 105
(at High Wind condition – 30 w/m²/K)

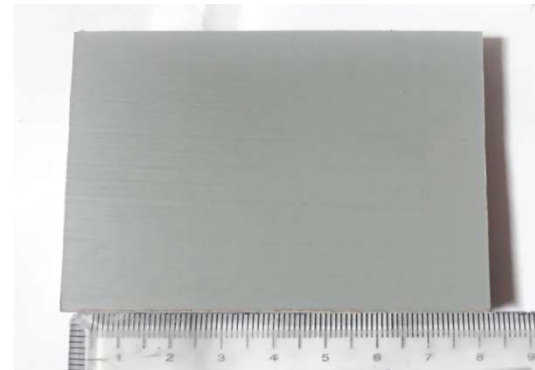
Emissivity >93%

Direct Solar Reflectance (SR) > 0.83

Standard Code –ASTM E 1980

LEED Requirement: SRI > 78

Energy Star Requirement : SR > 0.65



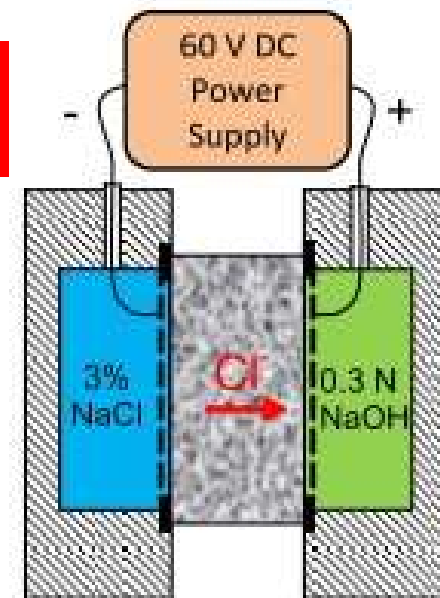
Anti-Carbonation coatings must have high chloride ion resistance that is low chloride ion penetration to prevent ingress of chlorides which lead to corrosion of steel and related problems. Chloride ion penetration is tested by Rapid Chloride Penetration test.

Specification Requirement :
Chloride Ion Penetration – Very Low (100 to 1000 C)

Standard Code –ASTM C 1202-03

Table 1. ASTM C1202¹⁰ ranking (charge measured vs. concrete chloride penetrability).

Charge passed (C)	Chloride permeability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible



It is the property of the coating to allow water to move in and out of concrete with fluctuation of humidity and temperature. If moisture movement is restrained in concrete, it lead to increase in osmotic pressure and eventually leading to **debonding of coating**. Breathable coatings also enhances drying of internal concrete there by arresting corrosion and increasing durability of structures.

Specification Requirement :
Water Vapour Transmission : >10 g/sqm/day

Standard Code – UNE-EN ISO 7783:2012

Specimen no.	Water-vapour flow rate G (g/h)	Water-vapour transmission rate V (g/m ² * day)	Diffusion-Equivalent air layer thickness Sd (m)	Water vapour resistance factor μ
1	0,0052	13,1	1,6	3635
2	0,0046	11,6	1,8	4517
3	0,0043	10,8	1,9	4181
Mean	0,005	11,8	1,7	4111

Requirements according to UNE-EN 1504-2:2004 Table 5

Class I (permeable to water vapour)	Sd < 5 m
Class II	5m ≤ Sd ≤ 50 m
Class III (dense against water vapour)	Sd > 50 m



Water Based Coating

An Anticarbonation coating should be preferably water based for following benefits:

- It eliminates usage of hazardous solvents during application and clean up process which brings down emission of Volatile Organic Compounds (VOC). These paints have less odour.
- Water Based coatings prevent drying, cracking and fading when exposed to sunlight.
- They also prevent the growth of mildew.
- Water Based coatings possess better elasticity and are not brittle.
- These coatings take lesser time to dry compared to solvented coatings



Application – Surface Preparation



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1. Surface Preparation – Surface Grinding to remove all dust and loosely laid particles

Application – Fair Coat



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2. Application of Fairing Coat/Putty – Renderoc FC to fill surface imperfections such as blow holes, undulations, etc

Application – Primer



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3. Application of Dekguard WB Primer using roller or an airless spray to seal the pores of substrate

Application – Top Coat



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4. Application of Dekguard E2000 top coat using either brush, roller or airless spray at specified coverage in two coats

Application – Finished Surface



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The background image shows a perspective view looking down the length of a bridge, with its steel truss structure and support pillars visible. A semi-transparent red band is superimposed horizontally across the middle of the image.

Project References

Dekguard E2000 – Anticarbonation Coating

Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting the exposed concrete surfaces of the prestigious **Delhi Meerut Expressway**



Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting the exposed concrete surfaces of the prestigious **Delhi Meerut Expressway**



Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting the exposed concrete surfaces of the prestigious **Delhi Meerut Expressway**



Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting the exposed concrete surfaces of the prestigious **Delhi Meerut Expressway**



Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting the RCC box culverts of Railways under Tumkur to Arsikere Section in Karnataka



Before



After



South Western Railways

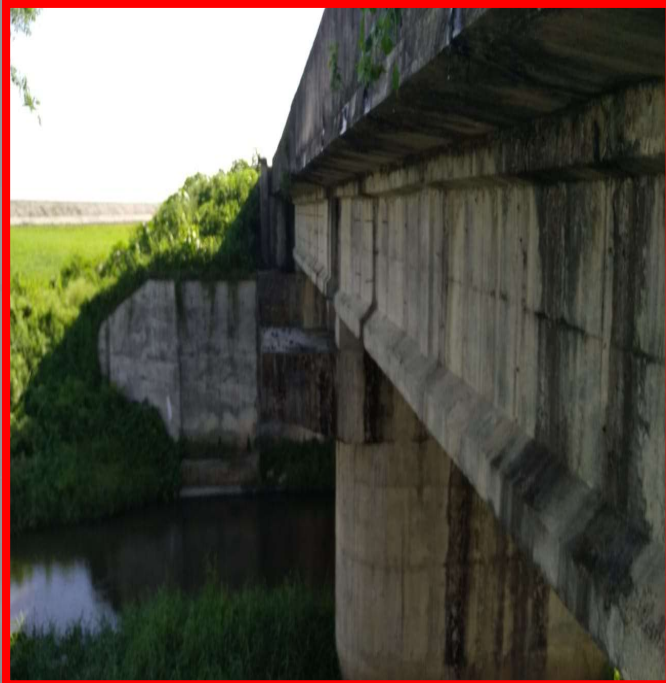
Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting RCC structure of bridges of Damalgaon Bogibeel section of the iconic Bogibeel Bridge Project of North East Frontier Railways at Assam.



Dekguard E2000 - High Performance, elastomeric, crack bridging anti carbonation coating protecting RCC structure of bridges of Damalgaon Bogibeel section of the iconic Bogibeel Bridge Project of North East Frontier Railways at Assam.



Before



After



Northeast Frontier Railways

Thank You!

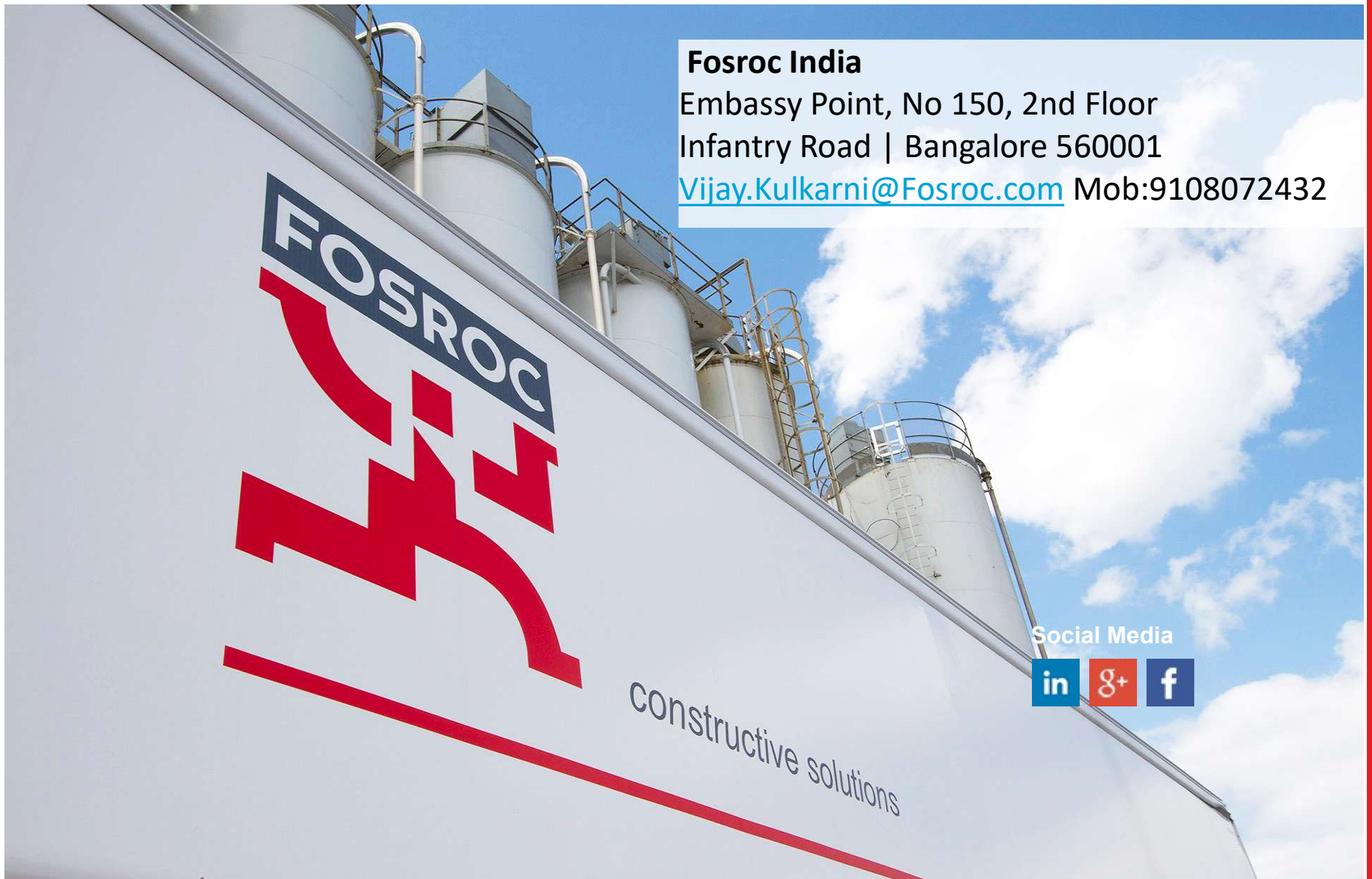


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Fosroc India

Embassy Point, No 150, 2nd Floor
Infantry Road | Bangalore 560001

Vijay.Kulkarni@Fosroc.com Mob:9108072432



Social Media

