

STRUCTURAL REHABILITATION

संरचनात्मक पुनर्वास
शून्य से अनंत तक हिंदी में

DR. GOPAL RAI



भारत

INDIA

Nation Building with Rehabilitation

Dr Gopal Lalji Rai (Ph.D)
Director

Dr Rachana Gopal Rai (MPTH)
Chairmen

Dhirendra Group of Company (DGC)

R & M International Pvt. Ltd.



R & M Rasayana Pvt. Ltd.



21st SHM Consultants Pvt. Ltd.

R & M Rehab Care

What is ?

- ▣ 40 year old Indian Railway PSC Girder
- ▣ 55 year old Pull mithai ROB
- ▣ Major Rehabilitation of abundant Railway Station Building

Strengthening Techniques



Flexural

Strengthening Techniques



Shear

Conventional Methods of Rehabilitation

Strengthening Techniques



Punching shear

Strengthening Techniques

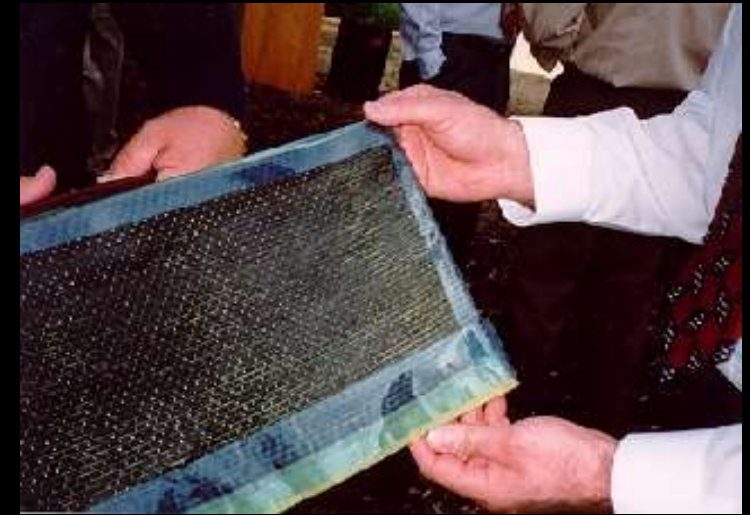


External Post-Tension

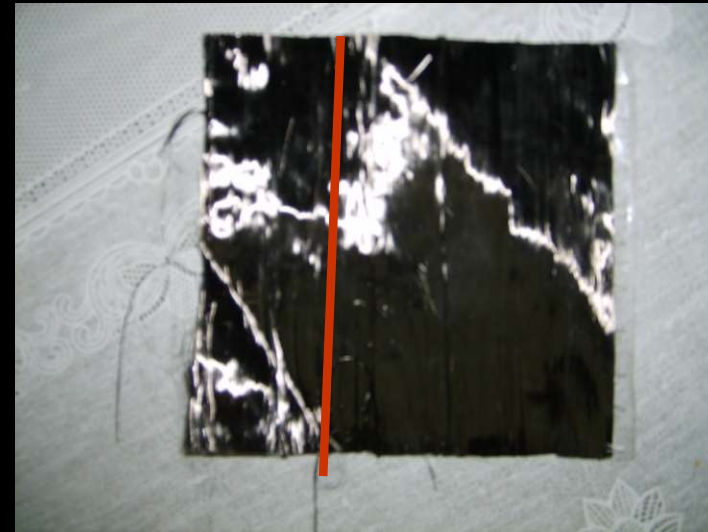
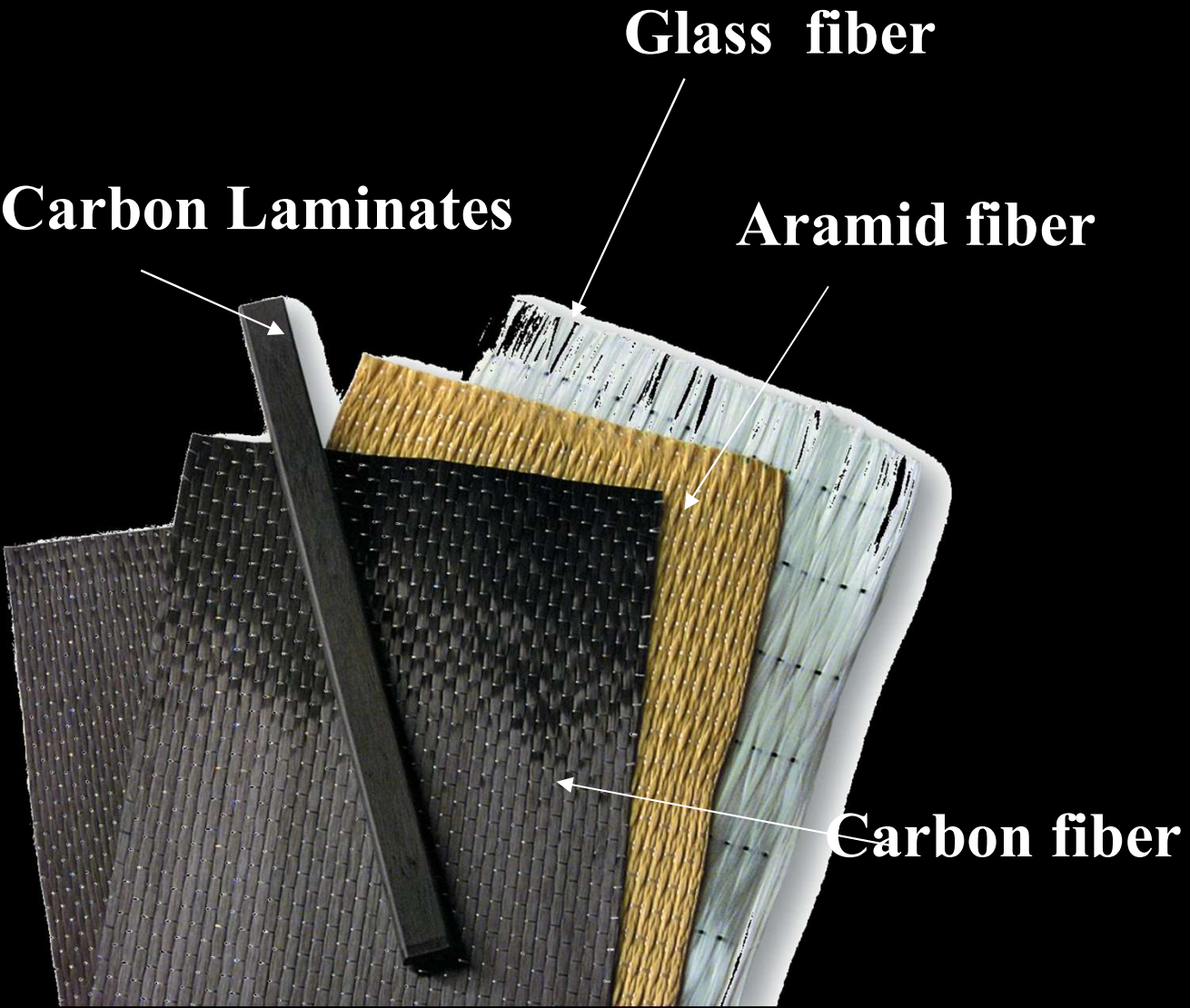


Fiber Reinforced Polymer

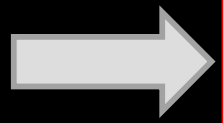
Composites



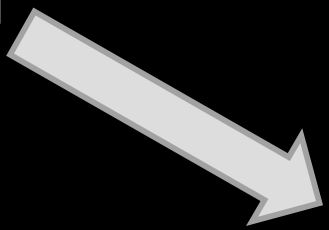
Reinforcement Woven fiber & Uni- Directional Fiber



Flexural / Shear
Strengthening



Carbon Laminate



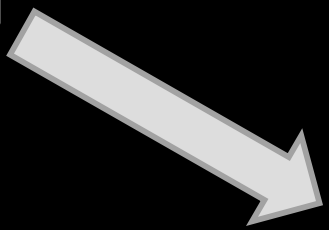
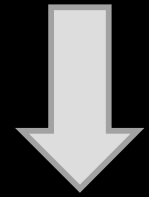
External Prestressing

- 21 June 2006 - 8



Shear Strengthening

Axial
Confinement



Junction Confinement



Moment enhancement

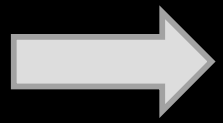
- 21 June 2006 - 9



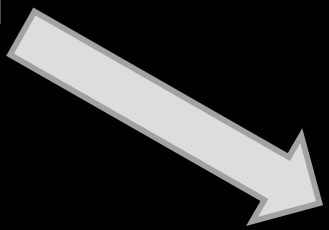
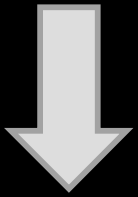
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Confinement

Slab
Strengthening



Anchor plate system



Non-Prestressed Laminate



Prestressed Laminate

Bridge Below The



CONDITION OF BRIDGE



Strengthening of Mumbai International Airport Runway Bridge

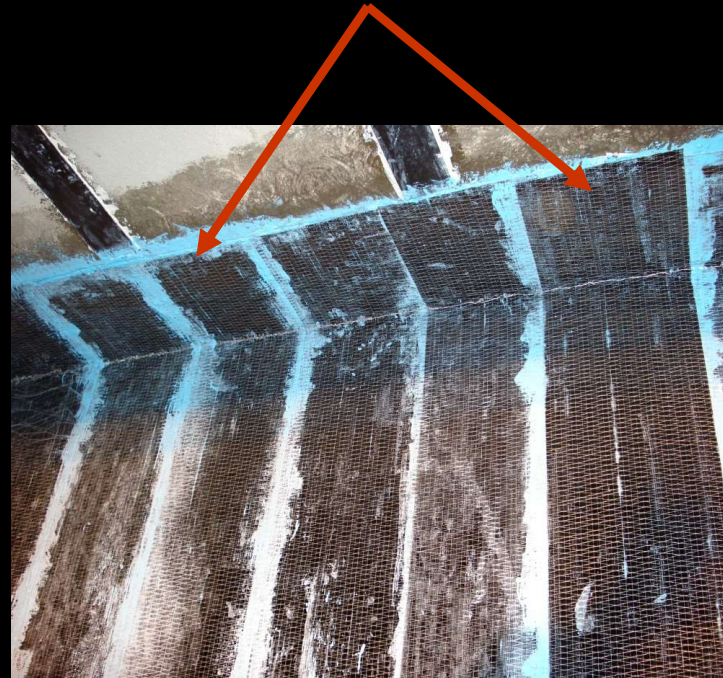


Strengthening of Beam By Double Wrapping

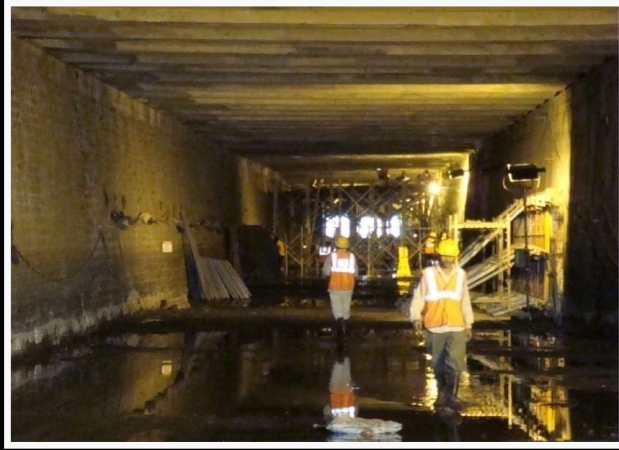


Cross Section Of the Girders
are 1.5m x 1m

ANCHORAGE ON THE
SLABS UPTO 300mm On
Both Sides



WATER FLOW OF TUNNEL - MITHI RIVER





**VERY COMPACT
SPACE**

**HARDLY 1 METER
WORKING AREA**





STRENGTHENING OF BOW-STRING Bridge

INTRODUCTION

- ▣ This is bow string Girder Bridge built for two lane traffic.
- ▣ There are two spans each of 42m long and built to avoid train traffic at the junction.
- ▣ The traction wires are running below the bridge.
- ▣ One half of the bridge was built in full away from its alignment, then it was shifted and placed in position. Total weight of the structure moved was 750tons.

OBSERVATIONS

Deck slab



Spalling of concrete in the deck slab

Hangers



Cracks on hangers.

Arch



Cracks and delamination of cover concrete on Arch member

Expansion joints



Condition of expansion joint.

INSTRUMENTATION

- ▣ **Static Method:** To find out the deflection of the Girders, **Linear potentiometers** will be installed at bottom flange of girder to monitor the deflection which is caused by Loaded Trucks.
- ▣ **Dynamic Method:** To find out the Natural Frequency of the Structure, **Dynamic load tests** will be performed to calculate the Natural Frequency.





DESIGN INSIGHTS

- In this bridge strengthening of each structural member is done using various techniques of FRP methods.
- Firstly, the **hangers (tension member)** are treated by groove laminates and are confined by CFRP Wrap.
- Secondly the **arch** which is a compression member is provided confinement by CFRP wrap.
- Thirdly the **Tie Girders** are strengthened under flexure and shear by Pre-stressed laminates and U-shaped CFRP wraps.
- Lastly the **cross girders** are strengthened by CFRP Wrap.
- Apart from all these retrofitting technics the existing non-functional bearings and expansion joints are replaced



METHODOL OGY

Surface Preparation and
Treatment to corroded
reinforcement





Bond Coat Application

Section Re-casting using Micro
concrete



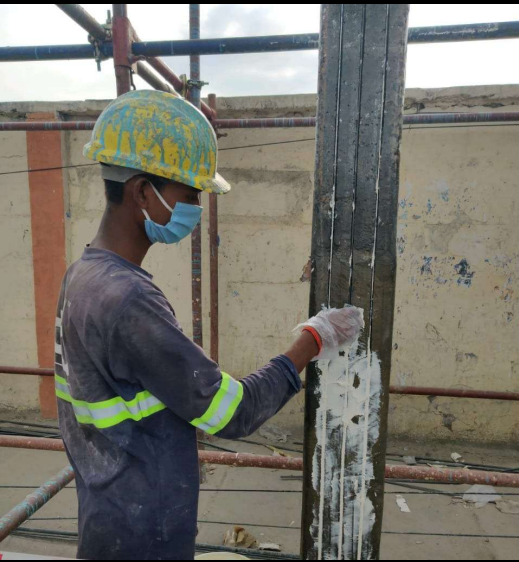


Grouting low viscous epoxy grout

Application of Primer Coat



Aug 8, 2020 1:22:06 PM
Katpadi
Vellore
Tamil Nadu



Providing Groove laminate in Hangers



Confining Arch of Bow String Bridge

STRENGTHENING OF BOW-STRING Bridge

Application of Pre-stressed laminates



Application of Anti Carbonation aliphatic acrylic coating





Post strengthening Load test

- ▣ Reduction In deflection : 26%
- ▣ Reduction In Natural frequency : 25%

INDIAN RAILWAYS PSC GIRDER



Client : Indian Railway
40 year old bridge
PSC I girder developed cracks



Surface Preparation



Before Strengthening test (Initial test)



Rebound hammer



Strain Gauge



LVDT



UPV



Potentiometer



Cleaning Reinforcement



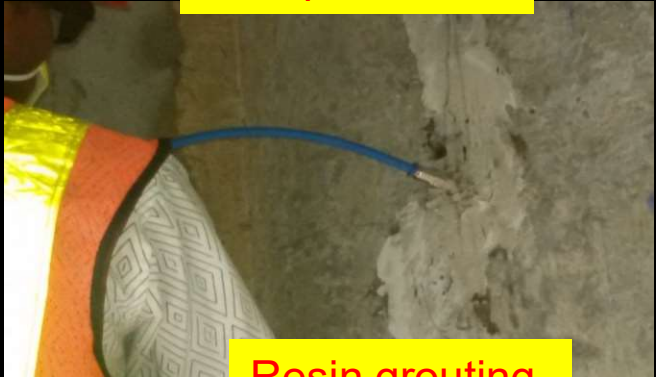
Rust cleaner



Rust protection



Sealing of crack with resin



Resin grouting



PMM



Strengthening at concrete location before prestressed begin

Prestressing End

End block to prevent slippage



Fix end



Carbon laminate after Prestressed



Resin Primer



U Wrap Carbon Fiber





Results

Deflection recover by 65%
Natural Frequency improve
90%

Speed restriction removed resulted in
saving of 17 min
Before strengthening speed restriction
was 20kmph

Now after strengthening 100 kmph



Bridge Below The



CONDITION OF BRIDGE



Strengthening of Mumbai International Airport Runway Bridge

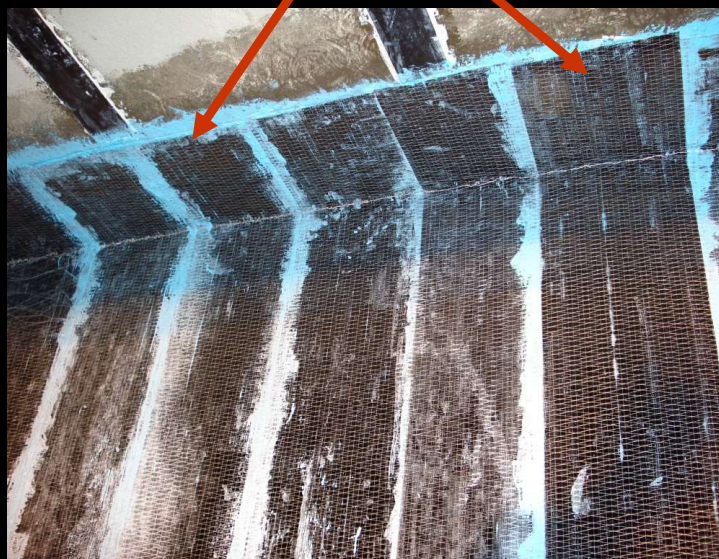


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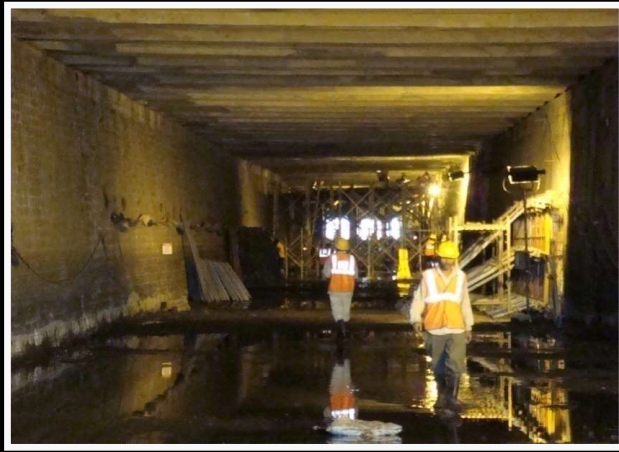


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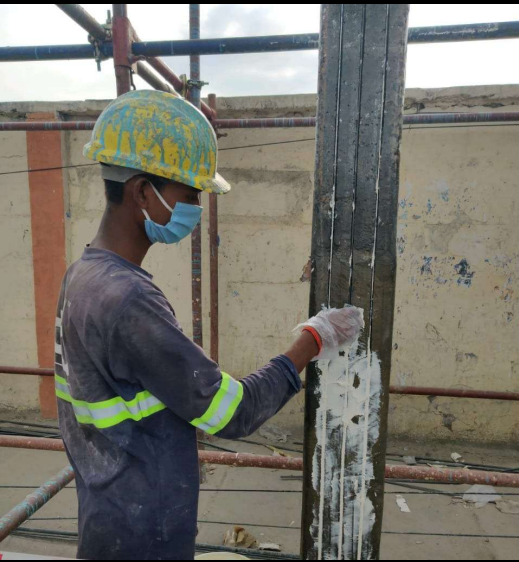




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STRUCTURAL
STRENGTHENING OF
PULMITHAI BRIDGE, DELHI

Pul mithai Bridge



Difficulties on Site

- ▣ **crowded during days**, it was difficult to work inside the pulmithai rob no. 5 during these days.
- ▣ fixing of shuttering for concreting in **congested space** was difficult.
- ▣ **erection of scaffolding** in a small portion was not possible.
- ▣ scaffolding need to erected in large portion and then shifted to next position.
- ▣ every day scaffolding need to be erected in the morning & removed in the the evening, cannot be left overnight **cause of slums area**.
- ▣ steel bending & cutting - difficult - congested working space.

Photos of Trouble working due to these objects



Before strengthening of columns & Beams



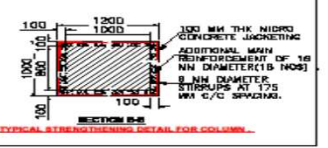
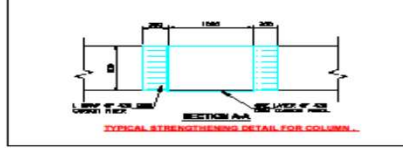
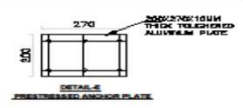
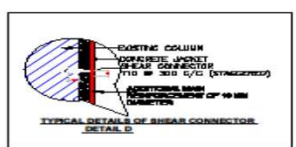
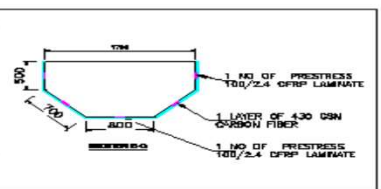
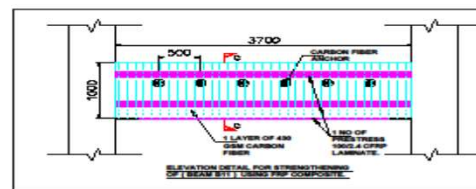
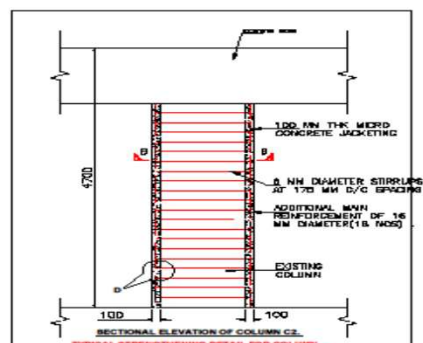
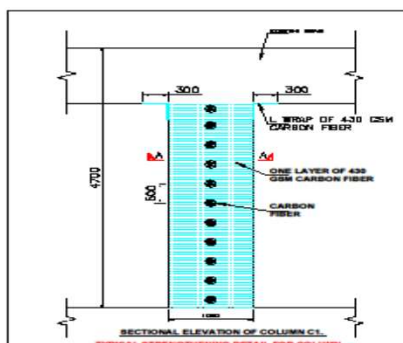
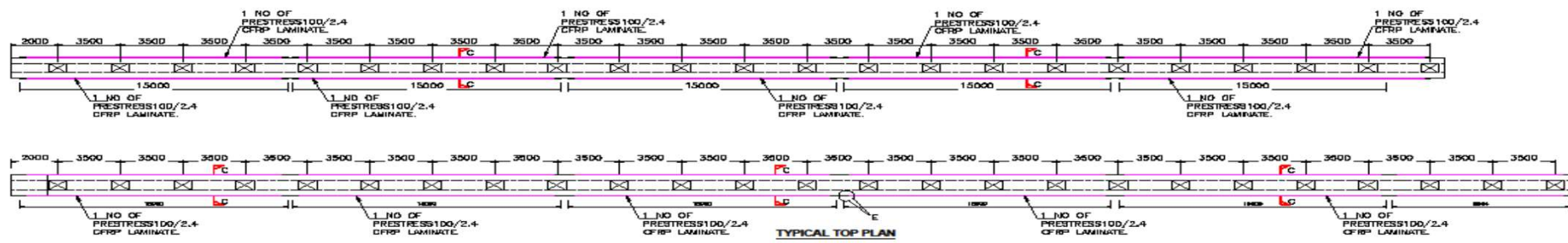
- due to **heavy loaded vehicles** pass through over the bridge , due to which cracks had been generated in the **beams & columns.**

Structural cracks on beam & column




Plan drawing for strengthening of Work

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FOR APPROVAL ONLY

REV.	DESCRIPTION	BY	APPR.	DATE
CLIENT INDIAN RAILWAY DELHI				
PROJECT PUL-MITHAI BRIDGE				
TITLE STRENGTHENING OF COLUMN & BEAM AT PUL-MITHAI BRIDGE DELHI				
 DGC ENGINEERING PVT. LTD. A-302, CHANDI GARHIAN BRITATE, CFF 6940 VEHAR ROAD, CHANDIGARH, ANDHRA PRADESH (S) - 500044-08 GZ.				
SCALE: MTS	APPROVED BY:	DATE: 27-10-2017		
DIV.: CIVIL	DR. GOPALRAJ			
DRAWN: J. VM				
CHECK: PTC	DATE: 27-10-2017	REV. NO.: RH-310-1-R1-01	SHEET NO. 11	

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

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Surface Chipping

- ▣ **roughening existing concrete surface** and/or removal of any plaster or other foreign material by chipping / hacking with chisel and hammer or by mechanical chipper machines.



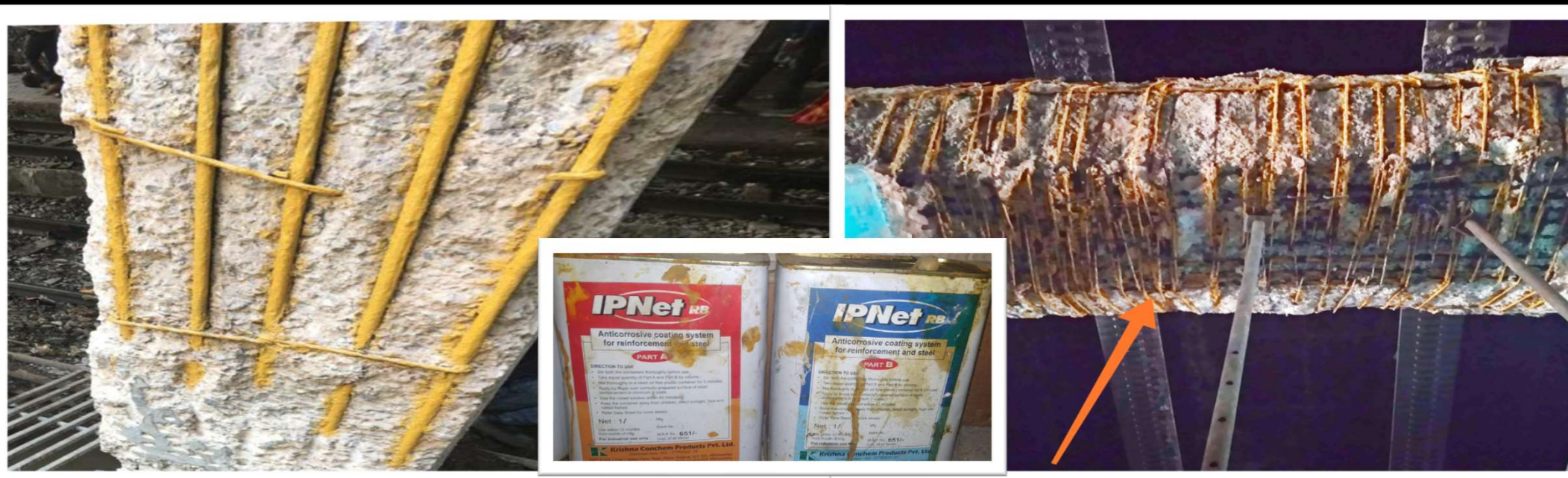
RUST REMOVAL

- ▣ **cleaning the rusted reinforcement and exposed surface** by wire brush, mechanical device or any other established method and applying rust removing solution of approved make and quality with cotton waste swap to reinforcement and allowing to dry the same for 24 hours,



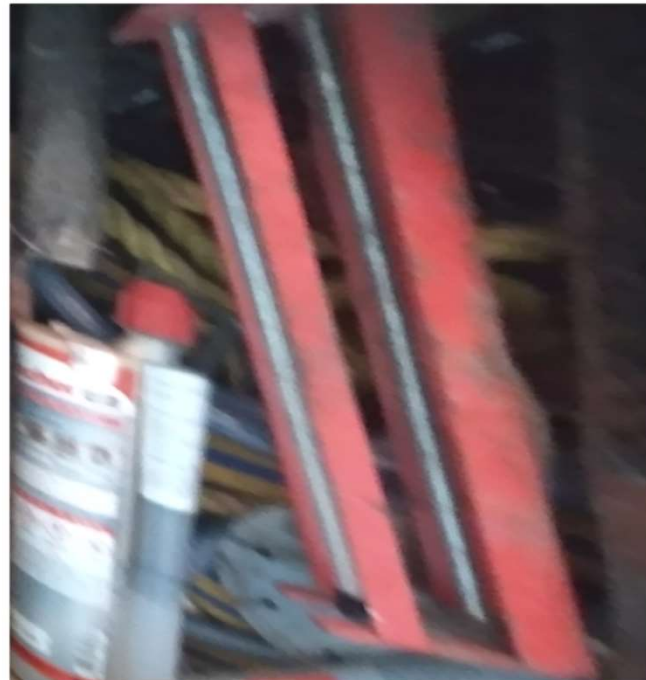
Anti corrosive

- **applying two coats of anticorrosive epoxy phenolic rebar protective system ip-net rb or equivalent of approved make and quality** comprises of resin and hardner mixed in equal proportion by volume with minimum 9-10 hours between the coats.



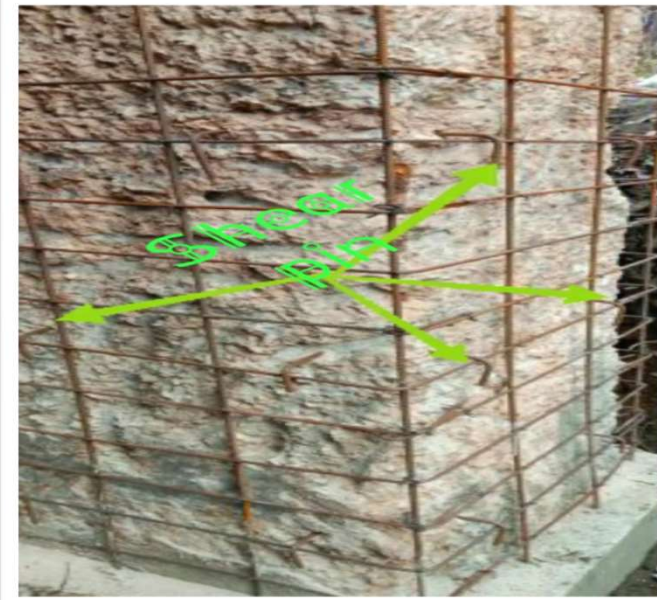
DRILLING FOR MAIN BAR GROUTING

- TO DRILL INJECTION MORTAR IS USED WITH THE APPROVED SYSTEM COMPONENTS FOR REBAR CONNECTIONS.



Steel fixing & shear key

- CUTTING LENGTH OF MAIN BAR = 5.4M (HT. OF COLUMN-4.7M, LAPPING - 500 MM, 100 MM DRILL IN BOTTOM & TOP), 10 MM OF DIA. OF BAR
- TOTAL SHEAR PIN ON ONE COLUMN-72 NOS. (500MM C/C SPACING), 12MM DIA. OF BAR OF 250 MM LENGTH SHEAR KEY).



Bondcoat & shuttering

- APPLYING A PRIMING CUM BONDING COAT OF TWO COMPONENT EPOXY RESIN AND CURING AGENT IN 2:1 PROPORTION BY WEIGHT FOR JOINING OLD AND NEW CONCRETE AS PER TECHNICAL SPECIFICATIONS OF MANUFACTURER.
- FORMWORK DESIGNED WITH PROPOSED MATERIALS (TO BE APPROVED PRIOR TO MAKING) SHALL BE ABLE TO RETAIN ITS SHAPE, LINE, DIMENSION, LEVEL WITHIN THE ALLOWABLE LIMITS OF VARIATIONS.
- MAKE FORMWORK JOINT TO BE WATERTIGHT USING POP.



Micro concrete

- **FREE FLOW HIGH STRENGTH NON SHRINK MICRO CONCRETE M-35 USING SINGLE COMPONENT CEMENT MICRO CONCRETE SHRINKAGE COMPONENTS AND ADDED WITH 100% BY WEIGHT SATURATED DRY STONE DUST WATER CEMENT RATIO SHALL BE MAINTAINED PROPERLY AS PER MANUFACTURES.**
- **MICROCONCRETE MIXING WITH 6 MM DOWN SIZE AGGREGATES IN THE RATIO OF 1 PART MICRO CONCRETE WITH 0.3 PART OF AGGREGATE BY WEIGHT**



De-shuttering & curing

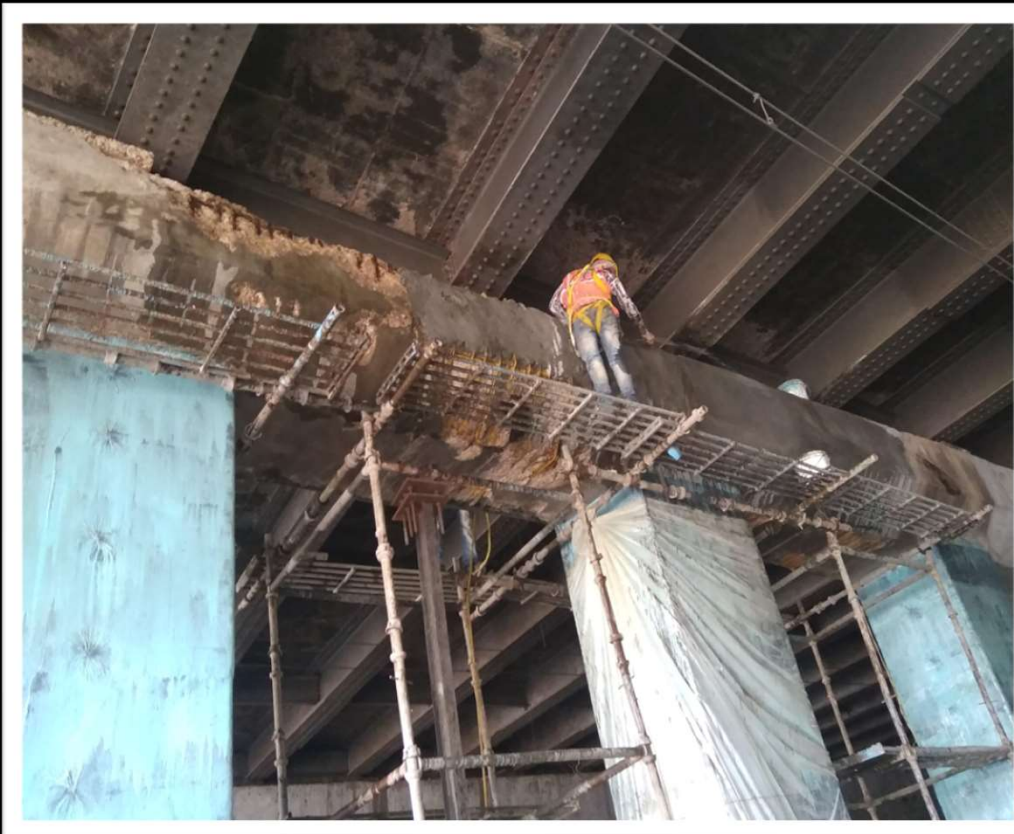
- DE-SHUTTERING OF FORMWORK AS WELL AS THE TIME PERIOD TO REMOVE THE FORMWORK FROM COLUMN, WALLS, BEAM ETC.

- SPECIFIED STRENGTH OF CONCRETE
- GRADES OF CONCRETE
- ATMOSPHERIC TEMPERATURE
- AS PER IS 456 – 2000 CONCRETE SHOULD NOT BE CURED LESS THAN 7 DAYS.



Polymer work on beam

15 MM THICK POLYMER MORTAR TO LOAD CARRYING R.C.C MEMBERS IN TWO LAYERS IN PROPORTION OF 1:5:15



METHODOLOGY OF CARBON FIBER WRAPPING FOR COLUMNS & BEAMS



METHODOLOGY OF CARBON FIBER WRAPPING FOR COLUMNS AND BEAMS

Fixing of carbon anchors

Grinding Work

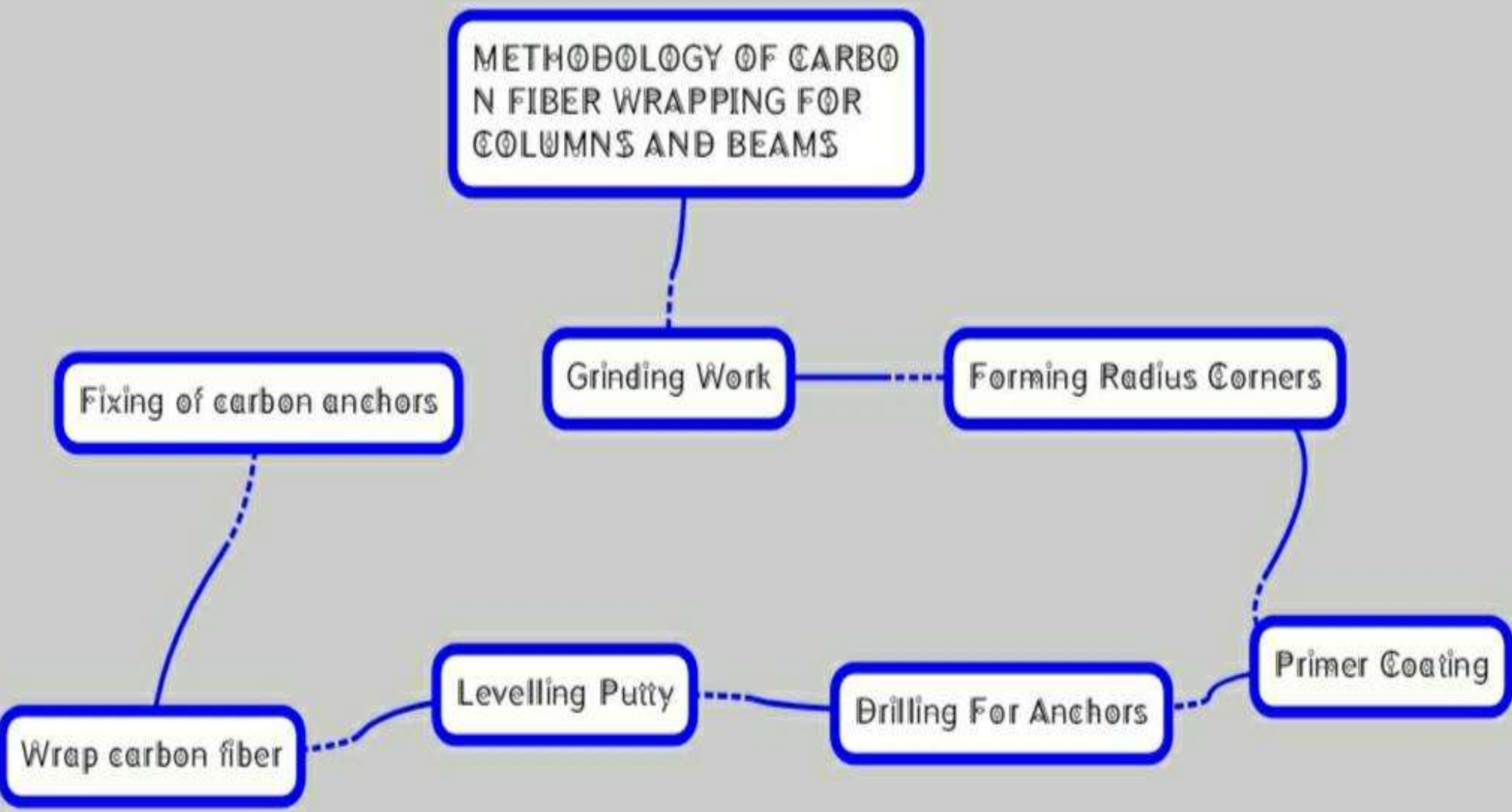
Forming Radius Corners

Wrap carbon fiber

Levelling Putty

Drilling For Anchors

Primer Coating



Grinding work & Forming radius corners

- ▣ plain surfaces.
- ▣ to remove all the **sharp corners.**
- ▣ form at least a of min. 20 – 25mm radius.





Primer coating

- to promote **adhesion & prevent** the surfaces.
- primer is a 2 component base materials: mixing proportion - 1) base - 4 kg
2) hardener - 2 kg
- application of primer allow the material to cure for at least **24 hours or overnight**.



Levelling putty

- ▣ **applying epoxy putty over the concrete surface** including mixing to the proportion as specified by the manufacturer.
- ▣ to fill the porosities to make it **smooth & uniform** in nature.



Carbon fiber wrapping

- ▣ **non metallic composite fiber wrapping system** comprise of uni-directional carbon fiber sheet (400 GSM) and compatible saturant by wet layup.
- ▣ using **tamping roller** to avoid any **air voids** on fiber wrapped.



Fixing carbon anchors & Applying top coats

- ▣ fixing carbon fiber anchor including drilling hole in the base concrete fixing the **anchor using epoxy 50X55 systems.**
- ▣ it gives a locking effects from all **360°.**



Applying of carbon laminates using adhesive

- ▣ adhesive is used to bond precured frp laminate.



Application of fire protective coating

- ▣ to provide **fire protection coat post strengthening** on the structural member to fire proof the members.



Our teams

PARWEZ HASAN

SITE-INCHARGE



RAGHAVENDRA KUMAR

SITE-ENGINEER



VIJAY THAKRE

SITE-ENGINEER



Our teams

BANTI RAI

SITE-SUPERVISOR



DHEERAJ YADAV

SITE-SUPERVISOR





DGC

R&M INTERNATIONAL PVT LTD

SITE NAME :- UDAIPUR STN BUILDING (TRIPURA)

- Retrofitting of existing crack structure using CFRP with 40 % load capacity
- Micro piling and slab cast for making plate action
- Sheet piling to confine station building

Consultant : Eng. Amandeep Garg



2011



BEFORE STRENGTHENING

LOCATION - UDAIPUR STN BUILDING



CONDITION OF SITE

PIC SHOWING BASE OF STN BUILDING



BEFORE STRENGTHENING SITE CONDITION



CRACK ON PLINTH BEAM



WALL BRECKING & CHIPPING

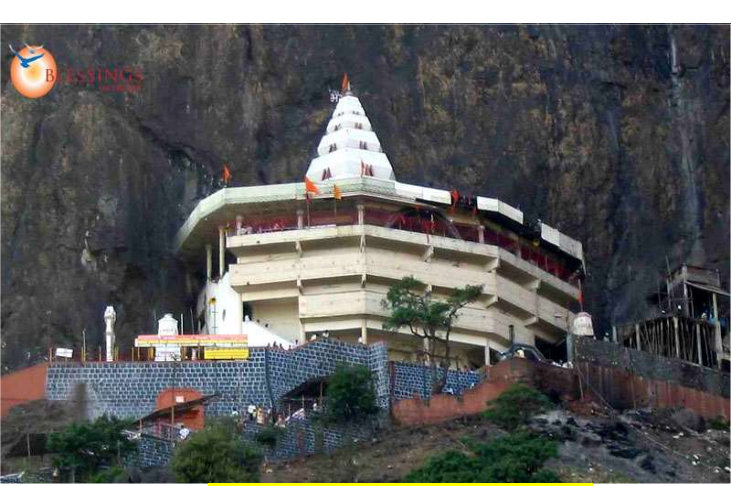




**AFTER WALL BRECKING
& CHIPPING**

AFTER





Temples (4)



Residential buildings (180)



Hospitals (4)



Commercial building (189) Education Institute (5)



Heritage structure (5)

**We Thank the Govt. Of India & FICCI for
Recognizing us
For
Process Innovation- Construction Chemicals
By Govt of India and FICCI
at**



**Event Inaugrated by The President of India Dr. Gopal Rai Reciving the Award From Secretary
Shri Pranab Mukherjee Shri K. Jose Cyriac**

Process Innovation- Construction Chemicals 2013



inaugurated by Shri Narendra Modi
(Chief minister of Gujrat)



By Govt of India and FICCI

Quality crown award at London November 2013



Best Entrepreneur of year 2014, in UK





Recognition at IIBE silver jubilee Function by Shri Nitin Gadkari (Minister)
To Dr Rachana Rai (Director)

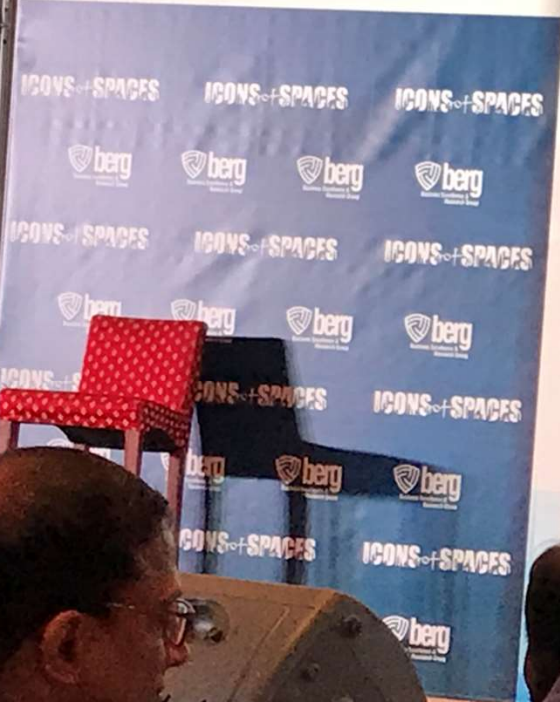
CIDC Vishwakarma award 2015 for best project



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Celebrating People in Sustainable Development
September 13, 2017 Singapore

Media Partner
CONSTRUCTION WEEK ARCHITECT AsiaBiz R&B
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JET AIRWAYS



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In 2017
Awards for Real Estate
September 13, 2017, Singapore
Category: LEADING STRUCTURAL REHABILITATION COMPANY

Presented to
DHIRENDRA GROUP OF COMPANY (DGC)

In Recognition of the Innovation & Excellence demonstrated

Mr. Thomas McMahon
Chairman
Advisory Board, BERG

Mr. Vishwesh Iyer
Managing Partner
BERG

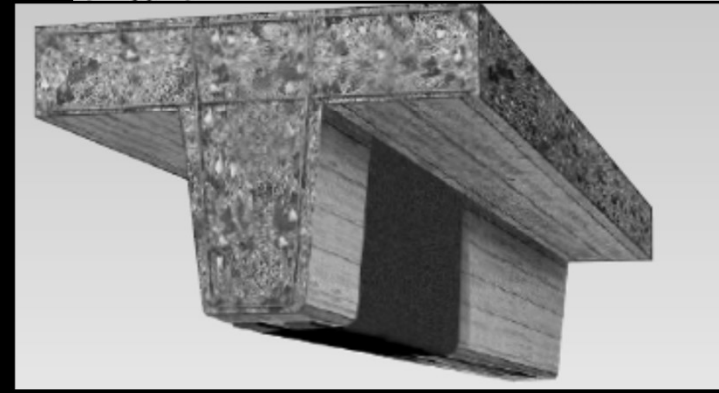
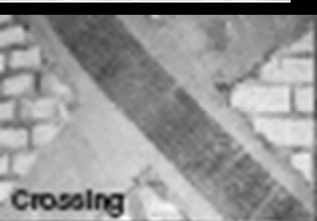
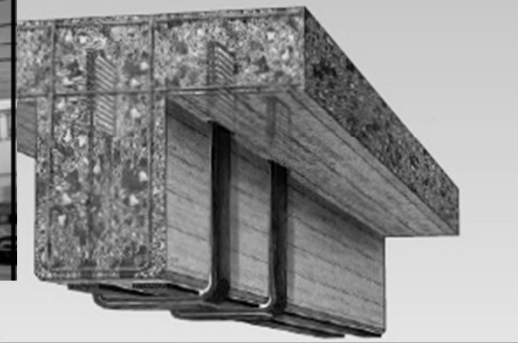
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LEADING STRUCTURAL REHABILITATION COMPANY
Presented to
DHIRENDRA GROUP OF COMPANY (DGC)
September 13, 2017 Singapore



Recognition at Dubai for 40/40 Most influence leaders , Dubai , 2018

Future Prospects for the Technology





People make R&M



Engineer R&M



Board of Directors



GOD



गुरुब्रह्मा गुरुविष्णु गुरुर्वैवो महेश्वरः ।
गुरुसाक्षात् परब्रह्म तस्मै श्री गुरवे नमः ॥

JAI HIND



Mahindra
Superior Productivity
at Amazingly
Low Down Payment



Mahindra
EARTHMASTER

BEST STORIES INTERVIEWS EVENTS TOP LIST PRODUCTS SPECIAL

THE RAJA OF RETROFIT

ENCOUNTER WITH ENGINEERS / OCT 2013

In the next in a series of interviews with prominent civil engineers, **JANAKI KRISHNAMOORTHY** meets **Dr Gopal Rai, CEO, R&M International Group of Companies.**

If you are proficient in your subject and believe in what you do, you should go ahead irrespective of what others say," asserts Dr Gopal Rai, Chief Executive Officer, R&M International Group of Companies. This has been his guiding principle in a career that is just a decade old. Focused on a specialised field—retrofitting and rehabilitation of concrete structures by composite materials—he has put several distressed structures and bridges back on their feet and enhanced the load capacity of others. His projects, which range from residential, commercial and heritage buildings to bridges, include the Mithi River runway



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Dr Gopal Rai

QUESTIONS?

DR. GOPAL RAI



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