दिल्ली सरकार

PWD

A HANDBOOK ON

# REHABILITATION WORKS OF FLYOVERS & UNDERPASSES


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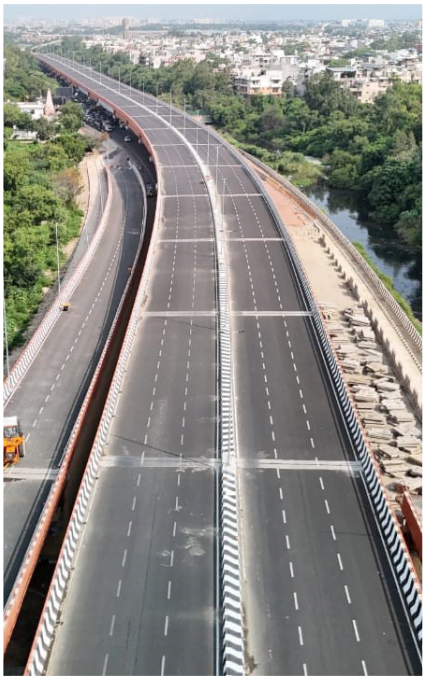

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# PREFACE

As urbanization continues to accelerate, the demand on infrastructure grows, and the structural integrity of flyovers and bridges faces increasing pressure. The repair and rehabilitation of flyovers and reinforced concrete (RCC) structures have become critical aspects of modern infrastructure management. Over time, these vital structures endure wear and tear due to environmental factors, traffic loads, and aging materials. As such, ensuring their longevity and maintaining public safety require systematic condition assessments and timely remedial measures.

This book ***"Rehabilitation works of Flyovers & Underpasses"*** is dedicated to providing a comprehensive approach to the repair, rehabilitation, and maintenance of flyovers and RCC structures, with a focus on condition assessment methodologies and strategies for enhancing the lifespan of these important assets.

It also serves as a standard guide for engineers, contractors, and professionals, offering detailed case studies, assessment, and procedural steps to repair these structures that can be applied in real-world projects. By presenting a structured approach to condition assessment, repair, and rehabilitation, it equips professionals with the tools they need to make informed decisions and execute effective maintenance strategies.

I would like to take this opportunity to express my heartfelt gratitude to the talented team of experts, researchers, and professionals who contributed to the creation of this book. Without their unwavering commitment, collaboration, and tireless efforts, this project would not have come to fruition. Their invaluable insights and expertise have enriched the content of this work, and I am deeply appreciative of their dedication to advancing the field of infrastructure repair and rehabilitation.

**Er. Naimuddin**
Engineer-in-Chief, PWD

# Message From
## Pr. Chief Engineer, PWD

In the rapidly evolving world of infrastructure, the challenge of maintaining and extending the lifespan of vital structures such as flyovers and underpasses is more pressing than ever. These essential components of our transportation networks are subjected to constant wear and tear, weather extremes, heavy traffic, and the inevitable effects of time. As the demand for safer, more sustainable, and cost-effective solutions intensifies, it becomes crucial to explore innovative repair and rehabilitation methods that can significantly enhance the durability and performance of Reinforced Cement Concrete (RCC) structures.

This book, ***"Rehabilitation works of Flyovers & Underpasses"*** Using New Repair Methods, introduces a breakthrough approach that is poised to revolutionize the way we think about repairing and maintaining these critical infrastructures. While traditional methods of repair and rehabilitation have served their purpose, they often come with limitations both in terms of cost and the ability to deliver long-term performance.

This book compiles various data of CPWD publications, MoRTH publications, IS/ BIS/ international codes, consultant's reports, practical work experience & industry knowledge in rehabilitation along with test Procedure to assess the condition of the RCC structure of flyovers & its rehabilitation. This new repair technique is not only a testament to innovation but also an important step towards enhancing the longevity and safety of infrastructure in our cities.

As we continue to face growing urbanization and increased vehicular traffic, this book is a timely and valuable resource for engineers, urban planners, and construction professionals. It provides a comprehensive guide to understanding the principles, applications, and benefits of these advanced repair methods, as well as practical insights into their implementation. By embracing these innovative solutions, we can ensure that our critical infrastructure remains robust and serviceable for generations to come.

I am confident that this book will inspire further research and application of this novel method, ultimately shaping the future of infrastructure rehabilitation in the years ahead.

I would like to extend my heartfelt congratulations to everyone involved in the preparation of the rehabilitation book.I appreciate the time and commitment you have invested in this important book, and are confident that it will have a lasting impact on the field of rehabilitation and repair of the Flyover and RCC structures.

**B. L. Meena**
Pr. Chief Engineer, PWD

# *Message From*

## Pr. Chief Engineer (Projects), PWD

This handbook aims to identify structural defects in flyovers, bridges, ROBs, and underpasses that may develop over their service life, using systematic surveys and diagnostic tests. It outlines appropriate repair strategies and methodologies for effective rehabilitation.

Post-commissioning, timely maintenance and rehabilitation are essential to preserve load-carrying capacity, structural integrity, durability, safety, and aesthetics. The maintenance approach emphasizes cost-effective preventive measures to minimise deterioration and retain structural performance close to the original state.

Key components addressed include piers, pier caps, abutments, girders, deck slabs, bearings, expansion joints, and crash barriers. Execution of such rehabilitation works necessitates specialised agencies with proven expertise in structural repairs.

I acknowledge the contributions of PWD engineers and domain experts whose technical inputs have shaped this publication. Special thanks to Sh. Naimuddin, Engineer-in-Chief; Sh. B.L. Meena, Pr. Chief Engineer (M&F); Sh. Mukesh Kumar, Chief Engineer (Flyover Zone); Sh. Rajan Mogha, SE (Flyover Circles F-1 & F-5); Sh. Neeraj Pandey, JE; and the entire project team. Notably, Sh. Rajan Mogha initiated and led the integration of rehabilitation practices into this consolidated reference.

The book is available on CPWD and PWD websites, with hard copies distributed for broader reach and reference.

Best wishes to all engineers and staff of PWD.

**Vibeka Nand Vibek**
Pr. Chief Engineer (Projects), PWD Delhi

# Message From

## Chief Engineer
## Judiciary & Projects Zone, PWD

I am pleased to acknowledge the publication of “Repair and Rehabilitation of Flyovers” by the Public Works Department, Government of NCT of Delhi. This comprehensive guide reflects PWD’s commitment to documenting best practices, technical expertise, and innovative approaches for the maintenance and upgrade of flyover infrastructure in Delhi.

The book serves as a valuable reference for engineers, contractors, and stakeholders involved in flyover construction and maintenance. It covers key aspects such as inspection, design, materials, execution, and includes case studies that highlight PWD’s dedication to infrastructure development.

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The book serves as a valuable reference for engineers, contractors, and stakeholders involved in the construction and maintenance of flyovers. It covers key aspects such as inspection, design, materials, and execution, and includes case studies that highlight PWD’s dedication to infrastructure development.

I commend the team of engineers and experts at PWD for their contributions. Their dedication and professionalism have resulted in a high-quality resource that will benefit both the department and the broader infrastructure community.

I extend my appreciation to Sh. Naimuddin, Engineer-in-Chief; Sh. B.L. Meena, Principal Chief Engineer (M&F); Sh. Rajan Mogha, Superintending Engineer, Flyover Circle; Sh. Neeraj Pandey, Junior Engineer; and all officers involved in this effort. Special recognition goes to Sh. Rajan Mogha for spearheading the initiative to consolidate the rehabilitation unit’s knowledge into this handbook.

The publication will be available on the CPWD and PWD websites, with printed copies distributed for wider accessibility.

My best wishes to all engineers and staff of the Public works Department.

**Vikas Rana**
Chief Engineer, Judiciary & Projects Zone, PWD

# Message From

## Chief Engineer, Flyover Zone, PWD

As infrastructure demands grow, the challenge of preserving and extending the lifespan of essential structures like flyovers and underpasses becomes increasingly critical. These vital components face constant pressure from heavy traffic, weather extremes, and time. While traditional repair methods have served their purpose, they often lack the cost-effectiveness and long-term durability needed for modern infrastructure.

This book ***"Rehabilitation Works of Flyovers & Underpasses"***using new repair methodsintroduce a groundbreaking approach to the repair and maintenance of Reinforced Cement Concrete (RCC) structures. This book compiles the important data from CPWD publications, MoRTH guidelines, IS/BIS standard codes, consultant reports, and practical experiences of site engineers.

It highlights innovative repair solutions that significantly enhance the longevity, safety, and sustainability of vital infrastructure. As urbanization and traffic continue to increase, this book provides crucial insights into modern repair methodologies that promise to ensure infrastructure remains robust and reliable for years to come.

I extend my deepest appreciation to all those involved in creating this book, confident that it will inspire further research and become an invaluable resource in the field of infrastructure rehabilitation, shaping the future of repair and maintenance practices in the years ahead.

**Mukesh Kumar**
Chief Engineer, Flyover Zone, PWD

# Message From

## Chief Engineer
## North Maintenance Zone, PWD

It gives me immense pleasure that a book titled as ***"Rehabilitation Works of Flyovers & Underpasses"*** is being published by the Public Works Department, Govt. of NCT of Delhi based upon valuable inputs of scientific assessment. This comprehensive guide is the culmination of PWD's collective efforts to document best practices, technical expertise, and innovative solutions for maintaining and upgrading flyovers, underpasses and other similar infrastructures in Delhi.

The book is a valuable resource for engineers, contractors, and stakeholders involved in the construction and maintenance of flyover infrastructure. It covers various aspects of flyover repair and rehabilitation, including inspection, design, materials, and execution. The book also highlights case studies showcasing PWD's commitment to improving the city's infrastructure.

I would like to extend my gratitude to the team of engineers and experts at PWD who have contributed to this publication. The dedication and expertise of PWD's engineers have resulted in a high-quality resource that will benefit not only PWD Delhi but will be very useful to nos. of departments, public sector undertaking, private sector builders and other infrastructure community. I am sure that this publication will serve as a valuable reference for years to come.

**Shri. Mukesh Meena**
Chief Engineer, North Maintenance Zone, PWD
(Link officer to Flyover Zone)

# Message From

## Chief Engineer)
## East Maintenance Zone, PWD

I am pleased to note about the publication of a book titled ***"Repair and Rehabilitation of Flyovers"*** by the Public Works Department, Govt of NCT of Delhi. This comprehensive guide is a culmination of the collective efforts of PWD to document best practices, technical expertise, and innovative solutions for maintaining and upgrading flyovers in Delhi.

The book is a valuable resource for engineers, contractors, and stakeholders involved in the construction and maintenance of flyover infrastructure. It covers various aspects of flyover repair and rehabilitation, including inspection, design, materials, and execution. The book also highlights case studies showcasing the commitment of PWD towards improving the city's infrastructure.

I would like to extend my gratitude to the team of engineers and experts of PWD who have contributed to this publication. The dedication and expertise of the Engineers of PWD has resulted in a high-quality resource that will benefit not only the PWD, but also the broader infrastructure community. I am confident that this book will serve as a valuable reference for years to come.

I want to convey my regards to Sh. Naimuddin, Engineer-in-Chief, Sh. B.L. Meena, Pr. Chief Engineer (M&F), Sh. Mukesh Kumar, Chief Engineer, Flyover Zone, Sh. Rajan Mogha, Superintending Engineer, Flyover Circle (F-1 & F-5), PWD and Sh. Neeraj Pandey, JE and other officers involved in bringing out this publication. I especially mention Sh Rajan Mogha, Superintending Engineer, Flyover Project Circle, PWD who has taken the initiative to amalgamate the knowledge of rehabilitation unit and bring out this handbook. This book is being uploaded on CPWD and PWD websites and hard copy will be distributed for wider reach and ready reference.

I convey my best wishes to all the engineers and staff of Public Works Department.

**Shailendra**
Chief Engineer, East Maintenance Zone, PWD

# Message From

## Superintending Engineer Judiciary & Project Circle, PWD

I am pleased to acknowledge the publication of the technical manual “Repair and Rehabilitation of Flyovers” by the Public Works Department, Government of NCT of Delhi. This document reflects PWD’s strategic initiative to consolidate and disseminate standardized methodologies, engineering practices, and innovative solutions for the structural maintenance and lifecycle enhancement of flyover infrastructure across Delhi.

The manual serves as a comprehensive reference for structural engineers, project managers, contractors, and other infrastructure professionals. It provides in-depth coverage of key domains including condition assessment protocols, deterioration mechanisms, structural evaluation techniques, retrofit design strategies, material selection criteria, quality assurance/control measures, and execution methodologies. The inclusion of case studies offers practical insights into real-world applications of these techniques in projects such as Nehru Nagar and Mayapuri flyovers.

I commend the technical team at PWD whose interdisciplinary expertise and commitment to engineering excellence have resulted in the production of this high-value resource. Their work contributes meaningfully to institutional knowledge and capacity building within the department and the broader civil engineering fraternity.

I would like to specifically recognize the contribution of the author Sh. Rajan Mogha for leading the effort to consolidate the operational expertise of the Rehabilitation Unit into this formalized technical handbook. I also extend my sincere appreciation and congratulations to PWD officers who made this work possible and M/s Cortex and Construma Consultants, whose detailed technical reports and analyses provided a critical foundation for the development of this publication. Their inputs significantly contributed to the accuracy and depth of the content presented. Further, I acknowledge the valuable contributions of our executing agencies and contractors. Their on-ground experience and operational feedback have played a pivotal role in enhancing the practical relevance and applicability of the handbook.

This publication is being made available in digital format on the CPWD and PWD official websites. Additionally, hard copies will be circulated to ensure broader accessibility and to serve as a ready reference for field engineers and technical personnel.

My best wishes to all engineers and staff of the Public Works Department for their continued contributions toward the development of resilient and sustainable infrastructure systems.

**Shailesh Ugrejeeya**
Superintending Engineer,
Judiciary & Project Circle, PWD, GNCTD

# FOREWORD BY AUTHOR

The rapid urbanization of Delhi has brought with it an ever-increasing demand for efficient transportation networks that can accommodate a growing population and its diverse mobility needs. Among the critical elements of this infrastructure are flyovers, which have become an integral part of the city's road network. Serving to alleviate traffic congestion, reduce travel time, and improve the flow of goods and people, flyovers play a vital role in the seamless functioning of the city. However, like all infrastructure components, these structures require diligent care, maintenance, and rehabilitation over time to ensure their continued safety, functionality, and longevity.

Delhi's flyovers, many of which were built decades ago, are now confronting the challenges of aging, wear and tear, and increased traffic loads. With rapid urban development and heightened pressure on existing roads, the need for repair and rehabilitation of these flyovers has never been more pressing. Additionally, the climatic extremes of Delhi—characterized by hot summers, cold winters, and monsoon rains—further accelerate the degradation of these structures, making their upkeep a significant concern for city planners, engineers, and policymakers alike.

Delhi PWD is constructing infrastructure projects, office blocks, residence buildings etc. in Delhi and maintaining these also. A dedicated repair and rehabilitation unit under Flyover Zone is doing structural repairs and retrofitting of flyovers all over Delhi and is applying state of art technologies.

Delhi has a huge infrastructure of roads and flyovers and it is a "mammoth task" to maintain these assets. This book is an amalgamation of knowledge accumulated for a period of time. This is a handy book which can be used not only in flyover works, but rehabilitation of other RCC structures also. This is first edition of book and I hope PWD will keep updating it on regular intervals to incorporate newer technologies.

The book consolidates a wide array of resources, including publications from the CPWD, MoRTH, IS/BIS, and international codes, alongside consultant reports, practical work experience, and industry expertise in the field of rehabilitation. It also presents detailed test procedures for assessing the condition of RCC structures in flyovers and underpasses, providing a comprehensive guide for evaluating the current state of infrastructure and determining the best course of action for its rehabilitation.

This innovative repair methodology outlined in this work is not only a reflection of technological advancement but also represents a significant step forward in ensuring the long-term durability and safety of urban infrastructure. By adopting these new repair techniques, we can enhance the resilience of critical infrastructure, extending its service life and safeguarding public safety.

It serves as a comprehensive guide for engineers, contractors, and infrastructure managers involved in the repair, restoration, and rehabilitation of flyovers in the capital city. The content is meticulously crafted to provide both theoretical knowledge and practical solutions to the diverse challenges posed by the repair and maintenance of flyovers in an urban environment as dynamic and demanding as Delhi.

The book offers deep insights into the full lifecycle of flyover maintenance—from routine inspections and early-stage damage assessment to advanced repair techniques and long-term rehabilitation strategies. The book emphasizes the importance of proactive monitoring to detect the first signs of deterioration, which, if addressed promptly, can greatly extend the lifespan of these structures and reduce the need for costly overhauls in the future.

What sets this book apart is its strong focus on Delhi-specific conditions and challenges. It delves into the unique environmental and traffic-related factors that impact flyover durability in the city. Given Delhi's heavy traffic, varying temperature extremes, and pollution, the book highlights the specialized materials, construction techniques, and repair methodologies that are required to restore flyovers to their optimal condition. Additionally, the case studies included within this book provide valuable real-world examples of successful repair and rehabilitation projects in Delhi, offering lessons learned and a practical roadmap for future work.

Another key strength of this book lies in its holistic approach to flyover repair. While much of the focus is understandably placed on the technical aspects, the book also emphasizes the importance of environmental considerations, safety protocols, and cost-effectiveness in the decision-making process. It is not just about fixing a problem; it's about doing so in a way that maximizes long-term sustainability and minimizes disruption to traffic and the environment.

This also bring attention to the often-overlooked aspect of rehabilitation: the integration of preventive maintenance strategies into the overall urban planning framework. It is imperative that flyovers are not only repaired when problems arise, but that measures are put in place to prevent further deterioration and extend their useful life. This preventative approach is key to addressing the challenges of increasing traffic volumes and reducing the overall costs associated with reactive repairs.

As the capital city of India, Delhi's infrastructure is a reflection of the nation's aspirations and growth. The rehabilitation and repair of its flyovers, which are among the most critical transport corridors, is a responsibility that cannot be taken lightly. This book will undoubtedly serve as a key reference for policymakers, urban planners, engineers, and construction professionals committed to ensuring that Delhi's flyover network remains strong, safe, and efficient for generations to come.

Case studies and practical applications of these techniques, used in the Nehru Nagar Flyover, Mayapuri Flyover, and others, are included in the book.

I personally congratulate and thank Sh. Anil Yadav, Executive Engineer; Sh. Bharat Kumar, AE; Sh. Sheikh Nizam, AE; Sh. Abdul Kadir Khan, JE; and other officers involved in bringing out this publication. I would especially like to acknowledge Sh. Neeraj Pandey, JE, Flyover Project Division, PWD, who took the initiative to amalgamate the knowledge of the Rehabilitation Unit and compile this handbook. I would like to express my sincere appreciation and make a special mention of Sh. Shishir Bansal, SDG (Retd.), CPWD and Principal Consultant SETU Infra Solutions, for his valuable inputs that significantly contributed to enhancing the quality of this book. I also extend my congratulations and thanks to M/s Cortex and Construma Consultants, whose reports were instrumental in the preparation of this publication. My sincere appreciation also goes to our working agencies and contractors, whose practical insights have greatly enriched the content of this book.

This book is being uploaded on CPWD and PWD websites and hard copy will be distributed for wider reach and ready reference.

I also hope more such publications are brought forward in future by Delhi PWD to publicize various works being done by PWD.

In conclusion, Repair and Rehabilitation of Flyovers in Delhi is not only an authoritative guide on the technical aspects of flyover repair, but also a thought-provoking resource that stresses the importance of proactive, sustainable, and cost-effective maintenance practices. I hope that this book will inspire professionals in the field to embrace modern technologies, share knowledge, and work together towards enhancing the resilience of the city's infrastructure. It is an invaluable resource for anyone seeking to contribute meaningfully to the development and upkeep of Delhi's flyover network, and, by extension, its broader transportation ecosystem.

**Rajan Mogha**
Superintending Engineer
Flyover Project Circle, F-5, PWD, GNCTD

# INTRODUCTION

The main aim to write this book is to identify the defects occur during lifespan of the Flyovers, Bridges, RoB's and underpasses etc. with the help of surveys and various tests to take appropriate remedial measures along with their methodology to repair them. Repair and Rehabilitation of these structures are very important after completion and commissioning of the same.

Various operations that may be required to do on it are Maintenance and repair- to preserve the intended load-carrying capacity and to ensure correct functioning, durability, aesthetic appearance and continuity of safety. The approach to maintenance of the structure is to take all possible cost-effective measures to prevent its deterioration and to see that it is preserved close to its initial state of construction.

Generally, we deal with the maintenance of main component of flyover like Pier, Pier Cap, Abutment, Girder, Deck slab, Bearing, Expansion joint and Crash barrier. This type of Rehabilitation work is required specialised Agency which are experts in this field.

This book serves as a comprehensive guide to the rehabilitation of flyovers and underpasses, focusing on a structured and methodical approach to repair and restoration. It covers essential topics ranging from the initial assessment of structural integrity to the final implementation of repair methodologies. The assessment process is supported by various destructive & non-destructive testing techniques, which are crucial for evaluating the current condition of the structures and identifying areas that require attention.

# 1. Main Issue to Mitigate

## 1. Cracks in Retaining walls, Pier and Pier caps, Girder, Deck Slab

**Vertical Cracks: -** It may occur due to differential settlement of the foundation or excessive shearing stresses in the substructure.

**Horizontal Cracks: -** These are more serious, and these could be due to inadequacy of section, defect in construction, failure of backfill drainage or excessive horizontal loads etc.

The main equipment used for locating the cracks was a powerful binocular.

**Diagonal Cracks: -** The main cause of diagonal cracks in concrete pier is inadequate load carrying capacity of the columns, insufficient cross-section and inadequate reinforcement steel.

**Diagonal Cracks: -** The main cause of Corrosion cracks in concrete columns is reinforcement corrosion and inadequate bond between concrete and steel bars. These are developed along the line of reinforcements.

*Fig: - Cracks in pier& pier caps*

## 2. Spalling of Concrete from RCC Members

Generally, the spalling of RCC is associated with cracking that has been initiated due to oxidation of reinforcement corrosion of rebar. The rebar corrosion is always associated with increase in the volume of the product of corrosion. This increased volume produces tensile stress in the surrounding location of the concrete. The materials, which are lying as cover, can get displaced due to the effects of corrosion. However, spall is also possible which may be called as **"Chipping of concrete"** due to hammering action of the loaded vehicles.

*Fig: - RCC Spalling in Deck slab, Pier Cap & Girder*

## 3. White Water Marks Resembling Leaching

Leaching of lime compounds can lead to the formation of calcium carbonate or calcium sulphate on the surface of the concrete; this is known as 'efflorescence'. Two forms occur, namely lime bloom, and lime weeping.

**Lime bloom** appears as white patches or an over-all lightening of the surface of the concrete and affects the aesthetic of the structure.

**Lime weeping** is caused by water leaking through the concrete and dissolving calcium hydroxide from the matrix and affects the durability of concrete.

*Fig: - Water Marks in Deck slab & Girder*

## 4. Fungus & Algae Growth (Wet Area)

These are vegetative growths occurring in the structure due to prolonged accumulation of debris and water. It may develop cracks in retaining, wing walls and affect the functionality of Bearings & expansion joints if the roots pass through them.

*Fig: - Vegetation Growth in Retaining wall and Railing*

## 5. Malfunctioning of Expansion Joints

The most common problem with wide and high movement expansion joints is water leaking through them, and therefore into the areas below causing damage to fittings, steel bearing corrosion, steel reinforcement corrosion and damage to the structural concrete.

*Fig: - Damaged Expansion joint Filled with debris*

## 6. Malfunctioning of Bearings

**Elastomeric Bearing: -** The common defects in Elastomeric Bearings are yield and rupture of the reinforcement, delamination of reinforcement, cracking or tearing of the rubber, fatigue, and instability. The most notable of these failure modes is slippage or "walking" out of position.

**Metal Bearing: -** Metal Bridge bearings can experience several common defects as mentioned below.

- **Corrosion:** - Caused by exposure to moisture, salts, and pollutants.
- **Bearing Pad Deterioration:** - Resulting from aging, chemicals, or extreme temperatures.
- **Separation of Components:** - Due to misalignment or improper maintenance.
- **Deformation or Crushing:** - From excessive loads or poor design.
- **Mechanical Wear:** - Accelerated by inadequate lubrication or abrasive particles.
- **Blockage or Debris Accumulation:** -Caused by dirt, debris, or ice.
- **Cracking or Fractures:** - Due to material defects or impact forces.
- **Alignment Issues:** - From improper installation or structural settlement.
- **Fatigue Failure:** - Resulting from repeated loading cycles.
- **Lack of Lubrication:** - Leading to increased friction and wear.

Preventive measures include regular inspections, protective coatings, proper installation, and routine maintenance to address these defects and extend the lifespan of bridge bearings.


*Fig: - Malfunctioning of Metal & Elastomeric Bearings*

### Bearing Inspection Sheet (POT-PTFE)

| Bridge No. | Chainage |
|---|---|
| Pier No. | Girder No. |
| Bearing Line | Bearing No. |
| Grouting Layer is not Solid | Inclination of Bearing |
| Coupling Bolt is not removed | h-value exceeding limit |
| Uneven Installation | Cracks |
| Upper Plate tilted | Inappropriate Movements & Rotations |
| Wrong Placement | Corrosion attack |
| Upper Plate Sliding w.r.t Pot Base | Locking Pin Removal |
| Inappropriate Concrete Pouring | Bearing Pedestal Defects |
| Any sign of Elastomer leakage | Any damage to Guide Bars |
| Loss of Contact | Bending in Plate |

| Bridge No. | Chainage |
|---|---|
| Joint Slip | Bolt Missing |
| Crack in weld | Condition of Dust Seal |
| Minimum gap between upper & lower parts of POT-PTFE to be not less than 5 mm | Bulging of Elastomer |
| Whether entirely supported on Bed Block/ Bearing Pedestal | Cracks in any component of POT-PTFE |
| Bending of any component of POT-PTFE | Longitudinal Displacement w.r.t mean position |
| Transverse Displacement w.r.t mean position | Rotation in Longitudinal Direction |
| Rotation in Transverse direction | Pedestal Size (LxBxH) |
| Separation between SS/PTFE | Any other Observations |

### Bearing Inspection Sheet (Elastomeric)

| Bridge No. | Chainage |
|---|---|
| Pier No. | Girder No. |
| Bearing Line | Bearing No. |
| Crack/Splitting | Sway/Flattening/Lifting |
| Bulging of Elasotmer | Hardness |
| Tearing in Layers of Elastomer | Slide |
| Corner Gap | Gap |
| Alignment | Uplifting |
| Pedestal Condition | Size of Bearing |
| Position of Bearings | Thickness of Elastomer (Shear Strain) |
| Unequal Load Distribution | Seating w.r.t bottom surface of Girder |
| Loss of Contact | Separation of Layers of Elastomer |
| Proper bond between the elastomers and the Reinforcing Plates | Condition of Holding Down Bolts |
| Condition of Stopper | Flattening of Elastomers |
| Any Corner Lifting | Tilting in Elastomeric Bearing |
| Height of Elastomeric Bearing | Any Other Observations |

### Bearing Inspection Sheet (Rocker Roller)

| Bridge No. | Chainage |
|---|---|
| Pier No. | Girder No. |
| Bearing Line | Bearing No. |
| Grouting Layer and Plate fixing | Inclination of Bearing |
| Bolt is aligned/tilted if | Alignment of Plates |
| Uneven Installation | Cracks in Plates |
| Upper Plate Tilted | Inappropriate Movements & rotations |
| Greasing or Oil working | Corrosion Attack |
| Condition of Packing Material if any | Concrete Pedestal Cracks |
| Crack in weld | Dust Deposition |

## 7. Distressed Crash Barrier and RCC Railing

Crash barriers on flyovers (also known as guardrails or crash rails) are critical for enhancing safety by preventing vehicles from veering off the road and into hazardous areas. However, they can develop defects due to various factors.

*Fig: - Distressed Crash Barrier and RCC Railing*

- **Corrosion and Rust: -** Caused by exposure to moisture, salt, and pollutants.
- **Bent or Deformed Sections: -** Resulting from vehicle collisions or heavy loads.
- **Loose or Missing Components: -** Due to wear, tear, and impact damage.
- **Concrete Spalling or Cracking: -** Caused by weathering, freeze-thaw cycles, or impact.
- **Misalignment: -** From improper installation or damage.
- **Structural Fatigue: -** Due to repeated stress from impacts.
- **Paint and Coating Damage: -** From UV rays and mechanical wear.
- **Vegetation and Debris Accumulation: -** Which can obstruct the barrier's function.
- **Inadequate Height or Design Issues: -** Resulting from outdated or incorrect specifications.

Preventive measures include regular inspections, timely repairs, protective coatings, proper installation, and adherence to design standards to ensure barrier effectiveness and safety.

## 8. Failure of Drainage System

There has been a drainage problem of the flyover due to damaged and clogged drainage and runner pipe. The water marks in the structure are also attributed due to inadequate drainage system.

*Fig: - Failure of drainage system*

## 9. Environmental impact & Chemical Weathering

Chemical weathering of Reinforced Cement Concrete (RCC) structures refers to the process by which chemical reactions lead to the deterioration of concrete over time. RCC structures, which are commonly used in construction due to their strength and durability, are not immune to environmental factors that can cause them to degrade. Here's a breakdown of how chemical weathering can affect RCC structures:

i. **Acid Rain:** Acid rain, which contains sulfuric or nitric acids, can react with the calcium hydroxide in concrete. This reaction forms calcium sulfate or calcium nitrate, which can weaken the concrete and cause it to deteriorate.

ii. **Carbonation:** Carbon dioxide from the air can react with calcium hydroxide in the concrete to form calcium carbonate. While this reaction initially makes the concrete harder, it can also lower the pH of the concrete, making the embedded steel reinforcement more susceptible to corrosion.

iii. **Chloride Attack:** Chlorides, often from de-icing salts or seawater, can penetrate concrete and lead to the corrosion of the steel reinforcement within. This corrosion expands and can cause cracking and spalling of the concrete.

iv. **Sulfate Attack:** Sulfates present in groundwater or soil can react with the calcium aluminate in cement to form expansive compounds like ettringite. This expansion can lead to cracking and deterioration of the concrete.

v. **Alkali-Silica Reaction (ASR):** Reactive silica in aggregates can react with alkali hydroxides in the cement paste, forming a gel that expands when it absorbs moisture. This expansion can cause cracking and weakening of the concrete.

vi. **Biological Growth:** In some cases, biological organisms like algae and fungi can grow on concrete surfaces, particularly in damp conditions. While these organisms themselves don't usually cause significant chemical weathering, they can contribute to moisture retention and subsequent chemical reactions.

vii. **pH value of construction water: -** Normally, the high pH of concrete (around pH 12-13) creates a passivating layer on the steel reinforcement, protecting it from corrosion. However, it can affect the formation of calcium carbonate or lead to the leaching of calcium hydroxide, impacting the long-term durability of the concrete.

Low pH or acidic water can significantly damage Reinforced Cement Concrete (RCC) structures by:

a. **Accelerating Corrosion:** Acidic water accelerates the corrosion of steel reinforcement bars (rebar), leading to structural weakening and potential cracking.

b. **Leaching Cement Paste:** Acid can dissolve calcium hydroxide in the cement paste, reducing the concrete's strength and durability.

c. **Chemical Reactions:** It can cause the formation of soluble compounds that further degrade the concrete.

d. **Increasing Porosity:** Acidic conditions can increase the porosity of concrete, allowing more aggressive agents to penetrate and cause additional damage.

e. **Surface Erosion:** Prolonged exposure can lead to surface erosion and pitting, affecting both aesthetics and integrity.

# 2. Condition Survey & Distress Observed

A conditional survey of a flyover is a specialized assessment focused on evaluating the current state and performance of the flyover structure. The aim is to identify any defects, deterioration, or safety concerns that might affect the flyover's functionality and safety. This survey is crucial for maintenance planning, ensuring structural integrity, and prolonging the lifespan of the flyover.

## Key Aspects of a Conditional Survey of a Flyover

**Objective**

- To assess the overall condition of the flyover, including its structural and functional elements.
- To detect and document any signs of damage, wear, or deterioration.
- To provide a basis for maintenance, repairs, or structural upgrades.

**Scope**

- **Visual Inspection:** Includes checking the visible parts of the flyover such as Girder, Pier & Pier Caps, deck slab, retaining wall and expansion joints.
- **Detailed Examination:** May involve destructive, non-destructive testing (NDT) techniques to assess internal conditions, such as ultrasonic testing for concrete or magnetic particle testing for steel.
- **Load Assessment:** Evaluating the load-bearing capacity and any potential impact from increased traffic loads or changes in usage.

**Components Assessed**

- **Deck Slab:** Look for cracks, spalling, or surface wear.
- **Support Structures:** Inspect abutment, columns, piers, and bearings for signs of damage or misalignment.
- **Expansion Joints:** Check for wear, leakage, or malfunction.
- **Guardrails and Crash Barriers:** Assess for any damage or misalignment.
- **Drainage Systems:** Ensure proper functioning and check for blockages or damage.
- **Foundation:** Evaluate the condition of the foundations for any signs of settlement or structural issues.

**Findings and Documentation**

- **Condition Report:** A detailed report on the current state of the flyover, including any observed defects or areas of concern.
- **Photographic Evidence:** Images documenting issues and conditions.
- **Recommendations:** Suggested maintenance actions, repairs, or further investigations required.

**Frequency**

Conducted at regular intervals as part of a maintenance schedule or in response to specific concerns, such as after a significant event (e.g., a heavy collision or natural disaster).

**Importance**

- Helps ensure the safety and reliability of the flyover.
- Aids in prioritizing maintenance and repair tasks.
- Supports compliance with safety regulations and standards.

Thus, a conditional survey is essential for effective management of flyovers, helping to prevent potential failures and ensuring the ongoing safety of road users.

# 3. Various Tests to Assess the Structure

To assess concrete structures, there are several types of tests, each designed to evaluate different aspects of the concrete's condition and performance. These tests can be broadly categorized into **destructive** and **non-destructive tests, Load Tests** etc.

## List of Non-Destructive Tests (NDT)

| S. No. | Type of Test | Purpose | Method | IS Code | Sampling | Tool |
|---|---|---|---|---|---|---|
| 1 | **Visual Inspection** | Detect visible signs of distress | Direct observation; use of magnifying tools or digital imaging | None | No sampling required; visual assessment of existing structure | Magnifying glass, camera |
| 2 | **Rebound Hammer Test** | Estimate surface hardness and compressive strength | Use a rebound hammer to measure surface hardness | IS 13311 (Part 2) | No sampling required; surface testing | Rebound hammer (Schmidt hammer) |
| 3 | **Ultrasonic Pulse Velocity (UPV) Test** | Assess concrete quality and uniformity | Measure the speed of ultrasonic waves through concrete | IS 13311 (Part 1) | No sampling required; surface testing | Ultrasonic pulse velocity tester |
| 4 | **Half-Cell Potential Test** | Determine likelihood of reinforcement corrosion | Measure electrical potential using a half-cell electrode | IS 516 (Part 5) | No sampling required; surface testing | Half-cell potential meter |
| 5 | **Chloride Content Test** | Measure chloride concentration in concrete | Chemical analysis of concrete samples | IS 14959 (Part 1 & 2) | Concrete samples collected for laboratory analysis | Chemical reagents, laboratory equipment |
| 6 | **Carbonation Depth Test** | Measure depth of carbonation | Apply pH indicator solution and | IS 516 (Part 2/ Sec 4 | No sampling required; surface testing | pH indicator solution, ruler or caliper |
| 7 | **Thermo graphic Inspection** | Detect moisture, insulation defects | Use thermal imaging cameras to identify temperature variations | None | No sampling required; surface inspection | Thermal imaging camera |
| 8 | **Sounding Test** | Identify delaminations or voids | Tap surface and listen for hollow or different sounds | ASTM D4580-23 | No sampling required; surface testing | Hammer or sounding tool |
| 9 | **X-Ray and Gamma Radiography** | Inspect internal concrete for defects | Use X-ray or gamma radiation to create images | IS 2595 | No sampling required; structural inspection | X-ray or gamma radiography equipment |

| S. No. | Type of Test | Purpose | Method | IS Code | Sampling | Tool |
|---|---|---|---|---|---|---|
| 10 | **Pulse Echo Method** | Evaluate depth and size of defects | Send and receive acoustic waves through concrete | IS 3664 | No sampling required; surface testing | Pulse echo testing device |
| 11 | **Ground Penetrating Radar (GPR)** | Locate embedded reinforcement and detect anomalies | Use radar pulses to create subsurface images | IRC 123-2017 | No sampling required; surface testing | GPR scanner |

## List of Destructive Tests (DT)

| S. No. | Type of Test | Purpose | Method | IS Code | Sampling | Tool |
|---|---|---|---|---|---|---|
| 1 | **Concrete Core Testing** | Determine compressive strength and quality | Extract cores and test in a laboratory | IS 516 / IS 1199 | Core samples drilled from structure | Core drill, compression testing machine |
| 2 | **Compression Test** | Measure compressive strength | Test concrete cubes or cylinders under load | IS 516 | Concrete samples collected or cast on-site | Compression testing machine |
| 3 | **Flexural Test** | Assess bending strength of | Test beams under flexural load | IS 516 | Concrete beams prepared and tested in laboratory | Flexural testing machine |
| 4 | **Split Tensile Test** | Evaluate tensile strength | Apply load along the diameter of cylindrical specimen | IS 5816 | Cylindrical samples collected or cast on-site | Tensile testing machine |
| 5 | **Shrinkage Test** | Measure volumetric shrinkage | Measure changes in sample size over time | IS 6441 (Part 2) | Concrete samples prepared and tested in laboratory | Shrinkage testing apparatus |
| 6 | **Water Absorption Test** | Assess porosity and permeability | Measure water absorption of concrete sample | IS 1124 | Concrete samples collected or cast on-site | Water absorption testing equipment |
| 7 | **Pull-Out Test** | Assess bond strength between concrete and reinforcement | Pull steel rod or bolt from concrete | IS 2770 (Part 1) | Steel rods or bolts embedded in concrete, tested in-place | Pull-out testing apparatus |
| 8 | **Density Test** | Measure density of concrete | Weigh and measure concrete samples | IS 1199 (Part 3) | Concrete samples collected or cast on-site | Density testing equipment |

## List of Load Tests

| S. No. | Type of Test | Purpose | Method | IS Code | Sampling | Tool |
|---|---|---|---|---|---|---|
| 1 | **Static Load Test** | Assess the load-bearing capacity of structural elements | Apply a controlled load to the structure and measure deflections and settlements | IRC: SP:51-2014 | No specific sampling; test on the actual structure | Load cells, deflection gauges, hydraulic jacks |
| 2 | **Dynamic Load Test** | Evaluate structural behavior under dynamic loading conditions | Apply dynamic loads and monitor responses like | IRC: SP:51-2014 | No specific sampling; test on the actual | Dynamic load generators, accelerometers, vibration sensors |
| 3 | **Proof Load Test** | Verify the structural capacity and safety margins | Apply a load to the structure to confirm its ability to support designed loads | IRC: SP:51-2014 | No specific sampling; test on the actual structure | Load cells, hydraulic jacks, deflection gauges |
| 4 | **Test Load Test** | Determine if a structure can support additional loads | Apply test loads beyond the design capacity and observe the performance | IRC: SP:51-2014 | No specific sampling; test on the actual structure | Load cells, hydraulic jacks, deflection gauges |
| 5 | **Service Load Test** | Check the structure's behavior under service loads | Apply service-level loads and measure deflections, strains, and stresses | IS 456 (Indirect) | No specific sampling; test on the actual structure | Load cells, strain gauges, deflection gauges |
| 6 | **Ultimate Load Test** | Assess the structure's performance under ultimate loads | Apply loads approaching or exceeding the design capacity to evaluate ultimate strength | IS 456 (Indirect) | No specific sampling; test on the actual structure | Load cells, hydraulic jacks, deflection gauges |

## LOAD TESTS

### Static Load Test:

A Static Load Test is a type of structural test applied to bridges (and other structures) to assess their load-carrying capacity and behavior under applied loads. In a static load test, predetermined loads are gradually applied to a structure at a constant rate, and the response of the structure (such as deflection, strain, and displacement) is carefully monitored. The primary goal is to evaluate whether the structure can safely support the intended loads without excessive deformation or failure.

### Purpose:

1. **Assess Structural Capacity:** Determines if a bridge can safely carry design or higher loads, ensuring it meets safety requirements.
2. **Verify Design Assumptions:** Confirms if actual bridge behavior aligns with design predictions for deflections and stresses.
3. **Check Serviceability and Deflection Limits:** Ensures deflections are within acceptable limits to maintain functionality, comfort, and safety.
4. **Evaluate Existing Structures:** Assesses the condition of older or rehabilitated bridges, identifying potential damage or wear.
5. **Detect Structural Weaknesses:** Identifies weak spots like excessive deflections or cracks, ensuring timely repairs.
6. **Establish Safety Margins:** Verifies that the bridge can handle loads beyond the design load, confirming safety factors.
7. **Validate Rehabilitation:** Confirms that strengthening or repairs improve the bridge's load-bearing capacity.
8. **Collect Data for Future Designs:** Provides valuable data to optimize future bridge designs.

### Dynamic Load Test:

Dynamic Load Testing is a method used to evaluate a structure's response to dynamic or moving loads, simulating real-world conditions where loads change or fluctuate over time, such as traffic, wind, or vibrations. Unlike static load testing, which involves stationary, constant loads, dynamic load testing assesses how a bridge or other structure performs under the influence of repetitive, transient, or varying loads.

### Purpose:

1. **Assess Dynamic Response**: Evaluates how a bridge responds to moving loads (e.g., vehicles, pedestrians) in terms of vibration, displacement, and resonance.
2. **Identify Resonance Issues**: Detects if the bridge experiences resonance, which can amplify vibrations and threaten safety.
3. **Verify Performance Under Real-World Conditions**: Simulates actual traffic and environmental conditions to see how the bridge performs under typical service loads and impacts.
4. **Check for Fatigue and Structural Health**: Identifies damage from repetitive loading that could weaken the structure over time.
5. **Evaluate Damping and Vibration**: Assesses how quickly vibrations dissipate and whether the bridge can handle dynamic forces without excessive oscillation.
6. **Test Post-Modifications**: Verifies improvements after rehabilitation or strengthening to ensure the bridge can handle dynamic loads effectively.

7. **Support Design Improvements**: Provides data to help engineers refine bridge designs for better stability, comfort, and durability.

## Flow Chart of Activities:

A method statement shall be prepared which includes a detailed activity schedule for the load test as programmed for timely completion of load testing. The method statement shall have the following details for conducting the load test.

i. Application of whitewash for critical locations of bridge
ii. Mobilization of testing personnel to site
iii. Visual inspection of bridge
iv. Recording existing status
v. Fixing of instrumentation
vi. Recording of thermal response of the structure
vii. System of measurements for temperature correction
viii. Position of the load on the bridge
ix. Measurement recording
x. Visual inspection during and after load testing
xi. Preparation of report

## Instruments for the Measurements:

The correct type, number and location of instrumentation used on a structure during a load test are critical to achieve satisfactory outcome. Deflections, Strains and Inclinations shall be measured with following devices.

a. Linear Variable Displacement Transducer (LVDT) system with least count of 0.01 mm
b. Dial gauges, with least count of 0.01 mm
c. Strain gauge and measuring system, with load-count of 1 micro strain
d. Inclinometer, with least count 0.1°
e. Precision digital leveling instrument with bar coded staff with least count 0.1 mm
f. Total station, with least count of 0.1 mm.
g. Thermometers, Digital or Analogue with least count of 0.5°C

## Instruments used for the Load Test

*Photo 1 - Linear Variable Displacement Transducer (LVDT)*

*Photo 2 - Dial Gauge*


*Photo 3 - Inclinometer*

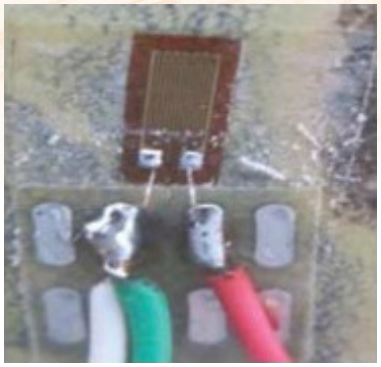


*Photo 4 - Strain Gauges*


*Photo 5 - Digital Thermometer*

*Photo 6 - Data Acquisition System*

## Loading and Unloading Procedure

| Phase | Description | Time Period |
|---|---|---|
| Phase -I | Commencement of load testing | 0 hours |
| Phase -II | Start & completion of 50%, 75%, 90%, 100% of loading on the structure | On or before 24 hours after commencement of load test. |
| Phase -III | Retention of 100% load on the structure | 24 hours. |
| Phase -IV | Start &completion of off-loading structure in the sequence of 100%,90%, 75%, 50%, 0% | On or before 24 hours after completion of retention period of 100% load on the structure |
| Phase -V | Structure without any load | 24 hours after complete off-loading. |

## Bridge Load Testing

*Photo 7 - Imprints Before Start of Load Testing*

*Photo 8 - Load testing by Static Method*

*Photo 9 - Load Testing by Static Method - a Closeup of Loads*

*Photo 10 - Load Testing by Vehicles*

### Acceptance Criteria:

The acceptance criteria of load test shall be as under:

1. Measured deflections and strains at critical location of particular structural member/ members shall be equal to or less than theoretical deflections and strains obtained from respective designs.
2. The percentage of recovery of deflections for various types of bridges after retention of test load for 24 hrs. shall be :

| S. No. | Type of Bridges | Minimum percentage recovery of Deflection at 24 hrs after removal of test load |
|---|---|---|
| 1 | Reinforced Concrete | 75 |
| 2 | Prestressed Concrete | 85 |
| 3 | Steel | 85 |
| 4 | Composite | 75 |

3. The structure shall not show any cracks more than 0.30 mm for (normal) moderate exposure and 0.20 mm for severe conditions of exposure, spalling or deflections which are incompatible with safety requirements, as prescribed in the relevant design codes.
4. Structures which do not meet the above criteria shall be considered as noncompliant.

## Ultrasonic Pulse Velocity (UPV) Test

The Ultrasonic Pulse Velocity (UPV) test is a non-destructive testing method used to assess the quality, uniformity, and integrity of concrete. This test evaluates the speed of an ultrasonic pulse passing through the concrete, which is influenced by the material's properties. The results help identify defects, measure concrete homogeneity, and estimate the material's strength.

### Purpose:

1. **Quality Assessment:** The test helps assess the overall quality of the concrete in a structure, identifying areas with low-density or defective concrete.
2. **Detection of Internal Defects:** The UPV test is used to detect internal cracks, voids, honeycombing, or segregation in concrete structures.
3. **Strength Estimation:** While the test doesn't directly measure compressive strength, there is a general correlation between pulse velocity and concrete strength. Low pulse velocities are often indicative of lower concrete strength.
4. **Monitoring Structural Health:** The test can be performed at various stages of a structure's life to monitor its condition, helping to assess any deterioration over time.
5. **Uniformity of Concrete:** The UPV test can evaluate the uniformity of the concrete in large sections or between different batches of concrete.

### Principle of the Test:

The ultrasonic pulse velocity test measures the time it takes for an ultrasonic pulse to travel through the concrete. **This time is inversely proportional to the quality of the concretehigher pulse velocities typically indicate higher concrete quality, while slower velocities may suggest the presence of defects such as cracks, voids, or inadequate curing.**

The basic principle involves transmitting an ultrasonic pulse from a transducer into the concrete. The pulse travels through the material and is received by another transducer placed at a known distance. The time it takes for the pulse to travel this distance is measured, and the pulse velocity is calculated.

### Test Procedure:

1. **Preparation of the Concrete Surface:** The surface where the transducers will be placed should be smooth, clean, and dry. Any dust, grease, or moisture can affect the transmission of the pulse.
2. **Placement of Transducers:** The pulse transmitter and receiver are placed on opposite sides of the concrete. They should be aligned on the surface and positioned as close to each other as possible for more accurate readings. The transducers are typically placed in parallel with the surface, aligned along the axis of the concrete element.
3. **Application of the Pulse:** The ultrasonic pulse is generated by the transmitter and travels through the concrete. The receiver detects the pulse once it reaches the other side of the concrete.
4. **Measurement of Travel Time:** The time taken for the pulse to travel through the concrete is recorded. The travel time is usually in microseconds (μs) and is measured by the timer.
5. **Calculation of Pulse Velocity:** The velocity (v) of the ultrasonic pulse is calculated using the formula:

$V = L/T$

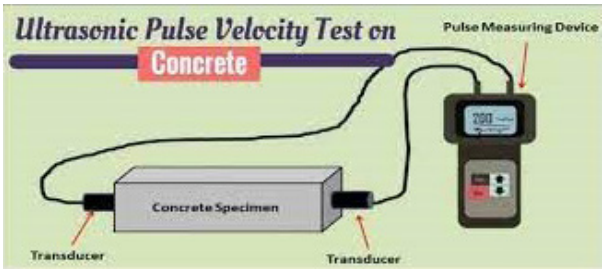
Where,

- V is the pulse velocity (in meters per second),
- L is the distance between the transducers (in meters),
- T is the time taken for the pulse to travel through the concrete (in seconds)

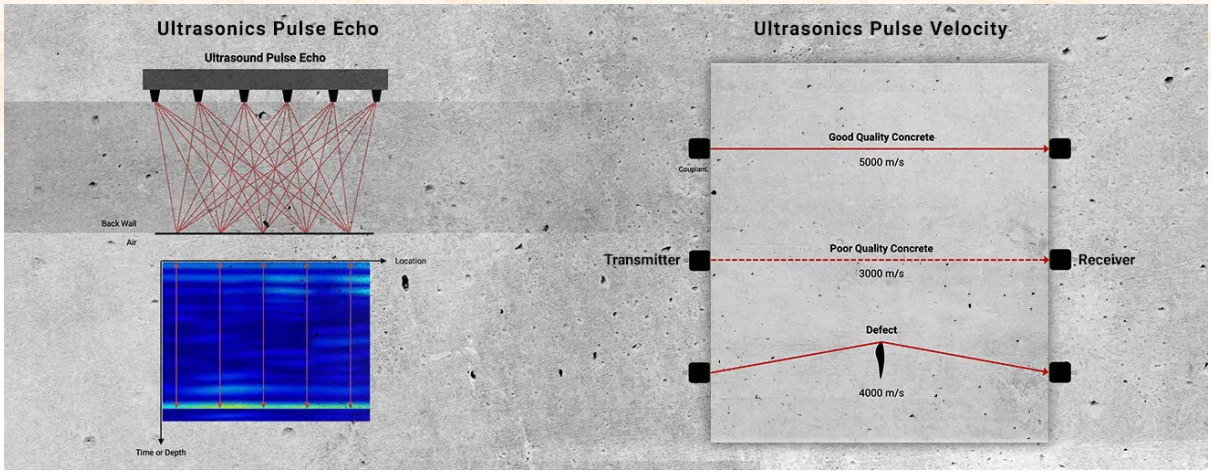
### Test Equipment:

1. **Transducers/Probes:** These devices generate and receive the ultrasonic waves. The transmitter sends the pulse through the concrete, and the receiver detects the pulse after it passes through the material.
2. **Timer or Digital Display:** Measures the time taken by the ultrasonic pulse to travel between the transducers.
3. **Coupling Gel:** A coupling medium is often applied between the transducers and the concrete surface to improve the transmission of ultrasonic waves.

### Interpretation of Results:




The results of the UPV test are interpreted based on the pulse velocity measured. The pulse velocity can be classified into categories that reflect the quality of the concrete. These classifications are based on the general relationship between pulse velocity and concrete quality, but it's important to note that velocity values can also be influenced by factors like moisture content, temperature, and the type of aggregates used in the concrete mix.




### Velocity Criterion for Concrete Quality Grading

| S. No. | Pulse Velocity by Cross Probing (Km/s) | Concrete Quality Grading |
|---|---|---|
| 1 | Above 4.5 | Excellent |
| 2 | 3.5 to 4.5 | Good |
| 3 | 3.0 to 3.5 | Medium |
| 4 | Below 3.0 | Doubtful |

**Note -** In case of doubtful quality it may be necessary to carry out further tests.

### Factors Affecting Pulse Velocity:

1. **Concrete Composition:** The type and amount of aggregate, cement, and water in theconcrete mix directly affect the pulse velocity.
2. **Moisture Content:** Moist concrete typically allows ultrasonic pulses to travel faster due to reduced internal friction.
3. **Temperature:** Higher temperatures can lead to faster pulse velocities due to reduced viscosity of the medium through which the waves travel.
4. **Curing Condition:** Well-cured concrete will generally have a higher pulse velocity compared to poorly cured concrete.
5. **Defects and Imperfections:** The presence of cracks, voids, or other imperfections reduces the pulse velocity since ultrasonic waves are slowed down or reflected by such defects.

## Carbonation Depth Test

Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous cover concrete and may reduce the pH to 8 or 9, at which the passivating/ oxide film is no longer stable. Carbonation process involves the following two stages:

First, the atmospheric carbon dioxide ($CO_2$) reacts with water in the concrete pores to form carbonic acid ($H_2CO_3$). This is followed by reaction of the carbonic acid with calcium hydroxide [$Ca(OH)_2$] to form calcium carbonate ($CaCO_3$) . This process leads to cause a reduction in the pH value of the pore solution from 12.5 to 13.5 to around 8 to 9, which causes depassivation of protective layer of the reinforcement bars and initiates their corrosion.

## Purpose:

The purpose of the Carbonation Depth Test is to evaluate the extent of carbonation in concrete, which affects its durability. The main objectives are:

1. **Assess corrosion risk:** Identify if carbonation has reached the reinforcement, potentially causing corrosion due to lowered pH
2. **Evaluate concrete durability:** Determine how carbonation impacts the long-term strength and integrity of the concrete.
3. **Monitor structural condition:** Track carbonation progression over time in existing structures.
4. **Guide maintenance and repair:** Indicate if protective measures or repairs are needed to prevent further damage.
5. **Assess concrete quality:** Ensure the concrete mix and construction provide adequate protection against carbonation.
6. **Predict service life:** Estimate how long the structure can maintain its durability before requiring interventions.

In short, the test helps ensure the safety, longevity, and maintenance of concrete structures by identifying potential risks from carbonation.

## Procedure:

1. **Application of Phenolphthalein Solution:** The phenolphthalein solution is applied uniformly on the freshly exposed surface of the concrete specimen. After applying the solution, the concrete surface will show different colour changes depending on the pH of the concrete.
   a) **Non-carbonated (Alkaline):** In areas where the concrete is non-carbonated (where the pH remains high due to the presence of calcium hydroxide), the phenolphthalein will turn pink or reddish.
   b) **Carbonated (Acidic):** In areas where carbonation has occurred, the pH will drop due to the formation of carbonic acid (a product of $CO_2$ reacting with the concrete), and phenolphthalein will remain colourless in these areas.
2. **Depth of Carbonation:** The carbonation depth is defined as the distance from the concrete surface to the point where the colour change (from pink to colourless) occurs. This depth is measured from the exposed surface to the boundary between the pink and colourless areas.
3. **Multiple Measurements:** For accuracy, the test should be performed at multiple locations on the sample. Typically, 5 to 6 measurements are made at different points on the surface of the core or specimen.
4. **Measurement and Recording:**
   a) **Carbonation Depth:** The carbonation depth is measured in millimetres (mm) from the surface of the concrete to the point where the phenolphthalein colour change occurs. The depth can be measured using a calibrated ruler or a calliper.
   b) **Depth Across the Surface:** To ensure uniformity and accuracy, carbonation depth measurements should be taken from multiple points along the specimen surface, preferably at several locations across the length of the sample.

### Interpretation of Results:

a. Shallow Carbonation Depth: If the carbonation depth is shallow (i.e., less than 10-15 mm), the concrete is considered to have good durability, and the reinforcement is unlikely to be affected.

b. Deep Carbonation Depth: If the carbonation depth is deeper, approaching or exceeding the depth of the reinforcement, it indicates that the reinforcement may be at risk of corrosion due to the reduction in pH, which can lead to rust formation and expansion, potentially causing cracks in the concrete and compromising structural integrity.

c. Critical Depth: The carbonation depth is considered critical when it reaches the level of the reinforcement steel, typically around 30 mm or more in certain environmental conditions. In such cases, protective measures such as concrete repair, application of coatings, or corrosion inhibitors may be necessary to prevent reinforcement corrosion.

### Factors Affecting Carbonation Depth:

a. Environmental Conditions: Carbonation depth is influenced by environmental factors such as temperature, humidity, exposure to carbon dioxide, and air circulation around the concrete.

b. Concrete Mix: The composition of the concrete, including the water-cement ratio, type of cement, and curing conditions, can affect the rate and extent of carbonation. Higher-quality concrete (with a lower permeability) tends to carbonate more slowly.

c. Age of Concrete: Older concrete structures may show deeper carbonation due to prolonged exposure to the atmosphere.

# 4. Repair Methodology

Repairing and rehabilitating Reinforced Cement Concrete (RCC) structures such as flyovers involves a meticulous, multi-stage process to restore their structural integrity and extend their service life. Below is a detailed step-by-step procedure for the repair and rehabilitation of RCC flyovers.

## 1. Preparation and Temporary Support: -

### 1.1 Traffic Management

- **Objective:** Ensure safety and minimize disruption during repairs.
- **Plan:** Implement detours, road closures, and signage as needed.

### 1.2 Temporary Propping

- **Objective:** Provide temporary support to the structure during repairs.
- **Installation:** Set up propping systems to support beams, decks, or other elements that may be affected by repair work.

### 1.3 Temporary Covering

- **Objective:** Provide safety nets to avoid spreading of dust and free fall of loose concrete and tools.
- **Installation:** Cover the external area by safety net and ply wood protection also depending on the area or work under consideration.

## 2. Execution of Repairs: -

### 2.1 Cleaning

- **Objective:** Prepare surfaces for repair.
- **Method:** Remove loose concrete, rust, and debris using wire brushes, sandblasting, or other methods. Clean surfaces to ensure proper adhesion of repair materials.

### 2.2 Concrete Repair

- **Objective:** Restore damaged concrete to its original condition.
- **Methods:**
  - **Patch Repair:** Use repair mortars or concrete to fill cracks and voids. Apply bonding agents if necessary.
  - **Surface Treatment:** Apply sealers or coatings to protect the repaired surface from environmental damage.

### 2.3 Reinforcement Repair

- **Objective:** Address issues with corroded or damaged reinforcement.
- **Methods:**
  - **Rebar Replacement:** Replace or augment corroded reinforcement with new bars.
  - **Corrosion Protection:** Apply protective coatings or use corrosion inhibitors to existing rebar.

### 2.4 Crack Repair

- **Objective:** Seal and stabilize cracks in the structure.
- **Methods:**
  - **Epoxy Injection:** Fill cracks with epoxy resin to restore strength and prevent further water ingress.
  - **Grouting:** Use cementitious or epoxy-based grout to fill larger voids.

## 3. Strengthening Measures: -

### 3.1 Jacketing

- **Objective:** Increase the load-carrying capacity of structural elements.
- **Method:** Apply additional layers of concrete around columns or beams, including reinforcement, to enhance strength.

### 3.2 Fiber-Reinforced Polymer (FRP)

- **Objective:** Provide additional strength and durability.
- **Application:** Bond FRP sheets or wraps to structural elements to improve load capacity and resistance to environmental factors.

### 3.3 Steel Plates

- **Objective:** Enhance the strength of structural components.
- **Installation:** Attach steel plates to beams or columns as required, using bolts or welds.

## 4. Finishing and Quality Assurance: -

### 4.1. Surface Finishing

- **Objective:** Ensure the repaired surface is smooth and aesthetically acceptable.
- **Methods:** Polish, smooth, or texture surfaces as required.

### 4.2 Inspection

- **Objective:** Verify that all repairs meet quality standards.
- **Inspection:** Conduct thorough inspections to ensure compliance with specifications and repair effectiveness.

## Detail of Repair Methodology: -

### 1. Preparation and Temporary Support: -

a. **Scaffolding Erecting:** Erecting bamboo/steel scaffolding to access he damaged part of structural elements.

*Fig: - Scaffolding Erection*

b. **Covering & Protection:** Cover the external area by dust net / safety net to avoid direct fall of material / loose concrete & to avoid spreading of dust. Alternately use safety net and ply wood protection also depending on the area or work under consideration.

*Fig: - Safety Net Cover*

c. **Covering & Protection:** Supporting the structure by using steel props prior to chipping of plaster and breaking of loose concrete.



*Fig: - Safety Net Cover*

## 2. Execution of Repairs: -

1. **Chipping:** Chip off loose and infected concrete from surface of existing structural elements with help of chisel and hammer till sound concrete is encountered. Remove laitance, oil etc. present on concrete surface by grinding/ sand blasting. De-scale the surface of exposed reinforcement with help of brush to remove the rust scales. Carbonated concrete if left in structure shall initiate deterioration process. It is necessary to treat RCC element from all sides hence brickwork on the periphery of the structure shall be removed tentatively for repairing.
2. **Corrosion of steel reinforcement in Concrete:** Due to water Entry through Cracks, Pores, etc. Excessive Corrosion due to Chloride, CO2 from Atmosphere, SO2, HCL from Acid Rain. This all factors removes passivity obtained from concrete Induces Acid Formation. Its conversion into a porous Non-Protective scale. Excessive corrosion/ Rust formation induces stresses that crack concrete making it unsafe.

   a. Treatment to corrosion damaged existing exposed steel reinforcement.

      i. **Application of rust converting alkaline primer:** Thoroughly clean the corroded reinforcement/steel rebar by wire brush or rotary grinder. Remove all the corrosion scales present on the bare and reach upto sound steel. Apply of rust converting alkaline primer on corrosion affected steel bars after removing all the scales. It is alkaline in nature and converts both hematite & magnetite compounds into stable compounds. The material shall pass minimum 400 alternate immersion cycles of 2 minutes in 3.5%NaCl solution at room temperature.



*Fig: - Corrosion treatment of Column, Beam and Slab*

i. **Application of two coats of IP Net-RB anti corrosive epoxy coating on steel rebar:**

Application of primer shall be followed with application of two coats of IPNet-RB (confirming to CBRI requirement) anti corrosive epoxy coating for bar protection against future corrosion. Coating is for old as well as newly provided steel. This system (Interpenetrating polymer network system for rebars: IPNet-RB) once applied on steel shall provide extended protection against future carbonation and chloride attack. The material shall pass minimum 720 hours as per ASTM-B-117 and shall confirm to IS 2770 PART I and ASTM3963-86.

*Fig: - Corrosion treatment of Column, Beam and Slab*

b. **Protection of unexposed steel reinforcement inside concrete by migratory corrosion inhibitor (MCI):** Carry out application of Bi-polar migratory corrosion inhibitor on concrete surface by brush in two coats. This inhibitor has migratory kind of property which permits the material to migrate to a virtual extent of 60mm, through pores of concrete, inhibiting the corrosion and de-passivating the Electro-chemical reaction. It has property to attack anode as well as cathode, which is purely alkaline in nature (pH-9.5).

Material shall have evaluated test reports indicating significant reduction in corrosion rate after minimum 90 thermal cycles at 60° Centigrade followed by 8 weeks of accelerated corrosion indicative of its suitability for tropical applications.

Grout the corrosion inhibitor in case of excessively damaged RC sections by drilling 50 to 75mm deep holes at the spacing of 500mm c/c with the dosing of 100 ml per hole in concrete body

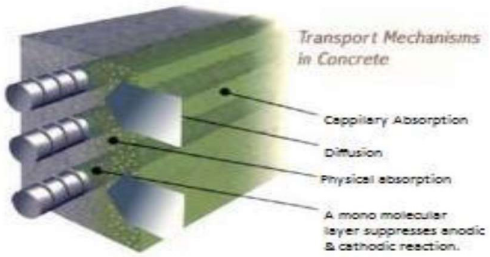



*Fig: - Reinforcement protection by Migratory Corrosion Inhibitor*

c. **Application of Corrosion inhibiting caplets:**

- Drill holes of 20 mm dia and 50 mm deep in RCC elements as per requirement at 2 to 4 per Sqm in corrosion damaged areas.
- Clean the drill holes and insert corrosion inhibiting power row caplet in it.
- Seal the hole with polymer cement putty

d. **Application of Embedded sacrificial Galvanic Anode for corrosion protection Installation:**

- Remove loose concrete from around and behind of corroding reinforcement
- Cleaning of corroded steel thoroughly with wire brush to remove loose rust and rust stains.
- Soak the Canode units in clean water for 20-30 minutes.

- Fasten the tie wires of Canode using pliers on the side or beneath the rebar to prevent free movement.

e. **Grouting of cracked concrete element:** Drilling holes in RCC / masonry element of 12 mm dia. and upto 100 mm deep and Fixing of injection nozzles with putty and allow to set and grouting the same with epoxy grout for RCC / cementitious grout for masonry element under pressure.

### 3. Making up of lost steel area due to corrosion by additional steel:

Makeup lost steel area due to corrosion by providing additional steel reinforcement. The steel shall confirm to IS 1786 grade Fe 415/ Fe 500. Anchor the steel rebar in sound concrete body up to desired depth by structural GRADE adhesive. Fixing of rebar is to be with pre left binding wires with existing steel at regular grid after aligning concrete profile with new mortar upto existing steel face.

*Fig: - Provision of additional reinforcement in Column, Beam and Slab*

### 4. Treatment to concrete core for strength improvement:

- Improving core concrete strength by pressure resin grouting Drilling holes & fixing nozzles in design grid.
- Pressure grouting of resin, monomer of polymers cement slurry as per requirement.
- Advantages: Penetrates even in fine cracks. Seals cracks, restores structural integrity.
- Good mechanical and durability properties.

*Fig: - Treatment to concrete core for strength improvement*

### 5. Sectional Reconstruction in excessively damaged reinforcement:

i. **Bonding Coat:** Bond between new and old concrete is important aspect for effective participation of total cross sectional area of concrete. Selection of type of bond coat is based on, type of stresses bond strata is expected to go and prevailing area where application is to be carried. After the various pre- treatments

apply liberal concrete surfaces as per detailed manufacturer procedure. Ensure that the application of new concreting is carried out during the pot life of material.

*Fig: - Bonding coat on Column, Beam and Slab*

**ii. Making up lost section with free flow Micro Concrete in case lost section is more than 25 mm:**

For replacing the carbonated part of concrete and repairing the damaged surface of concrete, fix the form work across the profile of damaged structural element. Pour the free flow concrete mix in the form work. Makeup concrete is based on type of structural element and its location.

*Fig: - Micro Concrete work on Column, Beam and Slab*

**iii. Making up lost section with latex modified mortar or premixed thixotropic repair mortar:**

Makeup mortar is based on type of structural element and its location. Here following type of modified mortars are recommended.

Modified mortar: For replacing the carbonated part of concrete and repairing the damaged surface of concrete usage of following formulated mortar is recommended.

Mix:

- Cement : 50 Kg
- Sand : 150 Kg
- Mono Bond : 2.5 to 5 Kg
- Water: 15 to 20 Ltr.


*Fig: - Modified Mortar work on Column, Beam and Slab*

### 6. Strengthening with non-metallic Fiber Reinforced composite :

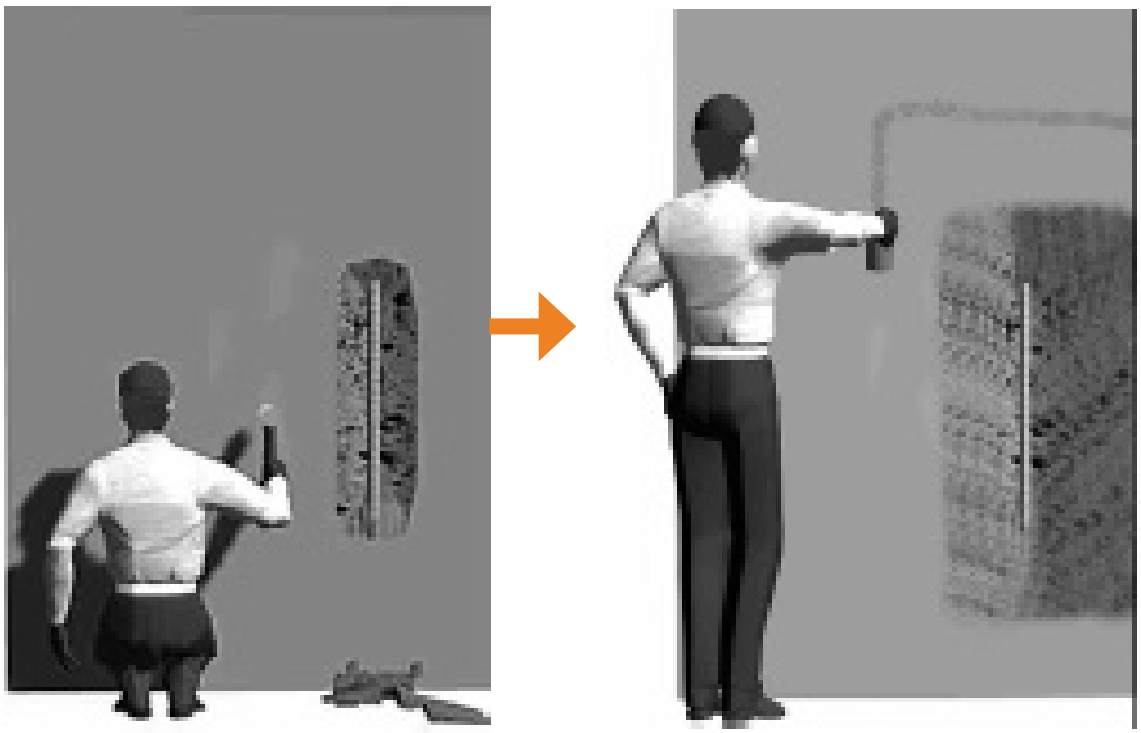
Wherever loss of shear and flexural reinforcement is more it is recommended to use various fibers wraps of glass and carbon in damaged areas.

- **Surface preparation:** Grind repaired concrete substrate for cleaning rounding sharp edges to min 20-25 mm radius.
- **Profiling:** Apply compatible primer on prepared substrate, Fill holes and uneven surface with thixotropic putty.
- **Wrapping:** Apply first coat of fiber compatible saturant, cut the fabric to size, wrap the fiber sheet to structural element at desired orientation using tamping roller to avoid any air voids.
- **Finishing:** Applying second coat of saturant after min. 12 hrs, rectify air voids if any.

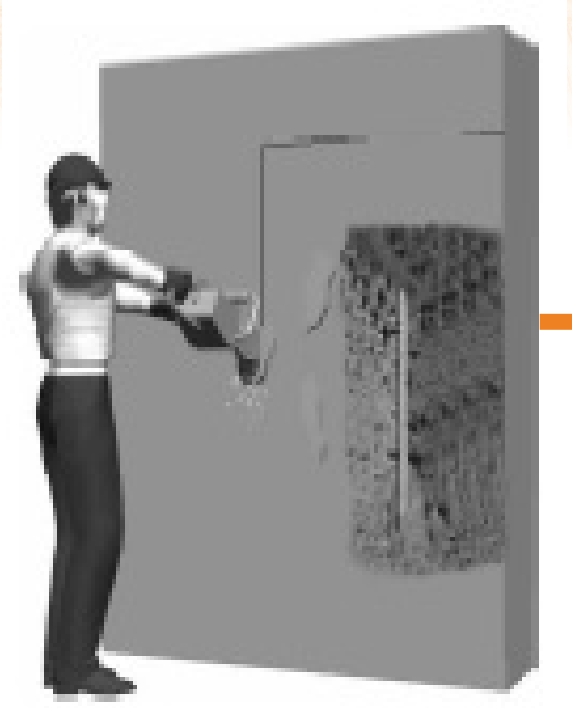
## Steps Followed for Repairs and Patch Repairs:-

**Step 1:-** Sounding of concrete to locate areas of delamination.

**Step 2:-** Mark perimeter of repair area. Layout should be simple geometric shapes.

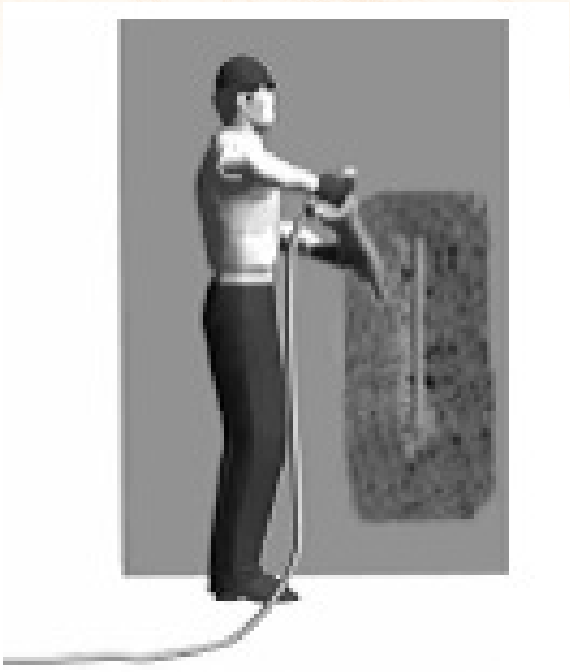


**Step 3: -** Saw cutting perimeter of repair.

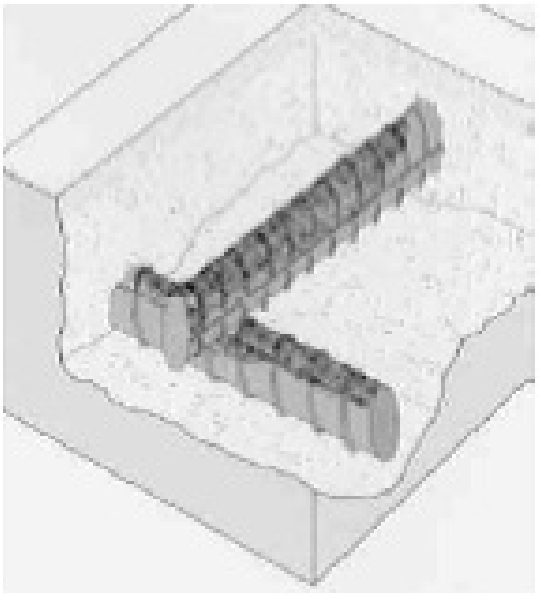


**Note:** saw cut should not be deeper than cover over reinforcement.

**Step 4: -** Unsound concrete removed with chipping hammer.



**Step 5: -** Reinforcement repair. When reinforcing steel is heavily Corroded & diameter is reduced.



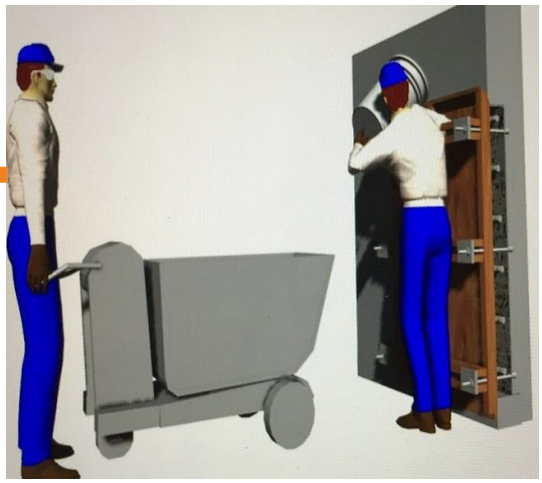
**Step 6: -** Cleaning of reinforcing steel& concrete with abrasive blast/ Grinding/ Wire brushing.

**Step 7: -** Treatment of exposed reinforcement- Alkaline rust converter, Zinc Rich Primer/ IPN, Sacrificial Anode, MCI Applications.

**Step 8: -** Typical equipment shall be used to mix materials- Ready to use mortars/ Micro Concrete.

**Step 9: -** Hand application of repair material in case of PMM application. The same can be done by fixing formwork in case of micro concreting.

**Step 10 : -** Sprinkle Curing.



## Methodology for WRAP SYSTEM

1. **Structural Preparation:**- Basic repairs must be made to the structure prior to strengthening with FRP. Spalled concrete removed, Corroded or damaged steel addressed, major cracks injected. Build the surface with polymer modified mortar or micro concrete.
2. **Surface Preparation: -** The surface to be repaired is typically rubbed off to smooth out irregularities, remove contaminants and provide corner radius to sharp edges. This can be performed by mechanical grinder.

*Fig: - Surface Preparation of RCC Column*

3. **Primer: -** In order to promote adhesion and prevent the surface from drawing resin from the FRP, a low viscosity epoxy primer is applied with a roller until the substrate is locally saturated.

*Fig: - Primer on RCC Column*

4. **Putty: -** Adhesive, high viscosity putty is applied where necessary to the surface to fill in 'bug holes 'offsets or voids.

*Fig: - Putty work on RCC wall*

5. **Cutting Fabric: -** In a clean area away from the resins, the fabric is carefully measured and cut in accordance with the specifications.

*Fig: - Cutting & Fixing of Carbon Fiber on Column & Beam*

6. **Saturating Fabric: -** On large, high volume projects, the fabric can be saturated using custom saturator. For lower volumes and shorter strips, the fabric can be either saturated on a table, or the surface can be coated with resin and the dry fabric applied.

*Fig: - Saturation of Carbon Fiber*

7. **Applying Fabric: -** The pre-wetted, or dry, fabric is carefully laid onto the surface and smoothened out to remove air bubbles and ensure that the fibers are straight.

*Fig: - Application of Carbon Fiber on RCC structure*

8. **Quality Control Monitoring: -** During the cure, 2 to 6 hours depending on ambient conditions, the fabric is checked to ensure that all air bubbles are removed and that the fabric is not sagging.

9. **Applying Second Coat: -** After inspection of wrapped fiber apply second coat of saturant on wrap and apply subsequent FRP layer as per design.

*Fig: - Application of second coat of Saturant on Carbon Fiber*

10. **Applying Sand pasting: -** When second coat becomes tacky apply coarse river sand if wrapping is to be followed by plastering or POP.

*Fig: - Sand pasting on Carbon Fiber*

11. **Applying Bond coat & plastering: -** Apply compatible bond coat on wrapped surfaces and carry out plastering with rich cement mortar

12. **Plying top Coat for Exposed surface: -** Apply compatible coating on external surfaces such as PU coating on FRP surface and anti-carbonation Coating on cement concrete surface.

## Methodology for Grouting

1. **Drilling Holes: -** Drill 12 mm diameter., 40 mm deep holes in structural members at the intervals of 600 mm in staggered manner or as directed by the consultants in RC structural element.
2. **Cleaning of Holes: -** Cleaning the


*Fig: - Drilling Holes*

holes by air blower prior to fixing nozzles.

3. **Fixing of Nozzles: -** Insert 12 mm diameter Teflon nozzles in cleaned holes, External end of nozzles to be machine to receive outlet of grouting gun. Fix it inside the holes by applying Epoxy putty to ensure complete sealing. Cure the system for min. 12 hrs.
4. **Mixing of materials: -** Mixing epoxy base material components (part A & B) in required quantities as per manufacturer's instruction by weigh batching.
5. **Grouting: -** Fill the grouting gun with epoxy resin. Maintain desired pressure in the gun by air compressor; maintain the pressure at exit (3 to 5 Kg/ cm2) by monitoring pressure gauge at exit or as per consultant's instruction. Grout the material through prefixed nozzles in the structural elements still its refusal. Seal the nozzle with Epoxy putty after the refusal. Monitor leakages through other nozzles while grouting and seal them as per the requirement. Repeat the process for all the nozzles. Complete the operation within pot life of the material.

*Fig: - Epoxy grouting through nozzle*

6. **Cutting of Nozzles: -** Cut the Nozzles by chisel after completion of grouting without damaging structural elements.

## Methodology for Bridge deck waterproofing:

1. **Site Assessment and Surface Preparation:**
   - **Inspection:** Conduct a thorough inspection of the deck surface to assess the extent of damage, cracks, leakage, and wear.
   - **Cleaning:** Clean the entire deck surface using mechanical means such as wire brushing, sandblasting, or water jetting to remove loose particles, dirt, old waterproofing materials, grease, and any contaminants. Ensure the surface is completely free from debris.
   - **Surface Repair:** Repair any visible cracks, potholes, or damaged sections of the deck using appropriate repair mortars or crack sealants. Ensure the surface is smooth and level.
   - **Drying:** Ensure the surface is dry before applying any chemical waterproofing treatment. This can take several hours or more depending on environmental conditions.
2. **Application of Priming Layer:**
   - **Priming:** Apply a primer suitable for the selected chemical waterproofing material. CPWD and MORTH guidelines specify that a good quality primer should be used to improve adhesion between the deck surface and waterproofing material.
   - Use epoxy or polyurethane-based primers as per specifications.
   - Apply the primer uniformly using rollers, brushes, or spray equipment. The primer must be allowed to cure for the recommended time as per the manufacturer's instructions.
2. **Selection of Waterproofing Material:**
   - **Chemical Waterproofing:** Select an appropriate chemical waterproofing material such as liquid membranes, elastomeric coatings, polyurethane coatings, or bituminous materials, depending on the project requirements and environmental conditions.
   - CPWD and MORTH guidelines typically recommend products that are durable, UV-resistant, and capable of withstanding vehicular load stresses and thermal expansion.
   - Ensure compatibility of the waterproofing chemical with the surface, traffic loads, and environmental exposure conditions.
4. **Application of Waterproofing Membrane:**
   - **Polyurethane (PU) or Epoxy Membranes:** The most commonly used methods include the application of a single or multiple layers of liquid membrane.
   - **First Layer:** Apply the first layer of the waterproofing chemical (e.g., PU or epoxy membrane) evenly over the primed surface. Use rollers or brushes for uniform distribution.
   - **Curing:** Allow the first layer to cure completely (as per the product instructions). Curing times vary based on temperature and humidity conditions.
   - **Second Layer:** If required, apply a second layer of the waterproofing material to ensure sufficient thickness for long-term protection.
5. **Application of Protective Coating (Optional):**
   - **Top Coating:** In some cases, a protective top coat (like UV-resistant coating or bituminous coating) may be applied over the

membrane to protect it from UV degradation, chemical exposure, and wear from traffic.

- **Thickness:** Ensure the coating has the required thickness, as per the specifications, to withstand extreme weather conditions, heavy traffic, and other environmental stresses.

6. **Detailing and Treatment of Junctions:**
   - **Edge Treatment:** Ensure proper detailing at the edges, joints, and corners of the deck. Apply additional layers of waterproofing material around the edges to ensure no water penetration at critical junctions.
   - **Drainage Treatment:** Inspect and repair the drainage system on the deck to ensure that water does not accumulate on the surface, which can compromise the waterproofing treatment.
   - **Joints and Cracks:** Use joint sealants to treat any existing joints (expansion joints, construction joints, etc.) and ensure they are adequately sealed with chemical sealants.
7. **Curing and Final Inspection:**
   - **Curing:** Allow adequate curing time for all layers of the waterproofing material, as per the manufacturer's instructions.
   - **Final Inspection:** After curing, conduct a final inspection to ensure that the waterproofing system is complete and has adhered to all quality standards.
   - **Testing:** Perform water spraying or water ponding tests to verify the effectiveness of the waterproofing system. Check for any leaks or failures.

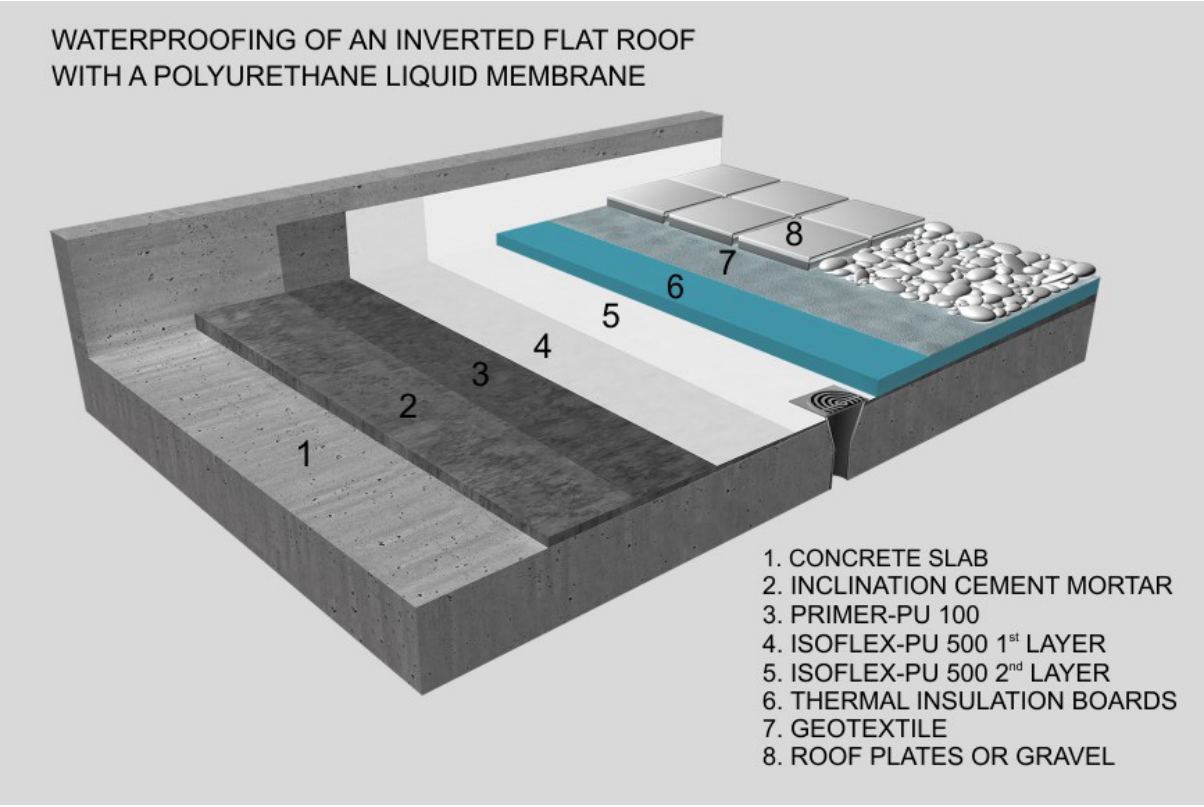



Fig: - Waterproofing of Bridge Deck Slab

## Methodology for Corrosion control of tendons of Pre-stressed concrete bridges:

The repair methodology for corrosion control of tendons in pre-stressed concrete bridges involves several critical steps to ensure the integrity of the tendons and prolong the service life of the structure. Here's a detailed methodology:

1. **Assessment of Corrosion Condition:**
   - Visual Inspection: Begin with a thorough visual inspection of the bridge's structure to detect visible signs of corrosion such as rust staining, spalling of concrete, or exposed tendons.
   - Non-Destructive Testing (NDT): Use NDT techniques like ultrasonic testing, radiography, or ground-penetrating radar (GPR) to assess the condition of the tendons, including the extent of corrosion and any potential damage.
   - Chloride Ion Testing: Measure chloride ion content at various depths in the concrete to determine the level of exposure and risk of corrosion.
   - Electrical Resistivity Measurements: Assess the likelihood of corrosion by measuring the electrical resistivity of the concrete surrounding the tendons.
2. **Identification of Corrosion Sources:**
   - Environmental Factors: Identify potential sources of corrosion, such as chloride ingress from de-icing salts, water seepage, or seawater in coastal environments.
   - Structural Factors: Check for cracks or defects in the concrete that might facilitate water ingress and accelerate corrosion.
3. **Corrosion Control Methodologies:**
   - Depending on the assessment and the severity of corrosion, the following corrosion control methods can be implemented:

a) **Cathodic Protection:**
   - Galvanic System: Install sacrificial anodes made of zinc or magnesium to protect the tendons by redirecting corrosion away from the steel.
   - Impressed Current Cathodic Protection (ICCP): This method uses a direct current system to protect the tendons. A power supply is used to impress a current that counteracts the corrosion process on the tendons.

b) **Concrete Repair and Protection:**
   - Crack Injection: For bridges with cracked concrete, use epoxy or polyurethane crack injection to seal cracks and prevent further water infiltration and chloride ingress.
   - Surface Coatings: Apply protective coatings, such as silane or siloxane-based treatments, to prevent moisture and chloride from reaching the tendons.
   - Corrosion Inhibitors: Integrate corrosion inhibitors into the concrete mix or apply them as surface treatments to slow down the corrosion process.

c) **Tendon Replacement or Rehabilitation:**
   - If corrosion has compromised the tendon strength, partial or full tendon replacement might be necessary. This could involve:
   - Post-Tensioning System: Install new post-tensioning tendons to replace the corroded ones.
   - Tendon Encapsulation: In cases where tendon replacement is not

feasible, encapsulate the corroded tendons in a corrosion-resistant material, such as a fiber-reinforced polymer (FRP) wrap or corrosion-resistant ducting, to protect them.

**d) Concrete Jacketing:**

- If significant concrete degradation has occurred around the tendons, use concrete jacketing to provide additional protection and restore the cross-sectional area of the structural members. This involves encasing the damaged element with a new layer of concrete.

**4. Monitoring and Maintenance:**

- Post-Repair Monitoring: After applying the repair techniques, monitor the bridge regularly for signs of re-corrosion or failure using sensors, regular visual inspections, and NDT techniques.
- Long-Term Maintenance: Implement a regular maintenance program to check for early signs of corrosion and apply preventive measures, such as re-coating or re-application of inhibitors, as necessary.

**5. Documentation and Reporting:**

- Maintain detailed records of the repair work, including the methods used, materials applied, and the current condition of the tendons. This documentation is essential for future monitoring and repairs.

**6. Preventive Measures:**

- De-icing Salt Management: In regions where de-icing salts are commonly used, ensure proper drainage systems are in place to limit salt exposure to the tendons.
- Environmental Protection: Consider using more advanced corrosion-resistant materials, such as stainless-steel tendons or FRP tendons, for future construction to avoid corrosion-related issues.

By following these steps, the corrosion of tendons in pre-stressed concrete bridges can be effectively controlled, ensuring the safety and longevity of the structure.

# 5. Inspection and Maintenance Requirements for POT-PTFE Bearings

1. **Design and Maintenance-Free Goal**
   - Bearings should be designed to be maintenance-free, minimizing the impact of environmental conditions.
   - The surrounding area of the bearings should be kept clean and dry to prevent damage.
2. **Access for Inspection**
   - Ensure easy access to the bearings for inspection and maintenance.
   - Provide enough space around the bearing for manoeuvring and ensure the ability to lift the superstructure for repairs or replacements.
3. **Inspection Frequency**
   - Inspect bearings yearly for the first five years, then every two years.
   - Perform additional inspections after unusual events like heavy traffic, earthquakes, cyclones, or floods.
4. **Cleaning Before Inspection**
   - Clean the bearings and surrounding area of debris, dust, salt, or other contaminants before inspection.

### Elements of Inspection: -

1. **Measurement of Movement**
   - Measure and record the bearing's movement and rotation during inspections.
   - Measure movement in winter and summer, with corresponding temperature records.
   - Compare the measured values with the design values.
2. **Measurement of Dimensions**
   - Measure the overall dimensions of the bearing and compare them to design dimensions to check for excessive stress or strain.
3. **Evidence of Locked-in Condition**
   - If any movable part is jammed, immediate corrective action must be taken.
4. **Evidence of Corrosion**
   - If corrosion is detected, clean the affected area, apply a protective coating, and identify the root cause to prevent recurrence.
5. **Condition of Adjacent Structure**
   - Inspect the adjacent bridge structure for damage and repair it as needed.

### Results and Actions: -

1. **Action Classifications**
   - No Action: No issues detected.
   - Further measurements or long-term monitoring needed (e.g., due to extreme conditions or variable loads).
   - Minor repairs such as cleaning or repainting.
   - Major repairs or replacement of bearings or parts of bearings.
2. **Consult Manufacturer**
   - If the cause of defects cannot be determined, consult the bearing manufacturer for guidance.

# 6. Material and Chemical Specifications

When rehabilitating RCC (Reinforced Cement Concrete) structures, the choice of materials and chemicals is crucial for ensuring the effectiveness, durability, and safety of the repairs. Here's a detailed guide on materials and chemicals commonly used in RCC structure rehabilitation.

## 1. Concrete Repair Materials: -

### 1.1 Repair Mortars: -

- **Types:**
  - **Cementitious Mortars:** Used for patching and resurfacing. Typically include Portland cement, sand, and additives.
  - **Polymer-Modified Mortars:** Enhance adhesion, flexibility, and durability. Includes polymers such as acrylic or styrene-butadiene rubber (SBR).
- **Specifications:**
  - **Compressive Strength:** Generally, 20-50 MPa (depending on the application).
  - **Bond Strength:** Typically,>1.0 MPa to concrete.
  - **Shrinkage:** Low shrinkage to prevent cracking.

### 1.2 Repair Concrete: -

- **Composition:**
  - **Cement:** Ordinary Portland Cement (OPC) or blended cements.
  - **Aggregates:** Clean, well-graded sand and gravel or crushed stone.
  - **Admixtures:** To control setting time and workability.
- **Specifications:**
  - **Compressive Strength:** Typically,>25 MPa.
  - **Workability:** Adjusted to match application requirements.
  - **Durability:** Must be resistant to environmental conditions.

## 2. Reinforcement Repair Materials: -

### 2.1 Epoxy Resins: -

- **Usage:** For bonding, crack filling, and corrosion protection.
- **Specifications:**
  - **Viscosity:** Low viscosity for deep penetration.
  - **Curing Time:** Typically, 30 minutes to 24 hours, depending on the formulation.
  - **Tensile Strength:** High, often >20 MPa.
  - **Adhesion:** Excellent adhesion to concrete and steel.

### 2.2 Corrosion Inhibitors: -

- **Types:**
  - **Surface Applied Inhibitors:** Coatings or treatments applied directly to the surface.
  - **Admixed Inhibitors:** Added to repair mortars or concrete.
- **Specifications:**
  - **Effectiveness:** Must significantly reduce corrosion rates of reinforcement.
  - **Compatibility:** Should be compatible with repair mortars and existing concrete.

## 3. Crack Repair Materials: -

### 3.1 Epoxy Injection Systems: -

- **Components:** Epoxy resin and hardener.
- **Specifications:**
  - **Viscosity:** Low to allow deep penetration.
  - **Bond Strength:** High bond strength to concrete.
  - **Curing Time:** Varies, but typically 24 hours to full cure.

### 3.2 Polyurethane Sealants: -

- **Usage:** For filling and sealing cracks.
- **Specifications:**
  - **Elasticity:** High to accommodate movement.
  - **Adhesion:** Good adhesion to concrete.
  - **Weather Resistance:** UV and moisture resistant.

## 4. Surface Protection: -

### 4.1 Surface Sealers: -

- **Types:**
  - **Penetrating Sealers:** Silicone or silane-based sealers that penetrate the concrete.
  - **Film-Forming Sealers:** Acrylic or polyurethane-based that form a protective film on the surface.
- **Specifications:**
  - **Water Permeability:** Low to resist water ingress.
  - **Durability:** Resistant to UV, chemicals, and abrasion.
  - **Application:** Easy to apply and maintain.

### 4.2 Protective Coatings: -

- **Types:**
  - **Epoxy Coatings:** For high-performance protection against chemicals and abrasion.
  - **Polyurethane Coatings:** For flexibility and UV resistance.

- **Specifications:**
  - **Dry Film Thickness:** Typically 200-500 microns.
  - **Adhesion:** Strong adhesion to concrete surfaces.
  - **Chemical Resistance:** Resistant to commonly encountered chemicals.

## 5. Bonding Agents: -

### 5.1 Acrylic Bonding Agents: -

- **Usage:** To improve adhesion between old and new concrete.
- **Specifications:**
  - **Composition:** Acrylic polymers in water-based formulations.
  - **Application:** Apply as a primer before placing repair mortar.
  - **Bond Strength:** Excellent adhesion to concrete surfaces.

### 5.2 SBR (Styrene-Butadiene Rubber): -

- **Usage:** As a latex additive in repair mortars.
- **Specifications:**
  - **Composition:** A liquid polymer that improves bond strength and flexibility.
  - **Mix Ratio:** Typically, 1:1 or as per manufacturer's instructions.

## 6. Concrete for Jacketing: -

### 6.1 Normal Concrete: -

- **Composition:**
  - **Cement:** Ordinary Portland Cement (OPC) or blended cement (e.g., Portland Pozzolana Cement).
  - **Aggregates:** Well-graded coarse and fine aggregates (clean sand and crushed stone or gravel).
  - **Water:** Clean and free from impurities.
  - **Admixtures:** To enhance properties, such as workability or setting time.
- **Specifications:**
  - **Compressive Strength:** Typically, 25-40 MPa, depending on the structural requirements.
  - **Mix Ratio:** Standard mix ratios are 1:1.5:3 (cement: sand) or as per structural design requirements.
  - **Workability:** Adjusted using water and admixtures to achieve the desired consistency.

### 6.2 High-Performance Concrete (HPC): -

- **Usage:** For environments requiring enhanced durability.
- **Composition:**
  - **Cement:** OPC or high-strength cement.
  - **Aggregates:** High-quality, well-graded aggregates.
  - **Admixtures:** Super plasticizers, shrinkage-reducing agents, and others.

- **Specifications:**
  - **Compressive Strength:** Typically>40 MPa.
  - **Durability:** Enhanced resistance to environmental factors like moisture and chemicals.

## 7. Admixtures: -

### 7.1 Waterproofing Admixtures: -

- **Types:**
  - **Integral Waterproofing Admixtures:** Added to concrete mix to reduce water permeability.
  - **Surface Applied Waterproofing:** Applied as a coating on the concrete surface.
- **Specifications:**
  - **Water Permeability:** Must significantly reduce water ingress.
  - **Compatibility:** Should be compatible with cement and other admixtures.

### 7.2 Accelerators and Retarders: -

- **Usage:** To control the setting time of repair mortars or concrete.
- **Specifications:**
  - **Accelerators:** Speed up setting time in cold weather.
  - **Retarders:** Delay setting time in hot weather.

## 8. Fibre-Reinforced Polymer Materials: -

### 8.1 Carbon Fibre-Reinforced Polymer (CFRP): -

- **Composition:** Carbon fibres embedded in an epoxy matrix.
- **Properties:**
  - **Tensile Strength:** Typically,>5000 MPa.
  - **Modulus of Elasticity:** Approximately 150-250 GPa.
  - **Density:** Around 1.5-2.0 g/cm$^3$.
  - **Thermal Stability:** High thermal resistance.

### 8.2 Glass Fiber-Reinforced Polymer (GFRP): -

- **Composition:** Glass fibres embedded in a polymer matrix, often epoxy or vinyl ester.
- **Properties:**
  - **Tensile Strength:** Generally, 800-1500 MPa.
  - **Modulus of Elasticity:** Approximately 70-90 GPa.
  - **Density:** Around 1.9-2.5 g/cm$^3$.
  - **Corrosion Resistance:** Excellent, particularly in acidic environments.

### 8.3 Aramid Fiber-Reinforced Polymer (AFRP): -

- **Composition:** Aramid fibres (such as Kevlar) in a polymer matrix.
- **Properties:**
  - **Tensile Strength:** Typically, 2000-3000 MPa.
  - **Modulus of Elasticity:** Approximately 60-80 GPa.
  - **Density:** Around 1.4-1.5 g/cm$^3$.
  - **Impact Resistance:** High impact resistance.

## 9. FRP Sheets and Plates: -

### 9.1 CFRP Sheets and Plates: -

- **Specifications:**
  - **Thickness:** Typically, 0.1-2.0 mm.
  - **Width:** Generally, up to 1.2 meters.
  - **Length:** Variable, often in rolls or cut to size.
  - **Tensile Strength :**> 5000 MPa.
  - **Modulus of Elasticity:** 150-250 GPa.

### 9.2 GFRP Sheets and Plates: -

- **Specifications:**
  - **Thickness:** Typically, 0.5-5.0 mm.
  - **Width:** Generally, up to 1.5 meters.
  - **Length:** Variable, often in rolls or cut to size.
  - **Tensile Strength:** 800-1500 MPa.
  - **Modulus of Elasticity:** 70-90 GPa.

### 9.3 AFRP Sheets and Plates: -

- **Specifications:**
  - **Thickness:** Typically, 0.2-3.0 mm.
  - **Width:** Generally, up to 1.2 meters.
  - **Length:** Variable, often in rolls or cut to size.
  - **Tensile Strength:** 2000-3000 MPa.
  - **Modulus of Elasticity:** 60-80 GPa

# 7. List of Approved Manufacturer & Supplier

| S. No. | Description of item | Approved Make |
|---|---|---|
| 1 | Reinforcing Bars | TISCO, SAIL, RINL, IISCO, Jindal Steel & Power Ltd. and JSW Steel Ltd. |
| 2 | Micro Concrete | FOSROC, SIKA, BASF, Asian Paints Limited “Smartcare, Sunanda |
| 3 | Admixtures | FOSROC, SIKA, Pidilite Industries Ltd, BASF, Asian Paints Limited “Smartcare”, Sunanda |
| 4 | Release Agent | FOSROC, BASF, Dura Build Care , CICO, Sunanda |
| 5 | Epoxy | FOSROC, SIKA, BASF, Pidilite Industries Ltd, HindCon Chemicals Ltd, Asian Paints Limited “Smartcare”, Sunanda. |
| 6 | Bonding Agent | FOSROC, SIKA, BASF, Pidilite Industries Ltd., Asian Paints Limited “Smartcare”, Sunanda. |
| 7 | Non-shrink grout | Conbextra HF of Fosroc Chemicals, Sika, Asian Paints Limited “Smartcare”, Pidilite Industries Ltd, BASF, Sunanda |
| 8 | Structural Steel | TISCO, SAIL, RINL, IISCO, JSW, JSPL |
| 9 | Stainless Steel | Prism Engineers, JSW, JSPL |
| 10 | Welding Electrodes | ESAB, Advani-orlikon, Weld Alloy, Lincoln |
| 11 | Expansion joint | Sanfield (India) Ltd., Hercules Structural Systems Pvt. Ltd. Mageba, Z-Tech (India) Pvt.Ltd. |
| 12 | Bearings | METCO, Sanfield (India) P Ltd., Mageba, Dynamic, Hercules Structural Systems Pvt. Ltd., |
| 13 | Mild Steel Tubes | TISCO, SAIL, RINL, IISCO, JSW, JSPL |
| 14 | Paints | Akzo Nobel, Berger (Luxol gold), Jenson and Nicholson, Asian Paints (Apcolite), ICI Dulux (Gloss), Nerolac (Full gloss hard drying), Sunanda |
| 15 | High Gloss Acrylic Polysiloxane paint | International, Sunanda |
| 16 | Anti carbonation paints | SIKA, FOSROC, Pidilite Industries Ltd, BASF, SUNANDA, Asian Paints Limited “Smartcare”, Sunanda. |
| 17 | Paver block | Nitco Tiles, TERRAFIRMA, UNISTONE, KK, Perfect tiles, KJS Concrete |
| 18 | Kerb stones | Nitco Tiles, TERRAFIRMA, UNISTONE, KK, Perfect tiles, KJS Concrete |
| 19 | Bitumen | IOCL, BPCL, HPCL |
| 20 | RMC | ACC, BIRLA, Laffarge Cement, Ultra Tech and other manufacturer of RMC subjected to approval of Engineer-in-charge. (The contractor shall submit the RMC plant list for approval) |
| 21 | Ploymer modified concrete (Pre-packed) | FOSROC, SIKA, BASF, Asian Paints Limited “Smartcare”, Sunanda. |
| 22 | CFRP composite material | FOSROC, SIKA, BASF, FYFE, Asian Paints Limited “Smartcare”, Sunanda. |
| 23 | Anchor fastener | HILTI, BOSCH |

| S. No. | Description of item | Approved Make |
|---|---|---|
| 24 | Pre-stressing System | Freyssinet, BBR, VSL, Dynamic Pre-stressing India Pvt. Ltd |
| 25 | PT Cables | FOSROC, BASF, SIKKA |
| 26 | Chemical Anchors | FOSROC, BASF, SIKKA, M/s Wuerth India Pvt. Ltd, Sunanda |
| 27 | Bearing Grout | FOSROC, BASF, SIKKA, Asian Paints Limited “Smartcare”, Sunanda. |
| 28 | High Tensile Steel Strand | TATA Steel, SSL, Usha Martin. |
| 29 | Epoxy Grout | M/s Huntsman Advance Materials Pvt. Ltd.,<br>M/s. Fosroc Chemicals (India) Ltd., M/s. BASF (India) Pvt. Ltd., M/s. Dr. Beck & Co. Pvt. Ltd. Asian Paints Limited “Smartcare”.<br>M/s Krishna Conchem Products Pvt Ltd, Sunanda |
| 30 | Epoxy Mortar | M/s. Huntsman Advance MaterialsPvt.Ltd.,M/s. Fosroc Chemicals (India) Ltd., M/s. Pidilite India Pvt. Ltd.<br>M/s. BASF (India) Ltd. Asian Paints Limited “Smartcare”.<br>M/s Krishna Conchem Products Pvt Ltd, Sunanda |
| 31 | Ferrocement Lining | Hilti India Ltd. , MICO Bosch Ltd. or any equivalent |
| 32 | Carbon Fibre Reinforced Polymer (CFRP) wrap : | Toyfo system of M/s FYFE<br>Sikadur of M/s Sikaqualcrete, MBRACE SYSTEM oF M/s BASF Pvt. Ltd. The above properties are for longitudinal direction of fibre, Relinforce of Reliance Industries Ltd.<br>Asian Paints Limited “Smartcare”, Sunanda. |
| 33 | Rebar Chemical | M/s Wuerth India Pvt. Ltd, Fisher FIS EB 390 S |
| 34 | SS Stone Cladding Clamps | M/s Wuerth India Pvt. Ltd, Hilti |
| 35 | Dash Fastener | M/s Wuerth India Pvt. Ltd, Hilti |
| 36 | Cement OPC | ACC, Ultratech, Birla, Vikram, Ambuja, Jaypee Cement, Century Cement, J.K.Cement |
| 37 | Low viscosity Grout cum sealer | FOSROC, SIKA, Sunanda. |
| 38 | Single component, liquid applied, moisture cured polyurethane elastomeric membrane with 700% to 900% elongation | FOSROC, SIKA, Sunanda. |
| 39 | Sacrificial Anode | Krishna Conchem, Vector, Sunanda |
| 40 | Rust Remover | FOSROC, SIKA, Sunanda |
| 41 | Polyurethane Coating | FOSROC, SIKA, Sunanda |
| 42 | Crystalline Admixture | Penetron, Xypex, Sunanda |

# 8. Flyover and Underpass Repair and Rehabilitation Check list

| S. No. | Component | Detail | Check |
|---|---|---|---|
| **1** | **Foundation** | | |
| 1.1 | Foundation Depth | Verify depth as per design specifications | [ ] |
| 1.2 | Foundation Width | Check width consistency with design drawings | [ ] |
| 1.3 | Foundation Integrity | Inspect for cracks or signs of distress | [ ] |
| 1.4 | Foundation Drainage | Ensure proper drainage to prevent water logging | [ ] |
| **2** | **Abutment** | | |
| 2.1 | Alignment | Verify alignment with design drawings | [ ] |
| 2.2 | Cracks | Check for any visible cracks or deformations | [ ] |
| 2.3 | Bearing Capacity | Confirm bearing capacity as per design | [ ] |
| 2.4 | Drainage | Inspect drainage systems for blockage or damage | [ ] |
| **3** | **Pier** | | |
| 3.1 | Alignment | Check vertical alignment with design | [ ] |
| 3.2 | Cracks | Inspect for cracks or any sign of deterioration | [ ] |
| 3.3 | Load Bearing | Verify load-bearing capacity | [ ] |
| 3.4 | Surface Finish | Check for any irregularities or spalling | [ ] |
| **4** | **Pier Cap** | | |
| 4.1 | Surface Integrity | Inspect for cracks or surface defects | [ ] |
| 4.2 | Dimensions | Confirm dimensions are as per design | [ ] |
| 4.3 | Load Distribution | Check for even load distribution | [ ] |
| **5** | **Pedestal** | | |
| 5.1 | Alignment | Verify vertical alignment with design | [ ] |
| 5.2 | Cracks | Inspect for any visible cracks or damage | [ ] |
| 5.3 | Load Bearing | Ensure load-bearing capacity meets requirements | [ ] |
| **6** | **Girder** | | |
| 6.1 | Alignment | Check alignment with design specifications | [ ] |
| 6.2 | Surface Condition | Inspect for any visible defects or damage | [ ] |
| 6.3 | Welds/Connections | Verify welds and connections for integrity | [ ] |
| **7** | **Deck Slab** | | |
| 7.1 | Surface Condition | Check for cracks, spalling, or surface defects | [ ] |

| S. No. | Component | Detail | Check |
|---|---|---|---|
| 7.2 | Thickness | Verify thickness meets design specifications | [ ] |
| 7.3 | Reinforcement | Ensure reinforcement is as per design | [ ] |
| **8** | **Wearing Coat** | | |
| 8.1 | Surface Condition | Inspect for wear and tear, cracks, or defects | [ ] |
| 8.2 | Thickness | Verify thickness is uniform and meets standards | [ ] |
| 8.3 | Adhesion | Check for proper adhesion to the deck slab | [ ] |
| **9** | **Bearing** | | |
| 9.1 | Condition | Inspect bearings for wear, corrosion, or damage | [ ] |
| 9.2 | Movement | Check for proper movement and alignment | [ ] |
| 9.3 | Lubrication | Ensure bearings are properly lubricated | [ ] |
| **10** | **Expansion Joint** | | |
| 10.1 | Condition | Inspect joints for cracks, damage, or deformation | [ ] |
| 10.2 | Functionality | Verify the expansion and contraction functionality | [ ] |
| 10.3 | Sealing | Check for proper sealing and absence of leaks | [ ] |
| **11** | **Crash Barrier** | | |
| 11.1 | Alignment | Verify alignment with design specifications | [ ] |
| 11.2 | Integrity | Check for structural integrity and damage | [ ] |
| 11.3 | Height & Strength | Ensure height and strength meet safety standards | [ ] |
| **12** | **Anti-Carbonation Paint** | | |
| 12.1 | Coverage | Inspect for complete and uniform coverage | [ ] |
| 12.2 | Condition | Check for peeling, cracking, or fading | [ ] |
| 12.3 | Application | Verify proper application techniques were used | [ ] |

# 9. Standard Operation Procedure for (SOP's) Repair and Rehabilitation work on Flyover

## Pre-Construction Phase: -

1. **Traffic Management Plan:**
   - Identify alternative routes and diversions.
   - Plan traffic signaling and signage.
   - Coordinate with traffic authorities.
2. **Media Publication:**
   - Publish notices in local newspapers.
   - Inform the public about the rehabilitation work, duration, and traffic arrangements through Radio FM, social media.
3. **Removal of Encroachments:**
   - Identify and remove encroachments, such as vendors, hawkers, and unauthorized structures.
   - Coordinate with local authorities and law enforcement agencies.
4. **Utility Shifting:**
   - Identify and shift utilities, such as electricity, water, and gas lines.
   - Coordinate with utility providers.
5. **Environmental Clearance:**
   - Obtain necessary environmental clearances.
   - Ensure compliance with environmental regulations.

## Construction Phase: -

1. **Traffic Closure:**
   - Close the flyover/underpass to traffic, as per the traffic management plan.
   - Ensure adequate signage and diversion routes.
2. **Site Preparation:**
   - Clear the site from encroachments and obstructions.
   - Ensure a safe working environment.
3. **Rehabilitation Work:**
   - Execute the rehabilitation work, including:
   - Repairing/replacing expansion joints.
   - Resurfacing the road.
   - Repairing/replacing damaged structures.

4. **Quality Control:**
   - Monitor and ensure the quality of work (Throughout construction phase).
   - Conduct regular inspections and testing (Throughout construction phase).

## Post-Construction Phase: -

1. **Traffic Opening:**
   - Open the flyover/underpass to traffic, after completion of work.
   - Ensure all safety measures are in place.
2. **Media Publication:**
   - Publish completion notices in local newspapers.
   - Inform the public about the completed rehabilitation work through Radio FM, social media.
3. **Removal of Site Establishments:**
   - Remove all site establishments, including scaffolding, cranes, and equipment.
   - Restore the site to its original condition.
4. **Final Inspection:**
   - Conduct a final inspection to ensure the work meets the required standards.
   - Obtain a completion certificate from the authorities.

## Additional Considerations: -

1. **Public Safety:**
   - Ensure public safety throughout the construction phase.
   - Provide adequate signage, barriers, and lighting.
2. **Emergency Services:**
   - Ensure access for emergency services, such as ambulances and fire trucks.
   - Coordinate with emergency services providers.
3. **Local Body Engagement:**
   - Engage with local authorities and stakeholders.
   - Address concerns and provide updates on the rehabilitation work.

# 10. Frequency to replacement of Bearings and Expansion Joint in Flyovers

The replacement interval for flyover expansion joints, elastomeric bearings, and metal bearings is not strictly defined in terms of a fixed timeline but rather depends on several factors such as condition, usage, and environmental impact. However, here are general guidelines and considerations for each type of component based on common practices and industry standards.

| S. No. | Component | Typical Replacement Interval | Factors Affecting Replacement | Guidelines for Replacement |
|---|---|---|---|---|
| 1. | Expansion Joints | 10 to 15 years | Heavy traffic, extreme weather, poor maintenance | Regular inspections for signs of wear, damage, or leakage. Replace if significantly deteriorated. |
| 2. | Elastomeric Bearings | 15 to 25 years | Quality of materials, load conditions, environmental impact (e.g., chemicals, temperatures) | Inspect for cracks, deformation, or loss of elastomeric properties. Replace if signs of significant damage are present. |
| 3. | Metal Bearings | 20 to 30 years | Corrosion, wear, mechanical damage | Inspect regularly for corrosion, wear, or deformation. Replace if severe damage or reduced performance is observed. |

# 11. Items for Rehabilitation Work

## (Analysis of Rate)

**Based on DSR-2023/Vol-1/1.1.18**

**Item 1 :-** Disposal of moorum/building rubbish/ malba/ similar unserviceable, dismantled or waste material by mechanical transport including loading, transporting, unloading to approved municipal dumping ground for lead upto 10 km for all lifts, complete as per directions of Engineer-in-charge. Note - item to be applicable in urban areas having directions for restricted hours for movement/ plying of load carrying motor vehicle of 3.5 cum or more

| Code | Descriptrion | Unit | Qty. | Rate | Amount |
|---|---|---|---|---|---|
| | Details of cost for 3.00 tirps of 8 cum capacity. | | | | |
| | **LABOUR** | | | | |
| **0084** | Hire charges of Diesel Truck - 9 tonne excluding diesel & mobile oil | Day | 1.00 | | |
| **0114** | Beldar | Day | 6.00 | | |
| **1235** | Diesel oil | Ltr | 19.56 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 8.0 cum | | | | |
| | Cost of 1.0 cum | | | | |
| | Say | | | | |

**Based on DSR-2023/Vol-1/2.1.1**

**Item 2.1 :-** Earth work in surface excavation not exceeding 30 cm in depth but exceeding 1.5 m in width as well as 10 sqm on plan including getting out and disposal of excavated earth upto 50 m and lift upto 1.5 m, as directed by Engineer-in- Charge: All kinds of soil

| Code | Descriptrion | Unit | Qty. | Rate | Amount |
|---|---|---|---|---|---|
| | Details of cost for 100 Sqm | | | | |
| | **LABOUR** | | | | |
| **0114** | Beldar | Day | 6.80 | | |
| **0115** | Coolie | Day | 5.60 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 100.0 sqm | | | | |
| | Cost of 1.0 sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/2.2.1 | | | | | |
|---|---|---|---|---|---|
| **Item 2.2 :-** Earth work in rough excavation, banking excavated earth in layers not exceeding 20 cm in depth, breaking clods, watering, rolling each layer with ½ tonne roller or wooden or steel rammers, and rolling every 3rd and top-most layer with power roller of minimum 8 tonnes and dressing up in embankments for roads, flood banks, marginal banks and guide banks or filling up ground depressions, lead upto 50 m and lift upto 1.5 m : All kinds of soil | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 10 cum. | | | | |
| | **LABOUR** | | | | |
| **0114** | Beldar | Day | 5.90 | | |
| **0115** | Coolie | Day | 3.60 | | |
| **0101** | Bhisti | Day | 0.40 | | |
| **0113** | Chowkidar | Day | 0.008 | | |
| | Roller charges (one roller does 1850 sqm. Of consolidation per day) | | | | |
| **0008** | Hire charges of Diesel Road Roller - 8 to 10 tonne | Day | 0.008 | | |
| **9999** | Sundries | LS | 2.73 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 10.0 cum | | | | |
| | Cost of 1.0 cum | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/2.6.1 | | | | | |
|---|---|---|---|---|---|
| **Item 2.3 :-** Earth work in excavation by mechanical means (Hydraulic excavator)/manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-in-charge. : All kinds of soil. | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 10 cum. | | | | |
| | Average output of Hydraulic Excavator per hour = 30cum | | | | |
| | **MACHINERY** | | | | |
| **0020** | Hydraulic Excavator (3D) with driver and fuel | Day | 0.041 | | |
| **0018** | Hire and running charges of loader | Day | 0.041 | | |
| | **LABOUR** | | | | |
| **0128** | Mate | Day | 0.32 | | |
| **0115** | Coolie | Day | 1.20 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 10.0 cum | | | | |
| | Cost of 1.0 cum | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/2.28.1 | | | | | |
|---|---|---|---|---|---|
| **Item 2.4 :-** Surface dressing of the ground including removing vegetation and in-equalities not exceeding 15 cm deep and disposal of rubbish, lead up to 50 m and lift up to 1.5 m. : All kinds of soil | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 100 sqm. | | | | |
| | **LABOUR** | | | | |
| **0114** | Beldar | Day | 1.97 | | |
| **0115** | Coolie | Day | 1.29 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 100.0 sqm | | | | |
| | Cost of 1.0 sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/2.31 | | | | | |
|---|---|---|---|---|---|
| **Item 2.5 :-** Surface dressing of the ground including removing vegetation and in-equalities not exceeding 15 cm deep and disposal of rubbish, lead up to 50 m and lift up to 1.5 m. : All kinds of soil | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | Amount |
| | Details of cost for 100 sqm. | | | | |
| | **LABOUR** | | | | |
| **0114** | Beldar | Day | 1.08 | | |
| **0115** | Coolie | Day | 0.60 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 100.0 sqm | | | | |
| | Cost of 1.0 sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/2.32 | | | | | |
|---|---|---|---|---|---|
| **Item 2.6 :-** Clearing grass and removal of the rubbish up to a distance of 50 m outside the periphery of the area cleared. | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 100 sqm. | | | | |
| | **LABOUR** | | | | |
| **0114** | Beldar | Day | 0.60 | | |
| **0115** | Coolie | Day | 0.25 | | |
| **9999** | Sundries | LS | 1.82 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 100.0 sqm | | | | |
| | Cost of 1.0 sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/5.9.2 | | | | | |
|---|---|---|---|---|---|
| **Item 3.1 :-** Centering and shuttering including strutting, propping etc. and removal of form for : Walls (any thickness) including attached pilasters, butteresses, plinth and string courses etc. | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details for 7.9m long and 1.00m high wall Area of contact 2x7.9x1.0 = 15.8 sqm. | | | | |
| | **MATERIAL** | | | | |
| | Assuming shuttering material will become unserviceable after use of 40 times Adding for maintenance @ 10% of cost Taking salvage value after full use of material @ 25% of cost | | | | |
| **7319** | Wall form panel | Each | 0.51 | | |
| | 1250x500 mm<br>2x3x2x2 = 24 Nos.<br>Qty taken for cost of using once<br>=24x0.85/40 = 0.51 | | | | |
| **7327** | 100 mm channel shoulder 2.5 m long | Each | 0.17 | | |
| | 4x2 = 8<br>Qty taken for cost of using once<br>=8x0.85/40 = 0.17 | | | | |
| **7328** | Double clip ( bridge clip) | Each | 0.51 | | |
| | 2x6x2 = 24<br>Qty taken for cost of using once<br>=24x0.85/40 = 0.51 | | | | |
| **7329** | Single clip | Each | 0.255 | | |
| | 2x3x2 = 12<br>Qty taken for cost of using once<br>=12x0.85/40 = 0.255 | | | | |
| **7330** | M.S. tube 40 mm dia | Metre | 0.68 | | |
| | 2x2x8m = 32m<br>Qty taken for cost of using once<br>=32x0.85/40 = 0.68 | | | | |
| **9999** | Nut & Bolts | LS | 27.62 | | |
| | Qty taken for cost using once<br>=1300x0.85/40 = 27.62 | | | | |
| **9977** | Carriage | LS | 78.00 | | |
| | **LABOUR** | | | | |
| **0116** | Fitter (Grade 1) | Day | 3.50 | | |
| **0114** | Beldar | Day | 6.00 | | |
| **9999** | Shuttering oil | Day | 78.00 | | |
| **9999** | Sundries | LS | 52.00 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 15.80 sqm | | | | |
| | Cost of 1.0 sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-1/5.9.6 | | | | | |
|---|---|---|---|---|---|
| **Item 3.2 :-** Centering and shuttering including strutting, propping etc. and removal of form for : Columns, Pillars, Piers, Abutments, Posts and Struts | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Detail of cost for 4.5 sqm<br>Size of column 450x450mm and 2.5m high<br>Area of contact = 4x0.45x2.5 = 4.5 sqm | | | | |
| | **MATERIAL** | | | | |
| | Assuming shuttering will become unserviceable after use of 40 times<br>Add maintenance charges @ 10% of cost of material<br>Less salvage value of material after full use @ 25% of cost of material | | | | |
| **7331** | Wall form panel 1250x450 mm | Each | 0.17 | | |
| | Qty taken for cost of using once<br>= 8x0.85/40 = 0.17 | | | | |
| **7332** | Corner angle 45x45x5 m 2.50 m long | Each | 0.085 | | |
| | Qty taken for cost of using once<br>= 4x0.85/40 = 0.085 | | | | |
| **7333** | Column clamp 450x1070 m | Each | 0.106 | | |
| | Qty taken for cost of using once<br>= 5x0.85/40 = 0.1063 | | | | |
| **7334** | Prop 2 m ( 2-3.5m) | Each | 0.085 | | |
| | Qty taken for cost of using once<br>= 4x0.85/40 = 0.085 | | | | |
| **9999** | Nut & Bolts | LS | 27.62 | | |
| | Qty taken for cost of using once<br>= 1300x0.85/40 = 27.62 | | | | |
| **9977** | Carriage | LS | 52.00 | | |
| | **LABOUR** | | | | |
| **0116** | Fitter (Grade 1) | Day | 1.00 | | |
| **0114** | Beldar | Day | 2.00 | | |
| **9999** | Shuttering oil | Day | 39.00 | | |
| **9999** | Sundries | LS | 26.00 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 4.50 sqm | | | | |
| | Cost of 1.0 sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-5.22.6 | | | | | |
|---|---|---|---|---|---|
| **Item 4.1 :-** Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete upto plinth level. : Thermo-Mechanically Treated bars of grade Fe-500D or more | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 1 quintal | | | | |
| | **MATERIAL** | | | | |
| | Deformed twisted steel bars = 1.00 q<br>Wastage 5% = 0.05 q<br>Total =1.05q | | | | |
| **1005** | Twisted steel / deformed bars | Quintel | 1.05 | | |
| **2205** | Carriage of steel 1.05/10 = 0.105t | Tonne | 0.105 | | |
| **9999** | Cover block | LS | 26.00 | | |
| | **LABOUR** | | | | |
| | For straightening, cutting, bending, binding and placing in position | | | | |
| **0102** | Blacksmith 1st class | Day | 1.00 | | |
| **0114** | Beldar | Day | 1.00 | | |
| **9999** | Sundries and binding wire | LS | 26.91 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 quintal | | | | |
| | Cost of 1.0 Kg | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-5.22A.6 | | | | | |
|---|---|---|---|---|---|
| **Item 4.2 :-** Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete above plinth level. : Thermo-Mechanically Treated bars of grade Fe-500D or more | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 1 quintal | | | | |
| | **MATERIAL** | | | | |
| | Deformed twisted steel bars = 1.00 q<br>Wastage 5% = 0.05 q<br>Total =1.05q | | | | |
| **1005** | Twisted steel / deformed bars | Quintel | 1.05 | | |
| **2205** | Carriage of steel 1.05/10 = 0.105t | Tonne | 0.105 | | |
| **9999** | Cover block | LS | 26.00 | | |
| | **LABOUR** | | | | |
| | For straightening, cutting, bending, binding and placing in position | | | | |
| **0102** | Blacksmith 1st class | Day | 1.00 | | |
| **0114** | Beldar | Day | 1.00 | | |
| **9999** | Sundries and binding wire | LS | 26.91 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 quintal | | | | |
| | Cost of 1.0 Kg | | | | |
| | Say | | | | |

**Based on DSR-2023/Vol-5.33.1.4**

**Item 5.1 :-** Providing and laying in position ready mixed or site batched design mix cement concrete for reinforced cement concrete work; using coarse aggregate and fine aggregate derived from natural sources, Portland Pozzolana / Ordinary Portland /Portland Slag cement, admixtures in recommended proportions as per IS: 9103 to accelerate / retard setting of concrete, to improve durability and workability without impairing strength; including pumping of concrete to site of laying, curing, carriage for all leads; but excluding the cost of centering, shuttering, finishing and reinforcement as per direction of the engineer-in-charge; for the following grades of concrete.

**Note:** Extra cement up to 10% of the minimum specified cement content in design mix shall be payable separately.

In case the cement content in design mix is more than 110% of the specified minimum cement content, the contractor shall have discretion to either re-design the mix or bear the cost of extra cement. : All works upto plinth level : Concrete of M40 grade with minimum cement content of 390 kg/cum

| Code | Descriptrion | Unit | Qty. | Rate | Amount |
|---|---|---|---|---|---|
| | Details of cost for 1 cum | | | | |
| | **MATERIAL** | | | | |
| **0295** | Stone Aggregate (Single size) : 20 mm nominal size | Cum | 0.57 | | |
| **0297** | Stone Aggregate (Single size) : 10 mm nominal size | Cum | 0.28 | | |
| **2202** | Carriage of Stone aggregate below 40 mm nominal size | Cum | 0.85 | | |
| **0982** | Coarse sand (zone III) | Cum | 0.425 | | |
| **2203** | Carriage of Coarse sand | Cum | 0.425 | | |
| **0367** | Ordinary/Pozzolana/Slag Cement | Tonne | 0.39 | | |
| **2209** | Carriage of Cement | Tonne | 0.39 | | |
| **7318** | Plasticizer / super plasticizer 0.50% of cement | kilogram | 1.95 | | |
| | Production cost, pumping to respective floors and laying in position | | | | |
| **0004** | Production cost of concrete by batch mix plant / ready mixed plant. | Cum | 1.00 | | |
| **0009** | Pumping charges of concrete including hire charges of pump, carriage charges for all leads,piping work & accessories etc. | Cum | 1.00 | | |
| | **LABOUR** | | | | |
| | Labour for pouring, consolidating & curing | | | | |
| **0155** | Mason (average) | Day | 0.17 | | |
| **0114** | Beldar | Day | 2.00 | | |
| **0101** | Bhisti | Day | 0.90 | | |
| **0012** | Vibrator(Needle type 40mm) | Day | 0.07 | | |
| **9999** | Sundries | LS | 13.00 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 Cum | | | | |
| | Say | | | | |

**Based on DSR-2023/Vol-5.33.1.4**

**Item 5.2 :-** Providing and laying in position ready mixed or site batched design mix cement concrete for reinforced cement concrete work; using coarse aggregate and fine aggregate derived from natural sources, Portland Pozzolana / Ordinary Portland /Portland Slag cement, admixtures in recommended proportions as per IS: 9103 to accelerate / retard setting of concrete, to improve durability and workability without impairing strength; including pumping of concrete to site of laying, curing, carriage for all leads; but excluding the cost of centering, shuttering, finishing and reinforcement as per direction of the engineer-in-charge; for the following grades of concrete.

**Note:** Extra cement up to 10% of the minimum specified cement content in design mix shall be payable separately.

In case the cement content in design mix is more than 110% of the specified minimum cement content, the contractor shall have discretion to either re-design the mix or bear the cost of extra cement. : All works above plinth level upto floor V level : Concrete of M40 grade with minimum cement content of 390 kg/cum

| Code | Descriptrion | Unit | Qty. | Rate | Amount |
|---|---|---|---|---|---|
| | Details of cost for 1 cum | | | | |
| | **MATERIAL** | | | | |
| **0295** | Stone Aggregate (Single size) : 20 mm nominal size | Cum | 0.57 | | |
| **0297** | Stone Aggregate (Single size) : 10 mm nominal size | Cum | 0.28 | | |
| **2202** | Carriage of Stone aggregate below 40 mm nominal size | Cum | 0.85 | | |
| **0982** | Coarse sand (zone III) | Cum | 0.425 | | |
| **2203** | Carriage of Coarse sand | Cum | 0.425 | | |
| **0367** | Ordinary/Pozzolana/Slag Cement | Tonne | 0.39 | | |
| **2209** | Carriage of Cement | Tonne | 0.39 | | |
| **7318** | Plasticizer / super plasticizer 0.50% of cement | kilogram | 1.95 | | |
| | Production cost, pumping to respective floors and laying in position | | | | |
| **0004** | Production cost of concrete by batch mix plant / ready mixed plant. | Cum | 1.00 | | |
| **0009** | Pumping charges of concrete including hire charges of pump, carriage charges for all leads,piping work & accessories etc. | Cum | 1.00 | | |
| | **LABOUR** | | | | |
| | Labour for pouring, consolidating & curing | | | | |
| **0155** | Mason (average) | Day | 0.17 | | |
| **0114** | Beldar | Day | 2.00 | | |
| **0101** | Bhisti | Day | 0.90 | | |
| **0012** | Vibrator(Needle type 40mm) | Day | 0.07 | | |
| **9999** | Sundries | LS | 13.00 | | |
| | (Extra labour for lifting material upto floor V level : = 0.75 x 2.5 = 1.88) | | | | |

| Based on DSR-2023/Vol-5.33.1.4 | | | | | |
|---|---|---|---|---|---|
| **0115** | Coolie | Day | 1.88 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 Cum | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.28.1 | | | | | |
|---|---|---|---|---|---|
| **Item 6.1 :-** Chipping of unsound/weak concrete material from slabs, beams, columns etc. with manual Chisel and/ or by standard power driven percussion type or of approved make including tapering of all edges, making square shoulders of cavities including cleaning the exposed concrete surface and reinforcement with wire brushes etc. and disposal of debris for all lead and lifts all complete as per direction of Engineer-In-Charge.: 75mm average thickness | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for One Sqm | | | | |
| | 75mm average thickness for beams | | | | |
| | **MACHINERY** | | | | |
| **9999** | Hire charges for HILTY-TE 504 Pneumatic Chisel | LS | 5.60 | | |
| | **LABOUR** | | | | |
| | For straightening, cutting, bending, binding and placing in position | | | | |
| **0157** | Machine Operator | Day | 0.20 | | |
| **0114** | Beldar | Day | 0.10 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 Sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.28.2 | | | | | |
|---|---|---|---|---|---|
| **Item 6.2 :-** Chipping of unsound/weak concrete material from slabs, beams, columns etc. with manual Chisel and/ or by standard power driven percussion type or of approved make including tapering of all edges, making square shoulders of cavities including cleaning the exposed concrete surface and reinforcement with wire brushes etc. and disposal of debris for all lead and lifts all complete as per direction of Engineer-In-Charge.: 50mm average thickness | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for One Sqm | | | | |
| | 75mm average thickness for beams | | | | |
| | **MACHINERY** | | | | |
| **9999** | Hire charges for HILTY-TE 504 Pneumatic Chisel | LS | 3.74 | | |
| | **LABOUR** | | | | |
| | For straightening, cutting, bending, binding and placing in position | | | | |
| **0157** | Machine Operator | Day | 0.13 | | |
| **0114** | Beldar | Day | 0.07 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 Sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.28.3 | | | | | |
|---|---|---|---|---|---|
| **Item 6.3 :-** Chipping of unsound/weak concrete material from slabs, beams, columns etc. with manual Chisel and/ or by standard power driven percussion type or of approved make including tapering of all edges, making square shoulders of cavities including cleaning the exposed concrete surface and reinforcement with wire brushes etc. and disposal of debris for all lead and lifts all complete as per direction of Engineer-In-Charge.: 25mm average thickness | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for One Sqm | | | | |
| | 75mm average thickness for beams | | | | |
| | **MACHINERY** | | | | |
| **9999** | Hire charges for HILTY-TE 504 Pneumatic Chisel | LS | 1.87 | | |
| | **LABOUR** | | | | |
| | For straightening, cutting, bending, binding and placing in position | | | | |
| **0157** | Machine Operator | Day | 0.07 | | |
| **0114** | Beldar | Day | 0.03 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 1.0 Sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.29.1 | | | | | |
|---|---|---|---|---|---|
| **Item 7.1 :-** Cleaning of reinforcement from rust from the reinforcing bars to give it a total rust free steel surface by using alkaline chemical rust remover of approved make with paint brush and removing loose particles after 24 hours of its application with wire brush and thoroughly washing with water and allowing it to dry, all complete as per direction of Engineer-In-Charge. : Bars upto 12 mm diameter | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Detail of cost for 3.00 sqm (95.54 meter length of 10 mm dia bar) Bars upto 12 mm diameter (1 litre chemical shall cover 3.00 sqm area of bars) | | | | |
| | 75mm average thickness for beams | | | | |
| | **MATERIAL** | | | | |
| **7911** | Chemical Rust Remover | Ltr | 1.00 | | |
| | **LABOUR** | | | | |
| | (Application charges for 3.0 sqm) | | | | |
| **0131** | Painter | Day | 0.162 | | |
| **0115** | Coolie | Day | 0.162 | | |
| **9999** | Putty, brush, sand paper | LS | 3.162 | | |
| **9999** | Sundries | LS | 1.98 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 3 sqm (95.54 m length of 10 mm dia bar) | | | | |
| | Rate per meter length of bar | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.29.2 | | | | | |
|---|---|---|---|---|---|
| **Item 7.2 :-** Cleaning of reinforcement from rust from the reinforcing bars to give it a total rust free steel surface by using alkaline chemical rust remover of approved make with paint brush and removing loose particles after 24 hours of its application with wire brush and thoroughly washing with water and allowing it to dry, all complete as per direction of Engineer-In-Charge. : Bars above 12 mm diameter | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Detail of cost for 3.00 sqm (47.78 meter length of 20 mm dia bar) Bars above 12 mm diameter (1 litre chemical shall cover 3.00 sqm area of bars) | | | | |
| | 75mm average thickness for beams | | | | |
| | **MATERIAL** | | | | |
| **7911** | Chemical Rust Remover | Ltr | 1.00 | | |
| | **LABOUR** | | | | |
| | (Application charges for 3.0 sqm) | | | | |
| **0131** | Painter | Day | 0.162 | | |
| **0115** | Coolie | Day | 0.162 | | |
| **9999** | Putty, brush, sand paper | LS | 3.162 | | |
| **9999** | Sundries | LS | 1.98 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Cost of 3.00 sqm (47.78m length of 20 mm dia bar) | | | | |
| | Rate per meter length of bar | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-26.30.1 | | | | | |
|---|---|---|---|---|---|
| **Item 8.1 :-** Drilling suitable holes in reinforced or plain cement concrete with power driven drill machine to a minimum depth of 100mm upto 200mm in RCC beams, lintels, columns and slabs to introduce steel bars for sunshades/balconies including fixing the steel bars in position using epoxy resin anchor grout of approved make but excluding the cost of reinforcement, all complete as per direction of Engineer-In-Charge. : Upto and including 12mm dia. | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 10 holes | | | | |
| | **MATERIAL** | | | | |
| **7913** | Epoxy | Kg | 0.20 | | |
| | Approx unit Weight of Epoxy<br>= 2000kg/cum or 2gm/cucm<br>Volume of Epoxy filled =3.14/4[(1.5)<br>2-(1.2)2] x 15.5cm = 9.86cucm<br>Weight of Epoxy for 10 holes<br>=10x9.86 x 2 = 197.20 gms say<br>200gms = 0.2 kg | | | | |
| | **MACHINERY** | | | | |
| **0088** | Hire charges of Drill machine upto 30 mm dia | Day | 0.50 | | |
| | **LABOUR** | | | | |
| **0116** | Fitter (grade 1) | Day | 0.50 | | |
| **0114** | Beldar | Day | 0.50 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 10 holes | | | | |
| | Rate for 1 hole | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.31.1 | | | | | |
|---|---|---|---|---|---|
| **Item 9.1 :-** Providing, mixing and applying bonding coat of approved adhesive on chipped portion of RCC as per specifications and direction of Engineer-In-charge complete in all respect. : SBR Polymer (@10% of cement weight) modified cementitious bond coat @ 2.2 kg cement per sqm of surface area mixed with specified proportion of approved polymer. | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of Cost for 10.00 Sqm bonding coat | | | | |
| | **MATERIAL** | | | | |
| **0367** | Portland Cement (OPC-43 grade) | Tonne | 0.022 | | |
| **7914** | SBR Polymer | | | | |
| | @ 10% of cement weight= 22.00kgx 10% =2.2 kg | Kg | 2.20 | | |
| | **LABOUR** | | | | |
| **0155** | Mason (average) | Day | 0.27 | | |
| **0115** | Coolie | Day | 0.27 | | |
| **9999** | Scaffolding and sundries (8.06/2=4.03) | LS | 4.03 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 10 Sqm | | | | |
| | Rate for 1 Sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.31.2 | | | | | |
|---|---|---|---|---|---|
| **Item 9.2 :-** Providing, mixing and applying bonding coat of approved adhesive on chipped portion of RCC as per specifications and direction of Engineer-In-charge complete in all respect. : Epoxy bonding adhesive having coverage 2.20 sqm/kg of approved make | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of Cost for 2.20 Sqm | | | | |
| **7916** | Epoxy | Kg | 1.00 | | |
| **9999** | Application charge for applying bonding coat of Epoxy | LS | 18.50 | | |
| **9999** | Cost of brushes etc. | LS | 8.40 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 2.20 Sqm | | | | |
| | Rate for 1 Sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.32.1 | | | | | | |
|---|---|---|---|---|---|---|
| **Item 10.1 :-** Providing, mixing and applying SBR polymer (of approved make) modified Cement mortar in proportion of 1:4 (1 cement: 4 graded coarse sand with polymer minimum 2% by wt. of cement used) as per specifications and directions of Engineer-in-charge. Note: Measurement and payment: The pre-measurement of thickness shall be done just after the surface preparation is completed and Payment under this item shall be made only after proper wet curing has been done and surface has been satisfactorily evaluated by sounding / tapping with a blunt metal instrument and/or the 75mm size cube crushing strength at the end of 28 days to be not less than 30 N/Sqmm2). :12 mm average thickness. | | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** | |
| | Details of Cost for 10 Sqm | | | | | |
| | **MATERIAL** | | | | | |
| | Cement mortar 1:4 (1 cement : sand) = 0.144 Cum | | | | | |
| **3.9** | Rate as per Item No.3.9 of SH:MORTARS | Cum | 0.144 | | | A |
| **7914** | SBR Polymer | Kg | 1.10 | | | |
| | Qty of cement in mortar= 0.144x0.38<br>= 0.055 MT or 55kg<br>@ 2% of weight of cement 55kgx2%<br>=1.10 kg | | | | | |
| | **LABOUR** | | | | | |
| **0155** | Mason (average | Day | 0.67 | | | |
| **0115** | Coolie | Day | 0.75 | | | |
| **0101** | Bhisti | Day | 0.92 | | | |
| **9999** | Scaffolding and sundries | LS | 12.61 | | | |
| | Total | | | | | W |
| | Add 1 % Water charges on W-A | | | | | |
| | Total | | | | | X |
| | Add GST 18% (multiplying factor 0.2127) on X-A | | | | | |
| | Total | | | | | Y |
| | Add 15% CPOH on Y-A | | | | | |
| | Total | | | | | Z |
| | Add 1% Cess on Z-A | | | | | |
| | Rate for 10 Sqm | | | | | |
| | Rate for 1 Sqm | | | | | |
| | Say | | | | | |

| Based on DSR-2023/Vol-II/26.32.2 | | | | | | |
|---|---|---|---|---|---|---|
| **Item 10.2 :-** Providing, mixing and applying SBR polymer (of approved make) modified Cement mortar in proportion of 1:4 (1 cement: 4 graded coarse sand with polymer minimum 2% by wt. of cement used) as per specifications and directions of Engineer-in-charge. Note: Measurement and payment: The pre-measurement of thickness shall be done just after the surface preparation is completed and Payment under this item shall be made only after proper wet curing has been done and surface has been satisfactorily evaluated by sounding / tapping with a blunt metal instrument and/or the 75mm size cube crushing strength at the end of 28 days to be not less than 30 N/Sqmm2). : 25 mm average thickness in 2 layers. | | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** | |
| | Details of Cost for 10 Sqm | | | | | |
| | **MATERIAL** | | | | | |
| | Cement mortar 1:4 (1 cement : 4 coarse sand) =(0.144/12)x25 =0.30 Cum | | | | | |
| **3.9** | Rate as per Item No.3.9 of SH:MORTARS | Cum | 0.30 | | | A |
| **7914** | SBR Polymer | Kg | 2.28 | | | |
| | Cement 0.30x0.38 = 0.114 MT OR 114 kg @ 2% of weight of cement 114kgx2% =2.28kg | | | | | |
| | **LABOUR** | | | | | |
| **0155** | Mason (average | Day | 0.94 | | | |
| **0115** | Coolie | Day | 1.02 | | | |
| **0101** | Bhisti | Day | 1.01 | | | |
| **9999** | Scaffolding and sundries | LS | 12.61 | | | |
| | Total | | | | | W |
| | Add 1 % Water charges on W-A | | | | | |
| | Total | | | | | X |
| | Add GST 18% (multiplying factor 0.2127) on X-A | | | | | |
| | Total | | | | | Y |
| | Add 15% CPOH on Y-A | | | | | |
| | Total | | | | | Z |
| | Add 1% Cess on Z-A | | | | | |
| | Rate for 10 Sqm | | | | | |
| | Rate for 1 Sqm | | | | | |
| | Say | | | | | |

| Based on DSR-2023/Vol-II/26.32.3 | | | | | | |
|---|---|---|---|---|---|---|
| **Item 10.3 :-** Providing, mixing and applying SBR polymer (of approved make) modified Cement mortar in proportion of 1:4 (1 cement: 4 graded coarse sand with polymer minimum 2% by wt. of cement used) as per specifications and directions of Engineer-in-charge. Note: Measurement and payment: The pre-measurement of thickness shall be done just after the surface preparation is completed and Payment under this item shall be made only after proper wet curing has been done and surface has been satisfactorily evaluated by sounding / tapping with a blunt metal instrument and/or the 75mm size cube crushing strength at the end of 28 days to be not less than 30 N/Sqmm2). : 50 mm average thickness in 3 layers. | | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** | |
| | Details of Cost for 10 Sqm | | | | | |
| | **MATERIAL** | | | | | |
| | Cement mortar 1:4 (1 cement : 4 coarse sand) 0.144/12)x50= 0.60 Cum | | | | | |
| **3.9** | Rate as per Item No.3.9 of SH:MORTARS | Cum | 0.60 | | | A |
| **7914** | SBR Polymer | Kg | 4.56 | | | |
| | Cement 0.60x0.38 = 0.228 MT OR 228 kg @ 2% of weight of cement 228kgx2% =4.56 kg | | | | | |
| | **LABOUR** | | | | | |
| **0155** | Mason (average) | Day | 1.88 | | | |
| **0115** | Coolie | Day | 2.04 | | | |
| **0101** | Bhisti | Day | 2.02 | | | |
| **9999** | Scaffolding and sundries | LS | 25.22 | | | |
| | Total | | | | | W |
| | Add 1 % Water charges on W-A | | | | | |
| | Total | | | | | X |
| | Add GST 18% (multiplying factor 0.2127) on X-A | | | | | |
| | Total | | | | | Y |
| | Add 15% CPOH on Y-A | | | | | |
| | Total | | | | | Z |
| | Add 1% Cess on Z-A | | | | | |
| | Rate for 10 Sqm | | | | | |
| | Rate for 1 Sqm | | | | | |
| | Say | | | | | |

**Based on DSR-2023/Vol-II/26.34.1**

**Item 11.1 :-** Providing and laying SBR Polymer modified (of approved make @ minimum 2% by wt. of cement used) plain/reinforced concrete jacket for the structural members e.g. columns, pillars, piers, beams etc with concrete having the specified minimum characteristic compressive strength [with ordinary portland cement, coarse sand and graded stone aggregate of 10mm maximum size in proportion as per design criteria] with specified average thickness all-round existing core of RCC member. Note: Rates shall be for finished surface area of concrete and shall include the cost of making holes in existing RCC slab, if required, for pouring concrete in shuttering mould of jacket and appropriate approved Super-Plasticiser for rendering concrete as flowable self compacting and SBR polymer but shall exclude cost of reinforcement, bond coat, Shear Keys, centering and shuttering, strutting, propping etc (Payment under this item shall be made only after proper wet curing has been done and surface has been satisfactorily evaluated by sounding/tapping with a blunt metal instrument) : 50mm thick in Grade M 25 with cement content not less than 330 kg per cum

| Code | Descriptrion | Unit | Qty. | Rate | Amount | |
|---|---|---|---|---|---|---|
| | Detail of cost for 10 sqm | | | | | |
| | M25 concrete 0.5 cum of concrete with cement content 330 kg/cum | | | | | |
| **5.33.2.1** | Rate as per Item No.5.33.2.1 of SH: Reinforced Cement Concrete | Cum | 0.50 | | | A |
| **0009** | Pumping charges of concrete including Hire charges of pump, piping work & accessories etc | Cum | -0.50 | | | |
| **7914** | SBR Polymer @ of cement 165 kg = 165X2% = 3.3 kg | Kg | 3.30 | | | |
| | Total | | | | | W |
| | Add 1 % Water charges on W-A | | | | | |
| | Total | | | | | X |
| | Add GST 18% (multiplying factor 0.2127) on X-A | | | | | |
| | Total | | | | | Y |
| | Add 15% CPOH on Y-A | | | | | |
| | Total | | | | | Z |
| | Add 1% Cess on Z-A | | | | | |
| | Rate for 10 Sqm | | | | | |
| | Rate for 1 Sqm | | | | | |
| | Say | | | | | |

**Based on DSR-2023/Vol-II/26.34.2**

**Item 11.2 :-** Providing and laying SBR Polymer modified (of approved make @ minimum 2% by wt. of cement used) plain/reinforced concrete jacket for the structural members e.g. columns, pillars, piers, beams etc with concrete having the specified minimum characteristic compressive strength [with ordinary portland cement, coarse sand and graded stone aggregate of 10mm maximum size in proportion as per design criteria] with specified average thickness all-round existing core of RCC member. Note: Rates shall be for finished surface area of concrete and shall include the cost of making holes in existing RCC slab, if required, for pouring concrete in shuttering mould of jacket and appropriate approved Super-Plasticiser for rendering concrete as flowable self compacting and SBR polymer but shall exclude cost of reinforcement, bond coat, Shear Keys, centering and shuttering, strutting, propping etc (Payment under this item shall be made only after proper wet curing has been done and surface has been satisfactorily evaluated by sounding/tapping with a blunt metal instrument) : 75mm thick in Grade M 25 with cement content not less than 330 kg per cum

| Code | Descriptrion | Unit | Qty. | Rate | Amount | |
|---|---|---|---|---|---|---|
| | Detail of cost for 10 sqm area (0.75cum) | | | | | |
| | M25 concrete 0.75 cum of concrete with cement content 330 kg/cum | | | | | |
| **5.33.2.1** | Rate as per Item No.5.33.2.1 of SH: Reinforced Cement Concrete | Cum | 0.75 | | | A |
| **0009** | Pumping charges of concrete including Hire charges of pump, piping work & accessories etc | Cum | -0.75 | | | |
| **7914** | SBR Polymer @2% of cement 247.50 kg = 247.50X2% = 4.95 kg | Kg | 4.95 | | | |
| | Total | | | | | W |
| | Add 1 % Water charges on W-A | | | | | |
| | Total | | | | | X |
| | Add GST 18% (multiplying factor 0.2127) on X-A | | | | | |
| | Total | | | | | Y |
| | Add 15% CPOH on Y-A | | | | | |
| | Total | | | | | Z |
| | Add 1% Cess on Z-A | | | | | |
| | Rate for 10 Sqm | | | | | |
| | Rate for 1 Sqm | | | | | |
| | Say | | | | | |

**Based on DSR-2023/Vol-II/26.34.3**

**Item 11.3 :-** Providing and laying SBR Polymer modified (of approved make @ minimum 2% by wt. of cement used) plain/reinforced concrete jacket for the structural members e.g. columns, pillars, piers, beams etc with concrete having the specified minimum characteristic compressive strength [with ordinary portland cement, coarse sand and graded stone aggregate of 10mm maximum size in proportion as per design criteria] with specified average thickness all-round existing core of RCC member. Note: Rates shall be for finished surface area of concrete and shall include the cost of making holes in existing RCC slab, if required, for pouring concrete in shuttering mould of jacket and appropriate approved Super-Plasticiser for rendering concrete as flowable self compacting and SBR polymer but shall exclude cost of reinforcement, bond coat, Shear Keys, centering and shuttering, strutting, propping etc (Payment under this item shall be made only after proper wet curing has been done and surface has been satisfactorily evaluated by sounding/tapping with a blunt metal instrument) : 100mm thick in Grade M 25 with cement content not less than 330 kg per cum

| Code | Descriptrion | Unit | Qty. | Rate | Amount | |
|---|---|---|---|---|---|---|
| | Detail of cost for 10 sqm area (1.00 cum) | | | | | |
| | M25 concrete 1.00 cum of concrete with cement content 330 kg/cum | | | | | |
| **5.33.2.1** | Rate as per Item No.5.33.2.1 of SH: Reinforced Cement Concrete | Cum | 1.00 | | | A |
| **0009** | Pumping charges of concrete including Hire charges of pump, piping work & accessories etc | Cum | -1.00 | | | |
| **7914** | SBR Polymer @2% of cement 330 kg = 330X2% = 6.6 kg | Kg | 6.60 | | | |
| | Total | | | | | W |
| | Add 1 % Water charges on W-A | | | | | |
| | Total | | | | | X |
| | Add GST 18% (multiplying factor 0.2127) on X-A | | | | | |
| | Total | | | | | Y |
| | Add 15% CPOH on Y-A | | | | | |
| | Total | | | | | Z |
| | Add 1% Cess on Z-A | | | | | |
| | Rate for 10 Sqm | | | | | |
| | Rate for 1 Sqm | | | | | |
| | Say | | | | | |

| Based on DSR-2023/Vol-II/26.35.1 | | | | | |
|---|---|---|---|---|---|
| **Item 12.1 :-** Providing and injecting approved grout in proportion recommended by the manufacturer into cracks/honey-comb area of concrete/masonry by suitable gun/pump at required pressure including cutting of nipples after curing etc. complete as per directions of Engineer-in-Charge. (The payment shall be made on the basis of actual weight of approved grout injected.) : Stirrer mixed Acrylic Polymer of approved make @ 2% of weight of cement used) modified Cement slurry made with non shrink compound in concrete/ RCC work | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Detail of cost for 100 kg Acrylic polymer mixed cement grout | | | | |
| | **MATERIAL** | | | | |
| **7927** | Acrylic Polymer chemical for cracks Considering 1 kg of cement grout mixed with non shrink polymer compound with cement @ 2% of cement | Kg | 2.00 | | |
| **0367** | Portland Cement (OPC-43 grade) | Tonne | 0.10 | | |
| **9977** | Carriage of materials | LS | 1.00 | | |
| **9999** | Injecting charges of Stirrer mixed polymer grout Gun, rubber, pipe and other accessories hire charges of plant, machinery including necessary fuel and transportation of site | LS | 2250.00 | | |
| | **LABOUR** | | | | |
| **0122** | Foreman | Day | 1.00 | | |
| **0157** | Nozzleman | Day | 2.00 | | |
| **0157** | Pump Operator | Day | 3.00 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 100 Kg | | | | |
| | Rate for 1 Kg | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.35.2 | | | | | |
|---|---|---|---|---|---|
| **Item 12.2 :-** Providing and injecting approved grout in proportion recommended by the manufacturer into cracks/honey-comb area of concrete/masonry by suitable gun/pump at required pressure including cutting of nipples after curing etc. complete as per directions of Engineer-in-Charge. (The payment shall be made on the basis of actual weight of approved grout injected.) : Stirrer mixed SBR Polymer (of approved make) modified Cement slurry made with Shrinkage Compensating Cement in concrete/RCC work | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Detail of cost for 100 kg of SBR Polymer mixed cement grout | | | | |
| | **MATERIAL** | | | | |
| **7914** | SBR Polymer for crack | Kg | 2.00 | | |
| **0367** | Portland Cement (OPC-43 grade) | Tonne | 0.10 | | |
| **9977** | Carriage of materials | LS | 1.00 | | |
| **9999** | Injecting charges of Stirrer mixed polymer grout Gun, rubber, pipe and other accessories hire charges of plant, machinery including necessary fuel and transportation of site Rs 4000/ - per day including plant shall be used of doing approximate v Hence cost per sqm (4000/50 = 80) | LS | 2250.00 | | |
| | **LABOUR** | | | | |
| **0122** | Foreman | Day | 1.00 | | |
| **0157** | Nozzleman | Day | 2.00 | | |
| **0157** | Pump Operator | Day | 3.00 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 100 Kg | | | | |
| | Rate for 1 Kg | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.35.3 | | | | | |
|---|---|---|---|---|---|
| **Item 12.3 :-** Providing and injecting approved grout in proportion recommended by the manufacturer into cracks/honey-comb area of concrete/masonry by suitable gun/pump at required pressure including cutting of nipples after curing etc. complete as per directions of Engineer-in-Charge. (The payment shall be made on the basis of actual weight of approved grout injected.) : Epoxy injection grout in concrete/RCC work of approved make | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Detail of cost for 10 kg of Epoxy grout | | | | |
| | **MATERIAL** | | | | |
| **7913** | Epoxy | Kg | 10.00 | | |
| **0092** | Hire charges of Plant and machinery, it can inject - 350kg/day | Day | 0.03 | | |
| | **LABOUR** | | | | |
| **0114** | Beldar | Day | 0.06 | | |
| **0157** | Nozzle Operator | Day | 0.03 | | |
| **9999** | Sundries (gloves gogles etc.) | LS | 5.00 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 10 Kg | | | | |
| | Rate for 1 Kg | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.36 | | | | | |
|---|---|---|---|---|---|
| **Item 13.1 :-** Providing, erecting, maintaining and removing temporary protective screens made out of specified fabric with all necessary fixing arrangement to ensure that it remains in position for the work duration as required by the Engineerin-charge. : Wooven PVC cloth | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 10 sqm | | | | |
| | **MATERIAL** | | | | |
| **7915** | Wooven PVC cloth | Sqm | 10.00 | | |
| **0092** | Hire charges of Plant and machinery, it can inject - 350kg/day | Day | 0.03 | | |
| **9999** | Fixing double scaffolding outside | LS | 11.00 | | |
| | Total Material | | | | |
| | **LABOUR** | | | | |
| | For fixing and removal after complete of work @25% | | | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 10 Sqm | | | | |
| | Rate for 1 Sqm | | | | |
| | Say | | | | |

| Based on DSR-2023/Vol-II/26.39 | | | | | |
|---|---|---|---|---|---|
| **Item 14.1 :-** Providing and inserting 12mm dia galvanised steel injection nipple in honey comb area and along crack line including drilling of holes of required diametre (20mm to 30mm) up to depth from 30mm to 80mm at required spacing and making the hole & crack dust free by blowing compressed air, sealing the distance between injection nipple with adhesive chemical of approved make and allow it to cure complete as per direction of Engineer-In-Charge. | | | | | |
| **Code** | **Descriptrion** | **Unit** | **Qty.** | **Rate** | **Amount** |
| | Details of cost for 20.00 Nos Hole | | | | |
| | **MATERIAL** | | | | |
| 7921 | Adhesive chemical | Ml | 188.00 | | |
| | (750 mm deep & 20 mm Dia Hole)<br>Volume of hole =20x(3.14/4)x2.00x 2.00x7.5=471 cub cm.<br>Adhesive @ 40% of 471 ml<br>=188.40 ml, Say 188 ml | | | | |
| 7922 | Bit of drilling machine for Hole upto 30mm dia | Each | 1.00 | | |
| | (One Bit done 20 Holes only) | | | | |
| 7923 | GI injection nipple 12mm dia, 75mm long | Each | 20.00 | | |
| 7924 | Blowing compressed air for cleaning holes upto 30mm dia | Each | 20.00 | | |
| | **LABOUR** | | | | |
| 0155 | Mason (average) | Day | 0.50 | | |
| 0115 | Coolie | Day | 0.50 | | |
| 0101 | Bhisti | Day | 0.50 | | |
| | Total | | | | |
| | Add 1 % Water charges | | | | |
| | Total | | | | |
| | Add GST 18% (multiplying factor 0.2127) | | | | |
| | Total | | | | |
| | Add 15% CPOH | | | | |
| | Total | | | | |
| | Add 1% Cess | | | | |
| | Rate for 20 Holes | | | | |
| | Rate for 1 Hole | | | | |
| | Say | | | | |

## BASIC INPUT PARAMETER

### Overhead and Contractor Profit

| S. No. | Description | Percentage | | |
|---|---|---|---|---|
| | | Large Project | Medium Project | Small Project |
| 1 | Overheads for Road Works | 8% | 10% | 12% |
| 2 | Contractors profit for Road Works | 10% | 10% | 10% |
| 3 | Overheads for New/ Widening of Bridge/ Structure Works | 20% | 20% | 20% |
| 4 | Overheads for Rehabilitation of Bridges / Structure | 30% | 30% | 30% |
| 5 | Contractors profit for Bridge Works | 10% | 10% | 10% |
| 6 | Overheads for Road Tunnel Works | 25% | 25% | 25% |
| 7 | Contractors profit for Tunnel Works | 10% | 10% | 10% |

### Lead Details

| S. No. | Description | Represent lead |
|---|---|---|
| 1 | Lead from Mixing Plant to working site | LI |
| 2 | Lead for Earthwork borrow area to site | L2 |
| 3 | Lead for Moorum/ Natural Granular material borrow area to site | L3 |
| 4 | Lead for fly ash from source to site | L4 |
| 5 | Lead for Sand from source to site | L5 |
| 6 | Lead for Sand from source to Plant | L6 |
| 7 | Lead for Aggregate from Quarry to working site | L7 |
| 8 | Lead for Aggregate from Quarry to Plant | L8 |
| 9 | Lead for Bitumen from source to Plant | L9 |
| 10 | Lead for HT Strands from source to Plant | L10 |

**Note:** All lead in km (one way).

## CHAPTER: 13 - SUB-STRUCTURE

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 13.18 | 2000 & 2200 | **Supplying, fitting and fixing in position true to line and level POT-PTFE bearing consisting of a metal piston supported by a disc or unreinforced elastomer confined within a metal cylinder, sealing rings, dust seals, PTFE surface sliding against stainless steel mating surface, complete assembly to be of cast st eel/ fabric a ted structural steel, metal and elastomer elements to be as per IRC: 83 part-1 & II respectively and other parts conforming to B$: $400, section 9.1 & 9.2 and clause 2006 of MoRT&H Specifications complete as per drawing and approved Technical Specifications.**<br>**Unit = one tonne capacity Considering a Pot bearing assembly of 250 tonne capacity for this analysis.** | | | | | |
| | | **a) Labour** | | | | | |
| | | Mate | day | 0.080 | 0.080 | 0.080 | |
| | | Mazdoor | day | 1.500 | 1.500 | 1.500 | |
| | | Mazdoor (Skilled) | day | 0 500 | 0.500 | 0.500 | |
| | | **b) Material** | | | | | |
| | | Pot type bearing assembly consisting of a metal piston supported by a disc, PTFE pads providing sliding surfaces against stainless steel mating together with cast steel assembiles/fabricated<br>structural steel assemblies duly painted with all components as per clause 2006 and complete as per drawings and Technical Specifications.<br>Add 1 percent of cost of bearing assembly for foundation anchorage bolts and consumables | each | 1.000 | 1.000 | 1.000 | |
| | | **c) Overhead charges** | | **@ on (a+b)** | **@ on (a+b)** | **@ on (a+b)** | |
| | | **d) Contractor's profit** | | **@ on (a+b+c)** | **@ on (a+b+c)** | **@ on (a+b+c)** | |
| | | cost for 250 tonnes capacity bearing = a+b+c+<br>**Rate per tonne capacity = (a+b+c+d)/250** | | | | | |

## CHAPTER: 14 - SUPER-STRUCTURE

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 14.21 | 2607 | **Strip Seal Expansion Joint Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's Instructions for installation.**<br>**Unit = Running meter Taking output = 12 m** | | | | | |
| | | **a) Labour** | | | | | |
| | | Mate | day | 0.050 | 0.050 | 0.050 | |
| | | Mazdoor | day | 1.000 | 1.000 | 1.000 | |
| | | Mazdoor (Skilled) | day | 0.250 | 0.250 | 0.250 | |
| | | **b. Material** | metre | 12.000 | 12.000 | 12000 | |
| | | Supply of complete assembly of strip seal expansion joint comprising of edge beams, anchorage, strip seal efement and complete accessories as per approved specifications and drawings.<br>Add 5 percent of cost of material for anchorage reinforcement, welding and other Incidentals. | | | | | |
| | | **c. Overhead charges** | | **@ on (a+b)** | **@ on (a+b)** | **@ on (a+b)** | |
| | | **d. Contractor's profit** | | **@ on (a+b+c)** | **@ on (a+b+c)** | **@ on (a+b+c)** | |
| | | cost for 12 m = (a+b+c+d)<br>**Rate per m = (a+b+c+d)/12** | | | | | |

**Note:**

1. The installation shall be done by the manufacturer or his authorised representative to the satisfaction of the Engineer
2. The concreting for joining the expansion joint assembly with the deck has not been Included in this analysis as the same is catered In the quantities of RCC deck.

## CHAPTER: 14 - SUPER-STRUCTURE

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 14.22 | 2600 | **Modular Strip / Box Seal Joint**<br>**Providing and laying of a modular strip Box seal expansion Joint Including anchorage catering to a horizontal movement beyond 70 mm and upto 140mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/ supplier or their authorised representative ensuring compliance to the manufacturer's instructions for Installation.**<br>**Unit = Running meter**<br>**Taking output = 12 m** | | | | | |
| | | **a) Labour** | | | | | |
| | | Mate | day | 0.056 | 0.056 | 0.056 | |
| | | Mazdoor | day | 1.000 | 1.000 | 1.000 | |
| | | Mazdoor (Skilled) | day | 0.400 | 0 400 | 0.400 | |
| | | **b) Material** | | | | | |
| | | Supply of a modular strip/box seal joint assembly comprising of edge beams, central beam, 2 modules chloroprene seal, anchorage elements, support and control system, all steel sections protected against corrosion and installed by the manufacturer or his authorised representative. | metre | 12.000 | 12.000 | 12.000 | |
| | | **c) Overhead charges** | | **@ on (a+b)** | **@ on (a+b)** | **@ on (a+b)** | |
| | | **d) Contractor's profit** | | **@ on (a+b+c)** | **@ on (a+b+c)** | **@ on (a+b+c)** | |
| | | Cost for 12 m Modular strip/box seal joint = (a+b+c+d)<br>**Rate per m = (a+b+c+d)/12** | | | | | |

**Note:**

1. The installation shall be done by the manufacturer or his authorised representative to the satisfaction of the Engineer.
2. The concreting for joining the expansion joint assembly with the deck has not been included in this analysis as the same is catered in the quantities of RCC deck.
3. The anchoring bars of the expansion joint assembly shall be welded to the mam reinforcement of the deck.

## CHAPTER: 14 - SUPER-STRUCTURE

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 14.23 | 2600 | **Modular Strip / Box Seal Joint**<br>**Providing and laying of a modular strip box seal expansion joint catering to a horizontal movement beyond 140mm and upto 210mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/ supplier or their authorised representative ensuring compliance to the manufacturer's Instructions for installation.**<br>**Unit = Running meter**<br>**Taking output = 12 m** | | | | | |
| | | **a) Labour** | | | | | |
| | | Mate | day | 0.070 | 0070 | 0.070 | |
| | | Mazdoor | day | 1.250 | 1.250 | 1.250 | |
| | | Mazdoor (Skilled) | day | 0.500 | 0.500 | 0.500 | |
| | | **b. Material** | metre | 12 000 | 12000 | 12000 | |
| | | Supply of a modular box/box seal joint assembly containing 3 modules/ cells and comprising of edge beams, two central beams, chloroprene seal, anchorage elements, support and control system, all steel sections protected against corrosion and installed by the manufacturer or his authorised representative. | | | | | |
| | | **c. Overhead charges** | | **@ on (a+b)** | **@ on (a+b)** | **@ on (a+b)** | |
| | | **d. Contractor's profit** | | **@ on (a+b+c)** | **@ on (a+b+c)** | **@ on (a+b+c)** | |
| | | Cost for 12 m Modular strip/box seal joint = (a+b+c+d)<br>**Rate per m > (a«b*c*d)/12** | | | | | |

**Note:**

1. The installation shall be done by the manufacturer or his authorised representative to the satisfaction of the Engineer.
2. The concreting for joining the expansion joint assembly with the deck has not been included in this analysis as the same is catered in the quantities of RCC deck.
3. The anchoring bars of the expansion joint assembly shall be welded to the mam reinforcement of the deck.

## CHAPTER: 17 - REPAIR AND REHABILITATION

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 17.07 | 2803 | **Sealing of crack / porous concrete with Epoxy Grout by injection through nipples complete as per clause 2803.1.**<br>**Unit = kg**<br>**Taking output = 1 kg** | | | | | |
| | | **a) Material** | | | | | |
| | | Epoxy Including 10 percent wastage | kg | 1.100 | 1.100 | 1.100 | |
| | | **b) Labour** | | | | | |
| | | Mate | day | 0.008 | 0.008 | 0.008 | |
| | | Mazdoor (Skilled) | day | 0.100 | 0.100 | 0.100 | |
| | | Mazdoor | day | 0.100 | 0.100 | 0.100 | |
| | | **c) Machinery** | | | | | |
| | | Epoxy Injection gun | hour | 0.100 | 0.100 | 0.100 | |
| | | **d) Overhead charges** | | @ on (a+b+c) | @ on (a+b+c) | @ on (a+b+c) | |
| | | **e) Contractor's profit** | | @ on (a+b+c+d) | @ on (a+b+c+d) | @ on (a+b+c+d) | |
| | | **Rate per kg 3 (a+b+c+d+e)** | | | | | |

## CHAPTER: 17 - REPAIR AND REHABILITATION

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 17.08 | 2804 | **Applying epoxy mortar over leached, honey combed and spalled concrete surface and exposed steel reinforcement complete as per Technical Specification**<br>**Unit = sqm**<br>**Taking output = 10 sqm**<br>Assume average 10mm thickness of epoxy mortar | | | | | |
| | | **a) Material** | | | | | |
| | | Epoxy resin-hardener mix for prime coat | kg | 2.SOO | 2.500 | 2.500 | |
| | | Epoxy mortar | kg | 2.200 | 2.200 | 2.200 | |
| | | Epoxy resin -hardener mix for seal coat. | kg | 2.000 | 2000 | 2.000 | |
| | | Add 3 percent cost of material for other consumables like acetone etc. and to cover wastage | | | | | |
| | | **b) Labour** | | | | | |
| | | Mate | day | 0.040 | 0.040 | 0.040 | |
| | | Mazdoor (Skilled) | day | 0500 | 0.500 | 0.500 | |
| | | Mazdoor | day | 0.500 | 0.500 | 0.500 | |
| | | **c) Overhead charges** | | **@ on (a+b)** | **@ on (a+b)** | **@ on (a+b)** | |
| | | **d) Contractor's profit** | | **@ on (a+b+c)** | **@ on (a+b+c)** | **@ on (a+b+c)** | |
| | | Cost for 10 sqm = a+b+c+d<br>**Rato per sqm = (a+b+c+d)/10** | | | | | |

## CHAPTER: 17 - REPAIR AND REHABILITATION

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 17.15 | 2810 | **Replacement of Bearings complete as per Technical Specification**<br>**Unit = No**<br>**Taking output = 3 No.**<br>Lifting of superstructure span by jacking up from below i.e. by placing the jacks on pief/abutment caps for span length of 30m. | | | | | |
| | | **a) Labour** | | | | | |
| | | Mate | day | 0.640 | 0.640 | 0.640 | |
| | | Mazdoor (Skilled) | day | 4.000 | 4.000 | 4.000 | |
| | | Mazdoor | day | 12.000 | 12.000 | 12.000 | |
| | | **b) Machinery** | | | | | |
| | | i) Hire charges for jack of 40 tonne lifting capacity, (lifting of span) | Dav | 3000 | 3.000 | 3.000 | |
| | | **c) Material** | | | | | |
| | | Wooden packing | cum | 0.150 | 0.150 | 0.150 | |
| | | Cost of bearing. (Replacement of bearing) | each | 3.000 | 3.000 | 3.000 | |
| | | **d) Overhead charges** | | @ on (a+b+c) | @ on (a+b+c) | @ on (a+b+c) | |
| | | **e) Contractor's profit** | | @ on (a+b+c+d) | @ on (a+b+c+d) | @ on (a+b+c+d) | |
| | | **Cost of repair of 3 bearings = a+b+c+d+e**<br>**Rate of repair per bearing = (a+b+c+d+e)/3** | | | | | |

**Note :** The work entails replacement of all the bearings on one side of the span.

## CHAPTER: 17 - REPAIR AND REHABILITATION

| S. No. | Ref. to M. | Description | Unit | Quantity as per project category | | | Rate (Rs.) |
|---|---|---|---|---|---|---|---|
| | | | | Large | Medium | Small | |
| 17.16 | 2811 | **Rectification of Bearings as per Technical Specifications<br>Unit = 1 No<br>Taking output = 3 No.<br>Lifting of superstructure span by jacking up from below I.e. by placing the jacks on pier/abutmant caps for span length of 30m.** | | | | | |
| | | **a) Labour** | | | | | |
| | | Mate | day | 0.640 | 0.640 | 0.640 | |
| | | Mazdoor (Skilled) | day | 4.000 | 4000 | 4.000 | |
| | | Mazdoor | day | 12.000 | 12.000 | 12.000 | |
| | | **b) Machinery** | | | | | |
| | | i) Hire charges for jack of 40 tonne lifting capacity | each | 3.000 | 3.000 | 3.000 | |
| | | **c) Material** | | | | | |
| | | Cost of parts to be replaced for 3 bearings. | each | 3000 | 3000 | 3.000 | |
| | | Wooden packing | cum | 0.150 | 0.150 | 0.150 | |
| | | **d) Overhead charges** | | @ on (a+b+c) | @ on (a+b+c) | @ on (a+b+c) | |
| | | **e) Contractor's profit** | | @ on (a+b+c+d) | @ on (a+b+c+d) | @ on (a+b+c+d) | |
| | | Cost of repair of 3 bearings = a+b+c+d+e<br>**Rate of repair per bearing =(a+b+c+d+e)/3** | | | | | |
| **Note:** The rectification of 3 bearings included in this analysis are on the same side of the span. | | | | | | | |
| 17.17 | | **Replacement of Expansion Joints complete as per drawings<br>Unit - 1 RM<br>Taking output = 12 RM** | | | | | |
| | | **a) Material** | | | | | |
| | | Epoxy for bonding new concrete to old concrete @ 0.8 kg/sqm | kg | 9 600 | 9600 | 9.600 | |
| | | M-30 grade cement concrete excluding OH & CP (Rate taken from items 14.01 C (i) p) | cum | 3.600 | 3.600 | 3.600 | |
| | | **b) Labour** | | | | | |
| | | Removal of old expansion joint including breaking of concrete, cutting of lugs and shifting of broken material etc. | | | | | |
| | | Mate | day | 0.260 | 0.260 | 0.260 | |
| | | Mazdoor | day | 6 000 | 6.000 | 6.000 | |
| | | Mazdoor (Skilled) | day | 0.500 | 0.500 | 0.500 | |
| | | **d) Overhead charges** | | @ on (a+b) | @ on (a+b) | @ on (a+b) | |
| | | **e) Contractor's profit** | | @ on (a+b+c) | @ on (a+b+c) | @ on (a+b+c) | |
| | | Cost for replacement of 12 RM = a+b+c+d<br>**Rate per RM = (a+b+c+d)/12** | | | | | |

**Note:** The rate For the Installation of new expantion joints may be taken from the chapter on superstructure. Broken concrete will have to be replaced which has been included m this analysis.

# 12. Case Study for Rehabilitation and Repair of Nehru Nagar & Mayapuri Flyover

## NEHRU NAGAR FLYOVER

| | |
|---|---|
| **Name of work** | Rehabilitation and strengthening of Nehru Nagar Flyover (ROB) near Ashram on Ring Road, New Delhi. |
| **Agency/Contractor** | The Freyssinet Prestressed Concrete Co. Ltd. |
| **Estimated Cost** | 13.92 Crores |
| **Tendered Cost** | 11.27 Crores |
| **Date of Start** | 01.09.2021 |
| **Stipulated Date of Completion** | 31.08.2022 |

### Background and History

The Ashram Flyover, also known as the Ashram Railway Over bridge (RoB), is a significant elevated structure located at the Ashram Chowk area in South Delhi. It is part of the road network that helps connect the traffic between key routes in Delhi, including the Mathura Road (NH 2) and Ring Road. The primary objective of the flyover was to reduce traffic congestion at the Ashram Chowk, which is a crucial intersection connecting Mathura Road, Ring Road, and other major routes.

It was constructed during 1969 and later on widened by 8.00 m on either side by MCD during 2003. The flyover has 13 spans out of which one span is in Railway portion. Two underpasses have been also provided for 'U' turn, one at Nehru Nagar side and other at Lajpat Nagar side.

The original structure comprises of RCC girders, tie beams and deck slabs supported on brick masonry piers. The added portion comprises of RCC girders, tie beams supported on RCC piers and elastomeric bearings. There is longitudinal construction joints on both side carriageways due to this add on structure.

## Objective

The main objective of the Repair and Rehabilitation of the flyovers was to increase life span and to provide safety of the road users passing over or under the flyovers. Over time, any infrastructure exposed to high vehicular loads can develop cracks or structural damage. Routine repairs ensure the flyover complies with posing a risk to commuters.

## Rehabilitation and Repair Operations

- Concreting by Micro concrete (M 60)
- Plastering by Polymer Modified Mortar (SBR)
- Removal of Honeycombing of Girder, pier and abatements by Grouting (Epoxy & Cementitious)
- Corrosion protection of reinforcements by applying Rust remover, Anti-corrosive treatments, and Canodes.
- Strengthening of tension zone of RCC Girder by Carbon Laminate strips
- Improvement flexural Strength and load carrying capacity of RCC Girder, Deck Slab by Carbon Fiber wrapping
- Strengthening of Pier and abatements by Jacketing with Micro Concrete (M 55) and reinforcement.

## Steps involved during repair of structures

- Erection of scaffolding
- Protection of structure by covering with Green net
- Chipping of loose concrete
- Apply Rust Remover
- Apply Anti-rust Coating
- Apply Corrosion Inhibitor on Concrete Surface
- Fix Galvanic Anodes
- Put Corrosion Inhibiting Caplets
- Plastering by Polymer Modified Mortar
- Fix Shuttering
- Placing of Micro-concrete
- Removal of Shuttering
- Carbon Lamination
- Carbon fiber wrapping
- Grouting in some structure to remove honeycombing if any.
- P/F reinforcement to strengthen the pier
- Jacketing of Pier by Micro Concrete (M 55)
- Removal of shuttering & Curing
- Anti-Carbonation Painting

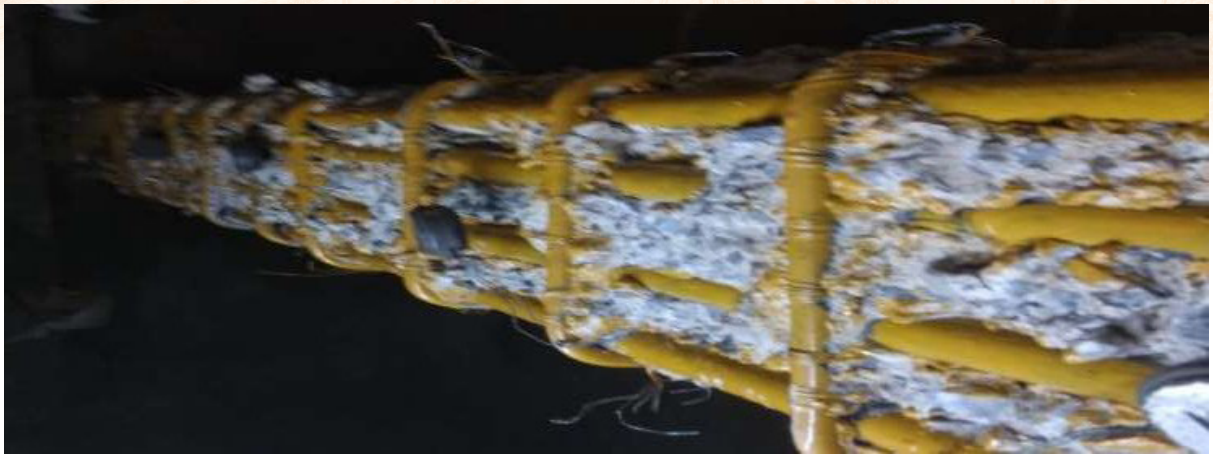
## Photograph Detail during rehabilitation works at Nehru Nagar Flyover (RoB)

### 1. Repair of RCC Girder and Tie Beam with Micro Concrete:-

**Step-1:-** Chipping of RCC Girder at Nehru Nagar Flyover (RoB)

**Step-2:-** Rust Removal of Reinforcement on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-3:-** Anti-Rust Coating on Reinforcement Bar at Nehru Nagar Flyover (RoB)



**Step-4:-** Application of Corrosion Inhibitor on RCC Beam at Nehru Nagar Flyover (RoB)

**Step-5:-** Fixing Sacrificial Galvanic Anode on Reinforcement at Nehru Nagar Flyover (RoB)

**Step-6:-** Fixing Corrosion Inhibiting Caplet on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-6:-** P/F Shuttering for Micro Concrete repair on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-7:-** Micro Concrete repair on RCC Girder at Nehru Nagar Flyover (RoB)

## 2. Repair of RCC Girder, Tie Beam and Deck Slab with Polymer Modified Mortar, Grout, Carbon laminate and CRFP wrap:-

**Step-1:-** Chipping of RCC Girder at Nehru Nagar Flyover (RoB)

**Step-2:-** Application of Corrosion Inhibitor on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-3:-** Application of Bonding Coat on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-4:-** Plastering with PMM on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-5:-** Fixing of Nipples on Deck slab at Nehru Nagar Flyover (RoB)

**Step-6:-** Injection Grouting on RCC Girder and Pier at Nehru Nagar Flyover (RoB)

**Step-7:-** P/F Carbon Laminate on RCC Girder at Nehru Nagar Flyover (RoB)

**Step-8:-** P/F CRFP wrap on RCC Girder, Tie Beam and Deck Slab at Nehru Nagar Flyover (RoB)

### 3. Repair of Abutment and Pier with Grout, Reinforcement and Micro Concrete Jacketing:-

**Step-1:-** Cementitious Grouting on Brick Pier at Nehru Nagar Flyover (RoB)

**Step-2:-** Surface Preparation for Jacketing on Brick Pier at Nehru Nagar Flyover (RoB)

**Step-3:-** Reinforcement Binding for Jacketing on Brick Pier at Nehru Nagar Flyover (RoB)

**Step-4:-** Shear anchoring to fix reinforcement on Pier at Nehru Nagar Flyover (RoB)

**Step-5:-** Shuttering work on Pier at Nehru Nagar Flyover (RoB)

**Step-6:-** Micro Concrete Jacketing on Retaining wall at Nehru Nagar Flyover (RoB)

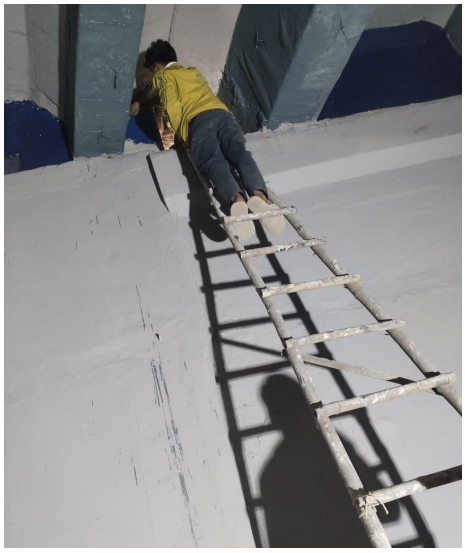
**Step-7:-** De shuttering from Pier at Nehru Nagar Flyover (RoB)

**Step-8:-** Curing on Pier and Abutment at Nehru Nagar Flyover (RoB)

## 4. Aesthetic works with Primer and Anti-Carbonation Paint:-

**Step-1:-** Primer work on Pier and Girders at Nehru Nagar Flyover (RoB)

**Step-2:-** Anti-Carbonation painting on Pier and walls at Nehru Nagar Flyover (RoB)



# MAYAPURI FLYOVER

| | |
|---|---|
| **Nameofwork** | Repair and Rehabilitation of Mayapuri Flyover Delhi. (SH: Repair of Spalled and Honeycomb Concrete, Replacement of Expansion joints and Bearing) |
| **Agency/Contractor** | M/s Rehabilitation Engineering |
| **Estimated Cost** | 2.08 Crores |
| **Tendered Cost** | 2.07 Crores |
| **Dateof Start** | 26.12.2022 |
| **Stipulated Date of Completion** | 25.06.2023 |


## Background and History:-

Mayapuri flyover is situated on ring road near Mayapuri Metro station, Delhi. Year of construction of this flyover is 2002. Width of the flyover is 20.00m with 2 nos. carriage way having 3 lanes in each carriage way. There are very heavy traffic load on the flyover as ring road is very important road of Delhi. Type of super structure of the flyover is having steel box girder (2 nos.) with RCC deck slab super structure in span P8-P9 and steel I- girder (4 Nos.) with RCC deck slab super structure in remaining spans. There are Elastomeric bearing under all spans.

## Rehabilitation and Repair Operations:-

- Replacement of Elastomeric Bearings
- Replacement of Old Expansion Joints
- Epoxy Grouting

## Steps involved during repair of structures: -

- Dismantling the old expansion joints.
- Cleaning the surface to remove debris, rust, old sealants, or remnants of the old joint.
- Protection of reinforcement by Rust remover, Anti corrosive treatment, Corrosion Inhibitor etc.
- Placement of new expansion joint.
- Fixing the expansion joint with Micro Concrete.
- Curing of the Joints.

**Step -1:-** Dismantling the old expansion joints

**Step -2:-** Cleaning the surface to remove debris, rust, of the old joints

**Step -3:-** Protection of reinforcement

**Step -4:-** Placement of new expansion joint



**Step -5:-** Fixing the expansion joint with Micro Concrete

**Step -6:-** Curing of the Joints



## CONCLUSION

In conclusion, the rehabilitation and repair of flyovers and RCC (Reinforced Cement Concrete) structures are critical aspects of infrastructure maintenance that ensure the safety, functionality, and longevity of essential transportation systems. These structures, being subjected to continuous stresses from heavy traffic, weather conditions, and environmental factors, inevitably experience wear and deterioration over time. Such degradation, if left unaddressed, can compromise the structural integrity, leading to potential hazards, higher maintenance costs, and disruption of public services.

The rehabilitation process typically involves a comprehensive assessment of the structure's condition, identifying key issues such as cracks, corrosion, spalling, and weakened joints. Once the problem areas are identified, repair strategies may include injection grouting, jacketing with high-performance concrete, and the application of protective anti-corrosive coatings to combat corrosion. Corrosion of reinforcement steel is one of the most significant threats to the durability of RCC structures, and the use of corrosion inhibitors, cathodic protection, or epoxy-based treatments helps mitigate these issues. In some cases, retrofitting measures, such as adding external post-tensioning systems or using Carbon Laminates and Carbon Fibre Reinforced Polymer wrap are employed to enhance the load-bearing capacity and stability of the structure.

The use of advanced materials, including high-strength, self-healing, and rapid-setting concretes, ensures that the repair work not only restores the structural strength but also minimizes disruption to traffic flow during the rehabilitation process. Moreover, technologies like non-destructive testing (NDT), structural health monitoring systems, and routine inspection allow for precise, real-time data collection, improving the accuracy of repairs and ongoing monitoring of the structure's health.

A key aspect of successful rehabilitation is proactive and routine maintenance. Regular inspections, conducted at predefined intervals, help identify potential vulnerabilities before they escalate into more costly or dangerous issues. By adopting a preventive approach, the service life of flyovers and RCC structures can be substantially extended, reducing the need for large-scale replacements and ensuring cost-effectiveness in the long run.

Ultimately, the rehabilitation and repair of these critical structures not only safeguard the public but also ensure the continued efficiency and reliability of transportation networks. This process requires careful planning, technical expertise, and the use of innovative materials and techniques to address the unique challenges posed by aging and damaged infrastructure. By prioritizing maintenance and timely repairs, we can continue to rely on these vital assets while supporting the growing demands of urbanization and transportation needs.

# Annexure –I

| FLYOVERS ON PWD ROAD | | | | |
|---|---|---|---|---|
| S. No. | Name of Flyover | Location of Flyover | Completion Year | Agency |
| 1 | Salim Garh Fort Velodrome | | 2010 | PWD |
| 2 | Road No. 37 (Ring Road) Underpass | | 2006 | DTTDC |
| 3 | Ring Road No. 41 (Intersection) | | 2001 | DDA |
| 4 | Ring Road NH-24 By Pass | | 2003 | DDA |
| 5 | Panchsheel Club | | 2004 | PWD |
| 6 | Oberoi Hotel | | 1982 | PWD |
| 7 | Neela Hauz | | 2010 | PWD |
| 8 | Lodhi Road | | 1982 | PWD |
| 9 | Jagat Puri (Vikas Marg & Road No. 57) | | 2002 | PWD |
| 10 | ITO Bridge | | | |
| 11 | I.P.Estates - Ring Road | | 1982 | PWD |
| 12 | Hanuman Setu | | 1996 | |
| 13 | General Store | | | |
| 14 | Corridor improvement of Outer Ring Road From IIT to NH-8 & its influence areas : Construction of (1) Flyover on portal Structure Linking Existing Munirka Flyover In the East to the point beyond Army RR Hospital in the West on the Outer Ring Road | Rao Tula Ram Marg | | PWD |
| 15 | Barapullah Nallah | | 2010 | PWD |
| 16 | Azadpur - Grade Seperator | | 2010 | PWD |
| 17 | Shastri Nagar Pushta | | 2009 | PWD |
| 18 | Road Over Disused Canal | Outer Ring Road No-26 (Rohini Depot to Mangolpuri ROB) | 2008 | PWD |
| 19 | ITO Chungi Under Pass | | 2009 | PWD |
| 20 | ROB-Marginal Bund Road (ITO Chungi to Noida Mor) | " Marginal bund road (AKSHARDHAM ROAD)" | 2005 | PWD |
| 21 | UP Link Road | NH-24 Ghazipur to Kondli Bridge | 2011 | DDA |
| 22 | R R Kohli Marg | Geeta Colony Yamuna Bridge Road (Ring Road Crossing to Marginal Bund Road) | 2010 | PWD |
| 23 | Geeta Colony Bridge | | 2008 | PWD |
| 24 | CWG Village (Akshardham) | | 2010 | DDA |
| 25 | RTR Flyover | Rao Tula Ram Marg | 2016 | PWD |
| 26 | Loni Road | | 1991 | DTTDC |
| 27 | Gokul Puri (ROB 68) | | 2014 | DTTDC |

| FLYOVERS ON PWD ROAD | | | | |
|---|---|---|---|---|
| S. No. | Name of Flyover | Location of Flyover | Completion Year | Agency |
| 28 | Wazirpur Depot | | 2005 | DTTDC |
| 29 | Mukerba Chowk | | 2008 | PWD |
| 30 | Madhuban Chowk (Pitampura) | | 2005 | DTTDC |
| 31 | ISBT Kashmere Gate | | 1991 | PWD |
| 32 | Britannia Chowk | | 2004 | PWD |
| 33 | Mangol Puri | | 2008 | PWD |
| 34 | Shyam Lal Collage (GT Road) | | 2011 | PWD |
| 35 | Shahdara | | 1999 | MCD |
| 36 | Seelampur | | 2006 | MCD |
| 37 | ROB 58 & 64 | | 2012 | PWD |
| 38 | Apsara Border | | 2011 | PWD |
| 39 | ISBT Anand Vihar (Road No. 56) | Road No. 56 (Chaudary Charan Singh Marg) | 2010 | PWD |
| 40 | Sarai Kale Khan | | | DDA |
| 41 | Safdarjung Hospital (AIIMS) | | 2003 | PWD |
| 42 | Ring Road Sarai Kale Khan Flyover | Ring Road Sarai Kale Khan Flyover | | PWD |
| 43 | Ring Road Nizamuddin Flyover | Ring Road Nizamuddin Flyover | | PWD |
| 44 | Ring Road AIIMS Flyover Loops | Ring Road AIIMS Flyover Loops | | PWD |
| 45 | Ring Roaad Maharani Bagh Flyover | Ring Road Maharani Bagh Flyover | | PWD |
| 46 | Oberoi Flyover | Sabj Burj Tomb to Lodhi Flyover, Nizamuddin Basti | | DDA |
| 47 | Nelson Mandela Marg, MM Road | | 2001 | DDA |
| 48 | Moolchand Underpass | | 2006 | DTTDC |
| 49 | Moolchand Flyover | Lala Lajpat Rai Marg | 1982 | PWD |
| 50 | Modi Mill (Okhla) | M.P. Road | | PWD |
| 51 | Lodhi Flyover | Lala Lajpat Rai Marg | | PWD |
| 52 | Lajpat Nagar to Sriniwas Puri | Ring Road Lajpat Nagar Flyover | 2006 | DTTDC |
| 53 | Flyover Bhishma Pitamah Road | Bhishma Pitamah Road | | PWD |
| 54 | Flyover Andrews Ganj Kendriya Vidyalaya | Road No. 2, Andrews Ganj | | PWD |
| 55 | B-Avenue | | 2005 | PWD |
| 56 | Ashram (ROB) | Ring Road Nehru Nagar Rail Over Bridge | | PWD |
| 57 | Andrews Ganj | Andrews Ganj Road No. 3 | 2002 | PWD |
| 58 | AIIMS Flyover, Ring Road | Ring Road AIIMS Flyover | | PWD |

| FLYOVERS ON PWD ROAD | | | | |
|---|---|---|---|---|
| S. No. | Name of Flyover | Location of Flyover | Completion Year | Agency |
| 59 | Kalkaji (Maa Anand Mayi Marg) | SA Road RD 0 to RD 5460 | 2004 | PWD |
| 60 | Nehru Place | Outer Ring Road | 2001 | PWD |
| 61 | Sarita Vihar | | 2001 | DDA |
| 62 | IIT | | 1994 | DTTDC |
| 63 | Savitri Cinema | Savitri Cinema Road | 2001 | PWD |
| 64 | JNU/CSMRS(AAA, Africa Avenue) | | 2009 | PWD |
| 65 | Demo Flyover | I.P. Marg(Bahadurshah Zafar Marg to Ring Road (I.P. Flyover)) | | PWD |
| 66 | B-AVENUE FLYOVER | Ring Road | 2005 | PWD |
| 67 | AFRICA AVENUE FLYOVER | Ring Road | 2001 | PWD |
| 68 | Panchsheel Club Flyover | Outer Ring Road | | DTTDC |
| 69 | IIT Delhi Flyover | Outer Ring Road | 1992 | DTTDC |
| 70 | Chiraj Delhi | Outer Ring Road | 1992 | MCD |
| 71 | RTR Marg (B.J.Marg) | | 2009 | PWD |
| 72 | Naraina | | 2010 | PWD |
| 73 | Munirka (Vivekanand Marg - Old of Palme) | | 2009 | PWD |
| 74 | Moti Bagh | | 2001 | PWD |
| 75 | Mayapuri (ROB) | | | |
| 76 | Mayapuri | | 2002 | PWD |
| 77 | Dhaula Kuan | | 2004 | PWD |
| 78 | Africa Avenue | | 2001 | |
| 79 | Lajwanti Chowk Flyover (Jail Road) | Shaheed Bhagat Singh Marg | | DDA |
| 80 | Raja Garden | Ring Road (Maya Puri to Raja Garden) | 2001 | DTTDC |
| 81 | Punjabi Bagh Club | Ring Road (Mahatma Gandhi Marg)(RAJA GARDEN to Punjabi Bagh) | 2005 | PWD |
| 82 | Punjabi Bagh | Ring Road (Mahatma Gandhi Marg)(RAJA GARDEN to Punjabi Bagh) | 2001 | PWD |
| 83 | Nangloi | NH-10 (Delhi Rohtak Road) from Peeragarhi Chowk to Nangloi Metro Pillar no. -410 | 2009 | PWD |
| 84 | Moti Nagar | Shivdass Puri Marg | 2005 | PWD |
| 85 | Behra Enclave (Underpass) | Outer Ring Road No-26(Peeragarhi Railway crossing to Najafgrh drain) | 2009 | PWD |

# Annexure –II

| LIST OF FLYOVER BEING REPAIRED DURING FY: 2024-25 | | |
|---|---|---|
| **S. No.** | **Description of Flyover** | **Agency** |
| 1 | Nehru Nagar Flyover (RoB) | The Freyssinet Prestressed Concrete Co. |
| 2 | ISBT Flyover (Yudhister Setu) | The Freyssinet Prestressed Concrete Co. |
| 3 | Sarita Vihar Flyover | Jha Construction Pvt. Ltd |
| 4 | Vikas Marg Flyover | Jha Construction Pvt. Ltd |
| 5 | Mukundpur Flyover | Jha Construction Pvt. Ltd |
| 6 | Karampura Flyover | Jha Construction Pvt. Ltd |
| 7 | Ashram Chowk Flyover | Jha Construction Pvt. Ltd |
| 8 | Najafgarh Drain (10 Nos. Bridge) | Jha Construction Pvt. Ltd |
| 9 | Shahdara Flyover | FRP Tech India Pvt. Ltd |
| 10 | Loni Flyover | FRP Tech India Pvt. Ltd |
| 11 | Africa Avenue Flyover | FRP Tech India Pvt. Ltd |
| 12 | Moti Bagh Flyover | FRP Tech India Pvt. Ltd |
| 13 | Savitri Cinema Flyover | FRP Tech India Pvt. Ltd |
| 14 | IIT Flyover | FRP Tech India Pvt. Ltd |
| 15 | Tilak Nagar District Centre Flyover | FRP Tech India Pvt. Ltd |
| 16 | Tilak Nagar Near Metro Station Flyover | FRP Tech India Pvt. Ltd |
| 17 | Punjabi Bagh Flyover | FRP Tech India Pvt. Ltd |
| 18 | Mayapuri  Flyover | Rehabilitation Engineering |
| 19 | Andrews Ganj Flyover | DP Associates |
| 20 | Nehru Place Flyover | DP Associates |
| 21 | Gokulpuri Flyover | Hercules Structural System Pvt. Ltd |

# Annexure –III

| LIST OF FLYOVER TO BE REPAIRED IN UPCOMING YEARS | |
|---|---|
| **S. No.** | **Description of Flyovers** |
| 1 | Raja Garden Flyover |
| 2 | Zakhira Flyover |
| 3 | Shadipur Flyover |
| 4 | Seelampur Flyover |
| 5 | Peeragarhi Flyover |
| 6 | IIT Flyover |
| 7 | Modi Mill Flyover |
| 8 | Barapullah Nallah Culvert |

## REFERENCE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