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भारत सरकार – GOVERNMENT OF INDIA
रेल मंत्रालय – MINISTRY OF RAILWAYS

इपॉक्सी रेजिन–संरचनाओं की मरम्मत में इसका उपयोग

EPOXY RESIN-ITS APPLICATION IN STRUCTURAL REPAIRS

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प्राक्कथन

प्रायः समस्त सिविल इंजीनियरिंग संरचनाओं को संरचनात्मक स्थिरता एवं स्थायित्व हेतु पुनर्वास की आवश्यकता होती है। स्थायी एवं विश्वसनीय मरम्मत के लिए सबसे अधिक आवश्यक कार्य होता है मरम्मत सामग्री का चुनाव करना। इपॉक्सी रेजिन, एक महत्वपूर्ण तथा व्यापक रुप में उपयोग किया जाने वाला पॉलीमरिक सिस्टम है जो कि पेंट्स एवं कोटिंग्स, एडहेसिव्हस, सीलेंट्स, इत्यादि में प्रयुक्त होता है।

केमटेक द्वारा तैयार की गई इस लघुपुस्तिका में विभिन्न उपयोगों को जिनमें इपॉक्सी रेजिन सामग्री का प्रयोग होता है, को समाविष्ट किया गया है।

यह उम्मीद की जाती है कि भारतीय रेल के समस्त सिविल इंजीनियरिंग स्टाफ के लिए यह पुस्तिका निश्चित रुप से उपयोगी सिद्ध होगी।

केमटेक, ग्वालियर *(ए. आर. तुपे)*

दिनांक 25, फरवरी 2013 *कार्यकारी निदेशक*

Foreword

Almost all civil engineering structures need rehabilitation in terms of structural stability and durability. The most important task for ensuring durable and trust worthy repair is the selection of repair material. The Epoxy Resin is one of the most important and widely used polymeric system, which includes paints and coatings, adhesives, sealants, etc.

The booklet prepared by CAMTECH incorporates various applications in which epoxy resin material is used.

It is expected that this booklet will be quite helpful to civil engineering personnel of Indian Railways engaged in this activity.

CAMTECH/GWALIOR ***A. R. Tupe***
DATE: 25, February 2014 ***Executive Director***

भूमिका

एक बड़ा संगठन होने के नाते भारतीय रेल के पास इंजीनियरिंग संरचनाओं एवं भवनों की विशाल सम्पदा मौजूद है। अधिक पुराने होने के कारण इन संरचनाओं में विकृति के चिन्ह देते हैं जिस कारण इनका रखरखाव आवश्यक हो जाता है। 1946 से लगातार रसायनयुक्त साम्रग्री इपॉक्सी रेजिन का उपयोग सिविल इंजीनियरिंग कार्यो जैसे कि दरारों की भराई, कटानयुक्त कंक्रीट संरचनाओं की मरम्मत, पुलों की आपात मरम्मत, कृत्रिम जलाशय, रासायनिक रुप से क्षययुक्त कॉलमों एवं बीमों में किया जा रहा है। इपॉक्सी रेजिन आकस्मिक मरम्मतों तथा संरचनात्मक पुनर्वास हेतु आदर्श सामग्री है।

'इपॉक्सी रेजिन–संरचनाओं की मरम्मत में इसका उपयोग' पर इस लघुपुस्तिका को तैयार करने का उद्धेश्य रखरखाव कार्यो में लगे सिविल इंजीनियरिंग स्टाफ के मार्गदर्शन के लिए तकनीकी जानकारी उपलब्ध कराना है।

यह लघुपुस्तिका वैधानिक नहीं है तथा इसमें दी गई जानकारी का उद्धेश्य केवल मार्गदर्शन है। किसी न किसी रुप में अधिकांश डेटा एवं जानकारी, साहित्य सर्वेक्षण तथा इंटरनेट खोज पर आधारित है। अधिक जानकारी के लिए, इस पुस्तिका में निहित किसी भी जानकारी को अंतिम रुप से लागू करने से पहले विषय पर उपलब्ध प्रासंगिक साहित्य का अध्ययन संदर्भ रूप में किया जाना चाहिए।

इस पुस्तिका के सुधार हेतु पाठकों के किसी भी सुझाव का हम स्वागत करते हैं।

केमटेक, ग्वालियर *(एस.के.सक्सेना)*
दिनांक 24, फरवरी 2014 *उप निदेशक/सिविल*

Preface

Indian Railways is a big organisation having large assets of civil engineering structures and buildings. These structures due to ageing show signs of deterioration and require maintenance. The chemically blended materials such as epoxy resins are in use since 1946 and find application in civil engineering works such as grouting of cracks, repairs of eroded concrete structures, emergency repairs of bridges, aqueducts, chemically corroded columns and beams. Epoxy resins are ideal for emergency repairs and structural rehabilitation.

This booklet is prepared with the objective to provide informative technical details on *'Epoxy Resin – Its application in Structural Repairs'* for the guidance of civil engineering staff involved in maintenance work.

This booklet is not statutory and contents are only for the purpose of guidance. Most of the data & information mentioned herein are available in some form or the other in various books and other printed matter and at Internet. For more in-depth information, the relevant codes and reports on the subject may be referred before final implementation of any technique/ or method described in this booklet.

We welcome any suggestions from readers for further improvement.

CAMTECH/GWALIOR ***S. K. Saxena***
DATE: 24, February 2014 ***Dy. Director/Civil***

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इस लघु पुस्तिका के लिये भविष्य में प्रकाशित होने वाली संशोधन पर्चियों को निम्नानुसार संख्यांकित किया जायेगा।

केमटेक/सि/2014/इपॉक्सी रेजिन/1.0 सीएस # **XX** दिनांक----------

जहॉ **"XX"** सम्बन्धित संशोधन पर्ची की क्रम संख्या है (01 से प्रारम्भ होकर आगे की ओर)

प्रकाशित संशोधन पर्चियॉ

क्र.सं.	प्रकाशन की तारीख	संशोधित पृष्ठ संख्या तथा मद संख्या	टिप्पणी

ISSUE OF CORRECTION SLIPS

The correction slips to be issued in future for this handbook will be numbered as follows:

CAMTECH/2014/C/EPOXY RESIN/1.0/CS. # XX date .....

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

Sr. No. of C.Slip	Date of issue	Page no. and Item No. modified	Remarks

1.0 परिचय / INTRODUCTION

Synthetic resins such as epoxy, polyester, acrylic, polyurethane and similar resins have found application in civil engineering. Epoxy resins, which were first commercialized in 1946, are one of the most important and widely used types of polymeric systems that include paints and coatings, adhesives, sealants, fillers, reinforced polymer composites and varnishes. These epoxy resin system find application in civil engineering works such as grouting of cracks, repairs of eroded concrete structures, emergency repairs of bridges, aqueducts, chemically corroded columns and beams. To support these applications, epoxy resins are formulated to generate specific physical and mechanical properties.

Epoxy resins are of particular interest to structural engineers because they provide a unique balance of chemical and mechanical properties combined with extreme processing versatility. They possess very high mechanical and adhesive strength properties most desirable for many civil engineering applications (structural and specialty composite applications) including curing under wet conditions. They are ideal for emergency repairs and structural rehabilitation.

The three basic elements of an epoxy resin formulation when selecting a thermoset system are the base resin, curatives, and the modifiers. It is generally agreed, that cured resin formulations suitable for elevated temperature applications are largely determined by cross-linking density. It is important to remember that the molecular structure and other characteristics of the cured product are equally dependent on the base resin, the curing agent, and modifiers employed in the formulation.

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Epoxy resins when cured with different hardeners offer wide range of properties. Once cured, they form irreversible system (thermosetting). The characteristic properties of cured Epoxy resin systems relevant to civil engineering applications are:

- High adhesive strength to almost all materials
- Low shrinkage during curing
- Exceptional dimensional stability
- Natural gap filling properties
- Thermosetting (does not melt)
- Resistance to most chemicals and environments
- Ability to cure in wet conditions and underwater (for selected grades)
- Ease of application

Other resins such as unsaturated polyester, polyurethane, etc. have also been used in civil engineering. Due to their higher shrinkage during curing, lower adhesive strength and mechanical properties, these resins have not found widespread application.

2.0 संरचनात्मक मरम्मत की आवश्यकता/NEED OF STRUCTURAL REPAIRS

The need of structural repairs can arise from any of the following:

- Faulty design of the structure
- Improper execution and bad workmanship
- Extreme weathering and environmental conditions
- High degree of chemical attack
- Ageing of the structure

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3.0 इपॉक्सी रेजिन / EPOXY RESIN

The term 'epoxy resin' is a generic name of compounds that describe a broad class of thermosetting polymers in which the primary cross linking occurs through the reaction of an epoxide group. In general, an epoxy resin can be thought of as a molecule containing a three-membered ring, consisting of one oxygen atom and two carbon atoms.

The most important raw material used in epoxy resin production is epichlorohydrin, which is used as a precursor for nearly every commercially available epoxy resin. The basic epoxy resin used in the building industry is "**D**i**G**lycidyl **E**ther of **B**isphenol-**A"** (DGEBA) that, in its simplest and most standard form, is the condensation product of bisphenol-A and epichlorohydrin. Depending upon the amount of excess of epichlorohydrin to bisphenol-A used in the manufacturing process, epoxy resins ranging from low molecular weight liquids to high molecular weight solids can be obtained.

However, basic resin of this type is not suitable for many applications because of its higher viscosity. Modification of basic resin is therefore, necessary to achieve the required wet-ability, curing rate and numerous other properties in addition to lower viscosity. Modifying the ratio of epichlorohydrin to bisphenol-A during production can generate high molecular weight resin variants. This growth in molecular weight increases the viscosity, resulting in resins that are solid at room temperature.

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4.0 इपॉक्सी क्यूरेटिव्स / EPOXY CURATIVES

The proper choice of a hardener/curing agent can be as important as the choice of resin itself, both playing a significant role in determining the extent and nature of inter molecular cross linking. This curing agent, commonly called as hardener, combines with the epoxy resin and changes it from a liquid to a solid.

Out of a vast number of compounds, most commonly used curing agents are aliphatic and aromatic amines and polyamides and their adducts, which form room temperature curing compositions relevant to construction applications. There are several categories of curing agents. Examples include:

- ***Aliphatic amines*** such as triethylenetetramine (TETA) and diethylenetriamine (DETA);
- ***Aromatic amines***, including diaminodiphenyl sulfone (DDS) and dimethylaniline (DMA);
- ***Anhydrides*** such as phthalic anhydride and nadic methyl anhydride (NMA);
- ***Amine/phenol formaldehydes*** such as urea formaldehyde and melamine formaldehyde;
- ***Catalytic curing agents*** such as tertiary amines and boron trifluoride complexes.

Some other resins/ elastomers such as phenol formaldehyde resin, thermosetting acrylics, isocynates and polysulphides are also used as co-cross linking agents with amines to obtain the desired properties of the finished products. They are mostly used for corrosion resistant linings, food and beverages containers / tank coatings, etc.

5.0 इपॉक्सी मॉडीफायर्स / EPOXY MODIFIERS

The modifiers are used to provide specific physical and mechanical performance in both the uncured and cured resin. General categories of modifiers include rubbers, thermoplastics, diluents, flame retardants, fillers and pigments and dyes. These are briefly described as below:

Rubber Additives: These are used to increase flexibility, fatigue resistance, crack resistance, and energy absorption (toughness) in epoxy resins. These polymers may be employed as liquid, solid, or particulate components in a formulation. The liquid rubbers most often used in epoxy composites are carboxyl-terminated butadiene acrylonitrile copolymers. The acrylonitrile content of the rubber is an important consideration when choosing a rubber modifier.

Diluents: These are used for lowering the viscosity and improving handling characteristics of epoxy resin and are classified as:

- ***Reactive Diluents*** are mostly low molecular weight glycidyl ethers with low viscosity, which reduce the cross link density of the system.
- ***Non-reactive Diluents*** such as toluene, xylene and other aromatic hydrocarbons can bring about significant reduction in the viscosity of low molecular weight resins. A popular non reactive diluent is dibutylpthalate, used with a liquid resin.

Flame Retardants: These can be added to epoxy resins as filler, or the matrix can be built to incorporate flame retardant characteristics. Generally, the more carbon and hydrogen in a polymer system, the more flammable it is. The presence of halogens and char-forming aromatics in the epoxy curative based resin decreases flammability.

Un-reactive Fillers: Fillers are used in epoxy resins as extenders, reinforcements, and to impart specific physical characteristics such as low density, low flow, shrinkage reduction, and thermal and electrical conductivity. The types of fillers used vary widely but can generally be categorized as minerals, metals, glass, fibers, carbon, and miscellaneous organics. Physically, they can be used in a variety of forms including powders, pulps, flakes, flocks, spheres, micro-balloons, short fibers, and whiskers.

Pigments and Dyes: Epoxy resins may be coloured using a wide variety of pigments and dyes, both organic and inorganic. Pigments are insoluble particles dispersed in a resin, whereas dyes are soluble organic molecules. Dyes are not suitable for epoxy composite applications due to temperature limitations.

6.0 इपॉक्सी रेजिन सिस्टम्स / EPOXY RESIN SYSTEMS

Epoxy resin systems are made up of an epoxy resin and a curing agent (also called a hardener or catalyst). Many epoxy products contain additives such as organic solvents, fillers such as fiberglass or sand, and pigments.

Coal Tar Epoxy System: Coal Tar epoxy resin combinations with polyamine hardener have been widely used as water resistant protective coatings. Coal Tar plays an important part in the improvement of corrosion resistance of epoxy resin system. It is Coal Tar/Epoxy in proportion of 40:60, which has been reported to give optimum results under aggressive environment.

Rubber Modified Epoxy System: This system is used to improve the drawback of brittleness and low elongation of unmodified epoxy resin based on bisphenol-A and epichlorohydrin with hardeners such

as polyamines and anhydrides. The system possessing both small and large particles provides maximum toughness. The most widely used toughner in epoxy resin is a liquid carboxyl-terminated butadiene acrylonitrile.

Epoxy Phenolic IPN Systems: Central Building Research Institute (CBRI), Roorkee has developed an Epoxy-Phenolic Interpenetrating Polymer Network (IPN) system for protection of structural steels and now extended to rebar. IPNs are relatively novel types of polymer alloys consisting of two or more polymers in network forms, at least one of which is synthesized and/or cross linked in the immediate presence of the other. Polymer phases are devoid of chemical linking between them interwoven to each other and help together by permanent entanglements.

Composite Fibre System: The system comprises of a fiber reinforcement layer that is wrapped to the exterior surface of the structural element to be retrofitted. The fiber composite reinforcement layer consists of at least one fabric layer that is located within a resin matrix. The primary fibres are oriented in a desired direction with reference to the axis of the structural element concerned. The composite reinforcement layer provides a quick, simple and effective means for increasing the resistance of the structural element to failure during the application of loads. All the components of the composite (epoxy, fabric etc.) shall be fully compatible and supplied by a supplier that is competent in the technology, design, installation and materials of the composite system.

Epoxy Mortar and Concrete: Epoxy resins are used with aggregate (silica sand) to produce epoxy mortar or epoxy concrete, which is used for structural repairs of concrete, RCC besides its use

in new construction in industrial flooring, foundation grouting, roads etc. They are normally used where volume of materials is not large and where rapid curing can be obtained. Epoxy Resins and epoxy resin based mortar possess several important characteristics which can be advantageously used for civil engineering applications.

7.0 खॉचादार पीआरसी स्लीपरों का इपॉक्सी आधारित उपचार/EPOXY BASED TREATMENT OF GROOVED PRC SLEEPERS

The damage of GRP (Grooved Rubber Pad) and formation of groove in PRC sleeper rail seats is a major problem due to the curves (more than 6 degree and gradient steeper than 1 in 100) consisting of fish plated joints at every 6.5 meter length in track. An innovative idea to repair the grooved sleepers with epoxy is the only feasible, economical and quick solution to keep the gauge within permissible limits.

The epoxy resin (DGEBA) and the hardener are to be mixed for starting the chemical reaction of hardening. For preparing the mortar, some silica flour is added to aggregates as per manufacturer's recommendation for the best application. The epoxy mortar so prepared has a compressive strength more than that of concrete of PRC sleeper.

Procedure:

- Every one sleeper after 10 sleepers is removed from the running track.
- The rail seat is cleaned with wire brush and cleaner chemical to make the surface free from grease, oil, loose materials and dust.

- The rail seat surface is raked out with wire brush for ensuring proper bond and grip.
- One coat of epoxy primer on rail seat is applied in dry and clean condition.
- The groove portion is filled with epoxy mortar using template.
- The repaired groove portion is trimmed and allowed for curing for at least 5-6 hours on cess.
- GRP on sleeper is fixed over repaired rail seat with adhesive.
- The repaired sleeper is inserted back onto track with doing necessary packing.


RAIL SEAT BEFORE REPAIR


RAIL SEAT AFTER REPAIR

8.0 संरचनाओं में दरारों की इपॉक्सी आधारित इंजेक्शन ग्रॉटिंग / EPOXY BASED INJECTION GROUTING OF CRACKS IN STRUCTURES

As compared to cement, epoxy is quick setting, has very low shrinkage, excellent adhesion, high strength, low viscosity to penetrate even hair cracks and good resistance to most of the chemicals. However, epoxy grouting, being expensive, should be used only when it is techno economically justified.

A very low viscosity epoxy resin and hardener composition is used for injection grouting of cracks. Grouting of wide cracks require large quantity of grout material. In such cases suitable fillers e.g. dry silicon flour etc. can be added based on manufacturer's recommendations. Considering the width, depth and extent of cracks and other relevant details, the viscosity of the resin hardener mix, their proportions, pot life, application procedure etc. should be chosen in consultation with the manufacturers. The shear strength on a specimen of two mild steel plates should not be less than 100 kg/cm2. The epoxy mortar should not be susceptible to fire and explosion during injection process and must be stable under varying climatic conditions.

Equipments required

- Pneumatic or electric hole drilling equipment.
- Pressure injection equipment of standard make with necessary control valves and gauges, etc.
- Air compressor of capacity 3 to 4 cum/min. and pressure of 10 kg/cm^2.
- Polythene or metal pipe pieces 6-9mm dia.
- Polythene/plastic containers for mixing the epoxy formulation.
- A portable generator.

Procedure for epoxy grouting

- The area to be grouted should be dry and free from oil, grease, dust and all loose and unsound materials.
- All cracks should be cut open to a 'V' groove about 10mm deep by mechanical or manual means. Loose material should be removed by using compressed air and groove fully sealed using epoxy mortar at least one day in advance.

- Nails are driven into the cracks at 15 cm to 50cm intervals along the crack.
- Holes of 7 - 10 mm dia should be drilled along the cracks and copper or aluminium or polythene pipe pieces of 6 - 9 mm dia fixed as grout nipples around the nails and allowed to rest on them.



- Epoxy formulation is injected from the bottom most pipe, keeping all other pipes, except the adjacent ones, blocked by wooden plugs. The injection is done using suitable nozzles connected to air compressors or by hand operated modified grease guns. Pressure of 3.5 to 7 kg per sq. cm is normally used. As soon as the epoxy comes out from the adjacent open pipes, they are plugged and the pressure increased to the desired level and maintained for 2 to 3 minutes. The injection nozzle is then withdrawn and the hole sealed with epoxy mortar. This operation is repeated for the other pipes also. Any resin that remains or overflows the copper pipe is scraped off with a metal spatula and the surface cleaned with a rag soaked in noninflammable solvent.
- Due to restriction of pot life, it is advisable to mix only small quantities of epoxy at a time. All proportioning should be by weight and mixing should be thorough.
- Low viscosity resins may be adopted for thin cracks.
- A record of materials consumed should be maintained.

9.0 पुरानी कंक्रीट का नई कंक्रीट के साथ इपॉक्सी आधारित जोड़/EPOXY BASED BONDING OF OLD TO NEW CONCRETE

Epoxy resin with a special polyamide hardener combination is successfully used for bonding old to new concrete. A test carried out by CSMRS, Delhi shows the bonding strength improvement after using epoxy resin as intermediate layer in monolithic bonding between old and new concrete. The process consists of:

- Removal of all loose and damaged concrete using mechanical means or water jet.
- Surface to be dried.
- A suitable epoxy resin [unmodified solvent-less epoxy resin and polyamide hardener (special grade)] is applied with stiff nylon brush.
- The fresh concrete should be poured when epoxy coating has become just tack free.
- Care should be taken not to completely dry the coating.
- In the case of epoxy bonding, no separation is observed almost up to failure in the concrete.

10.0 इपॉक्सी आधारित संक्षारक विरोधी बचाव रुपी परतें/EPOXY BASED ANTI CORROSIVE PROTECTIVE COATINGS

Fusion Bonded Epoxy Powder Coatings (FBEC) as well as IPN Coatings is being used for protection to reinforcing bars against corrosion in RCC structures located in highly aggressive environment. FBEC process provides a tough film, which can withstand bar bending without cracking, whereas IPN coatings are

used for new constructions for in situ coatings to steel reinforcement. IPN coatings are also used as surface coatings for RCC structures for arresting further carbonation of cover concrete or other chemical attack by sealing their surface against ingress of environmental aggressive chemicals and their consequential attack on concrete.

Two different resins i.e. *Medium viscosity epoxy resin based on epichlorohydrin and bisphenol as base and an aromatic amine adduct as the cross-linker* and *Phenolic resin obtained from an indigenous phenol with its cross-linker* are mixed in different ratios and cross-linked simultaneously by a separate non interfering mechanism. These are used with advantage in coatings for protection of concrete structures and steel reinforcement bars against corrosion due to their good resistance to chlorides and chemicals.

The method of application is as follows:

- For cleansing the surfaces of rebars, sand blasting/ shot blasting is done to remove rust and other deleterious material in a shed provided with proper ventilation.
- The first coat of Epoxy phenolic-IPN is applied by means of brush/ spray within 4 hours of sand blasting/ shot blasting.
- The application of coat should be done on a high platform of wood or steel where the rebars can be kept at ease.
- For effective polymerisation within 4 to 8 hours after the application of first coat. Resin component and Hardner component of Epoxy phenolic-IPN coating are mixed in plastic container in 1:1 proportion by volume and vigorously stirred for 5-10 minutes and then the mixture is allowed to remain in the container for another 5-10 minutes. The mixture is ready for use.

The plastic container should be clean and free from moisture, grease oil, etc.

- The mixture is applied by means of brush/spray.
- The treated rebar should be cured for 48 hours after the application of first coat.

Note: *Epoxy coatings in conjunction with epoxy grouting have been used to render leaking roofs, toilets, bath rooms as impervious. However, their use in exposed locations directly exposed to sunlight is to be avoided.*

Epoxy based Paints:

A - For locations where girders are exposed to corrosive environment i.e. flooring system of open web girders in all cases, girders in industrial, suburban or coastal areas etc., protective coating by painting with epoxy based paints may be applied:

i) Surface Preparation:

a) Remove oil/grease from the metal surface by using petroleum hydrocarbon solvent to IS : 1745.
b) Prepare the surface by sand or grit blasting to Sa 2½ to IS : 9954 i.e. near white metallic surface.

ii) Painting:

a) **Primer coat:** Apply by brush / airless spray two coats of epoxy zinc phosphate primer to RDSO specification No. M&C/PCN-102/86 to 60 microns minimum dry film

thickness (DFT) giving sufficient time gap between two coats to enable first coat of primer to hard dry.

b) **Intermediate coat:** Apply by brush/airless spray-one coat of epoxy micaceous iron oxide to RDSO specification No. M&C/PCN-103/86 to 100 microns minimum DFT and allow it to hard dry.

c) **Finishing coat:** Apply by brush/airless spray two coats of polyurethane aluminium finishing to RDSO Specification No. M&C/PCN-110/88 for coastal locations or polyurethane red oxide (red oxide to ISC 446 as per IS : 5) to RDSO Specification No. M&C/PCN-109/88 for other locations to 40 microns minimum DFT giving sufficient time gap between two coats to enable the first coat to hard dry. The finishing coats are to be applied in shop and touched after erection, if necessary.

B - Initial painting of weld collar can be done with high build Epoxy paint consisting of two pack as per RDSO's specification No. M&C/PCN/111/88 in Heavy Corrosion prone area.

Note: *Vide A&C Slip No.5, dated 30.08.2013, the RDSO specifications to IRS-B1-2001 as mentioned in A and B above have been replaced with M&C/PCN-102/2009 (Primer Coat), M&C/PCN-103/2011 (Intermediate Coat), M&C/PCN-110/2006 (Finishing Coat for Coastal locations) and M&C/PCN-109/2009 (Finishing Coat for other locations) and M&C/PCN-111/2006 (Initial painting of Weld Collar in heavy corrosion prone area).*

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11.0 इपॉक्सी आधारित अन्य उपयोग/EPOXY BASED OTHER APPLICATIONS

1. **Epoxy Based Self Flow Micro Concrete** is highly fluidic, non-shrink, self compacting concrete with very high early ultimate strength, excellent adhesion and possesses excellent mechanical properties and bonds with almost all building materials. It is suitable for sealing crack surface defects, concrete repair, thin jackets, thin film bonding, assembly of pre-stressed concrete segmental units and segmental bridge construction. It is also used for structural repairs like Jacketing, patch repair, retrofitting of RCC, grouting foundations, anchor bolts. It is not suitable in exposed location, at high temperatures or where temperature variation range is large.

2. **Epoxy Based Quick Setting Compounds,** rapidly sets concrete/mortar to yield early strength.

3. **Epoxy Based Floor Hardener,** possesses excellent abrasion resistance and other mechanical properties.

4. **Epoxy Based Acid Resistance Enhancer,** is an acid resistant coating for concrete and steel (Non-resistant to UV radiation). It possesses excellent bonding and adhesion under dry and wet conditions both.

5. **Epoxy Based Anchoring,** depends upon the area to be sealed. The number of capsules to be used is dependent on the pull out force. The capsules are manufactured in wide range of diameter between 25 to 40 mm and in 3 different lengths. The borehole diameter is about 8mm bigger than the anchor bolt diameter. In

general, for 12 t pullout force, 3x30mm dia x 300mm length capsules are sufficient.

6. **Epoxy Based Water Proofing Compounds** are used as surface coatings as well as Integral Water Proofing Compound, which seals pores & network of fine cracks, good bonding, withstands positive water pressure, resists chemicals aggression.

12.0 अपनाई जाने वाली सावधानियॉ/PRECAUTIONS TO BE TAKEN

The chemicals in epoxy resin systems can affect the health of a person during handling these chemicals. The main effects of overexposure are irritation of the eyes, nose, throat, and skin, skin allergies, and asthma. The solvent additives can cause other effects such as headaches, dizziness, and confusion.

Epoxies are generally toxic in nature and these require lot of care in their handling. The special care required to be taken during their mixing and applications are as under:

- They should not come in contact with the skin. Workers should be provided with rubber gloves.

- In case of eye contact, immediately rinse the eyes with water. Continue rinsing for 15 minutes and then seek medical attention.
- The utensils/ equipments used for the mixing resin and hardener should be cleaned immediately after their use.

- The pot life of the mixed epoxy is generally very limited, ½ to 2 hours. Therefore, material should be prepared just sufficient to

cover the area within the pot life period as recommended by the manufacturers.

- Epoxies have much higher bond strength than other polymers, but at the same time, these are costlier.
- Manufacturer's detailed instructions should be followed for safe handling and processing.
- The grease gun syringe should be washed with acetone immediately after use.

13.0 व्यापारिक रुप से उपलब्ध इपॉक्सी आधारित उत्पादित वस्तुऐं/COMMERCIALLY AVAILABLE EPOXY BASED PRODUCTS

Some of the epoxy based products as mentioned in the table below are not a part of the approved vendor list. The information based on details available on manufacture' websites has been given here for reference purpose only. User may refer relevant manufacture's guidelines before actual implementation of the product in the civil engineering applications.

S. No.	Name of Product	Application	Name of Manufactures
1.	**CERA SCREED EPLV** (High performance non shrink epoxy grout)	Injection grouting	Cera-Chemical Pvt. Ltd., No. 6, Park Street, Kilpauk Garden colony, Chennai-600010 www.cerachemindia.com
2.	**CERA BOND EP** (Epoxy bonding agent for structural concrete)	Bonding of old to new concrete	
3.	**CERA ZINC ZR** (Epoxy zinc rich primer)	Protective coat on steel	
4.	**MASTER- GROUT EP – 150-G**	Injection grouting	Choksey Chemical

	(Two pack epoxy resin system for injection grouting and for granting gap widths of 0.25 to 10 mm)		Pvt.Ltd., 111-Industrial Area, Sion, Mumbai-400022. www.chokseychem.com
5.	**MASTER- BOND – EP** (Two pack epoxy resin bonding agent providing strong bond between old concrete and new concrete)	Bonding of old to new concrete	
6.	**TECH FLOOR SL -2** (Self levelling polysulphide Epoxy floor coating provides a hard-wearing attractive floor which is chemical resistant, impervious and extremely clean)	Acid resistant coating for concrete and Steel	
7.	**EPCO KP/HP-250 SLV** (Low viscosity Epoxy grouting system for use in repairs of deteriorated concrete structural elements for strength and durability, grouting of honeycombs and cavities in concrete structures, to create proper bonding between separate concrete structures)	Injection grouting	Krishna Conchem Products Pvt. Ltd. 1 & 2, Bldg No.6, Sector No.3, M.B.P Mahape, Navi Mumbai. 400 705 www.krishnaconchem.com
8.	**EPIBOND** [Epoxy based bonding agent for bonding old to new concrete, concrete jointing (cold joints) and for repairs of concrete/ plaster/guniting]	Bonding of old to new concrete	
9.	**CORROSEAL ZR** (Zinc rich epoxy based coating system for use in protection structural steel, M.S. liners, pipelines, storage tanks, etc. from	Protective coat on steel	

	chemical and saline environments)		
10.	**CORROSEAL AE** (Aqua Epoxy Coating for use in anti-corrosive, anti-carbonation applications to marine and water retaining structures and in waterproofing of sunken slabs, bathrooms, terraces, etc.)	Anti carbonation protective coat on concrete	
11.	**IPNet RB** [Interpenetrating polymer network system (CBRI/ CSIR know-how) for use as protective, anti-corrosive coating to rebar in the repairs & also in construction of RCC structures exposed to aggressive corrosion, to enhance the durability]	Bond Coat that protect reinforcement from Chloride attack *and other chemical*	
12.	**MC DUR 1264** (Low viscosity Epoxy Resin for use in rigid filling by injection or deep penetration of cracks, joints and voids in building construction and civil engineering under dry conditions)	Injection grouting	MC. Bauchemi (India) Pvt.Ltd., 411 Arenja Corner, 4th Floor, Sectors-17, Vashi, Navi Mumbai-400703 www.mc-bauchemieindia.com
13.	**MC DUR 1200** (Two component, pigmented epoxy resin coating for use in industrial areas or similar, grouting of steel anchors)	Bonding of old to new concrete	
18.	**SUNEPOXY 368** (Very low viscosity epoxy injection grout material provides structural integrity, high	Injection grouting	Sunanda Speciality Coating Pvt Limited, 2, Anik Court Pandurang Naik Marg , Mahim,

	bond strength)		Mumbai-16
19.	**SUNEPOXY 358** (Two component high viscosity epoxy resin for use in corrosion protection of steel, bond coat for old and new concrete, joints of metals, flooring screed, etc.)	Bonding of old to new concrete	www.sunandaglobal.com
20.	**1. ICOSIT K25 (I)/3** (Two part epoxy resin based protective coating for use on concrete, cementitious mortars and rendering, epoxy mortars, steel, stone, wood, etc.) **2. FRIAZINC R** (Two component, low solvent, zinc rich epoxy resin based primer for steel)	Protective coating	Sika India Pvt. Ltd. Commercial Complex II, 620, Diamond Harbour Road Kolkata, 700 034 www. ind.sika.com
21.	**HIBOND** (Epoxy based, two component structural bonding agent applied between old and new concrete surfaces during casting of roof slabs, retaining walls, water tanks, extension of balconies, etc.)	Bonding of old to new concrete	
25.	**CICO POXY-21** (Low viscosity high strength injectable epoxy grout is a two component solvent free, free flowing, fast curing system used to grout fine cracks, voids and fissures of concrete structures and rocks)	Injection grouting	CICO Technologies Limited, A- 9 Chitranjan Park (LGF), Outer Ring Road, New Delhi-110019 www.cicogroup.com
26.	**CICO BOND EPO** (Two components 100% solid epoxy resin system used as a high strength	Bonding of old to new concrete	

	bonding agent for mortars, renders, stone, steel, iron, etc.)		
28.	**CICO POXY SBA** (Thixotropic epoxy resin adhesive for segmental bridge construction)	Self flow micro concrete	
29.	**CICO POXY TC 200** (Two component solvent free epoxy coating system for water proofing, dust proofing of concrete walls, floors and ceilings. Suitable for use on all types of structures, especially those in aggressive marine and coastal environment)	Water proofing coating	
30.	**CICO RESIFIX** (A polyester resin cartridge consisting of two components – resin grout and its catalyst, used for anchoring bolts into rock or concrete for the purpose of mining, tunnelling, etc.)	Anchoring of bolts, etc.	
31.	**CICO GROUT GP** (An expanding non-ferrous grout, consisting of a dry pre-mixed blend of special grade cement, siliceous aggregate with set regulating and reactive compounds in powder form. Non-shrink ready to use Cementitious Grout suitable for grouting of machine bases – steel and pre-cast concrete anchor bolts and similar grouting applications.)	Acid resistant coating for concrete and Steel	
32.	**FLOWGROUT EPLV** (Two part, pre formulated, low viscosity epoxy resin	Injection grouting	FAIRMATE Chemical Pvt Limited, 8/1, SAI

	used for injection of cracks and cold joints in concrete structures. Suitable for damp or dry surface)		Sudha, Arunoday Society, Alkapuri, Vadodra- 390007 www.fairmate.com
33.	**FAIRBOND EP** **(**two pack, solvent free, **epoxy based concrete bonding agent**)	Bonding of old to new concrete	
34.	**SAFECORE EP (S)** **(**High performance **solvent based coating** with minimum surface preparation, provides resistance to mild alkali and acid for steel surfaces)	Protective coat on steel	
35.	**SAFECORE EP (F)** **(**High build and decorative **solvent based chemical resistant coating** for industrial floor and walls)	Protective coat on concrete	
36.	**ANCHORGROUT** **(**High strength thixotropic, two part **polyester resin grout**. Suitable for grouting of steel bars bolt into concrete, stones, machinery and brick work)	Anchoring of bolts, etc.	
37.	**FIBPOXY (IR)**	Injection grouting	Fibrex Construction Chemicals Pvt. Ltd., Plot No. 73, First Floor, New DLF Industrial Area, Faridabad-121003, www.fibrexchem.com
38.	**FIBBOND 253** (Two component epoxy bonding adhesive for concrete)	Bonding of old to new concrete	
39.	**FIBMICROCRTE** (High strength material for use in parking decks, floor toppings, joint repairs, equipment bases, pedestals, pavements)	Self flow micro concrete	

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सन्दर्भ

REFERENCES

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6.	**Chapter-5 – Maintenance and Rehabilitation [Guidelines for Inspection, Maintenance and Rehabilitation of Concrete bridges]** Source: www.wiki.iricen.gov.in
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गुणवत्ता नीति

रेलों में यात्री और माल यातायात की बढती माँग को पूरा करने के लिए गुणवत्ता प्रबंध प्रणली में अनुसंधान, डिजाइनों और मानकों में उत्कृष्टता तथा सत्त सुधारों के माध्यम से सांविधिक और नियामक अपेक्षाओं को पूरा करते हुए सुरक्षित, आधुनिक और किफायती रेल प्रौद्योगिकी का विकास करना।

QUALITY POLICY

To develop safe, modern and cost effective Railway technology complying with Statutory and Regulatory requirements, through excellence in Research, Designs & Standards and Continual improvements in Quality Management System to cater to growing demand of passenger and freight traffic on the Railways.

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हमारा उद्देश्य

अनुरक्षण प्रौद्यौगिकी और कार्यप्रणाली को उन्नयन करना तथा उत्पादकता और रेल्वे की परिसम्पत्ति एवं जनशक्ति के निष्पादन में सुधार करना जिससे अन्तर्विषयों में विश्वसनीयता, उपयोगिता और दक्षता प्राप्त की जा सके।

यदि आप इस सन्दर्भ में कोई विचार और सुझाव देना चाहते हों तो कृपया हमें इस पते पर लिखें।

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OUR OBJECTIVE

To upgrade Maintenance Technologies and Methodologies and achieve improvement in Productivity and Performance of all Railway assets and manpower which inter-alia would cover Reliability, Availability and Utilisation.

If you have any suggestion & any specific comments, please write to us:

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