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भारत सरकार - **Government of India**

रेल मंत्रालय - **Ministry of Railways**

वेक्यूम डिवाटरिंग कंक्रीट फ्लोरिंग

VACUUM DEWATERING CONCRETE FLOORING

केमटेक/2021/सि/व्हीड़ीएफ/1.0

CAMTECH/2021/C/VDF/1.0

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अअमा संRDS
रेल अग्रदूत Transforming Railways

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VACUUM DEWATERING CONCRETE FLOORING

Foreword

In civil engineering structures, flooring work plays an important role and should be in fact time efficient with medium to high workability of concrete. Concrete floors are widely used in railway platforms, workshops, industrial floors, bridges, RCC Roads, etc. As an added advantage with applying vacuum dewatering process to fresh concrete in which surplus water is removed, the strength, durability and other properties of concrete floor may be achieved.

The handbook prepared by CAMTECH is informative in context of providing basic principle of vacuum dewatering process including equipments used, procedure followed and precautions taken in execution of concrete floors.

It is expected that this handbook will be quite helpful to those who are engaged in maintenance and construction of Civil Engineering Structures in Indian Railways.

CAMTECH/Gwalior ***(Jitendra Singh)***
2nd March, 2021 ***Pr. Executive Director***

Preface

Vacuum Dewatering of Freshly Placed Concrete provides a solution to lower the water-cement ratio to minimum desired level of a sufficiently high workability mix. When used for flooring purpose, it has ability to specially address the issues of concreting of large exposed surfaces in hot weather conditions and adopted in large scale flooring work in railway platforms, workshops, industrial floors, bridges, RCC Roads, Pre-cast Concrete Products etc. It is preferably recommended to be used where conventional concrete flooring fails to address the deficiencies like drying shrinkage, excess water in mix, improper grade/thickness control, poor finishing and curing techniques, and excessive load on the concrete.

The vacuum dewatering concrete is based on the principle of removing surplus water (or excess water). The concrete floor is dewatered by vacuum process wherein surplus water from the concrete is removed immediately after placing and vibration, thereby reducing the water cement ratio to the optimum level.

Effort has been made to make this handbook useful to civil engineering personnel engaged in construction and maintenance activities in Indian Railways.

This handbook is not statutory & contents are only for the purpose of knowledge dissemination. Most of the data & information in some form or the other are based on literature available and internet search. For more in-depth information / knowledge, the relevant detailed literature, BIS Codes, etc. available on the subject may be referred to.

We welcome valuable suggestions from our readers for further improvements of this handbook.

CAMTECH/Gwalior ***(Deepak Mehra)***
25th February, 2021 ***Joint Director/Civil***

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संशोधन पर्चियों का प्रकाशन
ISSUE OF CORRECTION SLIPS

इस हस्तपुस्तिका के लिए भविष्य में प्रकाशित होने वाली संशोधन पर्चियों को निम्नानुसार संख्यांकित किया जाएगा :

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

केमटेक/2021/सि/व्हीड़ीएफ/1.0/सीएस# XX दिनांक_____

CAMTECH/2021/C/VDF/1.0/CS # XX date_____

जहाँ XX संबन्धित संशोधन पर्ची की क्रम संख्या है (01 से प्रारम्भ होकर आगे की ओर)

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

प्रकाशित संशोधन पर्चियाँ
CORRECTION SLIPS ISSUED

क्र.सं./ Sr. No.	प्रकाशन दिनांक/ Date of issue	संशोधित पृष्ठ संख्या तथा मद संख्या/ Page no. and Item No. modified	टिप्पणी/ Remarks

1.0 Introduction

Flooring is an important part of any structure intended to use it as residential, commercial, and industrial purposes. In railways, various types of floorings are recommended at stations, workshops, colonies, etc. based on their usage and category.

As specified in the Guidelines on WSC Agenda Item No. 004/01/05 issued by Works Directorate/RDSO on "Standardization of specification of flooring, Roofing Material for Platform covering in Station Premises & Standardization of Specification of Workshop Flooring", it is recommended to provide fibre reinforced vacuum dewatered concrete flooring for all new work in station category A1, A, B, C and D for platform (covered area), platform (uncovered area), portico, circulating area, parking area, cloak room, parcel area. Vacuum dewatered concrete without fibre reinforcement can also be provided wherever considered necessary with the approval of Sr. DEN / Dy. Chief Engineer.

As in case of Railways, the VDF System is recommended for Workshops Flooring with the specifications as follows – "Vacuum dewatered cement concrete 200 mm thick of M20 grade or above with a tough & wear resistant topping layer of 1.5 cm thickness. This wear resistant topping will consist of hard metal chippings, cement and a metallic based chemical (with specially treated iron fillings). The wear resistant topping is to be provided only in case of heavy duty flooring".

The vacuum dewatering concrete flooring, also known as VDF System is suitable for high abrasion and heavy traffic movement. It is preferably used in making concrete roads, railway platforms, industrial floors, bridges, RCC Roads, Pre-cast Concrete Products etc.

This document is prepared to help the field staff of Indian Railways in execution of items of CPWD DSR and IRUSSOR – 2010 mentioned as follows –

Code No. 16.75 of CPWD DSR 2018 (Vol 2) – Providing and laying C.C. pavement of mix M-25 with ready mixed concrete from batching plant. The ready mixed concrete shall be laid and finished with screed board vibrator, vacuum dewatering process and finally finished by floating, brooming with wire brush etc. complete as per specifications and directions of Engineer-in charge.

Code No. 16.76 of CPWD DSR 2018 (Vol 2) – Deduct for using of M-20 grade concrete instead of M-25 grade concrete in C.C. pavement.

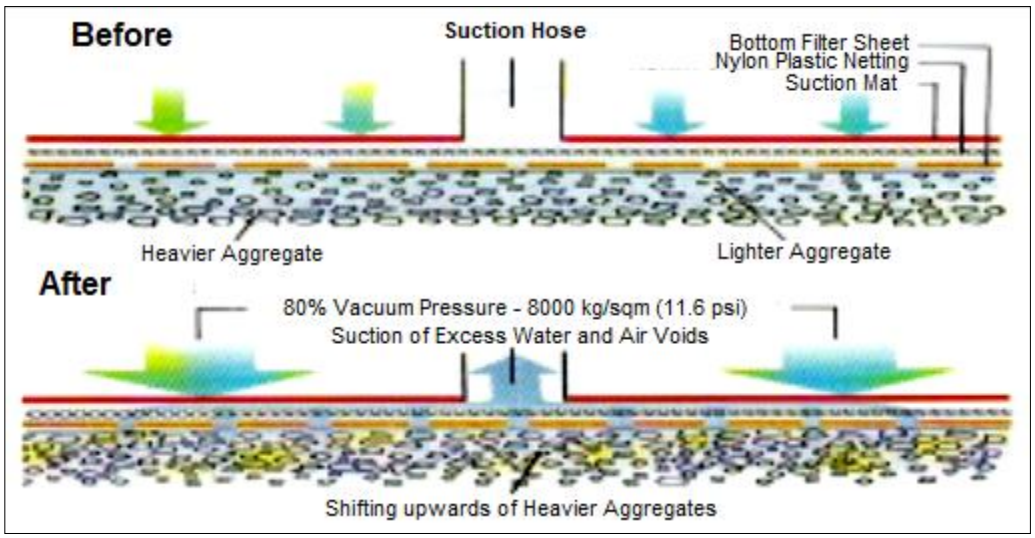
Item No. 092060 of USSOR 2010 of Indian Railways – Providing and laying plain cement concrete flooring of specified thickness with mix design concrete over firm, well prepared and well compacted bed including provision of designed expansion joint & finishing manually or mechanical trowelling & vacuum dewatering complete.

2.0 What is Vacuum Dewatering Flooring

Usually, the deficiencies like drying shrinkage, excess water in mix, improper grade/thickness control, poor finishing and curing techniques, and excessive load on the concrete are noticed in conventional flooring during its service period. To overcome the deficiencies of conventional concrete flooring, a system is devised to improve the properties of such concrete floors. The

system by virtue of its uniqueness is known as vacuum dewatering concrete in which surplus water (or excess water) from fresh concrete is removed to improve strength, durability, and other properties of concrete by reducing the water-cement ratio (to the optimum level) immediately after the mix is placed, usually in floors and other flooring purposes.

The VDF system is an effective technique used to overcome this contradiction of opposite requirements of workability and high strength. With this technique, both these workability and high strength are possible at the same time. The system is workable for laying high quality concrete floors with superior cost effectiveness to achieve High strength, Durability, Longer Life, Better Finish and Faster Work.



Condition of concrete before and after VDF

2.1 Need of Vacuum Dewatered Flooring

There are certain fundamental requirements due to which the vacuum dewatered flooring is preferred to be adopted in large scale flooring work in railway platforms, industrial floors, bridges, RCC Roads, Pre-cast Concrete Products etc.

- The uncontrolled removal of water from the concrete matrix can result in adverse effects such as plastic shrinkage cracking.
- Excessive bleeding of concrete can negatively interfere with surface characteristics such as resistance to wear.
- It renders an economical, time-efficient compaction technique to concrete that can be placed on a medium to high workability.
- The water added to a concrete mix generally exceeds the optimum required amount of water required to fully hydrate the cement constituent.
- The additional water functions as a lubrication medium to allow mixing, placing and consolidation.
- In conventional concreting practice, an important challenge is the prevention or limiting of evaporation of mixing water out of the freshly placed concrete.
- In hot and windy conditions it produces concrete of high quality & durability.

2.2 Functional Requirements of Floors

The following are the functional requirements of floors –

1. The movement of men, machine and materials should be smooth and trouble free.
2. The hardener on to surface of floors should have hygienic / anti-bacterial properties.
3. The floors should be easily cleanable and maintainable.
4. The floors should be wear (abrasion) resistant and chemical resistant.
5. The floors should have resistance from impact and static loading.
6. The floors should have anti-slip/ anti-stain properties.

3.0 Material Requirement

The following considerations in material requirement are necessary prior to start of vacuum dewatering concrete flooring –

3.1 Concrete Grade

In vacuum dewatered flooring, the grade of concrete used shall be as –

a) M20-25 where Industrial Floors, Car Parking, Railway Platform, Workshop floors are planned to be laid.

b) M30-60 where Highways, Airport, RCC Roads are planned to be laid.

3.1.1 Cement – The cement selected should be appropriate for the intended use as provided for in the specifications.

Vacuum treatment of concrete gives better results with Portland cement to increase the compressive strength of concrete.

3.1.2 Fine Aggregate – Locally available sand is used as fine aggregate in the concrete mix. The test procedures as mentioned in IS-383 shall be followed to determine the physical properties of fine aggregate.

3.1.3 Coarse Aggregate – Crushed stone aggregates ranging from 10mm to 20mm sizes shall be used in respective proportions in concrete mixes. The aggregates shall be tested in accordance to IS-383.

3.1.4 Water – As per recommendation of IS: 456, the water to be used for mixing and curing of concrete should be free from deleterious materials. Therefore potable water shall be used in all operations demanding control over water quality.

4.0 Workability Requirement

Workability requirement depends up on two factors i.e. Water-Cement Ratio & Slump of Concrete.

Workability tests shall be performed using Slump moulds as it is the quick measure of workability of concrete mixes.

4.1 Water-Cement Ratio

It is proven fact that the water-cement ratio is detrimental for concrete to achieve higher strength. Provided the flooring is fully compacted, the lower the water-cement ratio the greater the durability and wear resistance. A lower water cement ratio compatible with workability is, therefore, essential.

4.2 Slump

Since the water-cement ratio is lowered through vacuum dewatering, concrete of high initial slump can be used while pouring. Slump range of 25-40 mm or as per site requirement is provided. As according to IS 1199, the slump range for mass concrete, lightly reinforced sections in slab, beams, walls, columns, floors, hand placed pavements, canal lining, strip footing is recommended as 25-75 mm with degree of workability as low.

The slump test shall be done in accordance with the IS 1199.

5.0 Equipments used in VDF System

a. **MS – C Channel:** The MS C Channel of desired thickness is heavy and durable used as shuttering having holes in each interval max. 400 mm for dowel bars. The dowel bars are used for proper gripping of two adjoined panels of floor. The channels are placed and checked for zero levels.

b. **Auto Level Machine:** This is required to check the zero levels of MS C Channel placed as side supports.

c. **Poker Vibrator:** Used for vibrating the concrete especially to the sides of the panels.

d. **Surface Vibrator:** Termed as Double Beam Screed Vibrator which is used for levelling as well as compaction of concrete. Two passes are required to achieve maximum compaction. Self-contained water protective vibrator motor is mounted on the centre of the beam.

e. **Vacuum Dewatering Pump with Mat:** A system consisting of Vacuum Pump, Lower Mat (Nylon cloth to act as very fine filter) and Top Mat (large single PVC Sheet) is used to draw out surplus water from the green concrete. The magnitude of the applied vacuum pump is usually about 0.08MPa, which reduces water content about 15-20%.

Vacuum Pump is mounted on transportation trolley and powered by Electric Motor of 5 to 10 HP. The vacuum pump is connected through a Hose (pipe) with the mat to remove the surplus water from fresh concrete. The mat consists of two layers, one is in direct contact with green concrete to prevent removal of cement with water and other used for extraction of water through pipe.

Top Mat of standard size normally 5 M x 7 M or as of panel size is provided with junction box and short hose. Filter Mat is placed directly on the green concrete which acts like a filter made of backing sheet, expanded metal, wire gauze or muslin cloth sheet.

Water separator functions as to provide proper control on the magnitude of water removed is equal to the contraction in total volume of concrete. About 3% reduction in concrete layer depth takes place.

f. **Trowel Floater Machine:** The machine is used for grinding to make surface even and remove any of the undulations in floor.

g. **Power Floater Machine:** The machine is used to provide Mirror/Final finish of surface and usually deployed when hardener is used to make surface wear resistance.

h. **Wire Brush:** Wire brush is used when broom finish is required as in case of parking, road surface, etc.

i. **Groove Cutting Machine:** Used to create grooves of size usually 5 mm wide or as specified by Engineer In-charge.

j. **Backer Rod and Masking Tap:** Backer rods are usually round, flexible lengths of foam that are used as a "backing" in joints or cracks to help control the amount of sealant/ caulking used and create a back stop. Many sizes/ diameters are available for optimal fitting to the size of the joint being sealed.

6.0 Construction Process

It has been universally recognized that concrete is the best suitable material for long strip casting of floors. The method is a system for having high quality long strip casting of floors at an affordable cost.

A high quality long strip casting should have the following properties –

- maximum wear-resistance
- high compressive strength and
- minimum water-permeability

6.1 Preparation of Sub-Base

The ground or earth filling should be thoroughly compacted so that there are no loose pockets left anywhere in the whole area. This should then be covered with clean sand well consolidated to a thickness of not less than 100 mm. Great cart is necessary in the preparation of the sub-base, as a settlement in the sub-base may cause the failure of the whole floor.

It is to be noted that if the sub-base is made of compacted soil or WBM, a separation layer of plastic sheet (125 micron expanded polythene foam sheet), if specified, is placed over for protection against humidity and water which also act as a sliding layer to prevent floor concrete from sticking to sub-base in order to avoid cracking.

If the sub-base is PCC, then there is no need to provide polythene sheet. The primary purpose of the sub-base is to provide a level base for the floor slab.

Note: The position of trenches and pipes for services such as water and drainage, heating, electric supply and telephones etc. must be fixed before floor concreting starts.

6.2 Laying the Reinforcement

Reinforcement shall be provided as per drawing. Reinforcement at the interface of expansion joint shall also be provided as per drawing.

6.3 Concreting

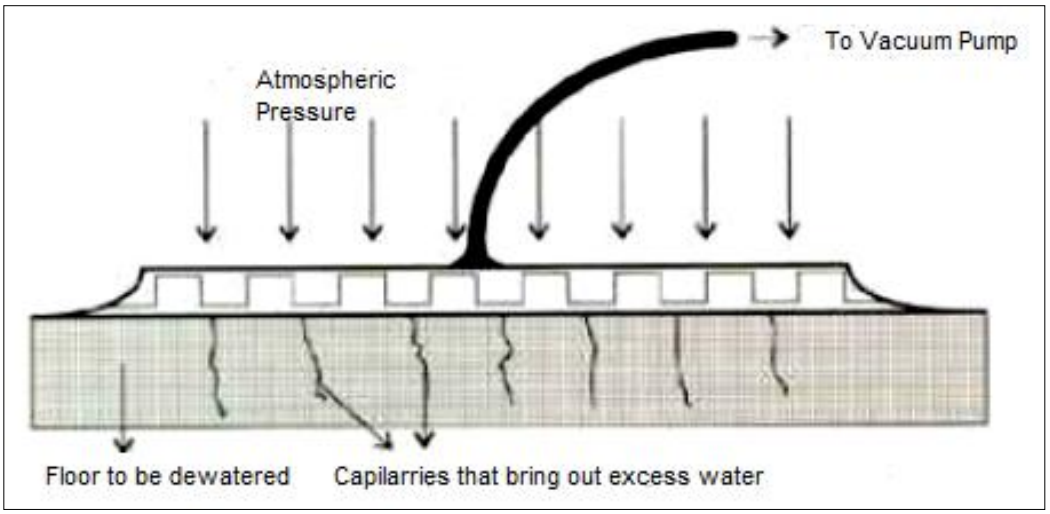
- The area to be paved should be divided into suitable panels so as to reduce the risk of cracking. This should be done by fixing screed strips, the depth of which should be equal to the combined thickness of the base concrete and the topping.
  - Generally, no dimension of a panel shall exceed 4 m in case of floor finish laid monolithically with the base concrete and 2 m in case of floor finish laid separately on a hardened base. Length of a panel shall not exceed 1.5 times its breadth.
- Before being laid in position the screed strip should preferably be coated with a thick coat of lime wash so as to prevent them from sticking to the concrete deposited in the panels.
- Before placing the base concrete, the sub-base should be properly wetted. The concrete should then be deposited between the screed strips, thoroughly tamped and the surface screeded uniformly below the desired finished grade of flooring to accommodate the required thickness of topping.
- Any slope desired in the floor finish should be given in the base concrete. The surface should not be finished smooth but kept rough to provide adequate- bond for the topping.

Concrete of specified strength (generally grade M 25) and workability is spread in specified thickness along the stretch of two parallel slotted M.S. channels acting as formwork placed approx. 3.0 to 4.0 m apart and well compacted using Tremix surface vibrator of suitable length. The pouring sequence should be from the grid and towards construction joint. The instructions of Engineer In-charge should be followed in vacuum dewatered concrete flooring.

6.4 Dewatering of Concrete

After compaction surplus excess water is sucked out placing filler pad consisting of two layers on wet concrete. The bottom layer of filler pad in contact with concrete is fine nylon cloth to act as filter whereas the upper layer consist of a special type of plastic net which acts as a water duct. The suction mat (filler pad) is attached to suction pump through suction hose (vacuum de-watering system). Vacuuming time is approx. 1 to 2 minutes per centimeter thickness of concrete.

The aim of this system is to reduce initial w/c ratio by 10 to 15% and this also makes concrete denser through static compaction. Care should be taken to ensure that optimum water required for hydration reaction must be there in concrete during vacuum treatment of concrete.



Vacuum Effect

6.5 Surface Finish

The surface should be towelled with the help of power trowelling floater to get neat finish. If specified, chemical hardener @ specified quantity per unit area is spread while power troweling in progress, to get hard top wearing surface. The same process is repeated in alternate stretches of concrete bay of specified size.

6.6 Curing

Immediately after the flooring surface is finished it should be protected from rapid drying by erecting barriers against wind or draught and strong sunlight. As soon as the surface has hardened sufficiently to prevent damage to it, it should be kept continuously moist for at least fifteen days by means of wet gunny bags, 50 mm thick layers of damp sand spread over the surface or pooling water on the surface. During this period the flooring shall not be exposed to any traffic. Regular traffic on the floor should be allowed only after 28 days. (IS 2571)

7.0 Advantages

- Compressive strength is increased.
- W/C proportion is reduced, which prompts early setting and high quality.
- Cement consumption is reduced as no cement is required separately for finishing.
- Abrasion resistance is increased.
- Wear resistance is increased.
- There are minimum dusting & crack formation.
- There are minimum dry and plastic shrinkage and floor wraps.
- There is uniform homogeneous floor with high flatness accuracy.
- There is lower water permeability due to increased density.
- High early strength minimizes damage on newly cast floors.
- Maintenance cost is reduced.
- Floors may be utilized early with the advantages of having minimum cleans, level floor, high evenness & exactness.

8.0 Disadvantages

- High initial cost or starting expense.
- Need prepared work for the vacuum dewatering process.
- Need specific equipment or explicit hardware for vacuum dewatering like vacuum siphon.
- Need power utilization during dewatering process.
- Need trained labour.

9.0 Precautions to be taken

- The sub-grade must be properly compacted.
- The bed over which concreting is done, should be free from dust and other unwanted material.
- The vapour-barriers like polythene sheets must be provided to minimise moisture transmission to the floor.
- The area for concreting should be marked longitudinally.
- The end channels should be placed at about 4 meters apart, avoiding any movement.
- The reinforcement should be provided with provision of dowel bars.
- The concrete should be placed as per design mix.
- The admixtures, if any, should be carefully chosen and decided for enhancing specific properties of concrete.
- The synthetic fibre, if used should meet the requirements as specified.
- Placing of concrete in large areas should be in long alternating strips.
- Needle vibrators should be used for spreading and compacting of concrete, specially near the ends.
- Excessive bleed water should be collected and removed prior to start of finishing operations or toppings or application of surface hardeners.
- The trained staff should be deployed to operate and to maintain correct pressure during vacuum process.
- The extra concrete is placed to compensate the floor slab which gets compressed about 2 percent during application of vacuum pressure.
- It should be ensured that the extracted excess water should not be remixed with the already placed concrete.
- The edges of floor slab should be finished manually.
- The concrete should be allowed initially to set prior to start finishing operations using power floaters.
- Grooves should be cut as specified and filled with sealant as recommended.

***

REFERENCES

1. Guidelines on WSC Agenda Item No. 004/01/05 issued by Works Directorate/RDSO on "Standardization of specification of flooring, Roofing Material for Platform covering in Station Premises & Standardization of Specification of Workshop Flooring"
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NOTES

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गुणवत्ता नीति

आर. डी. एस. ओ. लखनऊ में हम सतत सुधार और ग्राहक मूल्यांकन प्राप्त करने हेतु गुणवत्ता प्रबंध प्रणालियों की आवधिक समीक्षा के माध्यम से रेलों में यात्री और माल यातायात की बढ़ती आवश्यकताओं, माँग और अपेक्षाओं को पूरा करने के लिए गुणवत्ता प्रबंध प्रणाली की व्यवहारिक आवश्यकताओं और अनवरत सुधारों को पूरा करने के समर्पण गुणवत्ता उद्देश्यों को निर्धारित करके अनुसंधान, अभिकल्पों और मानकों में उत्कृष्टता के माध्यम से वैधानिक और नियामक अपेक्षाओं का अनुपालन करते हुए सुरक्षित, आधुनिक और किफ़ायती रेल प्रौद्योगिकी विकसित करने हेतु सेवाओं को बनाए रखने और अद्यतन पारदर्शी मानकों हेतु प्रतिबद्ध हैं। इसे संगठन के अंदर संसूचित एवं लागू किया गया है तथा सभी संबंधित पक्षकारों को भी उपलब्ध कराया गया है।

QUALITY POLICY

"We at RDSO Lucknow are committed to maintain and update transparent standards of services to develop safe, modern and cost effective railway technology complying with statutory and regulatory requirements, through excellence in research, designs and standards by setting quality objectives, commitment to satisfy applicable requirements and continual improvements of the quality management system to cater to growing needs, demand and expectations of passenger and freight traffic on the railways through periodic review of quality management systems to achieve continual improvement and customer appreciation. It is communicated and applied within the organization and making it available to all the relevant interested parties."

<u>डिस्क्लेमर / Disclaimer</u>

The document prepared by CAMTECH is meant for the dissemination of the knowledge/ information mentioned herein to the field staff of Indian Railways. The contents of this handbook/booklet are only for guidance. Most of the data & information contained herein in the form of numerical values are indicative and based on codes and tests/trials conducted by various agencies generally believed to be reliable. While reasonable care and effort has been taken to ensure that information given is at the time believed to be fare and correct and opinion based thereupon are reasonable. Due to very nature of research it can not be represented that it is accurate or complete and it should not be relied upon as such. The reader/user is supposed to refer the relevant codes/ manuals available on the subject before actual implementation in the field.

हमारा उद्देश्य

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

यदि आप इस संदर्भ 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 & comments, please write to us:

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