# IRICEN Journal of Civil Engineering

ज्ञान ज्योति से मार्गदर्शन

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Indian Railways Institute of Civil Engineering, Pune

# Key Recommendations of Chief Engineer/Track Machine's Seminar Held at IRICEN/Pune on 17th & 18th August, 2015

1. All railways to upload the LARs for AMC contracts on TMS site.
2. Railway Board will issue necessary guidelines for procurement of Capital Spares.
3. All Railways to send performance report of M/s Phooltas Harsco Rail Solutions Pvt. to Railway Board.
4. Railways to give their suggestions to RDSO regarding issue of codal life of track machines.
5. It is recommended that all trains passing on the adjoining track should be issued with a speed restriction of 30 kmph to 50 kmph depending on location of work.
6. Proposal to provide 'Camping coach' facility for UTV and BRM machines has been recommended for consideration of Railway Board.
7. CPOH/ALD to create post of Supervisory staff with money value from other Railways & send the proposal to Railway Board to address the issue of shortage of supervisory staff.
8. Railways may utilize existing power of GM for solar powering of Track Machines.
9. All railways may work on the project of portable/Mobile toilets for TMC staff at Zonal railway level as Pilot Project Program.
10. A committee comprising of Dir.TM/RDSO & representatives from ECoR, CR & WR to be constituted to work on the issue so that the input and output formats can be formalized based on which CRIS can prepare the software.



# *from director's desk*

Dear Readers,

On the occasion of the first anniversary of **"Swachh Bharat Abhiyan"** on 2nd Oct, 2015, it's time for renewed pledge and concerted effort to make public places cleaner and pleasant. I am sure that all of us are devoting adequate time and effort in this direction.

The **"Conservation of Water"** has been identified as mission area by Hon'ble Minister of Railways as WATER being the most precious natural resources essential for human life, the need of the hour is to not only avoid pollution of water resources, but also conserve. IRICEN has organized a special course on **"Water Audit"** to sensitize field officials with Water Auditing, water recycling at major water consumption centres and expand Rain Water Harvesting.

This edition of IRICEN Journal includes a number of papers encompassing issues related to safety, construction & quality etc. The paper on construction of cable stayed road over bridge in ER, elaborates the various stages involved in handling a large project. Another paper on a new approach adopted in viaduct construction & quality control shows the way to ensure better quality.

An informative article on working and maintenance of Diesel locomotive is the first paper written and published in Rajbhasha in IRICEN Journal.

I'm sure that the readers would find various papers and articles included in this edition of IRICEN Journal and request for their suggestions and also send their contribution for publication in future issues.

(Vishwesh Chaubey)
Director

Pune
Oct 2015

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Suggestion for improvement of **IRICEN JOURNAL OF CIVIL ENGINEERING** are welcome from the readers. Suggestions may be sent to mail@iricen.gov.in

## Guidelines to contributors

Articles on the Railway Civil Engineering are welcome from the authors. The authors who are willing to contribute articles in the IRICEN Journal of Civil Engineering are requested to please go through the following guidelines :

1. The paper may be a review of conventional technology, possibilities of improvement in the technology or any other item which may be of interest to the readers. The paper should be reasonably detailed so that it could help the reader to understand the topic. The paper may contain analysis, design, construction, maintenance of railway civil engineering assets. The paper should be concise.
2. The journal is likely to be printed in a paper of size 215 mm X 280 mm. While sending the articles the author should write in 2 columns. Sketches, tables and figures should be accommodated in a 2 column set up only.
3. Author should send the original printout of photograph along with the digital copy of the photograph.
4. Soft copy as well as hard copy of article must be invariably sent to the editors of concerned subject.
5. Only selected articles will be included in the IRICEN Journal of Civil Engineering.

### Maharashtra Govt to Invest Rs. 10,000 Cr. to Develop the Railway Infrastructure

Speaking at the ground breaking ceremony on Sawantwadi Railway terminus in Sawantwadi district in Konkan region, Maharashtra Chief Minister, Devendra Fadanvis, said that his government will be investing Rs. 10,000 Cr. to develop the Railway infrastructure of the state.

He said infrastructure development forms the basis of the economic development of any state and the state government is committed towards developing roads, railways, airports and port networks across Maharashtra. The Chief Minister further added that the state government will give priority to Chiplun- karad, Ahmednagar-Parli-Beed and Vardha- Nanded-Yevatmal railway route which will help to connect the interiors of Maharashtra.

**Ref: Masterbuilder- July 2015**

### Banihal-Katra Railway Link to be Completed by 2020

The railway link from Banihal to Katra connecting Kashmir valley with the rest of the country, would be completed by the year 2020. Speaking at a press conference A.K Putharia, General Manager, Northern Railways said that the railway track from Jammu to Katra has been completed and the 110 Kilometers link from Katra to Banihal is the final portion that will be connecting the Kashmir valley with rest of the country.

He added that 85% of the work involves tunneling and the rest was related with bridges and all efforts are being made to complete this project on time.

**Ref: Masterbuilder- July 2015**

### Centre Considering Rail Bridge Linking Rameshwaram and Talaimannar

Union Minister of state for road transport, highways and shipping, Pon Radhakrishnan revealed that the centre is considering a proposal to establish a rail bridge linking Rameshwaram and Talaimannar in Sri Lanka. If the project materializes, the two countries would be linked.

A short boat ride used to connect the railway lines that ended at Talaimannar in Sri Lanka and Dhanushkodi in India, which was in operation till 1966. During his visit to the city last week, the Union Minister told reporters during an informal chat that the BJP government is considering a proposal to establish a bridge to connect the two countries.

**Ref: Masterbuilder- July 2015**

### Railways and State Governments to Jointly form SPVs

Minister of State for Railways, Manoj Sinha, said that to expedite completion of projects, Ministry of Railways has approached all State Governments to form Special Purpose Vehicles (SPV) jointly with Ministry of Railways to undertake mutually identified rail infrastructure projects for project development, resources mobilization and monitoring. 17 State Governments have consented to form the SPVs. Possibility of participation of industry in project specific SPVs can also be considered depending on their willingness.

**Ref: Masterbuilder- August 2015**

### Centre Conducts Study on High Speed Rail Corridor

The Minister of State for Railways, Manoj Sinha, said that the government has initiated a feasibility study for Diamond Quadrilateral Network of High Speed Trains comprising of four sides. That is Delhi-Mumbai, Mumbai-Chennai, Chennai-Kolkata, Kolkata-Delhi; and both diagonals that is Delhi-Chennai and Mumbai-Kolkata. A joint feasibility study for Mumbai-Ahmedabad High Speed Rail (Bullet Train) Corridor co-financed by India and Japan, which started in December 2013, has been completed in July, 2015.

**Ref: Masterbuilder- August 2015**

### Northern Railway to Revamp Delhi's Oldest Station

The Delhi division of Northern Railway has started work on a planned revamp of the city's oldest railway station wherein it will be granted a look similar to that of New Delhi station. A second entrance to the station towards Kashmere Gate has been built at a cost of Rs 90 crore and it is expected to share 30 per cent of the footfall. It will be thrown open to the public soon. Officials say the

aim of the project is to eliminate the bottlenecks at the entrance and exit gates of the station which result in huge traffic jams. Hundreds of vendors who have encroached upon the area adjacent to the boundary wall of the station will also be asked to leave. The plan for the makeover has been approved and finalized by UTTIPEC (Unified Traffic and Transport Infrastructure Planning and Engineering Centre) and it will be implemented over one year. The cost of the project is Rs 16 crore. The portion which is on railway land is being handled by the railways at Rs 4.86 crore. The work of laning, development of bus shelters and other stuff on SP Mookerjee Road is being executed by the public works department and other Delhi government agencies. About 300 trains pass through the station every day and it records a huge footfall of over 3.5 lakhs.

**Ref : Masterbuilder- August 2015**

## Talgo Hopes to Bring its Trail Train to India by October

The Centre has given an informal approval for Madrid-based locomotive-maker Talgo to undertake trial runs of its lighter and faster trains that could cut travel time between Mumbai and Delhi from 17 hours to 12 hours without overhauling India's ageing rail tracks. Talgo Chief Executive Officer, Jose Maria Oriol, told that they are hopeful of bringing their trial train to India by October or early November at their own cost and risk to demonstrate its advantages. A formal nod is all that is awaited to start the process for shipping the train from Spain to India. The Railways' management as well as the 'political authorities' are enthusiastic about Talgo's technology and officials have already seen its trains at work in earlier visits to Spain. Oriol said about the firm's passenger trains that can run from 160 kilometres to 220 km an hour and are being used across the world including several routes in central Asia and the US. Enthused by Indian Railways' ambitious plan to invest $125 billion, Talgo is eager to set up a manufacturing hub in India to tap the Indian and Asia-Pacific market using the recently opened window for 100% FDI in the sector. Talgo already has a commercial office functioning in India for four years to explore opportunities in India and the Asia-Pacific. It has used the time to also identify a potential supply chain of tier-I and tier-II vendors that can help it localize its product swiftly once it sets up shop.

**Ref : Masterbuilder- August 2015**

## Railway to Construct 12,330 Road Over Bridges

The Minister of State for Railways, Manoj Sinha, said that the Indian railways has decided to construct 12,330 Road over bridges(ROBs) as most of accidents normally occur on the unmanned railway crossings. According to him, the cost of the construction of these bridge projects would be shared by the Indian railways and National Highway Authority of India (NHAI) in 50-50 ratio. He added that all these projects are being executed on the fast tracked basis.

**Ref. Masterbuilder- August 2015**

## New Body for High Speed Trains:

As part of government's ambitious programme, Diamond quadrilateral, IR is considering to set up a separate entity to build and operate high speed trains pro. The possibility of creating a separate entity like DMRC through an Act of Parliament is being explored for high speed train corridor. High Speed train corridor, a favourite scheme of the PM, plans to connect the cities of Chennai, Delhi, Mumbai, Ahmedabad and Kolkata. JICA is carrying out a feasibility study for some routes in this corridor and is expected to submit its report by July end. Japan could be one of the partners in this project on some routes.

**Ref: NBM&CT of July 2015 issue, Pg. 32**

## High-Speed Operators Need High-Speed Reactions

Two of Europe's leading high speed rail operators, French National Railways (SNCF) and German Rail (DB), have announced restructuring plans in a bid to revitalize the lackluster performance of their high speed services and revive growth.

The economic crisis of 2008-09 dealt a savage blow to both operators halting growth. This was followed by increased competition from low cost airlines, car sharing in France, and more recently, and particularly in Germany, long distance buses. In France, the financial performance of the TGV network has been seriously harmed by a sharp

increase in track access charges which almost doubled from €1.3bn in 2008 to €2.1bn last year, while in Germany, DB was hit by a severe storm last summer which damaged infrastructure followed by a series of strikes by train drivers later in the year.

Last year SNCF's TGV network suffered a 1.1% drop in sales while Ebita fell by 13% from €782m in 2013 to €680m. DB's long distance passenger business performed even worse, with Ebitda down 15.9% at €546m and Ebit down by a worrying 34.4% at €212m.

**Ref. : International Railway Journal, April 2015, Pg. 4, 6**

## Railway Floats Rs2,500 Crore Tender for High Speed Train Sets:

In line with railway minister Suresh Prabhu's announcement in this year's railway budget on acquiring electrical multiple units (EMU) – based train sets for intercity journeys, the Indian Railways has floated global tenders worth Rs.2500 crore, involving the procurement – cum-maintenance of 15 EMU sets.

The Selected bidder would require to manufacture and supply about 15 EMU train sets comprising 315 rail cars. Twenty three companies including Hitachi India, Toshiba, BHEL, Siemens, Medha Servo Drives and Alstom participated in the pre-application conference held by the railway ministry.

The selected bidder is allowed to procure two protype train sets and the subsequent train sets would have to be manufactured in India, in accordance with the PM's "Make in India" plan. The two types of EMU train sets which are to be procured should comprise 20 rail cars with sleeper arrangement and the other should have 16 rail cars with sitting arrangement. The ministry has proposed to entrust the maintenance obligation to the selected company for a period of seven years.

The ministry has also decided to designate staff of the Indian Railways in the project to ensure the transfer of skills and to enable them to learn the new system of maintenance, which would help them to maintain the new assets after seven years, for its life of 35 years. The introduction of EMU train sets will enable quicker acceleration and deceleration, which will help in cutting travelling time drastically.

**Ref: Civil Engineering & Construction Review- August 2015 , Pg. 14**

## Govt Unveils $142 –Bn Infusion in Rail Sector

In its unfailing quest to bring the counry's rail sector on the fast tracked growth trajectory, the government has decided to invest a staggering sm worth $142 billion in the Indian Railways. Railway Minister Suresh Prabhu, said explaining that the targeted funds would be infused to ensure the complete turnaround of the operational and financial position of the Indian Railways. In order to attract private investment in the rail sector, the government is currently preparing a blueprint facilitating public private partnership (PPP) in a big way. Adding to the momentum, the rail ministry in a recent move as also announced the setting up of a committee under former secretary of Department of Industrial Policy and Promotion Ajay Shankar to revive the PPP cell. With a view to raise financial resources for funding port-related railway projects, government has already approved the formation of a special purpose vehicle (SPV) with an initial capital of Rs 500 Crore to provide efficient rail evacuation systems to Major Ports and thereby enhance the handling capacity and efficiency.

**Ref: New Building Materials & Construction World- May 2015, Pg. 30**

## Railways Plans E-auctioning of Rs.10,000 Cr Stations

In an attempt to fast track the redevelopment of the 100 railway stations across the country on the PPP model, Indian Railways is all set to adopt e-auctioning model for awarding the projects to private players, said official sources, claming it is for the first time that the country's largest transporter is adopting e-auctioning to get rid of the perennial bureaucratic jurdles faced by private companies while undertaking PPP projects as they will be able to submit their bids online, afer which a technical committee will study and approve the bids. He added that private players tasked with converting the railway stations into world-class transit facilities will be given a specified area within the station premises and around it to be exploited commercially.

**Ref: New Building Materials & Construction World- May 2015, Pg. 30**

## Railways Partnering with States for Rail Projects

Railways have signed initial agreements with 20 states to jointly develop a company aimed at boosting railway infrastructure. "We are approaching all states to come forward and join hands for faster implementation of the projects," Union Railway minister Suresh Prabhu said. "For any infrastructure projects you need land. State's participation in projects will ensure faster implementation of the project " he added.

"We have signed MoUs with 20 states. Under the agreement, there will be a company jointly owned by the centre and the states. It will develop infrastructure and look into issues which the states think are important," he noted.

Apart from easier solution of land related problems, Railways is of the view, the partnership with states will make available institutional finance for infrastructure addition without burdening the Centre or the State.

## Tips on Tackling Termites

Often wrongly referred to as "White Ants", there is a lot about termites that most people are not aware of. Termites are in fact more closely related to cockroaches and have been on earth for over 250 million years. They are regarded as detrivores, or detritus feeders. They feed on dead plants and trees as well as dead parts of living trees including wood and wood in the soil.

Their ability to work unnoticed can lead you to be off your guard, but termites have a proven reputation for the vast devastation they are capable of causing in households. Ther e is a very methodical manner in which termites go about their business, starting from the formation of colonies. And o nce a termite infestation has been identified, it can be difficult to determine how long the colony has been established in the home.

Classified into three groups – Damp wood Termites, Dry wood Termites and Subterranean Termites, they are capable of causing damage worth billions of dollars' each year by eating away at the wood in homes, from roofs down to foundations.

Termites thrive in warm, moist and dark areas and a sight you would have witnessed during the monsoons is that of winged termites swarming around windows and doors. They are highly attracted to bulbs and other sources of light and are called reproductive termites. Once a colony has matured, these reproductive termites fly out, discard their wings and after mating, they identify a new breeding site with the specific aim of creating another colony. In this organized manner, they spread infestations in numerous locations.

Here are some sample measures yu can adopt in safeguarding your home from these destructive creatures:

1. Eliminating Moisture is a good start:
   - It is therefore essential to repair any leaking pipes, shower recesses or rusty down pipes.
   - Regular cleaning and maintenance of gutters will also ensure their proper and smooth functioning which will divert water away from the foundation.
   - Get rid of stagnant water on the roof.

2. Many of us are in the habit of storing wood and paper within our homes. It is best to get rid of any loose timber around the property. If it is necessary to store firewood, newspapers etc, these should be stored at a safe distance from your house.

3. It is also important to have a professional concrete contractor check the foundation for any cracks and get them fixed right away. This will prove effective in blocking termite access to your home in this manner.

4. The most vulnerable areas of wooden furniture are the sides that are fixed to the wall and are not visible to us on a daily basis. e.g.
   a) The side wall units/wardrobes/cupboars/ cabinets that are directly in touch with the wall.
   b) Lower area cupboards/wardrobe shelves that are just above the flooring.
   c) Wooden frames of doors and windows that are fixed into the wall.

5. Usage of effective anti-termite solutions like Terminator can also help eradicate termite infestation. Besides its efficiency, it does not have any toxic formulation making it an eco- friendly product.

6. It is also a good preventive measure to regularly check for mud tunnels or other signs of possible activity such as hollow timber or damp walls. Also, having your home undergo a termite inspection is one of the best preventive measures against large-scale termite infestation.

7. If you come across a termite colony, never attempt to get rid of it yourself as termites have the ability to quickly relocate to some other part of your home. It is best to contact a licensed pest controller immediately in order to adopt the best form of eradication.

It is important that such areas are pre treated with sufficient quantity of an anti termite solution so that termite attacks are prevented.

**Ref: Civil Engineering & Construction Review- Pg. 80**

## Overview on Alternate Cementitious Materials

### Wollastonite

It is a calcium metasilicate ($CaSiO_3$) mineral. The SIi present in this mineral reacts with water to form Calcium-Silicate-Hydrate (CSH) as in the ase of OpC hydration, which is accountable for imparing strength to cemented metarials. The study was in depth to compare.

Mechanical properties

Permeability

Carbonation and

Chloride diffusion coefficient

It concludes that optimum water binder ratio with wallastonite at 2.5 to 15% can produce comparatively similar to or better concrete in some case.

It is a very important to not from the text that approximately 270 million tons of wollastonite global reserve can be better utilized to reduce the overall production of cement. Since the manufacturing process of cement.

1. Depletes 33% excess resources in terms of raw materials. 1 ton is produced from 1.5 ton raw materaks
2. Emits 80% of production capacity as $CO_2$, 0.80 ton while producing 1 ton cement and
3. The green house effect.

### Geopolymer

It is a organic polymer, in which alumina sililcate performs the binding system. In OPC the addition of pozzolonic mineral admixtures (MA) such a fly ash (FA), ground granulated blast furnace slag (GGBS) etc. refines the hydrated OPC due its reaction with free lime formed during hydration, thereby improving resistance of penetration aggressive agents like chlorides, sulphates, oxygen etc. which causes adverse effects in RCC structures.

The study on Geopolymer concrete (GPC and Portland Pozzolona cement concrete (PPCC) was in dept to compare,

Chloride diffusion coefficients

Compression strength.

It concludes,

1. The concrete strength can be achieved ore than that for “Extreme” exposure condition of IS 456-2000.
2. Can be produced with equipments similar to conventional concrete
3. Do not have any portland cement, hence with low embodies energy. The Portland cement is highly intensive energy material next to Aluminum and Steel.
4. The green house effect and control on $CO_2$ emission could be better with GPC
5. The GPC is eco-friendly as it utilizes industrial wastages for producing the binding system.
6. Alkali Activator solution (AAS) used for geo-polymerization is sufficient with air/self curing system to achieve desired strength
7. The comparision of results express GPC are acceptable as that of PPCC for RCC constructions.

**Ref: Indian Concrete Institute Journal, Vol-15, July-Sept 2014, Pg. 7-12 & 23-28**

## Mould Release Agent

Nafuplan K is an economical concentrated mould release agent, which is supplied as a water-soluble emulsion. It should be diluted in ratio of 1:10 up to 1 : 30 with water, prior to application. Nafuplan K aids in easy and efficient demoulding of formwork and it renders the demoulded surfaces smooth and even.

Nafuplan U-ST is ready to use, non-staining mould release agent especially suitable for steel and other non-absorbent shuttering. It is combination of highly specialized mould release oil and a special high quality release agents. The presence of this specially chosen release agent imparts excellent release properties to the shuttering , thereby rendering the demoulded surfaces extremely smooth and even. Nafuplan U-ST is extremely suitable for application in tropical areas. Long-term application also helps reduce wear and tear of shuttering surfaces; thereby increasing its service life.

The shuttering surfaces to be coated should be clean and free from remnants of concrete and cement splashes. These materials are applied by means of suitable spraying devices, brushes or cotton rags. Care should be exercised o see that the applied film is thin and that no concentrated sports are visible. This helps avoid the adhesion of the cement slurry to the formwork surfaces as well as prevent the adhesion of the release film to the demoulded surfaces.

**Ref: New Building Materials & Construction World- May 2015, Pg. 130**

# Events



Independence Day Celebration



Sports on the occasion of Independence Day




Rajbhasha Week Celebration



Engineer's Day Celebration

# Elimination of Unmanned Level Crossings : A Case Study of 100% Elimination of UMLC Over Solapur Division

By
*Shri Raju Bhadke**
*Shri Surendra Kauraw***

**Synopsis:**
*On 01.04.2012 there were 71 UMLC on Solapur Division. Inherent problems of UMLC, enhanced by typical topographic issues and illiteracy of the countryside resulted in two to three fatal accidents every year. The UMLC were eliminated over a period of three years by focused efforts. Various strategies for quick completion of RUB works were devised over this period.*

## 1.0 Introduction :

Solapur Division of Central Railway had a unique geographical setting over the Mumbai-Chennai route. There were a large number of UMLC gates on the division, a majority of which were on the Miraj-Kurduwadi-Latur branch line. As on 1st April,2012, there were 71 unmanned gates on the division.

Though a number of preventive steps as mandated by Railway Board from time to time were taken, these helped in controlling the number of accidents, but not in eliminating them. Almost all the accidents at UMLC are inevitably fatal, causing a painful loss of lives. Efforts were started in March, 2012 to eliminate a few UMLC, wherever, the location, terrain and local population were amenable to closure of gate by either diversion, manning or RUB. In May, an accident at a unmanned gate between Pandharpur-Sangola took place, in which 5 lives were lost. This UMLC was manned on war footing in eight days. This awakened the Solapur team to the ever looming, omnipresent possibility of an UMLC accident. It was decided that as a matter of Principle, no lives will be allowed to be lost on UMLC.

## 2.0 Immediate Steps:

Within a week's time each UMLC was comprehensively inspected not only by field officers, but also senior divisional officers and HQ officers. Adjoining villagers were spoken to, explaining the importance of eliminating accidents at UMLCs. Villagers gave very important insights into the problems faced by them while negotiating the UMLC. At a number of locations, Railway team found that though the UMLC was satisfying the safety and visibility criteria of Railways, the villagers pointed out typical problem of approach topography, constricted spaces, inherent sounds in adjoining areas, which lead to the villages not noticing the approaching trains well in time. The Loco Pilots also gave very useful inputs about train visibility issues. At all the UMLC which were found vulnerable from any angle, suitable caution orders were imposed ranging from 50kmph to 90kmph.

## 3.0 Level Crossing Counsellors:

In the coming month, all the LC assets were improved including LC boards, LC surfacing and cleaning all the vicinity of vegetation. Divisional safety team also undertook a villagers counseling drive. Still, during regular visits at vulnerable gates, a sense of unsafe environment was felt during the passage of trains. A possibility of posting Trackmen as temporary Watchmen at these gates was considered, but dropped in view of acute shortage in Trackmen cadre. After considering various alternatives, division decided to provide “LC Counsellor” by finalizing a contract, on experimental basis. Solapur division was to first division to adopt this step and success of this step can be gauged from the fact that, as on date, this has been implemented universally in almost all Railways on UMLC. LC Counsellors were posted first

*Sr.DEN(Co), SUR,CR
**DEN(Central),SUR, CR

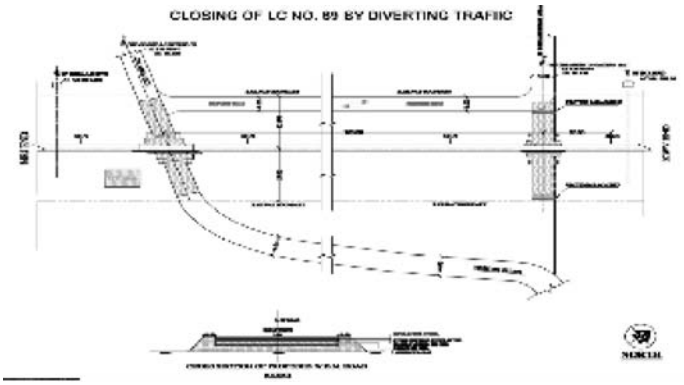
on quotation basis at 10 UMLCs and on crosschecking their efficacy LC counselors were posted on all 70 UMLCs of the division. No safety chains/boards or signals, etc. were provided to indicate very clearly that LC counselor is a temporary measure.

**4.0 Permanent Elimination of UMLCs:**

Improvement of the UMLC infrastructure, imposition of caution orders and posting of UMLC counselor helped us in gaining confidence of local population about our good intentions in protecting their lives. Based on feasibility plans, the adjoining villagers were approached to grant NOC for permanent closure of UMLCs. Receipt of quick consent and a positive intent of villages to rope in their own efforts, in fact, came as a very happy surprise to the executing team.

**5.0 Diversion to Adjacent Gates:**

Wherever another manned gate was available in vicinity, these gates were planned for immediate closure by providing permanent diversion roads. This was the lease expensive and quickest method of gate closure. In all 18 UMLCs were closed by diversion.








PHOTOS OF LC NO 69

**6.0 RUBs, ROBs and Manning:**

Road Under Bridges (RUB) was the next preferred mode of closing the UMLCs. Most of the locations were chosen based on topographical condition and availability of high banks. Some locations, where high bank was not available, but feasibility of draining off the RUB within 100m of RUB was available, were chosen for providing the RUB. In all 56 UMLCs were closed by providing RUBs. The liberal sanctioning and funding support given by Central Railway Headquarters and Railway Board ensured that none of the work was held up for any approval, sanction or funds.

**7.0 ROB:**

One ROB was constructed in deep cutting locations for closing the UMLC No.26 in Osmanabad Pangri section.

**8.0 Manning:**

Manning was adopted as the last resort to closing the UMLCs due to obvious shortcoming including long term higher costs and requirement of manpower. However, at 14 locations where UMLCs closure was simply impossible by diversion or RUB, manning was done. However, no new posts of Gatekeeper was created over the division. To offset the additional staff requirement for manning these 14 gates, requiring sanction of 35 gatekeepers, 12 manned gates were eliminated during this 3 years period, thus saving 36 gatekeepers. In fact, division has set an ambitious target of closing 20 manned level crossing gates by constructing RUBs in financial year 2015-16.

## 9.0 Expeditious Gate Closure by Constructing RUBs:

During the first six months of initiation of this project, division devised standard practices, protocols, systems and methodologies for expeditious approvals, sanctions, execution and completion of the RUB works. Some of the important amongst them are:-

A) Standardisation of :-

i) General arrangement drawing.
ii) Abstract Estimate.
iii) RUB proposal.
iv) Adoption of RDSO standard box designs.
v) Standard Wing wall designs.
vi) Type Drainage plans
vii) Standard Site plans.
viii) Box shuttering design
ix) Bar bending schedules
x) Precast wing walls
xi) Track removal and placement by crane system
xii) Excavation plan
xiii) Caution order relaxation schedule
xiv) RCC road and approach road practices.






## 9.1 Set of Practices were Evolved for :-

i) NOC obtaining from gram level to Collector.
ii) Standard documents set for accounts.
iii) Standard document set for HQ approvals.
iv) Standard documents for CRS (Manned gates)
v) Regular visits of safety, operating, signaling officers, DRM/ADRM to each work site.
vi) Every UMLC closure celebrate as divisional achievement.

## 9.2 Work Methodologies (in contract condition):-

i) Horizontal casting of boxes
ii) Compulsory adoption of 2 cranes of 180MT
iii) Compulsory use of computerized mini batching plant.

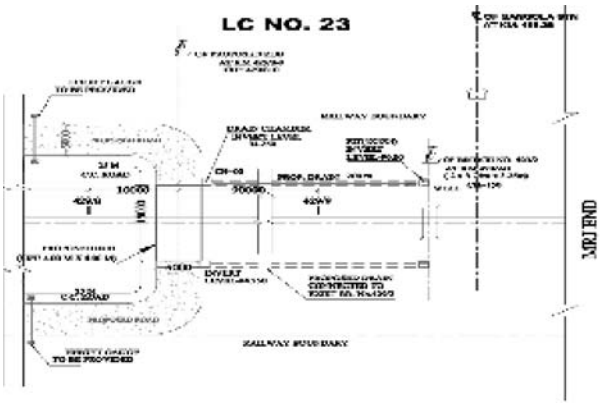




iv) Establishment of Centralized laboratories.
v) Standard Time schedule in tenders.

## 10.0 Innovations:

i) Adoption of rain water harvesting principles a method of disposing RUB water.




ii) Adoption of 3 poclain excavation system





iii) Box placement from 2 sides, using two 180MT cranes.





iv) Crane for track removal/refixing.



v) Adoption of precast wing walls.



vi) Wing wall on crane

**11. Achievements:**

i) Zero accident at UMLCs.

ii) Total cost of closing 71 UMLC come to Rs.56 crores.

iii) Elimination of 8 Permanent Speed Restrictions and 30 TSRs Temporary Speed Restrictions.

iv) Speed raising of KWV-LUR from 75kmph to 90kmph and KWV-MRJ from 90kmph to 110kmph. (proposed by the division)

v) Miraj-Latur running time reduced by about 60minutes.

vi) In the meantime, manned gates in SUR Division reduced from 201 to 189.

◆◆◆

# Installation of Automatic Banner Flag at Level Crossing No.-53 in BWN-TIT Block Section of HWH-NDLS Rail Line in Howrah Division of Eastern Railway

By
*Shri Avinash Jain**
*Shri Md. Tanveer Khan***
*Shri Sushil Kumar****

**Synopsis:**
*Automatic Banner Flag is installed at level crossing gate No. 53C/E at Km 110/23-25 between BWN & TIT in the section of JE/P.Way/West/BWN under AEN/BWN under Sr. DEN/2/HWH. This gate is a non-interlocked gate having a very high TVU i.e. 88703. At this level crossing the road is passing through quadruple rail line section, having permissible speed of 130 Kmph of two central lines & 110 Kmph of two outer lines. This section is on the grand chord route of NDLS – HWH rail line. Considering its high TVU & its location, It was the needs of hour to either interlock the gate or try this innovative idea of installing the automatic banner flag. In this paper it is tried to bring out in a simplified manner the facts, requirements, methodology adopted and approximate cost of installing the automatic banner flag.*
***Key words: -*** *Automatic Banner Flag, Level Crossing , TVU.*

## 1.0 Introduction:

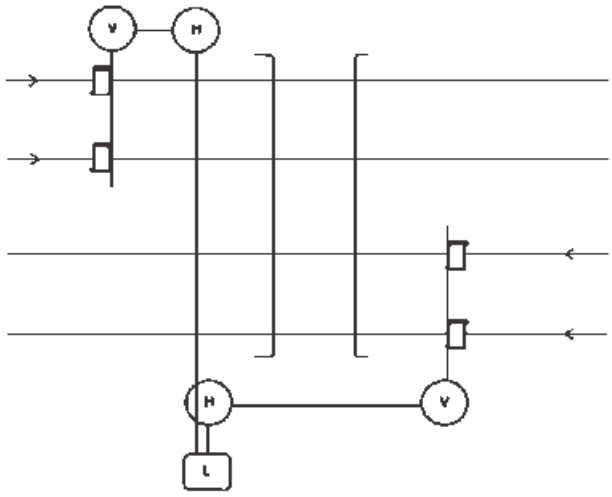
Automatic Banner Flag is an innovative idea in which the banner flag which is used to protect the non-interlocked level crossing gate by putting them at a distance of 5 m from the edge of road surface in the direction of traffic before opening the gate is controlled by some lever arrangement, so that the Gatekeeper is not required to go and put the banner flag. When the gate is closed to the road traffic and locked, the banner flag get closed itself and when the gate is unlocked the banner flag rises up & then the gate boom is lifted.

## 2.0 Material Requirement:

The material required for installing the Automatic Banner Flag successfully at the level crossing gate are:-

(1) Lever
(2) GI Rod as per requirement (25mm. dia)
(3) Horizontal Crank.
(4) Vertical Crank.
(5) Ball Bearing (25mm. dia)
(6) Computerised printed Banner Flag with Frame.
(7) Foundation for supporting Crank.
(8) Roller stands for supporting larger length rods.

LINE DIAGRAM




## 3.0 Methodology:

The methodology involved in the installation of the automatic banner flag is discussed in the subsequent paragraph.

*Sr DEN/2/HWH, , Eastern Railway; **ADEN/BWN, , Eastern Railway
***JE (P.Way)/West/BWN, Eastern Railway

A rod is connected to the lever which is used for locking the boom and this rod is connected to another rod through a horizontal crank for changing the direction of movement of the rod by 90°. Now this second rod is connected to the third rod through at vertical crank and the ball bearing to change the direction from translation to rotation. The banner flag is connected to this third rod supported by the ball bearings.

The sequences of operations are as follows:

Starting from the position when the gate is closed to road traffic and the trains are passing, at that time the banner flag are laying in between the track in non-infringing position. Now when the gate is to be opened to the road traffic the lever is operated to unlock the gate boom. When the lever is operated the gate is unlocked & simultaneously the rod-1 is pulled and this movement is transferred to rod-2 through horizontal crank which in turn is converted to rotational motion of the rod-3 through the combination of vertical crank & ball bearings. This rotational motion is sufficient for raising the banner flag. After the raising of the banner flag the gate boom is lifted. Thus ensuring the safe road traffic movement through the gate.

Now when the trains has to be passed and the road traffic is to be stopped the gate boom is lowered and the lever is operated to lock the gate boom. Simultaneously the motion is transferred to rod-1 through lever and from rod-1 to rod-2 through horizontal crank and from rod-2 to rod-3 through vertical crank and ball bearings, converting the translational motion to rotational motion and thus the banner flags are lowered and brought to the non infringing position and the trains are passed safely.

**4.0 Precautions:**

The following precautions should be taken while the installation.

1) The length of the rod 1, 2 & 3 should be correctly assessed so that problem do not occur at the time of fixing.
2) The drilling of the holes for the connection should be perfectly matched, otherwise there will be play between them which will result in malfunctioning of the whole assembly.
3) After installation it should be ascertained that there should be no infringement from the banner flag as it will be laying between the track during the train movement.

**5.0 Conclusions:**

This is really a very nice idea to be implemented over all Indian Railways on the non-interlocked gates having a very high TVU. Cost wise also it is not very expensive. In our case where there are quadruple line section and we had to provide four banner flags the approximate cost comes out to be around Rs. 100000/- .



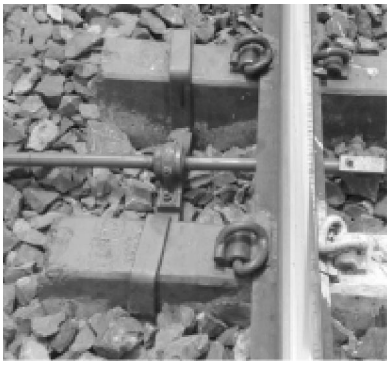
**Lever**



**Horizontal Crank**



**Vertical Crank**





**Ball Bearings**




**Banner Flag In Standing Position**

# Use of Canted Turnouts on Eastern Dedicated Freight Corridors

By
*Shri Manjul Mathur**

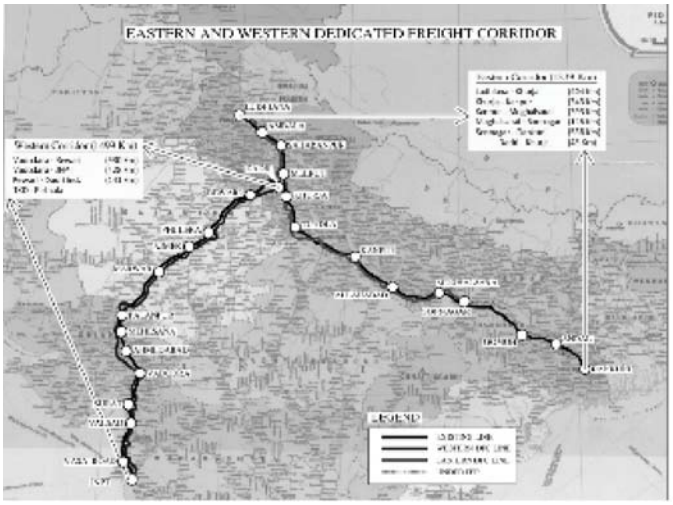
## 1.0 Dedicated Freight Corridor Project:

One of the India's building blocks for sustaining higher economic growth is investment in improved infrastructure. India's Twelfth Five Year Plan (2012-2017) sets out a high infrastructure investment with a target of US$1 trillion. An important part of that plan is to modernize critical parts of ageing and congested transport infrastructure, including the Railway network. More recently, Hon'ble MR in his Budget speech 2015-16, has announced a major increase in railway sector investment for both freight and passenger services over next five years.

The Indian Railways' quadrilateral linking the four metropolitan cities of Delhi, Mumbai, Chennai and Howrah, commonly known as the Golden Quadrilaterals and its two diagonals (Delhi-Chennai and Mumbai-Howrah), add up to a total route length of 10,122 km. It carries more than 55% of revenue earning freight traffic of IR. The existing trunk routes of Howrah-Delhi on the Eastern Corridor and Mumbai-Delhi on the Western Corridor are highly saturated, line capacity utilization varying between 115% to 150%. The surging power needs requiring heavy coal movement, booming infrastructure construction and growing international trade has led to the conception of the Dedicated Freight Corridors along the Eastern and Western Routes to fulfill the demand of additional capacity of rail freight transportation.

In the first phase, Government of India has approved construction of two corridors– the Western DFC (1500 route km) and Eastern DFC (1845 route km) – spanning a total length of about 3345 route km. The Eastern Corridor, starting from Dankuni in West Bengal will pass through the states of Jharkhand, Bihar, Uttar Pradesh, and Haryana and terminate at Ludhiana in Punjab. The Western Corridor will traverse the distance from Dadri in Uttar Pradesh to Mumbai – Jawaharlal Nehru Port (JNPT), passing through the States of Delhi, Haryana, Rajasthan, Gujarat and Maharashtra.

Dedicated Freight Corridors are being built using State of art technologies in the field of bridges and track. Many new technologies like use of Reinforced earth retaining walls, Mechanized track laying, use of canted turnouts, Friction buffer stops etc are being introduced in railways for the first time. This article describes the use of canted turnouts on Eastern DFC.




## 2.0 Canted Turnouts:

For a steady movement of the rolling stock, canting of rails has been adopted on all World railways. As soon as the wheel, deviates from its central position on the rails, canting of rails brings it back to its central position. The canting of rails however could not be continued on turnouts in the past, as the available technology in the manufacture of turnouts was not

* *Group General Manager*
*Dedicated Freight Corridor Corporation India Limited*

capable to carry the cant, through the switch and crossing portions. With the Computer aided design facilities available for the design of structures and with the development of numerically controlled machines, it became possible to fabricate the switches to the desired canted formation. Cast Manganese crossings also paved the way in bringing the cant into the crossing area. With these two developments the field is now open to continue the canting of rails through the turnouts.

The continuation of cant through the turnouts has numerous advantages. Few of them are listed below:

- The rolling wheels, while negotiating the turnouts remain in their normal position. The sudden shift of load to the gauge corner of the rail does not occur. This helps in minimizing the gauge corner defects in rails and damage to the wheels. This phenomenon is more pronounced when heavy loaded freight wagons with high level of unsprung mass, negotiate the turnout.
- Canted surface will shift the contact away from gauge face and will result in extending the service life of a switch point by reducing or delaying the initiation of RCF.
- Gauge corner contact (which happens for the normal turnout configuration of a vertical rail on horizontal bearers) results in gauge corner fatigue; which in turn results in shelling (the creation of scales due to high stresses and metal fatigue) and loss of section at the gauge corner (i.e. when strips of fatigued rail material peels away from the gauge corner) and it ultimately results in transverse defects leading to premature rail failure and rail breakage.
- Gauge corner contact results in similar fatigue mechanisms in wheels in the area between tread and flange of the wheel, resulting in either increased maintenance of the wheel profiles or fatigue cracking of the wheel. Conformal surfaces will reduce the contact stress and shear stress by producing a larger wheel/rail contact area, increasing wear life of rails and sleepers.
- The sudden sway of the vehicle on turnout which is a normal occurrence on vertical rails, does not happen with the canting of rails. This in turn results in a better distribution of vertical strains, less wear and tear of turnout and of its fastenings.
- Reduces hunting effects (i.e. lateral oscillations) of the wheelsets and vehicles as they pass through the turnout because of cant, the frequency of lateral oscillation is reduced and the wavelength of the lateral oscillation is increased resulting in improved riding and reduced lateral thrust. This in turn reduces the side-wear of both rails and wheels in freight and heavy-haul applications. The normal turnout configuration of vertical rails on horizontal bearers only accentuates this effect through a turnout. The net result is accelerated wear on the rails in the turnout; but also a correspondingly accelerated wear on the flanges of the wheels.
- There is no twist in the rails while entering or leaving the turnout. This avoids unnecessary stresses in rails.
- Special concrete sleepers required to accommodate the twist at the two ends of the turnouts, are no longer required.

**3.0 Usage and Experience on World Railways:**

**3.1** In a technical paper presented in the recently held heavy haul conference in Delhi on the subject of “The design and maintenance experiences for heavy haul turnouts”, Mr. Francesco Barresi and others, concluded, “the use of rails with modified head profiles, such as 60 E2, or RE 68 Mod, reduces the gauge corner contact thereby improving the life of the turnout and its components as well as extending wheel life”. Rails with head modified to the desired cant are now available in the world market.

**3.2** German Railways (DB) which carries both passenger and freight traffic, have issued instructions for adopting canting of rails on turnouts.

**3.3** In Australia, the only network, which is carrying 32.5 tonnes per axle (using AS60 kg rail) is the ARTC's Hunter Valley coalfields. The canted turnouts provided on this network are performing well; so much so, that the ARTC has ground the head profile of other turnouts in this network, and now specifies that all new turnouts must either be canted, or must be pre-machined or pre-ground to the inclined rail head profile before supply.

**3.4** It the North West iron ore networks of Western Australia (i.e. Rio Tinto, BHP Billiton Iron Ore, and Fortescue Metals Group), where axle loads range from 35 to 42 tonnes per axle, turnouts are to the normal turnout configuration of vertical rails on horizontal bearers (but using RE 68 kg/m AREMA 136 lb/yard) rails; however all of these turnouts are profile ground to the standard track cants (either 1:30 or 1:40 for these systems) very shortly after installation.

**4.0 Development in India:**

**4.1** DMRC is using canted turnouts on its entire network. The technology has stabilized and now sleepers and switches are manufactured in India. In the sleepers there is no basic difference except provision of canted bearing plates. Switches similar to IRS design have been adopted by DMRC.

**4.2** The first ever canted turnout on DFCCIL has been used on Sonnagar- Mugalsarai (122 Kms) section of Eastern Dedicated Freight Corridor. About 41 Nos of 1 in 12 canted turnouts with design speed of 50 Kmph are being used on this section. The design were approved by RDSO. On Bhaupur- Khurja section (343 Kms) about 210 Nos of 1 in 12 canted turnouts will be used. The cant on rail is 1 in 20. The designs are under approval.

**5.0 Technical Features of Canted Turnouts on EDFC:**

**5.1** The following re the important Design features of canted turnouts being used on Bhaupur- Khurja section of Eastern DFC:

- Tangential geometry to ensure smooth entry without knocking and consequent less lateral forces.
- Design speed of 55 Kmph against 30 Kmph being used on Indian Railway.
- Turnout can be welded into continuous welded rail using anti creep device.
- Switch is operated by two synchronized point machines at Toe and JOH ensuring full housing upto JOH. Fit and forget type arrangement with minimum maintenance.
- Slide chairs provided with rollers for easy and smooth operation and Ni-Cr coating to provide increased wear life.
- Rail cant is provided in lead area through steel canted bearing plates fastened to sleepers by plate screws.
- Rail supported on inclined steel base plate with 10 mm thick composite rail pad and self-tensioning rail sleeper fastening (ERC).
- Thick web switches and canted CMS crossings with wieldable legs for carrying long welded rails through the points and crossings.



*Figure 1 Overall view of 1 in 12 Canted Turnout*



*Figure 2 Wieldable CMS crossing*

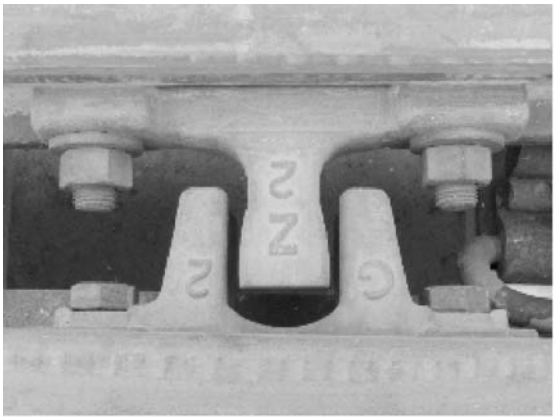


*Figure 3 Anti creep device*

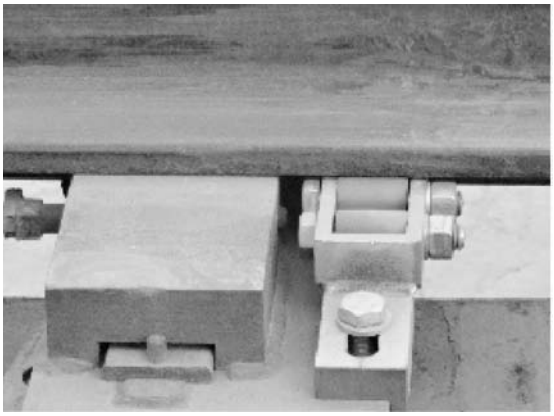


*Figure 4 Rollers under switches* ◆◆◆

# Rail Defects Development and Optimisation of USFD Testing Frequency

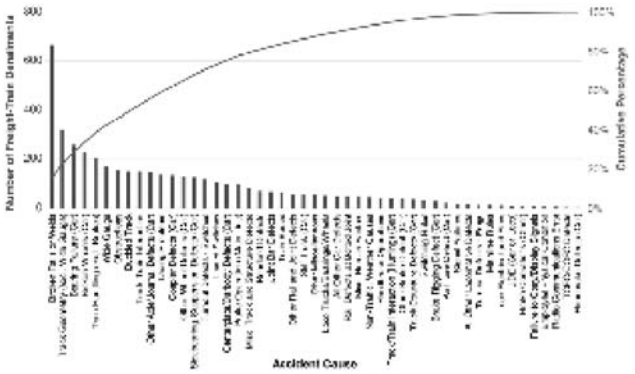
By
*Shri Sanjay Yadav**
*Shri Santosh***

## 1.0 Introduction :

After the introduction of PSC sleeper and mechanised maintenance the rail fractures is a main source of worry for Indian Railways not only because of the retardation of the traffic caused by this aspect but also because of its potential to cause a havoc in the form of a huge loss to the safety of travelling public. Till now no study or model testing regarding development of rail defect and USFD optimisation has been carried out in India hence the data and graph taken in this study is of different railways just to give the broad view.

## 2.0 Major Cause of Train Derailments:

As per the chart shown in Figure, the major cause of mainline freight train derailment during 2001-2010 is broken rail and welds.




Frequency of accident cause, Class I mainline freight train derailments, 2001-2010

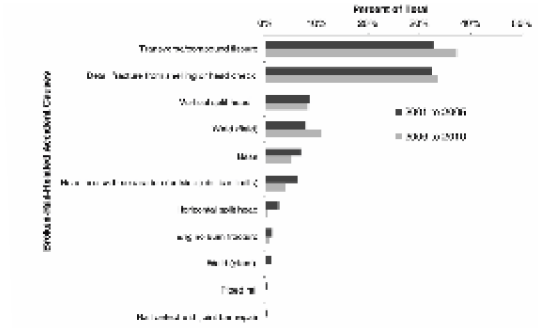
## 3.0 What is Rail Defects:-

RDSO has issued various guidelines for laying of blanketing layer on the top of the embankment as under.

- A critical defect is a rail defect that will affect the safety of train operations.
- Non-critical defects are the defects that occur in the rail but do not affect the structural integrity of the rail or the safety of the trains operating over the defect

## 4.0 Main Rail Defect Causing Derailment:

As per the graph shown below the transverse fissure and detail fracture from head check or shelling are contributed more than 60% of total derailment on account of rail breaks/fracture.



Distribution of Class I railroad mainline freight train derailments by broken-rail-related accident causes, 2001-2010

## 5.0 Crack Development Process

When repeated stresses of sufficient magnitude are applied to a rail section, a crack is initiated after a certain number of cycles, which goes on propagating when stresses are repeatedly applied (Nishida, 1991). The direction of crack propagation depends on the rail material, the point of crack initiation and the kind of metallurgical processing or the heat treatment method adopted for that particular rail section.

**5.1 Crack initiation**:- When repeated stresses of sufficient magnitude are applied to a rail section, a crack is initiated after a certain number of cycles.

**5.2 Crack propagation**:- Crack goes on propagating when stresses are repeatedly applied.

Cracks initiate in a very thin surface layer of the rail and develop inside the rail head. Crack development is facilitated by the presence of water (Ishida, *et al,* 2003). If the crack propagation is in the upward

* Sr. DEN/N/Kota
**Dy. CE/ROB/NER

direction towards the rail surface, pieces of rail material detach from the rail surface, but if these cracks propagate downwards, they may cause a railbreak. Cracks initiated by ratchetting (head checks) grow perpendicular to the direction of the resultant traction force (Grassie and Kalousek, 1997)

**5.3 Fracture or rail break**:-Rail break is the final result of the crack development process.

## 6.0 Crack Growth Models:

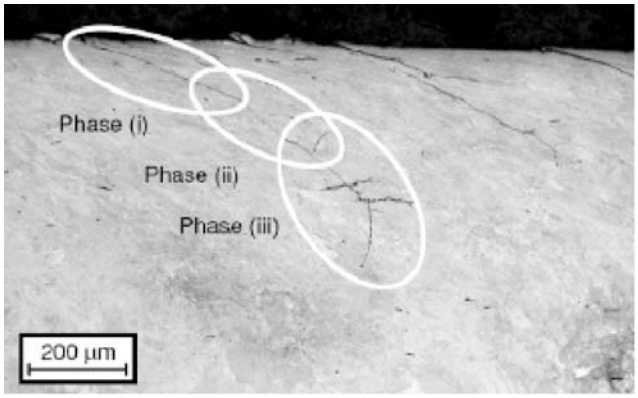
Many models have been developed to study crack initiation and its propagation. Miller (1997), proposed a model for crack growth in which he divided the crack propagation life into three phases:

Phase (i) - shear stress driven initiation at the surface

Phase (ii) - transient crack growth behavior

Phase (iii) - subsequent tensile and/or shear driven crack growth

Ringsberg (2001) explained those three phases with the help of figure :




*Three phases of RCF initiated crack propagation [Ringsberg, 2001]*

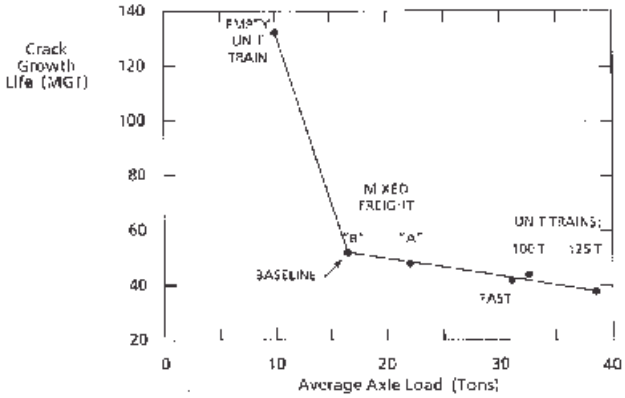
As per the model proposed by Nishida (1991, when the wheel passes over the rail section considered here, the axial load goes on increasing and decreasing cyclically, this process continues for a certain number of cycles until plastic deformation begins, usually at a relatively weak location. These deformations take place by the effect of compressive and shear forces. The rail steel layers start sliding under high axial load. When release of axial load takes place, the layers resisting plastic deformation tries to regain their original positions, thus applying a reverse force. This process goes on for a few cycles until a micro-crack is formed in the rail surface. These micro-cracks develop into cracks when stresses are repeatedly applied. Once a crack is initiated, stress concentration occurs at both ends of the crack and the crack may continue to grow. The micro-cracks may not always develop into cracks; this partly depends on the endurance limit of the rail material also.

## 7.0 Crack Developments in Rail:

The life of rail, in track, can be divided into two stages: defect initiation and defect propagation. The defect initiation refers to the period of time ( or the tonnage passing over the rails ) during which a defect develops internally, within the rail but cannot be detected by existing inspection techniques. Defect propagation refers to the period of time it takes a “detectable” detect to grow a size that will fail under traffic.

The crack growth life has been defined as the tonnage required to grow a defect from a size that is barely detectable to a size that will cause the rail to fail under next train. This interval can then be used to establish a maximum rail test interval and thus allow for more efficient scheduling of rail testing.

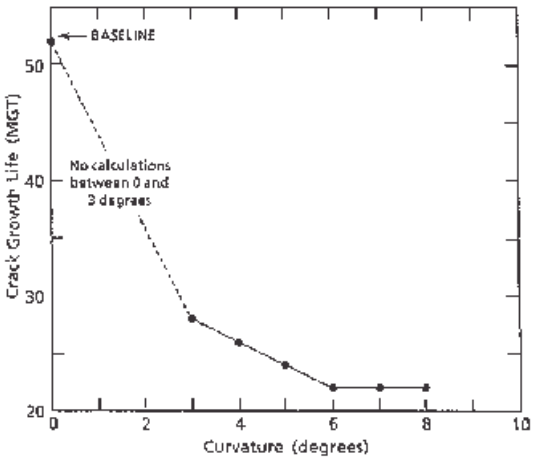
The effect of axle load on this crack growth life is illustrated in Figure below. While increased axle loads result in a reduction in crack growth life, empty




Effect of average axis load.

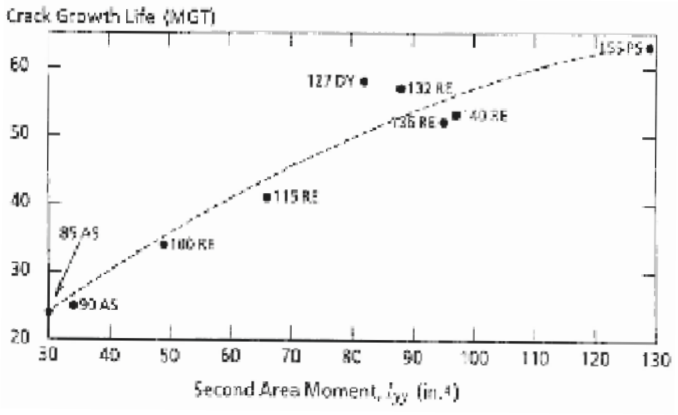
train appears to cause significantly less damage than loaded freight vehicles.

Figure below represents the effect of increased lateral loads, associated with increasing curvature. As can be seen in this figure, crack growth life is strongly affected by increasing curvature up until 6 degrees of curvature




Effect of track curvature.

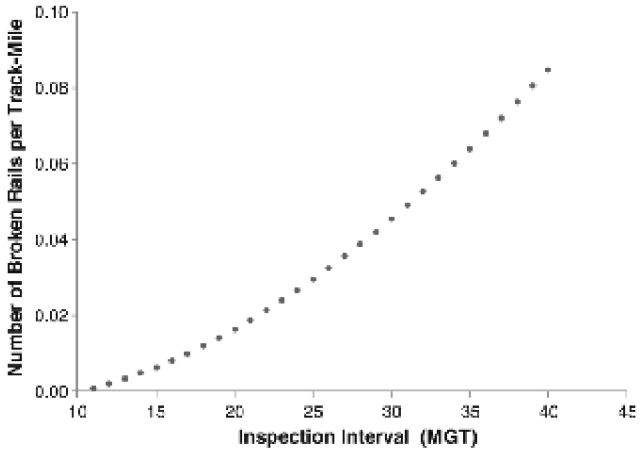
The relationship between track growth life and rail bending is illustrated in Figure below which shows the effect of rail section size on crack propagation.




Crack growth life versus rail vertical bending stiffness.

## 8.0 Number of Broken Rails Between Two Successive Inspection

The number of broken rails between two successive ultrasonic rail inspections can be approximated by a nonlinear function of the inspection interval as shown in figure below. The analysis shows that as the inspection interval increases, the number of broken rails per mile is expected to increase at an accelerating rate.




(α = 3.10; β = 2,150;  = 0.014;  = 10; N = 300)
Estimated number of broken rails by inspection interval.

α = Weibull shape factor

β = Weibull scale factor

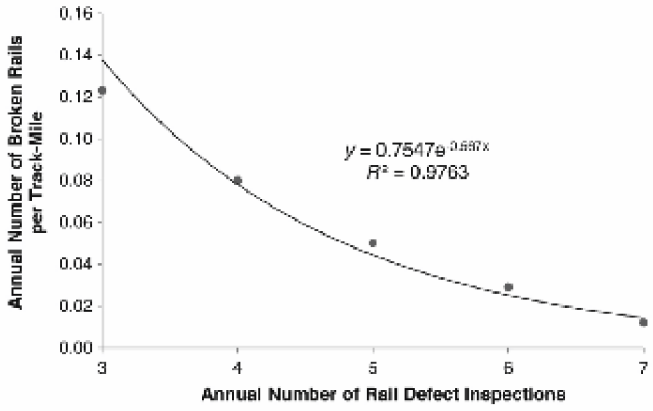
= Slope of the number of rail breaks per detected raildefects verses inspection interval curve

= Minimum rail defect in inspection interval

N = Rail age

## 9.0 Relation Between Number of Fracture and USFD Frequency:

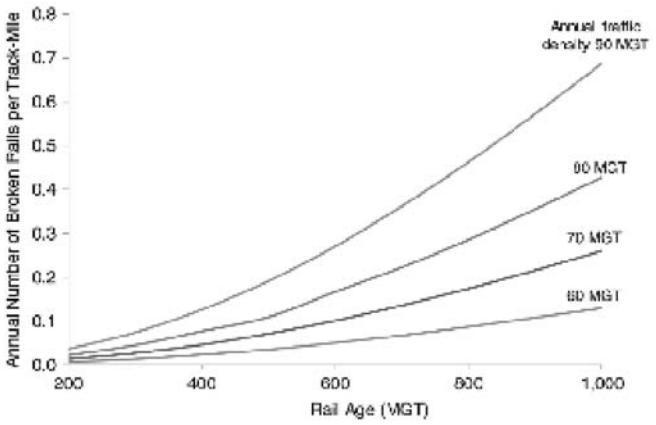
Given the total number of rail defect inspections per year, the optimization model can be used to determine the expected minimum number of broken rails with the optimal schedule for each inspection. In Figure below each data point represents the estimated number of broken rails given the number of ultrasonic rail defect inspections per year using the optimization model. The number of broken rails per track-mile can be approximated by an exponential function of annual inspection frequency. This observation is consistent with prior work (Zhao et al. 2006, 2007).




Relation between Number of Fracture and USFD Frequency

## 10.0 Relation Between Number of Fracture and Annual Traffic Density:-

Figure below illustrates the estimated number of broken rails per track-mile for different traffic densities and rail ages assuming four inspections per year. For each particular inspection frequency, the greater the rail age or annual traffic density, the more likely it is that a broken rail will occur.




Estimated annual number of broken rails per track-mile by rail age and annual traffic density (assuming four inspections per year)

## 11.0 Optimization of USFD Testing Frequency:

Equation to minimize the total cost related to ultrasonic rail inspection

$C_{Total}(K) = [(K)LC_{INS}/V)] + S(K)L(DDC+C_{DDT})/ [(T/K)- ] + S(K)L(SDC+C_{SDT}) + S(K)LØ(\mu DA+C_{DA})$

Where

$C_{Total=}$ Total cost related to rail defect inspection

L = Track length in miles

K = Rail defect inspection frequency per year

S(K) = Number of broken rails per track mile by annual USFD frequency

Ø = Proportion of broken rails causing train derailment,

DA = Av. Track and equipment damage cost per broken rail caused train derailment

μ = Multiplier for accounting for other related derailment costs

V = Av. Train speed in MPH

$C_{INS}$ = Rail defect inspection cost.

= Slope of the number of fracture per detected rail defect versus USFD test interval curve.

T = Annual traffic density

= Minimum USFD testing interval

DDC = Total cost for repairing a detected rail defect

$C_{DDT}$ = Train delay cost from repairing a detected defect.

SDC = Total cost for repairing a broken rail

$C_{SDT}$ = Train delay cost from repairing a broken rail

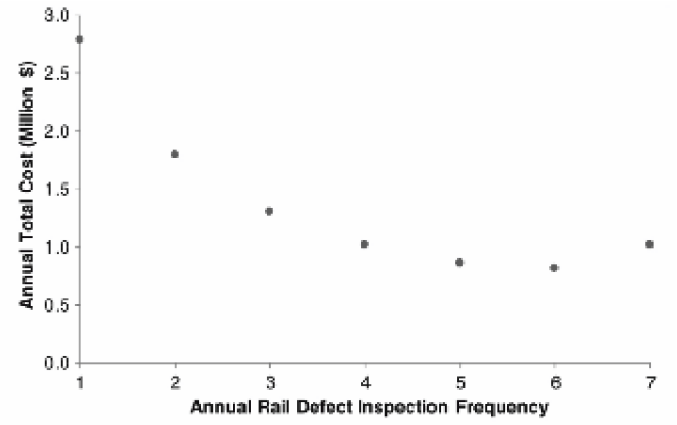
$C_{DA}$ = Total train delay cost

## 12.0 Relation Between Annual USFD Frequency And Annual Total Cost:

The optimal annual USFD frequency (K*) is determined so as to minimize total cost ($C_{Total}$)

$K^* = arg_k min [C_{Total}(K)]$

The total cost (including rail defect inspection, rail defect or broken rail repair, track and rolling stock damage, and train delay because of derailments or repair activities) is minimized at a certain inspection frequency.




Total cost by annual rail defect inspection frequency
(assuming initial rail age 300 GMT and annual traffic density is 80 GMT)

## 13.0 Conclusions:

A fracture initiation and development depends on many factor like reason of crack, location of crack, direction of crack, loading condition etc. Therefore it is very difficult to predict the crack development rate. However different model studies have been carried out in foreign railways to study the crack development process and accordingly fix the optimized ultrasonic flaw detection testing frequency. In view of ensuring safety against derailment due to rail fracture in India following steps has been suggested:

1. As we know that main rail defect which is responsible for derailment due fracture are transverse fissure and detail fracture due to head check. Hence more efforts are required to detect these defects at early stage.
2. Rail grinding should be extensively used to remove the surface defects especially head checks at initial stage to prevent detail fracture which is one of the major cause of rail fracture.
3. The Crack growth life reduced drastically in curve from 3 degree to 6 degree, hence special precaution is required in this area like USFD testing at reduced interval.
4. The Crack growth life is increasing with the increase of rail section hence all the renewal work should be planned with 60 Kg or heavier rail.
5. A detailed study on Indian condition is required for fixing optimized USFD frequency / variable frequency of USFD testing on rail age basis.

## 14.0 References:


i) "Flaw identification handbook" by Nordco rail services and inspection technology, USA.

ii) "Rail defects handbook" by Australian railtrack corporation Ltd.

iii) "Crack propagation life of detail fracture in rail" by Oringer O. et al

iv) "Rail flaw detection- where is it heading"by Roney, M. D.

v) "Study of rail breaks:-Associated risk and maintenance strategies" by Saurabh Kumar

vi) "Optimization of ultrasonic rail defect inspection for improving railway transport safety and efficiency"by Xiang liu, M. ASCE, Alexander Lovett, S. M. ASCE, Tayler Dick, M. ASCE, M. RapikSattand Christopher C. L. Barkan


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# Construction of Seawoods Viaduct: A New Approach

By
*Shri Ashutosh Gupta**
*Shri Ashutosh Kumar***

**Synopsis:**
*825 m long RUB cum viaduct is an important part of Belapur-Seawood-Uran electrified double line project. Effective planning, Quality control and use of new technology has resulted in outstanding quality and good speed in this project. The present paper highlights, some important steps undertaken to construct this prestigious project.*

**1.0 Introduction**

Nerul-/Belapur-Uran commuter Railway line has been contemplated to accelerate the growth of New Mumbai by providing direct access between URAN town, JNPT (Nhava Seva) Port and newly developed areas of Mumbai Metropolitan region as well as greater Mumbai. This work is being carried out on the cost sharing basis between CIDCO and Central Railway in the ratio of 67 % : 33% respectively. The revised estimate of work is approx. Rs. 1840 cr.

**2.0 Seawoods Viaduct :-**

Seawoods viaduct is a major landmark of this project. It includes a Road under Bridge at Palm Beach road followed by viaduct of 36 spans, which is connected to existing Panvel Creek Bridge. It is in $4^0$ curve and is in grade of I in 196. There is also a provision of station at viaduct, which will come in future.

Originally Earthen embankment was proposed at the location which was surrounded by mangroves.

This was changed to Viaduct due to Judgment of Hon'ble High Court Bombay in July 2008 to prevent destruction of mangroves and Subsequent decision from CIDCO for changing to Viaduct due to Higher formation width, effect on Proposed water transportation terminal and effect on existing salt commissioner's office.

**2.1 Configuration of Viaduct :**

Length of bridge is 825m, Span Arrangement is 1 X 9.00 M (PSC slab) + 4 X 20.5m PSC Voided slab) + 36 X 20.388M (PSC I-girder), Foundation is RCC Pile 1200 mm dia and Super-structure is PSC I Girder (2.1m depth) and PSC voided slabs (1.4m depth) for Palm Beach RUB.

**3.0 Construction Features of Viaduct :-**

**3.1 Alignment :**

Fixing of correct alignment is the most critical activity of any project. The alignment of Viaduct is partially in straight (upto P18) & partially in 4° curve ( P18 to P40). Although, few permanent structures were already constructed on both ends of Viaduct ( i.e. Minor Bridges on Seawood end & Panvel Creek Bridge on Uran end ), it was practically not possible to fix all the stations on the ground due to presence of dense Mangroves at the location of Viaduct.

Survey by Total station was started from Seawood end ( Zero station ) taking coordinates of all fixed structures & all accessible points nearby Mangroves including Apex point, which continued upto points of already constructed Panvel Creek Bridge on Uran end.

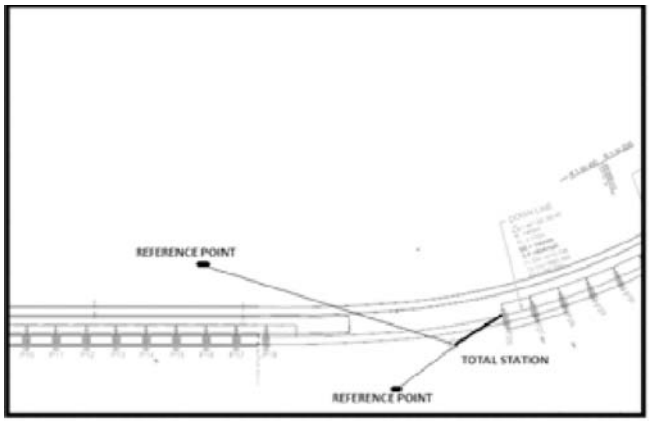



*DyCE/C/Juinagar
** XEN/C/Sanpada




Thereafter these points were transferred as Auto Cad points & rough alignment was drawn. It was superimposed over Project Sheet. Minor shifting of Apex point was done as one minor bridge across Palm Beach Road was infringing & curve required realignment. Finally all the spans were fixed & centre points of all piles, pile caps, piers & pier caps were found from Auto Cad Drawing.

When earthwork was started from Seawood end , coordinates of centerline were transferred to ground one by one & accordingly earth filling was done at the required alignment. Three reference points were also marked so that position of Total station could be fixed at any later stage during construction.




Steps for fixing station on ground just prior to construction :

i) Position of Total Station is fixed w.r.t. Reference points.
ii) Name of the station to be marked, is entered.
iii) Instrument rotated to adjust coordinates.
iv) Staff moved according to distance shown.

**3.2 Alignment Control During Construction :**

After construction, alignment is rechecked independently by staking out at the following locations to ascertain that coordinates of each component are correct .





i) Each pile centre;
ii) 13 stations on each pile cap;
iii) 8 stations for each pier;
iv) 12 stations for each pier cap;

**3.3 Pile Boring by Rotary Drilling Rig ( Bauer )**





Total number of piles required is 336. nos. This would take very long time, if done by conventional Bailer and

chisel method. Hence, a condition of "pile boring by hydraulic /pneumatic rotary rigs only" was incorporated in contract. The strata found was :

**Strata**

| Particulars | Min | Max |
|---|---|---|
| Depth of marine Clay | 2m | 6m |
| Depth of soft rock | 3m | 7m |
| Hard rock level | 8m | 16m |
| Depth of pile (including socketing) | 8m | 18m |
| Socketing in rock (2 D min.) | 2.4m | 4.0m |

For drilling, **BAUER** make rotary drilling is used. The features of machine are:

| | | |
|---|---|---|
| Overall height | (M) | 20.9 |
| Max. diameter<br>Max. drilling depth | (mm)<br>(m) | 1.800<br>59.6 |
| Av Progress in 10 hrs. shift | 8m in rock or 27 m in murrum/clay | |

The machine has inbuilt inclinometer which ensure pile is vertical. The depth is also measured by machine automatically.





6mm thick MS liner is used to prevent caving of surrounding soil, formation of cavities and protection against marine environment. Liner Continues Upto soft Rock Level. 1.5-2.5m length cylindrical Liners were welded together. During liner insertion, sometimes it was seen that liner bends at the first joint. Hence, extra plate was tack welded at the first joint, in addition to the 200mm liner shoe. Thus, it was ensured that liner went smoothly without bending.

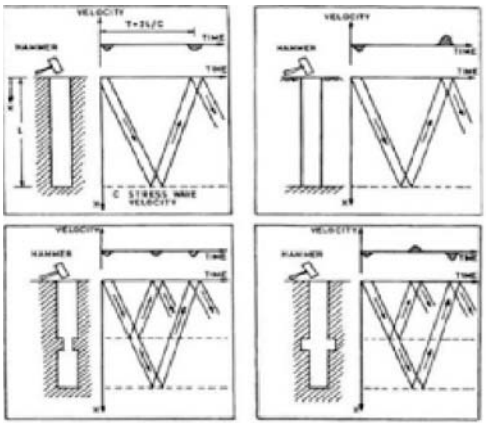


**3.4 Testing : Testing of piles was done by following methods**.

1) Dynamic testing by ASTM.
2) Static testing of Pile load.
3) Integrity Testing.

**Pile Integrity Testing ( as per ASTM D-5882 )**





All Piles are tested for integrity by Pulse Eco Integrity Testing Method. Piles are trimmed to Cut-off Level before Testing. This method is based on one Dimensional Stress Wave Approach, A Low Strain Integrity Testing. The Pile Head Motion Is Measured As A Function of Time.

**Dynamic Test Details**

| Description | Test Pile |
|---|---|
| Pile length below gauges | 9.7m |
| Pile length below grade | 9.4m |
| Concrete grade | M 40 |
| Liner length from top | 6.35 m |
| Pile diameter | 1200 mm |
| Hammer weight | 11.7 T |
| Drop height | |
| Working load | 500 T |
| Test load | 1250 T |

| Description | Test result | Permissible Limits |
|---|---|---|
| Pile capacity | 2365 tons | 1250 Tons |
| Total displacement | 4.98 mm | 12 mm |
| Compressive stress | 18.1 N/mm2 | < 0.85 fck (34 N/mm2) |
| Pile integrity (at sensor level) | 82 % (acceptable) | > 80 % |

**Dynamic Test as per ASTM D4945 : (Explain)**





Two pairs of strain transducers and accelerometers are attached to the pile head on diagonally opposite sides of the pile. The pile driving analyzer converts strain to force, and acceleration records are converted to velocities. The resistance developed by the pile Is function of force and velocity. The maximum pile top compression is obtained by integrating the pile top velocity.

**Static Testing of Pile (By Reaction Method) - Explain**

As per IS 2911 (Part 4)

Pile tested up to 1340 MT (Test load - 750 MT) and settlement was well within limits.

i) Total settlement of pile under test load 1340 MT = 3.5mm ( allowable = 12mm )
ii) Boring of 4 nos of 160mm dia holes.
iii) 17 nos of 12T13 strands used in each anchor.
iv) Anchors grouted with GP-2 epoxy mortar.

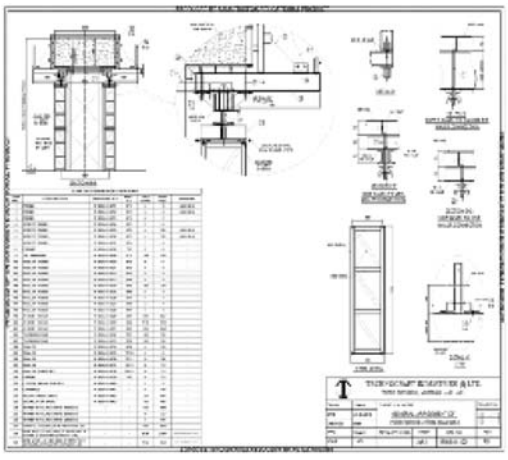




v) 4 hydraulic jacks of 500T capacity each provided.
vi) Bearing plates fixed over girder assembly.
vii) Strands locked initially with 5%-10% of its capacity.

**Static Testing Details**

Incremental load of 20% of safe load on pile i.e. 100MT After completion of final loading i.e. 1340 MT, load maintained for 24 hrs, De-cremental loading of 20%, after every 15 mins Settlement of pile at design load (750 MT) = 0.825mm.





**3.5 Shuttering :**

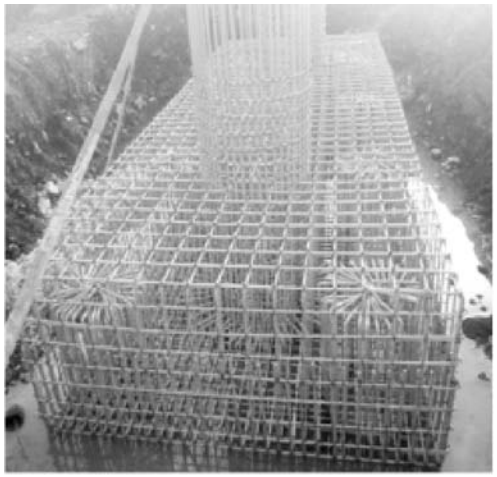
i) Shuttering fabricated as per approved design & drawings in workshop;

ii) All shuttering plates, props, H frames, screw jacks & fittings are of steel;

iii) Wooden planks & props not allowed for formwork and staging work;

iv) Formwork coated with approved releasing agent to effectively prevent sticking & non staining of surface.

**3.6 Pile Cap :**





The pile cap is common for all group of eight piles. Their salient features are:

i) Dimension : 10.5m * 4.5m * 1.8 M.

ii) M 40 Concrete ( Cement Content- 430 Kg/CuM )

iii) 85 Cum In Single Pour using concrete pump.

iv) Slump After Two Hrs- 170mm.

v) 1 Pump & Min 2 Vibrators.

vi) Time Taken About 3-3.5 Hrs.

vii) At Same Level For All Piers.

viii) Shuttering Weight : 8.5.T.

**3.7 Piers :**

The cut off level of pile cap is kept same. The viaduct is in grade of 1 in 400 at proposed station area and in 196 at other location. Hence the length of pier varies from span to span. The feature of pier are,







i) Diameter : 1600 mm
ii) Grade Of Concrete : M40
iii) Height : 5.2m To 8.0m
iv) C/C Dist : 5.30m
v) Shuttering Weight : 3.5T
vi) Concreting In Single Pour by Placer Boom

**3.8 Pier Cap :** Pier cap is common for both Column and common to both up & down lines.





i) Dimension: (Top-13.0*3.2 & Bottom- 9.2*3.2) *1.2m.
ii) M 40 Concrete – 45 Cu M.
iii) PCC Bed To Support Trussles.
iv) Concreting By Placer Boom In Single Pour.
v) Concreting In 2-2.5 Hrs.
vi) Shuttering Weight : 4.5t.
vii) Staging Weight : 10t.

**3.9 PSC Girders**

PSC girder for span of 20.388m ( centre to centre of pier cap ) are used. Total number of girder is 144. It is an I girder of dimension overall length 18.965 m & ht 2.1 m .The main features of girder are:







i) 28 CuM Concreting in single pour by Placer Boom.
ii) Two stage pre stressing one at ground other after casting of deck slab. (3 cables stressed at ground & remaining 2 cables are stressed after casting of deck slab).
iii) Fully Compacted Casting Bed.
iv) Bottom Plate & Side Shuttering With Turn Buckle Arrangement.
v) M 50 Grade ( Cement 475 Kg / CuM ).
vi) Shuttering weight : 12MT.

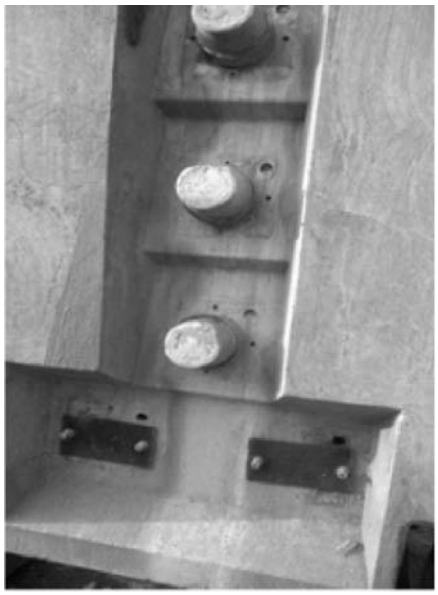
vii) Shutter vibrators used.

viii) Weight of each girder: 78 MT

ix) Precast Cover blocks.

x) Chairs for cable profile.



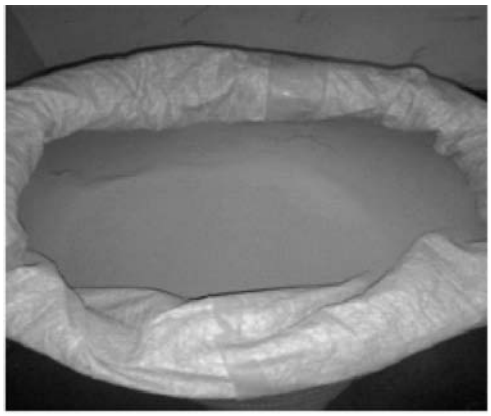


**Haunch Without Micro-silica concrete M50**



**Haunch With Micro-silica concrete M50**





i) Problem of air bubble entrapment was faced during casting of girders. Due to the shape of 'I' Girder, air used to get entrapped in lower haunch portion due to which chicken pox type air entrapment was observed in haunch. Though structurally acceptable, they gave a rough finish to the concrete surface. The problem has been solved successfully by adding micro-silica as an additive to conventional mix. 25 kg of micro-silica per CuM is being added. This has eliminated the problem of pin holes.

**Girder Launching**



Launching of girder is by 2 cranes of 200 MT each. Two Cranes 200 MT Each, Wt of Each Girder 78 MT in 8 hrs shift, 4 girders launched.

### 3.10 Use of 4 CAMERAS with 3 G Web Based Connectivity

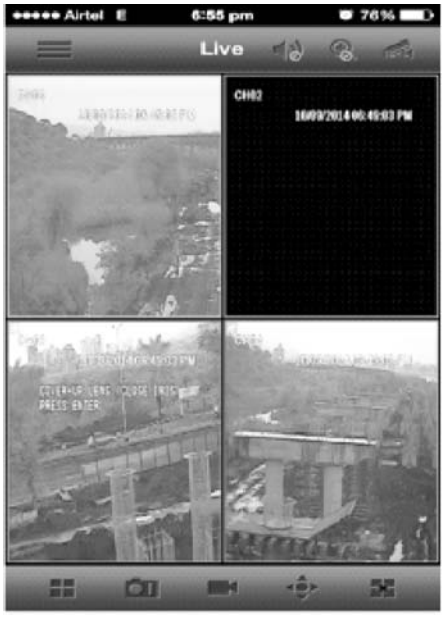
( App. Cost = 1.0 Lakh )



**Camera Fixed on Top of Pier**




**Single Screen View**




**Four Camera View**

## 4.0 Salient Features (Design )

**There are many salient features in design of the viaduct like,**

i) Provision of emergency cable for future pre-stressing,

ii) Pre-defined jacking points for in-service lifting and lifting points for launching in PSC Girders,

iii) Provision of utility ducts below foot path on both side, Proper access to bearing area for inspection,

iv) Railing along footpath for safety of inspecting officials, Instrumentation (under planning).

v) Permanent staircase for direct accessibility from Ground to Footpath cum cable duct .

## 5.0 Measures Adopted to Ensure QUALITY :

Quality has been given topmost priority in this prestigious project. Measures adopted at site to improve quality are mainly,

i) Proper Survey scheme for alignment control, by using Total Station.

ii) Casting of all elements like piles, Pile caps, Piers, pier caps, Girders and Deck slabs in single pour.

ii) PSC Girders casting in casting yard & launching by road cranes.

iii) Fully equipped concrete lab at site with equipment like Permeability testing machine, compression testing machine etc.

Contractual Provisions like pile boring by rotary, drilling rig, single pouring of concrete and setting up field laboratory and site office.

**Durability of Concrete**

For Severe exposure condition, as per IS 456 & Concrete Bridge Code :

| Descri-ption | Minimum Grade Of Concrete | | | Max. Water Cement Ratio | | Minimum Cement Content | | Permeability | |
|---|---|---|---|---|---|---|---|---|---|
| | Reqd | Provided | 28 Days Str At Site (N/Sq Mm) | Reqd | Provided | Reqd (Kg) | Provided | Reqd (mm) | Achieved (mm) |
| RCC | M 30 | M 40 | 50 | 0.45 | 0.31 | 350 | 430 | 25 | 11.8 |
| PSC | M 40 | M 50 | 64 | 0.45 | 0.29 | 430 | 475 | 25 | 11.2 |

Standard Deviation achieved at site is 0.8 As per international literature (Himsworth), SD for different controlled conditions is as under :-

| Type Of Control | Standard Deviation ( In N/Mm2 ) |
|---|---|
| Excellent | 2.8 |
| Very Good | 3.5 |
| Good | 4.2 |
| Fair | 5.6 |
| Poor | 7.0 |
| Uncontrolled | 8.4 |

As per IS 456 Cl 9.2.4.2:

| Grade of concrete | M 10 | M 15 | M20 | M25 | M30 | M35 | M40 | M45 | M50 | M55 |
|---|---|---|---|---|---|---|---|---|---|---|
| Assumed Std.Dev. ( in N/mm2) | 3.5 | | 4 | | 5 | | | | | |

NOTE: The above values corresponds to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability & strength. Where there is deviation from above, values given in the above table shall be increased by 1 N /mm2.

**Progress**

| | SCOPE | PROGRESS |
|---|---|---|
| PILE | 336 | 330 |
| PILE CAP | 40 | 38 |
| PIER | 40 | 38 |
| PIER CAP | 40 | 38 |
| PSC GIRDER | 144 | 142 |
| DECK SLAB | 72 | 55 |

**6.0 Conclusion :**

The work is still in progress and is expected to be completed in Mar'16. Proper planning prior to opening of tender. Proper tender documents effective site supervision, effective quality control measures, installing of web based camera and use of new material has resulted in outstanding quality and efficient site management.

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## Details of Latest Correction Slips

| Sl. No | Codes/Manuals | Last Correction Slip No. |
|---|---|---|
| 1 | Indian Railways Permanent Way Manual(second Reprint-2004) | **138 of 15-08-2015** |
| 2 | Indian Railways Bridge Manual-1998 | **31 of 09-02-2015** |
| 3 | Indian Railways Works Manual-2000 | **10 of 17-2-2005** |
| 4 | Manual of Instructions on long Welded rails-2006(II reprint-2005) | **16 of 12-6-2014** |
| 5 | Manual for Flash Butt welding of Rails(reprint-2012) | **2 of 05-06-2014** |
| 6 | Manual for Fusion welding of rails by the Alumino Thermit Process (Revised 2012) | **nil** |
| 7 | Manual for Ultrasonic testing of rails & welds (revised 2012) | **2 of 18-12-2014** |
| 8 | Manual for Glued insulated rail joints-1998 | **5 of 28-08-2012** |
| 9 | Indian Railways Track Machine Manual (2000) | **17 of 21-02-2014** |
| 10 | Manual of Inspection schedules for officials of engg. Dept-2000 | **nil** |
| 11 | Railways (opening for public Carriage of Passengers)Rules-2000 | **nil** |
| 12 | Indian Railways Schedule of Dimensions 1676 gauge revised 2004 | **15 of 19-06-2014** |
| 13 | Indian Railways code for the engg dept (third Reprint-1999) | **48 of 01-05-2014** |
| 14 | Guidelines for Earthwork in Railway projects-2003 | **1 of 22-7-2004** |

# Handling Massive Construction of 4-Lane Cable Stayed Road over Bridge over Barddhaman Yard of Eastern Railway in the State of West Bengal, India.

By
*Shri Harsimran Singh**

**ABSTRACT :**
*A massive bridge is under construction at Bardhaman in the form of 4-lane cable stayed ROB so as to replace an existing distressed ROB (Bridge No-213) on Howrah-Barddhaman route in a very busy yard of Barddhaman Station spanning across 5 platforms and 9 tracks. There are numerous constraints such as the restrictions on maximum height of road surface for connectivity to GT road, minimum clearance from track and 120.913m clear span across tracks. All these constraints resulted in an asymmetrical cable stayed bridge of 188.429m span with part RCC and part composite deck, and RCC piers and part RCC and part steel pylon. The practicality aspect is well incorporated into design by ensuring that the work over electrified tracks and platforms can be done uninterrupted with all safety aspects. This is achieved by deploying tower crane for erection of steel pylons and deck erection cranes for the launching of the segments of the main span across the track which are all connected together with HSFG bolts and supported with stay cables. The main span is supported by back span through the stay cables and the Pylon. Due to large spans and heavy loads, there are massive RCC Piers, pile caps and deck which have been constructed in built up area. These massive structures of high grade concrete (M50) need special precautions for manufacture, transport and placement of concrete and for holding of reinforcement cages for safety of workers. The paper deals with the evolution of design, various design related issues and special construction methodology for the bridge.*

## 1.0 Introduction

**1.1** Bardhaman is situated at 107 km from Howrah on Howrah-Delhi route. There is an old multi span ROB of brick masonry construction over the Bardhaman railway yard, which is connecting the G.T.Road side of Bardhaman town with Kalna-Katwa Road. The existing ROB is an extremely busy corridor carrying a large number of fast and slow moving vehicles along with pedestrian traffic. Since, condition of the existing ROB is poor due to its old age, rebuilding of the existing ROB was sanctioned in 2007-08 at a cost of Rs.15 Crore. However the State Govt and Eastern Railway could not finalize a plan within this cost and finally a new work was sanctioned at a cost of Rs. 156.68Crore (SF-Rs.60.35Crore, Deposit-Rs.96.33Crore) in 2009-10 for a 4 lane cable stayed ROB. A cable stayed ROB was the only option accepatable to Railways and the State Govt in this very busy Yard connecting very busy GT road on one side with two important roads on the other side. RVNL has been entrusted by the Eastern Railway to construct the new cable stayed ROB. On 2nd March, 2011, RVNL engaged Consulting Engineering Services ( I ) Pvt. Ltd (CES) as consultant for carrying out detail design and construction supervision. IIT, Roorkee has been assigned the task of proof checking of design, specifications and manuals. M/s GPT-RANHILL JV have been awarded the work of construction of the Cable Stayed Portion of the ROB.

**1.2** The proposed ROB is being constructed at a distance of 65.5m towards Durgapur from the centre line of existing ROB. In order to have a clear hindrance free span over the Bardhaman railway yard the proposed new ROB has cable stayed construction in a span of 188.429m(c/c). It is decided that clear distance between the northern face of the G.T. road side abutment and southern face of the intermediate pylon will be mandatorily 120.913m. The minimum

* DGM (G), SE Railway

vertical clearance between the lowest point of the soffit of the superstructure and the highest rail level beneath the ROB shall be 6.50m and the maximum vertical distance between the road surface and the track will be 7.5m.

**1.3** Structural design of the cable stayed ROB has been carried out using LARSA-4D Software. It may be noted that analysis of cable stayed bridge is integrally linked with the sequence of construction.

## 2.0 Structural Design Methodology

### 2.1 Overall Configuration

The bridge is an asymmetrical two span cable stayed bridge with span lengths(c/c) of 124.163m and 64.266m. At present 9 rail tracks run under the longer span. Height of the pylon above deck has been fixed as 54.768m. The height above ground level is about 67m, about 6m short of Qutb Minar at Delhi. The bridge spans over busy railway lines, so speed of construction is of essence, and since the depth of the bridge deck is severely limited by the highest rail level and the formation level of approach roads, a composite steel deck has been adopted for main span because of the restrictions of depth of the superstructure which has to be restricted to 1000mm.

Three are three steel pylon Towers connected ties and founded on pile foundation consisting of 1.5m diameter piles. The deck is supported by three planes of cables in a harp shaped arrangement. Each harp of cables is anchored to the pylon at one end and to longitudinal girders running along the deck. The deck to abutment connection at the Katwa/Kalna end is a fixed connection while the GT road end will accommodate thermal movements by means of Modular expansion joint.

The deck of main span consists of three longitudinal edge steel box girders connected by I-shaped cross girders attached to the lower half of the main girder to achieve a flush soffit. These cross girders will carry concrete slab acting compositely with the help of shear studs. The back span is of Concrete with three longitudinal beams (Girders) supporting the concrete deck slab cast monolithically. Cables from the pylons will connect to the longitudinal girders to support the deck.



Fig.1 3-D Model of the Bridge

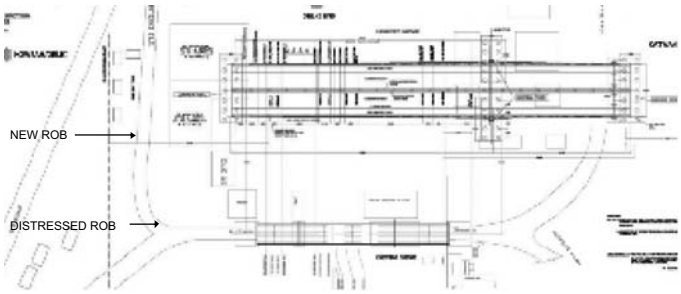



Fig.2 Structural Steel Fabrication Work

### 2.2 Deck Superstructure

The main span of the bridge is divided into longitudinal segments, which are pre-fabricated. 8 segments are 12m, one segment is 10.63m and one segment is 10m long with 3 main steel box girders tied together with cross girders. The main girders are connected at site to the end of previous segment and are connected with cables coming from pylon. The back span made of acts as anchor for the cables to support the main span.

The steel frame composed of three longitudinal built-up girders and cross girders has been fabricated in fabrication yard. It is erected in place with deck erection cranes and help is taken from cables previously attached to the pylons. The longitudinal girders are placed one by one and then the cross-girders using the cranes. After erection of one full panel, concrete deck is poured and this deck slab acts compositely with already erected steel structure with the help of shear studs. The last panel will span directly from end of previous girder to common pier and will not be supported with cables.

### 2.3 Pylon

The pylon consists of three Towers supported on RCC wall (pier) of M50 grade concrete resting on pile foundation. The towers are also of steel and of box shape in cross section (2.0MX2.5M). Height of the pylon is dictated by the stability analysis and economics of the bridge. A tall pylon will minimize the compression introduced into the steel deck system, but may increase the length of cable used while a short pylon will introduce undesirable compressive forces into the steel deck structure. The cross section is sized for not only strength and deflection requirements, but also to accommodate an stressing and inspection route.

Pylon is fabricated in segments which are later spliced with HSFG bolts at site. Tower crane is required for its erection and later on the three pylon towers are braced with lateral beams.

### 2.4 Stay Cables

Parallel strand HT cables (15.7mm dia-7 wire strand) are being used for the bridge. These cables have the advantages of having compact anchor sizes and can be accommodated in a limited space. The individual strands have seven wires and can be de-stressed individually for future replacement. Lower reach of cable will be sheathed in steel pipes, while the upper part will be protected by HDPE pipes.

### 2.5 Common Piers And Pylon Foundations

At the back span, the cables are anchored to common pier, which has been cast with M50 grade concrete. Common piers and Pylon be founded on pile foundations with M-35 grade piles of 1.5m diameter. The common piers also support loads from the approach roads.



Fig.3 RCC Portion of Pylon



Fig.4 Common Pier -1

### 2.6 Bearing System

Pot cum PTFE Bearings are being provided. These are to be provided only at the common pier supporting the main span. While finalizing the bearing system, it has been kept in mind that accessibility and replacement of each part of bearing are of paramount importance as the design life of bearings is shorter than that of the structure. All the pot bearings have been designed as per IRC: 83 Part III. The seismic forces used correspond to forces as arrived from interim specification of IRC: 6-2000.

### 2.7 Drainage Of Deck / Solid Pier

The drain pipe of GI with water collection box at top with cover made up of mesh of GI has been located within the solid pier to avoid aesthetics problems. The top of soffit slab has been profiled so as collect the run-off water at two points by providing a cross slope of 2.0%.

## 3.0 Construction Material

### 3.1 Concrete

Concrete with rebars is the majour material used in the construction of the bridge. Keeping the durability and structural requirement, the strength of various elements of structure are as follows:

- Deck Slab, fck = 50 MPa
- Abutment (piers & RCC part of Pylon), fck= 50 MPa
- for bearing Pedestal, fck = 60 MPa
- for piles & pile cap, fck = 35 MPa
- Crash barrier cum parapet over Deck Slab, fck = 40MPa.

### 3.2 Stay Cables

These stay cables used consist of the parallel strand system (PSS) made up of parallel individually polyethylene coated seven-wire strands, placed inside an external polyethylene stay pipe. The stay cable free length has redundant protection against corrosion of the strands by means of two complementary nested barriers:

- The first barrier (or internal barrier) is a hot dip galvanic coating applied directly to the strand which covers the full length of the cable without a break.
- The second barrier (or external barrier) consists of an outer envelope made of HDPE sheath and an intermediate medium of a special wax between the outer envelope and the internal barrier. To prevent the internal barrier being consumed, the external barrier must be completely airtight and watertight, in both the free length and the anchorage zone. In addition, the intermediate medium must prevent any water or moisture that might get inside the external barrier from reaching the internal barrier.

The resistance of the stay pipe to environmental aggression (thermal variation, mechanical attack, UV radiation and stress cracking) shall be ensured by a stay pipe with a thermal expansion range and an adequate formulation, as well as an anti-vandalism tube in the bottom anchorage zone. The strand lengths may have welds made on individual rods before drawing, but may not be welded during or after drawing. The main tensile elements of PSS stays are coated strands to with the following characteristics:

- Nominal diameter: 15.7 mm;
- Nominal resisting section: 150 $mm^2$;
- Nominal linear mass of the bare strand: 1.172 kg/m;
- Protective metal coating;
- Strength class $f_{GUTS}$ = 1860 MPa (maximum load $F_m$ = 279 kN, 0.1% proof load $F_{p0,1}$ = 248 kN);
- Strain under maximum load $A_{gt}$ at least 3.5%;
- Modulus of elasticity of the bundle of parallel strands of 195 GPa± 5%;
- Very low relaxation: no more than 2.5% at 1000 hours at 0.7 Fm ( at 20°);
- Fatigue strength: 2 million cycles with maximum stress of 0.45 $f_{GUTS}$ and stress variation of 300 MPa. This characteristics is checked on the strand anchored with the same wedge as the one used in the anchorage on the structure.
- Deflected tensile strength coefficient of no more than 20%.
- Curvature of strand should be as follows: when a length of strand is lying free on a flat surface, the maximum bow height from a base line of 1 meter length, measured inside the curve, shall not exceed 25 mm.

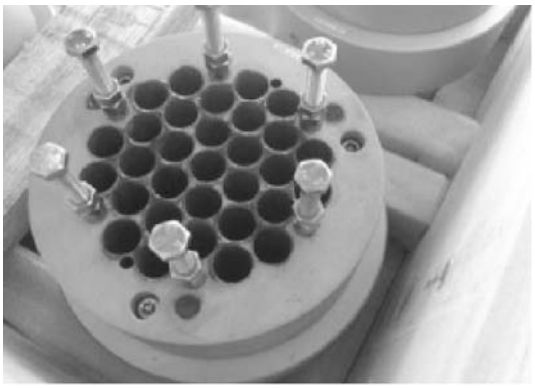


Fig. 5 Anchorage

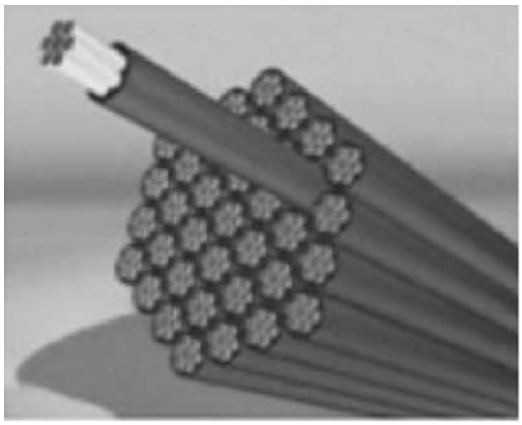


Fig.6 - 7-wire 15.7mm strands with HDPE coating

### 3.3 Structural Steel

Structural steel has been used for the pylon towers & ties and longitudinal and cross girders of the main span. The cross girders act compositely with concrete deck. Two types of structural steel have been as per the following standards- Fe540B for main built up sections and Fe410B for ancillary items.

The components are fabricated using welded connections in the fabrication yard and are connected together after erection using HSFG bolts. For composite action shear studs are used over cross girders.

**3.4 Reinforcement Steel (rebars)**

Only Thermo-mechanically treated reinforcement bars of grade Fe 500D conforming to IS: 1786 have been adopted.

**4.0 Construction Stages**

Detailed construction sequence is spelt out below.

**4.1** Construction of Pile foundation at common piers and pylon location.

**4.2** Setup of fabrication yard for steel.

**4.3** Construction of common pier and concrete portion of pylon.

**4.4** Erection of temporary trestles to support back span.

**4.5** Casting of RCC beams and deck of back span.

**4.6** Erection of steel pylon towers with tie beams and temporary bracings using tower crane.

**4.7** Bringing Components of first deck panel for the 123m span and placing and connecting together with already cast RCC stubs (protruding from RCC Pylon Wall).

**4.8** Detailed sequence of erection of first and subsequent panels is as follows:

- The middle girder MG 2 of the panel (which has 3 stubs for cross girders welded on either side) is erected first
- Next the side girders (which have 3 stubs for cross girders welded on one side) are erected one after the other.
- Thereafter the first cross girder, the second and the third are erected in sequence, the nearest first and the farthest last.
- Temporary platforms are then erected
- Profile alignment and levels of steelwork checked
- First set of cables strung into position
- Erection of pre-cast slabs
- Pouring of cast-in-situ concrete.
- Adjustments done

**4.9** Last panel will be erected spanning between penultimate panel and common pier-1. Temporary supports will then be removed.

**4.10** Cast deck slab on top of already erected panels with shear studs for composite action. Casting will proceed from pylon towards common pier -1.

**4.11** When whole slab is cast and second stage stressing is done the net deflection will bring the deck just above desired finish level.

**4.12** After completion all the above stages, forces in stay cables will be determined and if required adjustments will be made.

**4.13** Completion of miscellaneous work, e.g. provision of crash barrier, railing, wearing course, illumination, etc.

It is important to mention here that, the design analysis here is very much inter related to the construction methodology. In Larsa 4D these construction stages are simulated so as to get more realistic analysis. As cable elements have been used which are nonlinear in nature, nonlinear analysis is carried out at each stage. The initial structure has been kept with a pre-camber such that after complete construction, the deflection brings the structure to desired finish level.

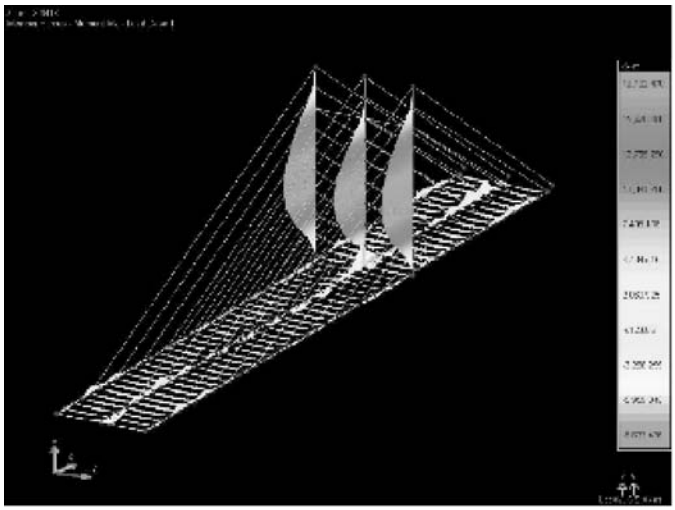


Fig.7 Bending moment diagram and axial force contour for DL + SIDL case

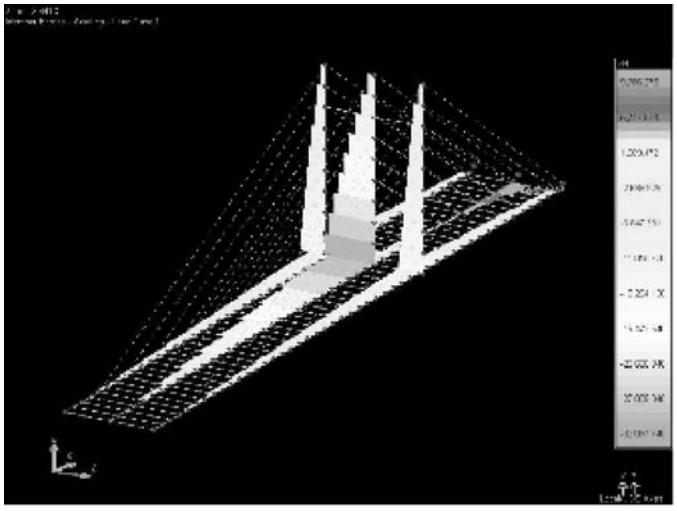


Fig.8 Member forces for DL + SIDL case

**5. Construction Quantities:**

Majour Quantities Involved in construction are as follows:

| Item | Quantity |
|---|---|
| Reinforced Cement Concrete for Piles and pile caps (M35) | 5516 CUM |
| Reinforced Cement Concrete for piers and superstructure (Complete back span and concrete portion of composite deck of main span) (M50) | 4513CUM |
| Structural Steel for built up pylon towers and steel portion of composite deck of main span (Fe540B, E410) | 1720 MT |
| Structural Steel for ancillary items (Fe410B, E250) | 280 MT |
| Stay Cables (15.7mm dia - 7wire strand) | 190 MT |

**6.0 Structural Steel Work :** Fig. 9 (Fabrication Yard)

**6.1 Fabrication Work :** The work consists of very high quality fabrication work for perfect matching of various components so that during erection, the bolts do not misfit and the abutting faces of plates match perfectly. The equipment required for fabrication were as per following list.

| Item Description | Quantity |
|---|---|
| 70 T Capacity Crawler Crane ( 670 P&H) | **01** |
| Gantry Crane, 25 T Capacity | 02 |
| Plate levelling / straightening Machine | 01 |
| End milling Machine / Profile cutting | 01 |
| Pug cutting machine set | 08 |
| Hand cutting set | 06 |
| Radial Drilling Machine. | 06 |
| Magnet base drill machine. | 10 |
| Angle Grinder | 20 |
| Bench Grinder. | 01 |
| Welding rectifier for SMAW | 06 |
| SAW Welding Machine | 04 |
| MIG/ GMAW Machine. | 06 |
| Hydraulic / Screw jack ( 50T /100T cap.) | 10 |
| Electrode heating portable Oven | 06 |
| Flux beating / mother Oven | 02 |
| Heating Torch | 10 |
| Pencil Grinder | 01 |
| Air Compressor | 02 |
| Blasting hopper with complete accessories | 02 |
| Spray pump / gun with complete accessories | 02 |



Fig. 9 Fabrication Yard




Fig.10 Radiography test



Fig. 11 SAW for Box Sections

**6.2** Following important actions were taken for ensuring highest standard of quality :

- The entire structural steel has been procured directly from only the most reputed manufacturer
- All required tests as per IS:2062 have been conducted in presence of the Engineer. 184 MT plates have been rejected and removed from site when they failed in certain tests.
- Only the welders found suitable as per welder qualification tests have been deputed at site.

- Only SAW(Submerged Arc Welding) is permitted by default. Only one other type of welding (MIG-Metal Inert Gas Welding) has been allowed where SAW is not possible.
- The welding material only from reputed manufacturer has been used and stored properly.

As the welding involved is of very complex nature involving very heavy sections and requirements of tolerances are very high, some design modifications were also required when the desired results could not be achieved with all types of trials. For example, two diaphragms were added in the box of segment of pylon towers to prevent distortion due to welding.

**6.3 Long Life Painting Scheme for Structural Steel:**

Considering the importance of the structure, the entire steel work has been cleaned with copper slag blasting and then long life paint with a life of about 15 years has been applied. The painting scheme consists of blasting & surface preparation to Sa 2½ of DIN EN ISO:12944/4 with sharp edged material roughness according to ISO:8503/1, Type G, Segment 2-3 consisting of

(i) Prime coat of 2-C Epoxy Zinc dust having film thickness of 75 µm, product Interzinc 52, colour gray

(ii) Intermediate coat of 2-C High Build MIO having film thickness of 125µm, product Intergard 475HS, colour shade according to RAL

(iii) Top coat consisting of 2-C Polysiloxan long time over coatable top coat having film thickness of 120 µm, product Interfine 878, colour shade according to RAL.

**7.0 Site Organization & Safety :**

For taking up such critical work in close vicinity of Railway track, roads and buildings, it is necessary to have a strong organization of technically qualified and experienced officials at site on behalf of the contractor as well as the Client. RVNL have deputed Well Experienced and Qualified team of Project Management Consultant having experience of construction of cable stayed bridge. The Contractor have also similarly deputed qualified and experience officials. The role of Safety officials in such work is of paramount importance. Therefore it is ensured that regular safety drills/seminars are conducted and training is imparted to all officials and workers for ensuring safety at site.



Fig.12 Safety Drill



Fig.13 RVNL and PMC officials at Site

**8.0 Casting of Bored Cast-in-situ Concrete Piles of 1500 Mm Diameter**

62 Bores of pile of 1500mm dia have been cast- 27 of shaft length 35m for PYLON and 35 of shaft length of 25 m for common piers (CP1 and CP2).

**8.1 Equipment and Materials Used for Construction**

- Survey instruments for layout setting of piles.
- Hydraulic Rotary Rig (Casagrande 250, MAIT HR180) for pile boring, reinforcement lowering and concrete pouring by tremie method
- Crane (TATA 325, 18MT) for material handling
- Boring Bucket for 1500 pile.
- Steel casing of 1500 mm inner diameter and the length of Casing as soil condition of site.
- Bentonite Tank comprising of mixing and

recycling tank, water pump, water tank, vertical pump

Diesel generator for power supply

Fabricated steel Reinforcement cage for pile

Transit Mixers (5Nos.).

Batching Plant for RMC.

250/200 mm dia tremie pipes and concreting funnel of 0.81 cum capacity.

Welding Machine for welding of cage laps.

sounding chain for checking & measuring the level of Bore hole.

Excavator / Loader for handling of muck.

Tipper for muck disposal.

Concrete where Transit Mixer access not available.

**8.2 Sequence of Pile Construction:**

**8.2.1** The position of the pile location is set out by total station as per co-ordinates provided in approved drawings and with respect to the control points. Existence of utilities is checked in advance and necessary disconnection / diversion is also made before staring of boring.

**8.2.2** Liner is driven for top 6.0m from GL or as per technical requirement to prevent loose soil falling in bore hole. First 1.25/1.5m depth of dry boring is done before driving of casing and then the fabricated casing is lowered in the borehole up to the required depth. Thereafter Kelley is used for driving the casing. Verticality of pile bore is ensured with the help of monitoring system available in the Rotary Rig.

**8.2.3** Boring operation is done by Rotary Rig with the help of Kelly and bucket. The size of the cutting tool shall not be less than the diameter of the pile minus 75mm. After completion of boring the reinforcement cage fabricated as per detailed drawing and approved bar bending schedule is lowered in position. If due to any reason start of reinforcement cage lowering is delayed beyond 2 hrs, the borehole is cleaned by rotary bucket and founding level is checked for length with sounding chain.

**8.2.4** Bore hole, after attaining the founding level is cleaned by removing all loose materials in the bore hole using the Rotary bucket.

**8.2.5** Reinforcement Cage is lowered using the Rotary rig.

**8.2.6** Immediately after lowering of the cage, tremie pipes of 250 / 200 mm diameter and of length 0.9 m to 2.0 m are joined together and lowered into the bore. Then the borehole is flushed with bentonite slurry of specified consistency. During flushing by pump contaminated bentonite is collected in the tank through a flexible hose connected to the tremie outlet & fresh bentonite is fed to maintain the bentonite at required level of density. Flushing shall be carried out until the density of the return mud is less than 1.20 gm/cc. Bentonite is tested as per IS 2720– Part V: 1985. Fresh Bentonite slurry shall satisfy the following properties at all times:

Mud density shall not exceed 1.05 g/cc.

pH value : 9 to 11.5.

Marsh Cone viscosity : 30-40 seconds.

The sand content of Size exceeding 0.075mm shall not be more than 1 percent.

Liquid limit of bentonite shall not be less than 400 percent.

Bentonite shall be saturated for minimum 24 hours before use.

**8.2.7** Concrete funnel of 0.81 cum capacity is fitted on the top of the tremie with lid closed. The concrete with minimum slump of 150 to 180mm is poured in to funnel from chute of Transit Mixer and the lid is removed and concrete is allowed to flow into the tremie and to reach the bottom of the pile. A min 500 mm of built up is formed in the first pour. After 4 to 6 M of built up is confirmed, the tremie is lifted by 2 M & one top piece of tremie is withdrawn out of concrete to remove choking of the tremie. The tremie is reintroduced on the old concrete with little penetration. A vermiculate ball plug is introduced in the tremie, fresh concrete of slump between 150mm to 180 mm is filled in the tremie which will go on pushing the plug forward and emerge out of the tremie. After this the tremie is pushed further in steps making fresh concrete displace the lean concrete. When tremie is buried about 0.60m to 1.0 m, concreting is resumed / continued. The concrete built up of 1.0 m above the cut off level is confirmed by sounding chain. The entire concrete built – up shall be recorded in the approved tremie chart format. Slump is measured at every trip of concrete and if due to any reason the concrete is held up for more than 35 minutes again slump shall be taken and if slump is

less than 140mm, re-dosing of admixture shall be done as per site requirement with the approval of the Engineer and then mixed for 1.5 – 2.0 minutes vigorously to get required slump of 150 – 180mm. Cubes are taken for laboratory tests from the poured concrete or from Transit Mixer.

**8.2.8** The concrete poured in to the pile is allowed to have initial setting time before moving the rig on the subsequent pile location. Generally, pile boring shall be done in a staggered manner so as to avoid sequential construction of adjacent piles. The temporary liners for such large diameter piles are likely to get stuck with the pile concrete and normal size cranes may not be able to withdraw these if these are not removed well in time when concrete has not fully set.



Fig. 14 Pile foundation construction with rotary rig



Fig.15 Pile heads finished for pile cap castin

**8.2.9** Complete piles shall be trimmed to COL as per drawing or until sound concrete is obtained, either by manual means or pneumatic breakers. Manual chipping shall not be commenced before 3 days from date of pile casting. In case of pneumatic chipping of concrete by breakers, the same shall not be started earlier than 7 days from pile casting.

**9.0 Construction of Pile Caps**

There are 3 number of Pile caps namely CP-1, Pylon and CP-2. All are rectangular in shape and Plan dimension are 28.9mX6.7m for CP-1, 37.9mX10.9m for Pylon and 28.9mX10.9m for CP-2 and depth of each one is 2.5m. The activity for construction work was started only after successful completion of testing of all piles and acceptance of the same as satisfactory.

**9.1 Equipments Details**

- Batching Plant model CP-30 – 1 No.
- Batching plant model CP-18 - 1 No.
- Concrete Pump – 2 Nos.
- Transit Mixer – 7 Nos.
- Back hoe Loader – 2 Nos.
- Hydra-12 – 1 No.
- Trailer – 1 No.
- Concrete Vibrator – 9 Nos.
- Shutter Vibrators – 14 Nos.

**9.2.** Preparation of Ground is undertaken for fixing the shuttering and its support arrangement as per approved drawing. 100mm thick PCC layer is laid after dressing the bored pile to required level.

**9.3.** Fabrication of shutter and its support arrangement as per approved drawing and specifications. Shuttering is particularly designed to take load of huge amount of concrete.

**9.4.** The bars will be cut and bent to lengths so that they can conform to as continuous bars by providing laps as specified in the drawing. Considering the height of vertical rods for tall and long piers, these are needed to be fixed along with pile cap. These rods will be braced and anchored properly for their stability.

**9.5.** Shutters are be fixed and made rigid as per approved drawing. Shuttering oil is applied as per requirement on the inner surface of the shutter plates before fixing, and the joints between shutter plates are filled with foam in the endeavor to make them leak proof.

**9.6** The steps involved in concreting of the Pile Cap are as following:-

**9.6.1** Stock of raw materials is checked with respect to total volume of concrete and the requirement of corresponding materials.

**9.6.2** Concrete of M35 grade is produced in the batching plant as per approved design mix.

**9.6.3** Concrete is transported to the location using transit mixers and is fed to the concrete pump. Concrete is pumped inside the shutter of the pile cap in layers of 300 mm. Considering 35 cum of concrete being produced at the batching plants and the plan dimension of the pile cap being 28.9 m x 10.9m (315.01 sqm), the volume of concrete in one layer will be 315.01x 0.3 or 94.503 cum. As per the mix design with Ambuja-43 grade cement and Fosroc Auramix-400 admixture(1%), it has been found that the initial setting time of 3 hour and 42 minutes is achieved, hence the first layer does not set before second is placed. During poring of concrete, it is vibrated by use of electrical/diesel needle vibrator as per the standard practice.

**9.6.4** After initial setting of the concrete the same is covered with hessian cloth / plastic sheet to minimize shrinkage cracks.

**9.6.5** Construction key joints are left/surface roughened at the part on which pier shaft would come up.

**9.7** De-shuttering is taken up after 24 hours of completion of the concrete work, from the centre of the pile cap proceeding in both directions. After completion of the De-shuttering operation, backfilling of the excavated area is taken up.

**9.8** The top of the pile cap is "ponded" with water to ensure proper curing at all times. For vertical face of pile cap, after completion of backfill, the entire area is kept sufficiently moist, so that proper curing of the vertical faces can be ensured.

**10.0 Construction of Pier**

**10.1** There are 3 numbers of Piers of M50 Grade Concrete namely CP-1, Pylon and CP-2. All are rectangular in shape and dimensions are 27.7mX4.0m, 7M high for CP-1, 28.2mX2.5m, 7.41M high for Pylon and 28.2mX2.0m, 6.805M high for CP-2.



Fig.16 RCC portion of pylon under construction



Fig.17 Common Pier-1

**10.2** The construction equipments required are nearly same as for the pile cap. However, quantity required is on lower side.

**10.3** Casting of Pier involves the fallowing sequence:

- Erection of staging for supports.
- Fixing and binding of reinforcement steel.
- Fixing and binding of reinforcement dowels bar for pedestal – (CP1).
- Fixing of side shuttering upto 2.5 mtr. Height.
- Placing of concrete pump and concrete pipe line.
- Pouring of concrete.

**10.4** Construction method for pier is similar to that of Pile cap except for the following important items-

- 100 mm thick layer of M-50 grade concrete shall be done to fix the shutter alignment.
- Erection of Portal Frame - The portal frame and channel will be erected as per drawing. This is absolutely necessary for ensuring safety of workers and the reinforcement cage fixing.

- Because of large weight involved, the entire pier cannot be cast in one go as the huge lateral pressure would affect the shuttering and also put excessive weight on lower layer of concrete which has not yet attained full strength. Hence, the piers have been cast in three lifts of nearly 2.5M.

**11.0 Construction of Back Span:**

Back span is of RCC of M50 Grade involving 2045 CUM volume. This required a very sturdy staging arrangement which would have to support the back span till all the Stay cables are fixed and stressed. The staging arrangement has been provided in such a way that enough space is left for stressing of cables from the bottom of the Beams and it been supported on concrete foundation whose Soil Bearing Capacity has been verified to be suitable to bear the load of about 800MT of staging apart from the weight of back span and the construction equipment to ply over and the construction material to be placed over the back span during erection of main span. is to be provided. The huge amount of concrete in the back span was cast in two parts (40% and 60%) with a designed construction joint. The casting was done with three concrete pumps working simultaneously and concrete was fed from two batching plants of capacities 30cum/hr and 18cum/hr. To check the rise of temperature after pouring, the water of the batching plant was cooled with ice.



Fig.18 Back span supported on massive staging



Fig.19 Back span casting in progress

**12.0 Pylon Erection :**

**12.1** Pylons towers are erected in segments (10 segments of each tower) using self climbing tower crane which is erected in its position on well designed foundation taking into account the loads to be lifted and the radius at which the loads are lifted. Preferably the manufacturer's representative should oversee this operation and certify that it has been properly done. The crane was be tested by lifting 40 tonnes load at a radius of 18 m .

**12.2** Each section of each Pylon has an erection mark and the splice plates for each joint are checked with respect to the erection mark of the particular joint for which they are to be used. The HSFG bolt sizes and quantity for each joint are checked and bagged along with their washers. An unloading area about 8m x 5m is prepared where the pylon sections are unloaded from trailers and lifted for erection. It is located at the proper distance from the crane so that specified radius for the maximum lift is not exceeded. The ground is excavated to a depth of 500 mm, properly compacted as much as possible and a hard bed for the handling of the pylon sections prepared.

**12.3** Base Pylon sections are placed very carefully and threaded through the anchor bolts. Great care should be taken to see that the anchor bolts are not damaged or hit during this operation. Screed bars are used to hold the bottom section in its proper level. The location

of the section is properly checked on the XX and YY axes and for being in proper level. After thorough checks, the anchor bolts are tightened in the proper order, alternating between the opposite sides, so that the base is uniformly tightened. Grouting of pylon bases is done giving due consideration to the slope of the base to be maintained (In this case there was a level difference of about 2.5mm in the edges of the base plate). On the first base section, the splice plates for the joint are loosely fixed to enable the next pylon section to be easily placed on top. Ladders properly fixed to scaffolding are erected progressively around each pylon section together with platforms at suitable levels to enable the joints between pylon sections to be made properly and when completed, to be checked by supervisory staff.

**12.4 Erection of second and subsequent sections of the Pylon Towers :** The Pylon section is held in proper position by the tower crane and workmen fix a few black bolts on all four sides and tighten the joint to enable the joints to be drifted. Then gradually drifts are driven in the joint suitably dispersed, till at least 50% of the holes are filled with drifts. It is important to hold the second Pylon section aloft by the crane till the two sections are adequately held together by drifts and a few black bolts. This ensures that the second section is held at the specified distance of 1 mm from the first section as per design requirement. The rest of the holes are gradually filled with HSFG bolts which are tightened to the required torque as observed from the load indicating washers. The drifts and the black bolts are then replaced one by one by HSFG bolts till the joint is completed in all respects. The slings are slowly released and freed from the Pylon section. Inspection and survey of the pylon is carried out for each segment during / after the erection to ensure proper alignment vis-à-vis design theoretical coordinates. Also the tower crane is monitored for any abnormal sways. In the similar manner all other sections are erected. When the ties are placed in position using the tower crane, there may be requirement of slight adjustment of tower sections to enable the ties to fit in.



Fig . 20 Erection of Initial panels of tower crane



Fig.21 Self Erection by Tower Crane



Fig.22 Erection of Pylon Segments alongwith temporary staircases and platforms



Fig. 23 After Completion of Pylon Erection

**13.0 Construction of Main Span :**

**13.1** Following equipments are involved in erection of the main span of the ROB.

- Custom designed and built deck erection.
- Mobile crane for feeding of materials capacity to handle weight of middle longitudinal girder with welded cross-girder stubs on both sides and stay cable fixtures, at the required radius
- Trailers and prime mover to carry material to the bridge head. The unit would be capable of turning in a short radius to accommodate constraints at site.
- Slings and pull-lift to hold longitudinal steel box girders temporarily, prior to fixing of stay cables, if necessary.
- Joint bolts (HSFG) checked for size and quality and sorted and kept ready size-wise for use in the joints
- Small tools and tackles, slings, etc.

**13.2 Deck Erection Crane :** The deck erection crane (hereafter abbreviated as DEC) basically consists of 16 m x 33 m rectangular steel frame, members being triangular in section. The frame is mounted on four tower legs with rollers to facilitate movement longitudinally along the bridge, on rails fixed to the deck. There are also rails on top of the longitudinal members of the above rectangular frame. A cross frame approximately 30 m x 3.3 m (of a double triangular braced section) moves on the rails fixed to the top longitudinal member of the rectangular frame. The cross frame is capable of movement along the bridge. The cross frame in turn has rails fixed on its top. Two hoists move on the rails fixed on top of the cross frame. These hoists lift the loads and carry it to their final location. The hoists move in a lateral direction with respect to the bridge. Thus the hoists in DEC can be moved longitudinally as well as transversely to hover over any point in the area covered by the DEC.



Fig. 24 Deck Erection Crane under testing



Fig.25 Erection of Deck Using DEC

**13.3** First panel of deck is erected by Mobile crane on ground with material fed by trailers. After steelwork is completed, the first set of stay cables are fixed to the first panel in the rear and first panel in the front and primary stressing is done. The precast concrete panels are placed in position. The first span deck is then concreted. Three sets of railway tracks are fixed on the deck of back span and the first panel of the main (forward) span. These three tracks would serve to transport steelwork. Two shorter tracks of about 40 m length are laid for the movement of the Deck Erection crane. These tracks would

progressively be removed from the rear and re-erected forward. The Deck Erection crane is erected over the deck by mobile crane. Steelwork in deck for rest of the panel is now erected by custom-built deck erection crane panel by panel. The cables for the panel are then fixed in position and tensioned to the required extent. After each panel is completed, the pre-cast portion of the deck is erected followed by the cast-in-situ portion of the concrete. The deck erection crane is moved forward and the process repeated till deck and cabling are complete. After final adjustment of cables, the deck supports of rear span are carefully removed, and balance works are completed. Power blocks of the overhead traction system must be arranged for all lifts and all activities that have to be performed near the high voltage conductors. The last panel is erected with road crane after placing the bearings over the common pier.

**13.4 Precast Slabs and Trial Assembly :** In order to avoid use of removable / permanent shuttering, deck slab is cast in two parts-precast slab segments which are cast in casting yard and the cast in situ concrete which is poured when the slabs are erected over the cross-girders. The dowels are left in place in precast slabs for monolithic behavior with cast-in-situ concrete. The precast segments have been cast using vitrified slabs for perfect finish and profile. These are also checked in trial assembly alongwith longitudinal and cross girders in the fabrication yard.



Fig.26 Trial Assembly



Fig.27 Bottom Surface of Slabs

**13.5 Erection of Temporary Platform and Safety Nets :** Temporary platform for workers and for inspection is erected at the front and on the sides of steelwork erected for safety For fixing of HSFG bolts of the girders and cross-girders, foldable portable light-weight platform is used. This arrangement saves a lot of precious time for traffic and power block. Safety nets should also be fixed to prevent any accidental fall on track or platform.

**13.6 Erection of Cables :** The First set of three cables strung into position. Temporary sling support is removed. Specified and necessary tension imparted to cables checking profile simultaneously and necessary adjustments made. The stay cables are transported to site from workshop as a completely assembled unit coiled on a reel ready for installation. On reaching the site the reel is to be lifted on the deck and the cable is to be uncoiled by using a motorized un-coiler. The sequence of erection is as described below -

**Step1 :** Lift one end of cable to pylon anchorage location.

**Step2 :** Guide anchor socket into the anchorages by means of special guiding device at pylon and bridge deck.

**Step3 :** After the top anchorage is in position, bottom socket is pulled back to the anchorage point at bridge deck.

**Step4 :** Stress the cable at pylon level by attaching the stressing assembly and pull rod. Temporary access platform will be required at pylon throughout the construction period as stressing will be done in several steps.

Similarly the next set of cables are erected. Geometry control is carried out throughout the erection process and the cables already erected are re-stressed as and when required and the forces in the cables to be erected are determined accordingly.

**14. 0 Wind Tunnel Study**

For a large bridge project, wind tunnel study is an important technical requirement to rule out any design flaw vis-s-vis storm in the terrain. Based on the preliminary Aerodynamic Studies by CRRI, the bridge had been found not susceptible to classical flutter and galloping. For conditions of Buffeting, Vortex Induced Oscillations, there was Limited Amplitude Oscillation. The Amplitude of vortex induced oscillation was very low and not likely to cause discomfort to users. Using Frequency Domain Approach, peak buffeting response was estimated as 0.160m for assumed aerodynamic force coefficients of terrain roughness (plain terrain, surface roughness parameter =0.005m). Model was designed and prepared having following sectional details :

- Model Scale : 1: 40 and blockage is about 5.9%
- Length of model: 1440mm
- Width of model : 692.5mm
- Aspect Ratio (length to width ratio): 2.08

On the physical model, wind tunnel test was conducted on 27th May,2014 and the design was found to be safe.

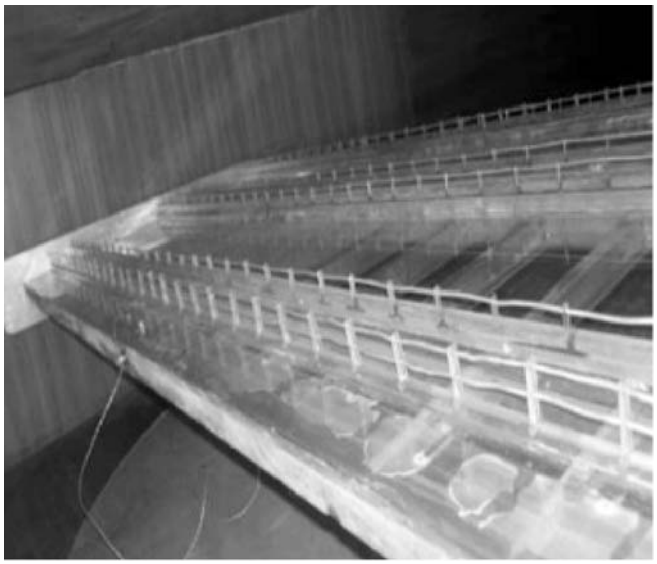


Fig.28 Model of the Bridge Deck



Fig.29 Wind Tunnel in progress at CSIR, Ghaziabad

**15.0 Constraints**

The project is confronting several constraints-technical as well as physical. The most important is the execution of work over electrified track with 25KV traction and railway platforms over a very busy Railway yard. The work has to be executed with highest standards of safety and accuracy. The launching scheme has been accordingly prepared. There are several other constraints like infringement of Railway offices and quarters, Railway over head equipment masts. The offices and quarters have been relocated for construction of ROB proper and OHE masts have been relocated as per drawing of remodeling of OHE approved by Railway.

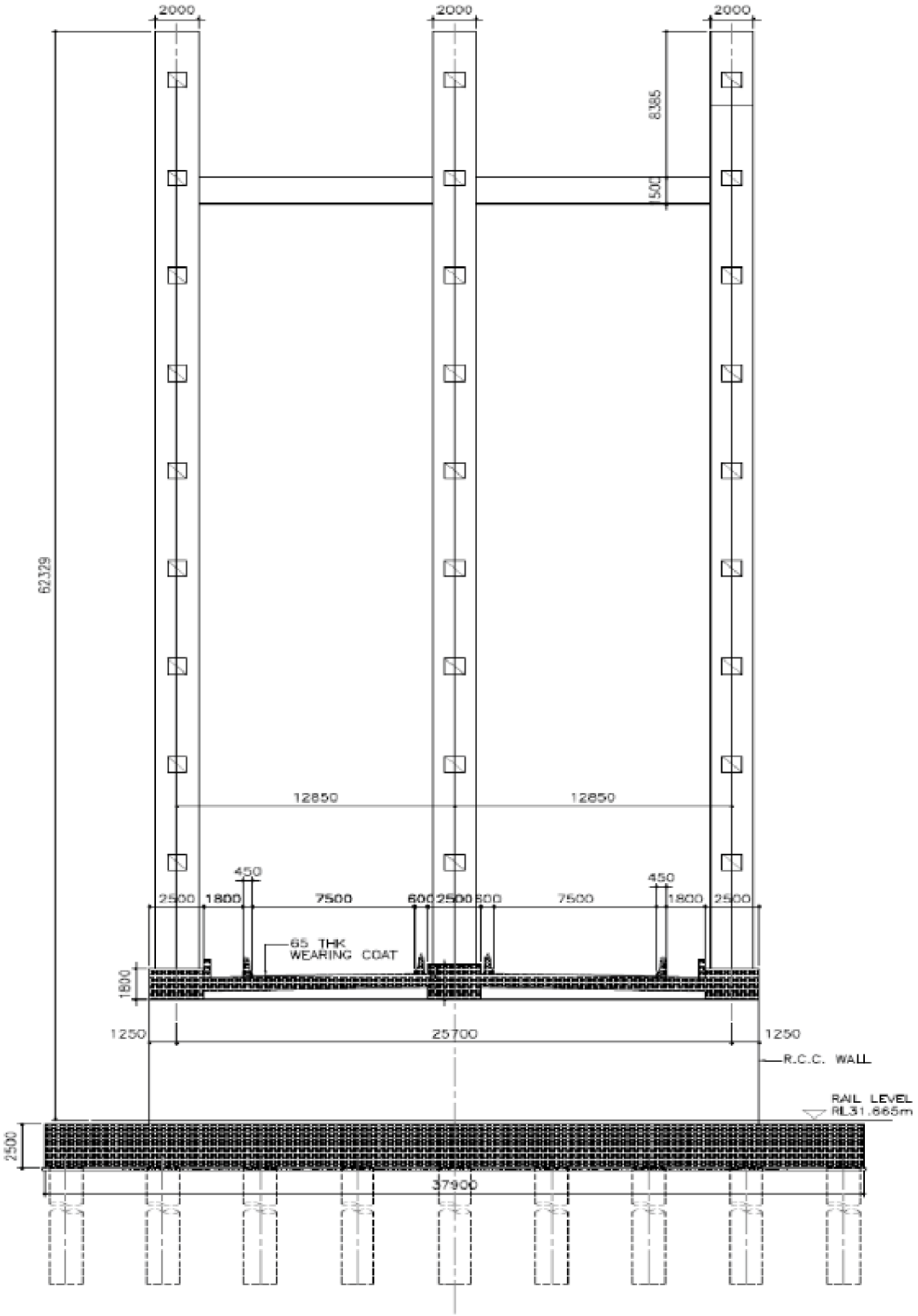
**16.0 Status of Progress:**

The ROB proper is in advanced stage of construction, only the construction of main span is left to be completed. 2 out of 10 panels have already been erected. The work of construction of approaches has been assigned to RVNL in Mar, 2015 by Public Works Directorate, Govt of West Bengal and accordingly RVNL has taken up the work. The geotechnical investigation and survey have been completed and detailed drawings are under finalization. The work involves relocation of 200 quarters which has already been taken up at site, apart from many service buildings for which drawings have been prepared.

**17.0 Conclusion**

Detailed The design and construction of cable stayed composite deck ROB across the busy railway station is a very challenging work involving very high level of accuracy and very close coordination of design and construction activities. The requirement of safety is of the highest order as work because of bridge located over electrified railway tracks of and platforms. The combination of massive concrete structures of high

grade concrete with high tensile steel has resulted in this unique structure one of its kind ROB in the world with RCC back span, composite main span, three planes of stay cables, Part RCC and Part steel Pylon. The uniquemess of the project has led to unique solutions such as ustom made Deck Erection Crane, specially designed interconnected temporary staircases with platforms for pylon erection and stay cable erection.




CROSS SECTION NEAR PYLON

# A Simple Method to Find out the Impact (Vertical Accelerations) on Rail Table from Wheel Loads (Using the Shape of Contact Stress)

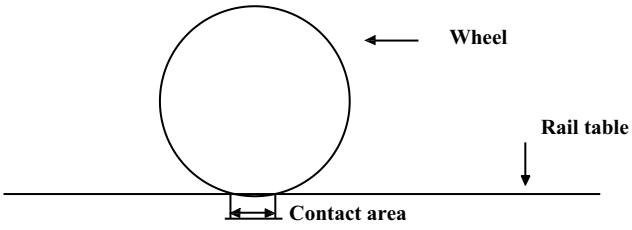
By
*Shri S.H. Babu**

**Synopsis:**
*In accordance with Hertzian contact stress calculation, area of contact pressure can be arrived at and the dimension of contact ellipse can be worked out with a reasonable precision. From the geometry of wheel and rail contact, impact of wheel load on rail can be found out, depending on speed.*

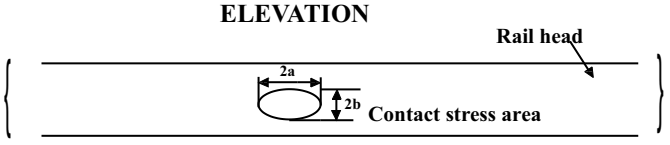
**1.0** The size of contact area between rail and wheel depends on the following parameters, broadly:

1. Hardness of Rail.
2. Hardness of wheel
3. Radius of wheel
4. Radius of rail table
5. Wheel load
6. Modulus of elasticity of wheel and rail steel.

**2.0** If a wheel load P is placed on the rail surface, an approximately elliptical shaped contact area is produced between wheel and rail, the dimensions of which depends on the wheel radius R, the radius of curvature 'r' of the rail head and the elasticity factors of the tyre and rail steels.




ELEVATION




PLAN

**3.0** According to Hertz, the following maximum compressive stress results at the contact area in the generally used types of steel:

$$\sigma = \frac{187}{n}\sqrt[3]{\left(\frac{1}{R}+\frac{1}{r}\right)^2}\cdot p$$

Where $\sigma$ is in KP/CM$^2$, R and r are in metres, P in KP, n is a complex function of R and r.

In practice n= 1.0495 is sufficiently accurate with a maximum deviation of upto $\pm$ 3.3%

$$\sigma = (178).\sqrt[3]{\left(\frac{1}{R}+\frac{1}{r}\right)^2}\,P$$

The stress follows an approximately parabolic line in the pressure area.

Therefore the size of the pressure area is approximately

$$F = \frac{2.P}{\sigma}$$

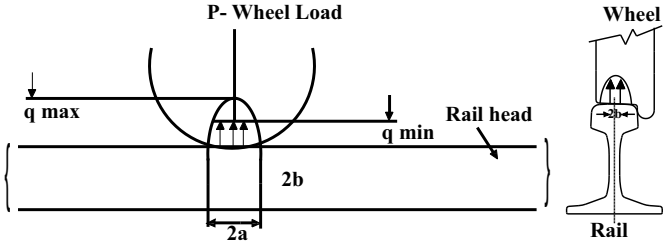
*F* in cm$^2$, P in KP, $\sigma$ in KP/CM2

For a normal track, if R = 0.5 M and r = 0.3m and P = 10,500 KP (for 52kg/m rail)

$$\sigma = (178)\sqrt[3]{\left[\left(\frac{1}{0.5}\right)+\left(\frac{1}{0.3}\right)\right]^2}\times 10500$$

Contact stress area –

$$F = \frac{2.P}{\sigma} = 1.78\ \text{cm}^2$$




* General Manager (Retd.), S.Rly.

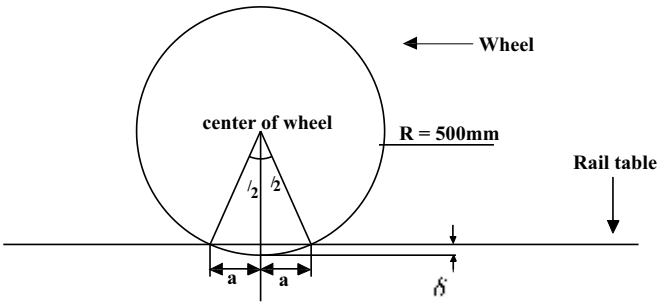
2a. 2b dimensions of the 2 axes of ellipse (contact stress area).

**4.0** Generally, b=6mm (approx.) i.e. half small axis of ellipse:

ab = area of contact stress = 178mm$^2$

a = 9.45mm (half longitudinal axis of ellipse)

When a wheel moves on rail table, vertical accelerations at the contact point can be found knowing the diameter of wheel and dimensions of contact area.




$\delta$ = depth of depression at the contact point on rail table.

a = 9.45mm

Assuming approximately the contact area, as a segment of a circle, along the rail table.

(a) (a) = $\delta$ ( 2x500 - $\delta$ ) = 1000 $\delta$ ignoring $\delta^2$ being of small magnitude.

$$\delta = \frac{axa}{2x\,500} = \frac{9.45x9.45}{1000} = 0.0893mm$$

Angle /2 can be found from the property

$$\frac{a}{\pi r} = \frac{\theta}{2}\,\frac{1}{180}$$ Where r = radius of wheel

/2 = (a) 180/ r = $\frac{(9.45)180}{3.14x500}$

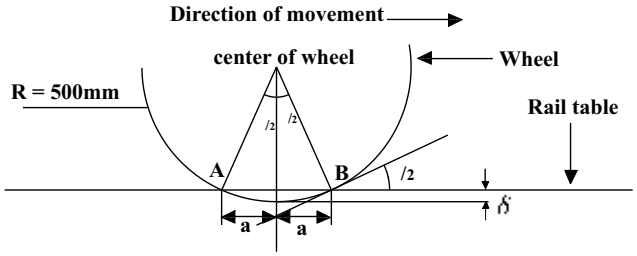
= 1.09$^o$

/2 in radians = $\pi\left(\frac{\theta}{2}\right)\left(\frac{1}{180}\right)$

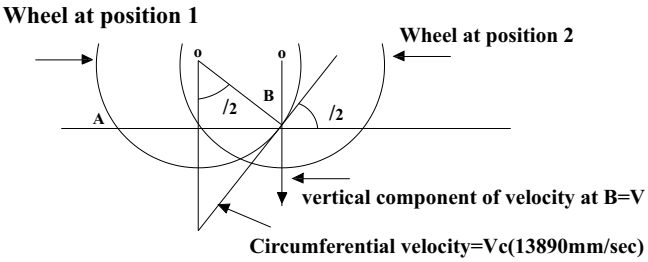
= $\frac{1}{52.6}$ radians ( Since 180 = *radians* )

Impact of wheel load depends on speed, besides the size and shape of contact area between wheel and rail.

For a speed of 50 kmph (13.89 metres/second) or (13890 mm/sec)




**5.0** Time taken for BO(radius), to become vertical, as the wheel moves through an angle of /2 at centre, initially the circumferential velocity of wheel, along the tangent at B, can be resolved, when wheel is in position BO, at an angle of /2 to vertical



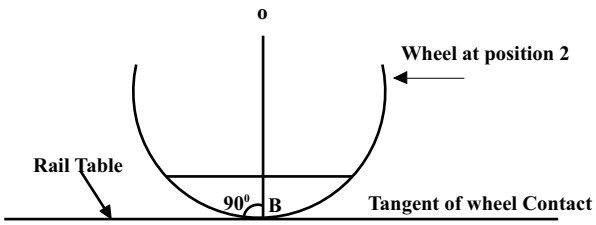

$V = V_c \sin /2$

= (13890) /2 in radians (since Sin /2 = /2 in radians, for small values of /2)

=13890/52.6

= 264.1 mm/sec

**6.0** As wheel moves to position 2, when BO$^1$ is perpendicular at the centre of contact stress area,




Vertical component of circumferential velocity Vc=0

From the basic laws of mechanics

v = u + (acceleration)t

V = final velocity

U = initial velocity

T = time in sec.

U = initial vertical component of velocity, in position 1, when BO makes an angle of /2 to vertical from centre of wheel.

V = final velocity when BO is vertical, after moving a distance of a along the rail = 0 (vertical component in position 2).

Time taken to move distance á'= t sec

A = 9.45 mm

t in sec = $\frac{9.45}{13890} = \frac{1}{1469.85}\,sec.$

Change in vertical velocity in time 't'(acceleration) = v/t

= - 264.1 x 1469.85 mm/sec2 (V=0, U = 264.1 mm/sec, V = +(acceleration) t)

In terms of gravity (9.81 m/sec$^2$) or 9810 mm/sec$^2$.

Acceleration of impact of wheel on rail= in terms of acceleration due to gravity 'g'

$$\frac{264.1x1469.85}{9810} = -\,39.57g = \approx 40\,g.$$

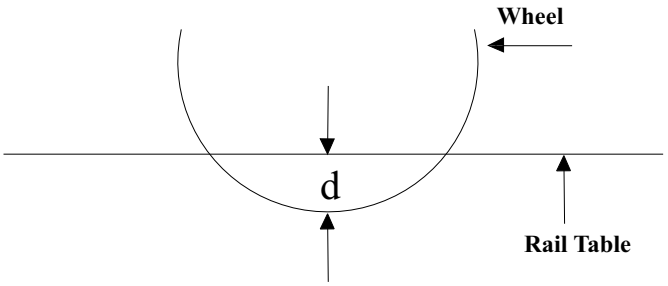
**7.0 Summary**

From the above mentioned approach, the vertical acceleration on rail are dependent on the value of á'- semi axis of contact ellipse (longitudinal) on rail table.

The parameters involved are (i) the vertical component of tangential velocity of wheel, which is decided by speed of wheel movement along the rail and (ii) the value of /2, angle subtended by the semi axis á', of contact ellipse on rail, at the centre of the wheel and (iii) the time taken 't' for the leading edge of contact ellipse point to reach the vertical line from centre of wheel, as wheel moves.

Vertical acceleration can be calculated, knowing the value of depression of contact ellipse – , on rail table, by another approach of Newton's law of motion.

= 0.0893 mm *(refer para 4)*




**8.0** $V^2-U^2 = 2$ as S= Vertical height =

U = initial vertical velocity = 264.1 mm/sec.

V = final vertical velocity = 0

t sec (time taken) = $\frac{1}{1469.85}$ sec.

a = acceleration ( on rail from wheel ) = $u^2/2$

$$= \frac{264.1 \times 264.1}{2 \times 0.0893} = 390530.8 \text{ mm/sec}^2$$

$=390.5308$ meters/ $sec^2$

= 39.81g [ in terms of gravitational constant g ]

(about 40g) gravity constant g = 9.81 meters/ $sec^2$

Same as the value, at para 7 above

**9.0** Since the assessment of vertical acceleration value on rail from wheel, depends primarily on the value of á'- semi longitudinal axis of contact ellipse, on rail table, values of a and b (semi axes of contact sllipse, have been worked out from: Theory of Elasticity by S. Timoshenko and J.N. Goodier-MCGRAW-HILL eldition) as an alternative approach.

For details, refer para 141 – page 414 of the above reference.

$$A + B = \frac{1}{2}\left[\frac{1}{R1} + \frac{1}{R2}\right] = \frac{1}{15}$$

$$B - A = \frac{1}{2}\left[\frac{1}{R1} - \frac{1}{R2}\right] = \frac{1}{60}$$

[Since cos 2 = 180 *deg* and where R1 = radius at rail table (12") and R2 = radius of wheel (20")]

$$\text{Cos } \theta = \frac{B-A}{B+A} = \frac{1}{4}$$

= approximately 75°

Values of m and n can be found from value of ,

M = 1.202 and n = 0.846 (refer table at p416 of above reference)

$$K_1 = \frac{1-p2}{\pi E1} \quad ; \quad K_2 = \frac{1-p2}{\pi E2}$$

Where p = poisson's ratio (0.25 for steel) and $E_1$ & $E_2$ are modulus of elasticity of rail and wheel steel.

If $E_1 = E_2$, $K_1 = K_2$

$K_1 = (1-(0.23))/(\pi(30 \times 10^6)$ for E = 30 x $10^6$ lbs/square inch

$= (0.09952)\ 10^{-7}$

$= K_2$

From the above, for a wheel load of P=22000 lbs, value of a semi longitudinal axis of contact ellipse, from theory of elasticity can be found.

$$a = m \times \sqrt[3]{\frac{3\pi}{4}\frac{P(K1+K2)}{A+B}}$$

= 1.202 x 0.247 inches

= 7.602 mm

b ( semi axis of contact ellipse )

$$= n \times \sqrt[3]{\frac{3\pi}{4}\frac{P(K1+K2)}{A+B}}$$

= 0.846 x 0.247 inches

= 5.35 mm.

**10.0 Conclusion :**

i) Generally the orders of magnitude, are nearly in agreement, for the values of semi axes a and b, determined from (i) the Hertzian theory of contact stress and (ii) theory of elasticity.

ii) Thus a reasonable assessment of vertical accelerations on rail from wheel loads, can be worked out from the shape of contact stress, wheel load and speed.

**11.0 Acknoweldgements:**

1. Permanent way technique and permanent way economy – page 40 by Gerhard Schramm)
2. Theory of Elasticity by S.P. Timosenko, & J.N.Godlier.

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# डीज़ल इंजन का रखरखाव

द्वारा
रियाज अहमद सय्यद*

**उद्देश्य –** डीज़ल लोकोमोटिव की कार्यप्रणाली एवं रखरखाव से अन्य विभागों का परिचय कराना

**प्रस्तावना –** सामान्यता मेंटेनेंस यानि रखरखाव करना क्लिष्ट एवं कभी समाप्त न होनेवाला कार्य है । किसी वस्तु या इंफ्रास्ट्रक्चर को एक बार बनाना या खड़ा करना उतना कठिन नही होता जितना कठिन उसका मेंटेनेंस यानि रखरखाव करना होता है । इसके प्राय: तीन कारण होते हैं ।

**1.0** वस्तु का प्रयोग करें या ना करें उसे समय समय पर धूल, नमी, गंदगी तथा जंग से होनेवाली खराबी से बचाना और खराबी आ जाये तो सुधार करना आवश्यक होता है, चलाकर देखना तथा निर्धारित परफॉर्मेंस प्राप्ति का सुनिश्चित करना आवश्यक होता है.

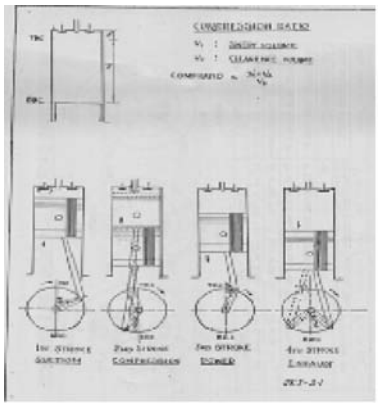
**2.0** जैसे जैसे समय व्यतीत होता है, उपभोक्ता की अपेक्षाएं बढ़ती जाती है जिसके कारण अपेक्षा और परफॉर्मेंस का अंतर कम नही होता,

**3.0** सामग्री जैसे जैसे पुरानी होती जाती है, उसके परफॉर्मेंस में कमी आती रहती है. अत: रखरखाव करनेवाला क्वचित ही उपभोक्ता को संतुष्ट कर पाता है. मेंटेनेंस यानि रखरखाव की यह सामान्य समस्या है. हर व्यक्ति जो किसी भी प्रकार का मेंटेनेंस कर रहा हो यह अवश्य अनुभव करता है. किंतु समस्या का अनुपात तब बढता है जब यह सामग्री स्थायी की अपेक्षा चलती रहती है और अधिक तब बढ़ता है जब यह स्वत: चलने के साथ अन्य सामग्री को चलाती है.

**डीज़ल लोको स्वत: चलने के साथ अन्य स्टॉक को चलाते है उनकी कार्य प्रणाली संक्षिप्त में इस प्रकार है:–**

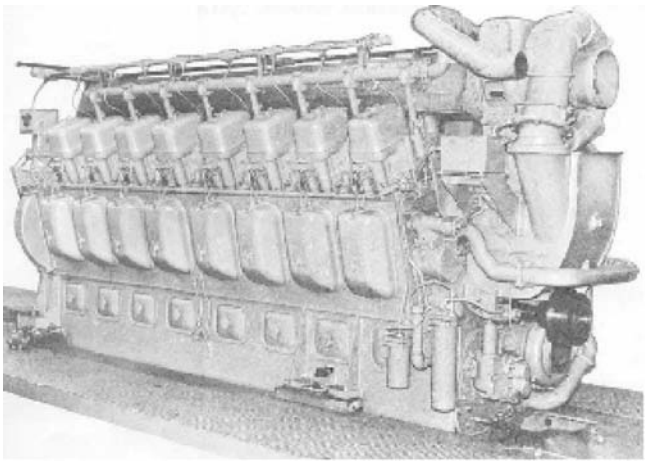
**डीज़ल लोकोमोटीव की कार्य प्रणाली:–**

लोको की क्षमता एवं अपेक्षित ट्रिप कार्य काल के मुताबिक लोको में डीज़ल टंकी की क्षमता होती है. यह डीज़ल इंधन लोको इंजन की प्रणाली के मुताबिक 2 स्ट्रोक/4 स्ट्रोक साइकल के तहत फायरिंग ऑर्डर के सिक्वेंस से विभिन्न सिलिंडरों में इंजेक्ट किया



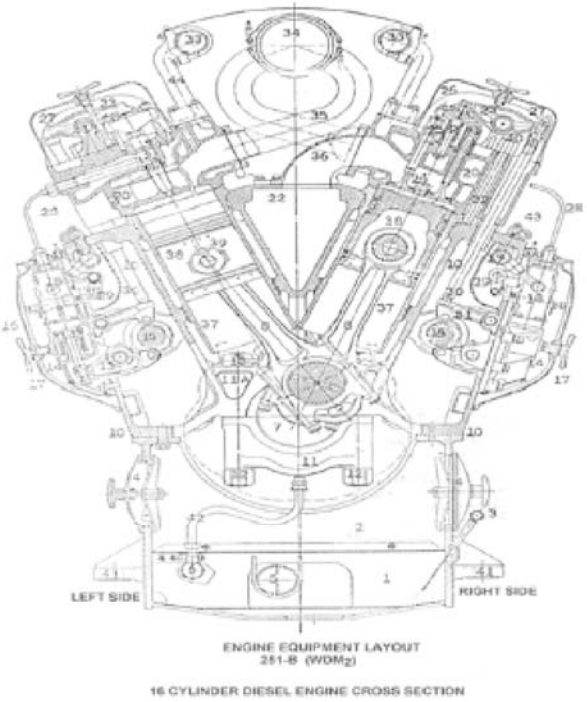
जाता है. इंधन जलने के लिये जो हवा आवश्यक होती है उसे पहले सिलिंडर में लेकर 12 से लेकर 16 गुना कम्प्रेस किया जाता है जिससे उस हवा का तापमान 100$^{0}$C से अधिक बढ़ जाता है. इस तापमान पर जैसे ही इंधन इंजेक्ट किया जाता है, वह जलना प्रारम्भ करता है, इस समय कम्बस्शन चेम्बर में 500 से 550$^{0}$c तापमान एवं उच्चतम फायरिंग प्रेशर 1950 पौंड/स्के. इंच तक जाता है. एक मिनट में हर सिलिंडर में फुल स्पीड में 525 बार फायरिंग होती है. इस केमिकल उर्जा को यांत्रिक उर्जा में कन्वर्ट किया जाता है जिससे इंजन क्रंकशॉफ्ट घूमता है और इंजन क्रंकशॉफ्ट पर फिट किए इलेक्ट्रिसिटी जनरेटर/आल्टरनेटर द्वारा इलेक्ट्रिसिटी बनायी जाती है. इस इलेक्ट्रिसिटी को कंट्रोल सिस्टम के माध्यम से आवश्यक मात्रा लोकोमोटिव के ट्रैक्शन मोटर को देकर लोको चलाया जाता है.

* वरि. अनुदेशक/मेकॅनिकल ॥/इरिसेन

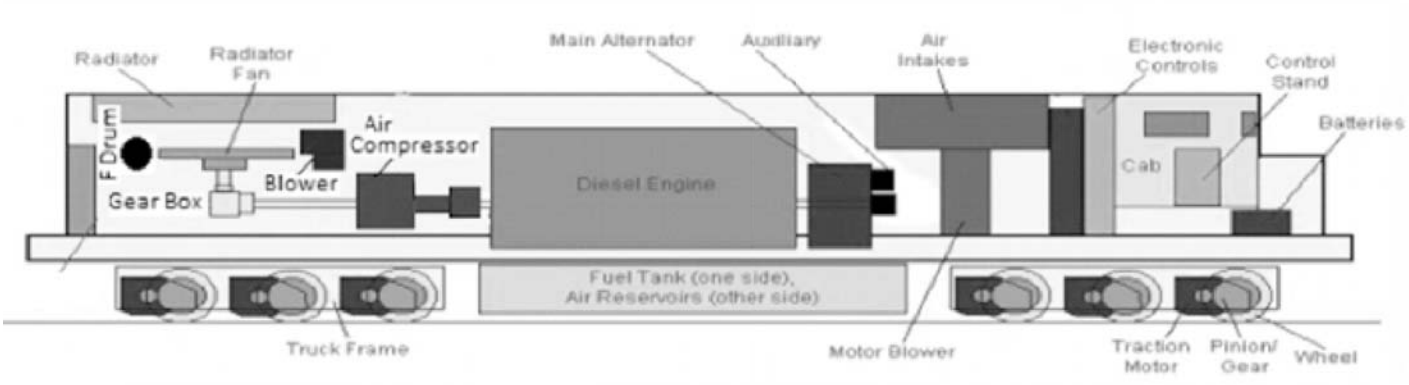


**पावर पैक अर्थात पूर्ण इंजन का चित्र**

16 सिलिंडर के इंजन में कई फंक्शनल पुर्जे जैसे कि सिलिंडर लाइनर, पिस्टन एवं रिंग्स, सिलिंडर हेड इंजेक्टर स्लीव, इनलेट व एक्झॉस्ट वाल्स इ. के साथ, कनेक्टिंग रॉड दोनो छोर के बेअरिंग के साथ, वाल्व लीवर मेकेनिज्म, क्रंकशॉफ्ट व केमशॉफ्ट उनके बेअरींग के साथ, फ्युएल इंजेक्शन पम्प व इंजेक्टर, इंस्पेक्शन एवं टेपेट कवर, गियर ट्रेन इ. होते हैं. इंजन को चलाने हेतु कुलेंट वाटर, इंधन, लुब्रिकेटिंग ऑइल, चार्ज एअर, एक्झॉस्ट गैस ड्रीवन टर्बो चार्जर, वाल्व टाइमिंग गीयर, क्रंक केस एक्झॉस्टर, इंजन गवर्निंग सिस्टम इ. प्रणालियां होती हैं. इन पुर्जों एवं इन के बीच की प्रणालियों का सुचारु रुप से चलना इंजन की विफलता रहित कार्य हेतु आवश्यक होता है.




**पावर पैक अर्थात इंजन का साइड सेक्शनल चित्र**




**डीज़ल लोको में इंजन के साथ अन्य सपोर्टिंग प्रणालियों का चित्र**

इंजन के अलावा पूर्ण लोको के कार्य में बैटरी चार्जिंग एवं पॉवर सप्लाइ सर्किट, कम्प्रेसर एयर, लोको एवं ट्रेन फ्रिक्शन ब्रेक, लोको डायनामिक ब्रेक, रेडिएटर फैन, ट्रैक्शन मोटर प्रपल्शन सर्किट, ट्रैक्शन मोटर कूलिंग ब्लोअर, बोगी प्रणाली, स्पीड रिकॉर्डिंग प्रणाली, हेड लाइट एवं फ्लैशर लाइट प्रणाली तथा इंजन व लोको की सुरक्षा प्रणालियां इन सब के साथ लोको चलते हैं. किसी भी पूर्जे एवं प्रणाली में खराबी आने पर लोको के परफॉर्मेंस पर प्रभाव पडता है. सुचारु रुप से लोको चलने के लिये भरसक प्रयास के बाद ही नतीजा मिलता है.

लोको में अधिकतर फंक्शनल पुर्जे ट्रेड से बन के आते है जिनमें कीमत का न्यूनतम होना, स्मॉल स्केल इंडस्ट्री को बढ़ावा देना आदि पॉलिसी का पालन करके पूर्जों का सही समय पर मिलना, गुणवत्ता का सही होना और अपेक्षित सेवा का मिलना इन सब पर

डीज़ल लोको का परफॉर्मेंस निर्भर करता है. अत: डीज़ल लोको का रखरखाव अपने आप में बहुत ज्यादा तकनीकी तथा कठिन कार्य है.

रखरखाव से संबंधित साधारण समस्याएं बताने के बाद विशेष रुप से यह बताना भी आवश्यक है कि स्थायी मशीन की अपेक्षा चलती रहने वाली मशीन यानि चल स्टॉक /रोलिंग स्टॉक का रखरखाव करने में अधिक समस्याएं जो आती है जिनकी चर्चा नीचे कुछ परिच्छेदों में की जा रही है.

1. स्थायी सामग्री (मशीन इ.) प्राय: उसी वातावरण में, सीमित ऑपरेटर तथा रखरखाव करने वाले स्टाफ द्वारा कार्य करने के कारण लगातार निगरानी में रहते है इनमें यथा सम्भव विफलता टाली जा सकती है इसके विपरीत रोलिंग स्टॉक केवल शेड्युल के समय ही डिपो में आता है, निर्धारित समय तक ही उपलब्ध रहता है तथा उतने ही समय में रखरखाव करके उसे कार्य हेतु रवाना करना पडता है.

2. रोलिंग स्टॉक कार्य पूरा करके डिपो/शेड में आने तक बिना कोई असामान्य घटना के आना आवश्यक होता है, यदि शुरुआत के स्टेशन से 15 मिनट या पूर्ण ट्रिप में 30 मिनट से अधिक विलम्ब होता है तो उसे विफलता करार दिया जाता है.

3. रोलिंग स्टॉक कार्य के मध्य विभिन्न प्रकार के सेक्शन जैसे घाट सेक्शन, कर्वेचर, शहर तथा जंगल विभाग से गुजरता है. कहीं पर्यावरण अत्यधिक गर्म, कहीं शीत, कहीं नमी भरा तो कभी अत्यधिक खुश्क होता है. इन सभी परिस्थितियों का रोलिंग स्टॉक विशेषकर लोकोमोटिव प्रणाली एवं पुर्जो पर विपरीत परिणाम होता जाता है.

4. इनके अलावा लदान तथा चलाने का तरीका भी परिणाम करता है, कई विफलताएं चालक की गलतियोंसे भी होती है.

5. छुट्टियों के समय विशेष गाड़ियां चलाने हेतु लक्ष्य से अधिक आउट टर्न देना पडता है, मेंटेनेंस हेतु पर्याप्त समय नहीं मिलता इसका परिणाम लोकोमोटिव के परफार्मेंस पर पडता है.

6. इलेक्ट्रिक लोकोमोटिव में इलेक्ट्रिक उर्जा उपरी तार में उपलब्ध होती है जिसे लेकर कंट्रोल सिस्टम के माध्यम से लोकोमोटिव के ट्रैक्शन मोटर को देकर लोको चलाया जाता है जब कि डीज़ल लोको में प्रथमत: इलेक्ट्रिक उर्जा बनाई जाती है उसके बाद कंट्रोल सिस्टम के माध्यम से लोकोमोटिव के ट्रैक्शन मोटर को इलेक्ट्रिक उर्जा देकर लोको चलाया जाता है. अत: डीज़ल लोकोमोटिव की प्रणाली अधिक क्लिष्ट होती है एवं मेंटेनेंस में अति सावधानी बरतनी पडती है.

7. यहां यह बताना आवश्यक है कि भारत में इलेक्ट्रिक उर्जा निर्माण की कमी के रहते साधारणत: 12% गांव में अभी तक इलेक्ट्रिक उर्जा नहीं पहुंच पायी है, वहां 4000 HP का एक डीज़ल लोको देश की 3 मेगा वाट इलेक्ट्रिक उर्जा क्षमता बढ़ाता है जिससे उसकी उपयोगिता बढ़ी हुई है.

भारतीय रेल की कार्य प्रणाली में डीज़ल लोकोमोटिव का बहुत बडा योगदान है.

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## POWERS OF ACCEPTANCE OF WORKS TENDER

**(Railway Board letter no. 2007/CE-I/CT/O/20/1 dtd 08-10-2015)**

| SN | Powers of acceptance of works tender ( For each tender) | Accepting Authority |
|---|---|---|
| 1 | Up to Rs. 4.00 Crore | S. Grade/ J. A. Grade |
| 2 | Above Rs. 4.00 Crore and Up to Rs. 20.00 Crore | SAG/DRM/ADRM/CWM |
| 3 | Above Rs. 20.00 Crore and Up to Rs.75.00 Crore | CHOD in S. A. Grade |
| 4 | Above Rs. 20.00 Crore and Up to Rs.100.00 Crore | AGM/PHOD in HAG |
| 5 | Above Rs. 20.00 Crore and Up to Rs.300.00 Crore | CAO/Const |
| 6 | Above Rs. 20.00 Crore and Up to Rs.500.00 Crore (For National Projects of NE Region & for Kolkata Metro) | CAO/Const |
| Note: where no AGM is posted, such tenders shall also be accepted by GM. | | |

## Bond Performance of Basalt Fibre-Reinforced Polymer Bars to Concrete

Fibre-reinforced polymers (FRP) offer a promising solution to infrastructure decay that results from corrosion of reinforcing steel bars. As a result, conventional FRP materials such as glass, carbon, and aramid FRPs have been widely used in reinforcing and strengthening concrete structures. Basalt fibers have been recently used in developing a new FrP composite, referred to as basalt fiber-reinforced polymer (BFRP). Recently, BFRP bars have emerged as a promising alternative to conventional FRP bars in reinforcing concrete structures.

Basalt fibers are processed from basalt rocks through a melting process similar to that used for glass fibers. The fibers are environmentally safe, nontoxic, noncorrosive, and have good magnetic insulation properties. They are characterized by their higher resistance to alkalinity in surrounding concrete overcoming a common drawback of glass fibers.. They have an excellent resistance to high temperature and high moisture conditions. Moreover, the fibers have outstanding chemical stability and excellent fatigue resistance.

**By: Ahmed El Refai, Ph.D., P.e. : Mohamed-Amine Ammar; and Radhouane Masmoudi.**

**Ref. Journal of Composites for Construction ASCE, May/June 2015 Vol. 19 Issue 3**

**Pg. 04014050-1**

## Holdup Problems in Construction Projects

Construction procurement involves a process in which the inputs from different participants are coordinated to produce a physical asset in accordance with the owner's requirements. The efficiency of the contracting process depends not only on how hard project participants have worked towards the owner's interest, but also on the way that project surplus is divided among parties exposed to various risks. In traditional design-bid-construction systems, the owner leverages price competition to drive down the contractor's "promised" cost ex ante and steps up monitoring to secure the achievement of this promise ex post. History evinces that this "squeeze-and-protect" strategy has led to excessive sources being applied to litigation (Latham 1994). A major cause of dispute stems from the contractor's tendency to exploit the owner's bargaining disadvantage in the post contract stage owing to the presence of appropriable quasi-rent (AQR). It is the origin of the well-known hold-up problem in the construction context. Change orders are prevalent in construction projects. The occurrence of a change order would damage the trust base between the parties if the price charged by the contractor is perceived to be "exorbitant" (Masten et al. 1991). As suggested by the Coase theorem, making post contract changes should not be a problem if frictionless bargaining can be achieved to ensure that trading parties agree on the deal that maximizes the joint interests of both parties (Farrell 1987.) Perfect information, an underlying assumption of frictionless bargaining, can also make it feasible to implement theoretical solutions to holdup problems by assigning full bargaining power to one party through a contract (Aghion et al. 1994: Chung 1991). However, in most real-life scenarios where traders face severe information incompleteness, this contractual solution cannot be enforced by the third party; thus, renegotiation still needs to be called upon to resolve the pricing of new orders. Whereas the ex post adaptability problem has occupied the central place in the theory of organizational economics (Baker et al., unpublished data, 2011), the empirical test is mostly focused on the connection between governance choices and relevant determinants. There is a lack of direct evidence of whether AQR can really serve as a good predictor for the outcome of post contract negotiations This research fills this gap by delving into the contracting process through developing a testable hypothesis using the Nash bargaining model and investigating the impact of the difference in profit margins achieved ex post and ex ante by the contractor. The statistical link found lends support to the core argument of an expanding body of literature on construction bold up problems (Chang 2013 a, b, c; change and Ive 2007b).

**By: Chen-Yu Chang and Yaming Qian**

**Ref. : Journal of Construction Engineering and Management, : June 2015. Volume 141 Issue 6- Pg. 04015004-1**

## In Situ Test of School Buildings Retrofitted with External Steel-Framing Systems

In situ push-over experiments and analytical assessments were conducted in this study to investigate the seismic capacity of RC school buildings at the Guan-miao Elementary School in Tainan City, Taiwan. Both prototype and external steel-framing specimens were constructed and compared. Reinforcements with steel channels were adhered to the captive columns and their adjacent beams in the weak direction, to retrofit the school building through the creation of external steel-framing systems. The design and construction procedures of the beam-column connection are introduced, as well as detailed drawings of the column-base anchorage system, both of which are key to the effects of the proposed retrofitting method. The experimental results show that the steel-framing system can be firmly bonded to the retrofitted specimen, providing continuous stress transference from the beam-column joints to the steel channels. The failure mode of the retrofitted captive columns was shifted from shear failure, as seen with the prototype specimen, to flexural-shear failure, with the retrofitted one. Both the experimental and analytical results show the following: The maximum total base shear strength increases 2.11 times, the total enclosed area of the stored energy increases 2.20 times, and ductility capacity increases 1.31 times. The external steel-framing systems proposed in this work can thus effectively enhance the base shear strength and the ductility of the specimens.

**By: C. T. Shih; S. Y. Chu; Y. W. Liou; F. P. Hsiao; C. C. Huang; T. C. Chiou; and Y. C. Chiou**

**Ref: American Society of Civil Engineering, January 201515, Pg. D4014002-1**

## Assessment of the Strengthening of an RC Railway Bridge with CFRP Utilizing a Full-Scale Failure Test and Finite-Element Analysis

A finite element (FE) model was calibrated using the data obtained from a full-scale test to failure of a 50 year old reinforced concrete (RC) railway bridge. The model was then used to assess the effectiveness of various strengthening schemes to increase the load-carrying capacity of the bridge. The bridge was a two-span continuous single-track trough bridge with a total length of 30 m, situated in Örnsköldsvik in northern Sweden. It was tested in situ as the bridge had been closed following the construction of a new section of the railway line. The test was planned to evaluate and calibrate models to predict the load-carrying capacity of the bridge and assess the strengthening schemes originally developed by the European research project called Sustainable bridges. The objective of the test was to investigate shear failure, rather than bending failure for which good calibrated models are already available. To that end, the bridge was strengthened in flexure before the test using near-surface mounted square section carbon fiber reinforced polymer (CFRP) bars. The ultimate failure mechanism turned into an interesting combination of bending, shear, torsion, and bond failures at an applied load of 11.7 MN (2,630 kips). A computer model was developed using specialized software to represent the response of the bridge during the test. It was calibrated using data from the test and was then used to calculate the actual capacity of the bridge in terms of train loading using the current Swedish load model which specifies a 330 kN (74 kips) axle weight. These calculations show that the unstrengthened bridge could sustain a load 4.7 times greater than the current load requirements (which is over six times the original design loading), whilst the strengthened bridge could sustain a load 6.5 times greater than currently required. Comparisons are also made with calculations using codes from Canada, Europe, and the United States.

**By: Arto M. Puurula; Ola Enochsson; Gabriel Sas; Thomas Blanksvärd; Ulf Ohlsson; Lars Bernspång; Björn Täljsten; Anders Carolin; Björn Paulsson; and Lennart Elfgren**

**Ref: American Society of Civil Engineering, January 201515, Pg. D4014008-1**

## Rail Cote

In the month of Oct 2009 in the busy suburbs of London a rail fracture took place hardly after working of three months in track, the rail was cracked due to corrosion in the food in the level crossing portion which was due to salty conditions, heavy road traffic and stray currents in the running rails.

The rail replaced on Oct 11, 2009 and an anticorrosive protective coat of “Rail Cote” made by Tata steel applied on web and foot of rail. The

rails were inspected in July 2011 and later in Aug 2014 and after 58 months after applying rail cote the rails are found in condition.

The rail cote has protected the rails in the level crossing in two ways: firstly as a barrier preventing oxygen and water necessary for oxidation (corrosion) reaching the steel of the rails and secondly by corroding itself in preference to the steel, en electro chemical reaction known as sacrificial protection. This means that if there is any damage to the coating, the rail cote around the point of damage corrodes rather than the exposed steel.

Theis process is applicable to Indian environment also where temperatures and conditions are different from London, in india varying temperatures, sea breezes, droppings from coaches, occasional floods and electrical currents passing through rails etc. are primal to effect corrosion on rails.

Main challenge to build a railway line through and across salt pans is to slow down rapid corrosion of the rails caused by the combination of water, salt and heat. Hence, it makes sense to use a corrosion protecting coat on rail foot where corrosion affect is severe.

Challange is getting any coated rail transported to site and installed with minimal damage to the coating, coatings like epoxy coatings gives good barrier against corrosion but are brittle and susceptible to damage during transportation and installation which in certain conditions can accelerate corrosion in the damaged area don the can be develop in to a pit which acts as a stress raiser causing all rail cracking . as a result an aluminium metal spray coating was developed with a very good resistance to mechanical damage. However, the metal spray coating does not protect the rails effectively when there are stray currents in rails. So the search was on for a coating to provide protection in all conditions.

Testing regime includes accelerated corrosion testing (prohension), simulated stray current corrosion assessments, natural exposure and impact tecting.

The prohension test is a standard test that takes place in a cabinet that goes through alternate hours of wet and dry cycles for 2000hrs. The wet cycle uses a weak salt solution that is atomised to create a fog followed by a dry cycle at 35 degrees centigrade. The test samples were fabricated from 100mm by 150 mm by 5 mm thick hot rolled mild steel panels, which were grit blasted and then coated. To simulate the damage often found on coated rails after they are installed, each sample had a 2 mm wide by 40 mm long defect gouged through the coating down to the metal substrata.

The prohension results established that all coating provided some protection over uncoated steel. The epoxy coated samples sustained heavy corrosion and deep pits in the damaged areas. This result suggested that while the coating would perform well if there is no any mechanical damage but severe corrosion will occur when there is any iota of damage to the epoxy coating. The aluminium metal spray showed a high level of creep back again indicating a low tolenrancwe to any mechanical damage in service.

The rail cote coated test panels were virtually free of under film corrosion after the 2000$^{th}$ test confirming that the coating provides effective protection nd prevents corrosion of the damaged area. The coatings impact resistance is determined by dropping a calibrated by dropping calibrated steel weight attached to 15 mm steel ball bearing onto the surface of coating. The height at which the weight is dropped determines the impact energy in joules using the formula E=mgh where E= impact energy in joules, m = mass of the impacterin kg, g=acceleration due to gracity, and h=drop height of the indentor.

The failure of the coat is determined when the impacter penetrates the coating through to the metal substrate.

| Material | Dry film thickness (um) | Scratch test load to failure (kg) | Impact | Resistance energy to failure (J) |
|---|---|---|---|---|
| Glass Flake expoxy | 350 | >10 | 1.5 | Coating cracked down to substrate |
| Railcote | 100 | >10 | >13 | Coating intact. Heavy deformation of substrate |
| Al. Metal spray | 200 | >10 | >13 | |

Above table shows railcote and aluminium metal spray deformed with the substrate did not flake off but epoxy coating cracked at 2J.

A test was devised to simulate the stray current

conditions found on track. A 50 mm plastic tube was glued to the coated steel which became the anote. Sand was put in to the tube and mesh cathode inserted to within 15 mm of coated steelsample. A 1% sodium chloride solution poured in to act as the electrolyte and allow a circuit to form between the mesh cathods and steel sample anode, A 500v potential was passed and the test run for 28 days. On the epoxy coating sample corrosion undercut the coating, the aluminium metal spray sample lost all the aluminium coating exposing the steel substrate which rusted. The railcote showed upto 20% coating loss and some blisters.

The results shows that epoxy coatings protects when the coating is undamaged and intact. However, damage in the coating leads to accelerated corrosion and resulting in cracking when impacts exceeds 2J. The aluminium coating has ahigh impact resistance and large creep back distance from any damaged area. However under stray current conditions aluminium coated sample has relatively rapid loss of coating around the damaged area leading to accelerated corrosion and rail failure. The railcote performed well in all laboratory tests providing good corrosion protection of the damaged area without blistering and creep back. The coating also performed well in stray current environments with only 20% loss of coating surrounding the damaged area.

Using these coatings in track offers valueable lessons which defines the product specifications and future research. It is difficult to avoid some damage to coatings during maintenance, so a coating that has good resistance to damage and still provides protection against corrosion when damaged is ideal. Networks have areas of stray currents and coatings need to be able to protect the rail here too. The railcote of M/s Tata steel provides protection against corrosion when demaged is ideal. Network have areas of stray currents and coatings need to be able to protect the rail here too. The railcote of M/s Tata steel provides good impact resistance and provides sacrificial protection even when it is damaged can be handy in Indian conditions also.

**By: Katherine Hawksqwell and Kevin Grahm**

**Ref: IRI January 2015**

## An Angle of Attack-Based Derailment Criterion for Wheel Flange Climbing

A three-dimensional equilibrium model of a wheelset is created that takes the geometrical contact and non-linear creep force between the wheel and rail into account. This model can thus be used to study derailment conditions during flange climbing. To ensure the validity of Nadal's criterion at small and negative angles of attack, the effects of the angle of attack and friction coefficient on an “equivalent friction coefficient”, which is defined as the ratio of the lateral creep force to the normal force, are studied. Using the results of the wheelset equilibrium equation, two curve-fitted formulas for the equivalent friction coefficient are generated in terms of the angle of attack and friction coefficient using, respectively, the Shen–Hedrick–Elkins creep theory and FASTSIM approach. A derailment criterion is proposed based on the curve-fitted equivalent friction coefficients, which takes the angle of attack, friction coefficient and contact angle into consideration. The effectiveness of the proposed criterion is verified through numerical comparisons with wheelset equilibrium equations for different contact angles and friction coefficients, and through experimental comparisons with scaled tests made by Japanese National Railways and full-scale field testing at the Transportation Technology Center, Inc.

**By: Qinghua Guan, State Key Laboratory of Traction Power, Southwest Jiaotong University, Chengdu, Sichuan 610031, People's Republic of China.**

**Ref: Rail and Rapid Transport, Sept., 2014, Vol. 228**

## Analysis of Train/Turnout Vertical Interaction using a Fast Numerical Model and Validation of that Model

A two-dimensional (2D) finite element model has been developed for simulation and analysis of train/turnout vertical dynamic interactions at a common crossing. The model has been validated through field measurements and simulation results obtained using a three-dimensional (3D) multi-body system (MBS) model. The dynamic behaviour of three turnouts on the Dutch railway network was simulated using the 2D model. The simulation results were compared with measured

data collected from the instrumented crossings containing corresponding turnouts. It was observed that the values of the vertical acceleration of the crossing nose obtained from the simulations were in good agreement with the measured values. The 2D model was verified by adapting the more intricate 3D MBS model established in the VI-Rail software. The vertical geometry of the rail used in the 2D model was obtained using the wheel trajectory from the 3D model. It was observed that the dynamic wheel forces in the two models were close to one another. From these results it was concluded that the 2D model is able to simulate train/turnout interactions with a good accuracy and thus it can be used instead of complex time-consuming numerical simulations.

**By: Chang Wan, Section of Road and Railway Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, 2628 CN, The Netherlands.**

**Ref: Rail and Rapid Transport, Sept., 2014, Vol. 228**

## Multimode Dynamic Response of Railway Bridge Superstructures to High-Speed Train Loads

High-speed passenger trains can cause destructive vibrations on bridge structures. The possibility of resonance is particularly related to the bridge superstructure's natural frequency and the frequency of moving loads, which is characterized by the train type and its speed. In this study, a multimode dynamic analysis has been performed for a variety of superstructures, span lengths, train speeds and train types. Numerical analysis has been applied to evaluate different girder support conditions such as simple, two-span continuous and three-span continuous. In addition, the train/structure interaction is included in the analytical models. The results are presented in terms of moment dynamic load factors for a practical range of the superstructure's fundamental frequency, which include various superstructure types such as concrete, prestressed concrete and steel. Different high-speed trains are considered moving at various speeds to capture the configuration for highest responses. This study provides a set of diagrams for initial estimation of high-speed railroad bridge bending moment response. Proposed diagrams will help bridge designers to avoid an uneconomic bridge system in early design stages.

**By: Terri R Norton, Faculty of Engineering, University of Nebraska-Lincoln, Omaha, NE 68182, USA.**

**Ref: Rail and Rapid Transport, Sept., 2014, Vol. 228**

## Dynamics of a Vehicle–Track Coupling System at a Rail Joint

**Abstract:** The dynamic behaviour at a rail joint is examined using a two-dimensional vehicle–track coupling model. The track system is described as a finite-length beam resting on a double-layer discrete viscous-elastic foundation. The vehicle is represented by a half car body and a single bogie. The influence of the number of layers considered, the number of elements between two sleepers, and the beam model is investigated. Parametric studies, both of the coupling model and the analytic formulae, are carried out in order to understand the influence of the main track and vehicle parameters on the $P_1$ and $P_2$ peak forces. Finally, the results in terms of $P_2$ force from the proposed model are compared, not only with measured values but also with other simulated and analytical solutions. An excellent agreement between these values is found.

**By: Ilaria Grossoni, Institute of Railway Research, University of Huddersfield, Queensgate, Huddersfield, HD1 3DH, UK.**

**Ref: Rail and Rapid Transport, Sept., 2014, Vol. 228**

## Behavior of High-Strength Friction-Grip Bolted Shear Connectors in Sustainable Composite Beams

Composite beams comprised of concrete slabs and steel beams joined by mechanical shear connectors are commonly used in modern building design. The use of innovative deconstructable high-strength friction-grip bolt (HSFGB) shear connectors and reduced-emissions precast geopolymer concrete slabs in composite beam design can greatly enhance the sustainability of building infrastructure. Hitherto, research contributions that address the behavior of

composite beams with HSFGB shear connectors and precast geopolymer concrete slabs are very limited. To provide a contribution to this area of research, an effective finite element model of push-out testing is developed to investigate the ultimate strength and the load-slip characteristics of shear connection using HSFGB connectors and geopolymer concrete slabs in this proposed sustainable composite beam application. The accuracy of the proposed finite element model is validated by comparing its predictions with experimental results on push-out test specimens also reported in the paper. The effects of the change in the bolt pretension, its clearance between the hole in the steel flange, its diameter and tensile strength,and the compressive strength of the geopolymer concrete are elucidated through parametric studies. Practical design recommendations in algebraic form are proposed and verified for predicting the ultimate strengths and the load-slip relationships for composite beams with HSFGB shear connectors.

**By: Xinpei Liu ,Mark A. Bradford**

**Ref: ASCE, June 2015, Volume 141**

### Seismic Response of Masonry Arches Reinforced by Tie-Rods: Static Tests on a Scale Model

This article presents an experimental study on the seismic behavior of arch-pier systems reinforced with tie-rods. In particular, the role of the tie-rod stiffness is stressed, with the aim of proposing innovative tie-rods characterized by lower stiffness than traditional ones. The experimental campaign was performed by adopting the inclined plane static test on a 1:10 scaled model. It is demonstrated that prestress applied to tie-rods barely influences the seismic capacity of the system. Moreover, it is shown that larger tie-rod deformability induces larger displacement capacity at collapse. Finally, a comparison between experimental results and simple analytical models based on rigid block systems shows the fundamental role of overall system deformability on the seismic response.

**By: Chiara Calderini, Sergio Lagomarsin,**

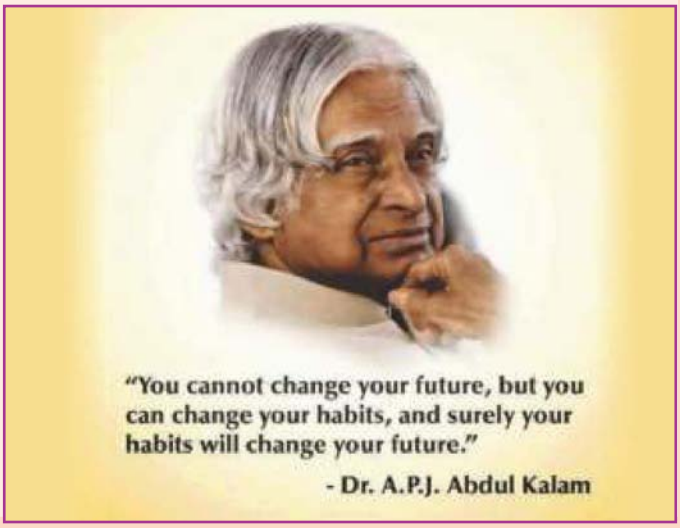
**Ref: ASCE, June 2015, Volume 141**

### Mechanistic Model for Simulating Critical Behavior in Elastomeric Bearings

When an elastomeric bearing is subjected to simultaneous vertical compressive load and lateral displacement, the shear force can pass through a maximum beyond which the bearing exhibits negative tangential horizontal stiffness and a condition of unstable equilibrium. This behavior has been experimentally demonstrated and has important implications on the stability and earthquake response of elastomeric seismic isolation bearings. Yet, analytical bearing models used for numerical earthquake simulation assume a positive second-slope stiffness irrespective of vertical load and/or bearing lateral displacement and therefore are unable to simulate the experimentally observed bearing behavior. Semiempirical bearing models have been developed and some of these models have been shown to simulate the influence of vertical load and lateral displacement on the shear force response with reasonable accuracy, however these models rely on a number of experimentally calibrated parameters, making them impractical for the purpose of design. An alternative approach to modeling the behavior of elastomeric bearings is explored in this study, which uses a series of vertical springs and a simple bilinear constitutive relationship to represent the rotational behavior of elastomeric bearings. The mechanistic bearing model, utilizing vertical springs, is shown to be capable of simulating the experimentally observed behavior with reasonable accuracy without relying on experimentally calibrated parameters.

**By: Xing Han, Gordon P. Warn**

**Ref: ASCE, June 2015, Volume 141**



# Malaviya Chair for Railway Technology to be Set Up at IIT(BHU), Varanasi

The Ministry of Railways has decided to set up the 'technology Mission for Indian Railways' (TMIR as a consortium of Ministry of Railways, Ministry of Human Resource Development, Ministry of Science and Technology and Ministry of Industries on an investment sharing model for taking up identified railway projects for applied research and use on Indian Railways.

The 'Technology Mission for Indian Railways' (TMIR) will function through the 'Mission implementation and co-ordination committee' (MICC), consisting of the following:-

(a) Prof. N.S. Vyas, former Head/Mechanical Engineering, IIT – Kanpur and presently Vice Chancellor/Rajasthan Technical University- Mission Chairman.

(b) Shri. Alok Kumar, Exe. Director/CE(G, Railway Board- Co-Chairman

(c) Nominees of Ministry of Railways, RDSO, railway Research Centres, Ministry of HRD, Ministry of Science & Technology and Ministry of Industries – Members.

The Mission implementation and Coordination Committee' (MICC) will formulate the 'Mission Management Manual' (MMM) for functioning of 'TMIR' and the domain specific Sub-Committees for various fields of railway working and also for monitoring the progress of research and technology projects.

'TMIR' will also monitor progress of research projects of the existing Railway research Centre (RRC) / Kharagpur and other 4 upcoming Railway Research Centres sanctioned in Budget 2015-16. Thus, Railways' investment in applied research activities will be fruitfully converted to technology development for actual use in railway working. Execution of various project under 'TMIR' will be dealt in terms of procedures, to be defined in its 'Mission Management manual(MMM)'.

The Nodal Directorate for functioning of the \'Technology Mission for Indian Railways' (TMIR) and its 'Mission implementation and coordination Committee' (MICC) will be Efficiency & Research Directorate of Railway Board.

**Ref: CT Today, June 2015, Pg. 20**



# ITTI Calender of Courses 2015 (Rev.13)

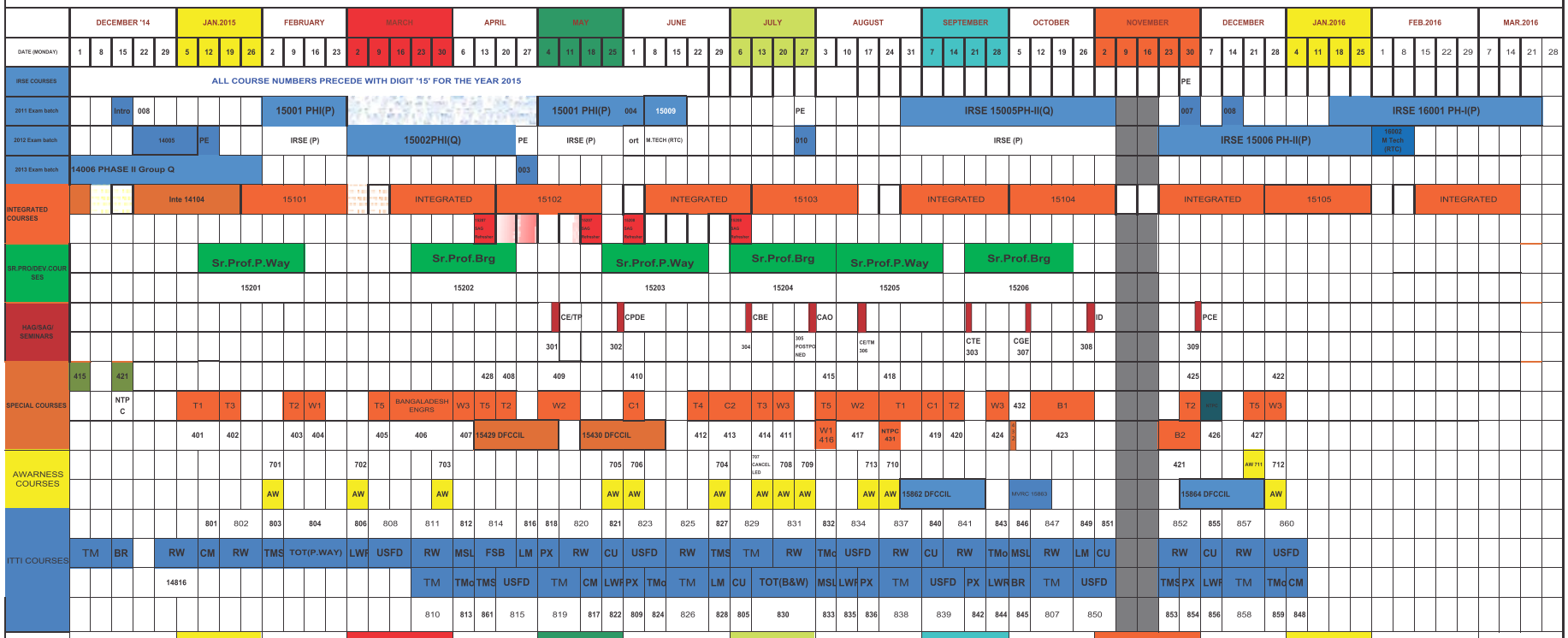
| Course No. | From | To | Name of the course | Duration Week(s) | Eligible Group |
|---|---|---|---|---|---|
| 15807 | 12-10-2015 | 23-10-2015 | Mechanized Track Maintenance and Renewals | 2 | SSE's/P.Way |
| 15845 | 05-10-2015 | 09-10-2015 | Inspection and Maintenance of Bridge | 1 | SSE's/Br |
| 15846 | 05-10-2015 | 09-10-2015 | Management of Store & Land for SSE(P.Way) | 1 | SSE's/P.Way |
| 15847 | 12-10-2015 | 23-10-2015 | Rail Wheel Interaction & derailments | 2 | SSE's & Instructor of ZRTI/ZRTS/P.Way |
| 15848 | 04-01-2016 | 08-01-2016 | Contract Management | 1 | SSE's |
| 15849 | 26-10-2015 | 30-10-2015 | Land Management for SSE/Works | 1 | SSE's/Works |
| 15850 | 26-10-2015 | 06-11-2015 | USFD,Welding & Rail Grinding | 2 | SSE's/P.Way |
| 15851 | 02-11-2015 | 06-11-2015 | Curves | 1 | SSE's/P.Way |
| 15852 | 23-11-2015 | 04-12-2015 | Rail Wheel Interaction & derailments | 2 | SSE's & Instructor of ZRTI/ZRTS/P.Way |
| 15853 | 23-11-2015 | 27-11-2015 | TMS | 1 | SSE's |
| 15854 | 30-11-2015 | 04-12-2015 | Points & Xings | 1 | SSE's/P.Way |
| 15855 | 07-12-2015 | 11-12-2015 | Curves | 1 | SSE's/P.Way |
| 15856 | 07-12-2015 | 11-12-2015 | LWR | 1 | SSE's/P.Way |
| 15857 | 14-12-2015 | 23-12-2015 | Rail Wheel Interaction & derailments | 2 | SSE's & Instructor of ZRTI/ZRTS/P.Way |
| 15858 | 14-12-2015 | 23-12-2015 | Mechanized Track Maintenance and Renewals | 2 | SSE's/P.Way |
| 15859 | 28-12-2015 | 01-01-2016 | Track Monitoring | 1 | SSE's/P.Way |
| 15860 | 28-12-2015 | 08-01-2016 | USFD,Welding & Rail Grinding | 2 | SSE's/P.Way |
| 15863 | 05-10-2015 | 16-10-2015 | Special Course for MVRC's Site Engineers. | 2 | MVRC's Site Engineers |
| 15864 | 30-11-2015 | 23-12-2015 | Special Course on Professional Training to DFCCIL Asstt. Managers/Executives. | 4 | DFCCIL Asstt. Managers/Executives |

# IRICEN Calendar of Courses 2015 (Rev. 13)

| Course No. | From | To | Name of the Course | Duration | Eligible Group |
|---|---|---|---|---|---|
| **Probationary Courses** | | | | | |
| 15005 | 31-08-2015 | 05-11-2015 | IRSE Ph.II (Gr.Q) | 10 weeks | IRSE (P) 2013 Exam. |
| 15006 | 23-11-2015 | 28-01-2016 | IRSE Ph.II (Gr.P) | 10 weeks | IRSE (P) 2013Exam. |
| 15007 | 30-11-2015 | 04-12-2015 | IRSE Posting Exam & Orientation | 1 week | IRSE (P) 2012 Exam. |
| 15008 | 14-12-2015 | 18-12-2015 | IRSE Introduction | 1 week | IRSE (P) 2014 Exam |
| **Integrated Courses** | | | | | |
| 15104 | 05-10-2015 | 23-12-2015 | Integrated | 12 weeks | Gr.B officers |
| 15105 | 28-12-2015 | 17-03-2016 | Integrated | 12 weeks | Gr.B officers |
| **Sr. Professional Courses** | | | | | |
| 15206 | 21-09-2015 | 23-10-2015 | Sr.Prof ( Br &General) | 5 weeks | JAG/SS having 6 yrs service in Group A |
| **PCE/HAG/SAG/Seminars/Workshops/Meetings** | | | | | |
| 15307 | 14-09-2015 | 15-09-2015 | Training Manager/CGE Seminar | 2 days | CGEs/Pr.CETCs |
| 15308 | 31-10-2015 | 01-11-2015 | IRICEN Day Seminar for IRSE '89' Exam | 2 days | SAG (IRSE '89') |
| 15309 | 03-12-2015 | 04-12-2015 | PCEs' Seminar | 2 days | PCEs |
| **Special Courses (Track/Bridges/Works)** | | | | | |
| 15421 | 21-09-2015 | 01-10-2015 | Steel structure &PSC (B-2) | 2 weeks | JS/SS/JAG |
| 15422 | 05-10-2015 | 09-10-2015 | Arbitration for Arbitator (W-3) | 1 week | JS/SS/JAG |
| 15423 | 12-10-2015 | 30-10-2015 | Courses for Br. Design Asstt.inclu. Earthquake complaint structure(B-1) | 3 weeks | ABE;sDesign Asstts. |
| 15424 | 23-11-2015 | 27-11-2015 | Arbitration for Arbitator (W-3) | 1 week | JS/SS/JAG |
| 15425 | 30-11-2015 | 05-12-2015 | Rail Wheel Interaction & derailments (T-2 | 6 days | JS/SS/JAG Of OL |
| 15426 | 07-12-2015 | 11-12-2015 | Special Course on Track & Bridge Maintenance for NTPC Engineers | 1 week | NTPC Engineers |
| 15427 | 21-12-2015 | 24-12-2015 | TMS(T-5) | 1 week | JS/SS of OL |
| 15432 | 05-10-2015 | 06-10-2015 | Special Course on Water Audit | 2 days | JS/SS |
| **Awareness Courses** | | | | | |
| 15711 | 21-12-2015 | 23-12-2015 | Awareness for IRSEE 2013 | 1 week | IRSSE (P) 2013 |
| 15712 | 28-12-2015 | 01-01-2016 | Awareness for IRPS 2013 (P) | 1 week | IRPS (P) 2013 |

# INDIAN RAILWAYS INSTITUTE OF CIVIL ENGINEERING, PUNE-411001

## CALENDAR OF COURSES 2015 CHART (Rev.13)




### SPL COURSES for IRICEN

| SPL COURSES | Course Name | No. | No. | No. | No. | TOTAL | Wks |
|---|---|---|---|---|---|---|---|
| T-1 | USFD, Welding,RG,Track Moni & M/C | 401 | 418 | | | 2 | 2 |
| T-2 | Rail Wheel Intraction & Derailment | 403 | 408 | 420 | 425 | 4 | 6d |
| T-3 | Points & crossing and Yards | 402 | 414 | | | 2 | 1 |
| T-4 | Railway Formation & Geo Tech Inv | 412 | | | | 1 | 1 |
| T-5 | TMS | 405 | 415 | 427 | 428 | 3 | 1 |
| B-1 | Bridge Design Assitant | 423 | | | | 1 | 3 |
| B-2 | PSC & Steel Structure | 421 | | | | 1 | 2 |
| W-1 | Land Mgt | 404 | 416 | | | 2 | 1 |
| W-2 | Contract & Arb and Project Mgt | 409 | 417 | | | 2 | 2 |
| W-3 | Arbitration for Arbitator | 407 | 411 | 422 | 424 | 4 | 1 |
| C-1 | Morden Surveying | 410 | 419 | | | 2 | 1 |
| C-2 | Construction Engineers | 413 | | | | 1 | 2 |
| BAN ENGRS | Special course for Bangalades Engineers | 406 | | | | 1 | 3 |
| NTPC | Special course for NTPC Engineers | 426 | | | | 1 | 1 |

### AWARNESS COURSES

| Awarness Courses | | No. | No. | No. | No. | WKs |
|---|---|---|---|---|---|---|
| Accouts | | | | | | 1 |
| Electrical engg. | | | | | | 1 |
| mechanical Eng | | | | | | 1 |
| Signal Engg. | | 701 | 702 | | | 1 |
| storres | | | | | | 1 |
| personel | | | | | | 1 |
| traffic | | | | | | 1 |

### SPL COURSES for ITTI

| | C.No | ITTI COURSES | No. | No. | No. | No. | No. | No. | No. | No. | No. | Total | Wks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TOT(P.WAY) | Trainers (P.Way) | 804 | | | | | | | | | 1 | 3 |
| 2 | TOT(B&W) | Trainer | 830 | | | | | | | | | 1 | 3 |
| 3 | RW | Rail Wheel Interaction & derailments | 802 | 811 | 820 | 825 | 831 | 837 | 841 | 847 | 852 | 857 | 10 | 2 |
| 4 | TMS | TMS | 803 | 827 | 853 | 861 | | | | | | | 3 | 1 |
| 5 | PX | Points & Xings | 809 | 818 | 836 | 842 | 854 | | | | | | 5 | 1 |
| 6 | USFD | USFD, Welding & Rail Grinding | 808 | 815 | 823 | 834 | 839 | 850 | 860 | | | | 7 | 2 |
| 7 | CU | Curves | 805 | 821 | 840 | 851 | 855 | | | | | | 5 | 1 |
| 8 | LM | Land Management | 816 | 828 | 849 | | | | | | | | 3 | 1 |
| 9 | MLS | Mangement of Store & Land | 812 | 833 | 846 | | | | | | | | 3 | 1 |
| 10 | Tmo | Track Monitoring | 813 | 824 | 832 | 843 | 859 | | | | | | 5 | 1 |
| 11 | BR | Inspection & Maintenance of Bridge | 845 | | | | | | | | | | 1 | 1 |
| 12 | LWR | LWR | 806 | 822 | 835 | 844 | 856 | | | | | | 5 | 1 |
| 13 | TM | Mechanized Track Maintenance & Renewals | 807 | 810 | 819 | 826 | 829 | 838 | 858 | | | | 7 | 2 |
| 14 | CM | Contract Managemen | 801 | 817 | 848 | | | | | | | | 3 | 1 |
| 15 | FSB | Fabrication of Steel Bridges & PSC construct | 814 | | | | | | | | | | 1 | 2 |

IRTMTC BREAK