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ज्ञान ज्योति से मार्गदर्शन

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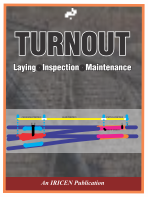
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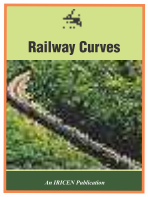
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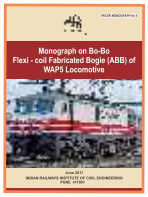
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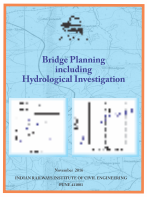
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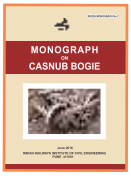
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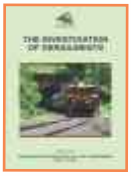
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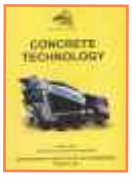
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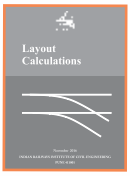
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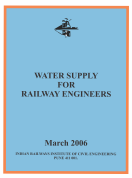
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from director's desk

Dear Readers,

This edition of journal is brought after the euphoria of 61st IRICEN Day celebration; an annual event. This celebration was graced by Shri Vishwesh Chaubey, Member Engineering, Railway Board and Shri Pradeep Kumar, Director General, National Academy of Indian Railways. During this, distinguished probationary officers of 2014 batch were awarded with medals etc.. A seminar on “Streamlining of project and delivery mechanism and Infrastructure maintenance preparing for next level” was conducted in which IRSE officers of 1992 batch presented the papers who have completed their 25 years of service.

In this edition, apart from regular features, 3 papers are included. One paper shares the challenges faced in construction of steel and concrete composite bridge in hilly region. Authors discussed about techno-economics and managerial aspects related to slip-form shuttering, launching of girder by push and pull method and other problems faced during execution and solution thereof.

In another paper, author discussed about the time dependent stress in RCC column visa-a-vis Indian Code and concluded that the underestimation of stress at initial stage need to be taken care. The third paper brought out issues related to noise and vibration due to Metro Railway in populated areas and the efforts taken by Bangalore Metro to mitigate noise related problems.

As always the IRICEN Journal has offered informative and thought provoking articles. The readers may find it useful and are welcome to share their suggestions as well as articles/papers for forthcoming issues of this journal.

My all the best wishes for New Year-2019.

(Ajay Goyal)
Director

Pune
1st January 2019

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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.

Prime Minister Inaugurates the Longest Rail-Cum-Road Bridge Constructed over Brahmaputra River in Assam



Hon'ble Prime Minister of India Shri Narendra Modi inaugurated the India's longest Road-cum-Rail bridge "Bogibeel Bridge" at Dibrugarh in Assam today i.e. the 25th December 2018.

Bogibeel Rail-cum-Road Bridge over River Brahmaputra is situated 17 Km from Dibrugarh City in Assam. Constructed for Double Line Broad Gauge Rail Line and Three lane Road, Bogibeel bridge will be the lifeline of North Eastern part of the country and will facilitate connectivity between North and South Banks of River Brahmaputra in the Eastern region of Assam and Arunachal Pradesh.

Bogibeel Bridge will also enhance the national security of the Eastern region of India by facilitating swift movement of Defence Forces and their equipment. Government of India has given utmost importance to this Bridge declaring it a National Project in the year 2007.

Bogibeel bridge will provide a connection between the Rangia-Murkongselek section of the North East Frontier Railway on the north bank of Brahmaputra and Lumding–Dibrugarh section that lies to the south of the Brahmaputra. Dibrugarh Railway Station, the largest in the region is to be linked to the Rangia – Murkongselek line via Chaulkhowa and Moranhat. The Railways have also initiated the gauge conversion of the Dhamalgaon to Sisiborgaon rail line to the north of the bridge and commissioned the 44 km Chalkhowa – Moranhat line to the south.

The remote districts of Anjaw, Changlang, Lohit, Lower Dibang Valley, Dibang Valley and Tirap of Arunachal Pradesh will be greatly benefited by this Bridge. Almost 75 percent of the 4000-km long border that India share with China is in Arunachal Pradesh and the bridge will help in logistical support for Indian Army manning this border.

With commencing of the bridge the Road distance from Dibrugarh, in Assam to Itanagar will be reduced by 150 km and the railway travel distance between these two points will be reduced by 705 km. Bogibeel Bridge Project was a part of Assam Accord 1985 and was sanctioned in the year 1997-98.

The foundation stone of the Project was laid by the then Prime Minister of India, H D Deve Gowda on January 22, 1997 and work commencement of the Project work was done by Prime Minister of India, Atal Bihari Vajpayee on April 21, 2002. The bridge has a total length of 4.94 km (revised from 4.31 km). The sanctioned estimated cost of the Project was Rs. 3230.02 Crores. Revised estimate of the project amounts to Rs. 4,857 Crores which has been approved and sanctioned by the Railway Board to cover escalation and increased bridge length.

The design of Bogibeel bridge has 39 spans of 125 m and a superstructure of composite welded steel truss and reinforced concrete. It is designed to carry a double line 1,676 mm(5 ft 6 in) broad gauge railway on the lower deck and a 3-lane road on the upper deck. Upon completion it will be the longest combined rail and road bridge in India and second longest bridge over the Brahmaputra after Dhola-Sadiya Bridge which is a road bridge of length 9.15 km.

New Intercity Express trains via Bogibeel Bridge to be introduced by N.F. Railway

With the proposed inauguration of the much awaited Bogibeel bridge over river Brahmaputra, N.F. Railway plans to introduce two new Intercity Express trains connecting Tinsukia and Naharlagun via the new bridge. While one train will run five days in a week, another will run weekly. The new trains will benefit greatly the people of Arunachal Pradesh and on the north bank of river Brahmaputra. The inaugural special train will run only on 25th December and regular services will start from 26th December as per details given below:

While train no 15908 will leave Naharlagun at 05-30 hrs on every Monday, Tuesday, Wednesday, Friday and Saturday to arrive at Tinsukia at 11-00 hrs, in the return direction train no 15907 will leave Tinsukia at 16-00 hrs on every Monday, Tuesday, Wednesday, Friday and Sunday to arrive at Naharlagun at 21-15 hrs.

On the other hand, train no 15912 will leave Naharlagun at 05-30 hrs on every Thursday to arrive at Tinsukia at 11-00 hrs and train no 15911 will leave Tinsukia at 18-45 hrs on Thursday to arrive at Naharlagun at 00-10 hrs on Friday.

The trains will have stoppages at New Tinsukia, Dibrugarh, Dhamalgaon, Dhemaji, Gogamukh, north

Lakhimpur and Harmuti during jouney on both ways. The train will have one AC chair car and nine second class day coach with sitting accommodation apart from two luggage cum generator car.

On 25th December, the inaugural special train no 05907 will start from Dibrugarh at 11-30 hrs to arrive Naharlagun at 18-45 hrs.

SAIL steel for Bogibeel Bridge

Steel Authority of India Limited (SAIL) has supplied around 35400 metric tonnes of steel for the construction of Bogibeel Road-cum-Rail Bridge on the river Brahmaputra. This quantity is little more than 50% of the total quantity of steel supplied for the bridge.

SAIL has also supplied TMT rebars, plates and structural for this 4.94 KM long bridge,which has composite welded steel truss girders in its structures. Earlier, SAIL had supplied 90% steel for the construction of the Dhola-Sadiyabridge, which is India's longest bridge.

The 4.9 km-long bridge on the Brahmaputra river is Asia's second longest rail-cum-road bridge. It has a serviceable period of 120 years.

Ref: http://www.railnews.co.in

State-of-the-Art Engine-less Train-18 will Run between Delhi and Varanasi soon



Train 18 route confirmed! The state-of-the-art engine-less Train 18 will run between Delhi and Varanasi, Minister of State for Railways Rajen Gohain has confirmed. According to PTI, in a reply to a question in the Rajya Sabha, Gohain said the Delhi-Varanasi route has been proposed for the first Train 18 set. As many as 36 train set coaches have been planned, to be developed during the financial year 2018-2019 at Integral Coach Factory (ICF), located in Chennai, he said. Train 18, the 'Make in India' engine-less train, recently became Indian Railways' fastest train by crossing the 180 kmph mark during its trials. It also suffered damages during its trial run on the Delhi-Agra route recently, with miscreants throwing stones and smashing a window of the train.

Manufactured at a cost of Rs 100 crore, the semi-high speed Train 18 has been undergoing extensive speed and safety trials by RDSO (Research Design and Standards Organisation) and is now ready to be inducted in the Indian Railways fleet of trains. Prime Minister Narendra Modi is expected to flag off the luxury self-propelled Train 18 by end-December. Codenamed after the year it has been manufactured in, Train 18 will get its official name soon, with the Railway Ministry mulling several options.

With automatic doors and sliding footsteps, several aircraft-like features and a whole new semi-high speed propulsion technology, Train 18 will herald a new era in the history of Indian Railways. The train sets have been conceptualised to replace Shatabdi Express trains. The fully air-conditioned chair car train has European-style seats, a swanky pantry and is also disabled-friendly. The advantage of faster acceleration and deceleration will help Train 18 save around 15-20% of the journey time and with no locomotive reversal required the turnaround time would also be reduced.

ICF Chennai has been asked to manufacture two more Train-18 like sets this financial year. The coach factory has said that if tasked with, it can manufacture around 8 such train sets in financial year 2019-2020.

Ref: http://www.railnews.co.in

Western Railway Develops GPS Location Tracking Solution to Determine Speed & Location of Disaster Management Trains



In a series of unique innovations, Western Railway has developed a GPS based location tracking solution to determine the precise location and speed of Disaster Management Trains. The system has been implemented in all Accident Relief Trains (ART),



Accident Relief Medical Equipment (ARME) and Self Propelled Accident Relief Trains (SPART) of Mumbai division of Western Railway. Earlier, it was always a challenge to know the actual location of Relief trains during the movement of Accident Relief Equipment to accident/disaster sites.

According to a press release issued by Shri Ravinder Bhakar – Chief Public Relations Officer of Western Railway, this tracking system provides an automated solution with real time location and speed tracking, recording and traceability. The recording is independent of GSM signals as the tracker obtains the location directly from satellite. The data is from GPS and hence undisputable. The tracking system is installed in all the Accident Relief Trains/Accident Relief Medical Equipment of Mumbai division at Udhna, Valsad, Bandra, Nandurbar.

The system comprises of:

- APT08 vehicle GPS tracker blue
- GPS + LBS(network) dual locating
- Inbuilt Geo-sensor
- Inbuilt Li ion battery(400 mAh)
- 24 V power supply
- Angle data uploads and data storage

The important information that can be derived from this system are, speed and location of the ART/ARME – On Real Time basis, GPS Tracker records location independent of GSM and a replay of actual movement with precise speed-time-location mapping is available later. The location overlap with Google Maps allows determining the closest/fastest road approach. The installation of the system is very simple. It uses a mobile charging point provided in the Rolling Stock. The mobile based app is universally accessible and the tracker should be switched on all times. The installation is not only easy but cost effective too with one time cost of the equipment of Rs.7900 only. With this innovation, Western Railway is truly moving in the direction of Digital India.

Ref: http://www.railnews.co.in

e-Drishti Software to Help Railways Minister and CRB keep Track of Punctuality of Trains

An 'e-Drishti' interface has been unveiled for the Union Railway Minister, Minister of State and Board Members. This software includes an interface which provides summary information on punctuality of trains for the previous day.

There is also an interface which provides information on current train running on the Indian Railway network. In addition, there are interfaces providing details of freight earning, freight loading and passenger earnings for the previous day & month and cumulative for the year, in comparison to the corresponding period of the previous year.

Punctuality of passenger carrying trains is being also monitored rigorously to improve punctuality performance on a daily basis at Divisional, Zonal and Railway Board levels by Divisional Railway Managers (DRMs), General Managers (GMs) and Railway Board Members and senior officers.

To ensure running of trains right time when pairing trains are running late, scratch rakes are inducted and rakes are standardized to the extent operationally feasible.

Also various steps have been initiated to improve punctuality such as prioritization of preventive maintenance of assets to minimize asset failures, capacity enhancement projects by construction of additional loop lines at stations, doubling, construction of third line corridors, automatic signalling, construction of limited height subways to replace level crossings, Road Under Bridges (RUB) and Road Over Bridges (ROB) etc.

Besides, punctuality drives are launched from time to time and staff involved in train operations is sensitized. In addition, Zonal Railways have also been advised to have better coordination with Civil and Police authorities of states to deal with situations arising out of law and order problems.

Using this software, Railway Minister can track any information with just a click of mouse — whether from his office or while on the move. It will also enable Minister to know at any given point of time day's freight and passenger earnings, freight loading and unloading, punctuality, progress of major projects, public grievances, movement of trains across the country, details of railway stations and much more.

It also has been connected with base kitchens of Indian Rail Catering and Tourism Corp (IRCTC) as many complaints comes regarding the quality of food served on trains. Through live video, Minister will be able to monitor the goings on in IRCTC kitchens. It will also provide the live status of reserved and unreserved passengers travelling on trains besides providing the exact location of trains at any point of time.

Ref: http://www.railnews.co.in

Railways to Introduce New System to Tackle Water Shortage in Trains



Water woes on trains will soon be a thing of the past with Indian Railways set to introduce a system which will reduce water filling time from the existing 20 minutes to just five minutes at stations.



The Railways will introduce the system in March next year at 142 stations which have the water filling system for trains. The rail board has sanctioned Rs. 300 crore for the project.

Water in long-distance trains, used in toilets and washbasins, is filled every 300-400 km.

With the use of quick watering system, a 24-coach train can be filled up within five minutes and multiple trains can be simultaneously watered at the same time.

"Earlier the water in the coaches was filled with the help of four-inch pipes. These would now be replaced with six-inch pipes with high power motors and the water would be supplied to the train coaches through a computerised system called SCADA (Supervisory Control And Data Acquisition), designed by RDSO," said Railway Board Member (Rolling Stock) Rajesh Agarwal.

The old pipes did not have enough pressure and took around 20 minutes to fill the tanks with capacity of 1,800 litre of water in a coach, which resulted in shortages.

A senior official of the ministry said the national transporter receives a lot of complaints about inadequate water in coaches and this system would ensure that there will be no water shortage.

He said the ministry has planned to install pumps of 40 horsepower to increase the water pressure.

Ref: http://www.railnews.co.in

Piyush Goyal gives the Railway Top Brass Two Weeks to Come up with Plan for Running 15-Coach Suburban Trains in Mumbai

Railway Minister Piyush Goyal directed that all local trains in Mumbai be turned into 15-coach trains and asked the Central and Western Railway top brass to come up with a timeline for the project within two weeks. At a meeting with senior railway officials at the state guesthouse Sahyadri, Goyal said that such a move will increase the Mumbai local trains' capacity by 25%.

A 12-coach train on the Western Line carries more than 5,500 passengers against its capacity of around 3,000 during the peak rush hours. Having run out of terms to describe the rush, the railways coined a new expression a few years ago — super-dense crush load. What it basically means is 16 people are crammed in just one sq mt of compartment space.

A 15-coach train has the capacity of around 4,200 people and carries more than 7,000 commuters during the rush hours.

Currently, the Western Railway has 105 rakes, of which just five are 15-compartment trains. The Western Railway runs 1,365 services daily, of which the five 15-compartment trains complete 54 services.

The Central Railway, which runs 1,772 services daily on the Mumbai suburban network, including the Main and Harbour lines besides services to Bandra, Andheri and Goregaon, has just one 15-coach train out of its running fleet of 133 rakes (37 rakes are on standby for maintenance).

While the Western Railway is already running an AC local train on its suburban network (a 12-coach train) and is scheduled to get another AC train next month, the Central Railway will get its first AC local in June next year.

Goyal told Mumbai Mirror that he wants the Central and the Western Railway top brass to submit a timeline for the project within two weeks. "We want all local trains in Mumbai to be 15-coach trains. It will increase the capacity of the railways by 25%. First up, we want the fast corridors on both Central line and Western line converted to 15-coach trains. This will be extended to the slow line," the minister said.

Asked about the cost, he said, "For Mumbaikars, money will not be a constraint."

Ref: http://www.railnews.co.in

Indian Railways to Change Track Configurations to Avoid Derailments

Passenger safety is at the forefront of the Indian Railways' (IR's) agenda. To upgrade safety standards for the more than 13,000 passenger trains which ply daily on its 67,000-km-long network, the transporter is going for changes in the configuration of railway tracks. This is over and above the plan to fully mechanise the process of inspection and maintenance of tracks on the trunk route by 2020 and the entire network by 2024.

Even as railway accidents have been an issue of grave concern in recent years, the fact that 56% of the 659 train accidents of the last five years have occurred due to derailment has heightened focus on systemic defects relating to railway tracks. This was borne out in 2017-18 when 4,405 km of track renewal and better maintenance saw the number of accidents fall to 73, the lowest in IR's history.

Integral to a change in the configuration of tracks beginning next year is use of rails with higher ultimate tensile strength (UTS) —a measure of stress that a material can withstand without losing its original shape—, wider and heavier concrete sleepers – rectangular supports beneath the rails –, and a thicker rubber pad between rails and sleepers. As against the present 90 UTS, IR would be opting for rails of 110 UTS, allowing it to operate 25-tonne axle load wagons—the permissible axle load at present is 22.8 tonne. The change in rail UTS would also allow seamless movement of wagons between the network and the upcoming freight corridors that would be operating only 25-tonne axle load wagons.

"The Steel Authority of India (SAIL) and Jindal Steel and Power (JSPL) have been told that the next rail tender would have this requirement and that is why they should be ready to produce such rails. Barring the suburban sections, we will be replacing the rails with those of higher UTS," says a railway official. While SAIL and IR have an agreement for supply of rails, shortage from SAIL's side saw JSPL recently bag an order for 1 lakh tonne rails.

Also being changed is the size of the rubber pad between rails and sleepers that absorbs vibrations caused by train movement. As against the earlier thickness of 6 mm, the new cushions would be 10 mm thick. To strengthen the base of railway tracks, the transporter is going for wider sleepers weighing 350 kg apiece compared to the present 280 kg.

"The railways has been using the same concrete sleepers for the last 40-50 years. We have now changed the design and are opting for wider sleepers which are also heavier," says the official. The new sleepers would make the track structure heavier, allowing movement of heavier and more number of trains. The new sleepers and rails would together make for a more robust and stable frame and check breakages and other problems which often lead to derailments. "From next year onwards, all replacement and fresh sleepers would be of the new design," he adds.

Ref: http://www.railnews.co.in

Jindal Stainless Joins Hands with Indian Railways for Rail Infrastructure Modernisation

The Jindal Stainless partnered with Research Designs & Standards Organisation (RDSO) in the third edition of InnoRail India 2018 here.

With a 60 per cent market share in the coach segment, Jindal Stainless has joined hands with the Railways for additionally modernizing rail infrastructure, particularly in the bridge segment..

"As a progressive organization, RDSO keeps innovating ways and means to build safe and sustainable infrastructure. Stainless steel coaches and foot-over-bridges validate their movement in this direction. Jindal Stainless is proud to partner their journey by expediting conversion of coaches into stainless steel and strengthening rail infrastructure at the same time."

Over the next 4-5 years, Railways plans to produce around 10,000 stainless steel coaches annually.

India has a coastline of 7500 km which necessitates the use of stainless steel infrastructure. High air-borne salts in marine environments cause rapid corrosion and degradation of infrastructure. Bridges, especially in these areas, are exposed to severe risk of collapse. As per industry data, around 1,35,000 rail bridges exist in India, of which over 25 per cent are over 100 years old and need immediate replacement. The first such stainless steel foot-over-bridge is coming at Bhayandar station in Mumbai next year. Though more than 1000 bridges are rehabilitated every year, there is a huge backlog in rebuilding these bridges.

The stainless steel material for wagons and coaches produced by Jindal Stainless is already tested and approved by RDSO, the highest advisory body to the Indian Railways. Apart from supply of stainless steel to Railways, Jindal Stainless also organizes fabrication training programmes at Integral Coach Factories to enhance their output. Other than the conventional coaches which are made out of carbon steel, both, LHB

(Linke Hofmann Busch) and suburban coaches are shifting towards stainless steel.

This shift towards stainless steel, undertaken by Railways, is an initiative in augmenting passenger safety, optimizing lifecycle costs, and building sustainable infrastructure. Stainless steel has high impact resistance, does not get deformed, and can absorb more energy during collision. This prevents loss of life during accidents and mishap. Easy design, fabrication, and reduced life cycle cost give stainless steel an edge over any other metal. Additionally, the inherent properties of corrosion resistance, fire resistance, high strength-to-weight ratio, easy weldability, and speed of construction make stainless steel an ideal choice for coaches and railway infrastructure.

Manufacturing India's Longest Rails

Failure in railway tracks due to fracture of welded joints of rails is one of the largest causes of accidents due to derailments. Using long rails increase the sustainability of railway infrastructure and mitigate accidents and loss of life.

For this reason JSPL has innovated to manufacture the longest rails in India. The country's longest rail length of 121 metres is being rolled at JSPL's Raigarh manufacturing plant site. In the plant site itself these rails can be further welded together to create 484 meter long rails that are then transported to the rail track location.

Further strict chemical composition control and reduction of dissolved gases to very low ppm levels produces superior quality steel of Head Hardened Grade (Grade 1080) suitable for the rolling of our rail tracks.

Some additional advantages of longer rail lengths:

Reduces the number of welding points at the railway track location. Welding of rails at the railway track location is more difficult to do than welding of rails in the plant.

Operations at our Raigarh plant is executed with the following special systems and equipment to guarantee maximum product integrity:

- Specialized system for flash butt welding into rails of upto 480mtrs length.
- Synchronized monorail hoist system for and handling and loading of long rails.
- Specialized rakes for transfer of long rail panels to site.
- No drilling in the rails is necessary for loading & unloading process.
- High security against tilting of trains.
- Deforming strain under admissible limits during handling & transportation.
- The testing of welded joints is done at our Raigarh plant itself.

Ref: http://www.railnews.co.in

Train 18, India's First Engine - Less Train



Case Study on Construction of High-Rise Steel Concrete Composite Girder Railway Bridges in Barkakana – Ranchi New BG Line Section

By
Sitesh Kumar Singh* and Lakhan Lal Meena**

Abstract :
In hilly regions, construction of new railway line requires construction of major bridges with high rise piers with different types of superstructure to suit the design requirements. Hollow circular piers and steel composite girder superstructure bridges are commonly adopted due to ease in design, construction and maintenance. Launching scheme of girders is decided based on technical feasibility, time and economic considerations. Local factors like land availability, approach road, availability of blasting materials, foundation and soil stabilization, forest cover, law and order problems, weather, forest insect bites etc. play a vital role in execution of projects. In the present study, the objective is to share the challenges faced in construction of new steel concrete composite railway bridge in hilly terrain.
Keeping above objective in mind, a case study has been presented newly constructed steel concrete composite girder bridge at km172.105 (span 8x30m, maximum height of pier = 55m) between Barkakana and Ranch stations of Koderma Ranchi new Broad-Gauge (BG) railway line project. Slip form shuttering has been used for faster & quality construction of piers. Launching of steel girders has been done by road cranes instead of cantilever pull and push method to save time. Law and order problems faced from militant outfit, Maoist Coordination Committee (MCC) were tackled. Problem of biting by honey bees just after launching of steel girders was tackled by use of special chemicals. From the study, it has been observed that much faster construction can be accomplished by use of slip form shuttering for piers and deploying high capacity road cranes for launching of girders. Techno-economic comparison of launching by road crane versus push and pull method has been presented.

1.0 Introduction & Objective

Construction of new railway lines through hilly regions is a challenging task. In such regions, construction of bridges with high rise substructures becomes inevitable. The challenges in constructing such bridges involve approach road, foundation in rocky strata, modern shuttering for faster construction, ensure quality control, viable super structure, appropriate launching scheme, safety and security concerns, rough weather, economy etc.

Construction of 8 out of 11 numbers of steel composite bridges have been completed so far between Barkakana and Ranchi stations (63 kms) of East Central Railway, details of which have been tabulated in Table-1.

From the table, it can be seen that these bridges have standard spans of 18.3 metres and 30.5 metres each. The maximum height of pier is 55 metres. On the basis of experienced gained in construction of these bridges, a case study has been presented in this paper on bridge at km172.105 (span = 8x30.5m Composite girder, maximum height of pier = 36.5m) (Fig.1(a) & 1(b)).

Table-1 List of composite girder bridges between Barkakana and Ranchi

S. No.	Location (Km from Koderma)	Span	Nature
1	145.970	2x18.3m	10m wide nullah crossing
2	152.650	6x30.5m	Viaduct
3	160.360	6x30.5m	Viaduct
4	171.010	9x30.5m	Viaduct
5	172.105	8x30.5m	Viaduct
6	174.560	3x18.3m	10m wide nullah crossing
7	175.659	4x18.3m	30m wide nullah crossing
8	178.238	7x30.5m	Viaduct
9	182.238	3x18.3m	16m wide nullah crossing
10	193.045	4x18.3m	70m wide Jumar river
11	193.942	4x18.3m	68m wide Swarnarekha river

** Chief Engineer/Construction\South East, Eastern Central Railway, Patna*
*** Dy. Chief Engineer/Construction, Eastern Central Railway, Barkakana*



Fig.1(a): U/s view of bridge at km 172.105



Fig.1(a): D/s view of bridge at km 172.105

Salient features of composite bridge at km 172.105 are as under:

- Foundation – Isolated open footing 2.5m embedded in rock & 1.5m rock bolted, due to rocky strata.
- Abutment – Spill-through with fly wing joined by cross-slab at every 6m, due to high pier and economy. Maximum height of abutment 26.941m from raft.
- Piers – Hollow circular piers (Internal dia = 3 to 3.8m, Outer dia = 4 to 5m) joined by diaphragm at every 10m intervals, for economy & speedy construction
- Shuttering – Slip form shuttering for faster construction
- Superstructure – Steel plate girder with reinforced concrete deck
- Bearings – Elastomeric bearings
- Track structure – PSC sleepers with 60kg rail in 1-degree curve
- Geometric control – Total station

The details have been summarised in Table-2.

Table-2 Summary of dimensional details (In metres)

S. No.	Structure	Raft size	Ext.dia	Int. dia	Th. of Diaphragm	Height (from raft)	Height (from OGL)	Bed block size	Overall height (up to Pedestal)
1	A1	15x8.3x2.5	-	-	0.8	22.291	11.221	1.85x7x2	26.941
2	P1	12x12x2.5	4.5	3.5	0.5	27.067	17.577	4.5x8.45x2	31.717
3	P2	12x12x2.5	4.5	3.5	0.5	27.071	23.057	4.5x8.45x2	31.721
4	P3	12x12x2.5	4.5	3.5	0.5	25.571	18.614	4.5x8.45x2	30.221
5	P4	12x12x2.5	4.5	3.5	0.5	25.460	20.832	4.5x8.45x2	30.110
6	P5	12x12x2.5	4.5	3.5	0.5	27.571	22.088	4.5x8.45x2	32.221
7	P6	13x13x2.5	5	3.8	0.5	32.166	18.608	5x8.45x2	36.816
8	P7	9x9x2	4	3	0.5	17.071	8.639	4x8.45x2	21.221
9	A2	11x8x2.5	-	-	0.8	13.121	6.927	1.85x7x2	17.771

Note: - For Overall depth from Rail Level add 4.0m (3.3m for girder & Slab + 0.7 for P. way)

The study of the above bridge is of utmost importance not only from the techno-economic considerations but would give a foresight to the engineers in decision making for construction of such bridges in future.

2.0 Methodology Adopted For Execution

The project is shared with Govt. of Jharkhand and Railways on 50:50 basis. Therefore, for faster construction, the following two methodologies were adopted for this project:

2.1 Use of Slip form shuttering for piers instead of conventional steel shuttering. Slip form shuttering during execution has been shown in Fig.2(a) & 2(b). This is the state-of-the-art shuttering method and requires adequate expertise and precision during execution.



Fig.2(a) Slip form shuttering being adjusted



Fig.2(b) Slip form shuttering in use

The advantages and disadvantages of slip form shuttering have been listed below:

2.1.1 Advantages of Slip form shuttering

i) **Fast & Smooth progress of work -** Manual process of work is time consuming & cumbersome like change of shuttering, extension of scaffolding, making working platform again & again, difficulty in lifting of concrete etc. whereas slip form shuttering process gives fast and smooth working.

ii) **Safe at height -** Platform of slip form shuttering provides adequate space of smooth work at height where as in manual method provides user space which is inconvenient & unsafe for working at height.

iii) **Easy to work at height -** Slip form shuttering is very easy as it does not require change of shutter, no need of scaffolding, making one time working platform and lifting of concrete through axis tower etc.

iv) **No need of scaffolding -** This process of concreting does not require scaffolding as this is performed under jacking method. Manual method of work requires tedious scaffolding repeatedly up to required height and making platform at every extension of scaffolding. In case of manual method work it is required to make scaffolding work inside the hollow pier & removal of shuttering and scaffolding becomes very difficult, especially removal of inside scaffolding. But slip form concreting work does not require this tough work.

v) **Easy concreting -** In manual process, concreting becomes tedious with rising of height, but slip form method concreting provides easy passage for man to man from bottom to top easily. It provides easy path for lifting of concrete pipes through its axis tower.

2.1.2 Disadvantages of Slip form shuttering

i) **Removal of shuttering before final setting of concrete -** Shuttering is required to slip to its next height of concreting level after initial setting time.

ii) **Time taking process in starting of slip form -** Assembling of initial segment of shutter, fixing of working platform, insertion of jack etc. takes more time.

iii) **Leakage of hydraulic oil from jack -** Sometimes leakage of hydraulic oil takes place and it spills on to the concrete which affects bonding.

iv) **Difficulty in slipping slip form on mid cross slab/diaphragm -** It becomes impossible to cross over mid slab/diaphragm without removing and reassembly of slip form shutter. Slipping of slip forms can be done by chipping method which harms tensile strength of slab/diaphragm reinforcement bars.

v) **Extra use of reinforcement bars as stuffing -** Extra reinforcing bars are required as stuffing through jacks in slip forms for slipping from bottom to top of structure which is extra cost and use less of concrete structure.

vi) **Uneconomical for less volume of concrete –** For less quantity of concrete, this form of shuttering works out uneconomical.

2.2 Use of road cranes for launching of girders instead of Push & pull method or cantilever launching method. Two cranes of 150 tonne and 200 tonne were used in tandem to launch these girders. One 300 tonne capacity crane was also hired but could not reach the site due to difficult approach road. Due to high piers (Fig.3) and limited boom

height of cranes, earthen platforms of varying heights were made to facilitate crane working as shown in Fig.4.



Fig.3 Showing pier height



Fig.4 Earthen platforms for crane working

The launching of girders has been shown in Fig.5(a) & Fig.5(b).



Fig.5(a): Launching by cranes in tandem



Fig.5(b) Another view of launching by cranes

The detailed breakup of cost incurred and time taken for launching for this bridge has been tabulated in
Table - 3 & Table - 4 respectively.

3.0 Observations in Launching of Girders

The breakup of actual cost incurred for launching of 8x30.5m plate girders of by Push and pull method and by road crane has been tabulated in Table-3.

Table-3 Comparison of cost for launching of 8x30.5m composite girder (Rs. in lakhs)

Pull and Push method		**Crane**	
Preparatory works	5.00	Cost on account of making access to crane	4.10
Laying of Sleepers, rails etc.	5.00	Cost on account of Skilled/ semi-skilled man power. 5 nos Skilled labour@700/day = 3500/day. 10 nos semi-skilled labour@ 500/day = 5000/day	1.02

to be contd....

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Pull and Push method		Crane	
Cost of equipment like- Winch, ropes, pulley etc.	20.00	Cost of Earth filling of making a level bed	5
Labour charges for lowering & placing in position	30.00	Daily Diesel consumption cost for- (a) 200 MT crane @30000/day (b) 150 MT Crane @24000/day	14.58
Gross cost	60.00	Hire charges for (a) 200 MT crane @ 18.00 lakh/month & (b) 150 MT crane @ 14.00 lakh/month	28.80
Less, Salvage for M/C, tools etc. @ 17%	10.00	Cost of steel plates & wooden sleepers etc. for packing	1.50
		The cost of crane transport from Delhi to work site and back @ 28 lakh	28.00
Net expenses (Rs. in lakhs)	**50.00**	**Total cost (Rs. in lakhs)**	**83.00**
Therefore, cost per MT (In Rs.)	**7800**	**Therefore, cost per MT (In Rs.)**	**12800**

From the above table, it can be seen that only 50 lakhs were incurred in launching of girders by Push & pull method against 83 lakhs for launching by road cranes.

The breakup of time consumed in launching of 8x30.5m plate girders by Push and pull method and by road crane has been tabulated in Table-4.

Table-3 Comparison of cost for launching of 8x30.5m composite girder (Rs. in lakhs)

Pull and Push method		Crane	
Preparation of embankment beside abutment (100m x 12m)	7	Preparation of base level (platform) for crane operation	15
Laying of sleepers (@ 600 mm c/c)	7	Preparation of access road parallelly transportation of crane to site	7
Placement of rails, fastening & alignment	3	Launching of girder @ 1 span/day + Shifting	8
Assembly of girders over bearing/ rollers (3 span to start units)	21	of crane	4
Placement of winches, ropes, connecting etc. is parrallel activity which shall take- 3 weeks			
Total length for which girders is to be pulled = 8x30.5 = 260 m. Average rate of pull @ 8 m = 260/8 = 33days	33		
Time required for assembling & travelling each span =7 days For remaining 5 spans = 5x7 = 35 days	35		
Lowering down & placing in position	21		
Total time (days)	**127**	**Total time (days)**	**34**

From the above table, it is seen that 127 days is taken for launching of girders by Push & pull method whereas only 34 days are required for launching of girders by road crane.

Based on the experience gained, a general comparison of launching of girders by Push & pull method versus by road crane has been summarised in Table-5.

Table-5 Overall comparison of launching of girders by Push & Pull method v/s crane

S.No.	Pull and Push method	Crane
1	Traditional & time tested	Modern method
2	Can be used at all the bridge locations	With the advent of hydra and telescopic high capacity crane, this modern method is being used in India since last 15 years
3	Is the only method which can be used for launching girders at any height	Has limitations with height of piers Availability of crane of higher capacity is less
4	Tools and material required for this method is easily available	
5	Transportation of tools & M/C is easier	Difficult to transport the crane in remote and non-motorable roads
6	No special access road is required for transporting	Substantial amount of money is required to make access road and working platforms due to large turning radius & heavy counter weight
7	A working platform of at least 2.5-3 length of the span of girder to assemble at least 3 girder lengths is required before starting of launching of girder	Not required
8	Substantial material viz. Sleepers, rails, locks, PTFE sheets, winch, ropes, rollers, connecting member as per design to connect girders, forward nose, arrangements to roll over girder etc. is required	Not required
9	Rate of Pushing/Pulling is slow i.e. @ 5-8 m/day can be achive	Takes much less time to launch a girder, can be launched one span/day easily
10	Overall cost of launching is low	Overall cost of launching is high
11	Launching can be started only when the approaches is completed	Launching can be done even if approach embankment beside abutments is not ready
12	Skilled manpower of about 70-80 nos is required for operation	Skilled operating staff for crane and less nos of skilled worker is required for placements (10-12 nos)
13	This method can be used for all types of steel superstructures, viz. bow string girder, open-web girder, plate girders etc.	Launching of girder by crane can be used for plate and composite girders
14	This method cannot be used for bridges in curves	This method can be used for bridges in curves as well

4.0 Problems Faced During Execution & Remedial Measures

Various problems were faced during execution of this bridge and have been mentioned below:

4.1 **No approach road** – The site is situated in hilly forest area with scarce population and as such there was no approach road. Approach road were made for plying of vehicles.

4.2 **Rough weather –** The weather in this forest region changes frequently with spell of rains. The roads get washed out and soil become slippery making it difficult to approach site. Weather pattern was studied and activities were planned accordingly.

4.3 **Height of work space -** Labourers were unwilling to work for deck casting of concrete due to height and wind velocity. They frequently left the work site. Local labourers were trained for specific jobs.

4.4 **Frequent law & order problems –** This region

has substantial presence of Maoist Communist Centre of India (MCC) and other militant groups who intermittently called bandhs and disrupted ongoing works in this area. In one of the bridge sites, MCC burnt contractor's machineries worth Rs. 7 crores. The work progressed by providing dedicated police camp by Jharkhand Govt.

4.5 Delay in supply of detonators – The progress of work hampered due to short supply of detonators due to fulfilment of stringent mandatory provisions. The detonators had to be used within 72 hours of supply. There is only one licensed supplier in Ranchi district. However, some detonators were procured from adjoining districts.

4.6 Uneconomical cost of deck concreting – The cost of deck concreting is same for concreting at such a height though quantity of concrete involved is less, making it uneconomical. Contract provisions need to cater to this economics.

4.7 Poisonous insects and snakes – Due to poisonous insects & snakes in this section, labourers, particularly, skilled manpower for reinforcement binding frequently left the contractor's camps**.** Special chemicals were used as precautionary measures along with first aid arrangements.

4.8 Problem of poisonous honey bees – Just after launching of steel girders, honey bees made their beehive on underside of the girders making it difficult for the labourers to work. Special chemicals were used to get rid of honey bees

5.0 Conclusion

From the above deliberations, it is concluded that

- For high piers, slip form shuttering should invariably be used.
- When time is the constraint, launching by road crane is the best option subject to feasibility at site.
- When cost is the constraint, launching by traditional Push & pull method is economical. This method can be used for all types of girders.
- Launching by road crane is not suitable for truss bridges.
- For long lead works, locally available manpower may be trained to carry out skilled jobs.
- At militant infested work sites, it is better to arrange police camps in advance for smooth progress of work.
- Special chemicals under skilled supervision can be used to tackle problems of poisonous snakes/ insects/bees.

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■■■

Many hands make light work

When many people work together to accomplish a difficult task, it doesn't seem so difficult. That is the general meaning of this proverb. In other words, if people work together, the work is easier and is completed more quickly.

An apple a day keeps the doctor away

Since apples are rich in vitamin C – which is vital to our health – this proverb means that proper nutrition contributes to good health and fewer visits to the doctor. In this proverb, apples are a symbol of healthy foods and proper nutrition.

Time Dependent Stresses in Reinforced Concrete Rectangular Columns – A Review of Indian Bridge Codes

By
R.Sundaresan*

Abstract :
After the introduction of Limit States Method in the Indian Railway Bridge Code in the year 2004, all the new Railway Bridges were designed for the Ultimate Strength at time of Collapse and also checked mainly for the Stresses and crack width in service based on the limitations stipulated in the Code. In 2011, the Indian Road Congress revised the Code for the design of Road Bridges based on the Limit States Method. This paper is a review for the calculation of time dependent stresses in RC cracked columns following the above Codes for the design of bridges.

1.0 Introduction:

The time dependent deformation observed in reinforced concrete members under the sustained loading condition is generally known as creep. The strain in concrete increases to two to four times the elastic strain due creep in concrete. The embedded reinforcement steel bars do not have the property of creep. The interaction between the creeping concrete and non creeping reinforcement bars leads to the modification of stresses in concrete and reinforcement steel bars. Shrinkage is another time dependent phenomena which will also cause additional strain in concrete. But shrinkage strain is not dependent on the initial stress in concrete. The necessity for this study and the methodology for the calculation of additional stresses are presented below.

1.1 Need for the Review:

The Indian Railway Bridge Code1 uses the empirical modular ratios of 280/*fck*, and 420/*fck* for the tension zone and compression zone to account for the effects of creep and shrinkage. The IRC:112-20112 provides for the Effective Modulus Method for calculating the time dependent stresses. Hence, it becomes necessary to study the effects of creep and shrinkage based on the above two codes for checking their reliability in the prediction of safe working stresses.

1.2 Limitation and possible extension of the work:

For the work of this review, a cracked rectangular Reinforced Concrete (RC) column subjected to an axial load and uniaxial bending is considered. The procedure for analysis for the time dependent stresses to be demonstrated in this paper can be easily extended to the analysis of RC rectangular beam by equating the external axial load to zero for determining the depth of neutral axis and also for the initial strain and curvature at the reference axis shown in Fig.1.

2.0 Distribution of strains and stresses:

The cross section of RC column and distribution of strain across the depth is shown in Fig.1. The strain at any depth, 'y' from the reference point is given by Eq.(1)

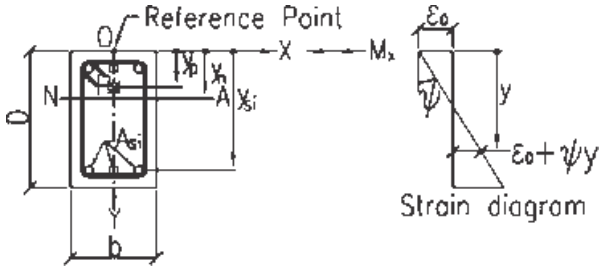


Fig. 1: Section of column and distribution of strain along depth

$e = e0 + y\ y$ Eq. (1)

where e0 = strain at any reference point

y = strain gradient, and

y = distance from reference point

Hence the stress in concrete can be expressed as

$s_c = E_C (e_0 + \psi y)$ Eq. (2)

where E_c = elastic modulus of concrete

Similarly, the stress in reinforcement steel can be found as

$s_c = E_s (e0 + y\ y)$ Eq. (3)

where E_s = elastic modulus of rebars

3.0 Methodology for calculation:

The four analysis steps suggested in Ghali A, et. Al[3] is used in this paper for calculating the time dependent stresses as described below.

* SSE/Drg., CAO/CN/O/MS, S.Rly.

Step 1. Apply the dead load or other bending moment, which becomes effective at the initial time of loading, on a transformed section composed of A_c plus aA_s. The distribution of strain is shown in Fig.2.

$$\begin{Bmatrix} N \\ M \end{Bmatrix} = E_c(t_0) \begin{pmatrix} A_{tr} & B_{tr} \\ B_{tr} & I_{tr} \end{pmatrix} \begin{Bmatrix} e0(t_0) \\ y(t_0) \end{Bmatrix} \qquad \text{Eq. (4)}$$

Where A_{tr}, B_{tr}, I_{tr}, are the area, first moment of area and second moment of area of transformed section respectively. The following equations, Eq.(5a) and Eq.(5b) are used to determine $e_0(t_0)$ and $y(t_0)$ which define distribution of the instantaneous strain.

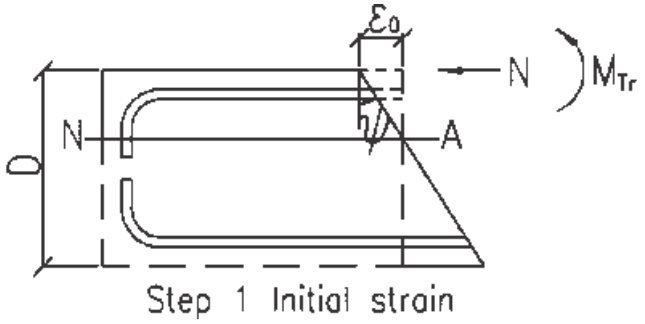


Fig. 2: Column under initial loading

$$\varepsilon_0(t_0) = \frac{(I_{tr}N_0 - B_{tr}M)}{(E_C t_0)\,[(A_{tr}I_{tr}B_{tr}^2]} \qquad \text{Eq. (5a)}$$

$$\psi(t_0) = \frac{(-B_{tr}N + A_{tr}M)}{(E_C t_0)\,[(A_{tr}I_{tr}B_{tr}^2]} \qquad \text{Eq. (5b)}$$

On substituting the values of $\varepsilon_0(t_0)$ and $\psi(t_0)$ in Eq.(2) and using the initial elastic modulus of concrete, , we can calculate the stress in concrete E_C-(t_0) at time of initial loading. Similarly, using Eq.(3) and Young's modulus of steel E_S, the initial stress in reinforcement bars can be found.

Step 2. Determine the hypothetical change, in the period to t, in strain distribution due to creep and shrinkage if they were free to occur. The strain change at O is equal to $[\varphi(t,t_o)\,\varepsilon_0(t_0)+\varepsilon_{CS}]$ and the change in curvature is $[\varphi(t,t_o)\,\psi_0(t_0)]$. The above free creep and shrinkage is shown in **Fig.3.**

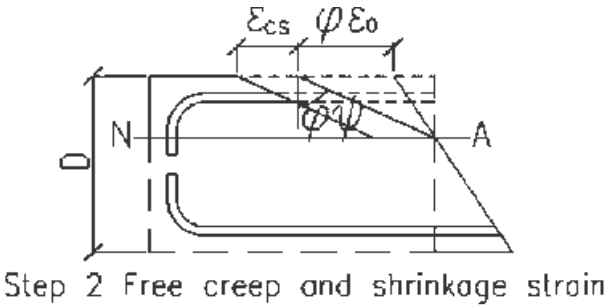


Fig. 3: Column under free creep and shrinkage strain

Step 3. Calculate artificial stress which, when gradually introduced on the concrete during the period t_0 to t, will prevent occurrence of the strain determined in step 2. The restraining stress is given by Eq.(6). The Fig.4 shows the restraining stress in concrete and the resultant forces at the level of reference axis.

$$\Delta\sigma_{res} = -\bar{E}_c\{\varphi(t,t_0)[\varepsilon_0(t_0)+\psi(t_0)y]+\varepsilon_{CS}\} \qquad \text{Eq. (6)}$$

where $\bar{E}_c = \dfrac{\bar{E}_c}{(1+\varphi(t,t_0))}$ and $\varphi(t,t_0)$= creep coef.

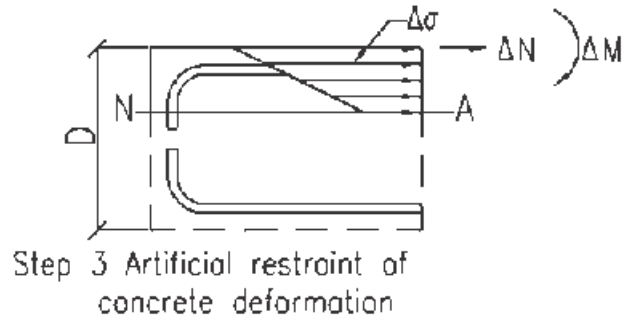


Fig. 4: Column under restraining stress to creep and shrinkage strain

Step 4. Determine by the following, a force at O and a moment, which are the resultants of $\Delta\sigma_{res}$.

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix} = \bar{E}_c(t,t_0) \begin{pmatrix} A_c & B_c \\ B_c & I_c \end{pmatrix} \begin{Bmatrix} \varphi(t,t_0)+\varepsilon_0(t_0)+\varepsilon_{CS} \\ \varphi(t,t_0)\psi(t_0) \end{Bmatrix} \text{ Eq. (7)}$$

Where A_c, B_c, and I_c are respectively the area, first moment and second moment of compression zone alone. ε_{CS} is the shrinkage strain in concrete.

The change in forces denoted by ΔN and ΔM are the artificially induced restraining normal force and the couple which are required to prevent, the change in strain due to creep and shrinkage. The following equations Eq.(8) and Eq.(9) are used to find the above forces.

$$\Delta N = \left\{ \bar{E}_c(t,t_0) \begin{pmatrix} A_c\{\varphi(t,t_0)\varepsilon_0(t_0)+\varepsilon_{CS}\}+ \\ B_c\varphi(t,t_0)\psi(t_0) \end{pmatrix} \right\} \qquad \text{Eq. (8)}$$

$$\Delta M = \left\{ \bar{E}_c(t,t_0) \begin{pmatrix} B_c\{\varphi(t,t_0)\varepsilon_0(t_0)+\varepsilon_{CS}\}+ \\ I_c\varphi(t,t_0)\psi(t_0) \end{pmatrix} \right\} \qquad \text{Eq. (9)}$$

To eliminate the artificial restraint, apply $\{\Delta N, \Delta M\}$ in reversed directions as shown in Fig.5 on transformed section composed of plus ; calculate the corresponding changes in strains by the Eq.(10).

$$\begin{Bmatrix} -\Delta N \\ -\Delta M \end{Bmatrix} = \bar{E}_c(t,t_0) \begin{pmatrix} \bar{A}_{tr} & \bar{B}_{tr} \\ \bar{B}_{tr} & \bar{I}_{tr} \end{pmatrix} \begin{Bmatrix} \Delta\varepsilon_0(t,t_0) \\ \Delta\psi(t,t_0) \end{Bmatrix} \text{ Eq. (10)}$$

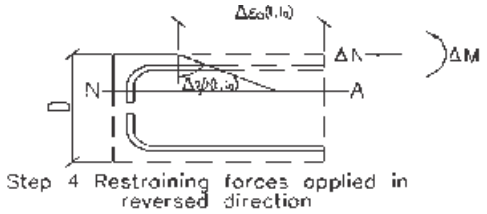


Fig. 5: Column under restraining forces applied in reversed direction

In Eq.(10) $\bar{A}_{tr}$, $\bar{B}_{tr}$, $\bar{I}_{tr}$, are respectively the area, first moment and second moment of transformed compression zone at time, t.

From the above equation the changes in strain and strain gradient at the reference point can be calculated as

$$D\varepsilon_0(t,t_0)= \frac{(-\bar{I}_{tr}\, DN+\bar{B}_{tr},\, DM)}{\bar{E}_C\ (t,\ t_0)[\bar{A}_{tr}\,\bar{I}_{tr}-\bar{B}^2_{tr}]} \qquad \text{Eq. (11)}$$

$$D\psi\,(t,t_0)= \frac{(\bar{B}_{tr}\, DN-\bar{A}_{tr}\, DM)}{\bar{E}_C\ (t,\ t_0)[\bar{A}_{tr}\,\bar{I}_{tr}-\bar{B}^2_{tr}]} \qquad \text{Eq. (12)}$$

Once $D\varepsilon_0(t,t_0)$ and $D\psi\,(t,t_0)$ are known we can calculate the change in stress in concrete by Eq.(13).

$$\Delta\sigma_C=\Delta\sigma_{res}+\bar{E}_c[\Delta\varepsilon_0+y\Delta\psi] \qquad \text{Eq. (13)}$$

In a similar manner, the additional stress in reinforcement steel bars can be obtained by Eq.(14)

$$\Delta\sigma_S=E_S=[\Delta\varepsilon_0+y\Delta\psi] \qquad \text{Eq. (14)}$$

4.0 Application of four analysis steps:

The initial and time dependent stresses in concrete and reinforcement steel bars can be calculated from the following.

4.1 Calculation of neutral axis at the time of initial loading:

Since the reference point is taken at extreme compression fibre, the given bending moment is to be transferred to this point by Eq.(15)

$$M_{Tr}= M+N\left[\frac{D}{2}\right] \qquad \text{Eq. (15)}$$

Taking the stress in extreme compression fibre of concrete as $_C$ and depth of neutral axis as y_n, the axial and bending capacities of the column can be arrived and equated to given axial load and bending moment due to permanent loads as given below by Eq.(16) and Eq(17)

$$\sigma_C\left\{\frac{by_n}{2}+\alpha\sum_{i=1}^{n_s}A_{si}\left(1-\frac{y_{si}}{Y_n}\right)\right\}=N \qquad \text{Eq. (16)}$$

$$\sigma_C\left\{\frac{by^2_n}{6}+\alpha\sum_{i=1}^{n_s}A_{si}Y_{si}\left(1-\frac{y_{si}}{Y_n}\right)\right\}=M_{Tr} \qquad \text{Eq. (17)}$$

In the above equations, ns is the number of reinforcement bars. On dividing the Eq.(17) by Eq.(16) and rearranging the terms we can find the following equation in terms of yn from which the depth of neutral axis can be calculated by trial and error using any numerical method like bisection method

$$\frac{\left\{\frac{by^2_n}{6}+\alpha\sum_{i=1}^{n_s}A_{si}\left(1-\frac{y_{si}}{y_n}\right)\right\}}{\left\{\frac{by_n}{2}+\alpha\sum_{i=1}^{n_s}A_{si}\left(1-\frac{y_{si}}{y_n}\right)\right\}}-\frac{M_{Tr}}{N}=0 \qquad \text{Eq. (18)}$$

4.2 Sectional properties of RC rectangular columns at time of initial loading, t_0:

The sectional properties of effective concrete section alone and transformed sectional properties of the column can be calculated as

$$A_C = by_C;\ A_{tr}= A_C+\alpha\sum_{i=1}^{n_s}A_{si} \qquad \text{Eq. (19a)}$$

$$B_C = \frac{by^2_n}{2}\ ;\ B_{tr}= B_C+\alpha\sum_{i=1}^{n_s}A_{si}Y_{si} \qquad \text{Eq. (19b)}$$

$$I_C = \frac{by^2_n}{3}\ ;\ I_{tr}= I_C\ +\alpha\sum_{i=1}^{n_s}A_{si}Y_{si} \qquad \text{Eq. (19c)}$$

where b is the breadth of RC rectangular column, Y_n is the depth of neutral axis from the extreme compression fibre and α is the ratio of Young's modulus of steel to the initial modulus of concrete.

4.3 Calculation of stresses at time of initial loading, t_0:

Having found the depth of neutral axis, Y_n from Eq.(18) and sectional properties from Eq.(19a), Eq.(19b), and Eq.(19c), the initial strain and strain gradient, $\psi(t_n)$ can calculated from Eq.(5). The stress in concrete and reinforcement steel bars can be found from Eq.(2) and Eq.(3) respectively from the above values and using the appropriate values of modulus of concrete and steel.

4.4 Sectional properties of rectangular columns at time, t:

The modified modulus of concrete and modified modular ratio considering the effect of creep can be found by

$$\bar{E}_C= \frac{E_C}{(1+\varphi(t,\ t_0))}\ ; \qquad \bar{\alpha}= \frac{E_S}{E_C} \qquad \text{Eq. (20)}$$

The sectional properties of effective concrete alone and transformed sectional properties modified to take care of creep of concrete in the column are given Eq.(21a), Eq.(21b) and Eq.(21c).

$$A_C = by_n ;\ \bar{A}_{tr} = A_C + \alpha \sum_{i=1}^{n_s} A_{si} \qquad \text{Eq. (21a)}$$

$$A_C = \frac{by_n^2}{2} ;\ \bar{B}_{tr} = B_C + \alpha \sum_{i=1}^{n_s} A_{si} Y_{si} \qquad \text{Eq. (21b)}$$

$$I_C = \frac{by_n^2}{3} ;\ \bar{I}_{tr} = I_C + \alpha \sum_{i=1}^{n_s} A_{si} Y_{si}^2 \qquad \text{Eq. (21c)}$$

4.5 Restraining stress to the free creep and shrinkage:

The restraining stress in the concrete section against the free creep and shrinkage can be written as

$$\Delta\sigma_{res} = -\bar{E}_c \{\varphi(t,t_0)[\varepsilon_0(t_0)+\psi(t_0)]+\varepsilon_{CS}\} \qquad \text{Eq. (22)}$$

4.6 Resultant force for restraining stress due the free creep strain:

The forces induced at the reference point due to the artificial restraint to the free strain of creep on concrete section alone is given by

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{crp} = -\bar{E}_c \{(t,t_0) \begin{bmatrix} A_{tr} & B_{tr} \\ B_{tr} & I_{tr} \end{bmatrix} \begin{Bmatrix} \varepsilon_0(t_0) \\ \varphi(t_0) \end{Bmatrix} \qquad \text{Eq. (23)}$$

4.7 Resultant force for restraining stress due the free shrinkage strain:

On the application of restraint to the concrete section the free shrinkage strain will induce the following force at the reference point.

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{shr} = -\left\{ \bar{E}_c \varepsilon_{CS} \begin{Bmatrix} A_C \\ B_C \end{Bmatrix} \right\} \qquad \text{Eq. (24)}$$

4.8 Additional strain due to creep and shrinkage at time, *t*:

The restraining force to prevent free creep and shrinkage strain can be found using Eq.(23) and Eq.(24). On summing up the additional axial forces and bending moments due to creep and shrinkage calculated from above equations can now be applied in reversed direction to nullify the effect of restraint. The mathematical equation for the above is expressed as in Eq.(25)

$$\begin{Bmatrix} D\varepsilon_0(t,t_0) \\ Dy\,(t,t_0) \end{Bmatrix} = \frac{1}{\bar{E}_C\,(t,\,t_0)} \begin{pmatrix} \bar{A}_{tr} & \bar{B}_{tr} \\ \bar{B}_{tr} & \bar{I}_{tr} \end{pmatrix}^{-1} \begin{Bmatrix} DN \\ DM \end{Bmatrix} \qquad \text{Eq. (25)}$$

$$where – DN = -(DN)_{crp} - (DN)_{shr}$$

$$-(DM) = -(DM)_{crp} - (DM)_{shr}$$

4.9 Change in stress in concrete due to creep and shrinkage at time, t:

The stress due to restraint to creep and shrinkage can be found from Eq.(6) using modified modulus of concrete, creep coefficient, shrinkage strain and initial strain. Adding the above restraining stress to the stress caused by the change in strain due to creep and shrinkage, the final stress in concrete can be calculated by

$$\Delta\sigma_C = \Delta\sigma_{res} - \bar{E}_c[\Delta\varepsilon_0 + y\Delta\psi] \qquad \text{Eq. (26)}$$

4.10 Additional stress in reinforcement bars due to creep and shrinkage:

Since the concrete in tensile zone is ignored, the changes in stress in reinforcement steel bars are calculated using the following equation.

$$\Delta\sigma_C = E_s[\Delta\varepsilon_0 + y\Delta\psi] \qquad \text{Eq. (27)}$$

5.0 Numerical example for cracked column section using IRC:112-2011 code:

An RC column having the sectional properties shown in Fig.6 is taken for demonstration of application of theoretical equations given in the previous sections to the real structural member.

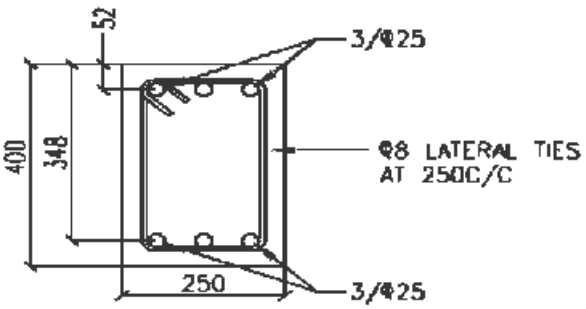


Fig. 6: Cross section of RC Column

The grade of concrete for the column is M35 and the grade of steel for the reinforcement bars is Fe500D. The Initial modulus for concrete taken from the code is 32308MPa. The Young's modulus of reinforcement steel considered for this example is 200000MPa. Hence, the initial elastic modular ratio of concrete can be calculated as 6.19. The creep coefficient and the shrinkage strain considered for this study are 2.5 and -0.0003 respectively.

5.1 External loads acting on the column:

The axial load while acting perpendicular to XY plane causing tension in the positive direction of Y-axis and bending moment acting about X-axis causing tension in the positive direction of Y-axis are taken as positive in this paper. The column section is subjected to an external axial load of -112.5kN and bending moment of 71kNm acting permanently due to dead and superimposed dead loads. In addition to the above, an axial load of -37kN and bending moment of 23.6kNm are acting as transient loads due to live loads. These loads are considered to be acting at the axis passing

through the mid-height of column. Since the reference axis is taken at the extreme compression fibre ie., the top fibre of column, the above loads are to be transferred to the above axis using Eq.(15). While transferring these loads to the reference axis, the value and direction of axial loads do not change. But the bending moment due permanent load will change from 71kNm to 48.50kNm and the bending moment due to transient loads will change from 23.6kNm to 16.20kNm.

5.2 Initial stresses for the total loads:

The depth neutral axis for the total loads of permanent and transient loads is calculated using Eq.(18) on substituting 64.7kNm in the place of and -149.5kN in the place of N. The neutral axis, yn Total is found as 139.29mm by using trial and error procedure stated in earlier section. The transformed sectional properties of the RC column section is found from Eq.(19). The Eq.(4) can be formulated in matrix form as

$$\begin{Bmatrix} -149.5 \times 10^{3} \\ 64.7 \times 10^{6} \end{Bmatrix} = 3.23 \times 10^{4} \begin{pmatrix} 5.16 \times 10^{4} & 5.99 \times 10^{6} \\ 5.99 \times 10^{6} & 1.35 \times 10^{9} \end{pmatrix} \begin{Bmatrix} \varepsilon_o(t_0) \\ \psi(t_0) \end{Bmatrix}$$

From the above, we find the strain and the

curvature or strain gradient by the Eq.(5) and stresses in concrete and reinforcement steel are calculated from Eq.(2) and Eq.(3) as

$\varepsilon_O(t_0)_{Total} = -5.42 \times 10^{-04}$; $\sigma_{C\,Toal} = -17.50$ MPa

$\psi(t_0)_{Total} = 3.89 \times 10^{-06}$; $\sigma_{SC\,Toal} = -56.94$ MPa

$\sigma_{st\,Total} = 162.37$ MPa

5.3 Initial stresses for permanent loads:

The depth of neutral axis for the permanent loads alone is calculated using Eq.(18) on substituting 48.50kNm in the place of M_{Tr} and -112.5kN in the place of N. The depth of neutral axis, ynPerm is found as 139.36mm by using trial and error procedure stated in earlier section. The transformed sectional properties of the RC column section for the depth of neutral axis found for permanent loads is found from Eq.(19). The values for the calculation of strain using the Eq.(4) can be formulated in matrix form as

$$\begin{Bmatrix} -112.5 \times 10^{3} \\ 48.50 \times 10^{6} \end{Bmatrix} = 3.23 \times 10^{4} \begin{pmatrix} 5.16 \times 10^{4} & 6.00 \times 10^{6} \\ 6.00 \times 10^{6} & 1.35 \times 10^{9} \end{pmatrix} \begin{Bmatrix} \varepsilon_o(t_0) \\ \psi(t_0) \end{Bmatrix}$$

We can find the strain and strain gradient by the Eq.(5) and stresses in concrete and reinforcement steel are calculated from Eq.(2) and Eq.(3) for the permanent loads as

$\varepsilon_O(t_0)_{Perm} = -4.07 \times 10^{-04}$; $\sigma_{C\,Total} = -13.14$ MPa

$\psi(t_0)_{Perm} = 2.92 \times 10^{-06}$; $\sigma_{SC\,Total} = -42.75$ MPa

$\sigma_{st\,Perm} = 121.77$ MPa

5.4 Stresses due to transient loads:

Since the principle of superposition cannot be applied for the analysis of RC column subjected to axial load and uniaxial bending, the stresses caused by the transient loads is found by the difference of stress produced by the total loads and the permanent loads as given below.

$\sigma_{CTrans} = \sigma_{CTotal} - \sigma_{CPerm} = -4.37$MPa

$\sigma_{CTrans} = \sigma_{CTotal} - \sigma_{CPerm} = -14.19$MPa

$\sigma_{CTrans} = \sigma_{CTotal} - \sigma_{CPerm} = 40.60$MPa

It is important to note that the stresses due transient loads or live loads act on the structural member for a short duration and hence the stresses produced by the transient loads are not affected by creep in concrete.

5.5 Restraining stress in concrete to free creep and shrinkage strains:

The stress in concrete due to the restraint of free creep and shrinkage can be calculated from

Eq. (6a) as $D\sigma_{re} = 12.15$Mpa

5.6 Equivalent forces causing restraining stress in concrete:

The forces likely to cause the restraining stress due to free creep strain and shrinkage strain can be found by Eq.(23) and Eq.(24) respectively as

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix} \begin{Bmatrix} 1.63 \times 10^{5} \\ 7.59 \times 10^{6} \end{Bmatrix}_{crp} + \begin{Bmatrix} 9.65 \times 10^{4} \\ 6.72 \times 10^{6} \end{Bmatrix}_{shr}$$

5.7 Additional strain due to creep and shrinkage:

The modified sectional properties are calculated from Eq. (21) for the depth of neutral axis, *YnPerm* found for the permanent loads, modified values of modulus of concrete and modular ratio. The additional strain and curvature can be formulated in matrix form by applying the restraint forces in the reversed direction as

$$\begin{Bmatrix} -2.60 \times 10^{5} \\ -143 \times 10^{7} \end{Bmatrix} = 9.23 \times 10^{3} \begin{pmatrix} 9.57 \times 10^{4} & 1.46 \times 10^{7} \\ 1.46 \times 10^{7} & 3.99 \times 10^{9} \end{pmatrix} \begin{Bmatrix} D\varepsilon_0(t,t_0) \\ Dy\,(t,t_0) \end{Bmatrix}$$

From the above, the values of $D\varepsilon_0(t,t_0)$ and

$Dy_{\,0}(t,t_0)$ can be found as

5.8 Additional stresses due to creep and shrinkage:

The time dependent additional stress in concrete and reinforcement steel bars controlling the design can be found as

$$\Delta\sigma_c = \begin{pmatrix} 12.15 + 9.23 \times 10^{3} \times \\ (-5.31 \times 10^{-4} + 1.55 \times 10^{-6} \times 0) \end{pmatrix} = 7.25 \text{ MPa}$$

$$\Delta\sigma_{sc} = \begin{pmatrix} (2 \times 10^{-5} - 9.23 \times 10^{-3}) \\ -5.31 \times 10^{-4} + 1.55 \times 10^{-6} \times 52 \end{pmatrix} = 85.96 \text{ MPa}$$

$$\Delta\sigma_{st} = \begin{pmatrix} 2 \text{ x } 10^{-5} \text{ x} \\ -5.31 \text{ x } 10^{-4} + 1.55 \text{ x } 10^{-6} \text{ x } 348 \end{pmatrix} = 1.92 \text{ MPa}$$

5.9 Final stresses considering creep and shrinkage:

The stresses in concrete and reinforcement steel bars can be obtained by adding the total stresses at initial loading and additional stresses due to creep on permanent loads and shrinkage strains as

$$\begin{Bmatrix} \sigma_c \\ \sigma_{sc} \\ \sigma_{st} \end{Bmatrix} = \begin{Bmatrix} -17.50 \\ -56.94 \\ 162.37 \end{Bmatrix} + \begin{Bmatrix} 7.25 \\ -85.96 \\ 1.92 \end{Bmatrix} = \begin{Bmatrix} -10.25 \\ -142.90 \\ 164.29 \end{Bmatrix}$$

6.0 Application of IRS concrete bridge code:

In this method, the modular ratio is calculated based on the empirical relationship given this code. The effect of creep and shrinkage is partially considered in the above relationship.

6.1 Depth of neutral axis:

Using the sectional properties of the column, the axial capacity of the column can be found for the bending compressive stress at the extreme compression fibre and the same is equated to given axial load, N by Eq.(28)

$$N_c + N_{sc} + N_{st} = N \qquad \text{Eq. (28)}$$

where $N_c = \sigma_C \frac{by_n}{2}$

$$N_{sc} = \sigma_C \frac{420}{fck} \sum_{i=1}^{n_s} A_{si} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{sc} < y_n$$

$$N_{st} = \sigma_C \frac{280}{fck} \sum_{i=1}^{n_s} A_{si} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{st} < y_n$$

Similarly the bending capacity can be calculated from the sectional properties of the column and the above is equated to given bending moment transferred to the reference axis, MTr by Eq.(29)

$$M_c + M_{sc} + M_{st} = M_{Tr} \qquad \text{Eq. (29)}$$

where $M_c = \sigma_C \frac{by_n}{6}$

$$M_{sc} = \frac{420}{fck} \sum_{i=1}^{n_s} A_{si} Y_{st} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{st} < y_n$$

$$M_3 = \frac{280}{fck} \sum_{i=1}^{n_s} A_{si} Y_{si} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{st} < y_n$$

On dividing the Eq.(29) by Eq.(28) and rearranging the equation we can get a function in terms of the depth of neutral axis, yn as given below.

$$F(Y_n) = \frac{M_1 + M_2 + M_3}{N_1 + N_2 + N_3} - \frac{M_{tr}}{N} = 0 \qquad \text{Eq. (30)}$$

where $M_1 = \frac{by_n^2}{6}$

$$M_2 = \frac{420}{fck} \sum_{i=1}^{n_s} A_{si} Y_{st} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{si} < y_n$$

$$M_3 = \frac{280}{fck} \sum_{i=1}^{n_s} A_{si} Y_{si} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{si} < y_n$$

and $N_1 = \frac{by_n}{2}$

$$N_2 = \frac{420}{fck} \sum_{i=1}^{n_s} A_{si} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{si} < y_n$$

$$N_3 = \frac{280}{fck} \sum_{i=1}^{n_s} A_{si} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{si} < y_n$$

6.2 Stress in concrete:

After finding the depth of neutral axis from Eq.(30), the bending compressive stress at extreme compression fibre can be obtained from the following equation.

$$\sigma_C = \frac{N}{N_1 + N_2 + N_3} \qquad \text{Eq. (31)}$$

6.3 Stress in reinforcement steel bars:

The stresses in reinforcement steel bars can be found as

$$\sigma_{SC} = \frac{\sigma_{SC}\, 420}{fck} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{si} < y_n \qquad \text{Eq. (32)}$$

$$\sigma_{SC} = \frac{\sigma_{SC}\, 280}{fck} \left(1 - \frac{y_{si}}{Y_n}\right) \; if y_{si} < y_n \qquad \text{Eq. (33)}$$

7.0 Numerical example for cracked column section using IRS concrete bridge code:

The example problem considered in section 5 and details of column shown in Fig.6 are used for this analysis of stresses as per IRS concrete bridge code also for the purpose of comparison of results.

7.1 Stresses for the total loads:

The neutral axis for the sectional properties of column found in section 6 above and for the total axial load and also total bending moment due to all loads transferred to the extreme compression fibre is calculated as 141.37mm.The calculated stresses for the above loads and depth of neutral axis are given below.

$\sigma_{C\,Total} = -13.98$MPa; $\sigma_{SC\,Total} = -97.23$ MPa

$\sigma_{C\,Total} = 163.50$MPa

7.2 Stresses for the permanent loads:

The neutral axis for the permanent load is found as 141.44mm. The stresses due to permanent loads alone are

$\sigma_{C\,Perm} = -10.50$MPa; $\sigma_{SC\,Trans} = -73.01$MPa

$\sigma_{Si\,Perm} = 122.62$MPa

7.3 Stresses for the transient loads:

The difference between the stresses due to total loads and the permanent loads are equal to the stresses caused by the transient loads. The values of the stresses due to transient loads are

$\sigma_{C\ Trans} = -3.49$MPa; $\sigma_{SC\ Trans} = -24.23$ MPa

$\sigma_{St\ Trans} = 40.88$MPa

8.0 Comparison of results for cracked column and discussion:

The calculated stresses in concrete and reinforcement steel bars using the Road and Railway Bridge Codes are tabulated in table 1 given below. The ratio of stresses obtained from IRS concrete bridge code to the stresses obtained by IRC:112-2011 are given in column 4 of the above table. From the above ratio, it can be seen that the IRS concrete bridge code underestimates the stress in concrete by 20% at the initial stage of loading and overestimates the long term stress by 36%. The stresses in compression reinforcement steel bars are overestimated by 71% by the railway bridge code at initial stage of loading. But, the long term stresses in the above reinforcement bars are underestimated by 32% by the IRS concrete bridge code. At the same time, the stresses in tensile reinforcement steel is more or less agreeable in initial loading and also in long term loading.

Stress (1)	IRC:112-2011 (MPa) (2)	IRS concrete bridge code (MPa) (3)	Ratio of stresses (4) = (3)/(2)
Total loads at initial loading stage			
s_c	-17.50	-13.98	0.80
s_{sc}	-56.94	-97.23	1.71
s_{st}	162.37	163.50	1.01
Permanent loads at initial loading stage			
s_c	-13.14	-10.50	0.80
s_{sc}	-42.75	-73.01	1.71
s_{st}	121.77	122.62	1.01
Transient loads at all loading stages			
s_c	-4.37	-3.49	0.80
s_{sc}	-14.19	-24.23	1.71
s_{st}	40.60	40.88	1.01
Creep and shrinkage or time dep. stresses			
Δs_c	7.25	-	-
Δs_{sc}	-85.96	-	-
Δs_{st}	1.92	-	-
Total stresses + time dependent stresses			
s_c	-10.25	-13.98	1.36
s_{sc}	-142.90	-97.23	0.68
s_{st}	164.29	163.50	1.00

9.0 Scope for the future work:

In railways, most of the RC columns are circular in shape. Hence, it becomes necessary to formulate the equations for the analysis of time dependent stresses for cracked sections of circular columns. Even though, uncracked rectangular and circular columns are not common in railway bridges, they can also given a separate study for the evaluation of time dependent stresses using slightly a different approach.

10.0 Conclusion:

The following conclusions are made from the above review for the time dependent stresses in RC cracked.

1). The methodology for the calculation of time dependent stresses in RC cracked columns can be understood clearly.

2). The step by step procedure followed in the illustrative numerical problem will be useful for checking the correctness of the computer program that can be developed for day-to-day working.

3). An appreciable decrease in the compressive stress in concrete, a large increase of stress in compression reinforcement steel bars and a marginal increase of stress in tensile reinforcement bars can be well understood.

4) The underestimation of the compressive stress in concrete at the initial stage of loading and the underestimation of the compressive stress in reinforcement bars under the long term loading by the IRS Code is now proved. This shall be taken care of while designing reliable and safe RC columns to avoid any mistakes.

5) It is the right time to reconsider the provision of empirically based modular ratios for the reinforcement steel bars by the IRS concrete bridge code from the safety and reliability point of view.

11.0 Notations:

A_c=Area of concrete section in compression zone alone.

A_s=Cross sectional area of reinforcement steel bars.

A_{si}=Cross sectional area of i^{th} reinforcement steel bars.

$A_{tr}=A_c\ \alpha\ A_S$ = Effective Transformed area of column section.

$\overline{A}_{tr}$= $A_c + \overline{\alpha} A_S$ = Effective transformed area of column section.

B_c= First moment of area of concrete section in compression zone alone.

B_{tr}= First moment of transformed area of column section.

$\overline{B}_{tr}$= Effective first moment of transformed area of column section.

$E_c(t_c) = E_c$= Elastic modulus of concrete at initial loading time

$$\overline{E}_c(t, t_0) = \overline{E}_c = \frac{E_c}{(1+\varphi(t, t_0))} = \text{Effective}$$

modulus of concrete at time, t

E_c= Elastic modulus of reinforcement steel bars.

f_{ck} = Characteristic compressive strength of concrete.

$F(Y_n)$ = A function expressed in terms of the depth of neutral axis, Y_n

I_c = Second moment of area of concrete section in compression zone alone.

I_{tr} = Second moment of transformed area of column section.

$\overline{I}_{tr}$= Effective second moment of transformed area of column section.

M = Uniaxial bending moment acting on the axis through the mid-depth of column.

M_c=Bending resisting force offered by concrete alone.

M_{SC} = Bending resisting force offered by reinforcement steel in compression zone.

M_{st} = Bending resisting force offered by reinforcement steel in tensile zone.

M_{Tr}= Uniaxial bending moment transferred to the reference axis.

M_1, M_2, *and* M_3, = Factors for bending moments used mainly to reduce the width of expression for printing in double column format.

N_S =Number of reinforcement steel bars.

N = Axial load acting on column.

N_{SC} = Axial resisting force offered by concrete alone.

N_{SC} = Axial resisting force offered by reinforcement steel in compression zone.

N_{St} = Axial resisting force offered by reinforcement steel in tensile zone.

N_1, N_2, *and* N_3 = Factors for axial loads used mainly to reduce the width of expression for printing in double column format.

t =Time elapsed after Initial loading.

t_0 = Initial loading time.

y = Distance of a point under consideration from the reference axis

Y_n = Depth of neutral axis from the reference axis.siy=Distance ith reinforcement steel bar from the reference axis

$$\alpha = \frac{E_s}{E_c} = \text{Elastic modular ratio for concrete}$$

$$\bar{\alpha} = \frac{E_s}{\bar{E}_c} = \text{Effective modular ratio for steel}$$

reinforcement bars at time, t.

$\varepsilon_0(t_0)$ = Strain at any point under consideration.

ε_{cs} = Shrinkage strain at time, t.

ε_e = Elastic strain at initial loading.

$\varepsilon_0(t_0) = \varepsilon_0$ =Strain at the level of reference axis at initial loading time.

$\varepsilon_0(t_0)_{total}$ and $\varepsilon_0(t_0)_{Perm}$ = Strain at the level of reference axis at initial loading time due to total loads and permanent loads respectively.

ε_{crp} = Creep strain at time, t.

DM#=# $(DM_{crp} + DM_{shr})$ =Sum of the restraining bending moments to the creep and shrinkage acting in reverse direction at the reference point.

DM_{crp} , and DM_{shr} =Restraining bending moment to the creep and shrinkage respectively acting at the reference point.

–DN#=# $(DN_{crp} + DN_{shr})$ = Sum of the restraining normal forces to the creep and shrinkage acting in reverse direction at the reference point. ,

DN_{crp} , and DN_{shr} = Restraining normal force to the creep and shrinkage respectively acting at the reference point.

$D\varepsilon_0(t, t_0)$= Additional strain at the level of reference axis at time, t

$D\sigma_c$ = Change in stress in concrete due to the creep and shrinkage.

$D\sigma_{sc}$ = Change in controlling stress in compression reinforcement steel bars due to the creep and shrinkage.

$D\sigma_{st}$ = Change in controlling stress in tensile reinforcement steel bars due to the creep and shrinkage.

$D\sigma_{res}$ = Restraining stress in concrete to the creep and shrinkage.

$D\Psi(t, t_0)$= Additional curvature at the level of reference axis at time, t

$$\varphi(t, t_0) = \varphi = \frac{\varepsilon_e + \varepsilon_{crp}}{\varepsilon_e} \text{ Creep coefficient.}$$

σ_c =Compressive stress at the level of reference axis.

σ_{sc} =Controlling compressive stress in reinforcement steel bars.

σ_{st} = Controlling tensile stress in reinforcement steel bars.

σ_{cTotal}, σ_{cTotal}, and σ_{cTotal}, = Stress at the level of

reference axis at initial loading time due to total loads, permanent loads and transient loads respectively.

$\sigma_{stTotal}$, σ_{stPerm}, and $\sigma_{stTrans}$, = Controlling stress in compression steel reinforcement bar at initial loading time due to total loads, permanent loads and transient loads respectively.

$\Psi(t_0) = \Psi$ = Strain gradient or curvature at the level of reference axis at initial loading time

$\Psi(t_0)_{Total}$ and $\Psi(t_0)_{Perm}$ = Strain gradient or curvature at the level of reference axis at initial loading time due to total loads and permanent loads respectively.

12.0 References:

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Ahmedabad-Mumbai Bullet Train project: First Consignment for Training Railway Officials on Special Tracks arrives from Japan

Mumbai-Ahmedabad bullet train project gets big consignment from Japan! With India gearing up for its first-ever bullet train, work on developing a training institute in Vadodara, Gujarat is going on in full swing. The institute, worth Rs 600 crore is being set up in the campus of National Academy of Indian Railways, in order to train people on various operations that are required to run the high-speed train network efficiently. Recently, the National High-Speed Rail Corporation Limited (NHSRCL), which is executing the project received a big consignment from Japan. This included slab tracks, rails as well as other fixing components. The development of the project is being carried out in three packages, out of which, work on the first two packages is almost 50-60% complete.

While talking to Financial Express Online about the project, Deputy Chief Project Manager Anupam Awasthi said that in the first two phases, the corporation is developing the hostel building and setting up the slab track for training. The slab track which is going to be 100 metres long will include 50 metres straight track and 50 metres curved track. The slab track is being set up to provide training to those who will be recruited by NHSRCL for operation and maintenance of the bullet trains. He further said that the radius of the curve on the bullet train corridor will be around 6000 metres, which is a flat curve, unlike the sharp curves that could be seen in conventional Indian Railways. This is because the bullet train will run at a speed of 320 kmph.

As the country does not has the technology to manufacture slab tracks, as many as 20 slabs have been imported from Japan to train the trainees. In addition, 200 metres rail of JIS (Japan Industrial Standard) has been imported from Japan. Also, as India does not produce 13 mm diameter rebar, it has been imported as well.

Awasthi said that the slab track will include an embankment, filled with crushed stones. However, on the main line, elevated tracks will be used. In the training institute, the slab track is being laid on the ground over roadbed concrete. He further said that unlike normal Indian Railways, where sleepers are used to hold the rail, there will be no such component for the bullet train. Therefore, three kinds of inserts that are used in Japan have been imported, which will hold the rail on the slab track. He also added that the corporation is expecting the consignment of cement mortar by the end of this month, which will be embedded between the concrete bed and slab track. According to him, the main purpose of cement mortar is to provide resilience and dampness to the structure.

Meanwhile, the third package, which is going to be bigger than the first two, is stated to come up by early next year. It will include consignment for simulator as well as other signalling equipment to train staff in the institute.

Ref. : http://www.railnews.co.in

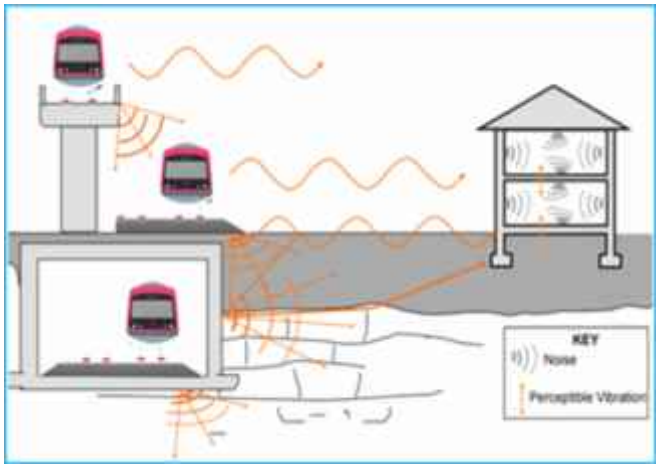
Noise Impact Mitigation Measures of Bangalore Metro

By
N M Dhoke*

Synopsis:
Noise and vibration-related issues along the Metro corridor(s) are one of the major issues which may be significant during the construction phase of the project. However, during the operation of the metro rail, rail–wheel interaction generates noise and vibration. Apart from this, motor, cooling fans and other auxiliary equipment increase ambient noise and vibration levels inside the coaches and also outside the metro rail corridor. Worldwide, several efforts are being made to reduce the impact of noise and vibration generated by the metro rails, both at the source as well as receptor levels. Bangalore Metro is using new and advance technology in rails and brake systems by providing damping wheels and tracks, reducing the roughness of the rails, improved version of saloon door seals etc. Moreover, noise levels can be further reduced by providing mass spring system technology and noise barriers along the corridor.

1. Introduction

Noise from Metro trains can be particularly relevant in urban or suburban areas, especially near residential areas. Metro Train noise results from a number of sources, namely, rail vehicle body itself, rolling movement, track and from interaction between track and the vehicle body.



AIRBORNE NOISE: Airborne noise from railways comprises the following sources:

Rolling noise generated by wheel and rail vibrations that are induced at the wheel/rail interface. Rolling noise is generally the most predominant source of railway noise.

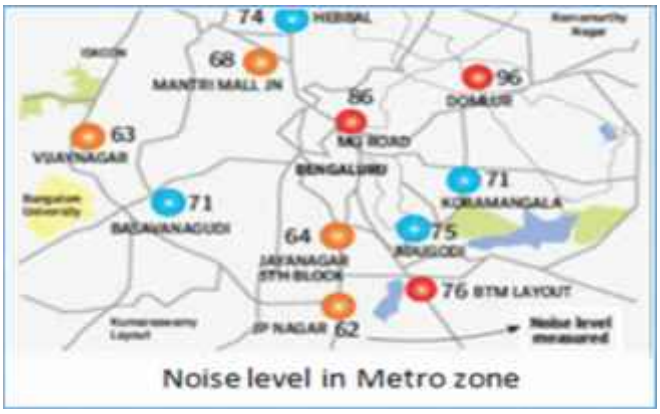
Curving noise generated by unsteady transverse forces in the wheel/rail interaction during curving. Aerodynamic noise caused by unsteady airflow over the body of the train.

Traction noise from Motors, intake and exhaust, traction motors and fans, gearboxes, turbo chargers etc., This paper covers the mitigation measures for Noise pollution which have been explored and implemented both in vehicle and Track.

2.0 Noise Pollution:

Figure shows a sketch of the typical dependence of the major sources of metro train noise on the train speed.

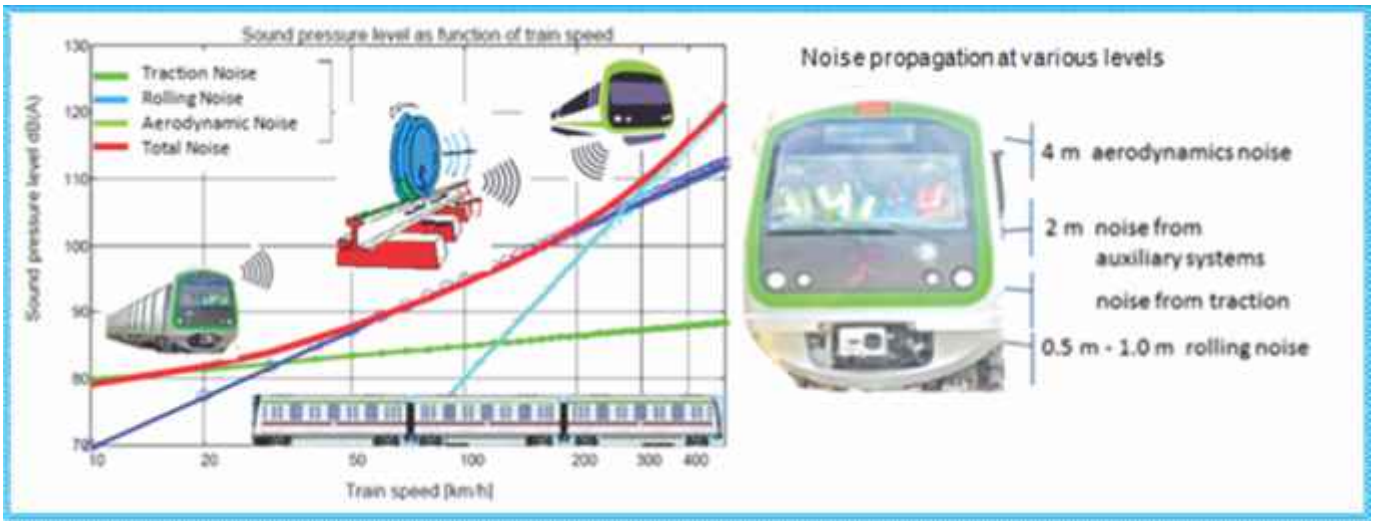
Noise Generating Mechanism of metro vehicle on ballast less track



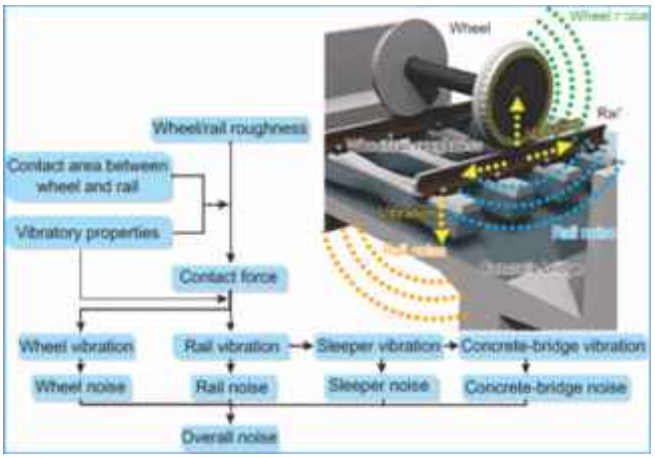
Metro noise level studies were carried out by National Physical Laboratory for Metro Subway and estimates that operation of metro can cause a cumulative increase in ambient noise level by maximum 2 to 3 dB(A) in medium and high traffic density areas.

Baseline noise monitoring indicate that day time noise levels are in the range ~56 to ~60 dB(A) and night time levels are in the range of ~45 to ~49 dB(A), which are within National Ambient Air Quality Standards for Noise (NAAQS). Similarly, for commercial area it is 65 dB(A) [day] and 55 dB(A) [night time] respective.

* *Director/IRSE, O&M/BMRCL/Bengaluru*



Noise Generating Mechanism of metro vehicle on ballast less track



The operation of metro trains can cause a cumulative increase in ambient noise level by maximum 2 to 3 dB(A) and still the resulting noise is envisaged to be within National Ambient Air Quality Standards for Noise (NAAQSN) for commercial area for the respective day and night time.

3.0 Noise abatement in vehicles.

3.1.1 Vehicle in stationary condition

- HVAC (Heating, Ventilation & Air Conditioning system)
- Auxiliary Power Supply (APS)
- Air Compressor

3.1.2 Vehicle in Running Condition

- Wheel rail interactions
- Track irregularities
- Traction motors
- Gear Boxes
- Braking
- HVAC (Heating, Ventilation & Air Conditioning system).
- Auxiliary Power Supply (APS).
- VVVF unit.
- Air Compressor

3.1.3 Passenger comfort

(a) Control of noise and vibration in vehicles is one of the critical issues effecting passenger comfort. Since all noise sources are located outside car body, the passenger comfort greatly depends effectiveness of noise insulation provided. Some of Noise mitigating features provided are

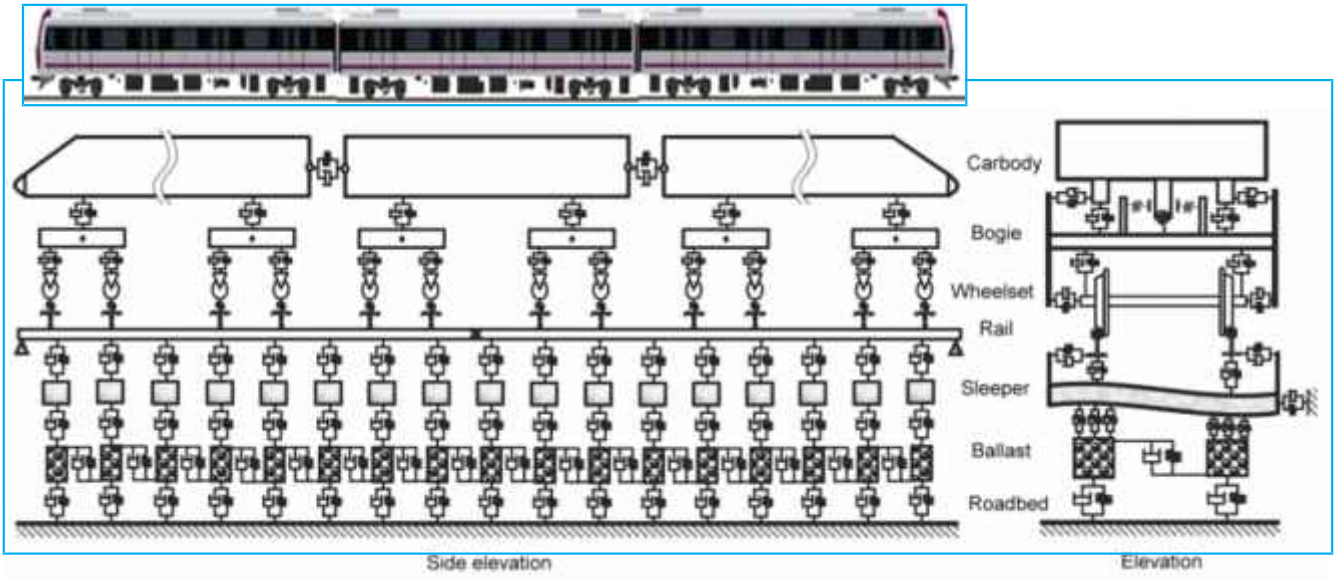
- Floating floor in the train
- Gangway design – (2-piece construction with double skin bellows)
- Door leaf construction with improved aquatics sealing
- Interior FRP – Semi sandwiched Nomex Honey comb panels.
- Windows – Insulated Glass units
- Body Insulation

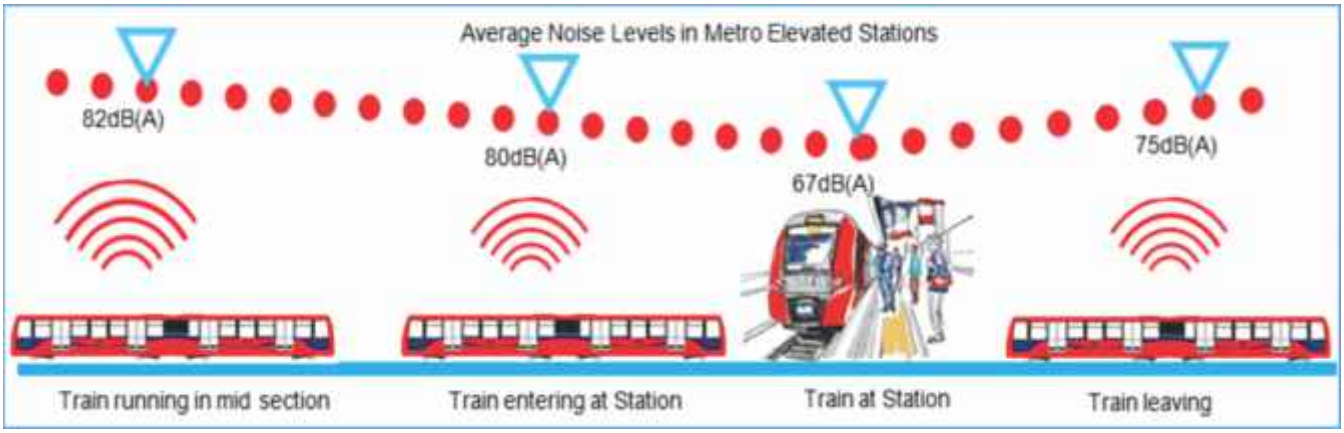
(b) Coaches with advanced sound-absorbing cushions lining on the walls with better buffing have been provided so that the doors will seal perfectly reducing sound filtering in from outside.

(c) Wheel maintenance by grinding

It is necessary to remove the irregularities on wheel running surface (mostly wheel flats) and provide required wheel profile. Compared to re-profiled, worn wheels increase vibration by 5 to 10 dB [5], while the wheel flats can cause additional vibration increase by 5 dB at frequencies above 60 Hz. High quality wheel grinding (re-profiling) program ensures the reduction of noise levels in the range of 5 to 10 dB(A).

Noise and vibration absorption diagram





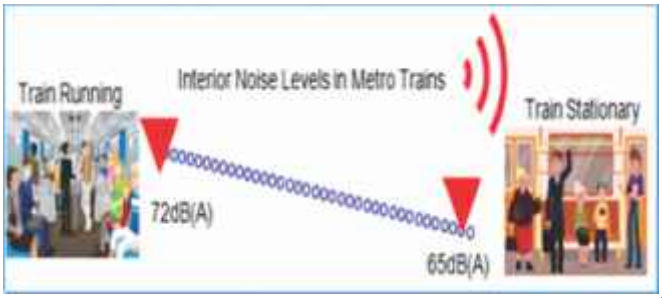
(d) Use of Disc Brakes.

Use of the disc brakes can reduce wheel corrugation that generates high frequency noise levels by 10 to 15 dB(A)

(e) Curves.

Squeal noise generates as a metro train negotiates a curve, producing a tonal noise of high amplitude. Damped wheels, like resilient wheels, serve to reduce rolling noise. Damping is more effective in eliminating wheel squeal on tight turns where reductions of 4 to 8 dB(A) on tangent track.

The noise will be generated due to friction of the Rolling Stock on the tracks, which will generate incremental noise levels.



4.0 Use of Long Welded Rails

Apart from con¬trolling the internal noise levels, Bangalore metro runs on a 'ballast less tracks' technology. The integration of turnouts into 'Long Welded Rails (LWR)' further ensures that complete tracks are virtually 'joint less' which, besides lower maintenance cost and higher safety, promises minimal vibration and greater riding comfort for passengers.

4.1 Use of Elastomeric components



The elastomeric rail pad plays a vital role in regard to passenger comfort and protection of the concrete plinth by dampening the rail vibrations and helps in reduction in noise caused by rail wheel interaction. The elastomeric pad between the sleeper and concrete slab in case of a ballast less track is pre-compressed by specially designed springs with a load which is about 80 % of the normal static load on the fastener

during vehicle passage The pre-loading spring is completely unloaded during vehicle passage and hence there is no vibration transmission through this spring to the lower parts of construction.

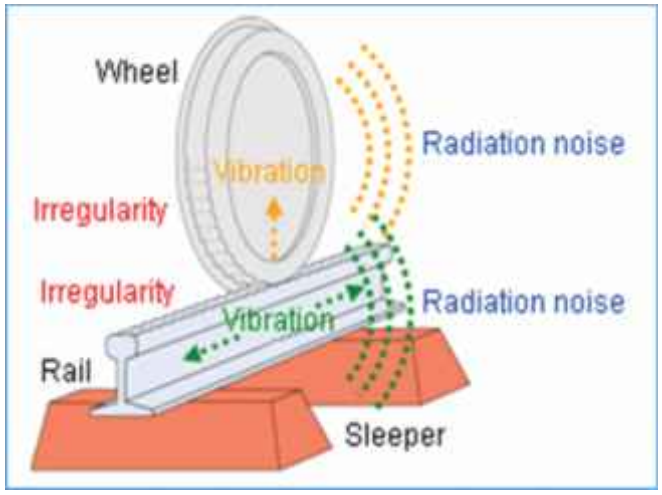
4.2 The elimination of discontinuities at the rail running surface by Rail Grinding

Welded rail continues to be installed throughout the Track for a several kilometres long as a proven noise reduction technique in continuously welded tracks, wheel impact at the rail joint is eliminated allowing vibration reduction for up to 5 dB.

4.3 Points & Crossings

A large percentage of rail traffic noise and vibration is caused by wheel impacts at the special track work for switches and crossings. This impact occurs because of the gap between the running rails and crossing and can cause an increase in noise levels from up to 6 to 10 dB(A).

Noise and vibration due to wheel impact at switches can be controlled by regular maintenance of the Switches and crossings by provision of mono block Cast Manganese Steel Crossings(CMS). Added to this, Switches and CMS crossings are welded.



4.4 Curves

The flanging and squealing noise generated by metro train while negotiating sharp curves due to abrasion of the wheel on the outer rail head. This noise can be reduced by lubricating rails or wheel flange. BMRCL Rail lubricator fixed on the Rail for lubrication at 120m Radius curve, improves wear levels and reduce the noise. Other curves are manually.


Rail Greasing

4.5 Rail running surface maintenance – Rail Grinding

The levels of noise and vibration caused by wheel rolling on corrugated rail running surface depend on the size of irregularities (amplitude and wavelength). Regular rail grinding is necessary for the removal of corrugated rail wear, largely responsible for rail traffic humming noise, and also removal of irregularities at rail welds responsible for the occurrence of noise and vibration due to wheel impacts.

4.6 Rail head hardening – thermal treatment during production

Increasing the hardness of the rail head slows down the formation of the corrugations at rail running surface i.e. the reduction of noise and vibration is achieved.

This increase in rail head hardness can be achieved by treating of the rail head with heat during rail production. BMRCL is used Head Hardening Rails throughout the network length.

4.7 Noise protection barriers

Implementation of noise protection barriers is the most effective measure of noise reduction at the receiver. Barriers enable the reduction of noise at the observed point of emission in the range from 5 to 15 dB(A), depending on the height and length of the barrier.

Thus it is suggested that noise barriers can be erected based on the noise levels observed in operational phase, if required at isolated places.



5.0 Conclusion

BMRCL continues to make substantial progress in reducing noise throughout the system. The combined thrust of these noise reduction efforts increasingly provides direct benefits to passengers, employees and the public. It is a top priority for BMRCL to respond to noise complaints, perform noise measurements and be an asset for community outreach on such matters.

Parameters for Concrete Mix Design

Introduction:

The Versatility of making concrete with locally available materials, ease in moulding it into any shape and size, and achieving economy in its making and use in the structures has made the concrete the 2nd largest material used on earth!.

Concrete has undergone rapid and phenomenal development in the past few years in India. Revision of IS 456 : 2000 with emphasis on the quality assurance, and suggesting the use of Mineral and Chemical Admixtures to achieve required compressive strength, and modification in micro-structure of the concrete in order to enhance the required durability against corrosion of embedded steel reinforcements in marine and chemical environment, including performance against accidental fires in r.c.c structures.

Research and development on new materials to replace the conventional concrete in order to achieve the requisite properties for application in different situations is well understood. The latest development in concrete is use of “Geo-polymer concretes”, where a new binder that replaces cement in concrete mix with a Geo-polymer combination (Resin and hardener) as binder, is becoming popular.

Concrete Mixture in the Hardened Stage

Compressive Strength :

It is one of the most important properties of concrete and influences many properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement (W/C) ratio of the mix. The other factors affecting the strength of concrete at a given age and cured at a prescribed temperature is the work ability factor, which has been already discussed. Mixing of chemical admixtures also reduces the (W/C) ratio to the extent of 15-20%, when High Range Water Reducing (HRWR) admixtures are used that increases the strength of the concrete without increasing the cement content. The slump is also increased to our requirement.

In India the main mineral admixture fly ash causing pollution and disposal problems is available from thermal power plants. The awareness of advantageous properties of fly ash and its use in concrete to achieve economy and enhanced durability of structures is increasing.

High strength (HSC), High performance Concrete (HPC) and Self Consolidation Concrete (SCC) is being used extensively in multi-storied concrete structures, particularly in the coastal cities, to realize the advantages of economy and durability. High Strength concrete (HSC) and High Performance Concrete (HPC) can benefit from the three most commonly used mineral admixtures produced as waste or by product. Fly ash, silica fume, and Ground Granulated Blast-furnace Slag are examples. These materials have become necessary constituents in the production of HSC, HPC and SSC in addition to the conventional basic materials. It is to be noted that they are to be designed using required normal/Special Chemical admixtures and tested in the laboratory before large scale applications.

Chemical Admixtures:

These are added to concrete in very small amounts mainly for the entrainment of air, reduction of water or cement content, plasticization of fresh concrete mixtures, or control of setting time. Seven types of chemical admixtures are specified in ASTM C 494, and AASHTO M 194, depending on their purpose or purposes in PCC. Air entraining admixtures are specified in ASTM C 260 and AASHTO M 154. General and physical requirements for each type of admixture are included in the specifications. Indian Standard codes; 456, 9103, 6925 discuss general use, specifications, and tests for chemical admixtures.

Mineral Admixtures :

Fly ash, Silica Fume [SF], and GGBS are mineral admixtures usually added to concrete in larger amounts to enhance the work ability of fresh concrete and to improve resistance of concrete to thermal cracking, alkali-aggregate expansion, and sulfate attack; and to enable a reduction in cement content.

Mineral admixtures are discussed in IS: 456, 3812, and 12089. Mineral admixtures that are popular are: Fly Ash, Silica Fume, and Ground Granulated Blast Furnace Slag.

Fly Ash :

The substitution rate of fly ash for Portland cement will vary depending upon the chemical composition of both the fly ash and the Portland cement. The rate of substitution typically specified is a minimum of 1 to 1 ½ pounds of fly ash to 1 pound of cement. It should be noted that the amount of fine aggregate will have to be reduced to accommodate the additional volume of fly ash. This is due to fly ash being lighter than the cement.

The amount of substitution is also dependent on the chemical composition of the fly ash and the Portland cement. Initially, maximum substitution permitted was in the range of 15 to 25 percent.

Effects of fly ash, especially Class F, on fresh and hardened concrete properties has been extensively studied by many researchers in different laboratories, the two properties of fly ash that are of most of concern are the carbon content and the fineness. Both of these properties will affect the air content and water demand of the concrete.

The finer the material the higher the water demands due to the increase in surface area. The finer material requires more air-entraining agent to five the mix the desired air content. The important thing to remember is uniformity. If fly ash is uniform in size, the mix design can be adjusted to give a good uniform mix. The carbon content, which is indicated by the loss of ignition, also affects the air entraining agents and reduces the entrained air for a given amount of air-entraining agent. An additional amount of air-entraining agent will need to be added to get the desired air content. The carbon content will also affect water demand since the carbon will absorb water. Again uniformity is important since the differences from non-fly ash concrete can be adjusted in the mix design.

Use of Fly Ash in Concrete – Precautions :

- Special precautions may be necessary to ensure that the proper amount of entrained air is present
- All fly ashes may not have sufficient pozzolanic activity to provide good results in concrete
- Suitable fly ashes are not always available near the construction site, and transportation costs may nullify any cost advantage and,

The following are the advantages of Fly Ash ;

- Fly ash reduces permeability and chloride diffusivity and increases resistivity
- Beneficial material in concrete that is exposed to chlorides such as bridge decks, Structures located in marine and structures located in chemical environment
- Fly ash also binds up the alkalis in the concrete and, thereby, reduces the potential for alkali aggregate reactivity and,

The addition of fly ash to concrete enhances the strength gain at later ages, making it beneficial, when high-strength concrete is specified at ages of 56 or 90 days.

Ref. Master Builder July 2018 Vol.20 No.7

By. H.G. Sreenth

Alternatives of River Sand

River Sand or the Bajri we refer to the sand that is used in the Construction purposes. Today it is the most required material for the construction industry, is been widely used and utilised all over the world. The question arises is that from where does this BAJRI comes ? The River sand is the Sand is deposited in river beds, so the sand which we are using is actually from the dry river or from the banks of river. Presently in states like Maharashtra, Rajasthan, Uttar Pradesh and Karnataka sand supply is becoming a mafia because sand supplies are limited. River waters are now behind dams due to which the sand does not get continually replenished like before. Riverine habitats get destroyed as mechanical dredgers are used.

Some of the alternatives for Sand that can be considered for Construction purposes:

Copper Slag, Granulated Blast Furnace Slag, Bottom Ash, Foundry Sand, Quarry Dust, M Sand etc.

Quarry Dust

About 20 to 25 per cent of the total production in each crusher unit is left out as the waste material-quarry dust. In of the studies about this states that the ideal percentage of the replacement of sand with the quarry dust is 55 per cent to 75 per cent in case of compressive strength. He further says that if combined with fly ash (another industrial waste), 100 per cent replacement of sand can be achieved. The use of fly ash in concrete is desirable because of benefits such as useful disposal of a byproduct, increased work ability, reduction of cement consumption, increased sulfate resistance, increased resistance to alkali-silica reaction and decreased permeability. However, the use of fly ash leads to a reduction in early strength of concrete. Therefore, the concurrent use of quarry dust and fly ash in concrete will lead to the benefits of using such materials being added and some of the undesirable effects being negated.

M-Sand

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word.

Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost.

Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed.

Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material

for construction. The other advantage of using M-Sand is, it can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

- It is well graded in the required proportion.
- It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained.
- It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete.
- M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is obtained.
- M-Sand is cubical in shape and is manufactured using technology like High Carbon steel hit rock and then ROCK ON ROCK process which is synonymous to that of natural process undergoing in river sand information.
- Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand.

Benefits of Alternatives

Size, shape, texture play an important role in work ability of concrete. With more surface area of sand, the demand for cement and water increases to bond the sand with coarse aggregates.

The control over these physical properties of manufacturing sand make the concrete require less amount of water and provide higher workable concrete. The less use of water also helps in increasing the strength of concrete, less effort for mixing and placement of concrete, and thus increases productivity of construction activities at site.

Construction defects during placement and post-concreting such as segregation, bleeding, honeycombing, voids and capillarity in concrete gets reduced by the use of M-Sand as it has optimum initial and final setting time as well as excellent fineness.

As discussed above, since usage of M-Sand has increased durability, higher strength, reduction in segregation, permeability, increased workability, decreased post-concrete defects, it proves to be economical as a construction material replacing river sand. It can also save transportation cost of river sand in many cases.

Ref. : Master Builder July 2018 Vol.20 No.7

By : Kapil Menghrani

Indian Railways on Track to Build World's Tallest Bridge in Manipur



Northeast Frontier Railway said they are constructing the tallest railway bridge of the world in Manipur at 141 metres surpassing the existing record of 139-metre Mala-Rijeka viaduct, at Montenegro in Europe.

The bridge is part of a new broad gauge line being constructed to connect the northeastern state with the rest of the country and the pillars have already been built.

"The bridge is being constructed across the valley of river Ijai near Noney with a pier height of 141 metre. It will surpass the existing record of 139 metre of Mala-Rijeka viaduct, Montenegro in Europe," NFR Senior Public Relations Officer S K Ojah said in a statement.

The bridge is part of the 111-km long Jiribam-Tupul-Imphal new broad gauge line project in Manipur, he added.

"The total length of the bridge will be 703 metre. The piers of the bridge are constructed using hydraulic augers. The tall piers needed specially designed 'slip-form technique' to ensure efficient and continual construction," Ojah said.

The steel girders are pre-fabricated in a workshop, transported in segments and erected at the site by Cantilever launching scheme, he added.

'Self-erecting' electric lifts are used at each pier for the safe and speedy conveyance of men and materials to the top," NF Railway said.

There are a total of 45 tunnels in the project. The longest is Tunnel No. 12 with a length of 10.280 km. This will be the longest railway tunnel in the North East," the official said.

He said the project picked momentum in the last three years after Centre giving it the status as a project of National Importance.

Reliance Jio Set to Make World Record. Bags World's Largest CUG Service Provider Deal from Indian Railways

After making the telecom war intense, Jio is now taking another leap in its service offerings. The telecom company will replace Airtel to serve the country's largest and most sought-after accounts in telecom – the railways – from January 1, with officials saying it is likely to slash the national transporter's phone bills by around 35 per cent at least.

Railways has been using Bharti Airtel for over six years as its telecom provider for 1.95 lakh mobile phone connections used by its employees in closed user group (CUG) across the country for which the railways paid around Rs 100 crore bill per year, they said. Its validity will expire on December 31 this year.

A Railway Board order issued on November 20 said it "had assigned the responsibility to RailTel (Railway's Telecom PSU) for finalisation of fresh CUG scheme for Indian Railways as the validity of the existing scheme is expiring on December 31, 2018. Fresh CUG scheme had since been finalised by RailTel and Reliance Jio Infocomm Limited has been awarded the contract to implement the scheme."

"The fresh CUG will come into effect from January 1, 2019," said the order which detailed the tariff rates to be provided by the company.

Closed User group (CUG) is a supplementary service provided by the mobile operators to subscribers who can make and receive calls from any member associated within the group. This service is applicable for SMS also.

Under the scheme, Reliance Jio, the latest entrant in the telecom market, will provide 4G/3G connections and calls will be free of charge.

The company will provide four packages to railways – one for its senior most officials (two percent subscribers) – a 60 GB plan with a monthly rental of Rs 125, a 45 GB plan at a monthly rental of Rs 99 for its joint secretary level officers (26 per cent subscribers), a 30 GB plan at a rental of Rs 67 for Group C staff (72 per cent subscribers) and a Rs 49 rental plan for bulk SMS.

For regular subscribers, a 25 GB plan of Jio is available for Rs 199 and subscribers have to pay Rs 20 per GB thereafter to top up their plans.

Railway employees have to pay Rs 10 for 2 GB of extra data they use and more thereafter, according to the plan worked out by Jio.

While under the present scheme railways is charged for calls outside CUG, the plan from January 1 will not do so. Also, the 3G/4G data pack in effect from next year is much cheaper than the present packs available to railways.

"While Airtel is serving around 1.95 lakh railway subscribers, Jio will serve 3.78 lakh personnel of the railways to start with, and because of the increase in the numbers, we are getting a better deal from the service provider. As a result of this, we are likely to reduce our phone bill by around 35 per cent," a senior official said. "Eventually, Indian Railways is planning to extend the services to all the Railway employees right upto the level of Gangmen," he said. This initiative will greatly facilitate in seamless communication among the officials/staff of Indian Railways for improved train operations and better management of railway system.

Last month, Reliance Jio Infocomm had emerged as the lowest bidder for the account beating Airtel and Vodafone. Sources say that while railways had demanded free calls from the bidders and got it from all of them, it was the low cost data that pushed Jio as the front runner.

The CUG connections will not only serve the Officers/Staff of Indian Railways, but also caters the communication requirements to all the officers/staff working under the Indian Railways PSUs.

Ref. : https://www.railnews.co.in

Methods for Detecting and Predicting Localized Rapid Deterioration of Track Irregularity Based on Data Measured with High Frequency

This study describes the development of methods to detect and predict localized rapid deterioration of track irregularity based on data measured with high frequency. First of all, a highly accurate position correction technique was developed. This technique seeks out phases where the correlation coefficient between waveforms of the different measured data reaches a maximum, and corrects these phase gaps. The automatic extraction of localized rapidly deteriorating track irregularity is made possible from the difference in measured data which has already had its position errors corrected. Secondly, a method for predicting track irregularity was developed. This technique predicts the track irregularity stochastically through updates using new measurement data, applying the Bayesian theorem. Finally, these techniques were applied to field data, confirming their effectiveness.

Ref. : Quarterly Report of RTRI August 2018
By : Hirofumi TANAKA, Shuhei YAMAMOTO, Takashi OSHIMA, Masashi MIWA

Development Status of International Standards on the Rail Track and the Trend of the Related Research of RTRI

The railway business is now one of the global growth industries. Even in Japan, overseas deployment of railway technology including the Indian high-speed railway is rapidly progressing, but the difference between European forces preceding in international standards and Japan is still large. Therefore, in order to respond to the further globalization of the railway business, Japan must also actively participate in international standard development. In this paper, the author introduce the activities of RTRI's track technology department for the development of the rail track international standards.

Ref. :Quarterly Report of RTRI August 2018

By : Katsumi MURAMOTO's

A Hybrid Experimental Numerical Approach to Predict Ground Vibrations from Localised Railway Defects

Local railway defects such as joints generate large forces when excited by a passing train. This is particularly a problem in urban environments where trams traverse lines densely populated with defects. This paper proposes a hybrid experimental numerical approach to predict the ground-borne vibrations caused by these singularities.

ABSTRACT Local railway defects such as joints generate large forces when excited by a passing train. This is particularly a problem in urban environments where trams traverse lines densely populated with defects. This paper proposes a hybrid experimental-numerical approach to predict the ground-borne vibrations caused by these singularities. Firstly, a multi body train-track numerical model is used to generate the force densities caused when a tram passes over a variety of defects. These densities are then coupled with experimental transfer functions, thus allowing for the effect of singular defects to be included in vibration studies. Using the proposed methodology, analysis is performed into the effect of different types of defect on vibration levels at several physical sites on a European tram network.

Ref. : PWay UK april 2018/136/2

By : David P Connolly

Shallow - Depth Asphalt Track form Development

BACKGROUND The railway is significantly increasing the coverage of electrification over the network as a result of the railway electrification programme, established in 2010. Increasing the proportion of the network with electrification will lead to a low-carbon, sustainable rail network ultimately leading to the railway becoming cheaper to use, faster, and more efficient. Where electrification schemes encounter overbridges, overhead line equipment (OLE) must be passed under the structure to allow continuity in the electrification. Where insufficient clearances exist between the structure and the track to allow for installation of OLE, there are a range of possible options to provide sufficient space:

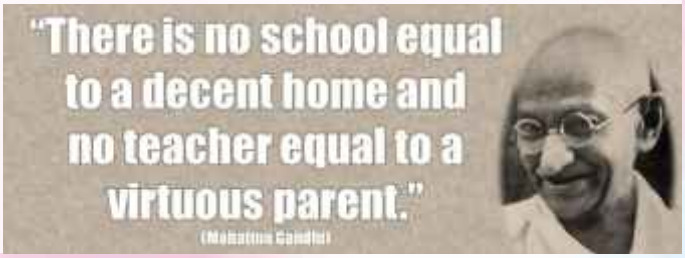
• Lower the track under the structure to create space for the OLE

• Undertake works to adapt or amend the structure

• Demolish and reconstruct the bridge with sufficient clearance for the OLE The preferred and cheapest option for the works is to lower the track through the structure, but this is not always possible due to the risk of undermining the structure. It is also not always possible to amend or adapt the structure, and therefore bridge reconstruction must be undertaken. Information supplied by RSSB indicates that around 25% of the cost of electrification schemes is for civil engineering related works, of which the bulk is for bridge reconstruction. Changes to railway systems which would allow the volume of bridge reconstruction to be reduced have the potential to generate significant cost savings and to ultimately benefit the fare-paying public. The RSSB Avoidance of Bridge Reconstruction Project was launched in 2014 to seek solutions which could reduce the volume of bridge reconstruction, minimising disruption to service and cost of electrification programmes. RSSB suggested that solutions could address the challenge through: • Improved gauging of the structure • Altering the design of OLE and train pantographs • Altering the structure to increase clearance • Revising the design of the track and substructure to reduce the depth of construction.

Ref. : PWay UK april 2018/136/2

By : Craig Govan Matthew Brough Menan



The Hardlock Nut Improving our Permanent Way Efficiency with New Applications

Staytite has been chosen to supply a specialist locking nut to Network Rail for use on re-railing jointed track, starting with four miles of jointed track in Scotland. Overall, Network Rail is responsible for more than 20,000 miles of track, of which 2,500 miles is jointed track, with each section measuring up to 60 feet in length. A total of 88 track lengths equals one mile of standard track and thus 88 pairs of fishplates are required for every single mile of track. That equates to 88 x 8 M24 (1") or M27 (1 1/8") Hardlock Nuts = 704 per mile of track. Network Rail has a highly proactive approach to track infrastructure and safety, particularly in the wake of previous accidents. With a commitment of 'zero tolerance' to any situation that might give rise to such incidents in the future, the company has pursued a maintenance and safety strategy that delivers the highest possible returns. Staytite was previously consulted by Network Rail on the redesign of its stretcher bars where the Hardlock Nut was specified to improve safety. Staytite has worked, first with British Rail and then Network Rail, for 20-plus years." A key aspect of that relationship was the supply of more than half a million components between 2008- 2010 in a retrofit campaign, in the wake of the Potters Bar and Grayrigg accidents. Staytite has been awarded the initial contract from Network Rail to supply for installation 1,480 Hardlock Nuts, washers and bolts. These will secure around two miles of track at Inverness & Fort William in Scotland – which will pave the way to supply similar requirements for up to 2,500 miles of jointed track across the UK. The Hardlock Nut is sold in the UK and throughout Europe by Staytite. It is being used in safety-critical applications, on account of its established performance and reliability. See image 1. The background to this contract goes back to July 2013 when a passenger train carrying 385 people derailed and hit the station platform in Brétigny-sur-Orge in the southern suburbs of Paris. Seven people died and nearly 200 were injured. The initial inspection found that a loose fishplate had caused the disaster where three of its four bolts had failed, due to the nuts working loose. See image 2. While the French investigation of the Brétigny derailment was on-going, the repercussions of the accident spread way beyond its borders, prompting urgent action in the UK. Here, the Rail Standards Safety Board (RSSB) wrote to Network Rail in November 2013 to enquire what steps it was taking to prevent a similar accident from occurring in the UK. It was at this point that, in light of the established relationship between the two organisations, Network Rail contacted Staytite for a possible solution. SAFETY STANDARDS Network Rail issued an expression of interest for solutions to the problem of fasteners coming loose on fishplates, Tony Jackson, Senior engineer - Track & Lineside – STE, Network Rail was appointed to oversee the project, in order to ensure the correct safety standards were applied to fishplates on UK rail, going forward.

Ref. : PWay UK april 2018

By : Craig Govan Matthew Brough Menan

Progressive Assurance for S&C Renewals

The key to delivering higher speed handbacks is accuracy and getting each step in the installation of the track Right First Time. The difference between handing back with a temporary speed restriction and reopening at full speed comes down to working within much narrower tolerances and ensuring that ballast is consolidated effectively before the line is reopened, rather than allowing the ballast to settle under normal traffic. The S&C North Alliance is a partnership between AmeySersa and Network Rail to deliver switch and crossing (S&C) renewals across the North of England and Scotland. Established in 2014 under a 10-year agreement, the Alliance approach combines the best of European processes and technology, UK rail design and engineering expertise, and safety practices aligned to Network Rail's Life Saving Rules, to improve safety, performance and reliability for passengers. By moving away from the more traditional client-contractor dynamic, the Alliance approach has improved collaboration between designer and installer, established joint accountability and firmly embedded the 'client' as an active participant in the partnership. This true 'Alliance' way of working, has allowed the team to focus on delivering a Right First Time, high quality approach to switch and crossing renewals and associated works. This increased focus on quality has enabled lines to be reopened at higher speeds than were previously possible after engineering work. High speed handbacks are not only good news for passengers who experience fewer delays, and for employees working in safer environments but the increase in quality is also significantly more efficient in the long term. This is because the Right First Time approach reduces follow-up and rework, improves reliability of the asset and reduces the whole life cost of the installation. Within the first year of the partnership, the S&C North Alliance increased its average hand back speed after S&C renewals from 50mph to 80mph and delivered the UK's first 90mph S&C handback at Craigentinny, near Edinburgh. Since then, the Alliance

has set about making handing back at line speed the norm, reducing delays for passengers and delivering several million pounds of schedule 8 savings for its route customers. In September 2016, the S&C North Alliance were tasked to complete a S&C renewal on the East Coast Main Line at Belford, of five turnouts over two 54-hour weekend possessions. The team made rail history by reopening the Down Main over 510bpts at line speed of 125mph immediately after the core renewal – the first time this has been achieved on a S&C turnout in the UK. The DVs 10.75 turnout 'Pts 510b' on the Down Main were deliberately targeted for the 125mph handback as it was a set of trailing points on a straight. See image 1. After a detailed Lessons Learned was conducted following the Belford 125mph handback In February 2017, the Alliance was tasked to complete a complex S&C Renewal at Sandy in Bedfordshire, a busy section of the East Coast Main line approximately 40 miles north of Kings Cross. The work at Sandy was technically much more difficult than Belford as it included one turnout and three S&C crossovers, a mixture of facing and trailing switches over two 54 hour weekend possessions. Seven point ends (see table 1) and associated OLE adjustment is a challenging volume for a 50mph handback for any renewal team. However, building on their success at Belford the S&C North Alliance Doncaster team, under the leadership of Eldon Atherton, took on the challenge to handback the entire Sandy renewal at linespeed of 125mph. In order to achieve 125mph handback all the normal renewal activities associated with 50mph hand to be completed but installed to 125mph construction tolerances. All the welds had to be completed in the core works. Furthermore, a way had to be invented to parallel tamp and dynamically track stabilise (DTS) the long through bearers of the crossovers. The team at Sandy made rail history by reopening all the lines on Monday and again on the following Monday at line speed of 125mph immediately after the core weekend – the first time this had been achieved on a complex S&C project in the UK and a worldwide first ever parallel DTS and Tamp of S&C. See image 2. Collaboration with our supply chain and partners was key. The Alliance team worked closely with Network Rail's IP Track Central Engineering and Delivery team who developed and supported the trials of the advanced technology that was used to ensure that machinery and processes could be used effectively on S&C sites. Working with the supply chain was also important to ensure that the high tech plant was available and, where necessary, adapted to work on a S&C renewal. A PROGRESSIVELY ASSURED, RIGHT FIRST TIME APPROACH The key to delivering higher speed handbacks is accuracy and getting each step in the installation of the track Right First Time. The difference between handing back with a temporary speed restriction and reopening at full speed comes down to working within much narrower tolerances and ensuring that ballast is consolidated effectively before the line is reopened, rather than allowing the ballast to settle under normal traffic. To make a 125mph handback on S&C a possibility, the Alliance team – as both designer and installer - reviewed every step of the track renewal process in detail to work out how best to achieve the narrow tolerances required. This has resulted in a series of incremental improvements that helped to deliver the first 125mph handback at Belford and made the attempt to replicate this on the more complex layout at Sandy a realistic and safe goal. Throughout the two core weekends, the team adopted a robust progressive assurance process which was measured and signed off at every stage of the construction process by a named Responsible Person for that stage.

Ref. : PWay UK April 2018

By : Nick Matthews

The Use of Geocells Reinforcement to Improve the Structural Performance of the Railway Track Bed in the UK

The railway track is considered to be a structural system which is designed to withstand the combined effects of traffic and the environment so the subgrade is adequately protected (Burrow et al., 2009). To achieve this, the thickness of the ballast and sub-ballast are mainly designed to ensure that the stresses from the dynamic loading are reduced to acceptable levels. In addition to that, other design considerations are taken into account such as subgrade erosion prevention and frost protection. However, when soft subgrades are encountered, the required thickness of track bed layers becomes very large which can impose financial and construction issues. Recent development and detailed understanding in track bed geosynthetics, in particular Geocells reinforcement due to its reinforcement properties, has allowed the reduction of the required thickness of track bed layers. A significant number of research studies have been carried out to investigate the benefits of using Geocells in railway track bed. They have concluded that Geocells reinforcement can reduce the granular fill material required by almost up to 40%. Nevertheless, in the UK, the use of Geocells is still limited to a number of bespoke sites; this is due to difficulties related to Geocells design and method of installation. Unfortunately, there is no universally agreed method to design the track bed using Geocells. Therefore designers in the UK are reluctant to incorporate them in their designs. In addition, the limited

experience in installing Geocells during track renewals has made construction contractors reluctant to provide performance assurances for such installation. The aim of this paper is to reiterate the benefits of Geocells found in literature and best practices for Geocells installation. This will be further supported with a case study from an existing site in the UK where Geocells were designed, installed and performed successfully to provide further confidence in this technology.

Ref. : PWay UK October 2018

By : Dr Mohamed Wehbi

HSGT Systems: HSR, Maglev and Hyperloop

Three systems have been explained in this paper and are based on different concepts and technologies with different current and future challenges. High Speed Railways can offer attractive travel times, high capacity, frequency, accessibility, comfort, reliability and safety as well as interconnectivity and interoperability. Developments in high-speed rail have historically been impeded by the difficulties in managing friction and air resistance, both of which become substantial when vehicles approach high speeds. Other transport modes are quickly evolving and competing more strongly with high-speed rail. Investments in research and developments are vital for this system to be competitive beyond the next 20 years. Maglev systems have some advantages over HSR. These systems are more energy efficient, produce less noise, possess better operational performance (because of their acceleration and deceleration times), and are safer than HSR. However, the infrastructure construction cost, energy and systems required for their operation is aggravated in the case of Maglev. One research approach is focussed on reducing cost for cooling superconductor and another research approach is on advanced light-weight materials to reduce the weight of the vehicles. Hyperloop technology is a highly innovative transportation mode that could enable the highest ground transportation speeds. However, the development of the technology is still in its early stages, there are engineering, economic, safety and social challenges to overcome and it will require coordination and acceptance from regulatory agencies on design, operations, security, and safety. Finally, the implementation of a new infrastructure has many economic, social and environmental implications, not only for today's society, but also for future generations. One of the main objectives should be to evaluate the new transport system in context with existing infrastructure, available resources, considering the development of new technologies and attending not only to initial construction costs but also to long-term operation and maintenance costs, to provide a new efficient, safe, sustainable, reliable and high-capacity transportation system that meets the current and future needs of society.

Ref. : PWay UK October 2018

By : Manuel Contreras

Single Span Strengthening of a Listed Masonry Arch Railway Viaduct: COL 120A, Castle Field Viaduct, Manchester

Commissioned in November 2017, the Ordsall Chord viaduct directly connects Manchester's Piccadilly and Victoria railway stations for the first time; reducing rail congestion, allowing new services to be introduced, and forecast to create over £4bn of subsequent economic benefit. A deteriorated span of the existing Grade II listed 1845 Castle field Viaduct required strengthening to accommodate a new alignment of rail tracks to be borne by the structure in conjunction with viaduct's 'widening', (construction of a new viaduct extension at one side to increase the width of the deck), to allow branching onto the Chord. This paper provides an account of the key design issues which were overcome in order to generate an effective strengthening solution. The benefits of a collaborative approach to working form a recurring theme throughout the narrative.

Ref. : PWay UK October 2018

By : Matt Brimble

Use of Inherent Standard Deviations as Track Design Parameters

The track design standards define a complex set of rules the designer must consider for a compliant design. The designer is looking for more than this; he is looking for a reliable design quality assessment tool, able to give an objective image of how 'good' a design is. For example, in our design proposals we do our best to avoid overlapping vertical curves with horizontal transitions and keep them as far apart as possible within the specific constraints of the site. But when 'far apart' means 'good', or 'good enough', is up to our engineering judgement and sometimes up to subjective preferences or even myths saying: "keeping this element 6.2 m (or 12.25 m?!) away from another is good enough but if that distance is 6.05 m (12.15 m) then that is a no-no" – even though the standard design parameters are practically

the same for the 'good-enough' and 'no-no' cases. In such circumstances it would be very useful to have an objective way to measure how good a design is. To have an objective measure of the design quality that will challenge the subjective rules of preferential engineering, which sometime define arbitrary and not very well justified design constraints. And we, the design engineers, saw the inherent standard deviations as being that objective measure of design quality and the Track Geometry SD Calculator developed in 2007 by David Marriott as the tool to assess the design. Unfortunately, to the personal disappointment of the author also, the inherent standard deviations calculated using the TGSD Calculator are not the holy grail of design quality checking. The Calculator was not developed for this purpose (Marriott – 2018). There is extensive British and international research on the impact track geometry has on the riding comfort (VTI notat 56A-2003, TRDOS-017 -1986, UIC Code 518) which can be used as a base to develop design review tools based on dynamic vehicle response. However, we already have a design rule based on that – the 'two seconds' rule (NR/L2/TRK/2102 – 2017 – 8.3.1). This best practice rule recommends a minimum design element length dependant on speed (table 2) which would allow the vehicle oscillations caused by the passage over a design element change to attenuate before passing over the next point of design element change. Quite often when designing a track alignment within the footprint of the existing railway, various site constraints force the designer to use design element lengths significantly shorter than those required by the 'two seconds' rule, still complying with the other design standard rules and limits. This is a justified compromise. Changing these short lengths by some metres or shifting these elements slightly to marginally avoid overlapping would not generate miraculous improvements in riding quality. The 'improved' design will still remain a compromise, no matter how much better the design SDs might be in that case. The examples and arguments discussed in this article are not challenging the track measurement principles and are not in any way implying that the track quality assessment based on standard deviations is wrong. Following on from the previous article written by David Marriott and from the examples presented in this article, the main arguments against using design (inherent) standard deviations as design parameters are as follows: a) The design SDs are calculated from the artefacts caused by the Butterworth filter when processing the position and characteristics of the points where a track design element change to another. The design SDs are independent of the design speed and do not reflect the dynamic behaviour of a railway vehicle. b) The vertical (Top) SD is a combination (summation) of the effect of cant and gradient changes. From this perspective, cant (level adjustment of one rail) and gradient (level adjustment of both rails) are equivalent. Whereas, the dynamic effect of a gradient change is completely different to the dynamic effect of a cant change and this is well reflected in the track design rules. c) The vertical (Top) and horizontal (Alignment) SDs are calculated independently of each other hence they cannot measure the extent to which the designer has applied cant to compensate for the effect of curvature in his design.

Ref. : PWay UK October 2018

By : Constantin Ciobanu

Elastic Elements in Track Influencing Total Track Costs and Reducing Vibrations

Under Sleeper Pads are a state-of-the-art technical solution reducing both lifecycle costs as well as reducing vibrations in railway tracks. Being already a standard product in countries like Austria, Germany, France and Italy, in recent years the positive effects of USP demonstrated also led to introduction of these elastic elements in the UK. As of 2018 more than 200.000 sleepers in the UK (mainline and urban railway) have been equipped with polyurethane USP. The biggest number of these USP have been installed for LCC reduction reasons; a smaller number for vibration isolation purposes. This development can also be observed worldwide, as the adoption of USP into best practices for railway superstructure construction continues to spread across all continents.

Ref. : PWay UK October 2018

By : Peter Veit Graz



Optimisation of the Wheel Rail Interface on London Underground

ABSTRACT London Underground faces an enormous challenge to run a modern metro service in excess of 40 million gross tonnes per annum on Victorian infrastructure. Line upgrade projects have invested in rolling stock and signalling to meet modern demands but investment in the infrastructure has remained within a separate track renewals programme. The removal of central funding in 2019/20 will lead to reductions in spending in this programme along with maintenance. In order to meet this challenge, optimising the wheelrail interface is essential to reduce costs and minimise risk. Preventative wheel turning, accurate predictions of rolling contact fatigue, and appropriate adhesion management are all essential to achieving this goal.

Ref. : PWay UK October 2018

By : Constantin Ciobanu

Design Challenges for Urban-Railway Transport Systems

Examples of the Development of Ballastless Track Forms including Noise and Vibration Mitigation for Metro Lines

Inner-city metro sections are highly frequented and they cross densely populated urban areas. Track systems to be installed have to take both of these aspects into account. This requires a high performance design resulting in low impact on the environment in terms of ground-borne noise and vibration. Ballastless track forms offer a state-of-the-art technical solution to fulfil both requirements. The structural design of ballastless track forms has to take into account limiting factors, such as space availability and maximum tolerable deflections and it has to provide a holistic best outcome solution for any given traffic loading, vehicle dynamics and subgrade in order to minimise costs over the entire life-time of the system. In vibration sensitive areas, ballastless track forms can be executed as a mass-spring system. The systems are analysed with numerical models in order to be tuned to the required insertion loss for optimal mitigation of impacts on the receiver. Different ballastless track systems have been developed for Metro Doha (Qatar) and Wiener Linien (Vienna Public Transport System, Austria) and will be presented in this paper. The system for Metro Doha includes a prefabricated slab track element installed on a concrete blinding layer. The system has been developed for installation in tunnels, at grade and on elevated viaduct sections. Vibration sensitive areas are equipped with heavy or light weight mass-spring systems. The system for Metro Vienna is a system with booted bi-block sleepers mounted on a track slab for installation in tunnel sections. The track slab is supported by an elastic element of polyurethane (PUR), providing vibration mitigation.

Ref. : PWay UK October 2018

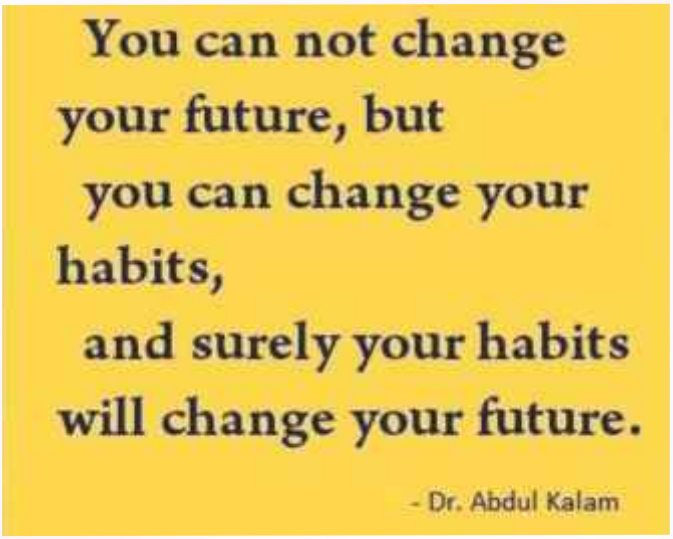
By : Hanno Toell Dieter Pichler

Development of the U-Doppler Non-Contact Vibration Measuring System for Diagnosis of Railway Structures

This paper introduces the non-contact vibration measuring system known as U-Doppler that has recently been developed by the RTRI. In the field of railway structure monitoring, dynamic characteristics estimated by vibration measurements are applied to evaluate structural integrity. Adopting a long-distance remote measurement method with U-Doppler enables improvement of the efficiency and safety of measurement, since it is unnecessary to install sensors and cables at locations high above structures and remove them later. This report first gives an outline of U-Doppler and its measuring method. It then goes on to verify the accuracy of U-Doppler using the results of laboratory experiments, microtremor measurement of a rigid-frame viaduct, impact vibration measurement of a bridge pier, and deflection measurement of a bridge girder.

Ref. : Japanese Railway Engineering April 2018

By : Fumiaki UEHAN



S.No.	ACS No.	Dt of Issue	Remarks
			TRACK
1. Indian Railways P-Way Manual			
01.	94	01.06.2004	Para No 410(3) and 410(4) replaced
02.	95	30.06.2004	Para No 826 replaced
03.	96	22.07.2004	New para 607(3) added
04.	97	19.10.2004	Note of Annex. 8/3 (para 807 & 808) replaced
05.	98	17.05.2005	Para No 202(1) replaced
06.	99	14.12.2005	Para No 107(1) replaced
07.	100	21.06.2006	Para No 902(1), 907(2)(a), 919(1), 924(b)(i) replaced. Addition to sub-para 916(1)(i), 924(b)(ii), 924(c)
08.	101	21.12.2006	Para No 107(1) replaced
09.	102	30.05.2007	Para No 244(2)(e), 273(1), 275(3), 276, 506(3), 716(2), 1404 replaced
10.	103	01.06.2007	Para No 237(6) replaced
11.	104	19.07.2007	Para No 1504 replaced
12.	105	22.08.2007	Para No 277(a)(3) replaced
13.	106	14.09.2007	Para No 124(2)(a) replaced
14.	107	12.11.2007	Para No 615(3) replaced
15.	108	18.12.2007	Para No 1302(2)(h) replaced
16.	109	15.02.2008	Para No 202(1) replaced
17.	110	04.03.2008	Annexure 8/1 – Para 806(1), 8/2 – Para 806(2), 11/4- Para 1118(5) and 11/5-1120(4)(C) replaced
18.	111	23.04.2008	Para No 222, 701(2), 1301(1), 1302(1), (1) (i), (2) (g), 1307(1)(g), 1309(1), 1309(2), 1309(4) and Annexures 13/1 (2), (4), (5) & Annexure 13/6 (heading) replaced
19.	112	25.04.2008	Para No 726(3)(b) replaced
20.	113	03.06.2008	Para No 1504 replaced
21.	114	10.10.2008	Para No 206(3) and 317(3) replaced
22.	115	24.11.2008	Note given at the bottom of item No. 9(a) of Annexure-9/1 para 904 replaced
23.	116	23.04.2009	Para No 220 replaced
24.	117	19.05.2009	Para No 322, 248(1), 248(2)(a), 244(4), 263(2)(a) replaced
25.	118	30.07.2009	A new sub para 146(vii) added
26.	119	18.08.2009	Para No 220(3) replaced
27.	120	16.04.2010	Para No 151(1)(a) replaced
28.	121	12.07.2010	Para No 1302 (2)(h) replaced
29.	122	23.11.2010	Para No 238(2)(g)(iii) and 238(2)(g)(iv) added Para No 257(4), (6), (7) & Para 917 replaced
30.	123	27.01.2011	Para No 170(15) added
31.	124	14.02.2011	Para No 250(2) replaced
32.	125	21.02.2011	New Para 272(4)(a) added. Para No 508, 510(3) replaced
33.	126	21.06.2011	Para No 263(2)(a)(i) replaced
34.	127	28.11.2011	Para No 1302(2)(g) replaced

S.No.	ACS No.	Dt of Issue	Remarks
35.	128	05.03.2012	Para No 234(5), 238(2)(d)(i) replaced. Annexure-2/11 Para 263 replaced, Para 273 renumbered as Para 273(a), New para added as Para 273(b), Para 904 replaced, Para 916 sentence deleted, Para 918(1), 924(b)(i), 924(c) replaced, Para 924(b)iii deleted
36.	129	28.06.2012	Para No 302(1)(a) and 248(2)(a) replaced
37.	130	16.11.2012	Para No 244(4), 1001(6), 302(1)(b)(ii), 224(2)(e)(v) and annexures-2/11 & 2/13 of para 263 replaced
38.	131	11.01.2013	Para No 277(a)(7), 429 and 502 replaced
39.	132	08.04.2013	Para No 238(1)(b)(5), Para 107, Para 108(2)(b), Para 123, 124, 127, 129, 136, 139, 144, 223, 237(5)(a) replaced. Added new para 108(2)(c), Para 124(A), 139(A) deleted
40.	133	04.06.2013	Para No 202(1) modified, New sub para (c) of para 1303(1) added
41.	134	18.07.2013	Annexure-2/6(B), (C) and (D) and Annexure-2/6/1of Par 237(5) added
42.	135	07.05.2014	Para No 151(1), 910(1)(g)(i), 1007(c), 1116(c), Annexure 9/7 of para 918(2), Annexue 2/11 & 2/13 of para 263, Annexure 2/6 of para 237(5), para 1014(1)(d) replaced, New note to para 107 added
43.	136	14.11.2014	Para No 237(8)(b), 279, 406(2)(a), 421, 427(2), 502(1), Annexure 7/2 part B of para 708(1), para 804, 824, 825, 910(y), 1007(1)(l) replaced, Para 708(1) modified
44.	137	18.06.2015	Para No 254, 257(4)(b), 317(3)(b), 814(1)(a), 1304(3) replaced, New para 255(6), 310(7) added
45.	138	25.08.2015	Para No 1302(2)(g) replaced
46.	139	08.02.2016	Para No 607(4) added, Para 248(2)(a), 910(1)(j) replaced
47.	140	28.11.2017	Para No 420(2), 502(1) replaced
48.	141	18.01.2018	Para No 152(2) replaced
49.	142	27.03.2018	Para No 169, 170(5), 170(6)(b) & 1408(3) Note (v) replaced
50.	143	19.04.2018	Para No 237 and Annexure 8/3, 8/3A & 8/4of Para No 807 & 808 replaced
51.	144	08.05.2018	Para No 302(1)(e), 919(1) & Annexure 9/5 Para 916(1) replaced
52.	145	23.07.2018	Para No 228(4), New Annexure 2/7 to para no. 228(4) added, Para No replaced
53.	146	15.18.2011	The existing 'Annexure 2/4 of para 211' shall be replaced.
54.	147	28.12.2018	The existing para 248(2)(a) replaced.
2. LWR Manual			
01.	02	1999	Para No 6.2, 6.2.1(i), 1.18 replaced
02.	03	1999	Heading of Para No 4.5.7 & sentence at para 4.5.7.1(1)(b)(i) replaced
03.	04	1999	Para No 6.3 modified, Para 6.3.1 added, Para 6.3.1 & 6.3.2 renumbered
04.	05	1999	New para 4.4.1(i) added

S.No.	ACS No.	Dt of Issue	Remarks
05.	06	1999	Text substituted to para No 2.2.1, Para No 5.2.1 reworded
06.	07	2000	Changes made to Figs 4.2.1(a) to (d)
07.	08	2002	Para No 1.1 & 1.2 reworded, Text added to para 4.5.3
08.	09	2005	Para No 6.2.1(i), 4.4.1 replaced
09.	10	2006	Fig. 5.6 & Para No 6.4.1(i)(c) replaced
10.	11	2006	Text substituted to Para 3.2.1
11.	12	2009	Para No 1.16, introductory para of Annexure XA [Para-9.1.2(i)] replaced
12.	13	2010	Para No 1.11 replaced
13.	14	2011	Para No 3.4, 8.2.5, 9.1.8(i), 9.1.8(iv), Annexure-VI item 1(c)(i), Annexure-V, Table-I replaced
14.	15	2012	Para No 8.1.5(i) & Figs 4.2.1(a) to (d) replaced
15.	16	2014	Para No 4.3.3(i), Fig. 4.2.1(a) to (d) replaced
16.	17	2018	Para No 5.6.1, Fig. 5.6, Annexure XIII-A replaced. New Fig 8.2.1 added
3. Track Machine Manual			
01.	01	Mar. 2000	Addition of text to the end of Preface.
02.	02	Mar. 2000	Annexure 8.1 para (A) & para (B) replaced
03.	03	May 2003	Para 4.6.8 added
04.	04		Para 4.6.8(iv) added
05.	05	Sept. 2003	Text added to para 5.6
06.	06	13.01.2004	Para No 4.3.3 & 8.3.2 replaced
07.	07	07.04.2004	Para No 4.3.1 modified
08.	08	25.10.2004	Para No 5.1.3 added & existing para 5.1.3 renumbered
09.	09	20.10.2006	Annexure 8.1 replaced
10.	10	12.12.2006	Para No 2 of Annexure 5.9 replaced
11.	11		
12.	12	22.08.2013	Annexure 8.2 replaced, New annexure 8.3 added, Table 6.2 in Para 6.3.5 modified, Text replaced in Para 8.4.5
13.	13	25.09.2012	Para 6.2.1 added
14.	14	14.06.2012	Para No 5.3.3 replaced
15.	15	14.06.2012	Para No 4.4.3 replaced
16.	16	12.11.2013	Para 9.6(ii) modified
17.	17		Para 6.2 modified
4. Manual For Ultrasonic Testing of Rails & Welds			
01.	01	Nov. 2014	Para No 8.15.1 replaced
02.	02	Dec. 2014	Para No 8.14, 8.15.1, Annexure IIA and IIB replaced
03.	03	Mar. 2016	Para No 4.1.1(c), 5.1.2, 8.6.4, 8.7.2, 8.10, 8.14, 8.15.1, Figs. 3 & 22 replaced. New clause b)(iii) below para 8.16 added, New para 6.3.1 & 6.3.2, 10.6 added
04.	04	Sept. 2018	Para 6.6, 8.14, 8.15, 8.15.1 & 8.15.2 modified,

S.No.	ACS No.	Dt of Issue	Remarks
5. Indian Railways Code For The Engineering Department			
01.	50	21.09.2017	Introduction of measurement & recording of 'executed works' by the contractor' in Rly Construction Works.
02.	51	27.09.2017	Para Nos 701, 1102, 1209 should be amended
03.	52	23.10.2017	Existing para 1238 replaced
04.	53	06.11.2017	Para No 701 should be amended
05.	54	22.01.2018	Para No 1264 (e) & 1264 (f) should be amended
BRIDGES			
1. Indian Railways Bridge Manual			
01.	01	01.09.1999	Para No 1007 replaced, New para 1007(A) added.
02.	02	21.07.2000	New para 16 added
03.	03	21.07.2000	Deleted para 513(b)
04.	04	21.07.2000	Deleted para 515
05.	05	21.07.2000	Deleted para 603
06.	06	21.07.2000	Deleted para 222(1b), 222(2f)
07.	07	21.07.2000	Deleted para 618
08.	08	21.07.2000	Para No 504(4) replaced, Add new para 521, sub para 5 under para 616 and sub para 5 under para 210
09.	09	27.07.2000	Add new sub para 317 of Chapter III
10.	10	31.08.2000	Para No 604 replaced
11.	11	14.01.2003	Add para before chapter 1
12.	12	18.12.2007	Para No 217.2(a)(i) and para 217.2.(b)(i) replaced
13.	13	22.01.2008	Para No 317 replaced
14.	14	20.03.2008	Delete para 310, 312(4), 313(2) and 313(3) of chapter III,
15.	15	05.08.2008	Para No 410(2)(b), 418(5), 430 replaced, Para 3(ii) of 606 is proposed for deletion and Para 3(i) renumbered as 3
16.	16	13.08.2008	Para No 317(iii) replaced
17.	17	15.09.2008	Para 318 added
18.	18	17.12.2008	Para 224 added
19.	19	11.01.2010	Para 318 modified
20.	20	07.06.2010	Para No 1104(5) replaced
21.	21	02.07.2010	Para No 1107 (d) modified. Add para 1107(15)(i)
22.	22	28.03.2011	Para No 1107(15)(i) replaced & renumber as 1107(15)(b)(i), para 1107(15)(b) is renumbered as 1107(15)(b)(ii)
23.	23	23.08.2011	Replace existing Chapter-VIII by revised Chapter-VIII
24.	24	14.09.2011	Para 714(2), 1005(1), 1005(3), 1104, 1104(2), 1104(5), 1106(2), Page No xi(Index)1104 modified
25.	25	17.12.2012	New sub para 3 may be added to existing para 311
26.	26	23.08.2013	Para No 217.2(a)(ii), 217.2(c), 217.4(c), 217.4(d), 217.4(e), 217.4(l), 615 to be replaced
27.	27	03.01.2014	New para 1107 5 i), 215 A added
28.	28	20.03.2014	Chapter-X, Part B – Title of Deep Cuttings replaced and para 1010 to 1015 & Annexure 10/2 replaced by Para 1010 to 1017 and Annexure 10/2 attached.

S.No.	ACS No.	Dt of Issue	Remarks
29.	29	15.04.2014	Para No 312(2), 312(4) replaced. Add new para 313(4)
30.	30	25.11.2014	Para 102(b), 504, 505, 506, 507, 508, 509 & Annexure 5/1 deleted
31.	31	09.02.2015	Para No 617 replaced.
32.	32	12.03.2015	Para No 222 2(f) replaced.
33.	33	21.03.2016	Para No 107(1) (a) is amended and 107 (1)(f) added. Para 222 (3) is amended by adding sub para (c), (d) and (e)
34.	34	04.10.2016	Added para 224
35.	35	31.07.2017	Para No 313(2) & 313(3) replaced.
36.	36	27.03.2018	Para No 317 & 318 replaced.
2. Indian Railways Bridge Rule			
01.	47	22.06.2017	Add new para 2.8.1.2
02.	48	22.06.2017	Add new clauses
03.	49	26.12.2017	Para 2.12 deleted. New para 2.12 inserted
3. Indian Railways Bridge Substructure & Foundation Code			
01.	01	17.04.2014	Para 4.8.1, 4.9.3 replaced
02.	02	20.10.2016	Modify description & heading of contents at S.No. 7.5, Delete para 7.5.3
03.	03	22.06.2017	Modified para 4.5.9
04.	04	11.08.2017	Modified para 4.9.2 & 4.9.3
4. Indian Railways Concrete Bridge Code			
01.	01	16.12.2014	Replace table 10 of para 10.2.1
02.	02	14.01.2015	Insert para 5.4.7 & 5.4.7.2
03.	03	20.01.2015	Insert note under para 4.5.1, delete para 14.9 & replace, delete para 15.9.4.1 & replace, delete para 15.9.4.2 & replace, delete para 15.9.9 & replace
04.	04	15.11.2016	Para 14.9, 14.9.1 & 15.9.9 deleted
05.	05	13.06.2017	Para 16.4.4.4.5 modified
06.	06	27.07.2017	Para 7.1.5 modified
07.	07	26.06.2018	New para 4.5.1 added
5. Indian Railways Arch Bridge Code			
01.	07	25.09.2000	Replace para 1.1
02.	08	28.01.2015	Replace para 5.3.3
6. Indian Railways Welded Bridge Code			
01.	01	16.02.2015	Para 27.1 replaced
02.	02	11.07.2018	Para 27.1 replaced

IRICEN Calendar of Courses - 2019

Course No	Course Name	From	To	Duration	Eligibility
JANUARY					
18005	IRSE Posting Exam	07/01/2019	11/01/2019	1 Week	IRSE Probationers - 2016 Batch
18103-Part-II	Integrated	14/01/2019	07/02/2019	4 Weeks	Gr. B Officers
19501	PSU	14/01/2019	18/01/2019	1 Weeks	Sr Level Officers of PSU
19001	Orientation	21/01/2019	25/01/2019	1 Weeks	IRSE Probationers - '16 Batch
19401	Track Module-1	21/01/2019	01/02/2019	2 Weeks	JS/SS Officers
19402	CA & PM	28/01/2019	08/02/2019	2 Weeks	SS/JAG/SG Officers
19301	SJV	14/01/2019	15/01/2019	2 Days	Officers of Rly & other Govt. Dept.
19302	EPC& PPP	15/01/2019	16/01/2019	2 Days	JAG/SG Officers
18316	PCE Seminar	17/01/2019	18/01/2019	2 Days	PCEs of All Rlys.
FEBRUARY					
19201	Sr Prof PWay	04/02/2019	01/03/2019	4 Weeks	SS/JAG/SG Officers with min. 6 years of service in Gr. A
19403	Advanced Track Maintenance with mechanized maintenance	04/02/2019	15/02/2019	2 Weeks	SS/JAG/JS who have attended Basic track maintenance/ Tr. Module-1
19502	PSU	11/02/2019	22/02/2019	2 Weeks	Sr Level Officers of PSU
19508	Adani Group	11/02/2019	16/02/2019	6 Days	
19404	Derailment investigation and advance track technology	18/02/2019	01/03/2019	2 Weeks	SS/JAG/SG/JS who have attended Adv. Tr. Mntn with mechanized maintenance
19101	Integrated	25/02/2019	16/05/2019	12 Weeks	Gr. B Officers
19405	Software Course - STAADPRO	25/02/2019	01/03/2019	1 Week	SSE/ABEs
MARCH					
19303	CEW/CPDE Seminar	07/03/2019	08/03/2019	2 Days	CEW/CPDE
19202	Sr Prof Bridges	11/03/2019	05/04/2019	4 Weeks	SS/JAG/SG OFFICERS with min. 6 years of service in Gr. A
19406	Bridge planning	11/03/2019	22/03/2019	2 Weeks	JS/SS
19005	IRS First mid review (Batch 1)	18/03/2019	23/03/2019	1 Week	IRSE (P) 2017 BATCH.
19407	MIDAS	18/03/2019	29/03/2019	2 Weeks	SSE/ABEs
19408	Construction & Maintenance of Steel & Concrete Bridges	25/03/2019	05/04/2019	2 Weeks	JS/SS

Course No	Course Name	From	To	Duration	Eligibility
APRIL					
19006	IRSE First mid review (Batch 2)	01/04/2019	05/04/2019	1 Week	IRSE (P) 2017 BATCH.
19409	Basics of Track Maintenance	01/04/2019	12/04/2019	2 Weeks	JS/SS Officers
19509	MES	01/04/2019	06/04/2019	6 Days	MES Probationers
19304	CE TMC Seminar	04/04/2019	05/04/2019	2 Days	CEs/TMc of All Zonal Rly
19503	PSU	08/04/2019	12/04/2019	1 Weeks	Sr Level Officers of PSU
19321	W/S DyCE/BL	08/04/2019	09/04/2019	2 Days	DyCE/Bridge Line
19324	W/S on Indian Railway Heritage	11/04/2019	12/04/2019	2 Days	Chief Heritage Officers of Zones & Pus
19410	GeoTech Inv. & Survey	08/04/2019	18/04/2019	2 Weeks	JS/SS/JAG/SG Officers
19510	MES	08/04/2019	13/04/2019	6 Days	MES Probationers
19203	Sr Prof PWay	15/04/2019	10/05/2019	4 Weeks	SS/JAG/SG Officers with min. 6 years of service in Gr. A
19411	Advanced Track Maintenance with mechanized maintenance	15/04/2019	26/04/2019	2 Weeks	SS/JAG/JS who have completed Basic track maintenance/Track Module-1
19504	PSU	22/04/2019	26/04/2019	1 Week	Sr Level Officers of PSU
19412	Derailment investigation and advance track technology	29/04/2019	10/05/2019	2 Weeks	SS/JAG/SG/JS who have attended Adv. Tr. Mntn with mechanized maintenance
19305	SJV	29/04/2019	30/04/2019	2 Days	Officers of Rly & other Govt. Dept.
MAY					
19306	CBE Seminar	02/05/2019	03/05/2019	2 Days	CBEs of All Zonal Rly
19413	CONST. ENGRS	06/05/2019	17/05/2019	2 Weeks	SS/JAG/SG Officers
19414	Basics of Track Maintenance	13/05/2019	24/05/2019	2 Weeks	JS/SS Officers
19505	PSU	13/05/2019	17/05/2019	1 Week	Sr Level Officers of PSU
19322	WS/TMS	20/05/2019	21/05/2019	2 Days	Sr DENs/DENs
19002	Phase-2	20/05/2019	12/07/2019	8 Weeks	IRSE Probationers - 2017 Batch
19307	CTE Seminar	30/05/2019	31/05/2019	2 Days	CTEs of All Zonal Rly
JUNE					
19102	Integrated	03/06/2019	22/08/2019	12 Weeks	Gr. B Officers
19415	BDA	03/06/2019	21/06/2019	3 Weeks	SSE/ABEs
19416	Advanced Track Maintenance with mechanized maintenance	17/06/2019	28/06/2019	2 Weeks	SS/JAG/JS who have attended Basic track maintenance/ Tr. Module-1

SSTW Calendar of Courses - 2019

Course No.	Course Name	From	To	Duration	Eligibility
JANUARY					
19801	Track Module-1	07/01/2019	18/01/2019	2 Weeks	JE/SSE/P.Way
19802	Bridge Module-1	07/01/2019	18/01/2019	2 Weeks	JE/SSE/Bridge
19803	Track Module-2	21/01/2019	01/02/2019	2 Weeks	JE/SSE/P.Way
19804	Bridge Module-2	21/01/2019	01/02/2019	2 Weeks	JE/SSE/Bridge
FEBRUARY					
19805	RWI (Rail Wheel Interaction)	04/02/2019	15/02/2019	2 Weeks	JE/SSE/P.Way
19806	Geo-tech	04/02/2019	08/02/2019	1 Week	JE/SSE/Bridge
19807	Survey	11/02/2019	15/02/2019	1 Week	JE/SSE/Works
19808	Basics of Track Maintenance	18/02/2019	01/03/2019	2 Weeks	JE/SSE/P.Way
19809	Bldg Const	18/02/2019	23/02/2019	1 Week	JE/SSE/Works
19810	Conc-Tech	25/02/2019	01/03/2019	1 Week	JE/SSE/Works
MARCH					
19811	Advanced Track maintenance including mechanized maintenance	05/03/2019	15/03/2019	2 Weeks	JE/SSE/P.Way
19812	Contract Mgmt	05/03/2019	15/03/2019	2 Weeks	JE/SSE/Works-P.Way
19813	RWI (Rail Wheel Interaction)	18/03/2019	29/03/2019	2 Weeks	JE/SSE/P.Way
19814	Land Mgmt	18/03/2019	23/03/2019	1 Week	JE/SSE/Works
19815	TMS	25/03/2019	29/03/2019	1 Week	JE/SSE/P.Way
APRIL					
19816	Basics of Track Maintenance	01/04/2019	12/04/2019	2 Weeks	JE/SSE/P.Way
19817	Bridge planning	01/04/2019	12/04/2019	2 Weeks	JE/SSE/Bridge
19818	Advanced Track maintenance including mechanized maintenance	15/04/2019	26/04/2019	2 Weeks	JE/SSE/P.Way
19819	Construction & Maintenance of Steel & Concrete bridges	15/04/2019	26/04/2019	2 Weeks	JE/SSE/Bridge
19820	RWI (Rail Wheel Interaction)	29/04/2019	10/05/2019	2 Weeks	JE/SSE/P.Way
19821	Geo-tech	29/04/2019	04/05/2019	1 Week	JE/SSE/Works
MAY					
19822	Survey	06/05/2019	10/05/2019	1 Week	JE/SSE/Works
19823	Basics of Track Maintenance	13/05/2019	24/05/2019	2 Weeks	JE/SSE/P.Way
19824	Bldg Const	13/05/2019	17/05/2019	1 Week	JE/SSE/Works
19825	Conc-Tech	20/05/2019	24/05/2019	1 Week	JE/SSE/Works
19826	Advanced Track maintenance including mechanized maintenance	27/05/2019	07/06/2019	2 Weeks	JE/SSE/P.Way
19827	Contract Mgmt	27/05/2019	07/06/2019	2 Weeks	JE/SSE/Works-P.Way

Glimpses of IRICEN Day



Welcome with Bouquet by Dr/IRICEN to Sh. Vishwesh Chaubey, Member Engineering & Sh. Pradeep Kumar, Director General, NAIR



Address by Sh. Vishwesh Chaubey, Member Engineering, Railway Board



Address by Sh. Pradeep Kumar, Director General, NAIR



Unveiling of IRICEN Publication books by Member Engineering, Railway Board



Gathering of Silver Jubilee IRSE 1992 batch & other officers



Award by Member Engineering to Meritorious IRSE Probationers of 2014 Batch



Award by Member Engineering to Meritorious IRSE Probationers of 2014 Batch



Cultural Programme on the eve of IRICEN Day



Group photo of Silver Jubilee IRSE Batch 1992 with Sh. Vishwesh Chaubey, Member Engg, Rly BD. & Sh. Pradeep Kumar, DG/NAIR on the Occasion of 61st IRICEN Day

IRICEN Calendar of Courses - 2019

Month & Year	DECEMBER'2018					JAN.2019				FEB.2019				MAR.2019				Apr.2019					May.2019				June.2019				July.2019					Aug.2019				Sept.2019					Oct.2019				Nov.2019				Dec.2019					Jan.2020			
HOSTEL CAP	78	126	48	48	78	98	98	90	80	95	60	60	105	65	70	105	105	100	95	95	90	105	118	103	98	83	108	108	103	103	90	85	80	110	110	110	105	100	95	95	100	95	110	110	105	105	0	0	65	95	95	95	105	88	75	75	40	0	0	48	0
Date (Monday)	3	10	17	24	31	7	14	21	28	4	11	18	25	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27
Institute holidays				25								19		4		21				17		1/5					5									12&15				2				2	8			28 & 29		12						25							
IRSE 2016		POSTING					ORIENTAI																																																								
Trainees		48					48																																																							
IRSE 2017		Phase -1 , 18004																						Phase-2, 19002																																										
Trainees	48	48	48	48	48	48																	48	48	48	48	48	48	48	48																																
IRSE 2018																																			Joing																														
Trainees																																			40																														
Integrated courses	INTEGRATED					18103 INTEGRATED								19101 Integrated									19101 INTEGRATED					19102 Integrated								19102 INTEGRATED									19103 Integrated													19103 INTEGRATED																														
Trainees	30	30				30	30	30	30	30			30	30	30	30	30			30	30	30	30	30				30	30	30	30	30			30	30	30	30	30					30	30	30	30	30					30	30	30	30	30																										
Sr.Prof. courses										SPT					SPB					SPT												SPB													SPT																								
Trainees										15	15	15	15		15	15	15	15		15	15	15	15									15	15	15	15										15	15	15	15																								
Track courses								T1	T2	T3								T1	T2	T3			T1					T2														T1	T2	T3																								
Trainees								25	25	25	25	25	25					25	25	25	25	25	25	25	25				25	25												25	25	25	25	25	25																								
Bridge & survey geotech course														W'S	Br-1		Br-2		G&S								BDA					Br-1		Br-2			W'S		G&S																																				
Trainees															25	25	25	25	25	25							30	30	0			25	25	25	25				25	25																													
Contract, Arbit & PM									CA&PM																						Const Eg.						TNLG	CA&PM																																
Trainees									25	25																					25	25					30	30	30																														
Software courses													SW			MIDAS																														MIDAS																														
Trainees													35			35	35																												35	35																										
Courses for PSU						PSU					PSU								PSU		PSU										PSU																					PSU		PSU																
Trainees						20	20				20	20							20		20										20																					25		25																
AWARENESS COURSES																																		G6		G1		G2		G3		G4		G5																														
Trainees																																		40	40	40	40	40	40	40	40	40	40	40																														
HAG/SAG SEMINARS																			WS/ TMS						W/S/ DyCE /BL																												WS/ DyCE /D														
Trainees								35						35				35	25			35			25	35					35					35					35									35		25		35		35	35								
				s				SJV; EPCP						CEW; CPDE				CE/TMC				CBE &			CTE					EPC &PP					PCE				SJV , CGE									CE/TP				CE/TMC			s	s								
Misc										S	S			S	S										S						S																S						S	S	S								

Proposed CoC -2019 chart for SSTW

Month & Year	DECEMBER'2018					JAN.2019				FEB.2019				MAR.2019				Apr.2019					May.2019				June.2019				July.2019					Aug.2019				Sept.2019					Oct.2019				Nov.2019				Dec.2019					Jan.2020			
HOSTEL CAP						50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	50	50	50	50	50	50	50	50	50	0	0	0	0
Date (Monday)	3	10	17	24	31	7	14	21	28	4	11	18	25	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27
Institute holidays				25								19		4		21				17		1/5					5									12&15				2				2	8					12						25							
Track courses						T1-19801	T2-19803			RWI-19805	T1-19808			T2-19811	RWI-19813			T1-19816	T2-19818			RWI-19820	T1-19823			T2-19826	RWI-19828			T1-19831	T2-19833			RWI-19835	T1-19838			T2-19841	RWI-19843		T1-19846	T2-19848								T1-19850	T2-19853			T1-19856	T2-19858										
Trainees						25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25					25	25	25	25	25	25	25	25	25							
Track courses																																																																				
Trainees																																																																				
Bridge courses						Br-1-19802	Br-2-19804											Br-1-19817	Br-2-19819											Br-1-19832	Br-2-19834											Br-1-19847	Br-2-19849																														
Trainees						25	25	25	25									25	25	25	25									25	25	25	25									25	25	25	25																										
Bridge courses																																																																			
Trainees																																																																			
Works courses										GEOTEC	SURVEY-	BLDG	CONCRET	CONTRACT MGMT	LAND	TMS 1981						GEOTEC	SURVEY-	BLDG	CONCRET	CONTRACT MGMT	LAND	TMS 1983					TNLG	SURVEY-	BLDG	CONCRETE	CONTRACT MGMT	LAND	TMS 1984									GEOTECH	SURVEY-	BLDG	CONCRET	CONTRACT MGMT	LAND	TMS-											
Trainees										25	25	25	25	25	25	25	25					25	25	25	25	25	25	25	25					25	25	25	25	25	25	25									25	25	25	25	25	25	25	25										
PSU courses																																																																		
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