ज्ञान ज्योति से मार्गदर्शन

IRICEN Journal of Civil Engineering

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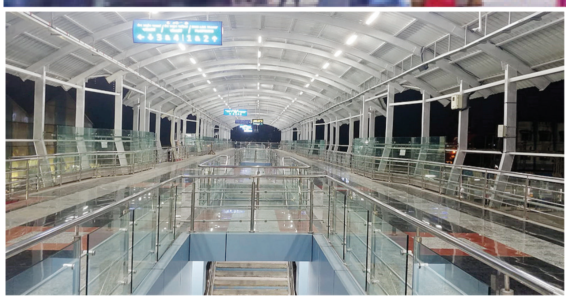

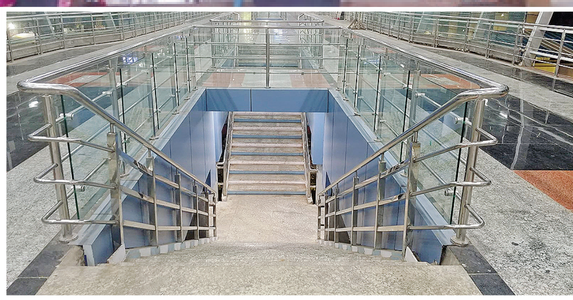

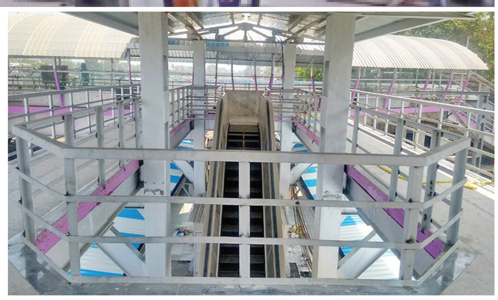

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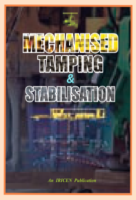

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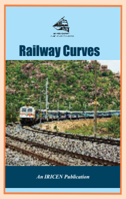

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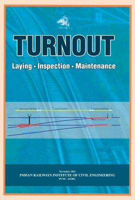

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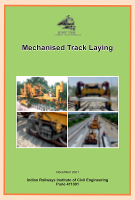

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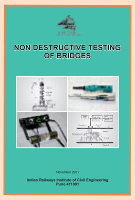

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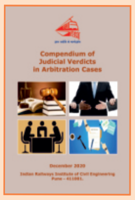

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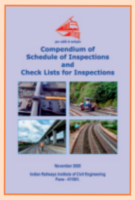

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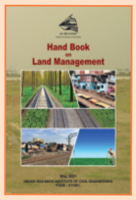

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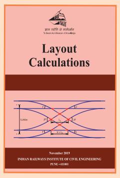

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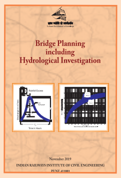

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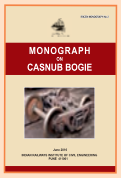

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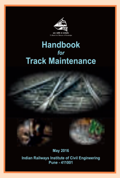

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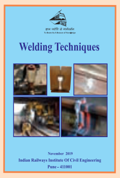

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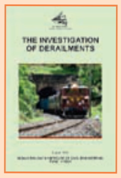

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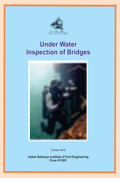

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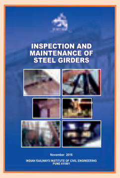

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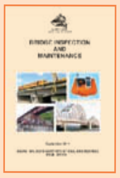

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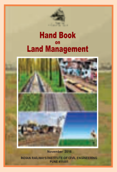

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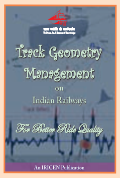

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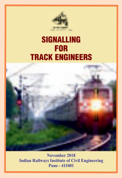

Signalling For Track Engineers

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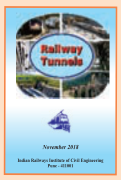

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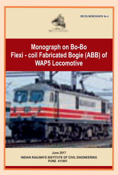

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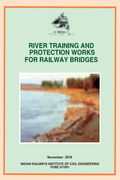

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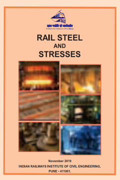

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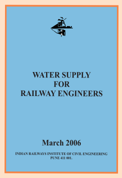

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From Director General's Desk

Dear Readers,

Railway fraternity has shown great enthusiasm to bring out this issue containing 8 papers. Papers have been included in diverse topics. The first technical paper is 'Innovative approach to optimize passenger dispersal at stations with restrictive width of platforms by adopting bifurcated design of FOBs'. Another paper is 'CAD Modelling of a prototype 'Mechanical Screw Coupler Lifting Jack' for 'faster manual track maintenance'. Third paper is 'Reduction in de-stressing temperature in Zone-IV to permit operation of 22.9t axle load wagons at 75 Kmph on 60 Kg 90 UTS Rail.'

We have also included one paper dealing with 'Ground Penetration Radar' technology in Indian Railways. Another is on Improving Running and Rating of run through yards for high speeds and higher axle loads.

There is also a paper on Arresting Track Creep in Braganza Ghats (Castle Rock -Kulem) through use of Sleeper Bracings using provisions of RDSO Report CT- 30 on SWR. Seventh paper deals with the analysis of parabolic catch siding and the last is related to utilization of EXCEL for creating Real Scale Drawings.

I sincerely hope that readers would find the papers and other articles contained in this journal informative and useful. The suggestions for making this journal more useful and relevant to the field user and the contribution for forthcoming issues in the form of technical papers, are welcome. This will help in sharing their knowledge and experience with the Railway Engineers.

Pune | (Ashok Kumar)
June 2022 | Director General

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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

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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.

Railway News

Indian Prime Minister Launches Pune Metro

INDIA's prime minister, Mr Narendra Modi, inaugurated the Pune Metro on March 6, with commercial operation commencing on two lines. The inaugural train operated on a 5km section of the Aqua Line from Garware College to Vanaz, which has five stations. The elevated Aqua Line will eventually be 15.7km-long with 16 stations, running from Vanaz to Ramwadi. Operation also began on a 7km five-station section of the Purple Line from Pimpri- Chinchwad Municipal Corporation (PCMC) to Phugewadi. When complete the Purple Line will be 16.6km-long, running from PCMC to Swargate, with 14 stations. 6km of the line will be underground, with the rest elevated. The 23.3km Line 3 which will run from Rajiv Gandhi Infotech Park to Balewadi is yet to open. This will be completely elevated and feature 23 stations. This line was the first project in India developed as a public-private partnership (PPP) under the government's New Metro Policy announced in 2017. Maharashtra Metro Rail Corporation (Maha Metro) plans to complete all three lines by December. Titagarh Firema has supplied 34 three-car trains for the network while Alstom has supplied its Urbalis 400 CBTC system for the first two lines. The Metro has been funded by the Indian government (20%), the State of Maharashtra (20%), Pune Municipal Corporation (5%), and Pimpri Chinchwad Municipal Corporation (5%) with the remaining 50% via loans from the French Development Agency (AFD) and European Investment Bank (EIB). Services are initially operating every 30 minutes from 08.00 until 21.00 each day.

Ref: International Railway Journal, April 2022

India and Nepal Open 35 km Crossborder Line after 11 Year's Construction

THE 35 km line between Jayanagar, India, and Kurtha, Nepal, was inaugurated by Indian prime minister, Mr Narendra Modi and his Nepalese counterpart, Mr Sher Bahadur Deuba, on April 2. Construction of the broad-gauge line, part of the 69.1km Jayanagar - Bijalpura - Bardiba line, began in 2010.Two five-car DEMU passenger trains will initially run on the Jayanagar - Kurtha section, which will provide a connection for pilgrims travelling to Janakpur. Testing has been successfully completed at 100km/h for passenger trains and 65km/h for freight. The cost of the project increased from Rs 5.4bn ($US 71.2m) to Rs 7.8bn. Indian Railways (IR) subsidiary Indian Railways Construction Company (Ircon), is responsible for projectdesign, planning and execution. "The second 17.5km Kurtha - Bijalpura section has also been completed and is likely to be made operational this year," says Ircon general manager, Mr Ravi Sahay. Construction on the Jayanagar - Kurtha – Bijalpura line has been relatively simple as it follows the route of a metre-gauge line built in 1937, with the Jayanagar – Janakpur section operational until 2014. "Bigger challenges are likely in building the third stretch from Bijalpura to Bardibas, which has hilly terrain," When complete, the line will connect India's Madhubani district in Bihar with the Dhanusa, Mahotara and Siraha districts in Nepal. The line will cross the Barhari and Rato rivers, with 15 large bridges and 127 smaller bridges proposed. The line will have eight stations,six halts and 47 level crossings.

Ref: International Railway Journal, May 2022

India Announces $US 32.7bn Rail Capital Investment in National Budget

INDIA's government announced Rs 2.45 trillion ($US 32.7bn) for rail in its national budget on February 1, along with an increased commitment towards rolling stock and infrastructure development. Under plans announced by finance minister, Ms Nirmala Sitharaman, Indian Railways (IR) will receive 400 aluminium bodied 160km/h Vande Bharat trains, while 100 new multimodal freight terminals will be built over the next three years. Two Vande Bharat trains are already in operation, while another is due to be completed at the Chennai-based Integral Coach Factory in June. IR has placed orders for 44 additional trains, while tenders for another 58 trains are being processed. Sitharaman said the Train Collision Avoidance System (T-CAS) will also be installed on 2000km of track in 2022-23, while Rs 238bn has been allocated to develop rapid transit systems and metro projects across India. Sitharaman did not mention previously announced items such as the restructuring of IR, the corporatisation of train manufacturing, or the introduction of private operation. There was also no mention of a targeted completion date for the Eastern and Western Dedicated Freight Corridors (DFCs), or about plans to improve railway finances. "This is the third year since 2019 when [IR's] operating ratio has gone beyond 100%, while IR has window dressed the numbers to keep it under 100% by meeting the pension expenses from government and extra budgetary support," says rail consultant, Mr Sudhanshu Mani. "In the last two years, the Comptroller and Auditor General (C&AG) has rapped IR for doctoring the numbers." IR currently has a moratorium on interest against loans, with current borrowing standing at Rs 4 trillion. However, this is expected to increase when the moratorium ends.

Ref: International Railway Journal, March 2022

Literature Digest

Dimensional Quality Assessment of Cablestayed Bridge by Combining Terrestrial and Drone Laser Scanner

Xinglinpu Bridge was built on the S3801 freeway in 2019 in preparation for the winter Olympics in Beijing, China. It is a cable-stayed steel bridge with pylons in the shape of flower baskets. Using Xinglinpu Bridge as a case study, a systematic approach to the dimensional quality assessment of complex bridges using a combination of threedimensional (3D) point clouds obtained by terrestrial laser scanning (TLS) and unmanned aerial vehicle (UAV) surveys is proposed in this paper. The currently available methods for dimensional quality assessment of complex bridges rely largely on manual inspection and contact-type measurement devices, which are time consuming and costly. To overcome these limitations, this paper presents a framework for dimensional quality assessment composed of three parts: scanning schemes for TLS and UAV, scanning implementation and measurement of geometric dimensions. The results of configuration detection verified the high-quality construction of Xinglinpu Bridge, although millimetrescale differences were obtained between the point clouds and the design value. The potential and limitations of 3D laser scanning for assessing the quality of complex bridges are discussed.

By : By Ma Yinhuai , Jiang Zhigang, Ma Ligang ,Li Changli ,Cui Shaoqian

Ref. : ICE/ Bridge Engineering Vol. 175 issue 2

Construction Monitoring of Cable Replacement: a Case Study

To ensure the structural safety and normal operation of a cable-stayed bridge in China (Rainbow Bridge), cables were replaced and construction monitoring and control were conducted. In the process of cable replacements, the cable force and girder elevation were monitored and the distribution of cable force was adjusted according to the construction monitoring results to improve the structural force and increase the safety reserve of the structure. In the process of monitoring the cable force, the difference between the measured cable force and the design cable force was 0.4–4.4%. After adjusting the cable force, the difference between the measured cable force and the design cable force was less than 2%, and the change in the cable force was uniform, meeting the original design requirements. In the monitoring process of the main girder elevation, the elevation was increased by a maximum of 0.054 m. After completing cable adjustment, the main girder elevation was increased by 0–5 mm. This elevation was more reasonable and met the design requirements.

By : Kexin Zhang , Dachao Li , Tianyu Qi , Guanhua Zhang , Yanfeng Li

Ref. : ICE/ Bridge Engineering Vol. 175 issue 2

How the Covid-19 Pandemic Helped to Achieve Better Well-being in Construction: a Case Study

Laing O'Rourke, like all other construction businesses, was confronted with a raft of challenges at the onset of the Covid-19 pandemic. This paper describes the approach adopted across the business to transform its focus on wellbeing and improve people's energy levels. It focused on three Hs: being more human, hybrid working and home complementing work, not competing. The approach has supported better well-being and performance by focusing on the type of work that needed to be done and how it is done. Removing the focus on where work was done has led to greater personal sustainability for project delivery teams and the functional colleagues who support them.

By : Kate Goodger , Josh Murray

Ref. : ICE/Civil Engineering / Vol 175 issue 5

The Importance of Networking for Civil Engineers both during and beyond Covid-19

The Covid-19 pandemic changed how civil engineers work, with increased virtual networking leading to greater collaboration and achievement of common goals – including sustainable development goals. This paper explores the importance of networking during the pandemic and the benefits it had in terms of inclusion, equality and sustainability. In particular, networking appears to have enabled a greater focus on the social, environmental and economic aspects of civil engineering projects to ensure positive effects for society. The paper concludes that, in a post-pandemic environment, it is important for civil engineers to continue networking, both within the workplace and the wider profession.

By : Alexandra Mather

Ref. : ICE/Civil Engineering / Vol 175 issue 5

Tyre Rubber and Expansive Soils: Two Hazards, One Solution

This paper presents the results of an experimental programme using shredded waste tyre rubber to reinforce expansive soils. Soil samples were reinforced with fine and coarse rubber particles at four different contents by weight. The rubber-reinforced soils were then subjected to unconfined compression, split tensile, direct shear and desiccation-induced crack tests. Improvements in cracking intensity and shear strength were found with higher rubber contents. However, rubber contents greater than 10% raised failure concerns during compression and/or

tension, attributed to clustering of rubber particles under non-confinement test conditions. Although the coarser rubber slightly outperformed the finer rubber, the effect of larger rubber size was mainly translated to higher ductility, lower stiffness and higher energy adsorption capacity rather than peak strength improvements. The swelling properties previously investigated by the authors were revisited and cross-checked with the strength-related features to arrive at the optimum rubber content. In this case, 10% rubber was found to result in a

notable decrease in the swell−shrink (and hence cracking) capacity as well as improving the strength-related properties and thus was deemed as the optimum choice.

By : Amin Soltani, Abbas Taheri, An Deng, Hamid Nikraz

Ref. : ICE/ Construction Materials / Vol 175 issue 1

Construction and Performance of Jarofix Waste Material Embankment

Jarofix is a waste material generated during extraction of zinc from its ore. It is investigated for its feasibility in embankment road construction. For this, three 100 m long test embankments of jarofix, jarofix−soil and soil alone were constructed. The performance of finished road pavements constructed over these embankments was monitored for a period of 2 years by measuring different functional and structural parameters. To investigate the possibility of

groundwater pollution, a leachate collection system was designed and installed below the embankment. The stiffness and failure stress of the jarofix−soil embankment were found to be higher than those of the jarofix embankment alone. The structural number (SN) estimated from deflection decreases with time, indicating a timedependent deterioration of the pavement. The value of SN of the jarofix section was marginally lower than that of the soil section. The stress−settlement relationships of prototype embankments predicted from the measured test

results on model embankments compared well with the actual stress−settlement relationships of the prototype embankments. Concentration of harmful constituents in the water leaching out of the jarofix embankment, namely, inorganic compounds and heavy metals, was insignificant, indicating the non-hazardous nature of the leachate water. Apart from cost saving, jarofix provides an alternative to conventional soil.

By : Anil K. Sinha, Vasant G. Havanagi, Jagdish T. Shahu

Ref. : ICE/CM Construction Materials / Vol 175 issue 2

Monitoring the Structural Effects of Internal Swelling Reactions in Aguieira Bridges

São João das Areias Bridge and Criz II Bridge, located in the reservoir of Aguieira dam, in the centre of Portugal, were affected by internal swelling reactions of concrete, which particularly affected their piers and foundations. Laboratory tests diagnosed both alkali–aggregate reaction and delayed ettringite formation as the causes of the expansions. This situation motivated important rehabilitation works on the piers and foundations of both bridges. These rehabilitation works were based on the construction of six piles around the footing of every pier founded on

the riverbed. The corresponding pile cap was connected to the immersed part of the pier. In the course of these works, a structural health monitoring system was installed on both bridges in order to characterise the structural effects of the swelling reactions, both in the loss of rigidity and the temporal evolution of this degradation. The instrumentation applied on the bridges is described in this paper and the preliminary results achieved are presented.

By : Luís Oliveira, Min Xu , António Santos Silva

Ref. : ICE/Construction Materials Vol 175 issue 3

Application of nanosilication reinforced Concrete Beams

The partial replacement of cement with nanomaterials such as nanosilica (NS) particles in concrete improves its strength and other properties. In this study, the effect of NS as a partial replacement of cement for concrete mixes and concrete beams was examined. The studied response characteristics of reinforced concrete beams included the compressive strength, failure mechanisms, load-carrying capacity and load–deflection behaviour. The results showed that compressive strength increased with an increase in NS content up to 2.0% replacement of cement weight. The rate of increase in compressive strength was no longer significant beyond 2.0% replacement, indeed there was a slight decrease in compressive strength for NS content of 3.0%. The effect of increased NS content on the flexural behaviour of beams was also studied. Increased NS content led to increases in the first-cracking and ultimate loads and reductions in the deflection at cracking and ultimate load levels. No major differences in the structural response parameters were observed for test beams with zoning of NS in the bottom tension or top compression zones. An increase in NS content led to a slight increase in the ultimate strain associated with the ultimate load. Good agreement was found between experimental and theoretical ultimate moments.

By : Tarek Sayed Mustafa ,Mohamed O.R. El Hariri, Mohamed S. Khalafalla, Yasmin Said

Ref. : ICE / Structures and Buildings / vol 175 issue 5

High-Performance Resilient Earthquake- Resisting Moment Frames

The need for resilient or sustainable seismic design is at the forefront of structural engineering challenges worldwide. Sustainable seismic design is a relatively new concept that is rapidly gaining interest and hints at the arrival of the next generation earthquake engineering practice. In the present context 'sustainable seismic' refers to structural operability with a view to post-earthquake realignment and repairs. Experience has shown that it is cost inhibitive to elevate the status of conventional earthquake-resistant structures to seismic sustainability by means of traditional methods of design and construction. This paper introduces two simple analytic concepts, performance control and design led analysis, that lead to the development of sustainable seismic designs for purpose-specific archetypes. Seismic energy control, global

stiffness reduction and restoring force adjustment are introduced as relatively simple methodologies that help achieve efficient post-earthquake realignment and repairs. Combinations of structures of uniform response and rigid rocking cores are used as ideal models for sustainable seismic design. Three simple technologies, the replaceable energy

dissipating moment connection, the energy-dissipating grade beams and the hybrid rocking–stepping core, are also introduced. Several parametric examples are provided to demonstrate the applications of the proposed methodologies.

By : Mark Grigorian, Mozhgan Kamizi

Ref. : ICE/ Structures and Buildings vol 175 issue 5

Vibration Performance Assessment of a Long-span Steel Footbridge

To meet the basic requirements of long spans, steel footbridges are generally lightweight structures with low stiffness. Moreover, current trends in innovative structural design have led to more vibration problems related to resonance or quasi-resonance of footbridge structures at typical pedestrian walking frequencies. The present authors apply a feasible methodology to assess the vibration performance of footbridges based on an equivalent beam model

developed from a detailed finite-element model and experimental measurements. Free- and induced-vibration tests are performed on a long-span inverted-queen-post-truss steel footbridge located in Rio de Janeiro, which exhibits vibration problems. Pedestrian walking simulations are performed with the simplified footbridge model using a typical dynamic load given from a Fourier series, as well as with a biodynamical formulation that considers human–structure interactions. The equivalent beam model provides a practical means of investigating corrective intervention strategies for the problem of excessive footbridge vibration using tuned mass dampers, and allows the in-service footbridge performance to be assessed based on current standards and design guidelines.

By : Filipe A. Rezende, Wendell D. Varela, Eliane Maria L. Carvalho, André M. B. Pereira

Ref. : ICE/Structures and Buildings vol 175 issue 6

Determining Track-Induced Lateral Thermal Expansion Forces on a Curved Railway Track

This research studies the development of lateral thermal expansion forces on a curved railway track. The geometric alignment of a railway right of way often requires railway tracks to be curved. This curvature which is usually defined by the radius of curvature or degree of curvature represents a higher level of complexity in the track's analysis and design process. Particularly, presence of curvature on the track introduces multiple sources of force in the lateral (radial) direction, including, but not limited to, lateral thermal expansion, lateral wheel/rail forces due to centrifugal action, lateral components of vertical loads, bogie hunting and nosing effects of locomotives and vehicle curving dynamics. Some of these forces are well understood such as centrifugal forces while some are not as well understood, such as lateral thermal expansion forces. To bridge this gap, this research studies the development of track-induced lateral thermal expansion forces on a curved railway track. In this research, the curved track is assumed to be an arbitrary arc section of a circular track and is modeled as an equivalent idealized circular ring for analysis. Owing to its importance, three analytical methods are used to include: 1) Timoshenko thermoelastic stress analysis in cylindrical coordinate system, 2) mechanics of thin wall cylinders and 3) adaptation of a variational calculus formulation method from a previous comparable study. A fourth analysis approach is also introduced using a commercially available finite element analysis package. The results of these analyses are compared through a wide range of parametric studies and are then validated by the finite element analysis. The results of this study showed that the several methods presented in this paper, could be used to approximate thermally induced expansion behavior (pre-buckling) on a curved railway track. While all three techniques are effective, the Timoshenko stress analysis method appears to be the most suitable as it is a direct method that examines the stress build up from the element level and takes into account additional material properties, such as the Poisson effect. The research resulted in a methodology for determining load transfer from thermally induced forces in curved railroad track to the fastener and supporting structure.

By : Jubair A Musazay, Allan M Zarembski and Joseph W Palese

Ref. : Rail and Rapid transit vol. 236- no.1

Railway Cyber Safety: An Intelligent Threat Perspective

Cybersecurity threats to railways are increasing, both due to improvements in the techniques of hackers and the increasing merger of cyber and physical spheres. Accepted approaches to safety can be extended to consider the risks from cyber, however the nature of railways as complex cyber-physical systems of systems may require a broader approach beyond functional safety. This paper explores some of the cybersecurity hazards using a war gaming approach. The authors find that, while standard engineering approaches are effective in building new rail control system components, a broader and more creative consideration of attacks has benefits. In particular they identify the ability to cause mass disruption by targeting the fail-safes designed to ensure safety or auxiliary systems that are not directly classified within the scope of the ICS.

By : Duncan Unwin and Louis Sanzogni

Ref. : Rail and Rapid transit vol. 236- no.1

Simulation Analysis of High-Speed Turnout Point Rail Switching Force Considering Influence of External Locking Device

This study simulates the complete switching process of a turnout and presents an accurate method for calculating the turnout switching force. By establishing an analysis model for the turnout switching of high-speed turnout elastic flexible single-leg point rail No.18 while considering the effects of external locking devices, the actual switching force timehistory curve is obtained. Simultaneously, the model is validated with experimental data from the field. Based on this model, the effects of different factors on the switching force of the point rail are calculated and analyzed. The research results show that the external locking device optimizes the stress state of the locking lever, and the switching force acting on the locking lever is much smaller than that on the point rail web. Foreign matter clearly increases the switching force, which is not conducive to the locking of the point rail. When the foreign matter size reaches 3 mm, the switching force of the point rail increases sharply, which causes the switching force to exceed the limit. Overall, the point rail switching force is proportional to the start time difference of each traction point; therefore, the maximum action time difference should be controlled within 0.7 s.

By : Jiasheng Fang , Rong Chen2, Chenyang Hu, Jiayin Chen, Jingmang Xu and Ping Wang

Ref. : Rail and Rapid transit vol. 236- no.1

Novel Approach for Validation of Innovative Modules for Railway Traffic Management Systems in a Virtual Environment

To increase operational efficiency, resilience and capacity of the railway system, the development of modern railway traffic management system (TMS) has attracted more and more attention in recent years. To support the development and implementation of the next generation of TMS and related applications, advanced data collection, transmission and processing approaches, digitalised databases, and virtual validation platforms, etc., are required. In the context of the TMS development (addressed by Technology Demonstrator 2.9 of Shift2Rail Innovation Programme 2), this support is to be provided by a scalable, interoperable and standardised communication platform for internal and external communication between different subsystems, applications and clients. This paper outlines the approach of the ongoing OPTIMA project aimed to develop a communication platform demonstrator for railway TMS based on a novel Integration Layer (IL) and its various interfaces to entities including integration layer services, TMS service, rail business service, external services and operator workstations. Further detailed discussion in this paper relates to the approach to validating the communication platform demonstrator as a functional entity, and as a virtual testing environment to validate railway traffic management and other applications. The validation approach for the applications tested on the communication platform demonstrator is also presented. The results of future implementation of this validation approach will be used to assess the functionality of the communications platform demonstrator developed, and the initial TMS applications tested on it, and form an important step towards developing and implementing IL based communications platforms for future TMSs.

By : Jin Liu , Cristian Ulianov , Paul Hyde, Anna Lina Ruscelli and Gabriele Cecchetti

Ref. : Rail and Rapid transit vol. 236- no.2

Running Safety Evaluation of High-Speed Train Subject to the Impact of Floating Ice Collision on Bridge Piers

In Northeast China and the areas along Sichuan-Tibet railway, collision between floating ice and piers of railway bridges seriously threatens the train operation safety. The safety of high-speed train running on the bridge subject to the impact of floating ice collision is rarely assessed considering the spatial interaction of the train-track-bridge-ice system. To evaluate the running safety and ride comfort of trains and the structural stability of railway bridges under the collision between floating ices and piers, a train-track-bridge (TTB) dynamic interaction model considering the impact of floating ice is established. Using the refined finite element model, the collision process of floating ice on bridge pier is simulated, and the impact loads are employed as the excitation input of the TTB dynamics model. Taking a 5_32m simplysupported bridges as a case study, the influence of bridge structural parameters on the floating ice collision system is investigated, and then the dynamic responses of the TTB system induced by the floating ice impact loads are analyzed in detail. Finally, the effect of the ice impact loads on the running safety of the high-speed train is revealed. Results show that under the floating ice impact loads, the angle of the pier sharp-nose (APSN) and lateral stiffness of foundations are the key parameters that influence the dynamic responses of the bridge, and an improperly small lateral stiffness of foundation would lead to an instability of bridge structure. The influence of ice impact loads on the dynamic responses of the train is remarkable. The lateral vibration acceleration, derailment factor and lateral wheel rail force caused by the ice impact loads are all greater than those caused by the track irregularity, while the wheel unloading rate is slightly smaller. In addition, the running speed of train is also closely related to the running safety and ride comfort when the collision occurs. When the train speed exceeds 400 km/h, the train passing through the bridge would have the possibility of derailment.

By : Penghao Li, Zhonglong Li, Zhaoling Han, Shengyang Zhu, Wanming Zhai and Huibin Lou

Ref. : Rail and Rapid transit vol. 236- no.3

Efficient Time–Frequency Approach for Prediction of Subway Train-Induced Tunnel and Ground Vibrations

In this paper, an efficient time–frequency approach is presented for the prediction of subway train-induced tunnel and ground vibrations. The proposed approach involves two steps. In the first step, a time domain simulation of the vehicle– track subsystem is used to determine the track–tunnel interaction forces and, in the second step, the resulting forces are then applied to a 2.5D FEM–PML model of the tunnel–soil system. There are two main aspects to the novelty and contribution of this work: First, the errors of the linearized Hertzian wheel–rail contact models in the calculation of the track–tunnel interaction forces are quantified by a comparison with the nonlinear Hertzian contact model. The results show that the relative errors are less than 2%. Second, an efficient time–frequency analysis framework is proposed, including the use of a strongly coupled model in the time domain solution and a 2.5D FEM–PML model in the frequency–wavenumber domain solution. Finally, the accuracy and efficiency of the proposed approach are verified by comparison with a time-dependent 3D approach, where three types of soil, i.e. soft, medium, and hard, are considered.

By : Lidong Wang, Yan Han , Zhihui Zhu, Peng Hu and CS Cai

Ref. : Rail and Rapid transit vol. 236- no.3

The Improvement of the Dynamic Behavior of Railway Bridge Transition Zone using Furnace Slag Reinforcement: A Numerical and Experimental Study

Transition zones between railway tracks and bridge decks can cause higher dynamic impacts. A solution is smoothly changing the track stiffness by gradually mixing steel furnace slag into the stone ballast. A nominated bridge transition zone is divided into 5 blocks of 7 meters long, with the mixing percentages of 0%, 25%, 50%, 75% and 100%. The mechanical behaviors of furnace slag-ballast combinations (FS-BCs) were studied using experiments of shear strength test, Los Angles abrasion index and plate load test. Furthermore, the dynamic behavior of bridge transition zone with FS-BCs blocks was investigated using a field validated FEM model. Results show that the 100%, 75%, 50% and 25% furnace slag by weight of ballast can increase the shear strength and ballast layer bending modulus by 13%, 12%, 9% and 7% at speed of 300 km/h compared with those of the stone ballast. The FEM study shows that rail deflections are reduced about 20%, 14%, 21% and 16% at speed of 300 km/h corresponding to 100%, 75%, 50% and 25% FS-BCs and accelerations are significantly reduced as well as increasing FS content of each block in bridge transition zone so that a smooth bridge transition zone can be achieved.

By : Guoqing Jing , Mohammad Siahkouhi , Haoyu Wang and Morteza Esmaeili

Ref. : Rail and Rapid transit vol. 236- no.4

Assessment of Derailment Risk in Railway Turnouts through Quasi-Static Analysis and Dynamic Simulation

Train derailments in railway switches are becoming more and more common, which have caused serious casualties and economic losses. Most previous studies ignored the derailment mechanism when vehicles pass through the turnout. With this consideration, this work aims to research the 3D derailment coefficient limit and passing performance in turnouts through the quasi-static analysis and multi-body dynamic simulation. The proposed derailment criteria have considered the influence of creep force and wheelset yaw angle. Results show that there are two derailing stages in switch panel, which are climbing the switch rail and stock rail, respectively. The 3D derailment coefficient limit at the region of top width 5mm to 20mm is much lower than the main track rail, which shows that wheels are more likely to derail in this area. The curve radius before the switch rail is suggested to be set as 350 m. When the curve radius before turnout is 65 m, the length of the straight line between the curve and turnout needs to be larger than 3 m. This work can provide a good understanding of the derailment limit and give guidance to set safety criteria when vehicles pass through the turnout.

By : Ping Wang, Jun Lai, Tao Liao, Jingmang Xu, Jian Wang and Rong Chen

Ref. : Rail and Rapid transit vol. 236- no.4

An Efficient Physical-based Method for Predicting the Long-Term Evolution of Vertical Railway Track Geometries

The dynamic wheel-rail contact forces resulting from the interaction between vehicle and track are responsible for the local track settlement. If these local settlements vary along the track, geometric irregularities develop further amplifying the dynamic loading of the track caused by the interaction between the vehicle and track. In this work, an efficient vehicle-track interaction (VTI) model is presented for predicting the long-term evolution of vertical track settlement during operation. The VTI model has two interacting components – vehicle and track. The vehicle model describes the vertical dynamics of an 8th of a car. The track model considers an elastic rail on discrete (sleeper) supports. Each sleeper location can have its own stiffness, relative height and settlement characteristics. Dependent on the distribution of stiffness and settlement behaviour along the track together with the initial track geometry, each sleeper settles dependent on the number of load cycles (vehicle passes). The track model is initialized with measured vertical track geometry data and static track deflection data at the beginning (day 0) for two types of track sections in the field, a track section where concrete sleepers with Under Sleeper Pads (USP) are used and a track section where only concrete sleepers are used. Using the same settlement model parameters (constant along the track) for the two tracks, the physical-based VTI model can predict the different track geometry quality evolution for both tracks over 350 days. Finally, the VTI model is used to assess the track geometry deterioration when the track/vehicle properties are changed. The prediction strength of the fast VTI model based on the physical understanding can assist in designing and optimizing tracks and in supporting of maintenance activities.

By : Nishant Kumar , Claudia Kossmann , Stephan Scheriau and Klaus Six

Ref. : Rail and Rapid transit vol. 236- no.4

Effect of Carbody Flexibility on the Dynamic Performance of an Empty Freightwagon

The structural flexibility of passenger car bodies is paid most attention in research due to the effect it has on the passenger ride comfort. But as we are moving towards high speed and lightweight freight Railway stock, the issue of structural flexibility becomes essential in the case of freight wagons also. This paper investigates the effect of including the structural flexibility of the carbody of Indian Railway open freight car BOXNHL in the dynamic analysis. A mid surface meshed model of the subject carbody is developed using Hyperworks. Then, modal analysis is done using MSC FEA to identify the dominant flexible body modes. A simulation study has been conducted using NUCARS (New and Untried Car Analytic Regime Simulation) for an empty freight car on straight track and curve. Four types of carbodies have been considered for comparison- rigid carbody, flexible carbody having modal damping factor 0.04, 0.03, and 0.02. Vertical and lateral accelerations are chosen as the representative dynamic response parameters. The novelty of the present work lies in analyzing the effect of modal damping factors on the different response parameters (vertical and lateral accelerations) of empty BOXNHL freight wagon at different speeds. The field test results have been compared with the simulation results for identifying the modal damping factor with a minimum standard deviation.

By : by Manish Pandey

Ref. : Rail and Rapid transit vol. 236- no.5

Virtual Homologation of High-Speed Trains in Railway Tunnels: A New Iterative Numerical Approach for Train-Tunnel Pressure Signature

Large overpressures can be produced when a high-speed train enters and crosses a railway tunnel. Predicting them is important since, in critical conditions, pressure variations may be dangerous for train structures and for passengers' health and comfort. European regulations impose pressure thresholds which trains must comply with in order to be homologated for travelling through tunnels. Currently, full-scale tests are required to demonstrate respect of these prescriptions. In this work, a procedure for calculating the pressure variations inside the tunnel based on 3D steady CFD simulations and a 1D compressible fluid-dynamics model is proposed, to be used both as a design tool and for virtual homologation of new rolling stock. Results of a large experimental campaign performed on the Italian high-speed line are used to set-up the proposed methodology and to validate it. Different train geometries, tunnel crossing speeds and tunnel initial air conditions are considered.

By : Elia Brambilla , Paolo Schito, Claudio Somaschini and Daniele Rocchi

Ref. : Rail and Rapid transit vol. 236- no.5

Dynamic Response Analysis of the Brake Disc of a High-Speed Train with Wheel Flats

To study the vibration characteristics and stress state of brake discs during vehicle operations, a spatial trailer car-track coupled dynamics model was developed with the consideration of flexible brake disc. In the model, the components of a trailer car are considered as rigid bodies. Flexible models of the brake disc and wheelset were established using the finite element method. The trailer car-track coupled dynamics model is validated using experimental test results. The effects of wheelset flexible deformation on the dynamic properties of brake discs were investigated with the excitations of track irregularity and wheel flats. Furthermore, the brake disc was systematically evaluated and discussed under the condition of wheel flats in the coupled dynamics system. The results indicate that compared to rigid wheelsets with wheel flats, flexible wheelsets can cause the brake disc to vibrate more severely with higher stress. The severe vibration and high stress state of the brake disc could cause it to crack in the region near the bolts. The established dynamics model can be further developed and employed to assess the dynamics of the brake systems of high-speed trains.

By : Wang , Jiliang Mo ,Micheale Yihdego Gebreyohanes , Kaiyun Wang, Junyong Wang and Zhongrong Zhou

Ref. : Rail and Rapid transit vol. 236- no.5

Innovative Approach to Optimize Passenger Dispersal at Stations with Restrictive Width of Platforms by Adopting Bifurcated Design of FOB's

By
Vivek Kumar Gupta[1]
B. K. Kushwaha[2]

ABSTRACT
With the increased capacity and frequency of trains, quick passenger dispersal from station premises is a challenge. The problem is more acute at Suburban sections and Terminal stations. Also, keeping pace with the growing aspirations of public,fulfilling demands for provision of Escalators and Elevators in addition to usual stairway at FOB's at limited width platforms ,is another big challenge for civil engineers.
in this paper, the innovative approach of conceptualizing, designing and construction of Bifurcated design FOB's with provision of Stairway and Escalators on same side simultaneously without compromising the precious platform space and without any need of additional width of platform is discussed .This design can go a long way in solving often faced challenge of accommodating stairway and escalators side by side and thereby optimizing the passenger dispersal.

1 Upgradation of Passenger Amenities at Railway Stations

Indian Railways, keeping pace with the aspirations of countrymen, have taken definite steps to upgrade passenger amenities at stations. Mandating norms for different categories of stations in terms of passenger amenities and making them available in a time bound manner has been a mission item. These facilities include passenger movement enabling facilities like Elevators, Escalators, and Ramps among others. Since existing Railway stations were constructed without any consideration to these modern amenities and lateral expansion of station premise is mostly a very difficult proposition in terms of space constraints and also limitation of Tracks (involving Yard remodeling), provision of these additional facilities on existing width of platform poses a very big challenge despite clear advantage in terms of enhanced passenger dispersal capacity. Escalator is one of most sought after amenity for passenger convenience. Considering the maintenance issues of electrically operated Escalators in open environment and criticality of dispersal at busy stations, there is need to keep stairway side by side of new Escalator. Considering the passenger volumes, FOB's as wide as 12 m are now being provided at suburban and important /major stations. These wide FOB's, however, cannot fulfill the desired objectives if adequate dispersal from Stairway and Escalators are not provided due to constraints of width of platform. Constricted width of Stairway could actually pose a safety risk to passengers.

The mishap at EPR station (renamed as Prabhadevi recently) of WR on 29th Sep 2017 involving 23 deaths on a stairway on a normal day traffic was an eyeopener and forced a solution for improving dispersal pattern at constricted exits.

2 IRWM Provisions for Passenger Movement

Para 417 of IRWM stipulates provision related to passenger movement:

"Foot-over-bridges or sub-ways as convenient and techno-economically feasible should be provided keeping in view the following factors:

(i) Interconnection between high level or low-level platforms;
(ii) The total number of passengersdealt with at the station;
(iii) Frequency of train services;
(iv) Blocking of the lines between platforms by freight trains.

The design and location of the foot over bridges and the sub-ways should be guided by the criterion of a rapid dispersal of the passengers through the identified exit points and keeping in view the future expansion of station building.

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[2] *Professor, IRICEN, Pune*

The width of the foot-over-bridge or the sub-way should be adequate to permit a free unhampered movement of the passengers. The capacity of the foot over bridges and sub-ways and their component structures in discharging passengers per meter width of unobstructed passage for movement in both directions can be taken as:

capacity (no. of passengers/min/meter width)

LOCATION	SUBURBAN	NON-SUBURB
Level Portion	60	40
Stairway(Upward)	55	35
Stairway (Downward)	60	40
Stairway (Both Upward & Downward)	50	30
Ramp (1 in 10 Gradient: both Upward & Downward)	55	35

At important suburban stations, the design for the stairways should be such as to facilitate installation of escalators in future for which the standard slope required is 30°. At major important stations, provision of escalators should be considered for speedy dispersal of commuters."

Above provisions mandate free and unhampered movement of passengers, provision of escalators for speedy dispersal of commuters.

Above stipulations clearly bring out criticality of Stairway in design of FOB to calculate capacity. Since all Stairway on Indian Railways are catering for both Upward and Downward passenger movement, capacity of FOB gets restricted with reduced width of stairway, which is 50 passengers /min/meter width.

3 Need of Bifurcated Design FOB and Basic Concept

Keeping in view the mandated provisions of IRWM for free and unhampered movement of passengers, provision of escalators for speedy dispersal of commuters, there is unambiguous need of Stairways and Escalators side by side at all important and major stations. Accommodating both Stairway and Escalator side by side is a big challenge especially at island platforms due to constraints of width of platform and minimum horizontal clearance stipulations in accordance with clause 7(a) Chapter II of IRSOD.Considering the need for wider staircases at Suburban stations, ACS 23 dated 08-12-2017 to IRSOD has been issued to allow reduced horizontal distances with special safeguards.

Considering the inevitability of provision of escalators and also need to have stairway side by side to tide over eventuality of mechanical/ electrical failure of escalators and criticality of dispersal at crowded stations, innovative solution of Bifurcated FOB was conceptualized. The concept of Bifurcated FOB is based on utilization of part length perpendicular to track for stairway and thereby reducing the requirement of length of stairway parallel to track. This concept allows additional space for placement of escalator in addition to stairway on platform for increasing the passenger dispersal and passenger convenience. This innovative concept need to be applied on case to case basis and the arrangement designed to accommodate both Escalator and Stairway without infringing IRSOD provisions and thus improving passenger dispersal substantially.

Perspective view of Bifurcated FOB is given in Fig. 1 & 2

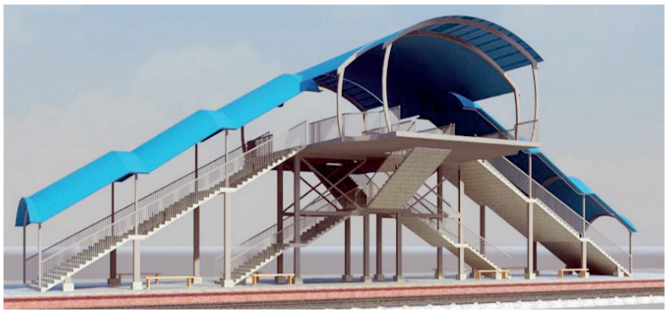


Fig.1

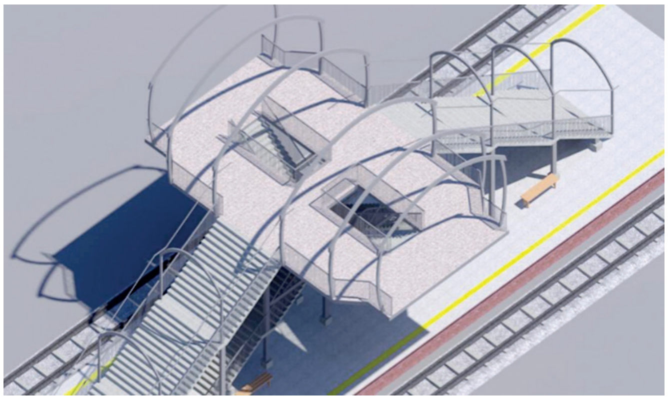


Fig.2

4 Additional Passenger Dispersal FOB by Extending the Deck Over Platform

Improvement to passenger dispersal by way of simply extending the FOB deck in direction parallel to track and providing additional stairway or escalators can also be achieved and tried successfully in Suburban section of Mumbai . This concept, however, results in higher occupation of precious space by having FOB deck footprints on platform and restricts passenger mobility. Perspective view is given in Fig. 3 & 4. Actual photograph of such FOB provided at Borivali station is placed at Fig. 10 and 11

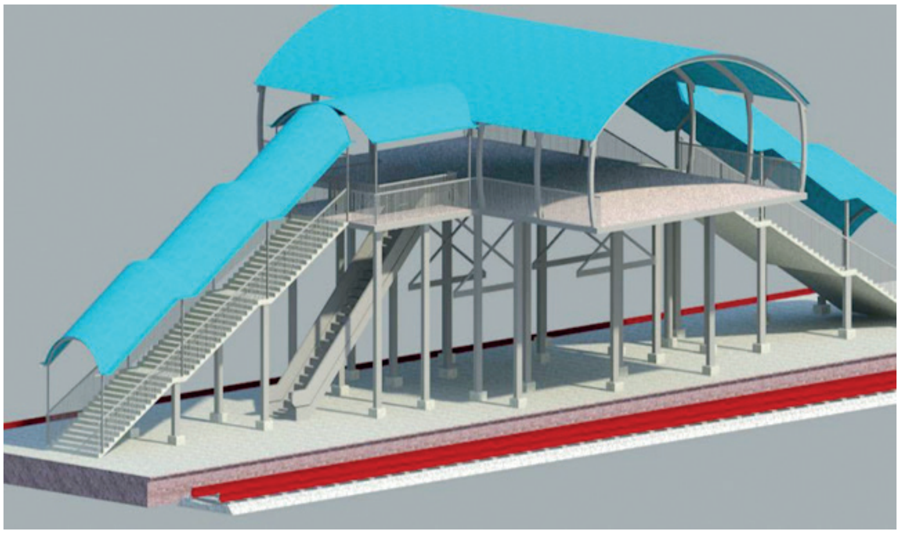


Fig.3

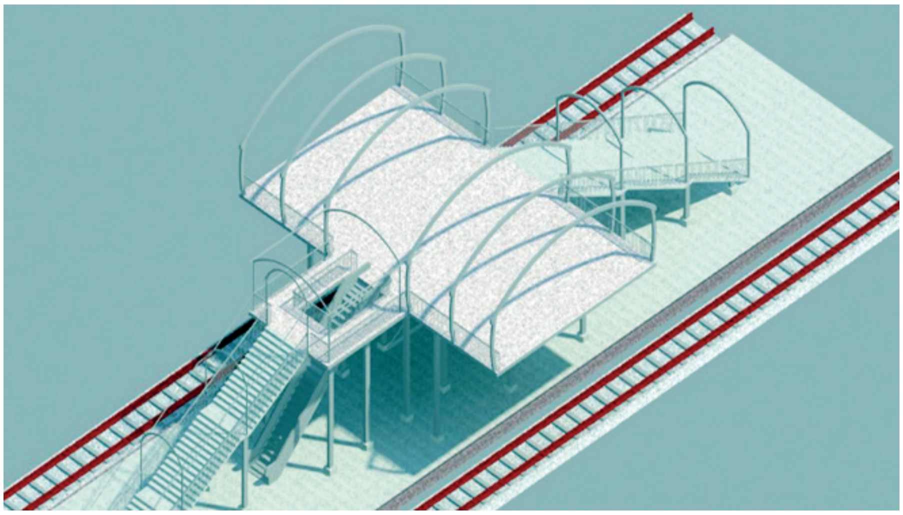


Fig.4

5 Passenger Dispersal Capacity Augmentation in Bifurcated Design of FOB

Considering a standard 12m wide FOB and stairway of 3m on either side at a passenger platform, the comparison of conventional design FOB and Bifurcated FOB dispersal is calculated and given in Table 1 below.

Table 1

SN	Description	Conventional FOB		Bifurcated FOB	
		Parameter	Dispersal potential*	Parameter	Dispersal potential*
1	Width of Deck	12m	720	12m	720
2	No of Stairway at one Platform	3m on either side	330	3m on either side+2 m additional from bifurcated	550 (330+220)
3	Stairway and Escalator for one Platform	3m on one side / 1escalators on other side(UP)	360 (165+195)	3m on one side/ 1escalators on other side (UP) + 2 m additional from bifurcated	580 (360+220)
4	Stairway and 2 Escalator for one Platform	3m on one side / 2escalators on other side (UP and Down)	555 (165+390)	3m on one side / 2 escalators on other side(UP and Down) +2 m additional from bifurcated	775 (555+220)

***Dispersal potential- passenger dispersion capacity per min**

6 Design and Construction of Bifurcated FOB’s

Taking up the challenge of designing and construction of Bifurcated design of FOB's first time on Indian Railways, scheme was prepared by accurately working out the dimensions at Suburban stations of Western Railway for the work entrusted to Mumbai Railway Vikas Corporation (MRVC).Five numbers of Bifurcated FOB's at Mumbai Central, Mahalaxmi, Mahim, Andheri and Nalasopara stations have been constructed with this concept .Typical arrangement of Bifurcated FOB is given in Fig 5 for better appreciation. Main features of typical Bifurcated FOB are:

1. Width of Main FOB - 12 m
2. Width of Main Stairway - 3m one side
3. Escalator - 2 escalators other side
4. Width of additional Bifurcated stair case- 2x 2m
5. Landing width at center of FOB to accommodate stairway-2m
6. Cantilever projection at location of Bifurcated stairway -2X 1m
7. Total length of Stairway perpendicular to Track- 2x 5.1m
8. Total length of Stairway Parallel to Track- 2x 7.5 m
9. Columns are small sized box columns manufactured by steel plates and designed as per availability of space. Slim size columns of 350x350 sqm and 200x400 sqm are most widely used.

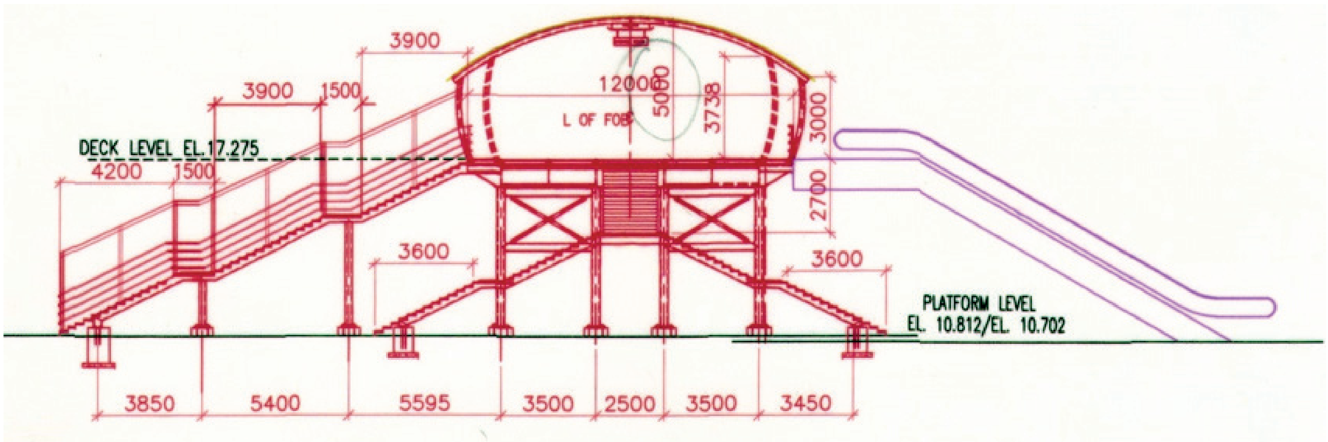


Fig.5

Actual photographs of Bifurcated FOB at Mumbai central station of Western Railway are placed at Fig.6 to 9.

Fig.6 Bifurcated design of FOB (Track side view)

Fig.7 Bifurcated design of FOB (Deck view)

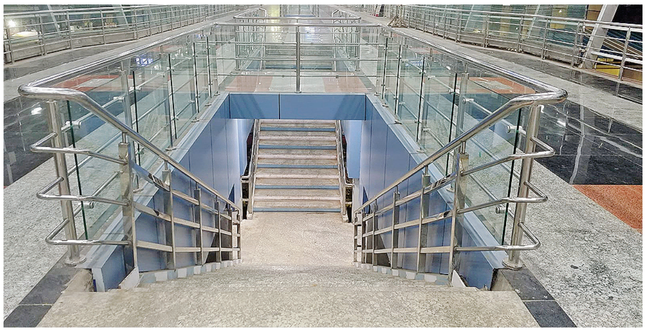


Fig.8 Bifurcated design of FOB (bifurcated stairway view)

Fig.9 Bifurcated design of FOB (Platform view)

Fig. 10 Additional dispersal FOB by deck extension at Borivali

Fig.11 Additional dispersal FOB by deck extension at Dadar (CR)

7 Way Forward

With the increasing demand of higher level of passenger amenities, provision of Escalators side by side of Stairway is the need of hour. Bifurcated design FOB provides a simple and effective solution to this challenge .Design and construction of Bifurcated FOB's at Suburban section has already proven its utility and can easily be adopted at other stations.

CAD Modelling of a Prototype Mechanical Screw Coupler Lifting Jack for Faster Manual Track Maintenance

By
*Mangal Yadav**

ABSTRACT
Manual Track Maintenance is routinely done in the Indian Railways, that utilizes various types of mechanical and hydraulic jacks for lifting and slewing of railway tracks. The idea was to study different types of mechanism that are currently in use in the railways and other domains, and come up with an improved solution that can bear heavy loads in a quick fashion while being non-infringing in nature.
The project has followed an iterative process where an existing design is used as a start point and modifications have been made to it, in order to achieve the required goals of speed, light weight, lifting capacity, ease of usage and non-infringing nature. Computer Aided Design software has been utilized for modelling whereas principles of computational fluid dynamics and finite element analysis have been used to validate the structural integrity, serviceability and longevity of the designs.
Furthermore, the design of the jack has been developed keeping in mind, the ease of manufacturing and its capability to be readily transported and carried while in field use.

1 Introduction to Problem

This report identifies the issues and proposes new and better solutions regarding the lifting jacks used in the Indian Railways for the purpose of track maintenance. The purpose behind the project was to improve upon existing jacks in order to come up with a design that can fulfill the following criteria:

- Speed: The jack must be easy to setup and quick in its capability of performing the lifting and slewing operation, in order to reduce maintenance time.
- Weight: The jack must be light in weight to facilitate mobility and ease of utility in, since manual movement of the jack is required at time in the course of maintenance.
- Load Bearing Capacity: The jack must be capable of bearing loads up to 60 tons, in order to be successful in railway maintenance.
- Ease of Handling: The jack should have a modular structure to promote quick assembling and disassembling, and facilitate ease of handling.
- Non-Infringing: The jack must be capable of performing the lifting and slewing operations without infringing the railway tracks.

In order to come up with an improved design, we studied the various different lifting and slewing methodologies currently in use in the Indian Railways. Ideas were derived from these designs and improvements were made to an existing mechanical jack system to come up with a solution that satisfies the above given criteria.

2 Literature Survey

2.1 Vankos Tralis:

It consists of two sets of vertical and horizontal hydraulic jacks operated by a single hand pump. Jacks and hand pump is connected by hoses and has Oil Distributor. Jacks can be controlled for vertical lifting and horizontal slewing from a central location. VANKOS Hydraulic TRALIS substitutes the time-consuming manual method of aligning the tracks. One person can set up and

* IRSE-2015

operate to lift and slew even fully ballasted concrete sleeper tracks in situ. The passing of the train over the TRALIS is possible as it is of non-infringing type. Only the oil controlling valves are to be released and pumping handle to be removed. The slewing operation can be resumed after the passage of the train. The device mainly consists of two pairs of Vertical and Horizontal Hydraulic Jack units operated from a single pump, provided with distribution head having centralised controls for Vertical Lifting and Slewing. It has a tested capacity of 15 tons.

2.2 Mechanical Track Jack:

Fig. 2.2 Mechanical Lifting Jack

The product is used to install and remove track to replace and properly align them. These jacks are track infringing type and therefore passing of the train with the jack in place is not possible. The jacks operate on a teeth-locking mechanism from lifting and must be operated manually. These jacks have a lifting capacity of nearly 15 tons and can be considered as slow and cumbersome in use.

2.3 Hydraulic Track Jack:

Fig. 2.3 Hydraulic Lifting Jack

This type of jack uses a hydraulic cylinder system instead of a mechanical tooth locking system to perform lifting and slewing operations. This jack can operate in the standard vertical position as well as in a horizontal position. The jack has a load bearing capacity of up to 25 metric tons and itself weighs around 80 kilograms. This jack is considered as an infringing type jack and therefore passage of trains with the jack in place is not possible. Additionally, the jack provides a higher degree of precision as compared with it', mechanical counterpart.

3 Methodologies Used

3.1 Cad modelling using solid-works :

CAD Modelling or Computer-aided Design is an important part of the design process, that brings ideas to life in a digital world before expending resources in the real world. This allows us to test, refine and manipulate virtual products prior to production. These high-quality 3D designs are identical in dimension and detail to the desired finished product, ensuring quality and accuracy for production. For this project SOLIDWORKS software has been used for CAD Modelling.

3.2 Structural Analysis on ANSYS :

Structural analysis software solution enables to solve complex structural engineering problems faster and more efficiently. With the given suite of tools, we can perform finite element analyses (FEA), customize and automate solutions for structural mechanics challenges and analyse multiple design scenarios. Using ANSYS software early in the design cycle, to test the structural integrity of the product we can reduce costs, minimise the number of design cycles and bring product to manufacturing stage faster.

3.3 Topological Analysis on ANSYS :

Topological optimization, uses the physics of the problem combined with the finite element computational method to decide what the optimal shape is for a given design space and a set of loads and constraints. Typically, the goal is to maximize stiffness while reducing weight and keep maximum stress below a certain value. Topology optimisation produces shapes which may be more optimal than we could determine by engineering intuition coupled with trial and error.

3.5 Fatigue Analysis on ANSYS :

Fatigue failure is defined as a structural breakdown that occurs due to repetitive cycles of stress. To prevent these events, and extend the life of their products, engineers need to understand a design's durability. The fatigue testing tools on ANSYS enables us to ensure their products and meet fatigue specifications by running numerous variations of the loads and designs until we are confident that it will survive past warranty.

4 Initial Design (First Iteration)

The Mechanical jack with a screw coupler mechanism was the initial design and is currently used in North-Eastern Railway and North-Central Railway. Research Design and Standards Organisation was working on analysing the flaws on this design, which was later given to us. The initial aim was to analyse this design and optimize it to increase its efficiency and decrease its weight. This jack was very heavy, was infringing in nature and had lots of weld joint hence making it tough to handle and hard to carry. Permanent joint didn't allow the handler to disassemble it hence it was not designed according to Design for Manufacturing (DFM). In the 1st iteration we mainly aimed at developing the jack so that it follows all points of Design for X.

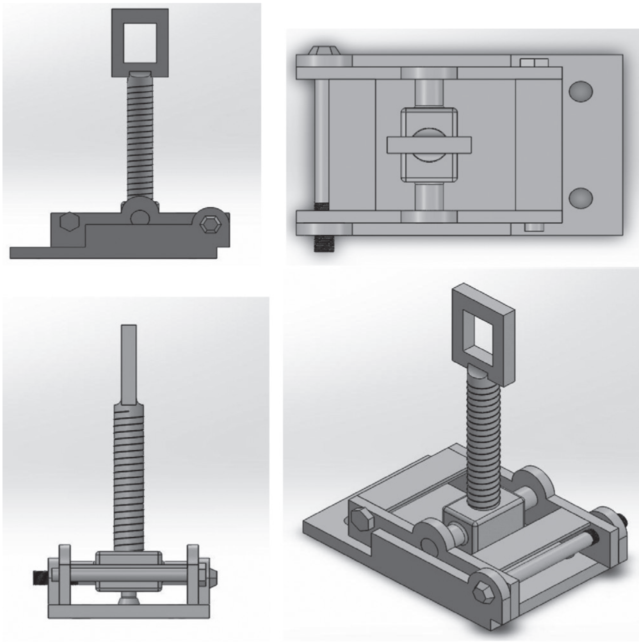
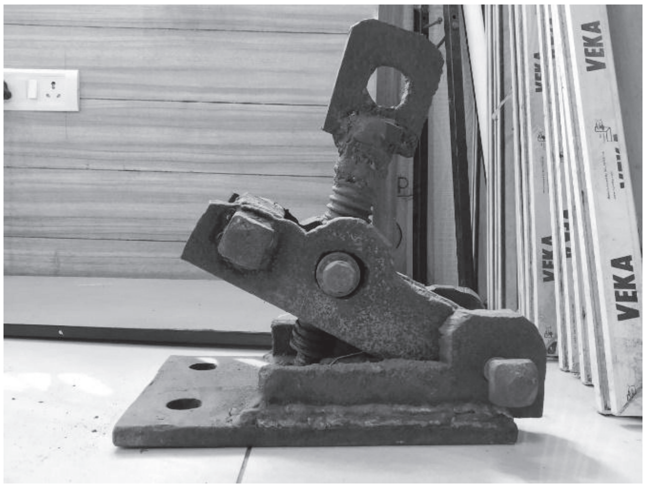


Fig. 5.1 CAD Model of the Initial Design

The jack was over engineered with extra weight and unnecessary parts in the assembly. According to the five parameters in the problem statement we found this design to only have one advantage, i.e., speed. It is faster than its competitors, that are currently in use, but fails to satisfy other requirements.

A CAD model was prepared of the given design at a scale of 1:1. Using this CAD model we performed Finite Element Analysis in a static condition at zero angle of deflection i.e., rail flange just resting on the front plate. A load of 15 tonnes and 60 tonnes were given respectively and it was observed that it had a deformation of 1.6 mm and 5.45mm. This proved that the current design is incapable of handling 60-ton loading. After a static structural analysis topological optimization was conducted to know the region where weight can be minimised.



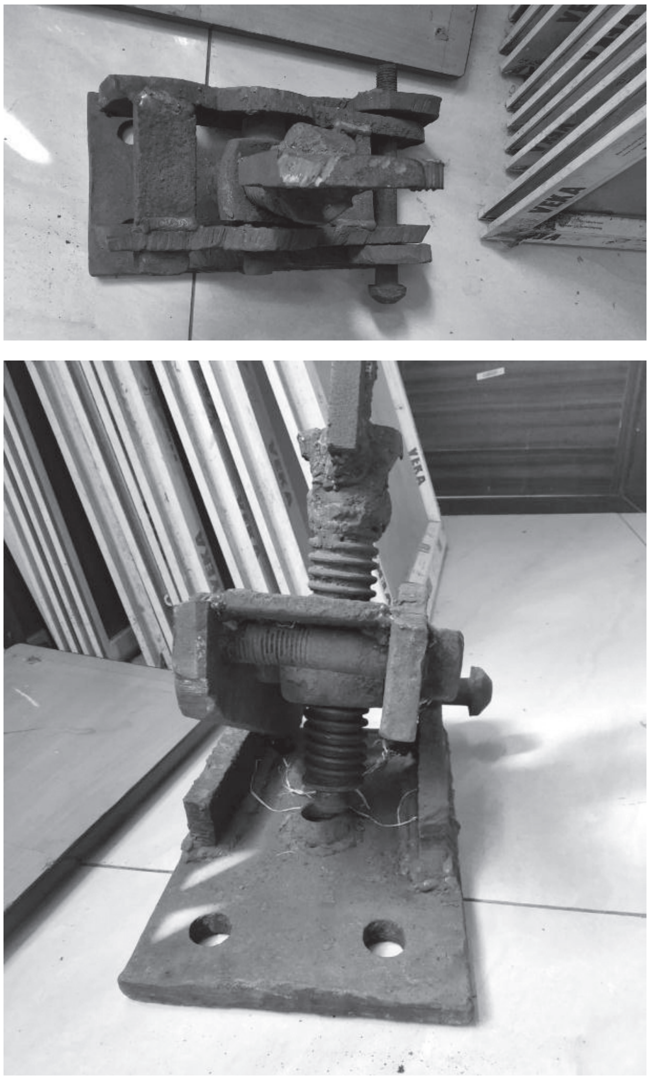


Fig. 5.2 The Original Screw Coupler Track Lifting Jack

While making the CAD model of initial design weld beads were made in Ansys Design Modular to get a better result. The distance of front screw supporting the load plate was varied with respect to the plate to see the deformation, this variation clearly indicated that the plate needed a support. When screw and plate are not in contact it showed a deformation of nearly 65mm and 17mm for 60 and 15 tonnes of load respectively. This led to the conclusion that the load plate needs a support part as absence of the later can lead to failure of the structure. The figure given below is the one where the screw is welded with the load plate. The load applied in the figure below is of 15 tonnes and a moment about the last screw. The main region of stress is near the centre point of the load and has maximum value of 1.62x103 MPa. This design is good for 15 tonnes of load but would fail under 60 tonnes. The Structure was further optimized using topological optimization under the loading condition of 15 tonnes. This generative designing helps us to cut weight on parts that was necessary according to the given boundary conditions.

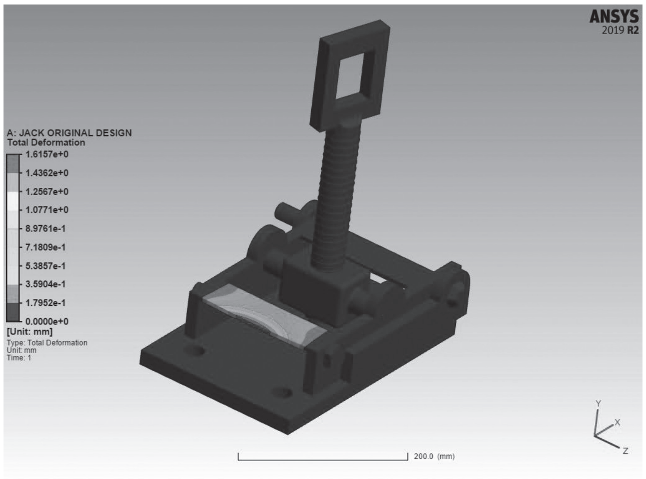


Fig. 4.3 Total Deformation of Initial Design under 15-ton Loading

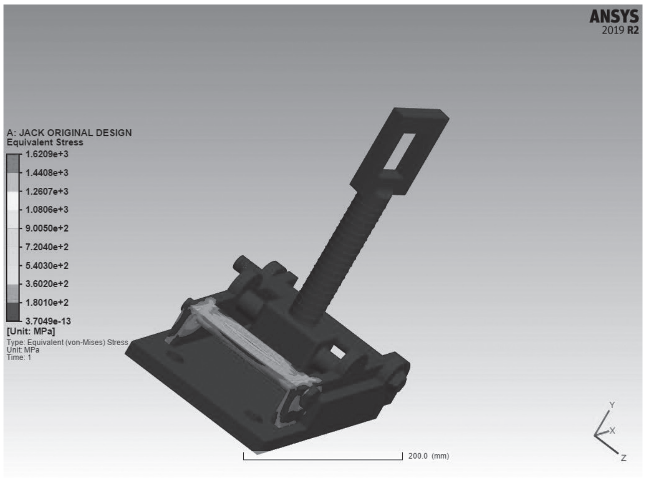


Fig. 5.3 Equivalent Stress on Initial Design under 15-ton Loading

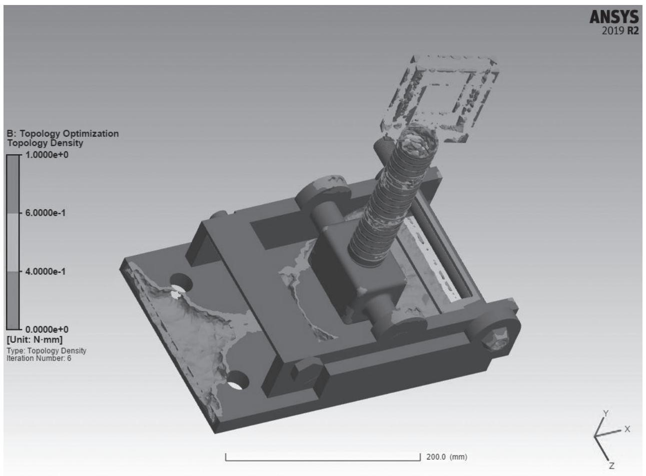


Fig. 5.4 Topological Optimization of the Initial Design

5 Second Iteration

The second iteration was made almost as a replica of the initial design, by replacing the mechanical screw with a hydraulic shaft for lifting. With certain modifications such as the reshaping of the shaft hold and the reduction in the length of the cylinder, the weight was reduced by nearly 3 kilograms as compared to the initial design. Main design change was that we removed a screw and added a cylinder for hydraulic jack, the screw hold was also optimized based upon the topological optimization. The main objective behind this design was to check the compatibility of a hydraulic mechanism in the existing design and its capacity to increase the load bearing.

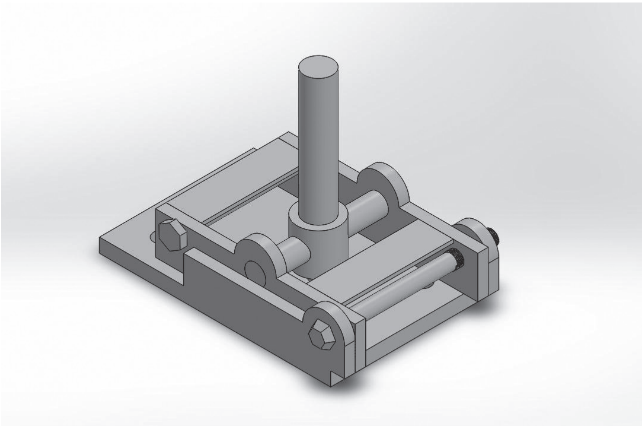


Fig. 6.1 CAD Model of the Second Iteration

The design was subjected to a load of 15 tons and 60 tons ANSYS. A deformation of 3.5mm and 13mm respectively indicated that even though the performance with the hydraulic mechanism is an improvement over the initial design, the jack has yet not achieved all the desired parameters. Furthermore, the angular motion of the hydraulic shaft that will accompany the lifting motion, is bound to hinder its proper functioning.

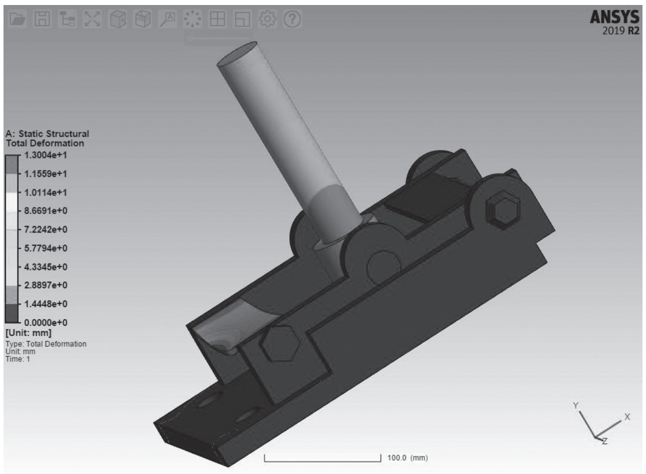


Fig. 6.2 Total Deformation of Second Iteration at 60-ton Loading

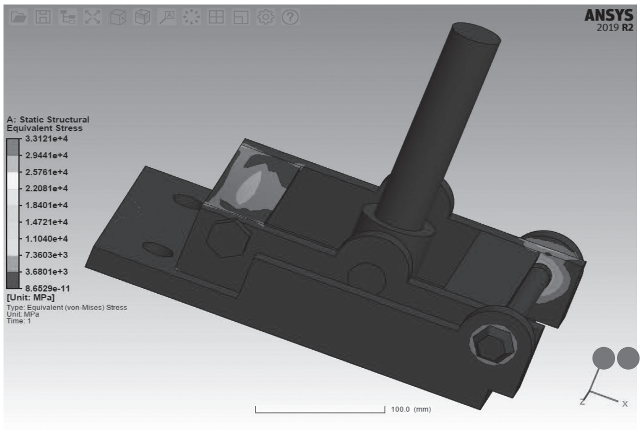
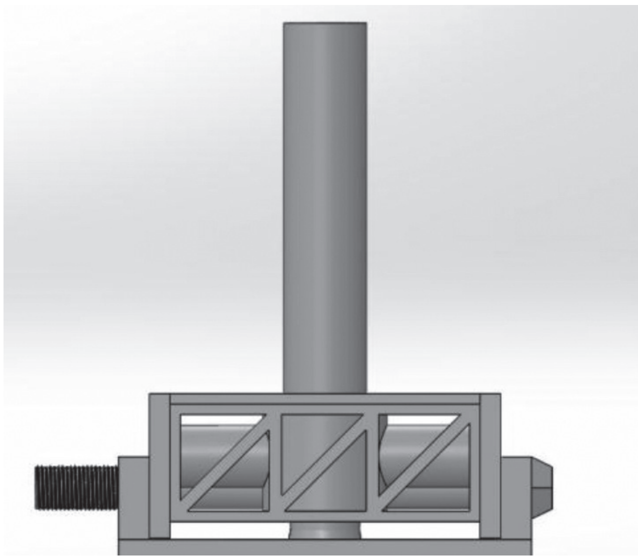


Fig. 6.3 Equivalent Stress of Second Iteration at 60-ton Loading

6 Third Iteration

Major design changes were brought in this particular iteration as many structural components were either changed or removed. The screw supporting the front plate was replaced with a truss support as it was less in weight and also provides enough support to the structure. The topological optimization of the first iteration suggested few spots on the jack that can be blanked which we followed in this particular iteration. The length of base was also increased from 330mm to 400mm to allow the jack to get beneath the track easily. An elliptical blanking was done in the base plate in accordance with the results received by topological analysis conducted on the previous iterations.

This design employs a hydraulic cylinder mechanism, embedded in the base using a slider mechanism, to perform the lifting operation. As the fluid flows into the cylinder, it moves upwards and backwards to facilitate the lifting.



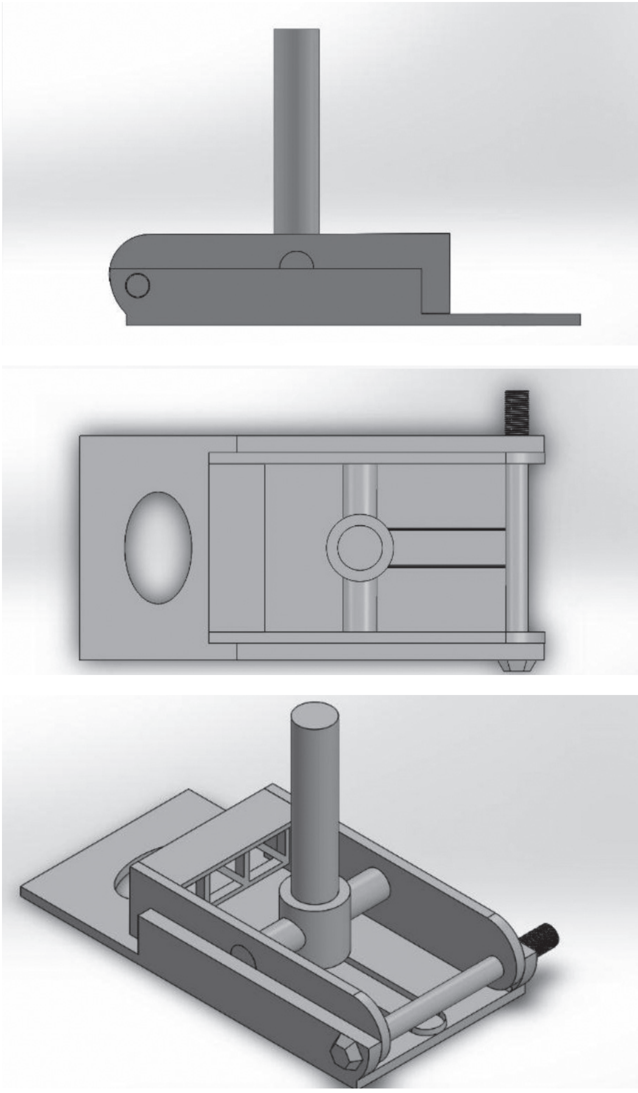


Fig. 7.1 CAD Model of the Third Iteration

The design was subjected to a static load of 60 metric tons on ANSYS which gave us minimal deformation of 3.9mm that validates its structural integrity.

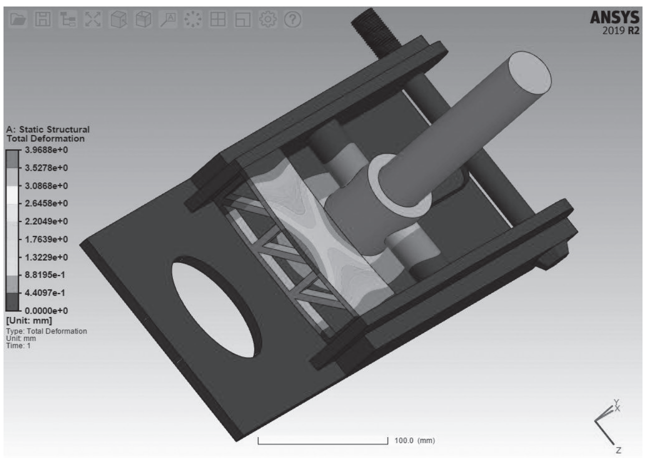


Fig. 7.2 Total Deformation of Third Iteration at 60-ton Loading

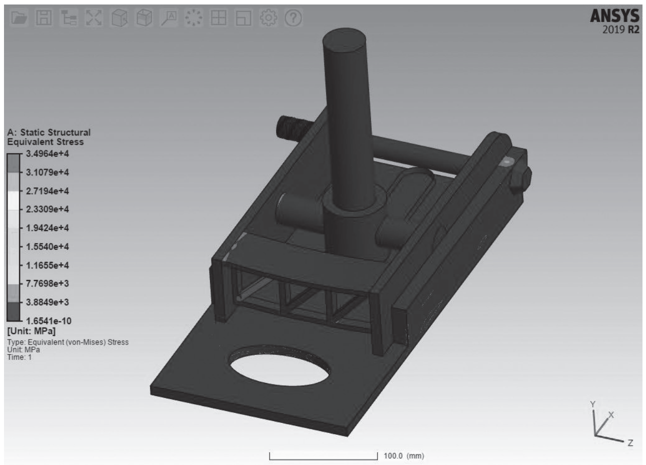


Fig. 7.3 Equivalent Stress of Third Iteration at 60-ton Loading

Although this design satisfied the initially defined requirements of weight reduction and load handling, the lateral motion of the hydraulic cylinder made it unfit for field work. Since there is a large chance for the slider motion to be damaged by rough usage, the deign might fail in service. Moreover, the friction between the cylinder and the base plate will require additional force to counter it, and will also reduce speed which was the distinguishing advantage of the initial design and the goal of the project to begin with.

7 Final Design

In order to rectify the issues in the third iteration and satisfy the primary requirements of speed, we reverted back to the mechanical screw design for lifting with a more sophisticated ball and socket mechanism connecting it to the base. The coupler screw is rotated to initiate the lifting. As the front plate rises the screw moves angularly about the ball and socket joint as opposed to the lateral movement of the hydraulic cylinder in the third iteration. This reduces the chances of failure during rough usage and frequent transportation, along with reducing the internal friction between parts.

To further increase the speed of the jack the top handle of the screw (as seen in the original design) has been replaced with a 32mm diameter nut, that can be rotated using an L-type wrench with a longer lever arm. Not only does this reduces the time required for the operation, but also minimises human effort. The height of this screw is kept at 15cm to ensure that it is of a non-infringing nature. Similar to the third iteration the final design employs a warren truss below the front plate for better load handling.

Piercings have been made in the base plate for weight reduction, in accordance with the results of the topological analysis conducted on previous iterations. The side holds of the jack have been made curvilinear instead of rectangular, as the stress analysis conducted on the previous iterations clearly indicated the accumulation of high stress at the corners.

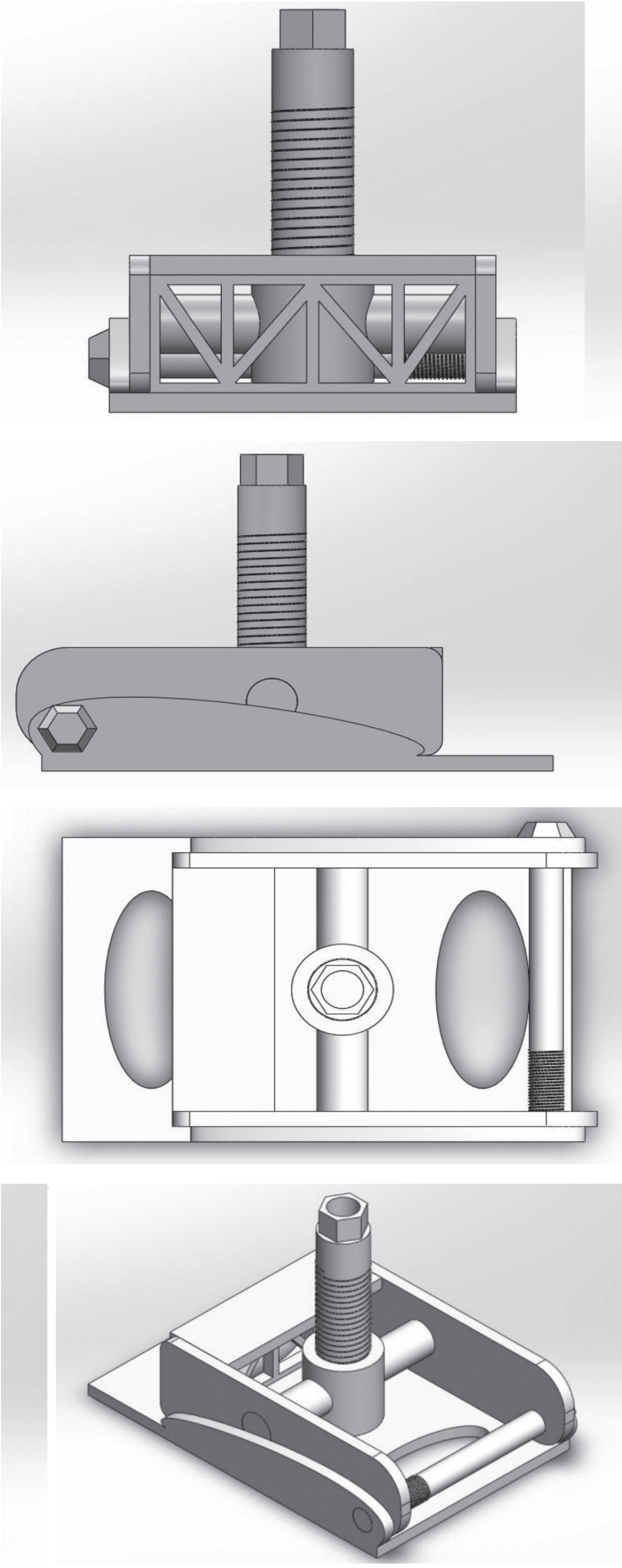


Fig. 8.1 CAD Model of the Final Design

The design was subjected to a static load of 60 metric tons on ANSYS acting vertically downwards for validations. A minimal deformation of 2.4mm and low stress of 2.04x104 MPa demonstrated its load handling capacity. The design was further subjected to loading in an elevated condition, and yet did not fail. Lastly, the fatigue analysis on ANSYS validates the longevity of the final design, under repeated cyclic loads.

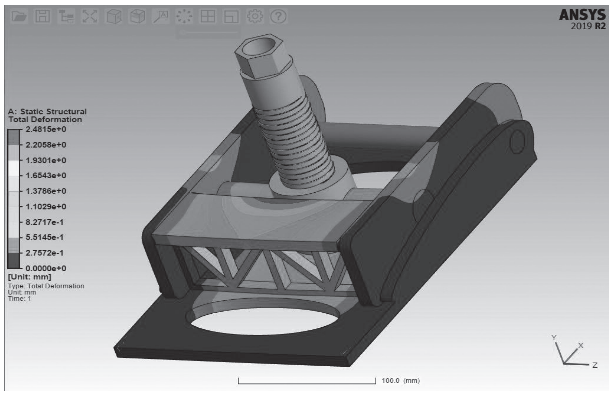


Fig. 8.2 Total Deformation of Final Design at 60-ton Loading

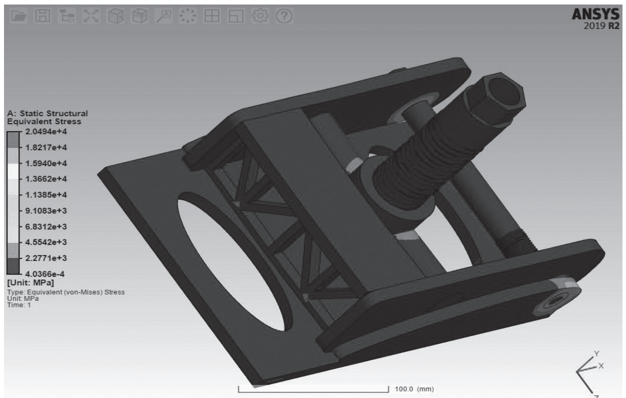


Fig. 8.3 Equivalent Stress of Final Design at 60-ton Loading

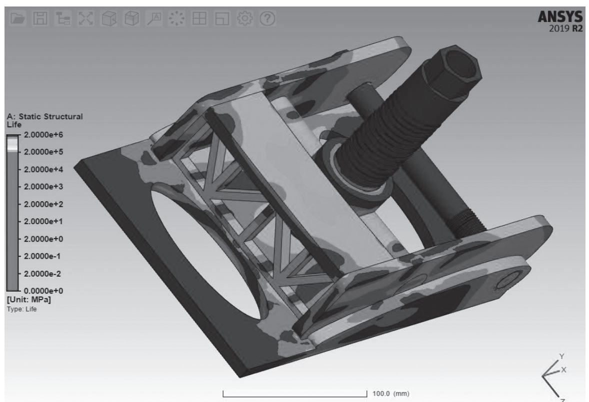


Fig. 8.4 Fatigue Life Analysis of Final Design at 60-ton Loading

8. Proposed Manufacturing Techniques

Subtractive Manufacturing Process was followed to manufacture the mechanical jack. The fabrication of the jack was done in the bridge workshop itself with all the existing machine processes. The processes available are lathe operations, CNC cutting and drilling, SAW welding, CO2 welding and some sheet metal forming processes. Each component of the jack will be manufactured separately which would be assembled later. The main components of the jack are- jack screw, base, screw hold, jack side hold, last screw and Flange truss. Each component will be fabricated by different machining process.

Manufacturing process caried out to fabricate each component are the following:

- **Lathe Threading operation:** Thread cutting on the lathe creates a helical ridge on the workpiece with a consistent section. This is accomplished by making many cuts with a threading tool bit of the same shape as the needed thread form. Since we are dealing with high strength steel, we need to choose the cutting tool very carefully. The cutting tool is selected on various parameters like hardness and wear resistance, strength and toughness, heat resistance and also process performance and economy.

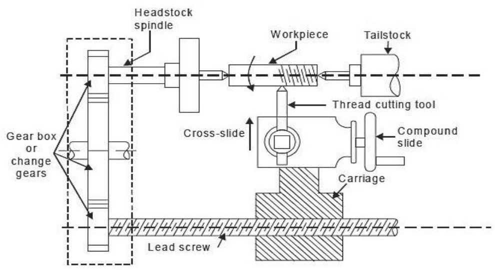


Fig. 9.1 Threading Operation on a Lathe Machine

- **Facing and Turning operation:** This operation shall be the one that would produce the screw hold and main body of the jack screw and last screw. These operations are conventional lathe operation which is used to generate a cylindrical shape body. The feed rate and cutting speed is decided using software tools which suggest the rpm of the spindle (chuck).

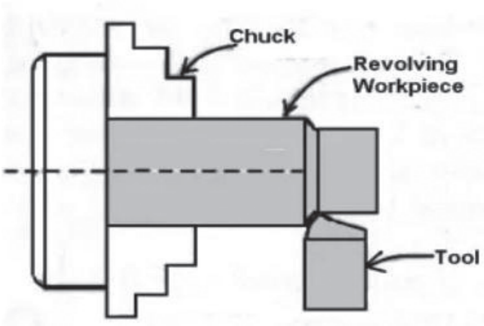


Fig. 9.2 Turning Operation

- **Profiling:** For the ball given at the end of the screw jack this operation is best suited using a lathe machine. Profiling is generally used to obtain a spherical shape using the lathe.

- **CNC cutting:** A 5 axis CNC machine will be used to cut a base plate from a 10mm steel plate and the side hold from a 15mm steel plate into the required shape using this CNC cutting. The machine process is automated hence reduces chances of manual errors and also if efficient. A G-code is generated using the 2D drawing and then a cutting operation is performed.

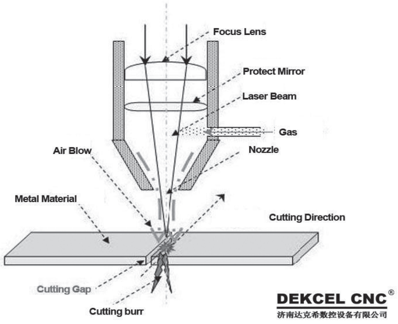


Fig. 9.3 CNC Cutting Operation

- **Arc Welding:** Welding operation is very important to join all components together to get the final assembly. Arc welding will be used to join base with its side plate. There are several joints that are welded using this conventional method. A 3mm welding bead is preferred, welding is done only in the region necessary as lot of welded joints can increase the weight.

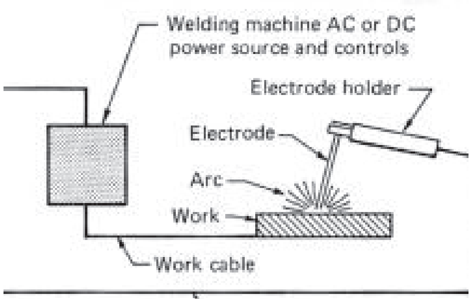


Fig. 9.4 Arc Welding Operation

All the above-mentioned fabrication process would help us manufacture each and every component and finally assemble them to get our final product i.e., a Mechanical Screw Coupler Lifting Jack.

9 Bill of Materials

S.No.	Item Name	Description	Material	Quantity
1	BASE PLATE	The base of the design that provides support to all other parts.	High Alloy Steel	1
2	SIDE HOLDS	The side walls about which the rotational motion of the jack takes place.	High Alloy Steel	2
3	SCREW	The coupler screw that facilitates lifting on turning.	High Alloy Steel	1
4	SCREWHOLD	Keeps the screw in place and aids in the angular motion of the screw.	High Alloy Steel	1
5	FLANGE BASE	The lifting surface that is to be placed below the railway flange and bear the load.	High Alloy Steel	1
6	TRUSSING	A Warren Truss structure placed below the flange base for better load handling.	High Alloy Steel	1
7	LAST SCREW	Placed at the aft most point of the jack, provides the axis for rotational motion.	High Alloy Steel	1

10 Conclusion

The final design of the screw coupler lifting jack was developed after multiple iterations and modifications to achieve all the desired goals and make it an enormous success in facilitating and speeding up manual track maintenance processes.

Starting with the initial design that had a lifting capacity of 15-tons and weighed over 35 kilograms, the final design was concluded such that it weighed half as that of the first iteration and had four times the lifting capacity. This was achieved by the proper application of modelling, analysis and topological optimisation, that allowed us to remove unnecessary parts and materials from the design to reduce the weight and reinforce the lifting capacity.

Furthermore, the number of permanent joints has been reduced, which not only aids in weight reduction but also makes the design easy to manoeuvre or transport, making it suitable for field work. The modular approach of the design allows it to be easily disassembled and transported. The handle for the screw coupler as seen in the initial design has been replaced with a 32mm nut that be turned with a L-type wrench with a longer lever arm, that speeds up the lifting process along with minimising the need of physical labour during the operation.

Additionally, the height of the coupler screw has been reduced to less than 15 centimetres, which ensures that the jack design is non-infringing in nature along with being fast, which was the foremost objective of the project to begin with.

The jack design has been subjected to a number of different analysis on ANSYS software that validates its structural integrity, utility and longevity.

11 References

- Mechanical Track Infringing Jacks-

  https://www.powerjac.com/mechanical-infringing-track-jacks.html

- Hydraulic Track Jacks-

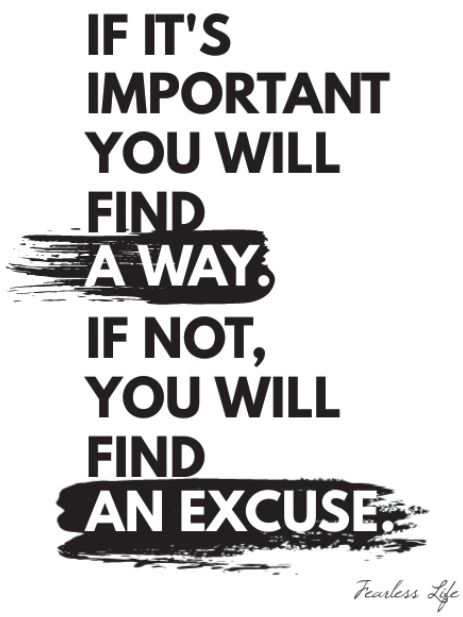
  https://www.worlifts.co.uk/rail/track-jacks/

- Other Jack designs in use-

  http://liftechniques.com/jaks_ratchet_type_screw_jacks.html

  https://images.app.goo.gl/oS6YteGepbCKbSVG7

  https://images.app.goo.gl/wGYFwMmUQsWkNziR7



Reduction in De-stressing Temperature in Zone-IV to Permit Operation of 22.9t Axle Load Wagons at 75 Kmph on 60 Kg 90 UTS Rail

By
Alok Kumar[1]
Rajesh Kumar Srivastava[2]
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SYNOPSIS

On routes with 22.9t axle load and higher, analysis of data on rail/weld failure reveals that the failure rate is very high for both 60 kg and 52 kg track structure and particularly high in the winter period (Nov-Feb), compared to rest of the year. High tensile stresses generated in LWR when the prevailing rail temperature is low increases the propensity of rail/ weld fracture under dynamic loading. As per rail stress calculations, there is a significant level of over stressing of rail resulting from operation of 22.9 t axle load wagonsfor 52 Kg track structure at the speed of 60Kmph. 60 Kg track structure also gets overstressed at speeds above 60 Kmph in temperature Zone-IV. The stresses induced in rails are mainly Internal residual stress, Stress due to temperature variation, Stress due to dynamic loading, Stress due to other factors such as flexed laying of rails in curve, one sided sun radiation etc.

Hence, a review of de-stressing temperature was necessitated to examine the possibility of its reduction intemperature Zone-IV for 52 kg and heavier rail sections.Reduction in de-stressing temperature by 5°C would result in reduction in over stressing of rail by 1.2 Kg/mm^{2}in Temperature Zone-IV. This would eliminate over stressing of rail resulting from operation of 22.9 t axle load wagons at 75 Kmph on 60 Kg track structure. However, there would still be an over stressing of 1.66 Kg/mm^2 on 52 Kg track structure at 60 Kmph.

This paper attempts to examine the need of reduction in de-stressing temperature, technical evaluation against safety, challenges in implementation in field and its advantages towards behaviour of LWR track.

1 Introduction

1.1 Indian Railways has been contemplating to increase throughput to keep pace with increased freight traffic by allowing higher axle load on existing track. At present 22.9t axle load are majorly plying on the main line section of Indian Railways.

On routes with 22.9t axle load and higher, analysis of data on rail/weld failure from TMS reveals that the failure rate is very high for both 60 kg and 52 kg track structure. Analysis of rail/ weld fracture shows that the incidence is particularly high in the winter period (Nov-Feb), compared to rest of the year. High tensile stresses generated in LWR when the prevailing rail temperature is low increases the propensity of rail/ weld fracture under dynamic loading.

As per rail stress calculations, there is a significant level of over stressing of rail resulting from operation of 22.9 t axle load wagons for 52 Kg track structure at the speed of 60Kmph. 60 Kg track structure also gets overstressed at speeds above 60 Kmph in temperature Zone-IV.

1.2 Type of Stresses Induced in Rail: In addition to stresses induced due to dynamic loading, the rail, unlike of other track components, is subjected to other stresses also. Some of these are very prominent and need very careful attention and address for a proper rail design. The stresses induced in rails are mainly Internal residual stress, Stress due to temperature variation, Stress due to dynamic loading, Stress due to other factors such as flexed laying of rails in curve, one sided sun radiation etc.

1.3 Stress due to Temperature Variation: The temperature variation with respect to its laying/ de-stressing or stress-free temperature, produce thermal stress in Long Welded Rail (LWR) which is held against expansion or contraction. Maximum variation in temperature occurs in Temperature Zone-IV. De-stressing temperature as perIRPWM

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[2]*ADE/Track-RF, RDSO*
[3]*SSE/Design,RDSO*

in Zone-IV is (t_d) = t_m + 5 to t_m + 10 degree Celsius The temperature stress considered in the design calculation is corresponding to temperature differential with respect to de-stressing temperature (t_d) as = t_m + 7.5^{0}Celsius. The value works out as 11.32 kg/mm2.

1.4 Overstressing in Rail for 22.9t Axle Load Operation:

As per rail stress calculations, the critical values are obtained at rail foot centre, which are having maximum residual stress. The values of rail stresses showing various types of stresses induced in rails are as under:

Stresses on 60 kg/90 UTS, 1540 sleeper density

	22.9 T axle load			
Stress (Foot centre, kg/mm^2)	**50 kmph (DA 43%)**	**60 kmph (DA 47%)**	**75 kmph (DA 53.5%)**	**100 kmph (DA 72%)**
Bending Stress	10.00	10.26	10.69	11.90
Residual stress	24.50	24.50	24.50	24.50
Thermal Stress w.r.t. 45.5 deg C differential	11.32	11.32	11.32	11.32
Unforeseen @10% of bending stress	1.00	1.03	1.07	1.19
Total Stress	**46.82**	**47.11**	**47.58**	**48.91**
Maximum permissible (Yield strength)	46.80	46.80	46.80	46.80
Over-stressing	0.02	0.31	0.78	2.11

Stresses on 52kg rail with 1540 sleeper density

	22.9 T axle load			
Stress (Foot centre,kg/mm^2)	**50 kmph (DA 43%)**	**60 kmph (DA 47%)**	**75 kmph (DA 53.5%)**	**100 kmph (DA 72%)**
Bending Stress	12.26	12.58	13.11	14.61
Residual stress	24.5	24.5	24.5	24.5
Thermal Stress w.r.t 45.5 deg C differential	11.32	11.32	11.32	11.32
Unforeseen @10% of bending stress	1.23	1.26	1.31	1.46
Total stress	**49.31**	**49.66**	**50.24**	**51.89**
Maximum permissible (Yield strength)	46.80	46.80	46.80	46.80
Over-stressing	**2.51**	**2.86**	**3.44**	**5.09**

As per the above, track structure with 52kg/90 UTS rails (YS = 46.8 kg/mm^2) is not having sufficient Yield strength to allow operation of 22.9t axle load. Track structure with 60 Kg/90 UTS rail is adequate for speed upto 60 kmph only.

Reduction in de-stressing temperature by 5 degree C would result in reduction in over stressing of rail by 1.2 Kg/mm^2. This would eliminate over stressing of rail resulting from operation of 22.9 t axle load wagons at 75 Kmph on 60 Kg track structure. However, there would still be an over stressing of 1.66 Kg/mm^2 on 52 Kg track structure at 60 Kmph.

1.5 Reduction in Temperature Stresses:

Analysis from TMS of rail weld fracture for the Main Line track of IR of the winter (Nov-Feb) and non-winter months indicates that the average monthly failure in winter months is almost 3 times higher than the non-winter months. The data is tabulated below:

Period	**Rail Fracture**						**Weld Fracture**					
	Other	**90 R**	**52 Kg**	**60 Kg**	**Total**	**Avg. per month**	**Other**	**90R**	**52 Kg**	**60 Kg**	**Total**	**Avg. per month**
Non-Winter Months (March-Oct) 2017	168	1	369	402	940	117	191	0	498	547	1236	154
Winter Months (Nov-Feb) 2017-18	142	0	473	443	1058	264	278	0	889	747	1914	478
Non-Winter Months (March-Oct) 2018	137	0	429	347	913	114	146	0	506	555	1207	151
Winter Months (Nov-Feb) 2018-19	208	0	621	468	1297	324	227	0	780	739	1746	436

Non-Winter Months (March-Oct) 2019	139	1	524	372	1036	129	122	2	425	484	1033	129
Winter Months (Nov-Feb) 2019-20	134	0	571	426	1131	283	116	0	586	547	1249	312
Non-Winter Months (March-Oct) 2020	56	0	238	173	467	58	41	0	169	198	408	51
Winter Months (Nov-Feb) 2020-21	79	1	431	250	761	190	81	0	350	359	790	197

The above trend of rail/ weld fracture strongly correlates with the fact that the total tensile stresses generated in Long Welded Rail (LWR) are higher in winters due to the higher tensile temperature stress resulting from lower rail temperatures. Reduction in the de-stressing temperature of LWR results in a lower tensile stress but a higher compressive stress. The de-stressing temperature is decided such that a balance between the risk to train operation arising out of rail/weld failure and track buckling is achieved.

Hence, a review of de-stressing temperature was necessitated to examine the possibility of its reduction intemperature Zone-IV for 52 kg and heavier rail sections.

2 Present Provisions of Manual [1]

Para 335 of IRPWM, June-2020 stipulates the range of de-stressingtemperature as under:

Temperature Zone	Rail Section	Range of de-stressing temperature (td)
I, II, III	All sections	tm to tm+50C
IV	52 Kg & heavier	tm+5 to tm+100C

3 Key Design Parameters

3.1 UIC Code 720 R on "Laying and Maintenance of CWR Track" 2nd Edition, March 2005 provides as under[2]:

Para 2.7.2 and Para 2.7.4 stipulates as under:

"The nominal rail temperature T_s is the optimum temperature at which the track should be fastened down. It should be several degrees above the mean rail temperature in order to limit the magnitude of compressive stresses.

$T_s = T_m + X$ (where X ranges between 0 and 10^0C)"

"Para 2.7.4 Installation temperature range

The installation temperature range is the nominal temperature $\pm 3^0$C (for example)."

On Indian Railways, the Installation temperature is called as de-stressing temperature td. For IR track, de-stressing temperature (td) is kept in range of T_m to T_m+5^0C for Temperature Zone-I, II & III and T_m+5 to T_m+10^0C for temperature Zone-IV. However, from above provisions of UIC Code, it is observed that as per UIC code de-stressing temperature range may be in the range t_m-3 to t_m+13^0C.

3.2 Evaluation of Safety of LWR against Buckling with Reduced De-stressing Temperature (t_d) by 5^0Cin Temperature Zone-IV[3]:

3.2.1 Static Buckling

Field trial for determination of lateral ballast resistance for just after tamping condition of track was done on 60 Kg rail with 60 Kg PSC sleepers having sleeper density of 1540, 1660 and 1818 in 2009. Values of lateral ballast resistance for just after tamping condition of track obtained from the field trials are as under[4]:

Sleeper Density	Lateral ballast Resistance (Kg/m)
1540	1347
1660	1516
1818	1572

Factor of safety (FOS) against static buckling for LWR withde-stressing temperature (t_d) reduced by 50C, for 4 degree curve for temperature zone-IV has been calculated as under:

Rail Section	FOS for Sleeper Density @1540 as per values of studies done in 2009	FOS for Sleeper Density @1660 as per values of studies done in 2009
52 Kg	2.18	2.46
60 Kg	1.99	2.23

On the Indian Railways, LWR with FOS against static buckling of 2 and above have been performing satisfactorily. Hence, FOS against static buckling of 2 and above may be considered as criteria for design and analysis of LWR.

3.3 Safety Evaluation using Safety Limit Charts given in UIC 720 R 'Laying and Maintenance of CWR track' by Reducing De-stressing Temperature (t_d) by 5^0C[2]:

3.3.1 Consistent with buckling safety assurance statement, it is required to find 'allowable or permissible temperature increase', T_{all}, which should be larger than anticipated maximum rail temperature increase referenced to the stress free temperature.

T_{all} can be considered as the "required buckling strength" which is dependent upon governing track and vehicle parameters. T_{all} can be derived by applying appropriate safety criteria to the analytically determined buckling response curves or it can be empirically determined by dynamic buckling tests.

In the above formula, T_n is not the installation of the fastening temperature T_f, but the actual value in service life of CWR, which is actually different due to changes induced by rail/track kinematics and maintenance actions. In the absence of non-destructive techniques to determine T_n, a 'safety factor' is usually established to account for variation of stress free temperature. The stress free temperature is given as under:

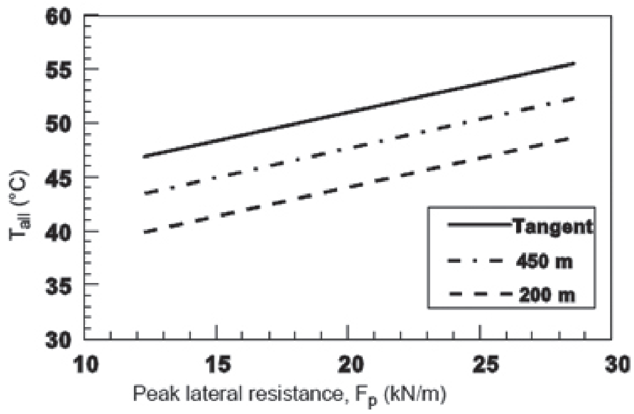
$T_n = T_f$ - SFTN

Where T_f is rail fastening or installation temperature and SFTN is stress free temperature variation safety factor. For UIC tracks, the recommended values of SFTN are in the range of 5-10^{0}C.

3.3.2 Safety Evaluation using Safety Limit Charts:

a) The buckling safety evaluation can be performed either directly by computer based buckling safety analysis software using the appropriate Tall safety criteria or through application of safety limit charts which give the safe allowable temperatures for a set of prescribed track conditions.

b) The Buckling Safety chart for CWR Tracks based on level -1 safety criteria as given in Figure-3 of UIC leaflet is as under:



Parameters

Rail: UIC 60 Axle Load: UIC/D4 (22.5 T)

Misalignment: 12 mm in 8 m /Sleeper Type: Concrete

Torsional Resistance: Medium Longitudinal Resistance: Medium

NB: Estimates on lateral resistance ranges-

Tamped to0.2 MGT ≈12–18KN/m

Stabilized (0.2to1MGT) ≈19–22KN/m

Consolidated ≈23–28KN/m

Comparison of Track parameters for UIC Tracks used in safety limit charts given in UIC 720 R and Indian Railway tracks is also done. Track Parameters are comparable as under:

Track Parameters	For UIC Track	For IR Track
Peak Lateral Resistance (Just Tamped) (KN/m)	12-18	15 (Approx.)
Axle Load (Tonne)	22.5	22.9
Misalignment	12mm in 8m	11 mm in 9m (NBML)

c) Based on the above, Allowable temperature (Tall) has been arrived at be using safety limit charts for UIC 60 Kg rail. For arriving at the value of Allowable temperature (Tall), value of lateral ballast resistance has been taken for just after tamping condition of track which will provide minimum allowable temperature (Tall). Also, Increase in rail temperature from stress free temperature (Δt) has been calculated for UIC 60 Kg rail and Temperature Zone-IV as under:

$$\Delta t = T_{max} - T_n,$$

Where, T_{max} is the maximum rail temperature of Zone-IV and

Stress free temperature (Tn) = Tf- SFTN

Where, Tf= Rail fastening or installation temperature or Td – as per IR terminology of LWR manual and

SFTN = Stress free temperature variation safety factor (5 - 10 ^{0}C for UIC tracks)

- Taking SFTN = 5 ^{0}C for calculations

Calculated value of allowable temperature (Tall) for sleeper density of 1540 and 1660 and Increase in rail temperature from stress free temperature (Δt) for UIC 60 rail and temperature zone-IV are given as under:

Sleeper Density	Straight		Radius (r) = 450m	
	T_{all}	Δt	T_{all}	Δt
1540	47	43	44	43
1660	48	43	45	43

From the above table, it can be seen that the calculated Increase in rail temperature above stress free temperature (Δt) is less than allowable rail temperatures (Tall) for straight and curved track up to 450 m radius.

d) Above calculations can not be arrived at for IRS 52 Kg rails as safety limit chart given in UIC 720 R are only for UIC 60 rail. For the same track structure and having IRS 52 Kg rail section, Tall can be taken as equivalent to for UIC 60 Kg rail. Also, 52 Kg rail section will have less thermal forces (about 14%) than 60 Kg rail section, which will provide additional safety against buckling, provided other track conditions are same.

3.4 For reduction in de-stressing temperature (td) in temperature Zone-IV, it is required to increase the value of parameters affecting buckling resistance viz. longitudinal & lateral ballast resistance andTrack frame resistance.

4 It is observed from the above discussion that there is reasonable level of safety against both static and dynamic buckling of track for both 52 kg and 60 kg track structure with PSC sleeper with density 1540 Nos./km with reduction in de-stressing temperature by 5^0C. However, this is pre-conditioned with proper maintenance of LWR track. Maintenance of adequate ballast cushion and profile and effectiveness of fastenings would be important for ensuring the required lateral and longitudinal resistance of track.

5 Keeping in view the above, RDSO has issued instructions for permitting LWR with destressing temperature (td) reduced by 5°C in temperature Zone-IV on provisional basis for a period of two years for 52Kg and heavier rail section with minimum sleeper density of 1540 nos./km. Monitoring of behaviour of LWR including creep and de-stressing consequent thereto was also recommended.

6 Advantages of Reduction in De-stressing Temperature

6.1 Safe operation of 22.9 t Axle Load Wagons at 75 Kmph:

Reduction in de-stressing temperature by 5 degree C would result in reduction in over stressing of rail by 1.2 Kg/mm^2. This would eliminate over stressing of rail resulting from operation of 22.9 t axle load wagons at 75 Kmph on 60 Kg track structure. However, there would still be an over stressing of 1.66 Kg/mm^2 on 52 Kg track structure at 60 Kmph.

6.2 Reduction in Rail/Weld Fractures:

As discussed in Para 1.5 above, analysis of rail/ weld failure of the winter (Nov-Feb) and non-winter months indicates that the average monthly failure in winter months is almost 3 times higher than the non-winter months. The trend of rail/ weld fracture strongly correlates with the fact that the total tensile stresses generated in LWR are higher in winters due to the higher tensile stress resulting from lower rail temperatures. Reduction in de-stressing temperature would eventually result in reduction in tensile stresses in extreme winter season. This is likely to result in reduced number of rail failures under the operating conditions prevailing on the Indian Railways.

7 Challenges inImplementation in the Field

With the introduction of de-stressing temperature reduced by 5°C in temperature Zone-IV, following challenges may be faced in the field for ensuring proper behaviour of LWR track:

7.1 Improved Maintenance effort: LWR track would require an improved level of maintenance effort considering that dynamic forces would be higher as a result of operation of 22.9t axle load wagons at 75 Kmph. Time bound completion of track maintenance activities will be required.

7.2 Assured availability of Traffic Block for Maintenance of LWR Track: LWR track would require an improved level of maintenance considering that dynamic forces would be higher as a result of operation of 22.9t axle load wagons at 75 Kmph. Further, the lower de-stressing temperature would result in reduction of period of maintenance by 1-2 months considering the daily/seasonal temperature variations. It would be essential that one planned corridor block of minimum duration of 2 and half hours is provided at suitable time of the day, considering prevalence of de-stressing temperature, and included in the working time table.

7.3 Increase in period for Imposing Speed Restriction due to Temperature rising above t_d+20^0C during Consolidation of Track: As per present provisions of IRPWM, if rail temperature after regular track maintenance operation mentioned in Para 345 of IRPWM, June-2020 exceeds t_d+20^0C during the period of consolidation, then the speed restriction of 50 Kmph shall be imposed. With the reduction in td, period of yearduring which speed restriction may become necessary due to temperature rising above t_d+20^0C during consolidation of track after tamping/regular maintenance would be increased.

7.4 Increase in Manpower Requirement for Hot Weather Patrolling: With the reduction in de-stressing temperature by 5 degree C, manpower for hot weather patrolling will be required to be deployed at prevailing rail temperature of 5 degree below existing temperature. As per present provision of IRPWM-2020, Hot weather patrolling on LWR is introduced when prevailing rail temperature goes beyond $t_d+25\ ^0$C for LWR track having PSC sleeper with sleeper density of 1540 nos. and above. Hence, manpower requirement will be more with reduction in de-stressing temperature by 50C due to increase in period of weather beyond t_d+25^0C.

7.5 Reduction in availability of temperature/time period for de-stressing operation of LWR using Rail tensors.

8 Review of Various Aspects Related to Maintenance of LWR to Overcome the Challenges in the Field [1]

In view of reduction in de-stressing temperature for 52kg and heavier rail section for temperature Zone-IV, following aspects need critical considerations:

i) Availability of adequate time for carrying out regular track maintenance work.

ii) Temperature limits for regular track maintenance works

iii) Period of year during which speed restriction may become necessary due to temperature rising above t_d+20^0C during consolidation of track after tamping/regular maintenance.

iv) Increase in manpower requirement for hot weather patrolling.

v) Reduced availability of temperature/time period for de-stressing operation using tensors.

8.1 Temperature limits for Regular Track Maintenance work[1]:

As per **Para 345** of IRPWM, Regular track maintenance in LWR/CWR includes following operations:

(i) Tamping/packing

(ii) Lifting

(iii) Aligning including minor realignment of curves

(iv) Shallow screening/shoulder cleaning

(v) Renewal of fastenings requiring lifting

Further, **Para 345 (1) (a)** of IRPWM, June-2020, stipulates 'The regular track maintenance in LWR/CWR shall be confined to hours when the rail temperature is between ***t_d+10^0C and t_d-30^0C*** and shall be completed well before onset of summer.'

8.2 Temperature limit for Speed Restriction after Regular Track Maintenance Period:

As per **Para 345 (1) (b)** of IRPWM, June-2020 'If rail temperature after the maintenance operation exceeds t_d+20^0C during the period of consolidation, then the speed restriction of 50 kmph shall be imposed.'

8.3 Temperature limit for Hot Weather Patrolling:

As per **Para 1005** of IRPWM, June-2020, Hot weather patrolling is carried out when the rail temperature exceeds t_d+25^0C on PSC sleeper track with sleeper density 1540 Nos. per Km and above.

9 Requirement of Changes in Track Structure and Maintenance Criteria

For reduction in de-stressing temperature (t_d) in temperature Zone-IV, it is required to increase the value of parameters affecting buckling resistance viz. longitudinal & lateral ballast resistance, track resistance to strengthen the track against buckling. Following additional measures/ maintenance efforts shall be required for increase in track resistance for reduction in de-stressing temperature in temperature Zone-IV:

9.1 Improved Fastening System : Increased lateral rigidity of track can be obtained by use of higher toe load ERC. ERC Mark-V which is having toe load in the range of 1200 to 1500 Kg should be used to replace ERC Mark-III, having a toe load in the range of 850 to 1100 Kg, wherever existing.

9.2 Modifications in Criteria for Fitting Renewals: The existing stipulations of IRPWM regarding through fastening renewal under **Para 628** of IRPWM, June-2020 would be required to be modified to incorporate a higher level of toe load of ERC as the criteria for renewal. Existing provision of IRPWM under **Para 628 (1)** is reproduced below:

Para 628 (1) Replacement of ERC

"If 20% or more of sample size records toe load below 400 kg which is to be confirmed by 5% sample size, proposal of through fastening renewal should be initiated."

Considering the increase in the Toe Load of ERC MK-V and the requirement for increased Longitudinal Resistance for LWR, the limit of 400 kg should be revised upwards to **600 kg**.

9.3 Adequate ballast cushion and ballast profile as per provision of IRPWM, June-2020 shall strictly be ensured. Adequacy of ballast on the outside of curve would be particularly ensured. In case, loosening of ballast is noticed, suitable speed restriction should be imposed.

10 Conclusion and Recommendations

10.1 The quest of IR to increase throughput with the use of increased axle loads stocks on the existing track can be justified to cater to the needs of ever increasing population, assuming certain risks. For reducing these risks, various elements and regime of heavier axle loads needs to be conceived and implemented meticulously. Even the option of use of reduced destressing temperature to contain rail stress caused by higher axle loads within limits can only be exercised in a disciplined maintenance environment.

It is observed from the above discussion that there is reasonable level of safety against both static and dynamic buckling of track for both 52 kg and 60 kg track structure with PSC sleeper with density 1540 Nos./km with reduction in de-stressing temperature by 5^0C. However, this is pre-conditioned with proper maintenance of LWR track. Maintenance of adequate ballast cushion and profile and effectiveness of fastenings would be important for ensuring the required lateral and longitudinal resistance of track. The monitoring and timely maintenance of fixed infrastructure are also pre-requisites to keep the forces low and long term economical sustainability of heavy axle load operations.

10.2 Reduction in de-stressing temperature would eventually result in reduction in tensile stresses in extreme winter season in Zone-IV. This is likely to result in reduced number of rail/weld failures under the operating conditions prevailing on the Indian Railways.

10.3 Further, to assess the behaviour of LWR more precisely and execution of maintenance activities to achieve the stress free temperature within limit, it is need of hour to introduce equipment/ technology for measurement of stress free temperature of LWR for better optimization of maintenance work related to LWR.

11 Way Forward

11.1 Performance of LWR with reduced de-stressing temperature on provisional basis shall be closely monitored by Zonal Railways. During performance evaluation, reduction in maintenance window for regular maintenance work of LWR may be recorded. Also, increase in period of speed restriction after regular track maintenance work and increase in manpower requirement for hot weather patrolling may be recorded by field officialsfor further analysis.

11.2 Further, assured availability of traffic block shall be ensured by Zonal Railways for these provisional LWR for their proper maintenance. Record of traffic block required for maintenance activities and sanctioned shall be maintained for further analysis.

12 Disclaimer

Above conclusions regarding reduction in de-stressing temperature in temperature Zone-IV are drawn based on the previous deliberations in the TSC and literature study.Initially continuation of LWR with reduced de-stressing temperature on provisional basis shall be done withstrict compliance of the all provisions stipulated in the Instructions for a period of 2 years and based upon the performance report of these provisional LWR, further decision on regular adoption may be taken.

13 References

[1] Indian Railway Permanent Way Manual, June-2020 Published by Railway Board.

[2] UIC Code 720 R ‘Laying and Maintenance of CWR Track’, 2nd edition, March 2005.

[3] RDSO Study Report No. CT-30 (Modified) Published in August, 2018.

[4] RDSO Report No.TM/TL/62, 2009 on Field Trial to determine Lateral and Longitudinal Ballast Resistance.

Byculla Station 1853

Improving Running and Rating of Run Through Yards for High Speeds and Higher Axle Loads

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ABSTRACT
In surface transport system, the best riding quality is found in railways. Indian Railways is heading for a drastic change in the operations by introducing high speed trains and higher axle load freight trains. There are very good advancements in locos and rolling stock in the recent past whereas the track remained almost the same. The track parameter standards have increased but the basic track structure remained the same. For meeting higher quality track standards, geometrical changes have to be made. One such area that worries the P.Way Engineers is the running of high speed trains and higher axle load trains in run through yards. The riding quality in the plain track doesn't need much change while transforming from 120 kmph to 160 kmph, but the riding quality is found to be inferior over turnouts, glued joints and girder bridges with free joints, SEJs etc. There is a substantial reduction of the TGI/TQI in run through yards. The major concerns are Points & Crossings, Glued joints, AT welded joints and caked up ballast cushion in run through platform lines. This paper aims at analyzing the problems and identifying short term and long term solutions of the problems. The problem of rough running in run through medium and major yards was not a very serious concern up to speeds of 110/120 kmph. As the speed of the trains is proposed to be increased to 130/160 kmph for passenger trains and up to 100 kmph for freight trains, the presence of series of discontinuities, switching over of wheel from one part to another etc in medium and major yards have to be addressed now as smooth and fast running over track will encourage rail travel by passengers and reduce the maintenance efforts of locos and rolling stock in addition to improving safety standards of Indian Railways.

1 Introduction

The committee constituted by Railway Board to recommend criteria for planning of track maintenance on the basis of TRC results has analysed 984 Kms of TRC data of various sections and geography of Indian Railways and has observed that the percentage of 200m blocks exceeding Planned Maintenance Limits (PML) of Unevenness, Alignment etc is quite high in case of yards as compared to block sections. It was also observed by the committee that the percentage is as high as 70% in some sections which adversely affect riding quality in yards. Hence yards require specific and focussed attention.

Points & Crossings, Switch Expansion Joints and Glued insulated rail joints are indispensible track features in yards and AT welding is predominantly used for joining them to plain track. The analysis of data on the census of AT Welds reveals that there are huge numbers of AT Welds in run through yards.

An example of the number of joints in three run through yards in Vijayawada division of South Central Railway is shown in Table-1.

Table 1. Salient features of Yards -Statistics

STATION	Kondapalli (KI) YARD		Rayanapadu (RYP) YARD		Krishna Canal (KCC) YARD		
KM	568	569	573	574	422	423	424
AT WELDS IN DN LINE	61	55	66	41	41	38	55
GLUED JOINTS IN DN LINE	7	10	16	7	7	7	7
PXING's DN LINE	3	3	4	0	5	2	5

[1]*Chief Track Engineer/SCR,*
[2]*ADEN/Lines/BZA/SCR,*
[3]*JE/PWay/HQ/SCR*

SEJ's DN LINE	2	2	2	2	2	2	2
CROSSING JOINTS DN LINE	6	6	8	0	10	4	10
AVERAGE JOINT DISTANCE DN LINE	**12.7**	**13.2**	**10.4**	**20.0**	**15.38**	**18.87**	**12.66**
AT WELDS IN UP LINE	41	51	39	22	46	47	37
GLUED JOINTS IN UP LINE	12	11	21	12	9	11	6
PXING's UP LINE	3	5	4	1	3	5	3
SEJ's UP LINE	2	2	2	2	2	2	2
CROSSING JOINTS UP LINE	6	10	8	2	6	10	6
AVERAGE JOINT DISTANCE UP LINE	15.6	12.7	13.5	25.6	15.15	13.33	18.52

Some joints in the track are unavoidable such as Stock Rail Joints (SRJ), Heel joints of switches, toe and heel joints of crossings. But population of such joints is less in comparison to the avoidable joints of glued joints and normal AT Weld joints used to form panels from free rails etc.

The prevailing practice in the yards is to connect the lead rails, rails in between Points & Crossings, glued joints etc by Alumino themit welding resulting in huge number of AT welds. Vertical alignment tolerance on finished welds should not be more than +1.00 mm, -0.00 mm measured at the end of one metre straight edge and +0.4mm, -0.00mm measured at end of 10cm straight edge. These permitted tolerances of AT welds in close proximity induce unevenness in track which adversely affects riding quality.

2 Suggestions for Reduction in at Welding Joints and Improving Running in Yards

2.1 Using of 65/130 mt length rails in yards: Using 65Mt length rails in the yards will reduce the AT Welding joints substantially. As of now, 13mts rails are welded to form the panels and they are being used for connecting the switches& crossings and in between points. Immediate steps can be taken to reduce the number of AT Welding joints by replacing the 13mt rails with 65mt long rails and re-using the 13mt length rails in other lines of yard. Railway board has already issued instructions for using longer rails in points and crossings (Ref. Rly Bd Lr. No. Track/21/2005/0110/AT Welding dated 16.08.2019). The implementation of these instructions will improve the riding quality in yards.

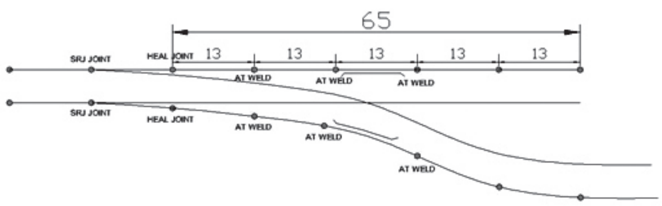

Fig. 1 AT Welding joints in Points and Crossings

2.2 Avoiding of Glued Joints by AFTC Track circuit: The glued joints are a serious concern in the maintenance of the yards. Due to the presence of glued joints, the frequency of joint is of very short wave length of 3.25mts resulting three joints in a length of 6.5mts. These glued joints make the running very rough when it is attached with SRJ. When the glued joint is attached with SRJ, the wheels have to negotiate the transition of 1 in 20 cant and joints at the same time. This introduces a lot of oscillations in the track. Moreover the glued joints are provided with lesser toe load "J" clips and cut liners which are not as rigid as the conventional fittings. Introduction of AFTC track circuit in medium and major run through yards will bring a lot of relief from rough running in yards.

2.2.1 Using longer glued joints to reduce close discontinuity in track : Using 12.5m long length glued joints can address this issue to some extent.

2.2.2 Removal of glued joints which are not required as per SIP : During doubling, tripling and yard remodelling works, large no of glued joints become redundant. PWay Engineers need to identify such glued joints in association with S&T Engineers and ensure elimination of such glued joints.

2.3 CWR's through yards Provision of SEJs in the approach and in rear of the points will deteriorate the running in the yards. The SEJs can be avoided by converting the LWR's to CWR's. The introduction of LWR/CWR through turnouts require introduction of canted turnouts and weldable CMS crossings for which Indian Railways is gearing up but there is a need to be expedited.

2.4 Removal of avoidable Points & Crossings : In medium and major yards, the basic requirement for the loops is one facing point for emergency cross over and one Points & Crossing to loop line on either sides of the yard but it is observed that nearly 3-4 turnouts in series in a length of 200mts are laid on main line on both sides of the yard. Many of the turnouts are seldom used but are laid for the convenience of the operations. It should be strictly legislated that there should be only four turnouts (Two on either side) on the main line of the yard. The laying of the other running lines grid has to be taken off from the first loop only but not from the main line as shown below. This will avoid unnecessary points and crossings on main line resulting in better riding quality.

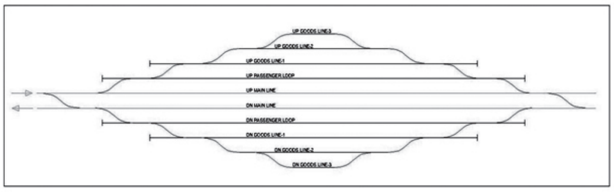

Fig. 2 Gathering lines (Ladder type layout)

2.5 Increase in the minimum distance between SRJ's and HOC-SRJ of adjacent Points & Crossings: In yards there is no minimum distance specified between SRJ-SRJ and SRJ-HOC. This is leading to the complication of introduction of joints in a short distance with a very small wavelength of discontinuity in track. Often it is observed that the SRJ's are provided at a distance of 6.5mts and if glued joint has to be provided between them, this will lead to the joints in a very short wavelength of 3.25 mts and less. If the distance between the SRJ's is less than 6mts, the wheels encounter more oscillations due to persistent change of rail-wheel contact points due to the transition of flat rail to 1 in 20 cant and from 1 in 20 cant to flat rail. The problem will persist even if the distance between the SRJ's is upto 13mts. In such cases, it is better to provide flat rail sleepers (sleepers with no cant as of Points & Crossings sleepers) between SRJs so that the changes in the cant is avoided and will have a smooth uniform profile of the rail top.

Deep screening and tamping of points and crossings require ramp in and ramp out of 1 in 1000 gradient as per para 221 of IRTMM-2019 manual. It would be impossible to provide the required ramp in or ramp out in case of butted SRJs and where the distance between SRJ-SRJ and SRJ-HOC is less than 20 mts of adjacent points and crossings in series. During tamping and deep screening, there will be a minimum lift of 25-40 mm to overcome the surface and cross level defects. For a proper ramp out and ramp in, it requires minimum 25-40 mts. When the distance is insufficient, the ramp out and ramp in is given in the switch portion or crossing portion of the adjoining point in series. Alignment correction will also be difficult if the points and crossings are closely located within a distance of 25-40 mts. It would not be always possible for deep screening or tamping of both points and crossings due to scarcity of traffic block. Hence, the minimum distance between SRJ-SRJ and HOC-SRJ of adjacent Points & Crossings may be specified around 37.5 mts i.e 25 mts (rail of 26 mts) + 12.5 mts (glued joint of 13mts) = 37.5 mts. This should not be compromised while initial planning of the yard or yard remodeling. This will help in providing ramp in and ramp out of 1 in 1000 gradient during tamping and deep screening of points and crossings and also avoid oscillations due to change of cant resulting in better riding quality.

2.6 Run through platform lines – RHEADA type RCC apron: Run through platform lines pose a lot of problems for high speed trains. The run through platform lines suffer with the problems of dumping garbage by the passengers and sweepings of the platforms. Maintaining clean cushion in these platform lines is really a difficult task. Drainage is one more serious problem in this run through yards. Introduction of high speed RHEADA type RCC apron track on run through platform lines will address all the problems of ballasted track run through platform lines.

2.7 Points & Crossings in curves: Points & Crossings taking off from the curves is a serious problem to be addressed. The trains while negotiating Points & Crossings (similar flexure/ contra flexure) laid in the curves will suffer oscillations. Trains while negotiating Points & Crossings in curves will be subjected to deficiency in cant and negotiating with change in rail top slope (1 in 20) simultaneously. This introduces oscillations in the wheels and stresses in the rails. The wheels negotiating the crossing portion will be subjected to sudden changes in the alignment due to straightness in the crossing. This problem of sudden change in alignment can be addressed by providing a fabricated longer check rail of length 13mts. With the introduction of the fabricated longer check rail, wheels will be guided by the curved check rail rather than straight crossing which can avoid oscillations.Swing nose crossings are a good alternative but introduction on large scale on Indian Railways is a big challenge.

2.8 Incentives for the P.Way staff working in high-speed and higher axle load routes : The P.Way staff working in high speed and higher axle load tracks have to put more efforts and be more sensitive towards track parameters. There is a trend in the P.Way staff preferring to work in less traffic routes and branch lines as there is no extra benefit for working in high speed and higher axle load tracks. If an incentive is given for staff working in high speed and higher axle load tracks, there will be an encouragement to the staff for working in high speed and higher axle load tracks. The minimum qualification for JE's and SSE's working in high speed and higher axle load tracks should be Diploma in Engineering. While giving promotion from J.E to SSE a minimum experience of 3 years in high speed and higher axle load routes should be made mandatory or should have specified weightage.

2.9 Requirement of adequate ETA for maintenance : Increasing of the speed/axle load on the existing track structure warrants more maintenance. Engineering Time Allowance is a very important aspect in maintenance of track. It would be very difficult to maintain safety if required ETA is not available for P.Way maintenance as reiterated below.

a) Bad banks require additional inputs in the form of machine tamping, ballasting and imposition of TSRs during monsoon/summer and cyclones. For all these additional inputs, requirement of speed restrictions are essential in view of safety of track and to maintain the track parameters within the prescribed limits.

b) Sanctions of overdue assets like curved switches, CMS crossings, SEJs, glued joints etc are to be renewed in view of safety of track. On an average, annual GMT on GQGD routes is around 50 GMT. Life of many assets like curved switches, CMS crossings, SEJs, glued joints etc is around 200 GMT. This means 25% of assets require renewal every year. Further, for increasing sectional speed on GD–GQ routes, all the main line points should be replaced/renewed with thick web switches which results in reducing the maintenance problems as well as improving the better riding quality. All these renewals shall be carried out under speed restriction of 30 kmph.

c) Deep screening on main line requires regular deployment of 2 BCMs along with CSM/UNIMAT to renew ballast, to reduce the Rail/Weld failures increasing the life of Rails and also for improving riding comfort to Passengers. The work is to be carried out in stages on various days after the start of the screening operations and the speed restrictions of 40/75 Kmph are recommended for 7 days and normal sectional speed can be resumed on the 8th day.

d) USFD testing of rails, welds, SEJs and points & crossings is a regular requirement for maintenance of the track. Speed restrictions of 30 kmph to be imposed at all the locations immediately after detection of IMRs. Rails, Welds & SEJs are to be replaced within 3days time which requires speed restriction of 30 kmph for 4days.

e) Due to heavy axle loads of train traffic, at many isolated locations, the PSC sleepers and P&C sleepers are broken /damaged badly. For renewal of these isolated broken/ damaged sleepers, renewal works should be carried out under speed restriction of 30kmph.

f) All LCs are to be overhauled once in 2 years. All LCs are required to be opened during through tamping works by closing the road traffic for about 4-7 days duly imposing speed restriction of 30 kmph.

g) Destressing of LWRs work shall be done once in 5 years or after special works for reducing the rail/weld failures which requires speed restriction of 30kmph.

h) Doubling/Tripling works being carried out also require caution orders.

In view of the above, it is evident that provision of required ETA is a must. Comparison of ETA in Working Time Tables (WTT) of last 4 years of South Central Railway is presented in Table-2.

Table 2. Reduction of ETA over various Working Time Tables of SCRly

	Running Length (Km)	ETA in WTT-72 (2016-17) (minutes)	ETA in WTT-73 (2017-18) (minutes)	ETA in WTT-74 (2018-19) (minutes)	ETA in WTT-75 (2019-20) (minutes)	ETA as per Board's letter* (minutes)	ETA required to carry out works (2020-21) (minutes)
SCRly TOTAL	7854.33	939	741	729	717	471.26	929

*Traffic Directorate of Rly Bd vide Lr No.2018/ Chg/30/2 dated 30.05.2018 issued instructions stipulating ETA at the rate of 6 minutes per 100 km on all sections of Indian Railways irrespective of traffic density, maintenance requirements by way of track renewal works, doubling/tripling works, safety related works like elimination of LCs by RUBs/ROBs etc. It is pertinent to mention that requirement of ETA is not universal but section specific. A sample calculation of requirement of ETA to carry out various track works of Vijayawada(BZA)-Kondapalli (KI) section is enclosed as **Annexure-I**.

P.Way Engineers are committed for maintenance of track despite the reduced ETA. This resulted in increase in no. of trains lost punctuality due to consumption of additional ETA as shown in Table -3.

Table 3. Number of Trains lost punctuality due to reduced ETA

Description	2016-17	2017-18	2018-19	2019-20
No. of Trains lost punctuality due to consumption of additional ETA (Major account)	28	422	1714	1252
Average No. of sections utilizing additional 'ETA' every day out of total 53 sections in SCRly	2.42	5.67	7.33	10
Average additional ETA (in minutes) utilized in above sections	11.42	44	68.75	68.8

As a result of reduced ETA, the average number of sections utilizing additional ETA also increased. This leads to tremendous pressure on P.Way Engineers to relax speed restrictions early, which may endanger safety. Hence ensuring provision of adequate ETA must not be compromised in view of safety. The issue of adequate ETA and assured traffic block needs attention at the highest level.

3 Rating of Yards Based on Ride Quality and Safety

There are many rating systems for station maintenance, environmental parameters, pollution parameters and ISO certifications for workshops and railway establishments. But there is no system available for rating the yards based on the ride quality and safety parameters. The rating systems will encourage the management at all levels for achieving the best rating. Hence it is proposed to have four categories of rating system for yards like Platinum, Gold, Silver and Bronze based on various parameters. The basis of classification is detailed in Table-4 below.

Upon introduction of the above rating system, it will enable the administration to assess the quality and strive to achieve the target of Platinum rating for the yard which will improve the inputs in yards across the departments there by improving the riding quality and safety in yards for high speed and pave the way for a 160 kmph track. Divisions may also be rated accordingly based on the number of platinum, gold, silver and bronze rated yards present in the division.

4 Conclusions and Recommendations

AT Welding joints in run through medium and major yards must be avoided as far as possible by making use of 65m long rails instead of welding 13m long rails. Instructions already exist for using long rail panels in points and crossings (Ref. Rly Bd Lr. No. Track/21/2005/0110/AT Welding dated 16.08.2019). There is a need to implement these instructions. The instructions regarding use of mobile flash butt welding plant in lieu of AT weld also need to be implemented. However, for this purpose departmental mobile plant operated on contract basis is required. Using longer length glued joints will reduce the close proximity of joints. AFTC track circuit may be used to avoid use of glued joints. Redundant glued joints must be eliminated. Adequate Engineering Time Allowance (ETA) and traffic blocks must be ensured for maintenance of track. Platinum rated yards must be planned by construction organizations by ensuring the minimum distance between SRJ's and HOC-SRJ of adjacent Points & Crossings during initial planning itself. Avoidable Points and Crossings must be removed during yard modifications/remodeling. Using swing nose crossings and fabricated long check rails in Points & crossing laid in curves significantly reduces oscillations resulting in better riding quality. Rating system for yards must be introduced which can help in assessing the quality and put in efforts to achieve better riding quality.

Innovation is the ability to see change as an opportunity – not a threat.

STEVE JOBS

Table 4. Classification of yards based on various paramenters

CATEGORY OF THE YARD	PARAMETERS									
	MOVING AVERAGE RIDE INDEX OF LAST 6 MONTHS	TQI VALUE (for >110 & ≤ 130 Kmph) FOR THREE SUCCESIVE RUNS	NO OF AT WELDS per km	NO OF CRITICAL FIXTURES (such as P&C's, GJ, SEJ, GB, LC) in any block of 200 mts of yard km.	BALLAST CUSHION in 80% length of track	NO OF DEFECTIVE LAY-OUTS	NO OF LAYOUTS with less than 37.5 mts between SRJ-SRJ and SRJ-HOC	NO OF ACCIDENTS in last one year on track account	RUN THROUGH PLATFORM LINE	P&C's IN CURVES
PLATINUM RATED	<1.5	TQI >100	25	2	200 mm	NIL	1	NIL	NIL	NIL
GOLD RATED	1.5-2.0	TQI 67-100	25-35	3	200 mm	1	2	NIL	NIL	1
SILVER RATED	2.0-2.5	TQI 49-67	35-40	3	150 mm	2	3	Nil	ONE	2
BRONZE RATED	>2.5	TQI < 49	>40	>3	<150 mm	>2	>3	ONE	>ONE	>2

*If Ride index and TQI is not recorded (NR) for two successive runs, the rating will be reduced by one level.

ETA requirement in section of BZA - KI DN line

Division : BZA

SECTION :BZA - KI

Minutes Required for year in WTT-75: 365 day x 07 min per day = 2555 min													
Sr. No.	Name of the work	Scope of the work for the year	Unit	Target of work	Progress per day per location	No. of locations	Total progress per day	Additional days required for relaxation (cushion)	No.of Unit Days SR exist	ETA per location/ day	ETA required per Day	ETA required to complete the work	Base for calculation
				1	2	3	4	5	6=(1/4)+5)	7	8=3X7	9=6X8	
1	TRR (P)	0.000	Km	0.000	0.260	1	0.260	2	0.00	3	3	0	Nil
2	CTR(P) by Manual	0.000	Km	0.000	0.214	1	0.214	10	0.00	3	3	0	Nil
3	TFR	0.000	Km	0.000	0.300	1	0.300	10	10	3	3	30	0.30 km per day per location. Assumed 2 locations per day. Assumed 10 days cushion for relaxation of SR per location.
4	TTRR (CS)	4	Nos	4	0.25	1	0.250	8	24	2	2	48	4 days per location.
5	TTRR (CMSC)	4	Nos	4	0.50	1	0.500	7	15	2	2	30	1 per every alternate day and a cushion of 7 days including hardening.
6	TTRR (TWS)	12	Nos	12	0.50	1	0.500	3	27	2	2	54	1 per 2 days & cushion of 2 days per each for ancilary works.
7	GLUED JOINTS RENEWAL	103	Nos	103	1.00	1	1.000	2	105	2	2	210	1 per day and a cushion of 2 days at 2 locations for ancilary works.
8	SEJ RENEWAL	6	Nos	6	0.25	1	0.250	2	26	2	2	52	1 in 4 days at 2 locations and a cushion of 2days reqd for welding of rail joints
9	DEEP SCREENING (MANUAL)	8.565	Km	8.565	0.150	1	0.150	11	68	3	3	204	0.150km per day and a cushion of 11days required for each locatoin for its normal sc
10	DEEP SCREENING PLAIN TRACK BY BCM	1.000	Km	1.000	0.143	1	0.143	11	18	3	3	54	1 km per week and a cushion of 11days required for each locatoin for its normal speed
11	DEEP SCREENING POINTS BY BCM	5	Nos	3.000	0.333	1	0.333	22	31	3	3	93	3 days per point and a cushion of 11days per point to normal speed.
12	DESTRESSING	8.000	Km	8.000	0.333	1	0.333	10	34	3	3	102	1.0 km in 3days and Overal cushion of 10days required per location
13	CANCELLATION OF PSRs	0	Nos	0	0.100	1	0.100	10	10	3	3	0	Nil
14	YARD LAYOUT CORRECTIONS	0	Nos	0	0.067	1	0.067	15	15	3	3	0	Nil
16	LC over hauling	2	Nos	2	0.250	1	0.250	2	10	3	3	30	Assuming 4 days per LC. For ancillary works 2days Cushion per LC
17	Misc works like pipe line crosings, cable crossings, Raising of Plat form/extension works, FOB works, etc	1.000	km	1.000	1.000	1	1.000	180	181	3	3	543	Assumed 180 days of such occassions.
18	EMERGENY SR like RF/WF, IMRs, Jerk message etc	2.000	Nos	2.000	1.000	1	1.000	100	102	3	3	306	Assuming 50 such occassions with 1days per occasion to cancel.
19	TSR of PSR NATURE	0.000	Km	0.000	1.000	1	1.000	90	90	3	3	0	Nil
20	Tamping	38.000	km	38.000	1.500	1	1.500	2	27	3	3	81	Assumed 1.50 km per day. Cushion of 2days required for each 1.5km for pre and post tamping ancilary works
21	**Bridge works :**												
a	Bridge Rehabilitaion works/ Strengtheni	1	Nos	1	0.07	1	0.067	15	30	2	2	60	1 per 15 days. 2min reqd for each
b	Renewal of Bridge Channel Sleepers	0	nos	0	20	1	20.000	15	15	3	3	0	Assumed 20nos per day.
c	ROBs	3	Nos	0	0.07	1	0.067	15	15	2	2	0	1 per 15 days. 2min reqd for each
d	RUBs	0	Nos	0	0.02	1	0.017	90	90	2	2	0	1 per 90 days
23	USFD testing on account of 130kmph	160	Days	160	1.00	1	1.000	0	160	2	2	320	It is assumed that USFD is to done at vulnarable locations i.e 50% of 313 days . 2.0 min per each location
24	Trolley Inspection on account of 130 km	84	Nos	84	1.00	1	1.000	0	84	1	1	84	Assuming that (1adens+2 PWIs (IC) +4 Apwis) * 12 months = 84 inspections bet BZA - KI Section. 1.0min per each
25	Trippingwoks/ Construction works	3	Nos	3	0.10	3	0.300	30	90	1	3	270	Considering 10days for NI Work at KI, RYP, NBWm yards each part of tripping CR Goods Line
	TOTAL MINUTES REQUIRED FOR THE SECTION											2571	2571/365=7.04min Say 7.0min required.

DEN/East/BZA

Ground Penetration Radar Technology in Indian Railways

By
S.K.Barnwal [1]
Rahul Singh [2]

SYNOPSIS

The ballast layer is designed to absorb the impact and dynamic energy of a passing train and to distribute the loads evenly over the formation layer to preserve a smooth ride. It is important that the ballast layer remains free of fines. Contaminated ballast causes an unstable pressure distribution on the subgrade and may lead to unwanted and undesired rates of deterioration of assets. On Indian Railways, assessment of attention required to Ballast in the form of deep screening of track was earlier based on criteria of passing of 500 GMT or 10 years. The assessment criteria for deep screening of main line tracks have now been modified on the basis of available clean ballast cushions. At present, there is no scientific method being adopted to check the available clean cushion and it is done by manual methods of collecting samples which is time taking, expensive and highly subjective. In the present paper an effort has been made to bring out the advantages of adopting Ground Penetration Radar technology for analysing the condition of Track Ballast and to assess the availability of a clean cushion for making scientific decisions about ballast renewal.

Ground Penetrating Radar (GPR) is a fast and effective electromagnetic survey technique utilized in the field of subsurface and underground explorations and is widely used in highways, archaeology and other fields. This technology uses electromagnetic waves of the frequency of radio waves for assessing conditions of subsurface strata.

The principle of GPR operation is based on transmission of short electromagnetic waves by an antenna into the subsurface, the subsequent reflection, scattering, and refraction of this energy from subsurface interfaces, and the receiving, recording, and display of this reflected energy. The data obtained from GPR testing represents the energy that is reflected off subsurface boundaries back to the radar antenna.

GPR requires two main pieces of equipment – a transmitter and a receiving antenna. The transmitter sends electromagnetic energy into the soil and other material. Ground Penetrating Radar works by emitting a pulse into the ground and recording the echoes that result from subsurface objects. GPR imaging devices also detect variation in the composition of the ground material. If the electromagnetic impulse hits an object, the density of the object reflects, refracts, and scatters the signal. The receiver detects the returning signals and records variations within them. The GPR system has software that translates these signals into images of the objects in the subsurface. This is how it is used to map structures and utilities buried in the ground or in man-made structures.

Ground Penetrating Radar signals can be used to find a wide range of items. GPR is often used to map items made of materials such as Metal, Plastic, PVC, Concrete, Natural materials etc. GPR is frequently utilized to detect underground utility lines and pipes, changes in ground strata, geological features and rock obstructions, air pockets or voids, excavated and back-filled areas, groundwater tables, bedrock and many more.

1 GPR Application in Railways

GPR application in railways uses electromagnetic waves of ultra high frequency (300– 3,000 MHz, wavelength 1–0.1 m) and enables the measuring of layers thickness, detection of changes on structure or on materials properties along the line.

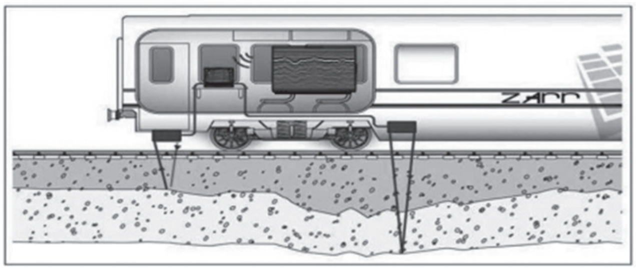

Fig. 1

It can also detect different types of defects such as ballast pockets, fouled ballast, poor drainage, subgrade settlement and transition problems, depending on their extension. These defects are generally the causes of vertical deviations in track geometry and they cannot be detected by the common monitoring procedures, namely the measurements of track geometry.

For above functionality, high speed GPR antennas

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[2] *Director/Track Machine*

are used and the same are being used to conduct Survey of railway Track at Speeds upto 180 kmph. The collected data is then analysed by high-end customised software and Expert Geophysicists, to finally assess the condition of the Ballast.

2 Importance of Maintenance of Ballast Bed

Ballast is an important component of track and plays a very important role in overall track strength, following are the important functions of Track Ballast;

(i) To distribute the axle load uniformly from sleepers to a large area of formation.

(ii) To provide elasticity to the track. It acts as an elastic mat between subgrade and sleepers.

(iii) To provide a levelled bed or support for railway sleepers so that the desired cross level is maintained.

(iv) To hold the sleepers in a firm position while the trains pass by. (v) To prevent the longitudinal and lateral movement of sleepers. (vi) To offer a good drainage to the track

To achieve the above functionalities with the desired level of efficiency, the Ballast is required to have the following qualities.

3 CHARACTERISTICS OF GOOD BALLAST

Ballast must have following characteristics for carrying out the above discussed functionalities;

(i) It should have sufficient strength to resist crushing under heavy loads of moving trains.

(ii) It should be durable enough to resist abrasion and weathering.

(iii) It should have a rough and angular surface so as to provide good lateral and longitudinal stability to the sleepers.

(iv) It should not make the track dusty or muddy due to its crushing to powder under wheel loads.

(v) It should allow for easy and quick drainage of the track.

4 Deterioration of Ballast

During the course of usage, the ballast laid in track gets deteriorated and loses its required properties which are essential for effectiveness of the Ballast, following are the few reasons as why the track ballast gets deteriorated;

(i) Under heavy axle loads, ballast gets crushed at a faster rate and thus the ballast loses its required property of Gradation.

(ii) Due to crushing of Ballast under load, the percentage of finer particles increases and thus it affects the property of required elasticity and drainage as the ballast gets choked up due to presence of unwanted fines.

(iii) In areas with heavy rainfalls and peculiar geographical territories like cutting and tunnels etc. rain water when flowing over track ballast deposits the silt and fines carried by it on ballast causing the increase in fine particle concentration.

(iv) In areas where Goods trains are carrying commodities like iron ore and coal, due to droppings etc. the fine content of ballast increases and thus it reduces the Ballast properties drastically.

(v) Punchering the ballast into the subgrade of formation also leads to fouling of the ballast.

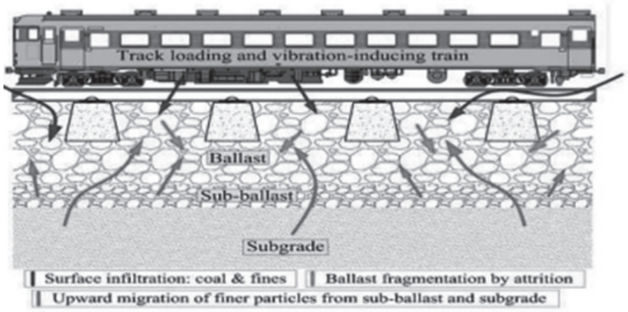

Fig. 2

5 Effect of Deterioration of Ballast

Following are few of the major effects on track Structure and Maintenance of the Track due to deterioration of Ballast

(i) Drainage- With increases in percentage of fines due to Deterioration of Ballast the drainage of Ballast gets hampered and water is retained in the track and due to water retention the Deterioration of Ballast is further increased and also as the water retention changes the frictional forces acting between the ballast particles the load transfer is not as desired.

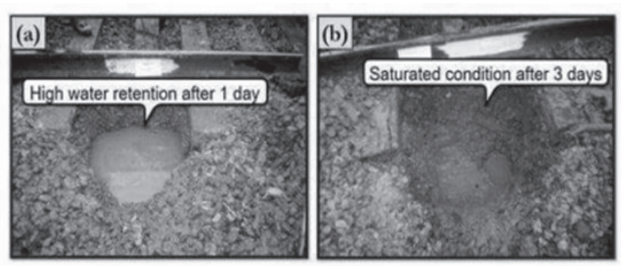

Fig. 3

In the above figure (a) is ballast which is comparatively less deteriorated than (b) and we can clearly see that in a similar situation of rainfall water retention in (b) is much more than (a).

(ii) Due to an increase in the percentage of fines due to Deterioration of Ballast the desired elastic properties of track are not achieved and due to improper behaviour of track life of other assets like Rails, Sleepers and Fittings comes down.

(iii) Due to the increase in Deterioration of Ballast, the requirement of maintenance inputs gets higher as retention of packing of ballast is severely affected.

6 Ballast Fouling and Ballast Fouling Indices

Before we discuss how the technology of GPR can be used on railway track and its benefits for Indian Railways, it is important that we understand the concept of Ballast fouling and Ballast Fouling Index.

7 Ballast Fouling is defined as the presence of unwanted contaminants of finer sizes which fill up the voids between the ballast and decrease the required qualities of Ballast like drainage, strength, resilience and elasticity etc.

8 Ballast Fouling Indices (BFI) are formulas for mathematically representing the extent of fouling of ballast. There are various formulae being used over different railways. It is important to have a BFI as it helps to decide the mathematical limits based on which the decision of attention to ballast can be taken.

The GPR-derived fouling index is based on measurement of the level of signal scattering within the ballast layer and is independent of the ballast layering.

Many different formulae for quantifying Ballast fouling have been proposed and following are a few being used over different railways;

I Selig's fouling index developed by Selig and Waters developed (FI), which has since been extensively adopted in the US.

FI=P4%+P200%,

where P4% is the percentage by mass of the sampled ballast material finer than the 4.75 mm (No. 4) sieve, and P200% is the percentage by mass finer than the 0.075 mm (No. 200) sieve.

Following guidelines are used to identify the condition of track ballast.

Table I

Category	F1 (Fouling Index)
Clean	<1
Moderately Clean	1 to <10
Moderately Fouled	10 to <20
Fouled	20 to <40
Highly Fouled	>= 40

II Australian Railways' formula for Fouling Index; The formula for fouling index F1P is defined as

$$F_{1P} = P_{0.075} + P_{13.2}$$

Where,

$P_{0.075}$ = Percentage passing 0.075 mm sieve

$P_{13.2}$ = Percentage passing 13.2 mm sieve

Following guidelines are used to identify the condition of track ballast.

Table II

Category	F1 (Fouling Index)
Clean	<2
Moderately Clean	2 to <10
Moderately Fouled	10 to <20
Fouled	20 to <40
Highly Fouled	>= 40

III South African Railways' formula for Fouling Index; This index takes into consideration a larger variety of sieves in assessing ballast fouling and sets a cleaning criterion at 80%.

FI=[0.1P0.15]+[0.2P1.18]+[0.3P6.7]+[0.4P19],

where

P0.15=(% by mass of material finer than the 0.15 mm sieve)×100 27, P1.18=(% by mass of material finer than the 1.18 mm sieve) ×100 11.5, P6.7=(% by mass of material finer than the 6.7 mm sieve)×100 18, P19=(% by mass of material finer than the 19 mm sieve)×100 27.

IV **Volumetric fouling index:** a volumetric fouling index (VFI) was established by Ebrahimi et al. to evaluate the actual volumes of contaminants in ballasts subjected to different fouling agents; the VFI is expressed as

VFI=FI×GrsGfs,

where FI is the fouling index expressed in Equation selig's fouling index, Grs is the specific gravity value of the reference ballast material (approximately = 2.6), and Gfs is the specific gravity value of the present fouling agent.

GPR technology is also now being used for assessing the condition of ballast for Ballast fouling (presence of unwanted percentage of finer particles) and clean ballast depth.

9 Advantages of GPR of Indian Railway Track

Monitoring ballasted trackbed with ground penetrating radar (GPR) will allow decisions to be made on timely and cost effective maintenance interventions.

Generation of exception reports for track-bed condition including ballast fouling and formation failure will result in accurate prioritisation of problem trackbed and delineation of the extent of remedial works required by,

- Deployment of ballast cleaning and tamping machines to where they are most needed,

- Reduction in the number of interventions during the life of the ballast through condition-based planning.

10 Planning of GPR on Indian Railways

On Indian railways it is planned to get the system installed in one of the Track Recording Cars. By GPR survey, the condition of ballast (fouling level) will be known and thereafter Deep screening of ballast will be planned on actual condition of ballast. This will be a scientific and rational approach to the deployment of Ballast Cleaning Machines (BCM) and is likely to significantly reduce the requirement of deep screening. This will also lead to a predictive system of track maintenance with regards to deep screening of ballast. Moreover, a clear scanning of problems below ballast level will also be available in locations of formation troubles, which will help in the decision of proper formation treatment solutions.

The Desired result shall be obtained by deploying two types of GPR antennas in combination; High frequency low wavelength antennas in the range of 2GHz for addressing issues of Ballast fouling and Low frequency high wavelength antennas in the range of 700 MHz to assess the formation related issues.

11 GPR and Track Geometry

Combining the GPR derived indices with track geometry data shall also provide an efficient means of identifying those track geometry faults that are associated with an underlying trackbed problem and helping determine the extent of that problem. It can also highlight areas of moderate or poor trackbed integrity that may not yet be manifested as a track geometry fault.

Data from multi-sensor survey platforms including GPR and track geometry, when integrated as part of a holistic strategy for prioritising and planning appropriate maintenance, will provide unique condition-based information and significant cost savings.Thus combining track geometry measurements with GPR provides unique condition-based information to plan a holistic and cost effective trackbed management strategy.

Fig. 4 Picture showing attached GPR antennas on railway vehicles.

Indian Railways is in the process of introducing this technology through a service contract to cover almost all the important routes, which is approx. 50000 kilometres. In the above work which is to be done under Service Contract, the experts will also develop the Ballast Fouling Index formula for Indian Railways. Thus by using the GPR technology on Indian Railways, we will have a scientific rationale for prioritizing ballast cleaning.

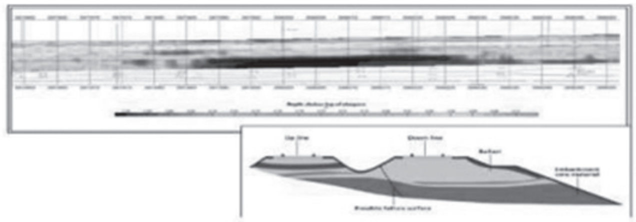

Fig. 5 Picture showing sample of report detailing formation related issues.

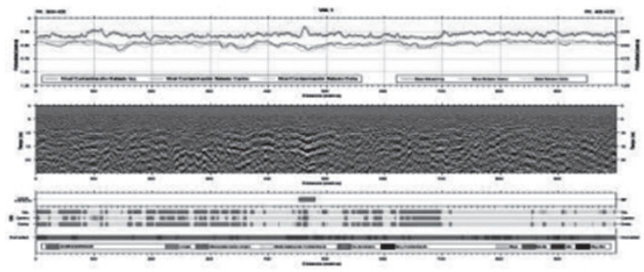

Fig. 6 - Sample report of a stretch of 10 kilometres displaying the detailed BFI values as per predefined ranges.

12 Previous Experience of IR on GPR vis-a-vis TRC Mounted GPR Survey

Earlier the Subsurface Interface Radar System was procured by RDSO in 1999 from the USA It was a Push trolley mounted system – bulky and heavy, difficult in handling, very less speed of survey and limited applicability, only display on monitor without any analysing software for report generation. System provided limited useful results as the required expertise to interpret the output of the survey was not available with RDSO. Displayed images of the ballast were not very clear as the frequency used was inadequate (1000 MHz as compared to the tentative frequency of 2 GHz being used at present for GPR survey of ballast). Advanced modelling techniques were required to allow complex GPR data to be interpreted by defining probable subsurface properties causing the signal which was not possible at that time due to limitation of technology.

The current system is an advanced version which uses hardware capable of recording data at high speed along with software application to interpret the data which was done earlier by experts. Present system being planned for induction in IR on service mode will be a vehicle (TRC) mounted with capability for recording at high speed, higher output (3000-4000 km per month), analysing software and involvement of firms geophysicists for interpretation of GPR data for generation of user friendly reports.

13 Cost Effectiveness of TRC Mounted GPR Survey

This system of survey for ballast fouling Other than being a scientific method of assessing the requirement of ballast cleaning is also a very cost effective method as the average cost of survey of ballast bed would come out to be around Rs.6500/- per kilometre. The average cost of ballast cleaning is to the tune of Rs 25-30 Lakhs per

kilometre. Therefore the survey cost is only around 0.2%-0.3% of the cost of Ballast Cleaning. Further there are quite likely chances of reduction in the total number of kilometres where ballast cleaning is required when the GPR system is adopted on IR.

14 Conclusion

The growth in rail traffic and associated increase in the cost of occupying track (traffic blocks) for routine inspection and maintenance is necessitating a change in the maintenance planning paradigm. The induction of GPR technology for making decisions for prioritising Ballast cleaning is an important step towards a more scientific approach on the subject. After the first round of GPR Survey, this technology may be adopted on a regular basis and with the application of several sets of data, in future predictive planning of the maintenance can also be done.

15 References and Acknowledgements

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v. “Source of Ballast Fouling and Influence Considerations for Condition Assessment Criteria”. Transp. Res. Rec. J. Sussmann, T.R.; Ruel, M.; Chrismer, S.M.Transp. Res. Board 2012

THE RAILWAY STATION AT POONA IN 1858

A comparison of this picture with that shown at the top of the page will give an idea of how India has progressed since the G.I.P. was built.

Arresting Track Creep in Braganza Ghats (Castle Rock -Kulem) through Use of Sleeper Bracings using Provisions of RDSO Report CT-30 on SWR

By
Danish Khan[1]
Vipul Kumar[2]

ABSTRACT

Castle Rock (CLR)-Kulem (QLM) is among the busiest and most critical ghats on Indian Railways which has a ruling gradient of 1 in 37 and an annual GMT of around 25.Due to steep gradient combined with sharp curvature upto 8.5 degree, along with movement of heavily loaded goods train which require 5 loco (2 leading+ 3 banking) for movement up the ghat results in huge tractive efforts on rails and consequently results in movement of rail in down gradient leading to frequency adjustment of track creep. In this section almost entire workforce of track maintainers round the year used to be involved in activity of Pulling back of Creep to maintain the section. So in order to minimise the Pulling back of creep in the stretch PSC sleeper bracing was done using the provisions of RDSO report CT-30 on trial basis for 300m stretch for the purpose of reducing rail movement (creep). This paper brings out analysis of trial stretch that includes comparison of creep before and after the bracing work; challenges faced; manpower and time saving; improving overall safety of train operations; benefits in terms of reduction in cost; etc.

1 Introduction

CLR-QLM is a ghat section in UBL Division with a gradient of 1 in 37 which is among the steepest on Indian Railways and this route has an annual GMT of about 25 making it among the busiest route of South western Railways where heavy loaded goods train move up and down the ghat. Due to the tractive effort of loaded goods train up the ghat and combined with steep gradient , the rails tends to move down the ghat thereby resulting in huge track creep as a results it leads to developing of excess gap at fishplated joints at higher gradient portion of track and excess pressure at joints at lower gradient, if not attended frequently excess gap results in shearing of fish plate bolts and ultimately creating large gap and making it unsafe for the movement of track and at lower portion excess pressure disturbs the alignment of the curve. Therefore, due to this continuous movement of rails, manpower of ghat is mostly involved in Pulling Back of Creep (PBC) operations. This problem of PBC is more critical at certain locations where gradient is very steep such that it has to be attended every 30 to 40 days. Therefore, in order to minimise the problem of movement of rails and unsquaring of sleepers, sleeper bracing was done using the provisions of RDSO Report CT-30 for a short stretch of 300m as trial to minimise creep in the stretch.

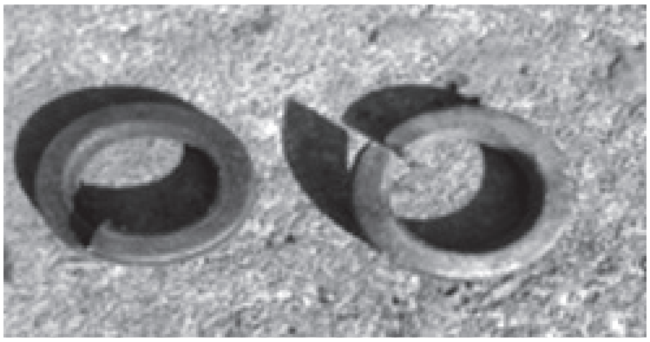
RDSO Report CT-30 provides provisions for continuation of long welded rails on sharp curves and steep gradient by doing cross bracing of sleeper and thereby improving the track frame resistance and hence resistance against compressive forces developed in rail and this overall monolithic structure also provide resistance against creep.

Therefore, provisions of RDSO Report CT-30 is utilised in CLR-QLM ghat section of UBL division for the purpose of arresting perennial rail creep on trial basis for a stretch of 300m at steep gradient of 1 in 39. The trial implemented in short stretch found to be effective after analysis done for a period of one year and thereby reduced creep attention frequency and completely eliminated sleeper unsquaring issue in the trial stretch.

2 Materials Used

[1] *ADEN/CLR/UBL*
[2] *Retd. PCE/SWR*

a) Fabricated Angle of Size 75 x 75x 10



b) Single Coil Spring Washer (T-10773)

c) Plate Screw (RDSO /T-3913)

3 Drawing Number Used

RDSO /T-8329

4 Methodology Used

a) Proper squaring and spacing of sleepers to be done.

b) Arranging required numbers of Duly chamfered angle section of size 75 x 75 x 10.c) Drill two holes to accommodate plate screw at the location specified in the drawing (RDSO/T-8329).

d) Make notch in one angle section at intersection point as specified in drawing.

e) Notched angle should be placed below the complete angle section.

f) After placing the angle sections as per drawing, plate screw shall be tightened to an extent that angles can freely rotate about the hinged point.

5 Challenges Faced During Course of Work

a) Fabrication of angle section (75 x75x10) was done at site as per the RDSO drawing as due to non-availability of adequate cess width in ghats only 30 to 40 angles were fabricated in advance after their installation further fabrication was done.

b) After fabrication of angle section, fixing of angle section was a difficult task as proper spacing and squaring of sleepers has to be maintained which used to get disturb after passing of train, therefore a workforce of about 30 personnel was employed for fixing angle in line block of 1.5 to 2hrs on daily basis therefore daily progress of about only about 30 sleepers was obtained

c) This work also became challenging as being a single line section getting a line block of 1.5 to 2hrs was also difficult as large no of goods train are plying in section being the busiest route of south western railways.

6 Comparison of Performance of Rail Creep after Implementation of RDSO Report CT-30.

6.1 Details of locations where cross bracing arrangement provided

Table 6.1.1.

Major section	CLR-QLM
Block section	CLR-CRZ
Location	25/284-25/584
Type of Track (LWR/ SWP)	Fish plated (13m free rails)
Length (m) 300 m	UP/DN/SL SL
Track structure	60 kg rail with 60 kg sleeper with sleeper density 1660
Value of gradient steeper than 1 in 100	1 in 39
Degree of curve	6.95
Annual GMT	25
Measure taken to arrest creep	ERC Mk-V (T-5919)
Vertical wear of rail	2.7 mm
Lateral wear of rail	4.0mm

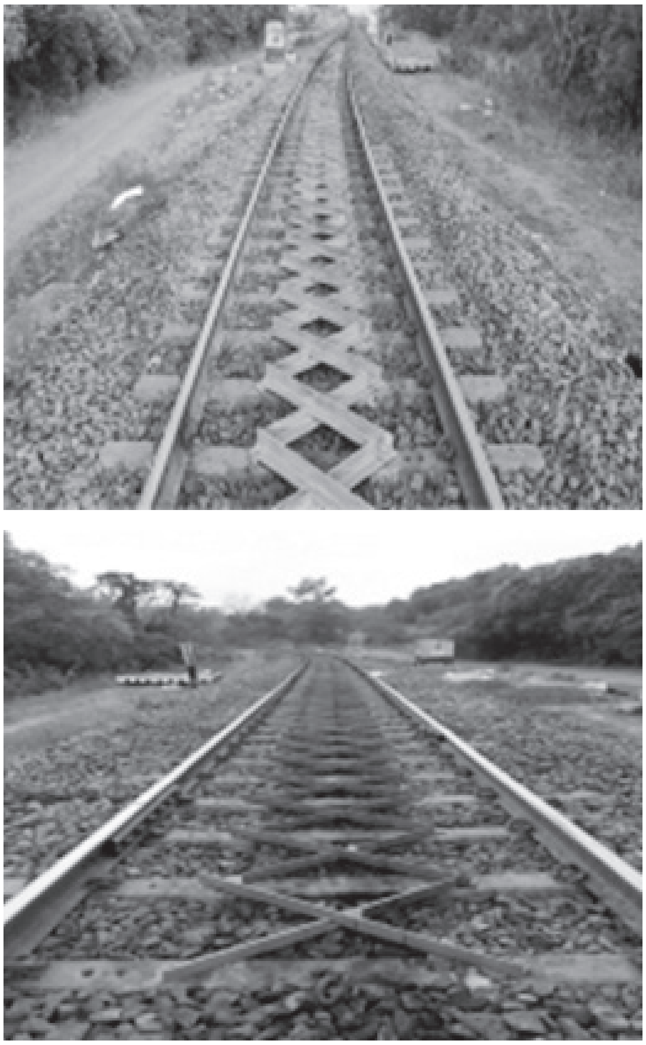


Fig. 6.1.1. Cross Bracing arrangements at trial location

6.2 Before implementation of cross bracing frequency of creep attention and sleeper squaring at trial location

Table 6.2.1

S. No	Date of Pbc (Lh Rail)	Date of Pbc (Rh Rail)	Date of Attention of Sleeper Squaring
1	17.01.2020	17.01.2020	15.01.2020
2	31.01.2020	20.02.2020	10.03.2020
3	17.02.2020	20.04.2020	18.05.2020
4	23.03.2020	28.05.2020	3.06.2020
5	23.04.2020	26.08.2020	22.08.2020
6	22.05.2020	02.12.2020	16.10.2020
7	13.07.2020	-	22.12.2020
8	12.10.2020 -		
9	14.12.2020	-	

6.3 After implementation (March 2021 -February 2022) frequency of creep attention and sleeper squaring at trial location

Table 6.3.1

S. No	Date of Pbc (Lh Rail)	Date of Pbc (Rh Rail)	Date of Attention of Sleeper Squaring
1	7.06.2021	1.06.2021	NIL as Sleeper
2	18.12.2021	22.12.2021	maintained at correct spacing

After comparison from table 6.1.1 and 6.1.2, it is evident that before implementation of cross bracing as per RDSO report, pulling back of creep was required on an average every 40 days in LH rail and every two months in RH rail which has reduced drastically to a frequency of 6 months on both LH and RH rail, thereby reducing maintenance operations and improving overall safety of ghat section.

7 Benefits

i. **Reduction in creep frequency:** As it is evident that before implementation of cross bracing as per RDSO report, pulling back of creep was required on an average every 40 days in LH rail and every two months in RH rail which has reduced drastically to a frequency of 6 months on both LH and RH rail, thereby reduced creep frequency to a very large extent.

ii. **Constant sleeper spacing :** Secondly, maintaining sleeper squaring was a cumbersome process which used to get disturbed every two months in the stretch has now reduced to zero as sleeper has maintained their spacing effectively.

iii. **No hinderance during tamping:** Cross bracings done in sleeper has an advantage that these need not to be removed during tamping as sufficient space is available for working of tamping tool.

Fig. 8.3.1

iv. Improving mobility: In addition to the above tangible benefits there are some other intangible benefits such as due to reduction in frequency of pulling back of creep caution order in the section will reduced hence thereby improving mobility and running in the section.

v. Enhancing safety and operational efficiency: Overall safety of Ghat section will improve since due to movement of rail and sleepers at fishplated joint large gap was created and closure need to be inserted and caution order is required to be imposed making location critical in terms of safety and maintenance becomes more difficult in monsoon period when track maintainers strength reduces as they are employed in monsoon patrolling, hence resulting in longer caution imposition in section and consequently affecting operational efficiency and punctuality.

vi. Reduced diesel consumption: Diesel loco moving up the ghat consumes more diesel when speed is low as more tractive effort need to be applied therefore with reduction in number of caution order in section and also in duration of caution order there will be overall saving in diesel consumption of locomotives.

vii. Enhancing line capacity/section capacity: Everyday on an average around two hours line block is required in different block section in order to attend pulling back of creep. As a result of implementation of cross bracing, frequency of attention to pulling back of creep is reduced from one month to six months, thereby if cross bracing is implemented for whole critical stretch will result in reduction of line block requirement on account of pulling back of creep. Hence, considering on an average around 15 days in a month when line block will not be required. Thus, there will be additional capacity in section for running goods train approximately 2/24*100 =8.33% thereby an additional rake can be accommodated and which will ultimately increase revenue of railways.

8 Financial Benefits

Though the improvement in safety of track is beyond quantification, an attempt has been made to work out financial benefits by calculating Savings over a period of 10 years for a total length of 6 kms which is the most critical in CLR-QLM ghat section of UBL division. The analysis along with assumptions made are as follows:

A. Fixed cost of Cross bracing :

Work of fixing of cross bracing of angle will be fixed cost

i. Cost of fixing and fabricating angle (per kg) = Rs 61.73

ii. Cost of drilling hole in sleeper (per hole) = Rs. 441.78

iii. Cost of plate screw per sleeper (required two numbers) = 39*2 =Rs 78

iv. Cost of single coil spring washer (required two numbers) = 5.90*2 = Rs 11.8

Total Fixed cost per metre (excluding contractor percentage above /below) = 4409.07/m Total cost for 300m =4409.07*300= Rs 13,22,721

Total cost of fixing cross bracing for a length of 6 kms = 4409.07*6000 = Rs 2,64,54,420

Note : The cost of fixing of angle will be fixed cost, once fixed they will be required to be removed only during deep screening or TSR which is done on an average around 10 years, after removal also cross bracing will have residual/reusable value. Hence financial benefits are calculated for a period of 10 years.

B. Savings in Track maintenance Cost :

Saving of contractual Manpower = 16*2 (Used for doing PBC, LH and RH Rail) + 10 (Used for sleeper squaring) = 42 nos

i. Effective months not requiring maintenance = 6-1 =5 months

ii. Cost of skilled Labour for working in ghat (assuming wages working in construction and maintenance operations = 724 per day

iii. Total saving in 300m stretch location in one year = 42*5*724 = Rs. 1,52,040

Total savings in track maintenance cost for a period of 10 year for 6 kms = 152040 *6000 *10/300 = Rs. 3,04,08,000

C. Savings in Track fittings Cost :

Due to regular rail creep rubber pad get crushed very frequently and get displaced therefore every month need to be recouped and metal liner also get wear and required to be changed every six months when pulling back creep is done, in addition to the above, ERCs which are required to be removed everytime during PBC loses toe load as inside of insert gets wear due to regular driving of ERCs every month during Pulling back of creep. Hence ERCs are required to be replaced once in a year. Therefore, now as result of cross bracing this cost of annual Through fitting renewal work will be saved.

Cost of track fittings is as anlaysed below per sleeper.

i. Cost of GR composite pads 6mm RDSO T 6618 = Rs. 35.70

Number of rubber pad required per sleeper = 2

Total cost = Rs. 71.4

ii. Cost of metal liner (T-3740) = Rs. 37

Number of metal liners required per sleeper = 4

Total cost = Rs. 148

iii. ERC Mk III (T-3701) = Rs.72.58

Number of ERC required per sleeper= 4

Total cost= Rs 290.32

Total cost of Track Fittings per sleeper = Rs. 509.72

a. Total saving on rubber pad cost per year per sleeper = 12 months -2 months = 10 months* 71.4= Rs 714

b. Total saving on metal liner cost per year per sleeper= metal liner required to be replaced twice in a year = 2* 148 = Rs. 296

c. Total saving of ERC cost per year per sleeper = ERCs required to be replaced once in a year = 1* 290.32 = Rs 290.32

Total saving in cost of track fittings per year per sleeper= Rs 1300.32

Total savings in cost of track fittings for 300m = Rs. 6,47,560

Total savings in cost of track fittings for 10 years for a length of 6 kms = 1300.32 *1660*6*5= Rs 6,47,55,936

Total savings of Cost in track maintenance and track fittings = 6,47,55,936 + 3,04,08,000 = Rs 9,51,63,936

Total Effective Savings over a period of 10 years for 6 Kms = 95,163,936 - 26454420 = Rs 6,87,09,516

Avg. Annual savings = Rs 6,87,09,516/10 = Rs 68,70,952 approx.

% Savings over 10 years = 68709516*100/26454420= 259.72%

This is the saving in terms of money. Safety enhancement is something which is priceless for IR operations!

Note:

a) Sleeper density in section is1660.

b) Considering once in two years Fittings will be required to change as due to sharp curve of more than 5 degree and gradient steeper than 1 in 100 as per ACS 2, IRPWM 2020 as against once a year which is present frequency of fitting renewal in ghat thereby savings track fittings cost for 5 years in 10 years period.

9 Conclusions and Way Forward

Braganza Ghat was commissioned in 1887 with MG line and Gauge conversion was done in the year 1996 from the inception of this section maintaining this ghat is one of the arduous task due to the presence of steep gradient of 1 in 37 combined with sharp curves and heavy loaded goods train movement up and down the ghat with several locomotives. Further in addition to the above heavy rainfall during monsoon also makes it more difficult and challenging for engineering staff to maintain the section.

Over the years one of the major maintenance operation involved in ghat section is pulling back of creep which is round the year activity but after the implementation of cross bracing in the trial stretch it is found to be very effective in minimizing the rail creep to a very greater tent frequency of creep attention has been reduced from one month to six months which has resulted in improved safety, improved mobility and also savings in terms of track maintenance cost and other track components cost and if implemented for the stretch of 6kms for a period of 10 years will give a financial benefit of around 259.72% making it viable and profitable option.

In addition to the above, RDSO report CT-30 for continuation of LWR on sharp curves and steep gradient has been worked out for plain track and all guidelines and drawings have been issued by considering the plain track sleeper. However, in Braganza Ghat section due to steep gradient point and crossings in yards are also subjected to creep resulting in sleepers getting out of square and tilting of point and crossings sleepers which disturbs cross level and housing of sleepers and also results in bending of S&T rods thereby resulting in frequent point failures and rough running on points. Therefore, cross bracing on similar lines may be replicated on trial basis on point sleepers also to study its effectiveness. It is understood that length of cross bracing angles will be different, as spacing of points sleeper are different in different portions of points but if found effective can solve major operations bottleneck in yards and will drastically enhance the safety of yards in Braganza ghat.

10 References

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3. South Western Railway Unified Standard Schedule of Rates, 2021.
4. Ministry of Labour and Employement F.No.1/26(3)/2021-LS-II) dated 28/10/2021.)
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ANNEXURE A

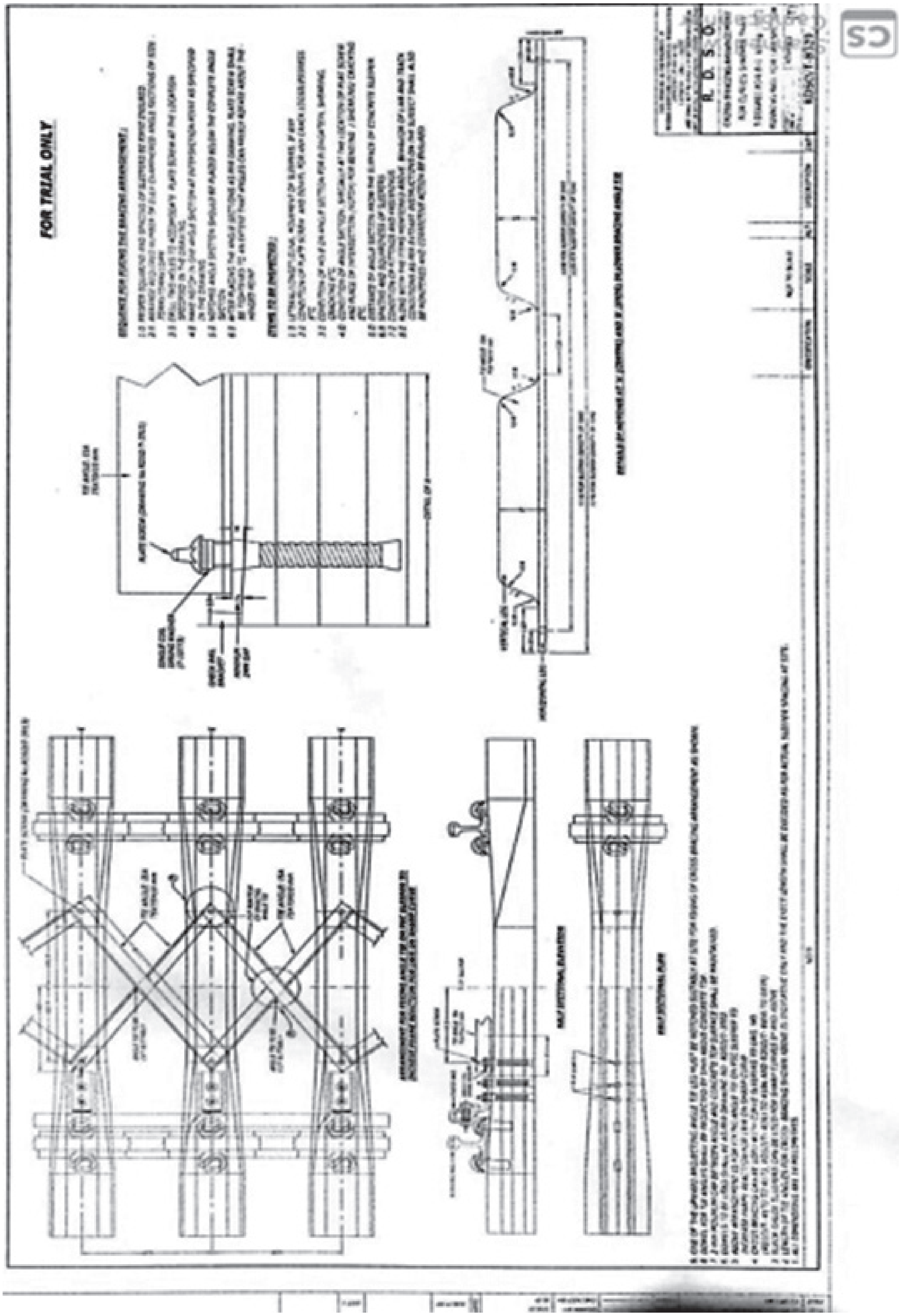
Critical location in Braganza Ghat which require cross bracing to reduce rail creep

S.No.	From Km	To Km	Length (m)
1	25.200	25.500	300
2	25.800	26.100	300
3	26.400	26.700	300
4	26.900	27.200	300
5	27.800	28.100	300
6	28.450	28.650	200
7	29.200	29.500	300
8	30.100	30.400	300
9	30.900	31.200	300
10	32.600	33.100	500
11	34.000	34.400	400
12	35.100	35.400	300
13	35.600	35.900	300
14	36.200	36.400	200
15	36.700	37.000	300
16	37.700	38.000	300
17	39.300	39.600	300
18	40.200	40.500	300
19	40.700	40.900	200
20	41.400	41.700	300
Total			6000 m

COLABA STATION 1920

ANNEXURE B

DRAWING NO-RDSO /T-8329



ANALYSIS OF PARABOLIC CATCH SIDING – REVIEW

By
Dr. Amaravel. R*

Synopsis:

Catch siding is a siding which takes diversion from main line with points. These points are set to receive the parted trains on uncontrolled train compartments guided from main line. The kinetic energy of moving parted trains are mitigated by providing suitable length of catch siding at convenient upgrades with sanded track. The upgraded track imparts gravity resistance whereas the sanded track develops sufficient frictional resistance. The total kinetic energy of parted train is neutralized by the cited gravity and frictional resistance generated on the full length of catch siding. This paper describes about analysis and design of new parabolic catch siding and non-parabolic catch siding.

1 Introduction

When the trains negotiate the curves which designed for lower speed and remains near the station which lies between steeper grades, there is a chance for trains running under high speed. This causes the parting of train compartments. Under these circumstances, catch sidings are essential. Safe catch sidings shall be provided. High speed than may be conceivably be attained by the train or part of the train which for one cause for another cause may have got out of control, then it is necessary to protect a station from uncontrolled trains or part of trains liable to enter it. For arresting the train which is out of control when approaching station down under control, provision of catch siding shall be limited to grades steeper than 1 in 80 only (as per railway board order dated,09-05-68 circulated under letter no 62/WDO/SD/38). In all other cases catch siding should be as far as possible be unnecessary by strict implementation of regulations and by reorganizing the positions of the signals at full breaking distance, if necessary. When the speed permissible on curve is lesser than the permissible speed on steep down grade, it is recommended to provide catch siding.

1.1 Precautionary measures adhered near and on catch siding :

Normally all catch sidings except those which are sanded shall be kept alive. On sanded catch siding, the rails shall be kept clear of sand for a length of 21.5 meters, beyond the section insulators in the overhead lines and the switches controlling the sanded catch sidings shall be kept in the neutral position. If an electric engine or single or multiple unit train runs into the sanded length of a catch siding, it may possibly be insulated from earth except through the buffers or couplings if connected to other vehicles, therefore these sidings shall not be made alive when an electric engine or single or multiple unit train or any vehicle coupled thereto are standing in the sanded tracks until all staff have been moved away from positions where they are likely to make contact between the permanent way formation and any part of the locomotive or single or multiple unit train or coupled vehicles. None of persons shall be permitted to enter, or leave or in any other way make contact between the permanent way formation and the electric engine or single or multiple unit train or any vehicles coupled thereto while the overhead equipment of the sanded length of siding is alive.

2 Rail and Sleeper Details for Catch Siding

2.1 Minimum Sleeper Density :

The minimum sleeper density for all track renewals (complete track renewal and through sleeper renewal), doubling, gauge conversion, new line construction works for main lines may be 1660 nos. per km and for loop lines & sidings(permissible speed up to 50kmph) it may be 1540 nos. per km. For sidings with permissible speed more than 50kmph minimum sleeper density may be 1660 nos. per km. (IRPWM P68) new sleepers should not be used in sidings. If the percentage of unserviceable sleepers becomes high, speed restrictions may have to be imposed. Table 1. Explains about rail and ballast sections for sidings. Table 2. Describes about track resistance parameters.

* *SSE/Designs/CN/BNC/SWR*

2.2 Rail and ballast sections for sidings

Table 1.a The rail sections for private and other sidings (C.S.No. 129 dt:28-06-2012 & 130 dt 08-02-2016, Part E, IRWPM)	
Type of sidings	**Rail sections**
Sidings taking off from DFC or feeder routes to DFC or 25 t axle load routes.	60 kg
Sidings other than (i) above with permissible speed up to 50 kmph.	52kg (SH) or 52 kg (IU)
Sidings other than (i) above with permissible speed more than 50 kmph.	60 kg

Table 1.b Ballast cushions for private and other sidings (C.S.No. 126 dt:21-06-2011, PART F, IRPWM)	
Type of sidings	**Ballast cushion in mm**
Sidings other than (i) above with permissible speed upto 50 kmph.	300
Sidings other than (i) above with permissible speed more than 50 kmph.	350

2.3 No station yard shall be constructed nor shall any siding join a passenger line on a steeper grade than 1 in 260, except where it is unavoidable and then also only with the previous sanction of the Railway Board. It is necessary to obtain sanction through the Commissioner of Railway Safety when a slip siding or other arrangement is made sufficient to prevent accident.

2.4 The power of condonation for gradient steeper than the specified standard maximum gradient of 1 in 400 (0.25%) shall be as under- Schedule of Dimensions-1676mm, Gauge 10 ACS-19 (SOD P 10). Minimum radius of curvature for slip points, turnouts of crossover roads is 218 meters (8 degree (SOD P 15). The length and capacity in terms of vehicles of sidings; position of fouling marks and buffer stops; distance, center to center of tracks; distance of all the facing points on the main line from the center of station, the serial numbers of the turnouts, the angles of crossings, inclination of gathering lines, the distance from the center of station of all signals, signal cabins with their distinguishing feature, signals are being shown as viewed by the Driver with their bases at the sites they occupy lengths of passenger and goods platforms and their heights above rail level; telegraph posts and crossings of tele-communication and power lines over head or underground. (IRWM-906)P 207.

Fig.1 Typical Catch Siding

Fig. 2 Catch Points and Main Lines

2.5 Various types of resistances experienced by train while running on railway track :

Table 2 . Track Resistance Parameters

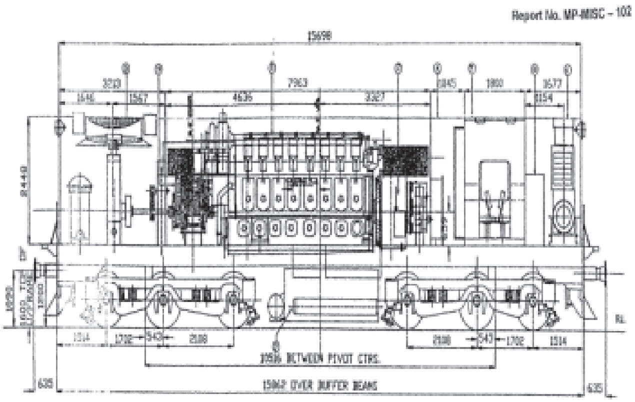
Sl. No	Nature of resistances	Value of resistances	Remarks
1	Resistance due to friction	0.0016W	Considered for design of catch siding
2	Resistance due to wave action and track irregularities	0.00008 W V	-----
3	Resistance due to wind	0.000000 W V2	------
4	Resistance due to gradient	W X % of slope / 100	------
5	Resistance due to Curvature (B.G)	0.004 X W X D	Considered for design of catch siding
6	Resistance due to starting	0.15 W1 + 0.005 W2	----
7	Resistance due to acceleration	0.028 X a X W	-----

Where V-velocity of loco, D-Degree of curve, a-acceleration, (W, W1&W2) - Weights of locos and Bogies etc.

2.6 Input Data to design of catch siding for [WDM2+BOXNHAM] :

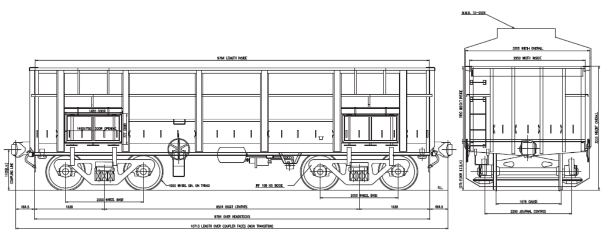
Table 3. Design input data for catch siding with various engines/wagons

Sl. no	Engine / Wagons	No.of Wagons /Engines	Weight of Axle for Engine / Wagon	Length of Engine / Wagon	Weight of loaded BOXNHAM/BOXN / WDM2	Total length of loaded BOXNHAM / BOXN / WDM2	Total Weight of loaded BOXNHAM / BOXN / WDM2
1	WDM 2	3	18.8 t	17.13 m	6 x 18.8 = 112.8 t	3 X 17.13 =51.36 m	3 x 112.8 = 338.4 t
2	BOXN HAM	58	22.82 t	10.713 m	4 x 22.8 = 91.28 t	58 x 10.713 = 621.354 m	58x91.28 = 5294.24 t



3. a Engine Diagram of WDM2.

3. b WDM2 Engine



STANDARD FEATURES OF BOXNHAM WAGON

3. c Wagon Diagram of BOXNHAM.

3. d BOXNHAM Wagon

Fig. 3 Engine / Wagons Features With Concerned Photos.

3 Varying Profile or Non Parabolic Catch Siding (RDSO METHOD) for Train Composition Considering [3 WDM2+58 BOXNHAM]

(Refer Fig. 5. b)

Further Input Data required for designing

1. Continuous long approach grade towards catch siding = 1 in 260
2. Total length of train composition
   = 3 ×17.132+ 58 × 10.713=672.750 m
3. Total weight of locos and wagons
   =58×91.28+3×112.8 = 5632.64 t

Determination of Centre of Gravity of train from Front end.

Load intensity of engine WDM2 /m

$$\frac{112.8}{17.13} = 6.585\ t/m$$

Load intensity of BOXNHAM Wagon / m

$$\frac{(4\times 22.82)}{10.713} = 8.52\ t/m$$

Taking moments with respect to A (front end of engine)

L×5632.64={58×91.28×(310.677+51.396) + (3×112.8×25.698)}

$$L = \frac{1925597.56}{5632.64} = 341.864\ m$$

Therefore Centre of Gravity of train from front end = 341.864 m

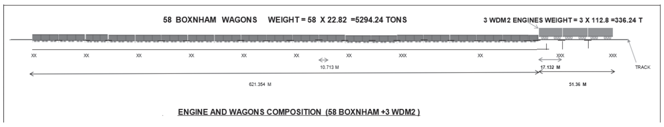


Fig. 4 Train formation with Engines and Wagons

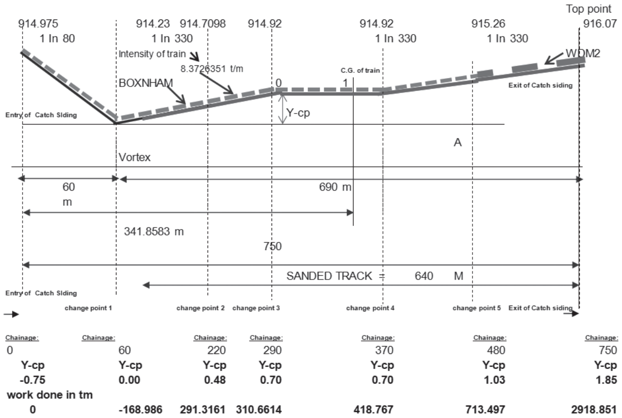


Fig. 5.a Working Profile of catch siding with varying levels and gradients for the train formation of (3WDM2+58BOXNHAM)

3.1 Calculation of velocity of runway train :

Clause 6.13 of Catch Siding calculations ((2nd Para of Page 22 IRICEN – Booklet)

$$\frac{1}{G} \times 5734 = 15.36+0.009\times V^2$$

Where V is in Kilometers per hour

$$\frac{1}{260} \times 5734 = 15.36+0.009\times V^2$$

V=27.27198KMPH,

$$\text{Velocity Head of train} = \frac{V^2}{235}$$

$$\text{Velocity Head of train} = \frac{V^2}{235} = \frac{27.27198^2}{235}$$

=3.165m

(As per the clause 6.3.2 of Page 23 of IRICEN – Booklet – last para)

Considering the natural velocity = 50 Kmph

Velocity head of train (for V =50 kmph) =

$$\frac{50^2}{235} = 10.6383\text{m}$$

This velocity head is to be dissipated by

i) Track resistance (to be taken as 1.5% as per Para 6.11 – Page 46 of IRICEN).

ii) Gravity head due to climbing of train as continuously over varying grades and levels on catch siding.

iii) Resistance due to sand drag and Curve resistance (neglected)

Head of C.G of train 914.92-914.23=0.69

Velocity head to be absorbed /exhausted 10.6383+0.69=11.33

3.2 Dissipation of Velocity head to be combated by track resistance :

Length of Catch siding from vortex = 690 m

Distance negotiated by train load system from Vortex

= 690+60-341.864=408.136 m

Work done in resisting track resistance at 1.5%

$$\frac{1.5\times408.136\times5632.64}{100} = 34483.247\text{ tm}$$

3.3 Velocity head loss due to track resistance:

$$H_{tr} = \frac{34483.247}{5632.64} = 6.122\text{ m}$$

Intensity of Train composition =

$$\frac{(6.585\times3\times17.132+8.52\times58\times10.713)}{(3\times17.132+58\times10.713)} =$$

$$\frac{(338.443+5293.936)}{672.750} = 8.372\text{ t/m}$$

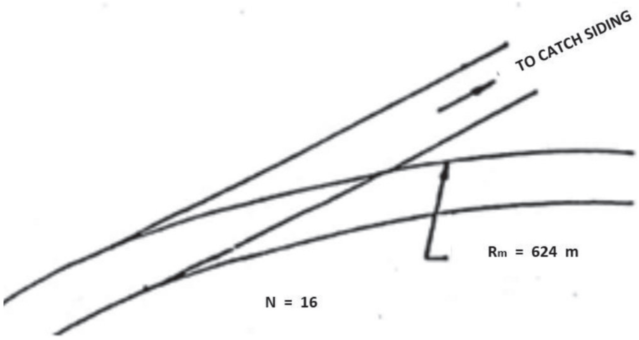


Fig. 5.b Plan view of catch siding model.

3.4 Catch siding profile Calculations for varying Gradient (G) (Refer Fig. 5. b) :

Table 4. Evaluation of gradients at varying chainages for (3WDM2+58 BOXNHAM)

Chainage, m		X, m	Y, m	Value of G for 1 IN G	Level / Upgrade / Downgrade
From	To				
0.00	60.00	60.00	-0.75	-80 (say)	Downgrade
60.00	220.00	160.00	0.48	330 (say)	Upgrade
220.00	290.00	70.00	0.70	330 (say)	Upgrade
290.00	370.00	80.00	0.70	-	Level

370.00	480.00	110.0	1.030	330 (say)	Upgrade
480.00	750.00	270.00	1.850	330 (say)	Upgrade

Work done in ton-m for climbing 1.85 m elevation at the end of Catch Siding.

$$\frac{(1.85+1.03) \times 270 \times 8.372)}{2} + \frac{(0.7 + 1.03) \times 110 \times 8.372}{2} + \frac{(0.7 + 0.7) \times 80 \times 8.372)}{2} + \frac{(0.7+0.48) \times 70 \times 8.372)}{2} + \frac{(0+(-1) \times 0.75) \times 60 \times 8.372)}{2} \text{ton-m}$$

Total work done = (3243.731 + 796.595 + 468.832 + 345.7636 + 321.4848-188.37 = 4988.0368 tm)

Neutralization of Velocity head

$$\frac{4988.0368}{5632.64} = 0.89 \text{ m}$$

3.5 Velocity Head to be nullified by Gravity :

= Total velocity head – Track resistance – Sand Resistance

11.33-6.122-X = 5.2063-X

Estimation of sand track resistance @ 4%

(As per page No.46, Para 6.1 of IRICEN Book)

Length of sand hump = 50 m

Length of sand drag = 640m

Provided length of sanded track = 551 m

Distance moved by C.G on sand drag

= 551-341.864-50 m

= 209.136-50 m

Work done (energy absorbed) on the sand drag

$$\frac{(209.136\text{-}50) \times 4 \times 5632.64)}{100} = 24588.92 \text{ tm}$$

Head of sand resistance

$$\frac{24588.92}{5632.64} = 4.365 \text{ m}$$

Hence gravity resistance required to develop 11.33-6.122-4.365 = -0.843

Velocity head absorption capacity = (6.122 + 4.365 + 0.89=11.377)

11.37>11.33 m

Hence SAFE.

4 Design of Parabolic Catch Siding (RDSO Method-58 BOXNHAM WITH 3 WDM2 LOCOMOTIVES)

Continuous long approach grade = 1 in 260

Composition of train assumed for calculations

Weight of engine = 112.8 t

Length of engine = 17.13 m

No pf engines = 3

No of BOXNHAM =58

Weight of loaded BOXNHAM wagon = 91.28 t

Total weight of loaded BOXNHAM wagon = 5294.24t

Length of loaded BOXNHAM wagon = 10.713 m

Total length of train = 672.75 m

Total weight of train = 5632.64 t

Centre of gravity of train from front end

Clause 6.13 of Catch Siding calculations (2nd Para of Page 22 IRICEN – Booklet)

$$\frac{1}{G} \text{x } 5734 = 15.36 + 0.009 \times V^2$$

Where V is in Kilometers per hour

$$\frac{1}{260} \text{x } 5734 = 15.36 + 0.009 \times V^2$$

V = 27.27198KMPH,

$$\text{Velocity Head of train} = \frac{V^2}{235}$$

$$\text{Velocity Head of train} = \frac{V^2}{235} = \frac{27.27198^2}{235}$$

=3.165m

(As per the clause 6.3.2 of Page 23 of IRICEN – Booklet – last para)

Considering the natural velocity = 50 Kmph

Velocity head of train (for V =50 kmph)

$$= \frac{50^2}{235} = 10.6383\text{m}$$

This velocity head is to be dissipated by

i) Track resistance (to be taken as 1.5% as per **Para 6.11** – Page 46 of IRICEN)

ii) Gravity head due to climbing of train as continuously over varying grades and levels on catch siding

iii) Resistance due to sand drag and Curve resistance (neglected)

5 Parabolic catch siding profile

Distance between SEJ and end of catch siding is 750 m

for vertical parabola with vortex as origin, x2 = 4 c y.

Substituting the values of x & y, [6902= 4.c.1.85], therefore, [c = 64337.84]. Distance between Vortex and end of catch siding is 690 m. Hence, y = [x2 / (4 x 64667.84)]. The value of G is [Xn / {(Yn-Y0)/2}]. The work done is equal to [(Xn x Yn x Intensity of train load) / 2]. The Table 5. Shows Grades at various chainages of catch siding

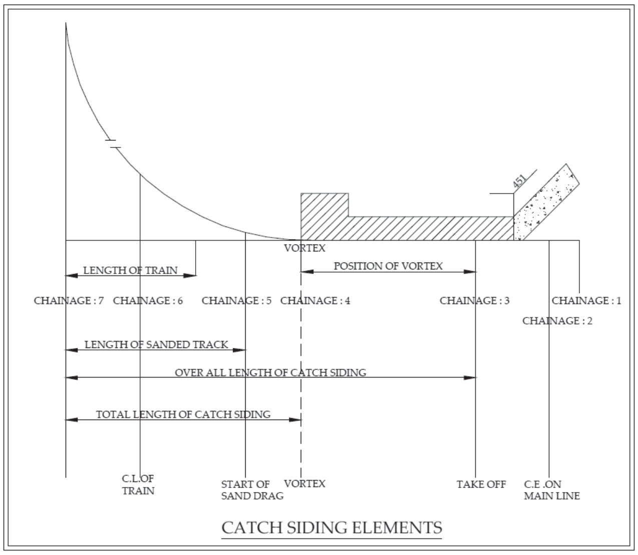


Fig. 6 Components of parabolic catch siding model

Table 5. Grades at various chainages of catch siding.					
Sl. no	Chainages	x	y	G-Grade (1 IN G)	Work done. tm
1	0	-60	0.75	260.00	-188.383
2	60	0	0.00	0.000	0
3	110	50	0.01	2573.51	2.033
4	160	100	0.04	1286.76	16.267
5	210	150	0.09	857.84	54.900
6	260	200	0.16	643.38	130.134
7	310	250	0.24	514.70	254.169
8	360	300	0.35	428.92	439.203
9	410	350	0.48	367.64	697.439
10	460	400	0.62	321.69	1041.075
11	510	450	0.79	285.95	1482.310
12	560	500	0.97	257.35	2033.348
13	610	550	1.18	233.96	2706.387
14	660	600	1.40	214.46	3513.626
15	690	630	1.54	204.25	4067.462
16	750	690	1.85	186.49	5343.787

The Fig. 7 shows CATCH SIDING PROFILE FOR (3WDM2+58 BOXNHAM) Wagons. Length of catch siding from vertex point is 690 m. The elevated level of catch siding top point above vortex is 1.85 m.

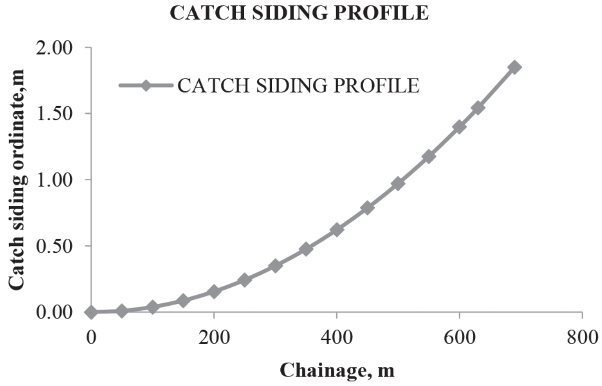


Fig.7 catch siding profile for (3wdm2+58 boxnham) wagons

The Fig. No 8 shows the variation of work don (Ed) with the ratio of (x/y) and G in (1/G). Steep gradient needs more work to be done.

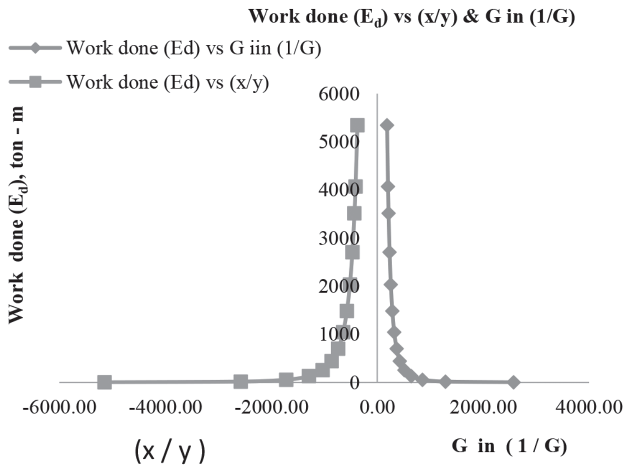


Fig. 8 Work done (Ed) vs (x/y) & G in (1/G)

The Fig. 8 shows the variation of work done (Ed) for the ratios of x and y and gradient (G). The increase in "y" leads to rise the the value of G and fall in x/y resulting in higher value of Ed. This indicates the higher the gradient, the work done will be higher resulting in the mitigating the movement of parted train.

Head at cg of train = 0.190 m

Total velocity head to be absorbed

= 10.638+0.190 = 10.830 m

Absorption of velocity head resisted by track resistance:-

I) Length of catch siding from vortex = 690 m

II) Distance travelled by train load system from vortex = 408.136 m

Work done in overcoming track resistance @ 1.5 % =34483.00 tm

Loss velocity head due to track resistance = 6.122 m

III. Calculation of GRADIENT resistance

Intensity of train load per m = 8.373 t/m

Total work done in t-m = 21,782 tm

Absorption of velocity head = 3.8671 tm

Velocity head to be absorbed by sand drag =

= 10.830 – 6.122 - 3.867 = 0.843 m

IV.Calculation of sand resistance

Length of sand hump = 60 m

Length of sand drag = 500 m

Proposed length of sand track = 362.0 m

Net length of sand drag =21.165 m

Work done to overtake sand resistance @ 4%. =0.847 m

Total velocity resistance = 6.122+0.847+3.867 =10.836 m > 10.832 m (velocity head)

Safe

6 The Parameters of Locos and Wagons for Designing Catch Siding

(From Institution of Permanent Way Engineers (India), Technical Diary 2017-18.)

And also, The Table 6. Shows the axle loads and length for various type of wagons being operated in Indian Railways. Based on this data, it is possible to arrive the actual profile of catch siding to bring down the parted trains under rest.

Table 6. shows the axle loads and length for various type of wagons

Coaches / Wagons Parameters			
1	O OPEN	16.3	7.214
2	BOXC/OPEN/COAL	20.32	13.729
3	BOXN/BOXNHS	20.32	10.713
4	BOXNHA	22.1	10.713
5	BOXNHL	22.9	10.963
6	BOY25	25	10.713
7	BVZ1	5.875	14.469
8	BOY/IR BOY/IRON ORE	22.9	11.929
9	CR COVERED	16.3	8.432
10	CRT COVERED	20.32	8.822
11	CMR/CATTLE/MILITARY	16.3	8.432
12	BCNHL	22.9	10.963
13	BCNA/BCNAHS	20.32	14.450
14	BOBY/BOBYN	20.32	12.00
15	BOBX/HOPPER	22.9	11.938
16	BOBSN25	25.0	10.713
17	TO/OIL TANK	16.3	8.280
18	TPR/PETROL TANK	16.3	8.280
19	BTALN/AMMONIA	20.32	17.529
20	BTPGLN	20.32	18.929
21	BVGT/BRAKE VAN GOODS	16.3	7.226
22	BLCA	20.32	14.556
23	BOST	20.32	13.729
24	BFNS	20.32	14.645
25	BRN25	25	14.645
26	Cement/ Fly ash	22.13	10.713

The Table 7. Shows the axle loads and length for various type of locomotives being operated in Indian Railways.

Table 7. Axle loads and length for various type of locomotives

Sl. No	Locomotives	Axle loads, t	Length, m
1	WAG9	20.50	20.562
2	WDM7	16.0	16.238
3	WDP3A	19.5	19.122
4	WDS4	20.0	11.030
5	WDS5	21.0	16.522
6	WDG3A	20.5	19.150
7	WDP4B	20.2	21.264
8	WDG5	22.3	22.262
9	WDG4D	21.7	23.000
10	WAG5/A/B/C	19.8	19.974
11	WAG5H	21.0	19.974
12	WAG6A	20.5	20.600
13	WAG9H	22.0	20.562
14	WAM4	18.8	19.974
15	WAP5	19.50	20.562
16	WCAG1	21.30	20.980
17	WCAM3	20.20	20.980
18	WCG2	22.00	19.974
19	WCM6	20.0	20.394
20	ICF Non AC(BG)	16.25	22.297
21	BEML Non-AC (BG)	13.0	22.297
22	EMU/ICF AC/DC/MC	20.32	20.726
23	HHPDEMU(DPC)	20.32	21.417
24	OHE CAR WHEELER (BEML)	16.25	20.726

Variations in kinetic and static heads for different parameters

The Fig.9 shows the relationship between the length of catch siding (ly) and length of sanded track (ls) based on the velocity resistance (VR) and velocity head (VH) for a particular profile of catch siding. It is possible to assess the length sanded track for different exit velocity of parted train.

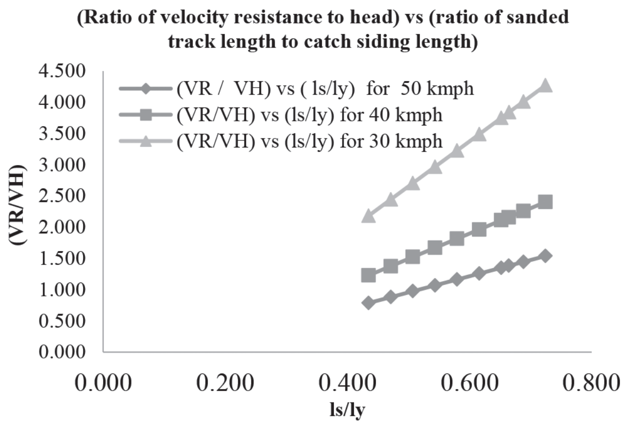


Fig. 9 Variations of kinetic and static heads for different parameters

Comparison of parabolic and non-parabolic catch siding is narrated in Table 8.

Table 8. Comparison of parabolic and non-parabolic catch siding

Sl. no	Description of items	Parabolic catch siding	Non Parabolic catch siding
1	Total length in m	750	750
2	Length up to vortex	60	60
3	Length beyond vortex, m	690	690
4	Gradients variation	uniform	Non uniform
5	Length of sanded track, m	362	501
6	Initial velocity, kmph	50	50
7	Track resistance @ 1.5 %,tm	34483	34483
8	Head of Sanded resistance, m	0.847	4.365
9	Head of gravity resistance, m	3.867	0.89
10	Head of track resistance, m	6.122	6.122
11	Total resistance of catch siding profile, m	10.836	11.37
12	Total velocity head to be resisted	10.832	11.33
13	Height of top point of catch siding above vortex, m	1.85	1.85
14	Gradient at top point of catch siding above vortex, m	1 in 186	1 in 330

7 Conclusions

1. It is suitable and feasible to establish catch sidings near the railway stations which situate between the tracks laid on steep gradients in the hilly terrains.
2. The analytical illustrations described above are essential for designer to arrive new catch siding profile and to confirm the adequacy of catch siding for different composition of train engines and wagons.
3. Under the circumstances that the parted train is not under the control of loco pilots/ train crews, facilitation of catch siding shall protect the passengers and train components and track assets of railways.
4. Catching of the parted trains negotiating steep down gradients and directing towards catch siding shall prevent fouling up the existing running lines.
5. The shunting or stabling operations shall not be performed through catch siding. The catch siding must be interlocked with block instruments.
6. The parabolic profiled catch siding offers more gradient resistance than that of non-parabolic profiled catch siding for the same train formation and length of catch siding.
7. The non-parabolic profiled catch siding warrants to have longer sanded track than that required for parabolic profiled catch siding for the same train formation and length of catch siding.
8. The profile gradient for the parabolic catch siding is more steeper than that for non-parabolic profiled catch siding for negotiating same height behind the vortex for the same train formation and same length of catch siding.

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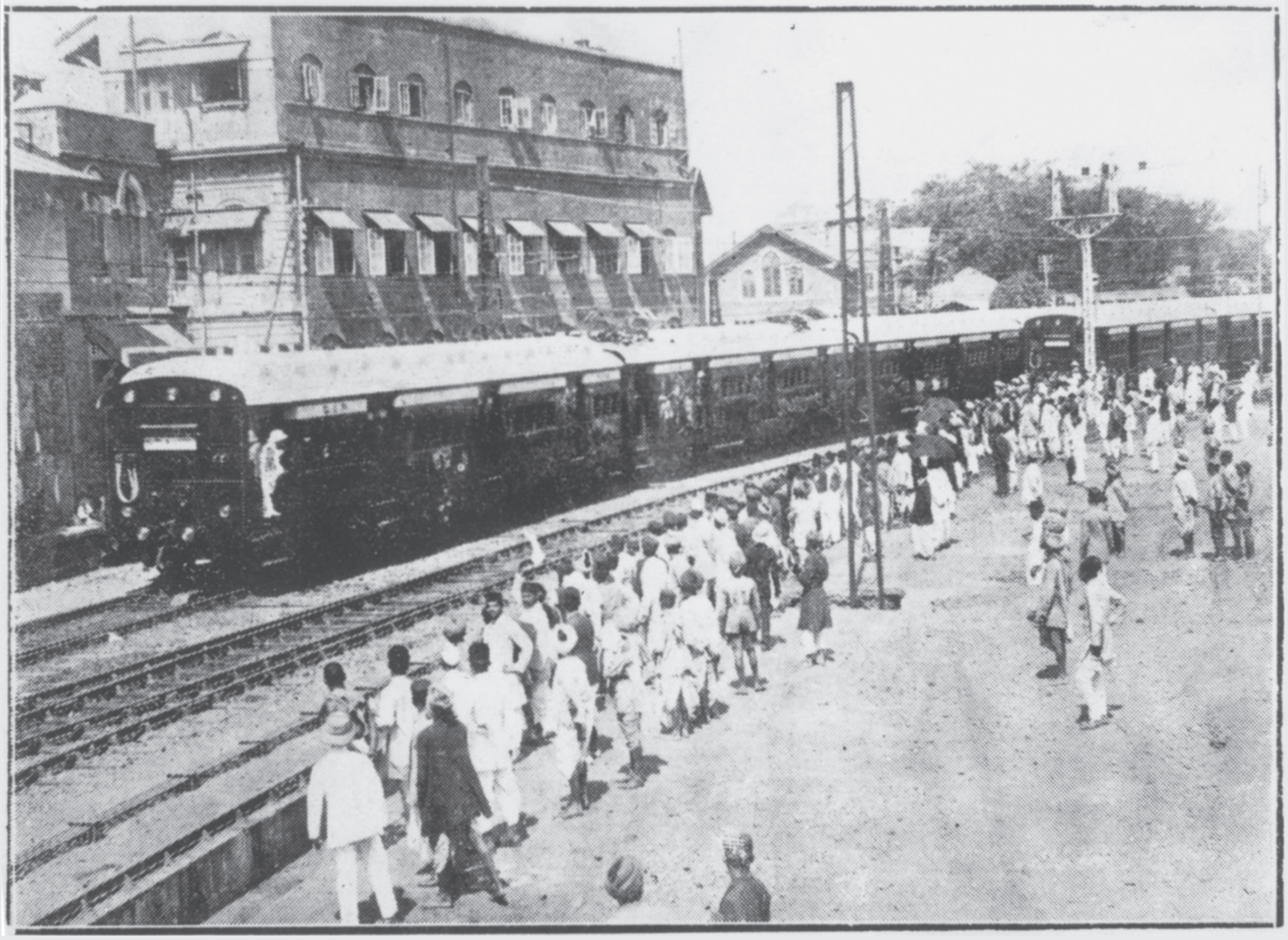
THE HARBOUR BRANCH ELECTRIFICATION



Some of the crown watching the first Electric Train carrying H.E. the Governer of Bombay and party, leaving Victoria Terminus Station.

Utilizing the EXCEL Graphs for Building Real Scale Drawings

By
Ananthakrishna Prabhu H*

SYNOPSIS
Microsoft Excel of Higher versions are aided with powerful graphical tools than the earlier Versions. Cross Sections of structures can be built to scale using some techniques as mentioned in this paper. This Paper aims at delivering knowledge regarding development of real scale graphical image which can be altered at later stage just by changing the input parameter

1 Introduction

Excel 2-d Scatter Graphs are exclusively used in several day to day works, Research, presentation etc. There are lot of unexplored capabilities of these graphs. For Civil Engineering Designers these graphs can be made very much beneficial once they are capable of utilizing one of its unearthed potential in terms of its graphical capability. These graphs can be used to built cross section views based on Variable Input parameters. Once the Civil Engineer Designers are well versed in using these graphical tools, fool proofing of design calculation can be achieved, by developing interlinked coordinates of corner points in a structure.

2 Literature Review

This method is developed by the author by unearthing the Potential of Excel Graph during his day to day work of Structural design. Hence there is no background Literature is referred. However Some textbooks pertaining to EXCEL programming are referred in order to obtain further improved presentation of outputs.

3 Methodology

This method includes creation of a Input Interface for developing interconnected coordinate geometry for developing a basic model. The same Input table is beneficial for future alteration of Drawing by changing the Input parameters. Once the two dimensional Coordinates are derived based on the Input parameters, EXCEL 2-D line graphs are utilized to develop real scale drawing. A two dimensional image is formed by interconnected lines by placing corner coordinates in correct desirable sequence.

3.1 Creating INPUT Table :

Input table is created to serve as an alteration interface for varying the dimension parameters at later stage for obtaining a stable configuration of the structure. An example Tabular format is presented to understand the concept.

Refer Table 1.

Table 1. Illustrative Input interface

S.N.	Input	Value	Unit
1	Footing Depth	1	m
2	Wall Thickness	0.6	m
3	Wall Height	5	m
4	Toe Projection	1	m
5	Heel Projection	3	m

3.2 Creating Corner Coordinates of the Structure :

Corner coordinates of the Structure are created by using the simple arithmetic formulation. Users must develop some 2-Dimensional Graphical imagination to develop such table. Once the User is conversant with this step, they can very easily develop corner coordinates. A sample method of developing such input is illustrated in table 2. Entire graph is built by keeping reference as Toe. i.e. Toe is kept as (0,0).

3.3 Drawing Excel 2 D Graph :

Using the Corner Coordinate Points create a 2-D scatter graph aided with straight line and markers. On the empty graph add data and and add new series. An output similar to that shown in Fig. 1 can be obtained.

Table 2. Corner Points (CP)

CP. No.	Location	Coordinate of the CP		Reference
		X	Y	
1	Toe of the Footing at FDNL	0	0	This point is taken as Origin

** JE/Design/P&D/CN/BNC*

2	Toe of the Footing at FTL	0	1	Y- Increase = Footing Depth = 1
3	Wall Base on Toe Side	1	1	X- Increase = Toe Projection = 1
4	Wall Top on Toe Side	1	6	Y- Increase = Wall Height = 5
5	Wall Top on Heel Side	1.6	6	X- Increase = Wall Thickness = 0.6
6	Wall Base on Heel Side	1.6	1	Y -Decrease = Wall Height = 5
7	Heel of the Footing at FTL	4.6	1	X Increase = Heel Projection = 3
8	Heel of the Footing at FDNL	4.6	0	Y Decrease = Wall Thickness = 0.6
1	Toe of the Footing at FDNL	0	0	Origin Point to Close the Loop

Work Flow: Main Menu > Insert > X Y Scatter > Scatter with Straight Line and Markers> Select Data> add Series> Add X & Y Series for Coordinate points.

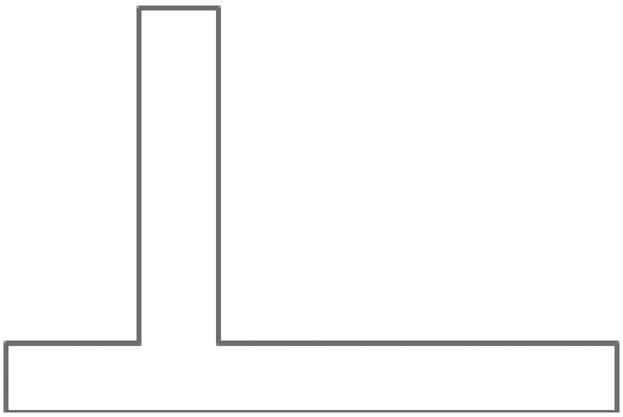


Fig. 1 Cross section of the wall

3.4 Creating Vertical Dimension Lines :

Vertical Dimension Lines can be formed by creating a Data table similar to table 3. In this step to maintain the gap between Vertical dimension line and Extreme left corner point of the drawing horizontal display gap is maintained. On the same graph created in previous step add new data and see the dimension Lines. Style this lines by adding arrows and changing the line type.

Work Flow : Right Click on the Graph > Add data > add new series > Add X & Y series

After Display of Lines on the graph

Select the dimension line on the graph and > Right click > format data series > style using the options available there.

Table 3. Vertical Dimension Lines

Vertical Dimension	Vertical Dimension Lines		Horizontal Display Gap From Toe (DG)	Calculation Reference for Vertical Dimension Lines	
	X	Y		X	Y
Depth of the Footing	-0.5	0	0.5	"X of CP-1" - "DG" = 0 - 0.5 = -0.5	Y of CP-1
	-0.5	1	0.5	"X of CP-1" - "DG" = 0 - 0.5 = -0.5	Y of CP-2
Empty row				This Row Must be Kept Blank	
Height of the Wall	-0.5	1	0.5	"X of CP-1" - "DG" = 0 - 0.5 = -0.5	Y of CP-3
	-0.5	6	0.5	"X of CP-1" - "DG" = 0 - 0.5 = -0.5	Y of CP-4

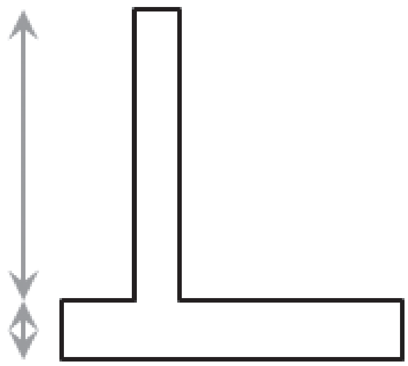


Fig. 2 Cross section of the wall after adding Verticle Dimension Lines

3.5 Creating Vertical Dimension Value Labels :

In this step the vertical Dimension value labels are placed at centre of the Vertical dimension lines. for this refer the calculations mentioned in Table No. 4.

Table 4. Vertical Dimension Value Labels				
Coord. of Vertical Dimension Value Display Points		Vertical Dimension Display value	Calculation Reference for Vertical Dimension Lines	
X	Y		X	Y
-0.5	0.5	1	"X of CP. 1" - " DG" = 0 - 0.5 = -0.5	Midpoint ordinate of CP 1 & CP 2
			This Row Must be kept Blank	
-0.5	3.5	5	"X of CP 1" - "DG" = 0 - 0.5 = -0.5	Midpoint ordinate of CP 3 & CP 4

Add this New data series into the Graph. Vertical Dimension Points are displayed on the Graph after this. Right click on them, add Data Labels. Then right click on the data labels and Select Format data Label option. Select the Option "Add Value from Cells" and Select the Range as Vertical Dimension Display values mentioned in the Table. Un check all other options in this window.

Work flow : *Right Click on the Graph > Add data > Add New Series*

After this Right click on the graph

Add data labels

Right Click on the Displayed data label values.

Format data label > Add value from cell> select Display value labels from table 4 (column 3).

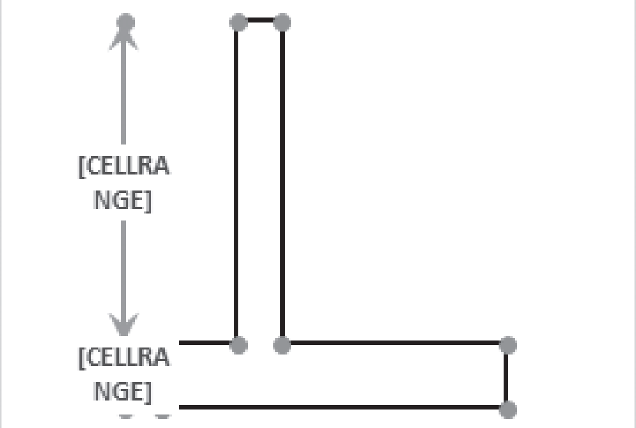


Fig. 3 Cross section of the wall after adding Verticle Dimension Value labels

3.6 Creating Horizontal Dimension Lines :

Horizontal Dimension Lines are Created by using coordinates mentioned in table no. 5. All other steps are similar to Step 3.4.

Refer Table 5 and Fig. 4.

Table 5. Creating Horizontal Dim. Lines					
Horizontal Dimension	**Coordinates of Dim. Lines**		**Vertical Display Gap From Base (DG)**	**Calculation Reference**	
	X	**Y**		**X**	**Y**
Width of Toe	0	-0.5	0.5	X of CP-2	"Y of FDNL" - "DG" = 0 - 0.5 = -0.5
	1	-0.5	0.5	X of CP-3	"Y of FDNL" - "DG" = 0 - 0.5 = -0.5
				This Row Must be Kept Blank	
Thickness of the Wall	1	-0.5	0.5	X of CP-4	"Y of FDNL" - "DG" = 0 - 0.5 = -0.5
	1.6	-0.5	0.5	X of CP-5	"Y of FDNL" - "DG" = 0 - 0.5 = -0.5
				This Row Must be Kept Blank	
Width of Heel	1.6	-0.5	0.5	X of CP-6	"Y of FDNL" - "DG" = 0 - 0.5 = -0.5
	4.6	-0.5	0.5	X of CP-7	"Y of FDNL" - "DG" = 0 - 0.5 = -0.5

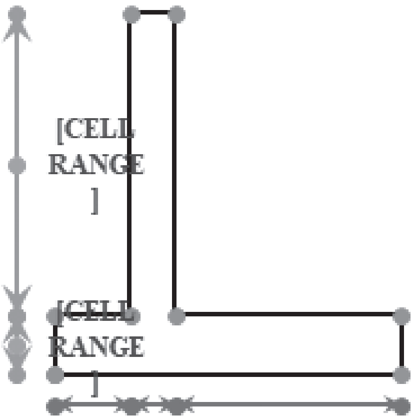


Fig. 4 Cross section of the wall after adding Horizontal Dimensions

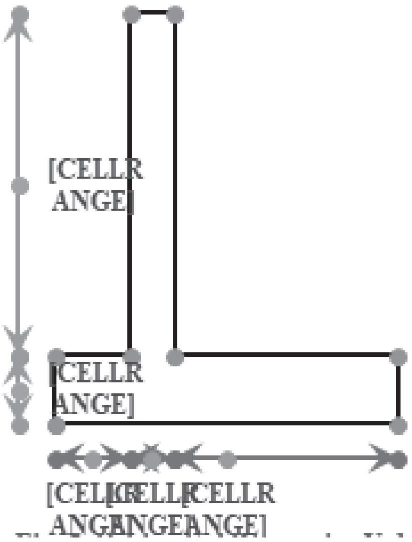


Fig. 5 Horizontal Dimension Value Labels

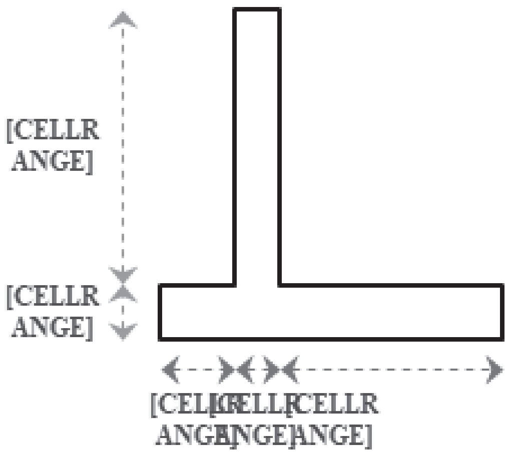


Fig. 6 Cross section of the wall

3.7 Creating Horizontal Dimension Value Labels :

Horizontal Dimension Value Lines are Created by using coordinates mentioned in table no. 6. All other steps are similar to Step 3.5. Refer Table 6 and Fig.5.

Table 6. Horizontal Dimension Value Labels

Coordinates of Horizontal Dimension Value Display Points		Horizontal Dimension Display value	Calculation Reference for Vertical Dimension Lines	
X	Y		X	Y
0.5	-0.5	1	Midpoint Coordinate of Line joining CP-2 & CP-3	"Ordinate of FDNL" - "DG" = 0 - 0.5 = -0.5
			This Row Must be Kept Blank	
1.3	-0.5	0.6	Midpoint Coordinate of Line joining CP 4 & 5	"Ordinate of FDNL" - "DG" = 0 - 0.5 = -0.5
			This Row Must be Kept Blank	
2.3	-0.5	0.3	Midpoint Coordinate of Line joining CP 2 & 3	"Ordinate of FDNL" - "DG" = 0 - 0.5 = -0.5

3.8 Removing the Marker Points from graphical Display :

Left click on the Graph and select Scatter with straight lines. Now the Modified graph can be see in which only lines are displayed.

3.9 Modification of the Input Values for New Outputs :

Once the task of creating real scale drawing is finished, the user can have choice to vary the input and get new drawing with Modified values. Change the Input values and see the New drawing. Several Required Outputs can be made available in this way. Refer table No. 7 and Fig.7.

Table 7. Modification of Input

Sl. No.	Input	Value	Unit
1	Footing Depth	0.5	m
2	Wall Thickness	0.3	m
3	Wall Height	4	m
4	Toe Projection	1	m
5	Heel Projection	4	m

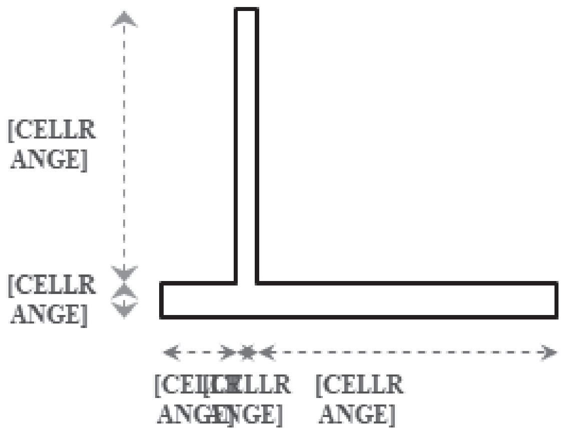


Fig. 7 Modified Cross Section of the Wall

4 Outcomes

1 Excel Programming can be used to build real scale 2-D models by utilizing its Graphical potential.

2 By linking the Input with the Real Scale images can be built which are useful to ensure the proper input data for design.

3 Designers can develop Excel programmes to get Automated Drafting outputs.

5 Conclusions

1 The potential of Excel programming can be enormously utilized for developing automated real scale drafting.

See Exampl Fig. 1

2 Structural Drawings and design calculations be done simultaneously. Thus, this technique will reduce the need for using other Computer aided Drafting tools for developing structural drawings.

3 It is very easy to modify the drawing without affecting the other part of the drawing, as a benefit of interlinked coordinate geometry.

6 Future Scope

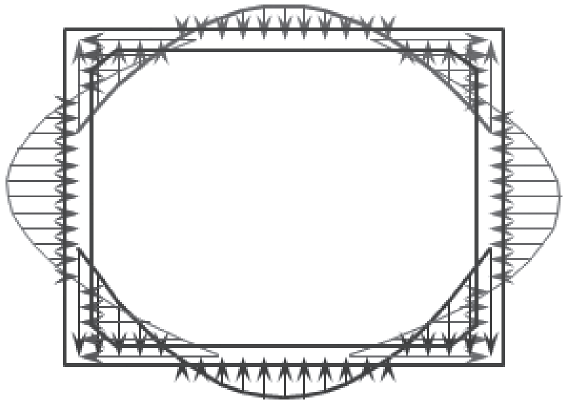
1 This method can be used for developing Isometric views also. See Example Fig. 2

2 This paper presents a basic technique to develop a simple two dimensional drawing. But this method can also be used for developing Isometric views.

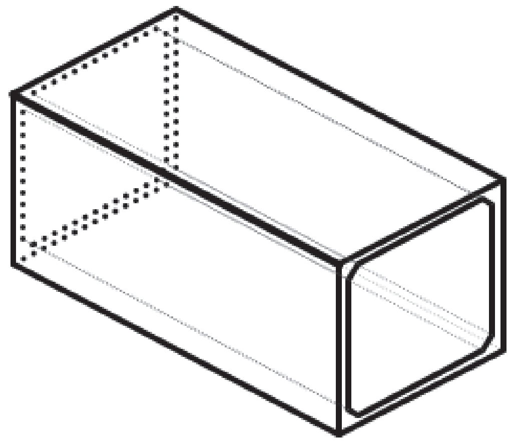
3 Additional logical operations can be utilized to develop different perspective views of the structure.

4 Some 3-D Images already developed using this techniques are presented.

Example Fig. 1 BMD of RCC Box



Example Fig. 2 Isometric View of a Box

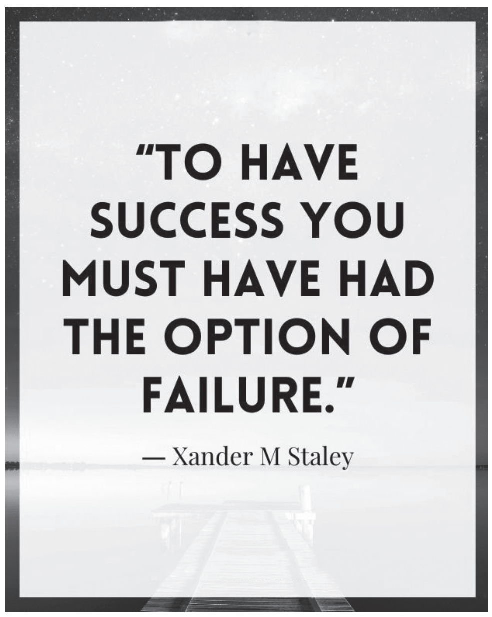


7 References

1 Microsoft EXCEL 2019 Application.

2 Excel Functions and Formulas by Theodor Richardson.

3 Beginning EXCEL 2019, Open book Library. Available online at https://open.umn.edu/opentextbooks/



Updates Of Codes & Manuals

S.NO.	ACS NO.	DT OF ISSUE	REMARKS
TRACK			
1. Indian Railways P-Way Manual			**New w.e.f. June 2020**
01.	01	July 2021	Para No 915 replaced
02.	02	Aug. 2021	Para 636(2)(e), 702(1)(d), 702(2), 717(1)(b), 718 replaced. Para 702(1)(2) renamed as Para 702(1)(b)
03.	03	21.10.2021	Heading of Para 228 replaced New para 228(4) added
04.	04	03.11.2021	Para 408(2)(e) replaced
05.	05	11.02.2022	Table 1A of para 103 replaced
06.	06	16.03.2022	Para 201 replaced
07.	07	03.04.2022	Para 1202 replaced
08.	08	20.06.2022	Para 409 (1), 405 (3) and 425.
BRIDGE			
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
S.NO.	**ACS NO.**	**DT OF ISSUE**	**REMARKS**
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.
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.
37.	37	09.10.2019	Para 1102.2(iv) replaced, Insert 11/2a proforma, Para 1107(15)(b)(i) & 1107(15)(b)(ii) modified
38.	38	14.01.2020	Para 317 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
06.	06	04.11.2019	Modified paras 1.2, 1.5 I (f), 5.12.1, 5.12.2 (a), (b), (c), 5.12.3, 5.12.5, 5.12.6, 5.12.7, 5.12.8, 5.16.2.7 (b).
07.	07	11.11.2019	Para 5.10
08.	08	11.11.2019	Para 3.1 of Appendix V (Clause 6.9.3) modified
09.	09	06.07.2020	Para No. 1.5 (I) - (c) & (g) modified
10.	10	30.08.2021	Para 6.9.2 replaced
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, existing para 7.1.5 modified

08.	08	23.05.2019	Replace the clause 7.2.6.4.2.4.1, Replace clause 7.2.6.4.2.4.2 and 12.3.2, Replace clause 15.4.2.2.1, Appendix B (Table B1), Appendix B (Table B2), Appendix B (Clause B-7.1), Appendix B1 (Fig B1-2),
S.NO.	**ACS NO.**	**DT OF ISSUE**	**REMARKS**
09.	09	08.07.2021	Para 5.4.7.1 replaced
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
03.	09	19.11.2019	Replace paras 2.1.2, 5.3.2, 5.3.4, 5.3.5, 5.3.5.1, 12.1.1, 12.1.2, 12.2, 12.3
6. Indian Railways Welded Bridge Code			
01.	01	16.02.2015	Para 27.1 replaced
02.	02	11.07.2018	Para 27.1 replaced
WORKS			
1. 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
06.	56	05.03.2019	Para No 1264 should be amended
07.	57	08.01.2020	Para No 1829 should be amended
08.	58	27.04.2022	Para No 1264 should be amended

Crowd waiting at Kurla Station to witness the arrival of the First Electric Train in India.

Statement of Courses IRICEN CoC-2022

COURSE NO	COURSE NAME	FROM	TO	DURATION	ELIGIBILITY
JULY					
22237	Webinar: Fundamentals of USFD, A- Scan, B- Scan & ensuring reliability of USFD Testing.	15.07.22	15.07.22	1 Day	All officers
22238	Webinar: Planning, construction & maintenance of RCC box bridges.	15.07.22	15.07.22	1 Day	All officers
22507	Special course for SAIL Engineers	18.07.22	23.07.22	1 Week	SAIL Engineers
22413	Tunneling	18.07.22	29.07.22	2 Weeks	All officers
22231	Webinar: Repair & maintenance of arch bridges including strengthening for higher loads.	19.07.22	19.07.22	1 Day	All officers
22239	Webinar: Construction & maintenance of FOBs including quality aspects and preparation of tender schedule.	22.07.22	22.07.22	1 Day	All officers & supervisors
22454	MIDAS	25.07.22	29.07.22	1 Week	Officers and Design Assistants
22505	Special course for NTPC Engineers	25.07.22	30.07.22	1 Week	NTPC Engineers
22304	CE/TP seminar	28.07.22	29.07.22	2 Days	All CE/TP of Railways
22240	Webinar: Inspection & maintenance of concrete bridges.	29.07.22	29.07.22	1 Day	All officers
August					
22502	Special Course for Assistant Project Engineers of RLDA	01.08.22	20.08.22	3 Weeks	Assistant Project Engineers of RLDA
22431	Advance track maintenance	01.08.22	12.08.22	2 Weeks	JS, SS, JAG
22421	Bridge Design	01.08.22	18.08.22	3 Weeks	Officers and Design Assistants
22241	Webinar: Surveying for design mode tamping & use of ALC.	05.08.22	05.08.22	1 Day	All officers
22005	IRSE 2019 (P)(EoL Batch)-Review.	08.08.22	12.08.22	1 Week	IRSE 2019 (P)(EoL Batch)
22242	Webinar: Quality Assurance Plan (QAP) for fabrication of composite girders and preparation of tender schedule.	12.08.22	12.08.22	1 Day	All officers & supervisors
22416	Course for Construction Engineers	16.08.22	26.08.22	2 Weeks	All officers
22243	Webinar: Inspection & maintenance of steel bridges.	18.08.22	18.08.22	1 Day	All officers
22011	Course for MES Eng.	22.08.22	26.08.22	1 Week	MES Engineers
22455	STAADPRO	22.08.22	26.08.22	1 Week	officers & Design Assistants
22207	Sr.Prof.P.Way	29.08.22	23.09.22	4 Weeks	JAG, Selection Grade, SAG Officers
22417	RWI, derailment investigation, CRS, LC, Track safety and inspections, formation rehabiliation, TMS	29.08.22	09.09.22	2 Weeks	All officers
COURSE NO	COURSE NAME	FROM	TO	DURATION	ELIGIBILITY
22418	Bridge Planning and const including fabrication	29.08.22	09.09.22	2 Weeks	All officers
22244	Webinar: USFD of Rail, weld & SEJ.	30.08.22	30.08.22	1 Day	All officers
September					
22245	Webinar: Calculation of design discharge of bridges using GIS techniques.	02.09.22	02.09.22	1 Day	All officers
22246	Webinar: Case studies of bridge failures.	09.09.22	09.09.22	1 Day	All officers

22305	CBE seminar	12.09.22	13.09.22	2 Days	All CBE of Railways
22420	Modern surveying & Land acquisition	12.09.22	16.09.22	1 Week	All officers
22419	Rail grinding, Rail stress management, Rails- Handling, metallurgy, USFD & welding	12.09.22	23.09.22	2 Weeks	All officers
22247	Webinar: Elastomeric bearings-manufacturing, testing, acceptance & installation.	16.09.22	16.09.22	1 Day	All officers
22426	Geotechnical Engg. aspects in Railway formations	19.09.22	23.09.22	1 Week	All officers
22262	Webinar: Quality management in track works including tender schedule preparation	20.09.22	20.09.22	1 Day	All officers & supervisors
22248	Webinar: Rail structure Interaction (Case studies for ballasted track bridges using MIDAS)	23.09.22	23.09.22	1 Day	All officers
22422	Mechanised maintenance, Track renewal, Track Monitoring & Curve	26.09.22	07.10.22	2 Weeks	All officers
22423	Contract & Arbitration, IRWCMS	26.09.22	07.10.22	2 Weeks	All officers
22208	Sr.Prof.Bridge	26.09.22	21.10.22	4 Weeks	JAG, Selection Grade, SAG Officers
22249	Webinar: Retrofitting of bridges.	27.09.22	27.09.22	1 Day	All officers
October					
22250	Webinar: Ground improvements for construction of embankment on soft soils.	07.10.22	07.10.22	1 Day	All officers & supervisors
22453	MIDAS	10.10.22	14.10.22	1 Week	Officers, Design Assistants
22424	LWR, Curve, Turnout, Layout calculation, yard planning, SOD, ballast, formation rehabiliation	10.10.22	21.10.22	2 Weeks	All officers
22425	Fabrication and inspection of steel girders	10.10.22	21.10.22	2 Weeks	All officers
22265	Webinar: Construction of Railway embankments-Quality control aspects and preparation of tender schedule.	11.10.22	11.10.22	1 Day	All officers & supervisors
22251	Webinar: Layout corrections for yard improvement graphical methods for undefined track geometry.	14.10.22	14.10.22	1 Day	All officers
22252	Webinar: LWR on open deck bridges.	21.10.22	21.10.22	1 Day	All officers
November					
22007	IRSE 2019 (P)(EoL Batch)Phase-II	21.11.22	20.01.23	8 Weeks	IRSE 2019 (P)(EoL Batch)
22103	Integrated	07.11.22	27.01.23	12 Weeks	Gr. B officers
22306	IRICEN Day	10.11.22	11.11.22	2 Days	IRSE 96 batch
COURSE NO	**COURSE NAME**	**FROM**	**TO**	**DURATION**	**ELIGIBILITY**
22013	Appreciation Course G-2	14.11.22	18.11.22	1 Week	IRTS/IRPS/IRAS/IRPFS Probationers.
22253	Webinar: Role & responsibilities of Respondents in arbitration.	18.11.22	18.11.22	1 Day	All officers
22201	Sr.Prof.P.Way	21.11.22	16.12.22	4 Weeks	JAG, Selection Grade, SAG Officers
22504	Special course for Junior Managers of DFCCIL Phase I	21.11.22	13.01.23	8 Weeks	Junior Managers of DFCCIL

22263	Webinar: Quality management in bridge works including tender schedule preparation	22.11.22	22.11.22	1 Day	All officers & supervisors
22254	Webinar: Raising of speed on curves to 160/200 KMPH	25.11.22	25.11.22	1 Day	All officers
December					
22255	Webinar	02.12.22	02.12.22	1 Day	All officers
22256	Webinar	09.12.22	09.12.22	1 Day	All officers
22257	Webinar: Quality management in NL, GC & DL	16.12.22	16.12.22	1 Day	All officers & supervisors
22258	Webinar	23.12.22	23.12.22	1 Day	All officers
22427	Concrete technology and PSC construction	26.12.22	30.12.22	1 Week	All officers
22307	PCE seminar	22.12.22	23.12.22	2 Days	All PCE of Railways
22259	Webinar	30.12.22	30.12.22	1 Day	All officers

SSTW Calendar of Courses -2022

COURSE NO	COURSE NAME	FROM	TO	DURATION	ELIGIBILITY
JULY					
22825	Special course for JRE/ JE(Design)/RDSO.	04.07.22	23.09.22	12 Weeks	JRE/JE(Design)/RDSO
22808	Fabrication and inspection of steel girders for FIUs	11.07.22	29.07.22	3 Weeks	JE/SSE (Bridge & Works)
August					
22902	Special course for executive of DFCCIL Gr. II Phase I	01.08.22	21.10.22	12 Weeks	Executive of DFCCIL
22616	Refresher Course (P.Way)	08.08.22	26.08.22	3 Weeks	JE/SSE (P.Way)
22618	Refresher Course (Works)	29.08.22	09.09.22	2 Weeks	JE/SSE (Works)
September					
22612	Refresher Course (P.Way)	12.09.22	30.09.22	3 Weeks	JE/SSE (P.Way)
22826	AutoCAD	26.09.22	30.09.22	1 Week	JE/SSE (Drawing)
October					
22613	Refresher Course (Bridges)	03.10.22	21.10.22	3 Weeks	JE/SSE (BRI)
22620	Refresher Course (P.Way)	03.10.22	21.10.22	3 Weeks	JE/SSE (P.Way)
November					
22615	Refresher Course (USFD)	07.11.22	11.11.22	1 Week	JE/SSE (USFD)
22810	Survey and Land Management	07.11.22	18.11.22	2 Weeks	JE/SSE (Works)
22903	Special course for executive of DFCCIL Gr. I Phase II	07.11.22	03.02.23	13 Weeks	Executive of DFCCIL
22617	Refresher Course (P.Way)	14.11.22	02.12.22	3 Weeks	JE/SSE (P.Way)
22815	Special course for JE/SSE-Drawing.	21.11.22	25.11.22	1 Week	JE/SSE (Drawing)
22816	AutoCAD	28.11.22	02.12.22	1 Week	JE/SSE (Drawing)
December					
22619	Refresher Course (USFD)	05.12.22	09.12.22	1 Week	JE/SSE (USFD)
22623	Refresher Course (Works)	05.12.22	16.12.22	2 Weeks	JE/SSE (Works)
22622	Refresher Course (P.Way)	12.12.22	30.12.22	3 Weeks	JE/SSE (P.Way)
22621	Refresher Course (Bridges)	19.12.22	06.01.23	3 Weeks	JE/SSE (BRI)

Glimpses of IRICEN DAY

Group photo of IRSE Silver Jubilee (1995 Batch) Officers with member Infrastructure

Group photo of IRSE Silver Jubilee (1994 Batch) Officers with member Infrastructure

Calendar Of Courses IRICEN 2022(Revision-6 Date:-29.06.2022)

Month & Year	JUNE 2022				JULY 2022				AUG.2022				
Hostel Capacity	82	117	100	100	78	94	65	100	75	86	75	110	65
Date (Monday)	6	13	20	27	4	11	18	25	1	8	15	22	29
Institute holidays										9	15 & 19		31
IRSE 2018/2019(EoL Batch)										22005 IRSE 2019 (P)(EoL Batch)-			
Trainees										11			
IRSE 2018/2019													
Trainees													
Appreciation Course					22012 G-1	22014 Contract management						22011 MES Eng.	
Trainees					53	19						35	
Integrated courses													
Trainees	25	25	25	25	25	25	25						
Sr.Prof. courses													22207 Sr.Prof.P.Way
Trainees	15												15
Track courses			22410 Mechanised maintenance, Track renewal, Track Monitoring & Curve			22430 RWI & derailment investigation			22431 Advance track maintenance				22417 RWI, derailment investigation, CRS, LC, Track safety and inspections, formation
Trainees			25	25		25			25	25	25	25	25
Bridge Courses		22429 Concrete technology & durability of	22406 Bridge Planning and const including fabrication						22421 Bridge Design				22418 Bridge Planning and const including fabrication
Trainees		25	25	25					25	25	25		25
Work courses			22411 Building(Including Station)-	22412 Geotechnical Engg. aspects in		22428 Modern surveying & Land	22413 Tunneling				22416 Course for Construction Engineers		
Trainees			25	25		25	25	25	25	25	25	25	
Online Course(AN)													
Software courses								22454 MIDAS				22455 STAADPRO	
Trainees								25				25	
Courses for PSU													
Trainees													
Courses for PSU							22507 Special course for	22505 Special	22502special course for RLDA				
Trainees	17	17					15	25					
Webinars	22233 Webinar	22234 Webinar	22235 & 22261 Webinar	22232 Webinar	22229 Webinar	22237,22238 Webinar	22239 Webinar	22240 Webinar	22241 Webinar	22242 Webinar	22243 Webinar	22244 Webinar	22245 Webinar
HAG/SAG Seminars		22303 CE/TMC						22304 CE/TP					
Trainees		25						25					
Misc.													
Spare Capacity available	18	-17	0	0	22	6	35	0	25	14	25	-10	35

Month & Year	SEPT.2022				OCT.2022				
Hostel Capacity	65	90	65	65	65	90	65	0	0
Date (Monday)	5	12	19	26	3	10	17	24	31
Institute holidays				2	5				
IRSE 2018/2019(EoL Batch)									
Trainees									
IRSE 2018/2019									
Trainees									
Appreciation Course									
Trainees									
Integrated courses									
Trainees									
Sr.Prof. courses				22208 Sr.Prof.Bridge					
Trainees	15	15	15	15	15	15	15		
Track courses		22419 Rail grinding,Rail stress management, Rails-Handling, metallurgy, USFD & welding		22422 Mechanised maintenance, Track renewal, Track Monitoring & Curve		22424 LWR, Curve, Turnout, Layout calculation, yard planning, SOD, ballast, formation			
Trainees	25	25	25	25	25	25	25		
Bridge Courses						22425 Fabrication and inspection of steel girders		Diwali Holiday, No teaching activity	
Trainees	25					25	25		
Work courses		22420 Modern surveying & Land	22426 Geotechnical Engg. aspects in	22423 Contract & Arbitration, IRWCMS					
Trainees		25	25	25	25				
Online Course(AN)									
Software courses						22453 MIDAS			
Trainees						25			
Courses for PSU									
Trainees									
Courses for PSU									
Trainees									
Webinars	22246 Webinar	22247 Webinar	22248 & 22262 Webinar	22249 Webinar	22250 Webinar	22251 & 22265 Webinar	22252 Webinar		
HAG/SAG Seminars		22305 CBE							
Trainees		25							
Misc.									
Spare Capacity available	35	10	35	35	35	10	35		

Month & Year	Nov.2022				Dec.2022				Jan.2023				
Hostel Capacity	86	98	51	51	51	71	56	86	25	25	25	25	0
Date (Monday)	7	14	21	28	5	12	19	26	2	9	16	23	30
Institute holidays	8												
IRSE 2018/2019(EoL Batch)				22008 IRSE 2019 (P)(EoL Batch)Phase-II									
Trainees	11	11	11	11	11	11	11	11					
IRSE 2018/2019													
Trainees													
Appreciation Course		22013 G-2											
Trainees		62											
Integrated courses	22103 Integrated												
Trainees	25	25	25	25	25	25	25	25	25	25	25	25	
Sr.Prof. courses			22201 Sr.Prof.P.Way										
Trainees			15	15	15	15							
Track courses													
Trainees													
Bridge Courses								22427 Concrete technology and PSC					
Trainees								25					
Work courses													
Trainees													
Online Course(AN)													
Software courses													
Trainees													
Courses for PSU			22504 Special course for Junior Managers of DFCCIL Phase I										
Trainees			40	40	40	40	40	40	40	40			
Courses for PSU													
Trainees						20	20						
Webinars		22253 Webinar	22254 & 22263 Webinar	22255 Webinar	22256 Webinar	22257 Webinar	22258 Webinar	22259 Webinar					
HAG/SAG Seminars	22306 IRICEN Day						22307 PCE						
Trainees	50							25					
Misc.													
Spare Capacity available	14	2	49	49	49	29	44	14	75	75	75	75	100

Calendar Of Courses SSTW 2022(Revision-5 Date:-03.06.2022)

Month & Year				June 2022				July 2022				AUG.2022					SEPT.2022				OCT.2022					NOV.2022				DEC.2022				JAN.2023				
Hostel Capacity	89	89	89	89	89	89	54	89	89	89	89	92	88	88	88	88	88	88	88	78	78	78	78	0	0	79	79	79	79	79	79	79	79	54	29	29	29	29
Date (Monday)	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30
Institute Holidays	16												9	15 & 19		31				2	5					8												
Track courses		22611 Refresher				22614 Refresher Course (P.Way)							22616 Refresher Course (P.Way)					22612 Refresher Course (P.Way)			22620 Refresher Course (P.Way)					22615 Refresher	22617 Refresher Course (P.Way)			22619 Refresher	22622 Refresher Course (P.Way)							
Trainees	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			22801 Fabrication and inspection of steel						22808 Fabrication and inspection of steel												22613 Refresher Course (Bridges)			Diwali Holiday, No teaching activity								22621 Refresher Course (Bridges)						
Trainees			25	25	25				25	25	25										25	25	25									25	25	25				
Work courses																22618 Refresher				22826 AutoC						22810 Survey and Land		22815 Specia	22816 AutoC	22623 Refresher								
Trainees																25	25			25						25	25	25	25	25	25							
Courses for PSU	22901 Special course for executive of DFCCIL Gr. I Phase I											22902 Special course for executive of DFCCIL Gr. II Phase I														22903 Special course for executive of DFCCIL Gr. I Phase II												
Trainees	29	29	29	29	29	29	29	29	29	29	29	57	28	28	28	28	28	28	28	28	28	28	28			29	29	29	29	29	29	29	29	29	29	29	29	29
Misc.								22825 Special course for JRE/JE(Design)/RDSO.																														
Trainees	35	35	35	35	35	35		35	35	35	35	35	35	35	35	35	35	35	35																			
Spare Capacity available	-34	-34	-34	-34	-34	-34	1	-34	-34	-34	-34	-37	-33	-33	-33	-33	-33	-33	-33	-23	-23	-23	-23			-24	-24	-24	-24	-24	-24	-24	-24	1	26	26	26	26