ज्ञान ज्योति से मार्गदर्शन

IRICEN Journal *of* Civil Engineering

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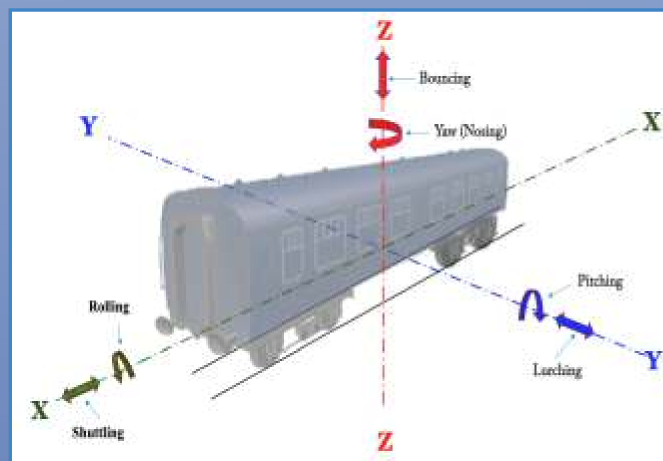

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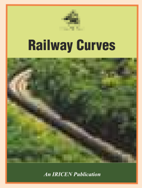

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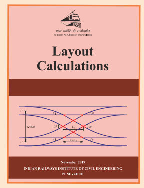

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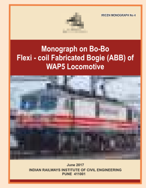

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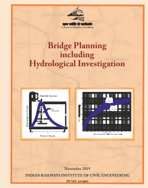

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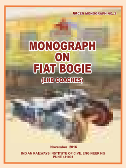

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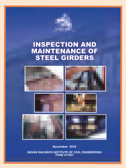

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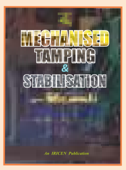

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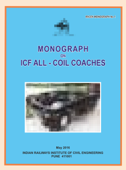

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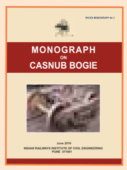

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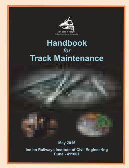

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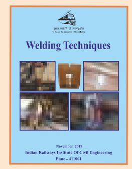

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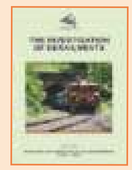

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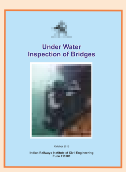

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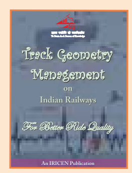

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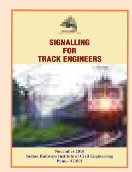

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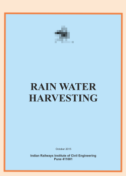

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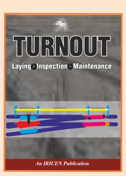

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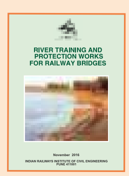

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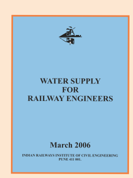

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From Director General's Desk

Dear Readers,

In this edition of IRICEN Journal, papers have been included on diverse topics. First technical paper is on Track geometry deterioration model which sets a direction for optimal use of assets. Another paper deals with increasing speed of passenger trains to 130/160 KMPH on existing track. This paper gives an insight of dealing with curves while raising the speed in existing track including highlights of software application dealing with subject developed in-house by IRICEN.

Third paper is Redesigning cover over platforms for new design adopted at Habibganj station during redevelopment of the railway station.

Another paper tells about value mapping the processes in modernization of Bridge Workshop, Lucknow. Fifth paper is Re-girdering of 45m open web through girder by road crane. The last paper defines easy calculation for extra clearance on curves.

I am sure that the readers of this Journal would find value addition through various papers /articles included in this journal. I request all the readers to send suggestions and their article/paper etc. for inclusion in future editions of this journal.

Pune
June, 2021

Santosh Kumar Agrawal
Director General

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Suggestions may be sent to mail@iricen.gov.in

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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.

Literature Digest

Effect of track irregularities of high-speed railways on the thermal characteristics of the traction motor bearing

The operating temperature plays a key role in the service reliability of ball bearings used in the traction motor of high-speed trains. Studies on the heat generation and temperature distributions of the bearing under the vehicle vibration environment are critical for designing the high-speed train traction motor bearing and to monitor its operation. In this paper, an SKF friction torque model that considers the inlet shear heating reduction and kinematic replenishment / starvation reduction was used to calculate the power loss of the bearing operating in a high-speed train. A thermal analysis model of the bearing, which takes into account the vehicle vibration due to track irregularities, was developed to study the thermal characteristics of the bearing operating in a high-speed train. Experiments were conducted on a service high-speed train (i.e. CRH380B) to validate the proposed bearing thermal analysis model. The thermal characteristics of the bearing and the influence of key factors on the operating temperature of the bearing under vehicle vibration due to track irregularities were studied with the proposed bearing thermal analysis model. The results show that the thermal failure of the bearing subassemblies most likely occurs at the balls region owing to the highest temperature in that region, compared to the inner and outer raceway of the bearing. The method of applying grease with appropriate kinematic viscosity should be adopted to reduce the power loss of bearing while meeting the lubrication requirement. The vehicle vibration due to track irregularities significantly influences the thermal characteristics of high-speed train motor bearings, which cannot be ignored in the thermal analysis of bearings operating in a high-speed train.

By : Tingting Wang, Zhiwei Wang, Dongli Song,

Ref : Rail & Rapid Transit , January 2021

Vertical vibration modelling and vibration response analysis of Chinese high-speed train passengers at different locations of a high-speed train

To study the vibration of a passenger's head and internal organs at different locations of a high-speed train, a 9-degrees-of-freedom (DOF) model of seated passengers is proposed in this paper, and its parameters of the damping coefficients and stiffnesses are identified. Next, the response of the head and internal organs is simulated by applying the vibrational stimulation generated by a 27-DOF vehicle model under track irregularity. Moreover, by applying the measured vibration signal, the following conclusions can be drawn: (1) The weakest response is detected at the centre of the compartment of the wagon, and a stronger response is detected at the centre of the bogie, with the rolling motion having a greater effect 1m away from the centre of the bogie; (2) The response of the human internal organs is stronger than that of the head under stimulation with a lower frequency of less than 3 Hz, and a similar conclusion can be drawn in the range of 5 to 8 Hz. However, if the frequency is in the range between 8 and 15 Hz, the situation is entirely different. The responses of both the head and internal organs are reduced at frequencies over 20 Hz; (3) From the real application, it can be inferred that the greatest response can be detected at approximately 3 Hz for internal organs and at 8 Hz or higher for the head.

By : Chun-jun Chen, Chao Fang, Guo-qing Qu

Ref: Rail & Rapid Transit , January 2021

Numerical simulation of rail surface-initiated rolling contact fatigue in the switch panel of railway turnouts

Considering the complex characteristics of the track structure in railway turnouts, it is difficult and also expensive to experimentally study rail damages; therefore, numerical methods are an effective alternative. This study presents a numerical method to simulate rail surface-initiated rolling contact fatigue in the switch panel of railway turnouts. This method includes simulation of the vehicle–turnout wheel–rail dynamic interaction, analysis of the wheel–rail multipoint non-Hertzian rolling contact that considers the relative motion between the switch and stock rails, and calculation of the accumulated rail surface-initiated rolling contact fatigue. The accumulated rail surface-initiated rolling contact fatigue after the vehicles passed a turnout switch panel 80 times (the average number of vehicles running on the Chinese high-speed railway lines per day) in the through route with facing move was simulated based on this procedure. The result showed that the maximum surface-initiated rolling contact fatigue damage of the switch rail and the stock rail was 1.57×10^{-2} and 0.62×10^{-2}, respectively. Surface-initiated rolling contact fatigue in the switch rail mainly occurred at the gauge angle, and in the stock rail it mainly occurred at the center of the rail. In addition, the influence of track parameters (rail inclination, track gauge, and friction coefficient) is analyzed. The friction coefficient influenced the rail surface-initiated rolling contact fatigue. When the coefficient exceeded 0.3 in particular, the rail rolling contact fatigue damage increased sharply. Hence, suitable friction control measures should be taken during rail maintenance in order to mitigate the rail surface-initiated rolling contact fatigue damage, e.g. by keeping the wheel–rail friction coefficient below 0.3.

By: Xiaochuan Ma, Ping Wang, Jingmang Xu

Ref: Rail & Rapid Transit , February 2021

Parallel co-simulation of locomotive wheel wear and rolling contact fatigue in a heavy haul train operational environment

Locomotive wheel wear and rolling contact fatigue simulations that consider both train dynamics and detailed traction control systems have not been reported. This paper developed a parallel co-simulation method to link an in-house longitudinal train dynamics simulator to a commercial software package named GENSYS. An advanced longitudinal train dynamics model, a traction control system model and a wheel–rail contact model were then incorporated into the simulation. Three wear calculation models (T-gamma model, USFD model and Archard model) and two rolling contact fatigue calculation models (T-gamma-based rolling contact fatigue model and shakedown-based rolling contact fatigue model) were implemented. A train with the configuration of 1 locomotive +54 wagons +1 locomotive +54 wagons was simulated. This paper shows that the simulation method is successful and can be used for such more detailed locomotive wheel wear and rolling contact fatigue calculations. Wear and rolling contact fatigue calculation results show that the wear numbers that were calculated using the T-gamma wear model and damage indexes that were calculated using the T-gamma-based rolling contact fatigue model were similar between the leading and remote locomotives. However, wear rates that were calculated using the USFD wear model, wear volumes that were calculated using the Archard model and fatigue indexes that were calculated using the shakedown-based rolling contact fatigue model have evident differences between the leading and remote locomotives. Maximum differences in these results were about 12, 18 and 34%, respectively.

By: Qing Wu, Maksym Spiryagin, Yan Sun

Ref: Rail & Rapid Transit , February 2021

Influence of out-of-round wheels on the vehicle–flexible track interaction at rail welds

The dynamic analysis of the vehicle–flexible track interaction involves the study of vehicle motion and its dynamic impact transmitted to the track structure. This paper studies the influence of the out-of-round vehicle wheels running over rail welds on a flexible ballast track. The rails are modeled as an Euler-Bernoulli beam discretely supported by a spring-damper force element that represents the flexibility of the track structure. The dynamic behavior of the vehicle–flexible track interaction is studied using the combination of the finite element method and the multi-body system. In this paper, the simulation of the vehicle with the out-of-roundness wheel running over rail welds on a flexible ballast track in the high-frequency range and the vehicle–track interaction is coupled by a non-linear wheel–rail contact model. The effects of the out-of-roundness wheel on the vehicle–flexible track interaction at rail welds are investigated by comparing the effects of the round wheel under different vehicle speeds. Results indicate that the out-of-roundness wheel at rail welds creates a high magnitude dynamic effect on the vehicle and track components. The obtained simulation results were used to set a safety limitation for the wheel and rail irregularity size.

By: G Bethel Lulu, Rong Chen, Ping Wang,

Ref: Rail & Rapid Transit , March 2021

Effect of ballast retaining walls on the lateral resistance of railway tracks

In this study, the application of a retaining wall was proposed as a solution for reducing the lateral displacement of the ballast layer, particularly in sharp curves and bridges. In this regard, a series of single tie push tests were performed on panels with shoulder ballast widths of 300mm, 400mm, 500mm with and without the presence of L-shaped and T-shaped retaining walls. Overall, it was proven that the application of an L-shaped wall led to a 15.8% increase in the lateral resistance, and that T-shaped walls have a higher impact on the stability of the track. A shoulder width of 400mm was proposed as the optimum width for ballasted tracks with retaining walls.

By : P Aela, WL Jia, GQ Jing

Ref : Rail & Rapid Transit , April 2021

Reinvestigation into railway wheel-track interaction and suspension damage

Without considering either velocity or acceleration effects, the current conventional method presented in literature applies the vertical deflection of a wheel centre caused by a flat defect to the Hertzian contact theory. This method has been numerically and theoretically proved to be inappropriate and can incorrectly predict a higher wheel-rail impact force for a low speed than a high speed. Therefore, under a hypothesis of no wheel bouncing and sliding, two new methods, the velocity-based and the acceleration-based have been proposed. The former method takes the wheel centre deflection change in each computational increment from the Hertzian contact theory while the latter applies the wheel centre acceleration caused by the flat in revolutions to the wheel as a force in dynamic simulation, which interprets the speed effects on impacts precisely. A sensitivity study proves that the velocity-based method is unreliable as opposed to the acceleration-based method. A beam/rigid FE model has also been developed to inspect the wheel-track interaction by performing dynamic analysis in the time domain. It has been found out that the impact responses predicted by the FE analysis and the velocity method are similar and the FE results heavily depend on the compute increment, which implies the FE modelling in ABAQUS may be unreliable for this issue with current applied increments. Finally, the results calculated using the acceleration method have been employed to study the suspension/damper torsional stress caused by a wheel flat. This indicates that a wheel flat may lead to potential fatigue damage if without proper maintenance management.

By: Renfan Luo, David Vincent

Ref: Rail & Rapid Transit , April 2021

Dynamic responses of a high-speed train passing a deformed bridge using a vehicle-track-bridge coupled model

With the development of the railway network in a harsh environment, the additional bridge deformations accumulated over time may endanger high-speed trains passing through a bridge, since the bridge deformation directly affect the geometry of the track on the bridge, thus affecting the dynamic responses of the train. This paper investigates the effects of different types of bridge deformation on the dynamic responses of the high-speed train passing through a deformed bridge. First, a finite element model is established for a high-speed railway bridge to study the dynamic responses of vehicle-track-bridge system under bridge deformations. Then, the rail deformation caused by bridge deformation is calculated using a bridge-track deformation mapping model, and used as the excitation to the vehicle-track-bridge system to study the influence of bridge deformations on the dynamic responses of the train. Results show that the vertical bridge deformations mainly affect the vertical vehicle dynamic indices, and have negligible effect on the lateral dynamic indices. The additional bridge deformation generates an additional low-frequency excitation to the train. The bridge deformations mainly affect the dynamic responses at specific characteristic frequencies, which are independent on the magnitude of the deformation. The frequencies for bridge deformations are magnified at about 1 Hz, indicating that the additional bridge deformation may aggravate the vertical vibration of the train.

By : Hongye Gou, Chang Liu, Wen Zhou, ...

Ref: Rail & Rapid Transit , April 2021

Methods used to construct underwater pile caps on the Hong Kong–Zhuhai–Macao Bridge

The embedded pile-cap design in the Hong Kong–Zhuhai–Macao Bridge project meant that prefabricated pier shafts and pile caps had to be installed under water. This posed a host of daunting construction-related challenges. The designer for the bridge – the Highway Planning and Design Institute, Beijing, China – proposed a method using temporary retaining structures to assist in the underwater installation. According to the local hydrogeological conditions and the capacity of the equipment available in each section, three methods of construction for these temporary works were used. Following completion of the project in 2018, this paper provides a technical comparison of the three methods with the aim that it will serve as a reference for similar projects in the future.

By : Mingshan Fang, Lizhi Yu, Yu Tan

Ref: ICE : Bridge Engineering, March 2021

"The best brains of the nations can be found on the last benches of the classrooms."

Investigating asymmetric spatial butterfly-shaped steel arch bridges: a case study

Jiusha Bridge in Hangzhou city, China, is an asymmetric spatial butterfly-shaped steel arch bridge. The bridge deck and steel arch rib form a half-through structure at one end and a through structure at the other. The bridge sits on a soft soil foundation with poor thrust resistance; therefore, different force transmission structures adopted at the asymmetric ends to balance the large arch thrust during internal force transmission of the structure were researched. The mechanical behaviour of the asymmetric steel arch bridge under dead load and live load was compared with that of a symmetric half-through and through steel arch bridge. Subsequently, a full-bridge finite-element (FE) model was established in order to adjust the stiffness contribution of the middle arch and side arches to the bridge, optimise the hanger forces in the finished bridge state and analyse the bridge's stress, stiffness, stability and dynamic characteristics. The stresses in some key members and joints were calculated by means of a refined FE model consisting of beam elements, truss elements and plate elements. Some of the special construction technologies used on Jiusha Bridge are also briefly discussed.

By: Jianyuan Sun, Jinbao Xie, Chao Liu,

Ref: ICE: Bridge Engineering, March 2021

Safety risk assessment of cast-in-situ box girder of mountainous high-pier interchange

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By : Yong Zeng, Changchun Yang, Qianping Zhang, Hongmei Tan,

Ref : ICE: Bridge Engineering, March 2021

Rapid construction and advanced technology for a Covid-19 field hospital in Wuhan, China

A specialised emergency field hospital was constructed in record time in Wuhan, China shortly after the initial outbreak of the Covid-19 pandemic. Covering an area of 34000m^2 and providing 1000 beds, Huoshenshan Hospital was more advanced and had more rigorous isolation systems than most current infectious-disease hospitals, but it was delivered in just 10 days. The rapid construction benefited from a unique modular design, over 4000 people who worked around the clock and a series of advanced technologies such as building information modelling, modular construction and 5G communications. The hospital played a crucial role in controlling the pandemic in China.

By : Man Zhou, Yaying Chen, Xiaolong Su, Ling An

Ref : ICE: Civil Engineering, Feb. 2021

Case studies on best practices in construction of long-span bridge projects in India

This paper describes the key challenges faced in three recent long-span bridge projects in India and explains how they were overcome through the application of novel construction methods. They include constructability changes in the precast works for the Barapullah elevated corridor phase 3 in New Delhi, a temporary bamboo pile jetty system for Bihar's New Ganga Bridge project near Patna and a combined precast yard with a load-out facility for the Durgam Cheruvu Bridge in Hyderabad. The new approaches adopted in these case studies resulted in considerable cost and time savings compared with the original plans.

By: G Muneeswaran, P Devadas Manoharan, T Vijayakumar

Ref: ICE: Civil Engineering, Feb. 2021

Past, current and future use of physical models in civil engineering design

Prior to the 1970s it was common for the designers of major civil engineering projects to use experimental tests on reduced-scale physical models to complement design calculations made by hand. Since then the use of physical models has declined as the power and reliability of computer modelling has grown. However, they have by no means disappeared. Following a review of the growth of physical modelling since the 1870s, this paper provides an overview of how it is still able to make an essential contribution to civil engineering design, particularly when used alongside numerical modelling, and how such work may develop in the future.

By: Bill Addis,

Ref: ICE: Civil Engineering, May. 2021

The hyperloop challenge for tunnelling: higher productivity and lower costs

Triggered by the potential challenges of providing supporting infrastructure for future very-fast ground-transport systems such as hyperloop, the British Tunnelling Society carried out a year-long research and thought-leadership project into ways of increasing productivity and reducing costs of tunnelling. This paper describes the research and its findings. It also lists tunnel projects that might become technically viable with greater productivity and lower costs. Proposals are made for the direction of future work, noting that a broader commitment from all stakeholders in tunnelling projects will be needed to achieve significant improvements.

By : Bill Grose,

Ref : ICE: Civil Engineering, May. 2021

Civil engineers' role in saving the world: updating the moral basis of the profession

Today's civil engineering profession was born in the industrial revolution with the vision of 'harnessing the forces of nature for the benefit of mankind'. However, the industry's alarming environmental impact means that civil engineers must urgently change their impact on the world. Viewing the dangers of climate change through the lens of behavioural science, this paper identifies the four 'levers' that civil engineers must pull to put the profession on a sustainable and morally justifiable path. Three of the levers focus on behaviours, outlining measures that individuals, companies and institutions can take to realign decision making to the needs of sustaining life on the planet. Only one lever relates to new technological solutions. These levers offer a pragmatic to-do list of actions, to unlock systemic change, and thereby accelerate the profession's transition to a net-zero future.

By: Nick Francis

Ref: ICE: Civil Engineering, May (spl.). 2021

Opportunities for a civil engineering climate action strategy

This paper outlines the technical and anecdotal findings of a horizon scanning exercise into the ability of civil engineers to deliver impactful climate action. Examples of interaction between extreme weather and built environment assets are broken down via systems thinking. The concept of unconscious bias is addressed in how infrastructure climate risk is diagnosed; beyond the effects of flooding, drought, and heatwaves. Differentiations between climate mitigation, resilience and adaptation are made. Opportunities to address each throughout the infrastructure lifecycle are discussed, including how to balance conflicts of interest between them.

By: Reece Cammock,

Ref: ICE: Civil Engineering, May (spl.). 2021

Concrete containing recycled waste glass: strength and resistance to freeze–thaw action

The mechanical strength, mass loss and dynamic elastic modulus of Portland cement concrete incorporating recycled glass powder (GP) as a cement replacement material or crushed glass aggregate (GA) as a fine aggregate replacement material subjected to different cycles of freezing and thawing were investigated. A series of 11 concrete mixing proportions was designed with a constant water/cement ratio of 0•5 including fractions of GP or GA. Tests were conducted on 100 × 100 × 100 mm cubes, 100 × 200 mm cylinders and 100 × 100 × 500 mm prisms. The tests of compressive strength, flexural strength and indirect tension were used to examine the impact of the inclusion of different percentages of glass (GP or GA) on the mechanical properties of concrete cured for 7, 28 and 60 d. Two non-destructive testing approaches (ultrasonic pulse velocity and resonance frequency) were used in the freezing and thawing test. The test results indicated that, compared with conventional concrete, the mechanical strength characteristics of concrete containing GP or GA were more enhanced. The use of GP decreased the deterioration of the concrete under the effect of frost action, whereas the use of GA had an adverse influence on the frost resistance of the concrete.

By: Raed M. Abendeh, Zaydoun T. AbuSalem, Mousa I. Bani Baker, Taisir S. Khedaywi

Ref: ICE: Consruction materials, April 2021

Shear strengthening of plate girders using carbon-fibre-reinforced polymer composites

New methods for strengthening steel structures using fibre-reinforced polymer composites have been the subject of much recent research. Few studies have been carried out on shear strengthening of plate girders using carbon-fibre composites. In the study reported in this paper, the impact of carbon-fibre composite plates on end-zone shear capacity of steel-plate girders is investigated. A section of plate girder with a length and height of 300 mm was chosen for numerical modelling. All specimens were modelled using finite-element software. Initially, the software was verified using experimental data available in the literature. Eleven specimens with different arrangements of composite strips on the web of the plate girders were then investigated. Different ratios of composites were pasted on one side or both sides of the web. Static non-linear methods were used to analyse the specimens. The results indicated that fully strengthening the plate girders on both sides of the web significantly increased bearing capacity.

By: Saeed Azizi Hossein Mehmandoost Kotlar Kambiz Narmashiri

Ref: ICE: Consruction materials, April 2021

Early properties of concrete with alkali-activated fly ash as partial cement replacement

Cement manufacture is one of the reasons for society's increasing carbon dioxide footprint. The development of a sustainable construction material is therefore needed to replace Portland cement fully or partially in building construction applications. Geopolymer concrete is a sustainable cementitious material, which is claimed to reduce carbon dioxide emissions and utilise waste materials such as fly ash, metakaolin and blast-furnace slag. Fly-ash-based geopolymer concrete with an activating solution of a mixture of silica fume, sodium hydroxide and water was investigated. Four Portland cement replacement weight ratios (0%, 5%, 10% and 15% by weight of fly ash) were studied. The effects of the Portland cement replacement on the early geopolymerisation process, compressive strength, modulus of elasticity and Poisson's ratio were investigated. Acoustic emission monitoring results showed that the early geopolymerisation process was enhanced when Portland cement replacement was increased. The compressive strength and modulus of elasticity were significantly increased when the Portland cement ratio increased, while Poisson's ratio was adversely affected.

By: Lateef N. Assi, Ali Majdi, Yasir Alhamadani, Paul Ziehl

Ref: ICE: Consruction materials, Feb. 2021

Numerical evaluation of the ultimate load of concrete funicular shells of circular plan

A special type of shell structure – a concrete shallow funicular shell of circular plan – is considered in this paper. Funicular shells carry their dead weight only by in-plane compression forces. Numerical analysis of funicular shells was performed using the non-linear finite-element method, considering both geometric and material non-linearities. A circular-plan concrete funicular shell unit was also constructed and its ultimate central concentrated load is determined. The ultimate load of the shell unit predicted by the numerical model was very close to the experimentally determined ultimate load, thus confirming the validity of the numerical model. The numerical results revealed the effect of the base radius and the thickness of funicular shells on their stiffness and ultimate central concentrated load. It was found that an increase in the thickness of funicular shells increases their ultimate uniformly distributed load (UDL) while an increase in the base radius decreased the ultimate UDL, linearly for the former and non-linearly for the latter.

By: Alireza Javid, Massood Mofid

Ref: ICE: Structures and Buildings, January 2021

Cyclic behaviour of eccentrically braced frames fabricated with high-strength steel

This paper reports on a study performed on cyclic testing of two half-scale, one-bay, one-storey, Y-shaped, eccentrically braced frames fabricated with high-strength steel to investigate their hysteretic behaviour and performance, including the failure mode and load-bearing, ductility and energy-dissipation capacities. A comparison between experimental and finite-element model results was performed. In addition, non-linear analyses of the numerical models were carried out to investigate the effects of shear-link length on hysteretic behaviour. The test results indicated that the specimens had a good deformation capacity. The hysteretic curves were very full, implying the frames had significant energy-dissipation capacity. The frames are a safe dual system with useful hysteretic behaviour and seismic performance. The designed shear links dissipated the energy by way of shear deformation during cyclic loading. The numerical analysis indicated that shear-link length could influence the cyclic behaviour.

By: Ming Lian, Mingzhou Su, Hao Zhang, Qianqian Cheng

Ref: ICE: Structures and Buildings, January 2021

Prestressed lightweight concrete slabs strengthened with carbon-fibre-reinforced polymer

The effect of applying carbon-fibre-reinforced polymer sheets together with a prestress force to strengthen lightweight reinforced concrete slabs was investigated experimentally and numerically. As reported in this paper, load–deflection curves, stiffness, energy-absorption capacity and crack width of the prestressed slabs were examined and a detailed numerical model is presented. Strengthening with polymer layers resulted in a larger lever arm, while prestressing slightly reduced the lever arm of the section. The maximum deflection of prestressed slabs was smaller than that of the control specimen due to a small reduction in energy absorption. Using polymer sheets increased both the strength and maximum ultimate deflection simultaneously due to a higher energy-absorption capacity. The formation and propagation of cracks was postponed due to prestressing, so the ultimate crack width was reduced. Owing to the increase in stiffness, the polymer strengthening reduced crack spacing, crack width and crack growth for all strengthened specimens. In addition, a parametric study revealed that the variations in tendon eccentricity had a significant influence on the force–displacement response of slabs, whereas variations in characteristic strength and dilation angle only had a slight effect.

By: Vahid Azami, Mehdi Dehestani, Sina Mahmoudi, Hadi Nazarpour

Ref: ICE: Structures and Buildings, February 2021

Progressive collapse of regular- and irregular-plan concrete structures in an earthquake

Progressive collapse, in which local failure of an element causes significant deformations leading to the collapse of a structure, is a catastrophic structural phenomenon that can occur due to natural disasters or human negligence. Common practices in progressive collapse analysis generally prevent this phenomenon due to unusual gravity loads or explosions; however, progressive collapse behaviour due to earthquakes is less evaluated. An experimental methodology was used to study the progressive collapse of concrete structures with an intermediate moment frame both in regular and irregular plan using the alternative load path method and guidelines issued by the US General Services Administration and the US Department of Defense considering three cases of column removal using OpenSees. The investigation studied the function of the structure regarding the rotation of plastic hinges and its robustness. The pushover method was used to cover non-linear static analysis and the time history method was used to perform non-linear dynamic analysis for three-, six- and ten-storey structures in three dimensions. The results showed that structures with irregular plan and low heights are more vulnerable to progressive collapse.

By: Ardeshir Ghadamian, Mehdi Alirezaei

Ref: ICE: Structures and Buildings, February 2021

Study on load-carrying capacity of partially exposed reinforced concrete beams

When a partially exposed reinforced concrete beam deforms under tensile loading on reinforcements, the load-carrying capacity of the exposed reinforced concrete beam will significantly change, as the deformation of the exposed reinforcement bars and concrete do not follow a harmonising relationship. In this paper, the load-carrying capacity of a partially exposed reinforced concrete beam was investigated. By analysing a large quantity of test data, the changing patterns of the load-carrying capacity were obtained and two typical failure modes of the exposed reinforcement concrete were summarised. In the study, finite-element software was employed to simulate the test results. The simulated values were consistent with the test results. An extensive analysis of the influencing factors using a finite-element method was conducted. The length of the exposed reinforcement and the reinforcement ratio were considered as the controlling variables to obtain the changing failure modes of the exposed reinforced concrete beam. The analytical results confirmed the conclusions of a previous analysis.

By: Fangyuan Li, Wenhao Li, Yunxuan Cui, Peifeng Wu, Yin Shen,

Ref: ICE: Structures and Buildings, March 2021

Seismic performance of concrete joints strengthened with hybrid-fibre-reinforced polymers

This paper presents the results of experimental and numerical investigations performed on nine one-third scaled exterior beam–column joints. They were first damaged in a displacement-controlled manner with constant column axial load and reverse cyclic load at the tip of the beams. The damaged joints were then repaired with new concrete and strengthened with hybrid-fibre-reinforced polymer laminates. These had combinations of natural and glass fibre mat and chopped laminations together with eight layers of glass-fibre-reinforced polymer wrapping. The aim was to restore and enhance seismic capacity parameters such as strength, stiffness, ductility and energy dissipation. It was observed that specimens with hybrid fibre mat laminations and glass-fibre wrapping exhibited a better performance in terms of ductility, with up to 81% increase. Numerical investigations were carried out using finite-element software to validate the experimental results. It was observed that the numerical results were in good agreement.

By: Marimuthu Sumathi, Sivasankarapillai Greeshma

Ref: ICE: Structures and Buildings, April 2021

Seismic retrofit of stone walls with timber panels and steel wire ropes

Historic constructions are common in Europe, but natural hazards can produce significant damage. Shear reinforcement of historic walls, especially in seismic areas, is often necessary and new retrofitting methods have recently been proposed to restore or increase the lateral capacity of shear walls. In this paper the combined use of cross-laminated timber panels and steel wire ropes is proposed to reinforce rubble stone masonry walls with the aim of increasing their lateral load capacity while improving the energy performance of the building envelope. An experimental programme was carried out in the laboratory to assess the mechanical effectiveness of this retrofitting method. The results from a series of quasi-static cyclic shear tests are presented. The test programmes are described and the analysis of test results is included. The potential benefits and limitations regarding the use of the proposed combined method for reinforcing masonry structures are discussed, with an emphasis on the in-plane behaviour.

By: Antonio Borri Romina Sisti, Marco Corradi

Ref: ICE: Structures and Buildings, May 2021

Influence of historic roof structures on the seismic behaviour of masonry structures

Historic buildings are complex structures in which all the composing elements work together. Studies of heritage structures after seismic events have shown that timber roof structures strongly influence the seismic response of masonry structures, being able to reduce or enhance the out-of-plane displacement of the structure. Starting from these observations, three different types of roof structures, from the eighteenth, nineteenth and twentieth centuries, were introduced in the finite-element simulation software SCIA Engineer. The roof structures were subsequently placed on the same eighteenth-century masonry building with a ground floor and two upper floors, respecting its geometric features. Simulations were performed considering successively rigid, hinged or sliding connections between the roof and the masonry structure. At the same time, the traditionally crafted joints of the roof structures were consecutively modelled as hinged, rigid and semi-rigid (determined using three different methods). Ultimately, the top horizontal displacement, inter-storey drift and damage level of the masonry structure were compared. The main aims of this study were to observe if roof structures have an influence on the seismic behaviour of masonry buildings and to determine if selected parameters suffer any changes depending on the roof structure type, the roof–wall connections and joints' axial stiffness.

By: Alexandra I. Keller, Maria Adelaide Parisi, Eleftheria Tsakanika, Marius Mosoarca,

Ref: ICE: Structures and Buildings, May 2021

Workability and compressive strength of self-compacting geopolymer concrete exposed to elevated temperature

Concrete is the most common and widely used construction material throughout the world. Portland cement is the primary binding ingredient to manufacture concrete. Cement production has substantially increased over the years in developing countries. The statistical data for the year 2013 indicates that India was the second largest cement producer in the world with nearly 381 million tons of cement production capacity. The production of cement is not only energy intensive, but also responsible for emission of carbon dioxide (CO2) in large quantity. It is estimated that approximately 97.76 x 106 Joules of energy is required for the production of each ton of cement3 and an equal quantity of CO2 gas is released to the atmosphere. According to McCaffrey, the production of one ton of Portland cement generates and releases approximately one ton of carbon dioxide gas into the atmosphere. The quantity of CO2 produced due to cement manufacturing contributes to about 5% of the total release of CO2 to the atmosphere. As a result, the need for alternative binders capable of achieving an ecologically sustainable concrete proves to be essential to reduce the huge emission of CO2 attributable to Portland cement.

Geopolymer is an inorganic alumina-silicate polymer synthesized from materials predominantly rich in silicon (Si) and aluminium (A1) of geological origin and/or by products such as fly ash, rice husk ash and other that have these elements. The two major constituents of the geopolymer binder are the source materials (fly ash, rice-husk ash, silica fume, slag red mud etc.) and the alkaline liquids (sodium hydroxide with sodium silicate. Potassium hydroxide with potassium silicate).

By: S. Jeeva Chithambaram, Sanjay Kumar, and M.M.Prasad

Ref: Journal of Structural Engineering (SERC) Vol. 46 no. 5 (Dec. 2019- Jan 2020)

Track Geometry Deterioration Model

Ramesh Pinjani*

Abstract : *The paper deals with basic theoretical concepts of track geometry deterioration, developing a conceptual track geometry deterioration model (t.g.d model) for Indian Railways using PML (planned maintenance limits) & NBML(need based maintenance limits) stipulated in IRPWM (Indian Railway P.way manual). Using this t.g.d model, requirement of maintenance on km basis with intervening maintenance input on basis of blocks of 200 m track length can be worked out taking into account current / existing track parameter recorded.*

The t.g.d (track geometry deterioration) model will facilitate introduction of concept of predictive maintenance for track tamping on I.R, thereby helping in rationalizing deployment of track tamping machines, savings in traffic block time, machine working hours & requirement of frequent ballasting etc. The Implementation on a route of 1500 km track length, using t.g.d model & concepts for improving tamping cycle discussed in this paper, with assumed reduction in tamping requirement by 20% is expected to yield saving of Rs 10 crores (approx.) per annum to I.R

1. Introduction:

The introduction of predictive maintenance for track geometry correction by track tamping, on Indian railways is an important issue, which will facilitate introduction of need based maintenance input in the track.

Presently IRPWM specifies planned maintenance input to be provided on complete block section basis, whenever % of blocks (200 m track length) exceeds PML are more than 40%.

The paper deals with concept of predictive maintenance to impart maintenance input using t.g.d model evolved using PML & NBML stipulated in IRPWM, which is to be applied on km basis & intervening attention on block (200 m track length) basis.

2. Basic concepts of track geometry deterioration

2.1 Mechanics of track geometry deterioration

Under the passage of traffic there is differential settlement in the ballast (having non homogenous mass & non homogenous supporting strata), thereby deterioration of track geometry parameters. The mechanism of track geometry deterioration phenomenon is rather complex.

The magnitude of settlement in the ballast & track geometry deterioration thus, depends upon magnitude of axle load, number of loading cycles / magnitude of traffic, speed, percentage content of fouling material (i.e. undesirable fine material of size 9.5 mm or less) & characteristics of rolling stock suspension.

2.2 Reasons for track geometry deterioration

The track geometry deterioration happens mainly due to 3 reasons:

1) Differential settlement of the ballast, arising from the ballast itself, or from variations in the stiffness of the foundation,
2) Lack of straightness of the rails & poor weld geometry.
3) Variation in the dynamic loads caused by vehicles. The most significant dynamic loads could come from un sprung masses

2.3 Rate of track geometry deterioration *(Ref: ORE D161 Report-3 Para-3.2)*

- The track quality i.e. vertical quality (Unevenness) and alignment deteriorate linearly with tonnage between maintenance operations after the first initial settlement;
- However this trend is not always the case, for sections with high deterioration rates.
- The rate of track deterioration is very different from section to section even for apparently identical sections carrying the same traffic.
- The rate of track deterioration appears to be constant parameter for a section of track, regardless of the quality achieved by the maintenance machine;

**Additional Director General RDSO / Lucknow / India*

- In general tamping machines improves the quality of a section of track to a more or less constant value.

2.4 Factors affecting track geometry deterioration

(Ref: ORE D-117 Report-29,D161 Report-3 Para-3.4)

The studies undertaken by ORE D-117 & D161, to analyze the effect of different types of traffic, track construction and maintenance machine on the quality of the track & its rate of deterioration, shows that

- The factors governing the rate of deterioration are not obvious and that the unknown factors in the track are the most important in determining both the average quality and the rate of deterioration.
- While the results of these tests were not very conclusive, it was observed that
  - The quality of the track on relaying was the most important factor.
  - In general, a high rate of deterioration in individual areas of a larger section can be linked to characteristics, which are quite easy to detect:
    - Singular features (rail bridges, level crossings, etc.); (related to variation in stiffness of base/ foundation)
    - Local geometry faults present from the start;
    - Sub-layers of inferior quality formation;
    - Welds of inferior quality;

2.5 Conclusions on factors affecting track deterioration

- The quality of track on relaying is the most important factor to affect the rate of track geometry deteriorations.
- Track can be constructed such that it has a good inherent quality & the inherent quality of existing track can be improved.
- The maintenance interval can usually be lengthened.
- Low lift tamping is unlikely to achieve a permanent improvement in track quality.
- Tamping should only be undertaken when necessary

2.6 Important reasons for frequent tamping/maintenance

- Poor Quality of track at the time of initial laying and during subsequent track renewals.
- Poor Condition of sub-grade and Non-provision/ absence of sub-ballast / blanket layer.
- The surface defects in the rail wheel contact area, i.e. cupped welds, low joints, poor geometry on welds, poor support conditions at the joints, corrugation on rail top, flat tyre, generates higher dynamic forces, thereby causing faster deterioration.
- In efficient methods available with field staff for isolated spot attention /slack packing.
- Inadequate availability of clean ballast cushion / hard caked ballast mass.
- Overloading of freight stock.
- Poor maintenance of rolling stock, causing higher lateral forces.
- Poor maintenance of track machines.
- Inadequate pre tamping, post tamping attention, which is pre requisite for getting satisfactory quality of tamping out put.

3. Conceptual track geometry deterioration (t.g.d) model

3.1 Basic concepts used in developing t.g.d model

i) Planned Maintenance Limit (PML) – This tolerance limit provide the guidance to plan through- maintenance of track. When PML is exceeded, it will require analysis of track geometry condition to consider for planned maintenance operations. The limits are specified in terms of standard deviation*(S.D value) as under (Ref IRPWM para- 522)

Track parameter	Speeds up to 100 kmph	Speeds above 100 & upto 110 kmph	Speeds above 110 kmph & upto 130 kmph	Speeds above 130 kmph & upto 160 kmph
UNI(L&R)	5 mm	3.8 mm	3.3 mm	2.9 mm
UN2(L&R)	5.4 mm	5.4 mm	5.1 mm	4.4 mm
AL1(L&R)	3.3 mm	2.5 mm	2.5 mm	1.9 mm
AL2(L&R)	4.1 mm	4.1 mm	3.5 mm	2.5 mm

** Standard deviation (S.D): The track parameters are measured @ m 0.4, therefore in the block of 200m, 500 data are picked up, To assess & represent general pattern of these data, standard deviation is used, for example S.D value for unevenness is 1.6 mm then 68.27% data shall have unevenness up to 1.6 mm, similarly 99.73% data shall have unevenness up to 3 x 1.6=4.8 mm, Therefore higher the value of S.D value, bigger is the defect)*

ii) Need Based Maintenance Limit (NBML) – This limit is defined to apply timely correction in track geometry before the defect grows to level of urgent maintenance limit thereby requiring imposition of speed restriction. The limits specified are as under: (Ref. : IRPWM para- 522)

Track parameter	Speeds up to 100 kmph	Speeds above 100 & upto 110 kmph	Speeds above 110 kmph & upto 130 kmph	Speeds above 130 kmph & upto 160 kmph
UNI(L&R)	6.8 mm	5.5 mm	4.9 mm	4.4 mm
UN2(L&R)	7.5 mm	7.5 mm	7.4 mm	6.6 mm
AL1(L&R)	4.9 mm	3.9 mm	3.6 mm	3.6 mm
AL2(L&R)	6.7 mm	6.7 mm	5.3 mm	4.9 mm

iii) Urgent Maintenance Limit- (Ref. : IRPWM para- 522)

Track Parameter	Speeds up to 110 kmph	speed above 110 & upto 130 kmph	speed above 130 & upto to 160 kmph
vertical and lateral acceleration peaks exceeding	0.3 g	0.25 g	0.2 g

iv) Track length for maintenance input: In this paper, the maintenance input in the t.g.d model is considered on km basis & not full block section (as given in P.way Manual) because prediction of geometry deterioration for a km is more accurate as compared to a block section, as all the kms in a block section do not deteriorate with same rate & fashion. This is an essential step to achieve predictive maintenance philosophy based on actual condition of the track.

v) Measurement of Track Parameters with TRC (Ref.: IRPWM para- 508)

Track parameters	**Rail**	**Short chord**	**Long chord**
Unevenness	Left Rail & Right Rail	9 m (UN-1)	18 m (UN-2)
Alignment	Left Rail & Right Rail	9 m (AL-1)	15 m (AL-2)

vi) Rate of track geometry deterioration for a block (200m length)- Rate of deterioration is defined as change in SD value (mm) of track parameter per 100 GMT of traffic. The rate of deterioration of a track parameter in a block of 200 m is calculated as under:

If Run 2 (SD Value) > Run 1 (SD Value) (i.e. when no track attention between 2 successive runs)

$$\text{Then } \frac{SD\ value\ (Run2) - SD\ Value\ (Run\ 1)}{(GMT\ carried\ between\ Run\ 2\ \&\ Run\ 1)}\ x\ 100$$

Note : If between two successive track recording runs maintenance input has been given then SD value will improve & there will be two rates of deterioration in this case, one prior to maintenance input and second post maintenance input. To work out these rates the track geometry /SD value before and after maintenance input are required which are not available therefore, in this model wherever SD value has improved in the subsequent run the rate of deterioration (which is actually improvement in track geometry due to maintenance input) has been ignored.

This rate of deterioration Is calculated for all the 8 track parameters & for all the 5 blocks of 200m length
The rate of deterioration between 2 successive runs is calculated for all the track recording runs & the value of maximum. & average rate of deterioration is worked out using rate of deterioration for all the track recording runs.Similar exercise is done for all the 8 track parameters & for all the 5 blocks of 200 m.

vii) Track geometry deterioration (t.g.d) model parameters

a) Average rate of track geometry deterioration for a km: It represents average rate of deterioration of a km, considering average value of average deterioration rate of all 5 blocks of 200m length falling in the same km. This exercise is done for all track parameters.

b) Maximum rate of track geometry deterioration for a km: It represents maximum rate of deterioration of a km, considering maximum value of maximum deterioration rate of all 5 blocks of 200m length falling in the same km. This exercise is done for all track parameters.

2.6 Basic Philosophy of Track geometry deterioration (t.g.d) model

- The need for imparting maintenance input arises when track parameter (current measured SD value) exceeds PML tolerance (say Limit-1), however it cannot be delayed beyond a stage when it (current measured SD value) reaches NBML tolerance (say Limit-2).
- The quantum/magnitude of traffic required to cause deterioration of track parameter from current measured SD value to reach PML(Limit-1) and NBML(Limit-2) is required to be accordingly calculated.
- To calculate limit-1 & Limit-2 for each track geometry parameter, average or maximum rate of deterioration of that track parameter is to be used.
- In this t.g.d model, to reach from the existing measured SD level to PML in the block, average deterioration rate of block (200m track length) is considered, The value on km basis is worked out considering average of all 5 blocks falling in this km. In this case even if in some blocks (falling in this km), the actual deterioration rate is more than average value, possibility of exceeding it beyond NBML is very less.
- Further to reach from the existing measured SD level to NBML in the block, maximum deterioration rate of block (200 m track length) is considered. The value on km basis is worked out considering average of all 5 blocks falling in this km.

  In this case there is a possibility that in some of the 200m blocks, due to actual deterioration rate of block being more than average of a km, some parameter value in that block may exceeds NBML. To address this issue,

i) An intervening track attention on block of 200 m is considered, which is calculated based on maximum deterioration rate for that block

ii) The current measured SD value (based on last TRC run) of track parameter is compared with NBML, to decide whether an immediate attention is due on this account.

To calculate magnitude of traffic required to reach PML (Limit-1) & NBML (Limit-2), following formulae are used

a) For a particular track parameter, traffic GMT required block-wise, to reach PML from SD measured level (Limit-1)

$$100 \times \frac{SD\ value\ (for\ planned\ maint.) - SD\ Value\ (measured\ value\ for\ that\ block)}{average\ \ rate\ of\ det.for\ a\ block}$$

The average of all 5 blocks, will give value for a km and minimum of all 8 parameters considered on km basis is taken as limit-1

b) For a particular track parameter, traffic GMT required block-wise, to reach NBML from SD measured level (Limit-2)

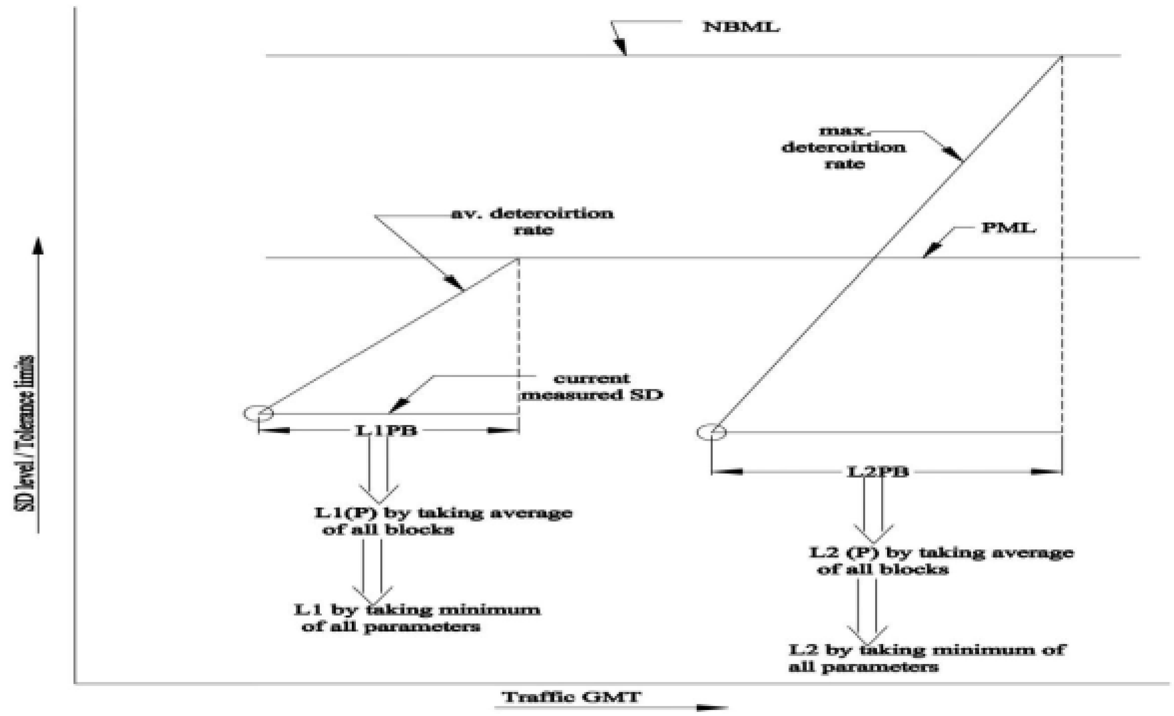
$$100 \times \frac{SD\ value\ (for\ need\ based\ maint.) - SD\ Value\ (measured\ value\ for\ that\ block)}{Max.rate\ of\ det.for\ a\ block}$$

The average of all 5 blocks, will give value for a km and minimum of all 8 parameters considered on km basis is taken as limit-2 Further in this case, maximum value of all 5 blocks, also will be considered, to fix up / decide intervening attention.

Note:

1) In case traffic GMT calculated, for intervening attention is more than traffic GMT carried between successive TRC runs, then intervening attention can wait for results of next TRC run.

2) In case in next TRC run, for some parameter SD value exceeds NBML, the track is to be attended immediately preferably in next 3 days to 21 days time depending upon actual SD measured value & value of lateral & vertical acceleration in that block, recorded during last TRC run.



2.7 Concept of predictive maintenance :

1) There are two limits (in terms of traffic GMT) within which, the maintenance input is required to be given to track. Limit-1 is decided by traffic GMT required to reach PML considering average value (of all blocks) using average deterioration rate of blocks (falling in that km) and Limit-2 is decided by traffic GMT required to reach NBML considering average value (of all blocks) using maximum deterioration rate of blocks (falling in that km).

2) Further intermittent attention to a particular block is decided based on traffic GMT required to reach NBML from existing measured SD level using maximum deterioration rate of that block.

3) In addition wherever in last TRC run track parameter value has exceeded NBML, it qualify for immediate maintenance input

2.8 Existing criteria for planning Through tamping based on PML (Ref: IRPWM, Para 523 (3))

i) The block section should be planned for through tamping if the percentage of blocks exceeding PML is more than 40%.

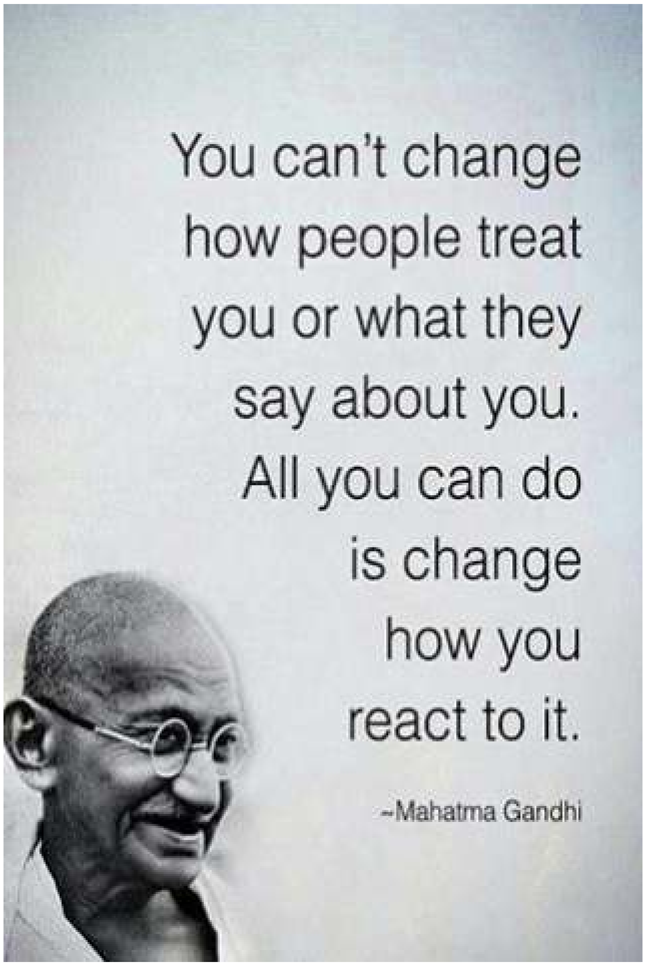
ii) Yard should be planned for through tamping if the percentage of blocks exceeding PML is more than 50%.

Important note : *The existing criteria (laid down in IRPWM) for imparting planned maintenance input is to be provided on full block section basis, with bench mark tolerance applicable as 'PML'. When t.g.d. model is available (i.e. when track geometry deterioration rate can be predicted) then maintenance input, which is to be provided on km basis, can be optimized by allowing the usage of track for traffic, till the existing track geometry reaches close to 'NBML'. This will help in reducing tamping requirement & improve tamping cycle.*

3 Development of conceptual track geometry deterioration (t.g.d) model

3.1 Sample size: The t.g.d model has been developed using TRC results of 14 Kms of Virar-Surat section, involving TRC results of 11 runs, of period Jan-05 to Aug-08 . The SD values (block wise) of all 8 track parameters i.e. UN1 (L&R), UN2 (L&R), AL1 (L&R), AL2 (L&R) have been considered in analysis. The total sample data size = 14 (Kms) x 5 (blocks) x 8 (Parameters) x 11 (TRC runs) = 6160 nos. of data.

3.2 t.g.d model has been developed based on the philosophy & concepts discussed under para 1, 2 & 3 above , The analytical tool can be accessed @ the link given below.
t.g.d model final.xls (one sample output sheet is placed under para- 3.3 below)



3.3 Results / output sheet

Speeds above 130 kmph & upto 160 kmph									km	226	227
1. Planned Maintenance											
The planned maintenance in this km should be done after the passage of 25 GMT & completed before passage of 41 GMT, with an intervening maintenance requirement in Block-5 , on passage of 17 GMT. The intervening attention for all 200 m blocks is also indicated below.											
Requirement of Intermediate attention for 200 m blocks on passage of (in GMT)	Block-1	Block-2	Block-3	Block-4	Block-5						
	17	43	42	23	17						
Note- The next TRC run is due after 8 GMT, whereas first maintenance intervention is required in Block-5 is to be done after 17 GMT, so We can wait for next TRC Run											
2. Need based Maintenance req. for individual blocks											
Need based maint req. due to track parameters exceeding NBML (based on last TRC run)	No Block exceeding NBML										
3.Track Geometry Degradation Model (t.g.d model)											
km 225-226 DN	**UNIL**	**UNIR**	**UN2L**	**UN2R**	**AL1L**	**AL1R**	**AL2L**	**AL2R**			
AV. rate of det.	1.40	1.15	8.03	4.66	2.87	2.81	3.51	3.56			
Max. rate of det.	3.00	4.00	20.99	22.22	8.00	10.00	14.00	17.00			
Maintenance input guidance	UN1=	Not Req.	UN2=	**Req.**	AL1=	**Req.**	AL2=	**Req.**			

3.4 Brief Summary of results of t.g.d model for Virar Surat section & Agra- Palwal section

S.No.	Km.	Planned maintenance (GMT)		Intervening attention	t.g.d model, av. rate of deterioration of parameters (mm/100 GMT)			
		Limit-1	**Limit-2**	**IA (GMT)**	**UN1L**	**UN2L**	**AL1R**	**AL2R**
Virar Surat section (Results based on 11 TRC runs held between Mar-5 to Aug-08)								
1	253-254	61	66	39	1.63	3.95	1.80	2.27
2	255-256	51	55	13	2.36	6.62	2.47	3.33
3	226-227	47	49	19	1.4	8.03	2.87	3.51
4	235-236	45	52	21	1.94	4.06	2.05	3.12
5	254-255	37	49	22	2.0	5.04	1.97	3.37
6	225-226	32	42	24	2.17	6.8	2.96	4.43
7	227-228	26	41	17	1.65	5.52	2.68	3.07
8	227-226	14	20	12	2.94	10.76	4.24	6.83

9	236-235	4	19	5	2.87	9.08	2.79	4.18
10	252-251	1	11	3	4.52	15.26	4.77	6.68
Agra- Palwal section (Results based on 06 TRC runs held between Jan-19 to Oct-20)								
11	1355-1354	40	40	22	5.05	6.21	3.01	4.22
12	1356-1355	34	36	11	5.84	7.76	4.36	4.7
13	1400-1399	19	25	13	4.40	6.62	3.60	4.99
14	1396-1395	Immediate	3	Immediate	9.38	15.55	20.41	25.47
15	1398-1397	Immediate	4	Immediate	9.12	13.27	8.75	13.70

Comparison w.r.t different speed bands

S. No.	**Km**	**(speed 130-160 kmph) (In GMT)**			**(speed 110-130 kmph) (In GMT)**			**(Up to speed 110 kmph) (In GMT)**		
		Limit-1	**Limit-2**	**IA**	**Limit-1**	**Limit-2**	**IA**	**Limit-1**	**Limit-2**	**IA**
1.	253-254	43	62	31	61	66	39	68	73	40
2.	255-256	19	48	10	51	55	13	59	63	16
3.	226-227	25	41	17	47	49	19	47	50	21
4.	235-236	10	43	17	45	52	21	45	54	22
5.	227-226	7	16	9	14	20	12	17	21	12
6.	236-235	Immediate	13	1	4	19	5	9	19	5
7.	252-251	Immediate	7	Immediate	1	11	3	3	11	3
8.	1355-54	26	34	19	40	40	22	47	48	25
9.	1356-55	19	30	9	34	36	11	34	42	11
10.	1398-97	Immediate	4	Immediate	Immediate	4	Immediate	Immediate	5	Immediate

4. Conclusion:

4.1 based on limited sample analysis of 10 kms of track on Virar- Surat section, the average deterioration rate (mm/100 GMT) for various parameters is as under

Track Parameter	UN1L	UN2L	AL1R	AL2R
Range(Good track)	2	6-7	2-3	3-4
Range (Bad track)	3-4	11-12	3-4	5-6

(Deterioration rate Unit- mm/100 GMT)

4.2 To improve/ lengthen tamping cycle i.e. to control rate of track geometry deterioration following important issues needs to be monitored:

i) Quality of track at the time of initial laying & during subsequent track renewals
ii) Condition of sub-grade & provision of blanket layer
iii) Adequate availability of clean ballast cushion
iv) Efficient method for isolated spot attention /slack packing
v) Maintenance of track machines
vi) Proper pre tamping, post tamping attentioN
vii) surface defects in the rail i.e. cupped welds, low joints, poor geometry on welds, poor support conditions at the joints
viii) Maintenance of rolling stock including flat tyre
ix) Overloading of freight stock.

4.3 With introduction of predictive maintenance based on t.g.d model discussed in the para-2 & 3 above & by monitoring issues discussed in para 4.2 above, the maintenance input requirement will reduce. By processing the TRC run data, t.g.d model will give clear idea at what stage planned maintenance (of a km) & intervening attention (of block of 200 m track) is required. This will save requirement of frequent tamping, requiring tamping machines, traffic blocks & ballast.

In a section if existing tamping cycle is one year, if it becomes 1.25 years with introduction of t.g.d model / predictive maintenance, there will be 20% saving in tamping action. One tamping action per km costs Rs 3.5 lacs approx., in terms of saving in tamping (Rs 50,000 per km), traffic block (Rs 1.0 lacs per hr.) & ballast (Rs 2 lacs for 100 cum ballast).

The saving to Indian Railways, by introduction of predictive maintenance by adoption of t.g.d model & monitoring issues discussed under para- 4.2 above on a route of 1500 km length (with assumed saving of 20% tamping requirement) is expected to be (20% per annum x 3.5 lacs per km tamping cost x 1500 kms) Rs 10 crores (approx.) per annum.

5. Future approach/ Way ahead:

i) The conceptual t.g.d. model developed, as discussed in this paper, is to be used for developing a separate module in existing TMS software, to introduce predictive maintenance on selected routes of Indian Railways, on trial basis.

ii) The conceptual t.g.d model which is specific for a km, based on past TRC run performance, is to be further co related with:

i) Age of track components spl. a) Ballast b) Rail c) Blanketing thickness
ii) Track features such as a) condition of formation good/ bad, b) stretch type i.e. block section / station yard c) magnitude of changes in subgrade stiffness, d) straight/ curved track
iii) Quantum of maintenance input in terms of a) average tamping cycle, b) av. manual attention frequency, c) average ballasting frequency, to develop universal t.g.d model, wherein by giving input values of above variable / parameters, average & maximum deterioration rate can be predicted without using data of last TRC runs.

<u>References:</u>

1. Indian Railway P.way manual (IRPWM) (Published in June-2020)
2. ORE(Office for Research & Experiments of the international Union of Rlys) D-161 &117 report
3. Modern Railway Track (Second Edition) by Coenraad Esveld
4. Project on t.g.d Model by Ramesh Pinjani, & SK Jain (2009).

I had rather excel others in the knowledge of what is excellent, than in the extent of my power and dominion.

Alexander the Great

■ ■ ■

Increasing speed of passenger trains to 130/160 KMPH on existing track

R K Bajpai* / Anil Choudhary **

Abstract : *Indian Railway has decided to raise the speed of passenger train to 160kmph in existing track. Zonal Railways have already initiated move in this direction and proposal for first phase of raising speed from existing 110 kmph to 130 kmph are being prepared and sent to CRS.*

In speed raising of trains in existing track one of the important and critical parameter is the radius of curvature of existing curves. The technical requirements of other associated parameters such as Transition length, cant, cant excess and cant deficiency are also to be ensured for safety of running trains.

In this paper the track aspects specially the suitability of curves and action required to be taken for increasing the speed from110 kmph to 160 kmph has been addressed.

1.0 Suitability of curves for various speed: As per IRPWM the permitted values of cant deficiency (Cd) and cant excess (Ce) are 75 mm. Cd can be increased to 100 mm with permission of CE for higher speed train/section. Curve is a necessary evil to be provided in the track to take it through various obligatory points. The curve is laid between two tangents if a simple circular curve is laid or between multiple tangents if compound or reserve curve is laid in the track. However, the basic principles of track laying are followed in all types of curves.

The maximum speed potential on curves of various degree of curvature is as under (assuming sufficient transition length is available and there is no issue of Ca & Cd)

Table 1

S N	Deg-ree of curve	Radius	Maximum permissible speed with Ca=165 mm Cd=75 mm	Maximum permissible speed with Ca=165 mm Cd=100 mm	Maximum Speed potential with Ca=185 mm Cd=75mm	Maximum Speed potential with Ca=185 mm Cd=100mm
1	0.5	3500	247	260	257	269
2	1.0	1750	174	183	182	190
3	1.25	1400	156	164	162	170
4	1.5	1166.6	142	150	148	155
5	2.0	875	123	130	128	134
6	2.5	700	110	116	115	120
7	3.0	583.3	101	106	105	110
8	3.5	500	93.5	98	97	101
9	4.0	437.5	87.5	91	91	95

for rising of the speed to 160 kmph with goods train running at 75/100 kmph requirement of cant & transition length with limits on Cd and Ce is given in table - 1A and 1B as under :

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Table 1-A For 160 KMPH with goods train running at 75 kmph

Radius of curve (M)	Deg of curve	Required Eq cant for 160 kmph (mm)	Eq cant for goods train at 75 kmph (mm)	AVG of two (mm)	Provi de cant (mm)	Cd (mm)	Ce (mm)	Transition length required (m)
1750	1	201.57	44.29	122.9	120	81.57	75.7	154
1600	1.09	220.47	48.44	134.4	122	98.47	73.5	156
1400	1.25	251.97	65.36	153.7	130	121.2	74.6	166.4
1250	1.4	282.20	62.01	172.1	165	117.2	103.0	211
1000	1.75	352.75	77.51	215.1	185	167.7	107.5	236.8
875	2	403.15	88.58	245.3	185	218.2	96.4	236.8

Table 1B For 160 KMPH with goods train running at 100 kmph

Radius of curve (M)	Deg of curve	Required Eq cant for 160 kmph (mm)	Eq cant for goods train at 100 kmph (mm)	AVG of two (mm)	Provide cant (mm)	Cd (mm)	Ca (mm)	Transition through required (m)
1750	1	201.57	78.7	140.10	140	61.85	61.2	179.2
1600	1.09	235.17	91.9	163.5	160	75.1	68.1	204.8
1400	1.25	251.97	98.4	175.	160	91.9	61.5	204.8
1250	1.4	282.0	110.2	196.2	185	97.2	74.7	236.8
1000	1.75	352.75	137.8	245.2	185	167.7	47.2	236.8
875	2	503.93	196.8	280.3	185	218.1	(- 11.8)	236.8

Similarly for raising of speed to 130 kmph with goods train running at 75/100 kmph the data is given in table 2A and 2B.

Table 2A Raising of speed to 130 KMPH with goods train running at 75 kmph

Rad-ius of Curve	Deg-ree of curve	Required Eq cant for 130 kmph	Eq cant for goods train (mm)	Aver-age of two (mm)	Provi-de cant (mm)	Cd (mm)	Ce (mm)	TL Required (m)
1750	1	133.07	44.29	88.68	90	43.1	45.71	93.6
1500	1.166	155.25	51.67	103.46	105	50.7	53.3	109.2
1400	1.25	166.34	55.36	110.85	105	61.3	6.9	109.2
1250	1.4	186.29	62.0	124.15	125	613	63.0	130
1000	1.75	232.87	77.50	155.19	150	82.8	72.5	156
875	2.0	266.14	88.58	177.36	165	101.1	76.41	--
700	2.5	332.67	110.72	221.7	185	147.6	74.27	--

Table 2B Raising of speed to 130 KMPH with goods train running at 100 kmph

Radius of Curve	Degree of curve	Eq cant for 130 kmph	Eq cant for goods train at 100 kmph	Average of two	Provide cant	cd	ce	TL Required
1750	1	133.07	78.74	105.9	90	43.0	11.25	94
1500	1.166	155.25	91.86	123.5	110.5	45.2	18.1	115
1400	1.25	166.34	98.42	132.04	120	16.3	21.5	125
1250	1.4	186.29	110.23	148.02	130	56.2	19.7	135
1000	1.75	232.87	137.74	185.3	160	72.8	22.2	167
875	2.0	266.14	157.48	211.8	165	101.1	7.5	172
700	2.5	332.67	196.85	264.7	185	147.6	- (11.85)	193

It can be seen from above tables that curve upto 1.25 degree (R = 1400 m) has a potential upto 160 kmph provided we permit cant up to 165 mm and Cd = 100 mm and there is no restriction on account of running of goods train at lesser speed. However on calculation it is found that for curve upto 1600m radius the speed potential of track can be maintained upto 160 kmph along with goods train running at 75 kmph (Table No. 1A). Similarly if goods train also start running at 100 kmph then even curve upto radius 1250m will have speed potential upto 160 kmph (table 1 B). However, transition length and cant will require to be changed.

Since the goods train will run at 75 kmph on the same track for, may be another 10-15 years. It would be prudent to redesign the curves suitable for 160 kmph for passenger trains and 75 kmph for goods train.

2.0 Basic principles of curve design and requirement for making the existing curve suitable for higher speed of 160 kmph:

2.1 Radius of curve :- In para 1.0 above, we have seen the limitations of radius of curve for speed upto 160 kmph. Hence wherever the radius of curve is lesser than the required for 160 kmph the curve will have to be redesigned by increasing the radius of curve or imposition of a PSR may be resorted to.

2.2 Cant/Super elevation

Taking the case of a very highly canted curved track. It is possible that a vehicle standing or travelling at a very low speed may overturn about the inner rail. Overturning occurs on account of following two factors.

1. Absence of centrifugal force (due to very slow speed), causing substantial offloading on outer rail,
2. Wind pressure on train due to wind blowing from outside towards inside of curve.
3. Vibration and other disturbing/curving forces.

In consideration of above facts the maximum cant with factor of safety of 3 works out to be 304mm and if we consider winds and apply additional factor of safety of 1.5 , the maximum cant can be about 200mm.

However, in addition to overturning, offloading of outer wheel also plays controlling role when the vehicle start moving on canted track after being stationary. The Y/Q ratio for the outer leading wheel thus become adverse and wheel may mount the rail. Since on flatter curve the force Y i.e. Flange force is less, higher cant can be provided compared to sharper curve where flange forces increase. Keeping all above in to considerations IR has fixed maximum design cant at 165 mm and in exceptional case for high speed it can be raised to 185 mm.

2.3 Cant Deficiency : - Cant deficiency occurs for trains moving at higher speed then equilibrium speed. Limits on Cd depends on three factors.

(a) Safety against overturning

(b) Safety against derailment.

(c) Maintainability and comfort.

(a) Safety against overturning : In case of train moving at higher speed than the equilibrium speeds the excess of unbalanced lateral outward acceleration will tend to overturn the vehicle about outer rail.

On this consideration the maximum permissible cant deficiency is calculated as (with factor of safety of 4)=228mm

(b) Safety against derailment : It can be seen that before condition of overturning around outer rai is reached, the wheel may climb on outer rail and derail. As per C & M -1 report of RDSO for this in case of BG, CD upto 150 mm can be permitted without danger of derailment.

(c) Maintainability and comfort : If higher cant deficiency is permitted than the resulting outward lateral forces will have a tendency to distort the track and alignment. However with close mechanized monitoring this can be detected well in time and corrective action taken. Unbalanced lateral acceleration due to cant deficiency causes discomfort to the passengers. (i.e. Δ P not more than 0.4 to 0.7 m/sec^2), Unbalanced lateral acceleration is related to Cd as under:

Δ P = g x Cd/G ; where g is acceleration due to gravity, G – dynamic gauge

If we workout for G=1750 then range of Cd comes to 71 mm to 125 mm for Δ P = 0.4 To 0.7 m/sec^2

Hence keeping all above in view the cant deficiency has been pegged at 75 mm which can be raised to 100 mm. In our opinion this can be further raised to 125 mm for high speed passenger trains only as axle load in pass train is less.

2.4 Cant Excess : Since in the existing track we have to run goods train running at slower speed, hence cant excess also needs to be accounted while considering the higher speed. The permissible limit of cant excess get dictated by the consideration of permissible excess loading and excess wear on inner rail. We can allow higher cant deficiency if high speed trains are less in numbers and less cant excess if number of goods train is large or equal in number as compared to passenger train, otherwise there will be frequent renewals of inner rail. In general higher values of cant deficiency can be adopted compared to cant excess considering the axle load of high speed passengers train vis a vis low speed goods train with higher axle load. If we increase cant excess then there will be higher level of stresses on inner rails. Keeping these factors in to account IR has allowed cant excess to be 75 mm.

Curving forces are large in small rad curve more cant deficiency should not be allowed in small radius curve.

3.0 Increasing the speed to 160 kmph on existing track for mixed traffic :

From above discussion in para 2.0 regarding cant deficiency and cant excess including maintainability and comfort criteria the possible ways of increasing the speed of trains on existing track with existing rolling stock can be done by following ways.

(1) Increasing the speed of freight trains to 100 kmph (This will increase the permissible actual cant for a given limit of cant excess)

(2) Increasing the limit of cant excess (This will also enable the increase in actual cant but may result in early wear of inner rail if the section has large number of goods trains).

(3) Increasing the limit of actual cant; overturning needs to be checked

(4) Increasing the limit of cant deficiency.

(5) Increasing the speed of freight trains to 100 kmph and realign few curves of sharp radius to permit high-speed for passenger trains.

Option (1) can be used for curves of larger radius provided raising of speed of freight trains does not result in increase in permissible stresses of rails but for smaller radius curve option (5) will have to be resorted. Option (2) & (3) should be resorted if there are very less goods train in section. Option (4) & (5) will have to be adopted based on maintainability criterion & depend if section is having predominantly passenger trains. For this some of the curves will have to be realigned either with increase in transition length or by increase in radius of curve.

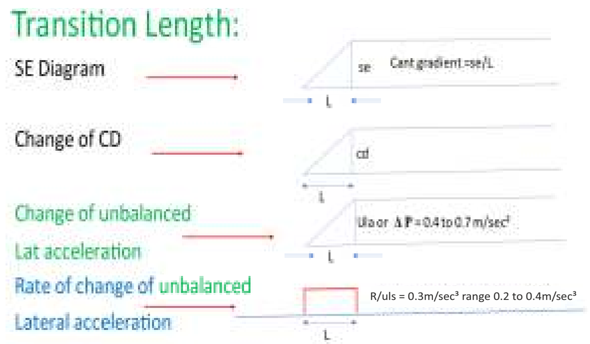
Introduction of Transition and Cant:

In any curve the transition length is calculated from following three equations-

L1 = 0.008*Cd* Vm

L2 = 0.008 *Ca* Vm

L3= 0.72 Ca , the maximum of three above is selected to be provided. Equation 1 and 2 above are based on rate of change of cant deficiency or cant which is equal to 35 mm/sec. This transition length can be reduced by 0.67 times if on Ca/Cd considerations, and half if on cant gradient consideration by increasing the rate of change of cant deficiency/cant to 55 mm/sec and cant gradient to 1 in 360. However for higher speed it would be desirable to keep cant gradient as 1 in 720 with rate of change of Cd / Ca as 55mm/sec, if required, and then selecting maximum of three. The introduction of transition has to be such that at no point the rate of change of ULA(unbalanced lateral acceleration) exceed 0.2 to 0.3 m^3/sec(which corresponds to rate of change of cant deficiency of 35 to 55 mm/sec), though world wide its range is from 0.2 to 0.4 m/sec^{3}The transition length is introduced half in straight portion and half in circular portion of the curve. The transition and cant so calculated are introduced gradually as shown below.



4.0 How to increase the transition length:

When we go for increase in speed we may have to adopt higher cant and cant deficiency for which increase in transition length is required. The steps to be followed are as under:

1. Find the original beginning of the curve:

(a) From curve register find out the length of the transitions on either side, length of circular curve and radius of curve; say they are L_1 , L_2, C and R. Also record all actual versines recorded recently in the register or they can be once again measured at site.

(b) Find $\varphi 1t = L_1/2R$ and $\varphi 2t = L_2/2R$ (these are angles subtended by transition arcs at either end) in radians and convert them in degrees; L_1 and L_2 may be same in most of the cases.

(c) Find deflection angle between tangents,

$$\Delta = 360 \times C/(2\pi R) + \varphi 1t + \varphi 2t$$

(φ1t & φ2t in degree) ....(1)

Cross check this calculated delta with existing curve on ground as below

$$\sum V = (c/2)^*(\Delta/2) = c\Delta/4 \quad \text{or,}$$

$$\Delta = 4x(\sum V)/c \quad ....(2)$$

where c is chord length for measurement of versine. If there is difference between the two angles so calculated above, then take the angle based on field measurements of versine as calculated in equation (2)

(d) Establish the correct beginning of original circular curve on ground; The distance from intersection point to the beginning of circular curve is given as (ref Fig 1)

$$TL = R \tan \Delta/2,$$

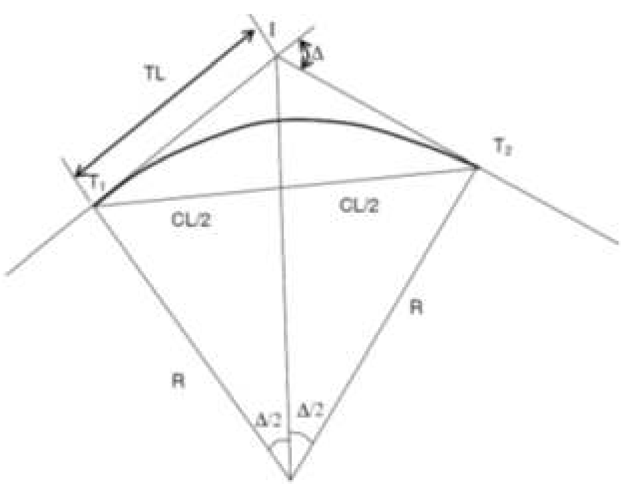


Fig. 1

and correct beginning of TPTC1 i.e. beginning of transition curve(Ref Fig.2) is given as

$$TL1 = (R + S1)\tan \Delta/2 + L1/2;$$

Similarly correct ending of curve from intersection point TPTC2 will be given as

$$TL2 = (R+S2) \tan \Delta/2 + L2/2,.$$

Correct intersection of two tangents can be established with the help of total station. For this one has to establish minimum two good points on either side of two tangents on straight portion and then plot the tangents on drawing sheet to establish the intersection point and also deflection angle on drawing sheet. There after the correct beginning and end of circular curve can be located on drawing sheet which ultimately to be transferred on ground.

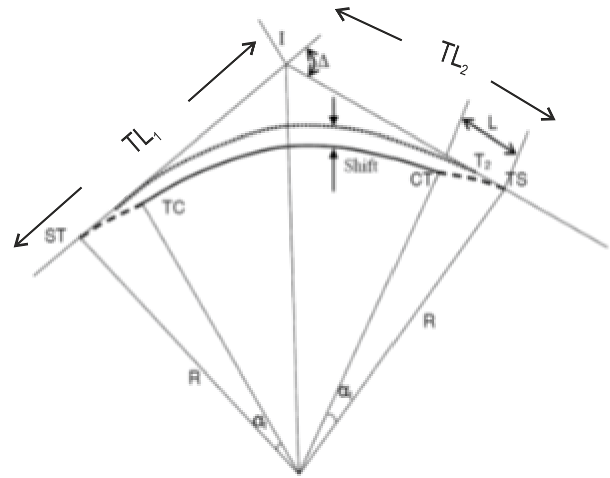


Fig. 2

Correct beginning can also be established by optimization method and with available versine record as detailed in IRICEN book on curve by going for ROC of existing curve.

2. Introduction of increase in transition length: After locating correct beginning and ending of the circular curve then increased transition should be introduced half on straight and half on circular part of the curve which will result in additional shift of curve.

3. Work out the additional shift and check the feasibility and repercussion of such shift on ground for any infringement etc. as under;

Additional shift towards inside will be

$S = (L^2)new/24R - (L^2)old/24R$, the shift in transition part of the curve can also be located station wise by y2-y1 i.e = $x^3/6\,RL1 - x^3/6\,RL$. This is better calculated by use of software as explained later.

5.0 How to increase the superelevation : Increase of superelevation can be done by usual methods of machine tamping or manually depending on the quantum and site condition.

6.0 How to increase the Radius of curve : Increase in radius involve downward shifting of the entire curve. Refer fig below;

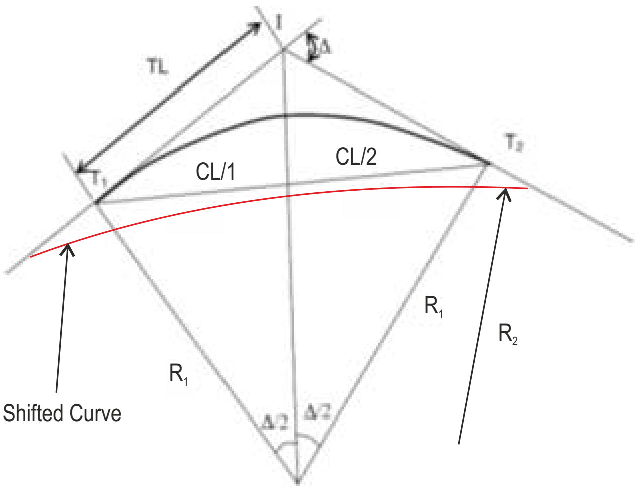


Fig. 3

The shift of curve at apex will be;

$= (R_2 - R_1) \text{ Sec } \Delta/2 + (R_1 - R_2)$ ....(3)

Altogether a new curve is to be laid if shift is large.

Steps to be followed.

1. Work out the correct location of start and end of circular curve as explained earlier
2. Calculate revised transition length with proposed speed and new proposed radius of curve.
3. Calculate new tangent length TL for the proposed curve and locate correct new beginning and end of curve. Also workout the shift at apex as per equation (3) above and at every point on curve so as to asses the feasibility of laying the realigned curve.

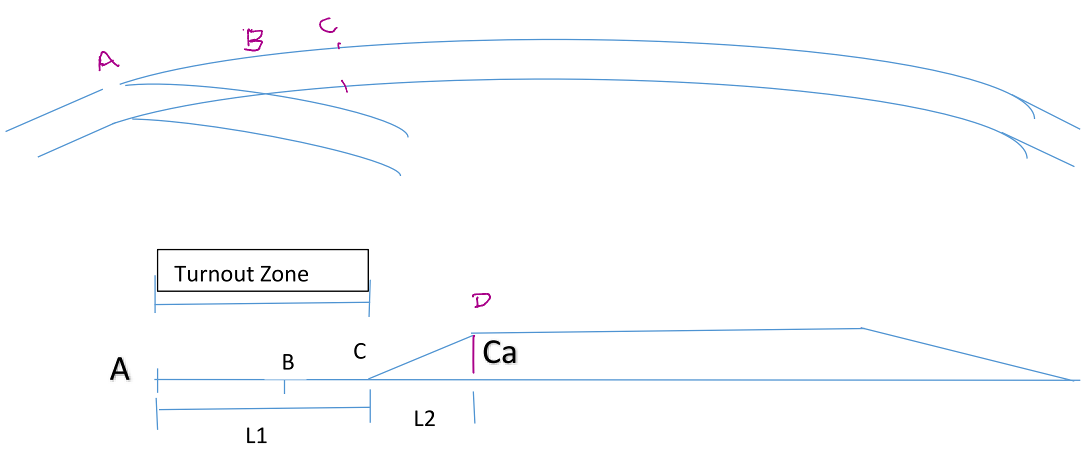
- Finding shift from original curve in transition portion:
- Ox1 = $x1^3/6R2\ L2$ similarly we can workout other offsets.
- At point 5 the shift is calculated as
- Ox5' = $x5^3/6R2\ L2 - x1'^3/6R1L1$
- Likewise workout the shift at each station to decide further course of action. Or go for complete laying of new curve If shits are large. In case shifts are large either the formation has to built up or a new formation altogether needs to be constructed. This is better done by use of software as explained later.

7.0 Constraints in Increasing the speed:

(a) Points and crossing taking off from curve : There are few yards where track is on curve and points are taking off from curve. On locations where points take off from circular part of the curve the speed potential will be determined based on whether points are taking off from symmetrical or contrary flexure by usual methods and observing the provisions of SOD and IRPWM depending on resultant radius of lead curve and the cant which can be provided on main line.

However, there are situation when points are situated in transition part of the curve. Though as per IRPWM normally turnout should not be provided taking off from transition on safety and maintenance considerations. However, for existing such locations there can be mainly following three situations.

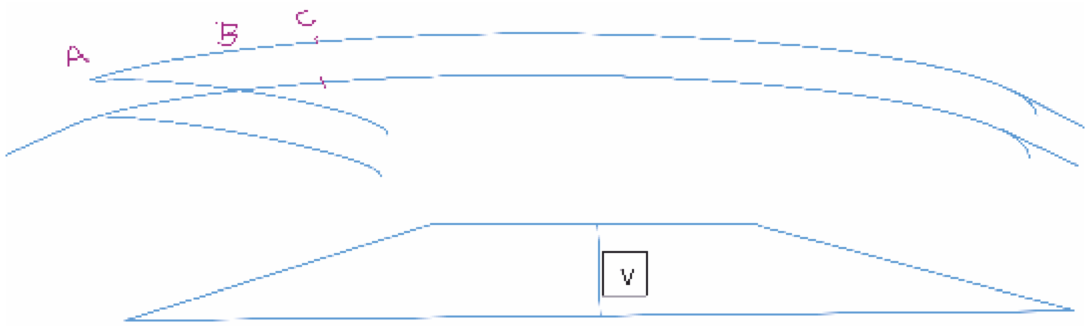
1. Turnout taking off from beginning of transition : In this case the provision of cant will begin only after 20 m from TNC as shown in fig. below.



In above situation transition starts from A, crossing nose lies at B and hence we cannot provide any cant between A-C (which is equal to 20m + SRJ to ANC + 20m) and whatever possible with allowable cant and rate of change of cant deficiency in C-D portion that much cant can be provided in L_2 portion. Length AC i.e. L_1 is termed as turnout zone (which is equal to 20m + SRJ to ANC + 20m) Let L be length of transition so that L= L_1+L_2. The Ca which can be provided in L_2 is calculated by solving;

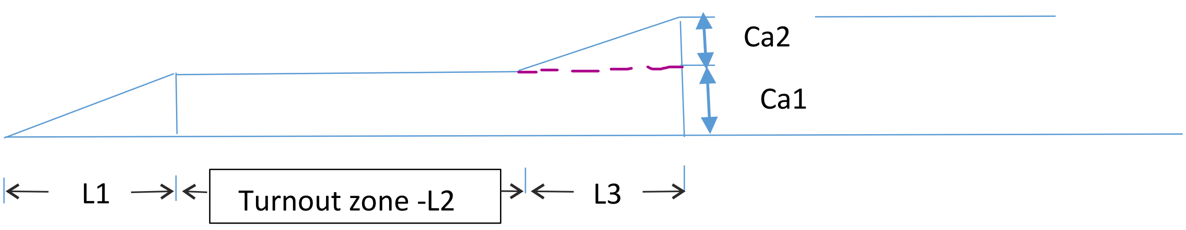
$$\frac{55 * L2 * 3.6}{Ca} = 0.27\sqrt{R(Ca+Ca)} \text{ taking } Ca = Cd$$

This calculated Ca should not be more than Cg + 75, where Cg = G*V²/127R and Cd = Ca but not more than 75/100 as permitted. Then the speed would be calculated as V= 0.27 √R(Ca+Cd). Versine diagram will be as under:



Versine Diagram

2. Turnout taking off in between transition : In this case the turnout zone as defined above fall un between the transition length. Hence cant whatever feasible at approach of turnout zone in transition part will be continued over turnout zone also and the possible cant diagram will be as under:In this case the Ca1 and Ca2 will be calculated as under:



With Ca1 = Cd1, using formula below calculate Ca1,

$$\frac{55 * L1 * 3.6}{Ca1} = 0.27\sqrt{R(Ca1+Ca1)} \text{ taking } Ca = Cd$$

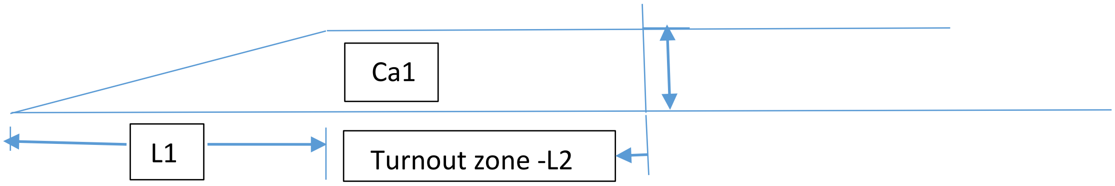
Using the similar formula calculate Ca2 in L3 length,

$$\frac{55 * L3 * 3.6}{Ca2} = 0.27\sqrt{R(Ca2+Ca2)} \text{ taking } Ca2 = Cd2$$

Then calculate speed using Cd = Cd1+Cd2 provided Cd1+Cd2 is less than 75/100 as permitted.

$$V = 0.27\sqrt{R(Ca1+Ca2+Cd)}$$

3. Turnout taking off from end of transition :



n this case the cant can be provided only in L1 zone. Provide Ca = Cd in this length as per following formula;

$$\frac{55 * L1 * 3.6}{Ca} = 0.27 \sqrt{R(Ca+Ca)}, \text{ calculate Ca}$$

Calculate V = 0.27 √R(Ca+Ca), this Ca should be less than Cg+75 and if Ca comes out to be more than 100 mm then Cd should not be taken more than 100 mm.

8.0 Obligatory points restricting Realignment / shifting of curve : As discussed in above paras sometimes we may go for increase in transition or radius needing shift of curve. But curve may have obligatory points such as bridge ROB, FOB, Yard etc. where shift may not be accommodated. In such cases if shift is of small values may be upto say 100-150 mm can be adjusted by realigning the curve with the help of ROC software so that slews at such locations are restricted. Otherwise we may have to go for imposition of PSR or rebuilding the structure if the cost involved is less by cost benefit analysis.

9.0 Mistakes or confusions that field official encounter in field : following common mistakes people may commit in calculating the speed potential or provision of cant etc. in field.

1. Taking Cd as 75/100 mm without consideration of rate of change of Unbalanced lateral acceleration or rate of change of Cant deficiency and calculating the speed potential.
2. Taking Ca in small portion of available transition length at 1 in 360/720 cant gradient and working out the speed potential again without consideration of rate of change of cant or cant deficiency in small transition length.
3. Taking Ca whatever is calculated based on available transition on one end or the other end because of existing turnout in transition portion and extending same cant beyond turnout upto end of such transition and bringing down the cant thereafter in straight portion. By doing so not only we are providing cant excess to all trains at approach of curve without getting any advantage in speed potential as speed potential does not improve by doing so, as it fails in rate of change of cant deficiency.
4. Providing change of cant in circular portion of curve immediately after transition so as to gain additional cant and then calculating speed with increased cant and Cd also as 75/100 or Cd as calculated for available transition. This is also not possible as it results in excess of Cd or rate of change of Cd in transition portion.

Software for designing curve and for increasing speed

I. Brief on what software can do :

A software on curve has been designed by IRICEN and loaded at IRICEN website and has following provisions:

- Designing a new curve of known Radius, Fastest train speed (Vmax) and Speed of Goods train(Vg).
- Estimating Speed of existing curve (Known R,Ca,Vg,Vmax) and increasing speed (by changing R, L and Ca)
- Shifting at different locations of existing curve to design curve
- Speed potential of M/L curve with Points and crossing

The calculation and flexibility given to designer in deciding his curve is explained below in brief:

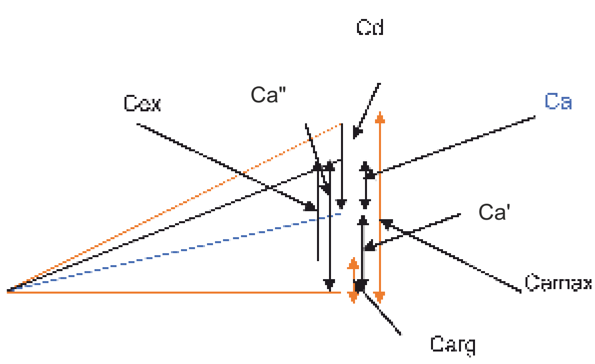
A. Designing a new curve of known Radius, Fastest train speed (Vmax) and Speed of Goods train(Vg) :

i. Speed and Cant on Circular portion of curve is calculated as below:

- Find equilibrium cant (Camax) for the maximum sectional speed (Vmax)
- Find minimum cant (Ca') that can be provided for this fastest train- Calculated by deducting the cant deficiency (Cd) from equilibrium cant
- Find cant required (Carg) for booked speed of goods trains.
- Add cant excess (Cex) and find out the maximum cant permissible for goods train (Ca").
- The cant (Ca) to be provided shall be between the two values computed above.

Two situations may arise

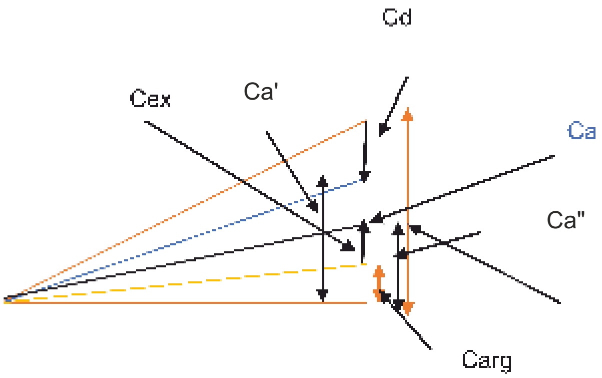
a. Case-1 when Ca">Ca'



In this case Ca can be provided between the limits of Ca' and Ca". By keeping it closer to Ca' i.e on lower side we will have more Cd encountered by fast moving trains and less Cex encountered by slow moving goods train. If kept close to Ca" i.e on higher side, we will have less Cd encountered by fast moving trains and more Cex encountered by slow moving goods train. Accordingly a judicious decision on cant can be taken based on whether it is primarily goods carrying or Passenger carrying and accordingly Ca can be provided for some speed in between i.e Veq, for maintaining proper balance between Cd and Cex as per requirement.

b. Case-1 when Ca"< Ca'

In this case, Ca can be provided maxm upto Ca". This is going to restrict the speed of trains to maximum for this cant .



B. The length of transition is calculated for this Ca , Vmax permitted and actual Cd (by recalculating encountered) using the formulas :

$L_1 = C_a * V_m / R_{Ca}$

or

$L_2 = C_d * V_m / R_{Cd}$

or

$L_3 = C_a / i$

Where Rca and RCd is taken as 35 mm/s and i as 1 in 720. The transition length should be taken as maxm of the above and be in multiple of 10.

The minimum transition length permitted under limiting case shall be for Rca and RCd as 55 mm/s and i as 1 in 360 .

Based on my requirement, for known R, Vmax, Vmin and Ca , Length of transition is calculated, thus designing of curve is completed.

The software gives the best curve parameters for achieving maxm speed at minimum cant.

C. Speed of existing curve (Known R,Ca,Vg,Vmax) and increasing speed (by changing Ca,L and R):

For an existing curve i.e known Radius(R),Vgoods (Vg), Maxm speed of train(Vmax), Cant (Ca) and Length of transition (L).If transition lengths are different at both end of curve, minimum of the two will be taken for calculation process. Speed potential will be calculated separately for curve and transition length i.e

a. Speed potential of circular curve (Based on maxm Cd) i.e **Vm1**

b. Speed potential of given transition length based on permitteed Rca and Rcd.

$L = C_a * V_{m2} / R_{Ca}$ **or**

$L = C_d * V_{m3} / R_{Cd}$

i.e

V_{m2}= (L*Rca)/Ca and Vm3= (L*Rcd)/Cd

The minimum speed (Vm1,Vm2 and Vm3) gives the speed potential of the curve as a whole.

Two situations may arise:

i) Transition length may be of sufficient length and it is the circular curve (R and Ca) which decides the speed potential of curve. *Many times we have margin to increase the cant to increase the speed potential of curve till Vm1 remains deciding speed.*

ii) Transition length is insufficient and it restricts speed potential of curve as a whole. That means Vm2 or Vm3 is less than Vm1.

There is always a scope of getting best speed potential by reducing cant in such situations. This can be understood by seeing the relation between Vm1, Vm2 and Vm3. As Ca is reduced, Vm1 reduces i.e speed of circular curve is reduced but speed potential of transition length due to Rca i.e Vm2 increases and speed potential of transition length due to Rcd i.e. Vm3 is reduced as Cd for fastest train is increased.

So best Ca is when speed is obtained such that:

Speed on circular curve=Speed potential of Transition

And speed potential of transition is best when Ca=Cd as can be seen from the formula of Vm2 and Vm3.

Knowing this cant (Ca), speed potential of existing curve can be increased by simply reducing the existing cant by properly balancing speed potential due to Vm1,Vm2 and Vm3.

The software gives the option

a. To increase and reduce the existing cant to find the possibility of increasing speed.

b. It also suggests that, for same R, what maximum speed can be obtained by simply increasing L and Ca.

c. Based on the suggestion, a new curve can be decided with all flexibility i.e increase/decrease only cant, increase cant and L keeping same radius or all together a new curve with even changed radius. The curve speed potential is simultaneously given for reviewing curve parameters and increasing speed further.

D. Shifting of existing curve to design curve:

Normally we take final curve to be laid to the ideal geometrical profile. There can be two situations as far as existing curve is concerned:

a. When versines of existing curve at each station is not known but deflection angle of tangent line/total length of curve/sum of versines (either of these three are known).

Here the software can be used to get the shift at crown and shifting of start and end of curve.

b. When versines of existing curve is known and shift at each station is required. Here again two situations may arise

- The Original curve start and last station is known. This helps in placing the design curve symmetrically about original layout.
- If original curve detail is not known, in that case, the software takes C.G of versine diagram of existing curve to place the final curve equally about that station.

The software accordingly gives Final versine, Shift at each station after some adjustment in versine of final curve to get best curve. The result can be down loaded in excel format. The R,L,V of final curve is also shown in the excel sheet.

E. Speed potential of M/L curve with Points and crossing.

The software gives solution to T/o taking out from curve in symmetrical and non symmetrical manner. The T/o in curves restricts the cant that can be provided in M/L as speed on T/o is less and cant that can be provided on T/O is restricted. Since sleepers of M/L and T/o is common, this limits the cant that can be provided on M/L.

a. Symmetrical T/o case: Cant that can be provided for M/L is

$$Ca=Ct+Cex$$

Here Ct is cant required for T/o calculated for resultant lead radius on T/o . Cex is cant excess that can be provided to vehicle negotiating T/o. This helps in getting maxm cant for M/L

The speed potential of M/L shall be calculated for (Ca+Cd).

b. Asymmetrical T/o case: Cant that can be provided for M/L is

$$Ca=Ct-Cd$$

Here Ct is cant required for T/o calculated for resultant lead radius on T/o . Cd is cant deficiency that can be provided to vehicle negotiating T/o. This helps in getting maxm cant for M/L

The speed potential of M/L shall be calculated for (Ca+Cd).

The software gives this speed potential for 1 in 8.5, 1 in 12, 1 in 16 and 1 in 20 T/o in symmetrical and asymmetrical layout.

II. Software explained:

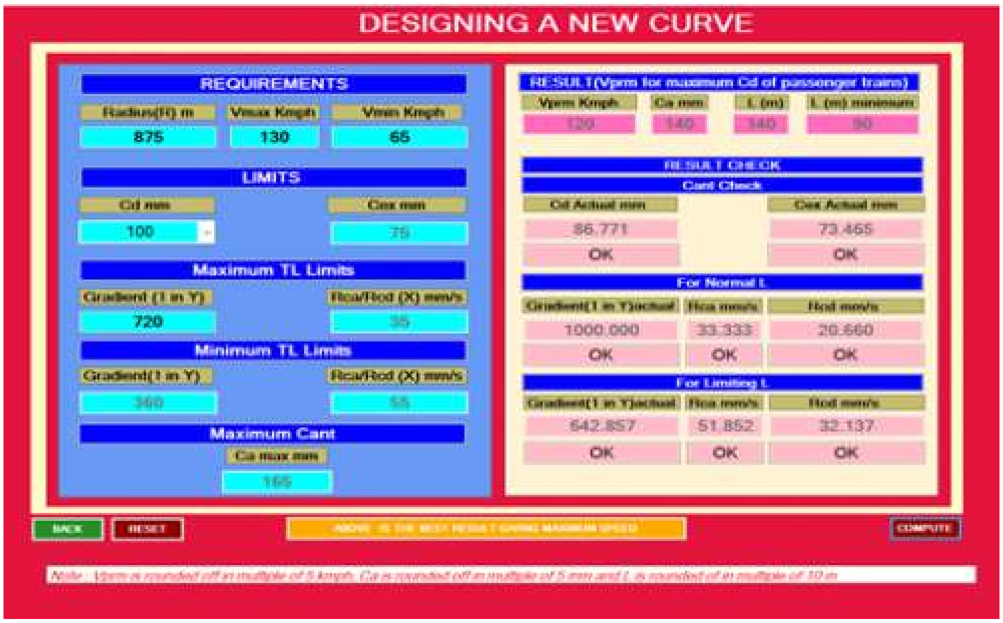
a. Home screen:

Contains three options, Designing a new curve, Speed on existing curve, increasing speed and shift of revised curve, Speed on curve with pts and crossing as shown below

b. Designing a new Curve:

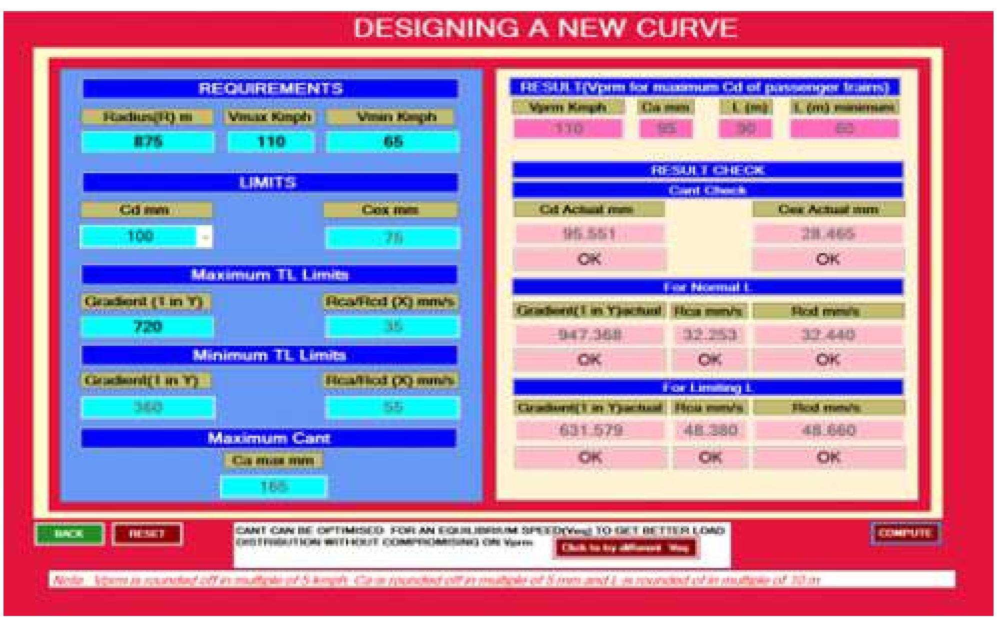
Software asks for Radius,Vmax and Vmin. In addition other limiting parameters like Cd,Cex, Cant gradient and Cant maxm permitted are to be entered. The software gives maxm speed achievable and corresponding Ca and length of transition taking full Cd. Checks like actual Cd and Cex is also given for satisfaction of user.

e.g Design curve of 2 degree (R=875 m) for carrying train at max speed of 130 Kmph and Goods speed of 65 Kmph :



Max speed permitted is 120 Kmph, Ca=140 mm, L=140m (min 90m). Thus SR of 120 Kmph will be imposed on the curve and that is the best speed achievable.

If the Vmax is taken as 110 Kmph, the design parameters as calculated is given below:

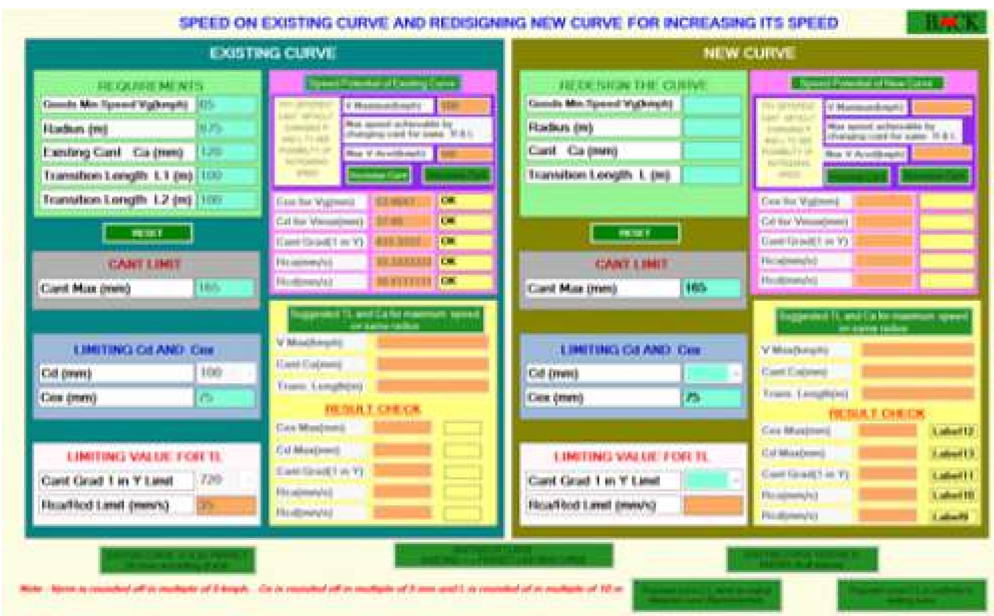


Maxm speed of 110 Kmph is achieved but Cd is 98.551 and Cex is 28.465 mm. The software suggets that Cex and Cd can be balanced by choosing cant for some speed in between Vmax and Vmin. In this example say I try to balance Cex and Cd for speed say 90 Kmph.The result will be:

So Cd becomes 60.551 and Cex 63.465. However in the process, length of transition and cant has also changed. The designer has flexibility to decide final curve.

c. **Speed of existing curve and increasing speed:**

Say I have as existing curve with R=875m, Ca=120mm,L=100, Vg=65 Kmph. The software calculates the speed as 100 Kmph.



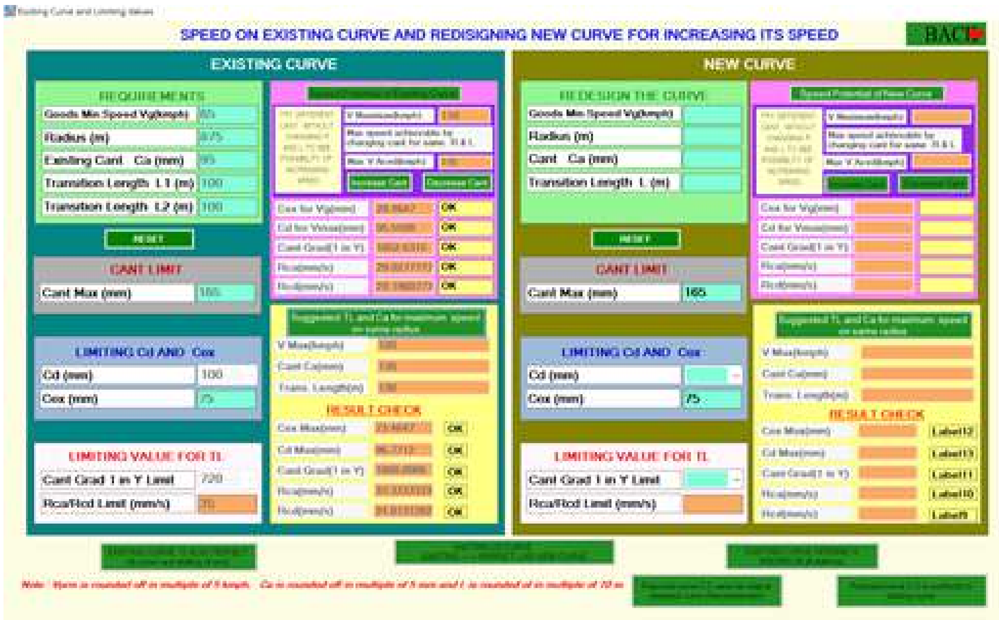
Easiest thing in a curve is to increase/Decrease cant to check if speed can be increased by adjusting cant. Using Increase/decrease button, cant can be modified . In the process, software keeps record of maxm speed achieved as max V Acd.

In the present case it is found that speed can be increased to 110 Kmph by reducing cant to 95 mm.

The software also suggests that by L and Ca can be increased to 130 m and 130 mm without changing R for achieving speed of 120 Kmph.

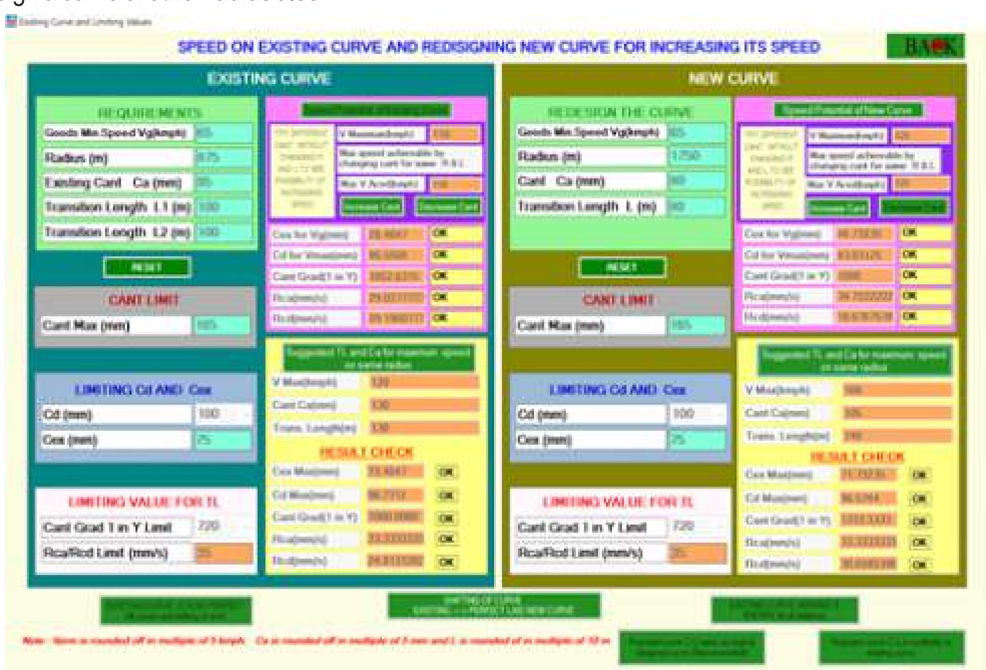
So the designer has option of increasing speed upto 120 Kmph by changing L to 130 m and Cant to 130mm. However we have flexibility to design a curve of other radius also.

Say in new curve calculation, radius chosen as 1750m and cant abruptly is kept as 80 mm and L as 80 m.Speed achieved is 125 Kmph.

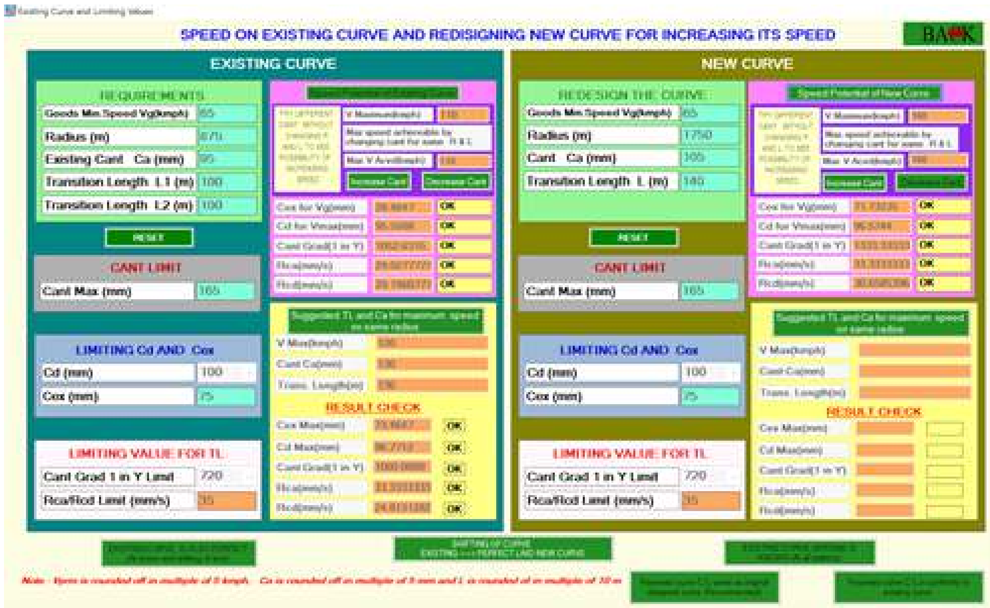


So the designer has option of increasing speed upto 120 Kmph by changing L to 130 m and Cant to 130mm. However we have flexibility to design a curve of other radius also.

Say in new curve calculation, radius chosen as 1750m and cant abruptly is kept as 80 mm and L as 80 m.Speed achieved is 125 Kmph.



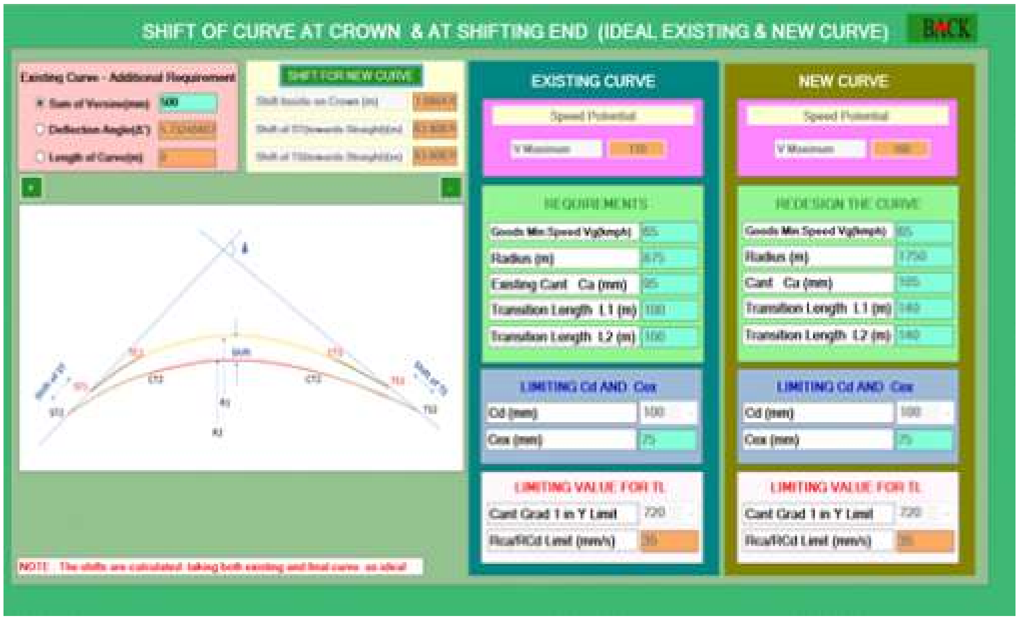
The software suggests L as 140 m and Ca as 105 mm for getting maxm speed for same radius which in this case is 160 Kmph. The designer should thus keep L as 140 m and Ca as 105 mm in new curve as entered below.



Once the new curve is decided, the shift of curve from existing to new can be calculated

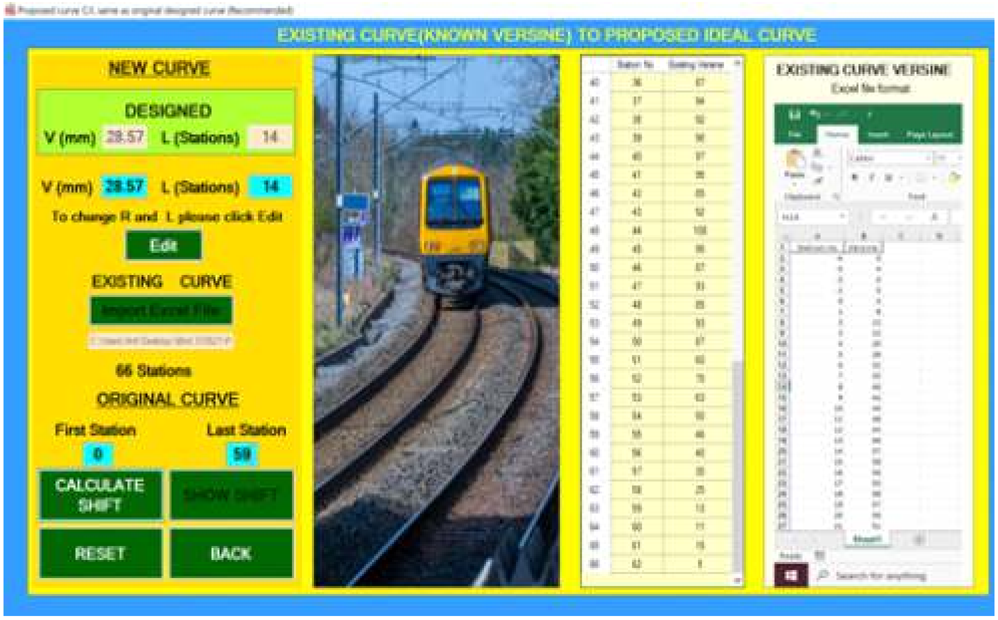
d. **Shift of curve :**

i) If we know the total length of curve or deflection angle between tangents or sum of versines, the shift of curve will be calculated at crown and shift of ST and TS will be given by software for ideally laid Existing and New designed curve . Say sum of versine is 500 mm, the curve shift will be 1.08 m at crown and shift of ST and TS wil be 63.8 m as shown below.

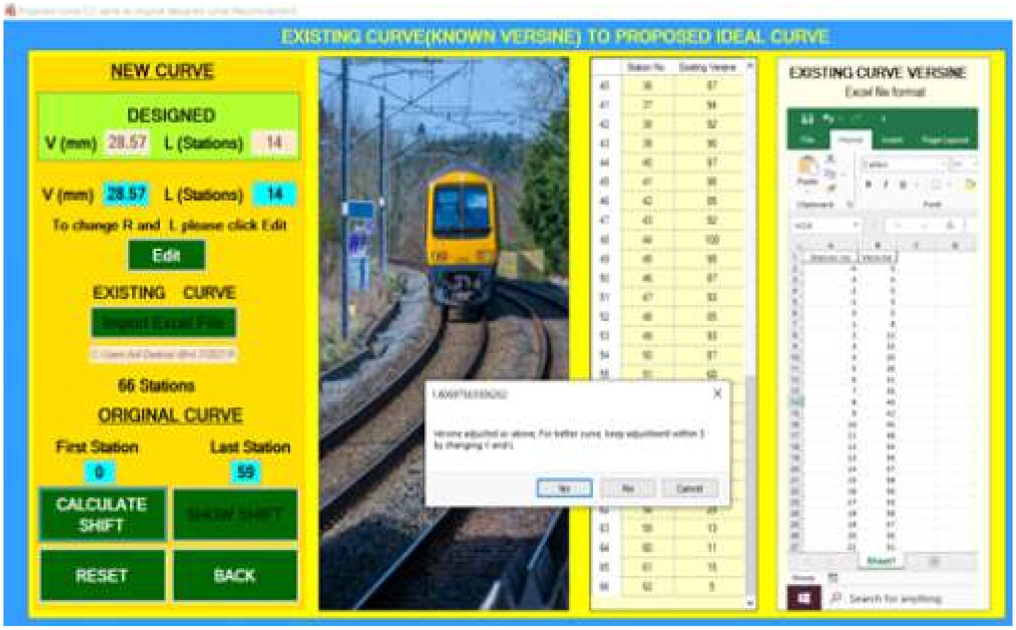


ii) If existing versine is known, the data file can be made in excel and shift of existing curve can be calculated for two situations:

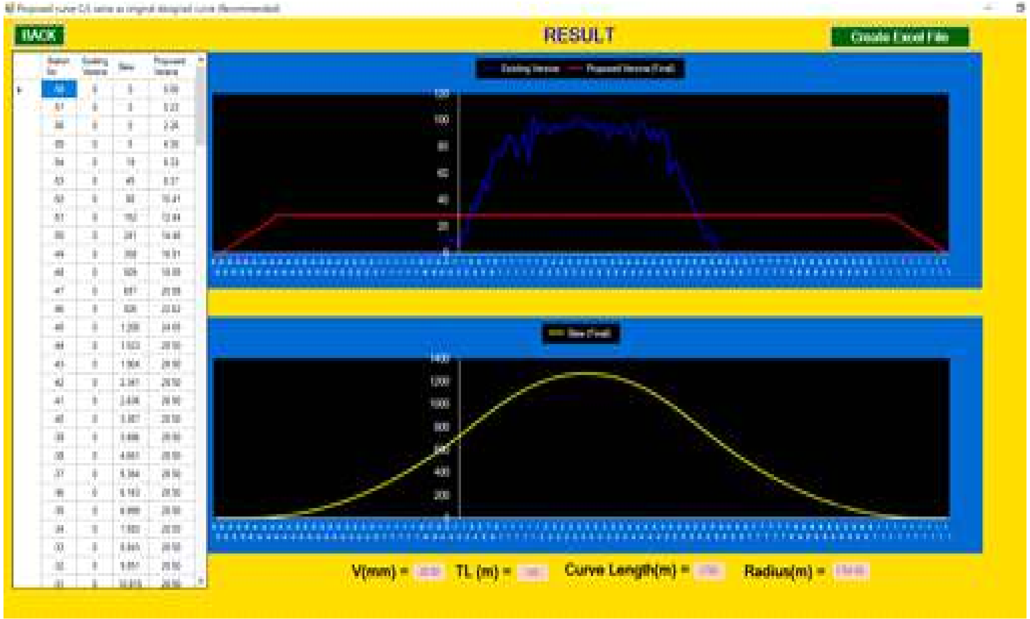
a. The original stations known and proposed curve is about C/L of that original curve: Say the original curve stations were 0 to 59 and measurement of versine is done from station -3 to 62 and an excel file is created.The format of excel file of existing curve is give on screen itself. The new curve versine is taken by software and existing curve in excel format is imported.The first and last stations of original curve is also entered before software calculates slews.



The software suggests that for better curve, a correction factor displayed should be kept below 3.



This is only suggestion. In this example it is less and acceptable so we can proceed by clicking yes. The result will be displayed as below



The result can be taken in excel as below giving versine and slews at every station including shifting of start and end of curve is tabulated.

Station No.	Existing Versine	Proposed Versine	Slew		
-58	0	00.00	0	V(mm)	28.5
-57	0	00.23	0		
-56	0	02.26	0	TL(m)	140
-55	0	04.30	5		
-54	0	06.33	19	Curve Length(m)	1750
-53	0	08.37	45		
-52	0	10.41	88	Radius(m)	1754.58
-51	0	12.44	152		
-50	0	14.48	241		
-49	0	16.51	358		
-48	0	18.55	509		
-47	0	20.58	697		
-46	0	22.62	926		
-45	0	24.65	1200		

b. If original curve details are not known the above calculation is done using CG of existing versine as centre of revised curve.

e. Speed on curves with Points and Crossing:

For this only, Radius or Degree of main line curve is to be entered, the speed will be calculated by the software for both similar and contrary flexure as the case may be

In the above case of 1 in 12 in similar and contrary flexure, the speed will be 115 Kmph and 100 Kmph respectively on M/L.

Conclusion: From the foregoing discussion it becomes clear that though raising of speed may be desirable in existing track but will have to be achieved by observing all technical, practical and maintenance considerations including the cost benefit analysis. One easy way to increase the speed to some extent can be achieved by increasing the cant deficiency specially for high speed train to 125 mm which can be done without any effect of comfort and safety. For modifying the existing curves specially the longer curves or the curves with obligatory points the efforts required and the cost involved should be properly worked out. An idea of speed potential of existing curve and efforts required to increase the speed in existing track by realigning/redesigning can be assessed with help of software which has been uploaded in IRICEN Website for the same purpose. Suggestions for further improvements from readers are most welcome which can be mailed to bajpai@iricen.gov.in and anil.ptm2@iricen.gov.in

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"Value Mapping the Processes in Modernization of Bridge Workshop, Lucknow"

By : Qazi Mairaj Ahmad

Abstract : *Scenario of Industrial Development in the Country is set to take the 'Atma Nirbhar' course. Even the Public Sector Organizations have to evolve and shed their extra baggage. With Corporatization in a big way is on the anvil, every Organization, whether in Public Sector or Private Sector, has to go through the rigors of Principles of Management, outlined through Leadership, Operations Management, Operations Strategy, Business Models and Quality Management etc. These Principles have to be implemented at Ground Zero for them to fructify and to extract the benefits for the Organization.*

Primary reasons for various problems, which troubles one unit is generally common over all Indian Railways Engineering and Bridge Workshops; as such, the course for corrections and applications of Principles of Management are also similar.

2. Introduction of the Problem

For the Project Work, the areas identified are

- To identify the areas of improvement in Prioritization and Scheduling of Tasks as per Work Orders received,
- Value Mapping the Processes involved, improving effectiveness & efficiency of Operations and Cost Control,
- Making a Monitoring and Control Mechanism as part of the Enterprise Resource Management,
- Re-engineering for Quality Control and Modernization of Bridge Workshop, Lucknow.

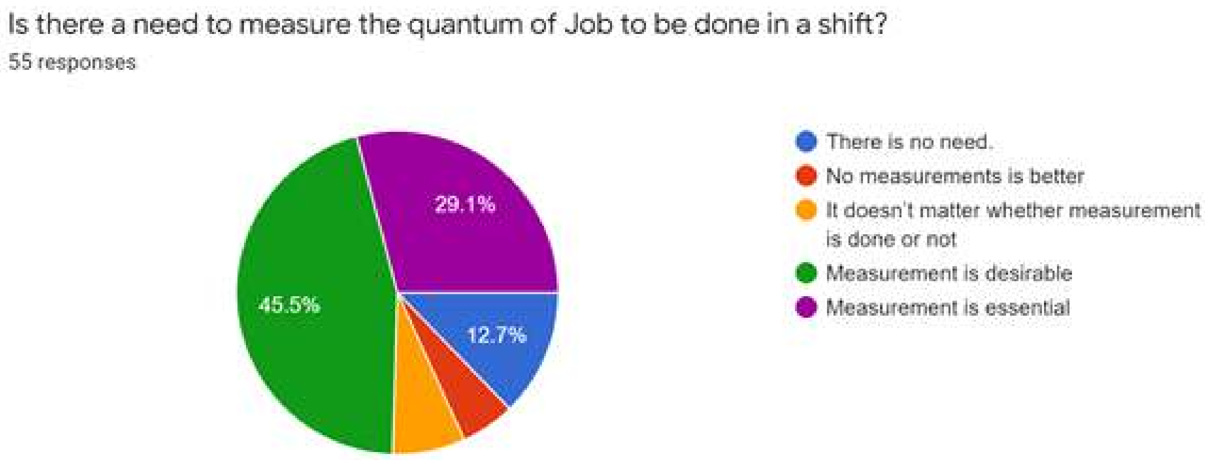
3. Methodology

The survey of the 9 Railway's Engineering Bridge Workshops and Private Steel Fabrication Workshops was undertaken & the response of 55 respondents has been analyzed and elucidated in this Report.

4. ANALYSIS

4.1 Need for Monitoring and Planning

Issue No 1 :



There is an overwhelming response of about 74.6 % of the respondents stating the need to determine the quantum of job to be done and measuring the performance, in a shift.

At Bongaigaon, Manmad and some other workshop, a metrics based on experience is in practice.

A versatile App **"Setu"** is indigenously developed by the Bridge Workshop Lucknow, hosted on Google Play Store (Keywords : Setu, RK Official, Bridge Workshop Lucknow) which empowers Stakeholders for tracking the various Work Orders and live Fabrication Progress through the various tasks for completion.

There is a strong case for pre-deciding the quantum of actual works, based on Drawings, which may be prepared along with the Cut List, to be displayed in the Monitor at each WorkShop Floor. The actual work done performance data may be fed as soon as the work is done at the Shop Floor itself.

Issue No 2 :

Is there a need to schedule the various activities in a calendar schedule?

55 responses

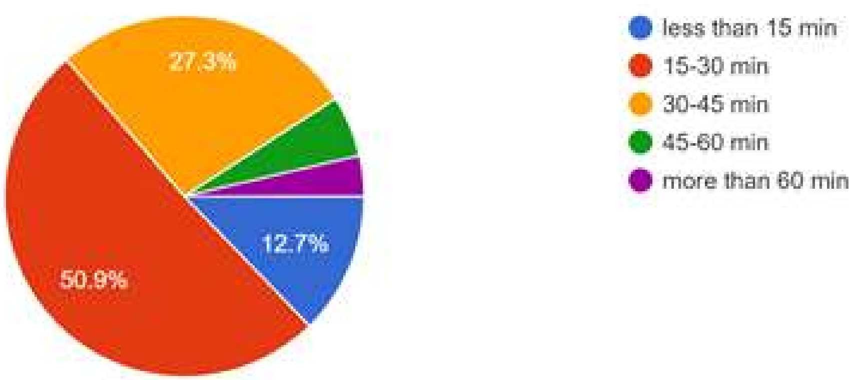
Around 84% agree that Scheduling of various Jobs or Work Orders in a year is a MUST. Accordingly, the Work Orders need to be organized in terms of their priority. At the Bridge Workshop Lucknow, Work Orders were pending for long, thus priority would be to clear the backlog and organize the Work Orders in specific order with the calendar of activities.

4.2 Avoidance of Wastages

Issue No 3 :

How much time is lost by other workers at the Workshop, on an average, at the start of a shift before the actual start of a job?

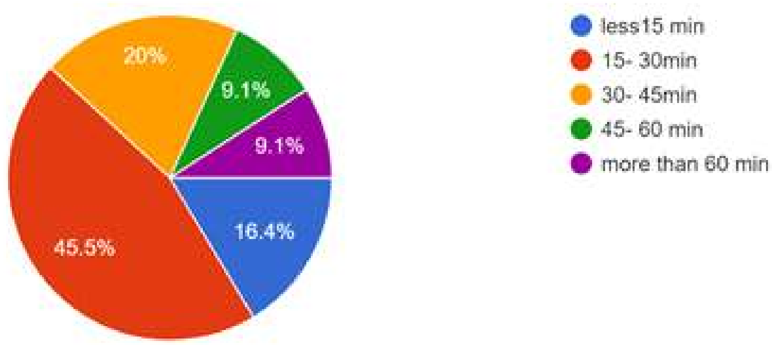
55 responses



Issue No 4 :

The next job is taken generally by other workers, if there is still a margin available at the end of a shift?

55 responses



Total wastages more than 15 min upto 60 min & beyond add up to 87.3% before the start of the working and 83.6% at the end of the shift duty. Besides, it has also been noted that there are wastages around 30 min in the name of Tea-break. Thus around 90 min (1 and half hrs) is lost from productive working. As a first step, an awareness for increasing productivity has been sought to be instilled by frequent inspections and checking the attendance and entry process.

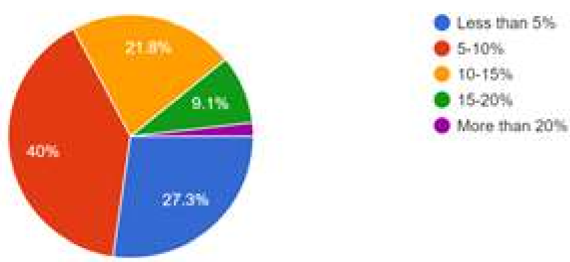
As per Railway Servant (Hours of employment)Rules 1961 upto 30 minutes period at the start of the shift is included in the hours of Employment.

It is recommended that use of Technology may be used and attendance based on Face -recognition for contactless handling at the start and end of shift may be carried out for maintaining integrity of the system.

Issue No 5 :

According to you, how much percentage is lost in wastage, rework and scrap?

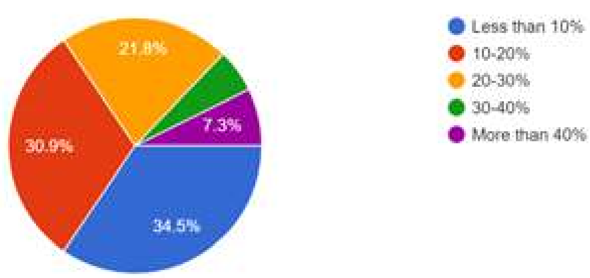
55 responses



Issue No 6 :

According to you, how much cost reduction in overall process is possible?

55 responses



In response to Question No 5, it is noted that 32.7% feel that there is a loss of more than 10% due to Wastages, Rework and Scrap etc. In response to Question No 6, more than 65% feel that Cost reduction in the overall process to the tune of more than 10% is possible, which itself would be quite significant and lead to substantial realization in monetary terms!

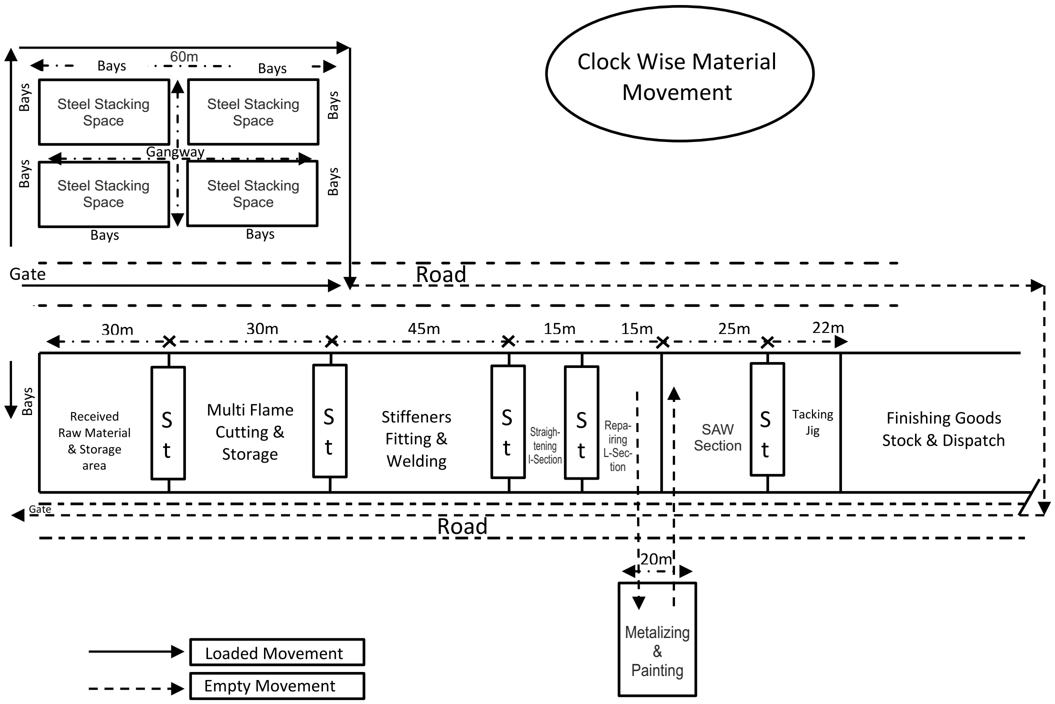
At BW Lucknow, first sequencing of activities has resulted in reduction of working times. In a case of 12.2m Plate Girder, by proper sequencing of activities, the time required for Complete Fabrication from receipt of Work Orders through Templating upto dispatch after completion has been reduced from earlier 40 days to 28 day; thus a reduction of 30% time happened.

ERP Enterprise Resource Planning is required to be implemented at the Workshop level, for Optimization of Activities and overall time.

Enterprise Resource Planning (ERP):: Bridge Workshop, Northern Railways, Lucknow Observations regarding the present Process Proposed Layout

Inbound

1. For avoiding minimum movements, the Fabrication process is to be made unidirectional avoiding criss-cross movements.



Outbound

Dispatch area to be made with proposed least movement for finished goods from Exit Gate.

PROPOSAL For changes in Planning Process

Material

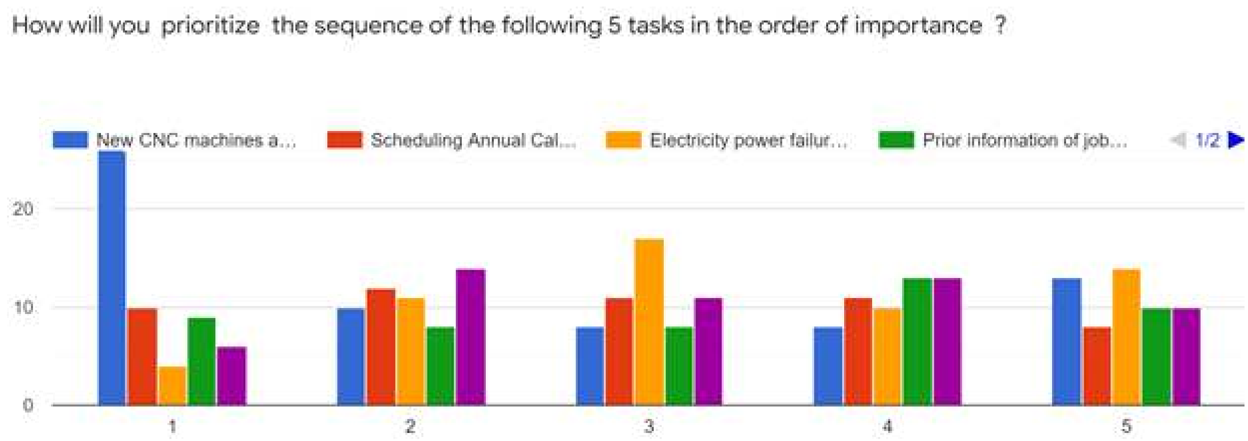
1. It was observed that stock qty of 150 different parts is maintained. Standardization should be done to bring the total type of metal.
2. Work Order Plan to be prepared on a monthly horizon.
3. Review mechanism to be prepared for monitoring the stock of inventory levels on monthly/quarterly basis for orderly management.

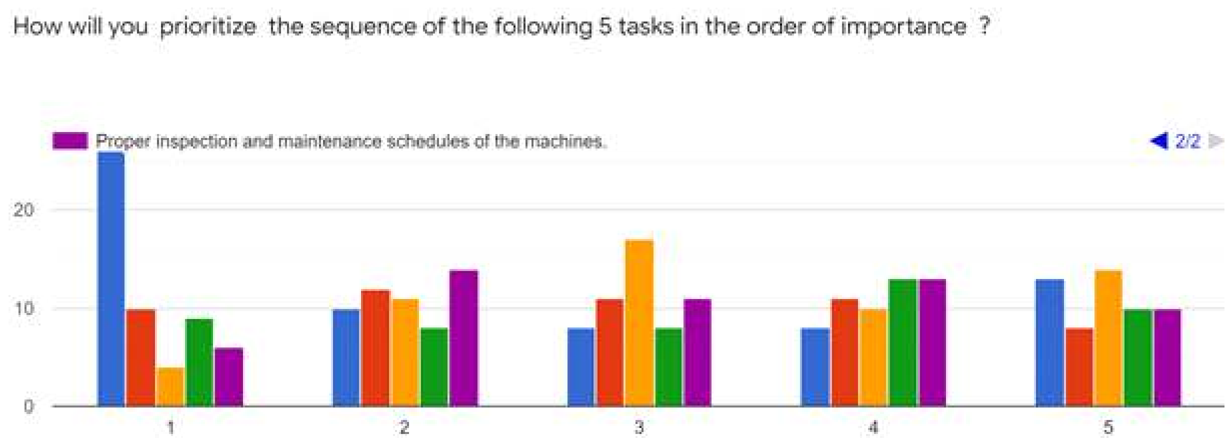
Manpower

4. Mapping of locational level load capacities (manpower, production capacities, present production plan) for managing distribution of the tenders for meeting the additional/peak requirements.
   a. Ensuring non-delays in the tenders with automatic allocation to the nearest location for optimal capacity utilization
   b. For any additional requirements, no manpower needs to be shifted to the other locations. Contract based employees can be hired at locations for meeting the increased requirements.

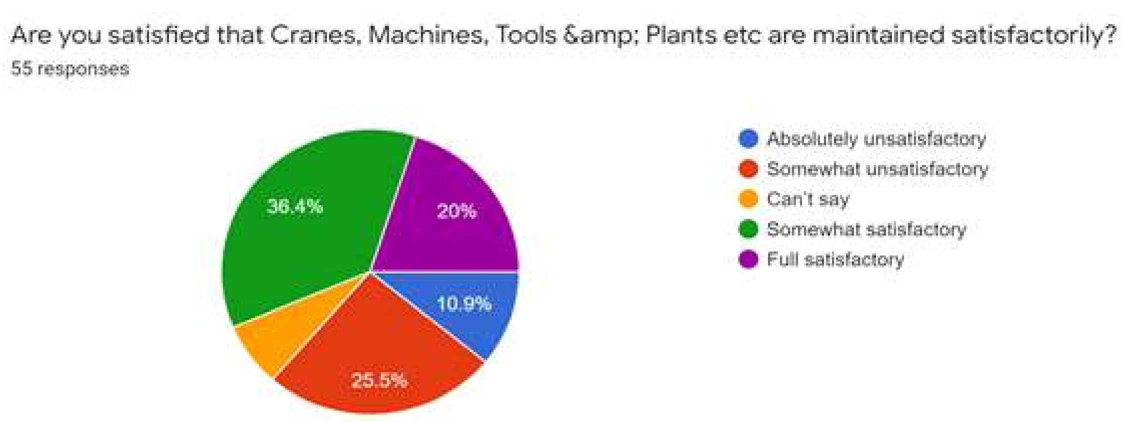
4.3. Prioritisation of Issues

Issue No 7:





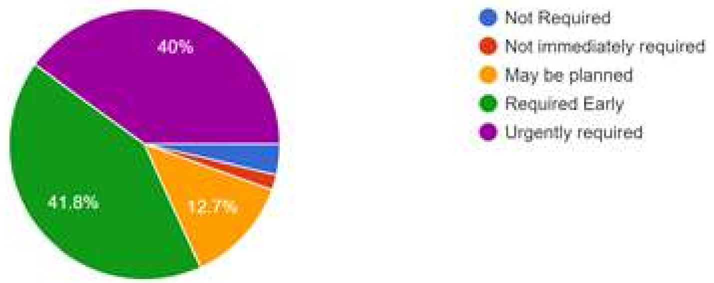
Issue No. 8 :



Issue No. 9 :

How important is the implementation of Modernization and procurement of New CNC Machines/ T&Ps?

55 responses



As per analysis, procurement of new CNC Machines and Modernisation of the Workshop alongwith matching Information Technology and Electrification.is the Foremost requirement, which are being procured under sanctioned work.

Second most Important work to be undertaken is with respect to overhauling & maintenance of existing Machines and T&P, EOT Cranes etc. Sudden breakage fails the entire system, while planned inputs in maintenance enhances the longevity of the Machines. Each Machine is required to be Technically Inspected, and Immediate & Planned attentions including maintenance schedule, need to be worked out.

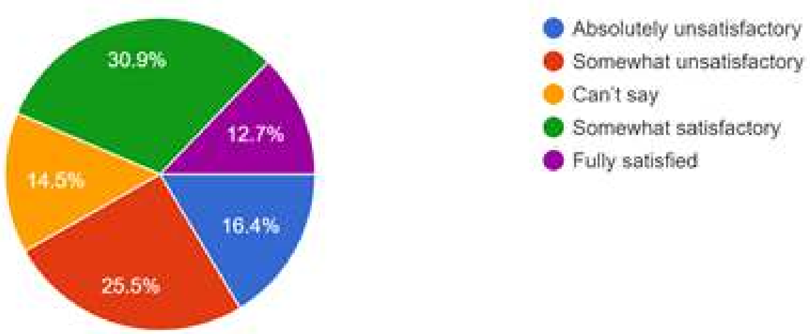
Third most Important Work highlighted during the Survey has been irritants like repeated failure of power supply almost on a daily basis. Failures of Electric Supply during working creates precious loss of productivity of working hours, besides creating Quality Assurance issues. Necessary measures to ensure regularity of the supply need to be taken. On a few of the occasions, there has been disruption to power supply for a longer duration due to shutdown taken by Railway CPH. Preventive Maintenance during Night/Holiday working may be organized to avoid such cases.

4.4. Material Procurement Policy and Training Requirements

Issue No 10 :

Are you satisfied with the Material Procurement Procedure adopted at the workshop?

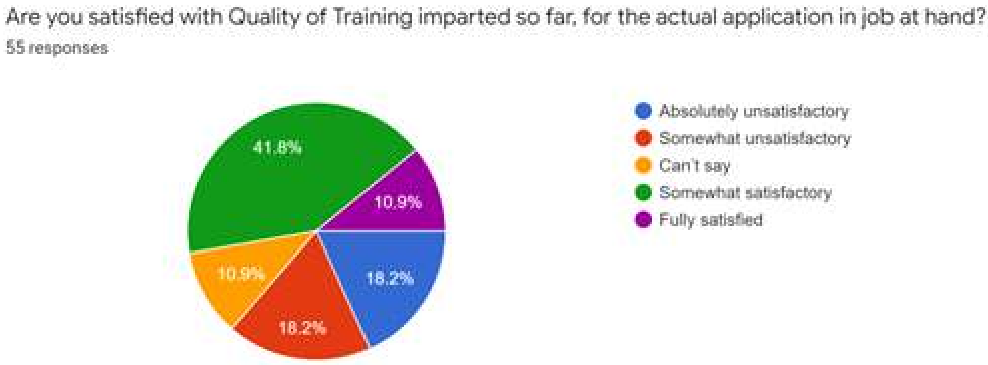
55 responses



Steel sections are being procured while the direct correlation between requirements for the year and the supply process may not be existing.

Indian Railways have implemented Material Management System through iMMS (Integrated Material Management System). It is imperative and urgently desirable that the iMMS is comprehensively implemented at Bridge Workshop, Lucknow at the earliest, for the updating and monitoring of the Inventory maintained at the Workshop.

Issue No. 11 :



It is found that only 10.9% respondents are fully satisfied with the training process, rest other 89.1% have found a gap in Training Process to varying degrees.

The Training being imparted for Northern Railway Bridge Supervisors and Staff has components:

1. Initial Course :
2. Promotional Course:
3. Refresher Course :
4. Special Course:

However, it is found that Training procedure is not being implemented rigorously by different field units and there is a difference in requirements of Training needed for different Staff and Supervisors and the actual performance.

It is found that the planning of Training requirements for various strata of the Staff is quite upto the mark, yet it is the implementation of the Planning, which requires the attention. Each and every Staff needs to be examined for his training needs, depending upon length of his career, frequency of Refresher requirement and impending exposure to New State of the art Machines.

A monitoring system is recommended to be developed for determining the efficacy of Training Modules, so as to cover the entire spectrum of Staff and Supervisors. Training has to Machine and Task Requirement Specific and Efficacy will be responsibility of concerned Heads of Workshop units.

5. CONCLUSIONS AND RECOMMENDATIONS

1. The primary work to be done for improvement in working of Bridge Workshop is implementation of Modernisation of Workshop Works, including the Enterprise Resource Planning. This includes early procurement, installation and commissioning of T&P, Machines, Electrification Works and Information Technology Works.
2. Second Most Important work is to organise the Maintenance of various Machines. This will create reliability of the operations, instill safety and confidence in the working.
3. Third Most Important Work is to look into the frequent power or Electricity failure . After implementation of the Electricity related works pertaining to Modernisation of Bridge Workshop, there has been enhancement in the reliability of availability of Electricity. However, the State Government Electricity Deptt needs to be pursued for bringing down the failure rates at their level.
4. Then after, the Task of Prioritising Work orders, knowing the importance of scheduling Work Orders and developing the monitoring mechanism, needs to be done. The App "SETU' developed for memberwise monitoring and updating needs to be used extensively. Further, the App and the hardware for task-wise monitoring and updating at the shop floor itself would expedite the ERP implementation.
5. Implementation of Contactless Face-recognition Entry Mechanism based may be carried out for greater availability of working time.
6. Close Monitoring of Material and Inventory Management System need to be done. It requires urgent implementation of iMMS at BWS, Lucknow.
7. Implementation of Training Management Module, particularly emphasising the Training for New Machines.

■ ■ ■

Redesigning Cover Over Platforms New Design Adopted at Habibganj During Redevelopment of the Railway Station

Vivek Bhushan Sood* / Baldev Singh**

Abstract : *Cover over platforms (COP) is an important structure that serves to provide protection from rain and sun to the passengers. In addition, the COP structure also helps in providing electrical fixtures, signages for trains/advertisements, providing solar cells, running cables etc. An important requirement of COPs is that there shall be no space for birds to sit so that the passengers are not discomforted on this account. Being in passenger area, aesthetics are very important aspect. This paper presents the approach followed for redesign of COP at Habibganj railway station, which is the first station taken up for redevelopment on PPP mode on Indian Railways. The authors have been associated for over 2 years with the project execution on behalf of IRSDC.*

1. Introduction : On 1st March 2017, Habibganj station entered the annals of history as the first station handed over by Indian Railways on PPP mode to private developer. M/s Bansal Pathways Habibganj Private Limited (BPHPL), the developer, had bid a premium of Rs 1.36 lakhs over the mandatory project cost of Rs 100 Cr for the station. In lieu, the Developer has got concession for 12 lakh square feet of Built Up Area for 45 years and the obligation for Operation & Maintenance of Habibganj railway station for 8 years. Habibganj is one of the over 110 stations which are under planning currently for redevelopment under the massive program that Ministry of Railways have been trying to launch. Work on the project is going on at full swing and soon enough, we are going to witness the first redeveloped station on Indian Railways.

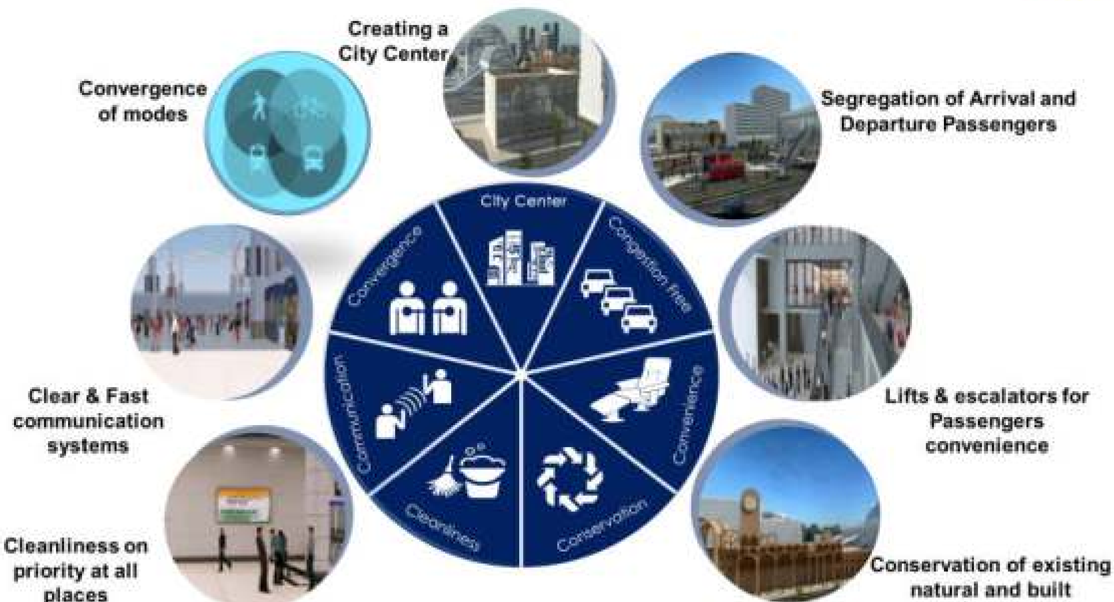
3-D view of the proposed Habibganj railway station; actual site photo during construction

	Planning	Detailed Design	Proof Check	MEPF Proof Check	Green Building Consultant
Consultants	M/s GMP Gmbh – a German architectural firm along with M/s ICT Pvt Ltd – an Indian architectural and consultancy firm.	M/s AECOM India Pvt Ltd (Architecture + Structure + Services)	M/s Sterling Engineering Consultancy	M/s Pankaj Dharkar Associates	M/s Blue Earth Enterprise

**CGM/Civil/IRSDC New Delhi, **CGM/Projects/IRSDC New Delhi*

2. Rethinking Railway Stations : Redevelopment of Habibganj was an excellent opportunity to rethink the railway station. Essential elements of the design were to provide a 36 m wide and 80 m long concourse which shall be the main waiting area for passengers who have to catch the train as against the current design where most passengers have to wait in semi-open or open areas of platforms and have to suffer the rains, sun, dust, odours etc. Two subways, each 4 m wide were planned for passengers getting down from the train to quickly lead them outside, without conflicting with the movement of passengers who have to board the train.

The ambience of the entire station is being upgraded to airport like standards so that the overall comfort level of passengers is improved and train journeys are a pleasure from the moment a passenger enters railway premises right upto the time she leaves the premises. The plans for the station have been prepared by involving urban planners, traffic planners, architects, station designers, structural engineers and utility experts. The station design is based on concept used for Heidelberg station in Germany. It is planned as an IGBC Gold rated Green building.



3-D view of the proposed Habibganj railway station; actual site photo during construction

3. Redesigning the Cover Over Platform (COP) : Being a unique project, it provided opportunity to innovate and solve the existing challenges differently. The COP was one of the items in which lots of efforts were put in and redesign has been done. The requirements from COP are as follows:

a. To provide shade to the passengers against sun and rain.

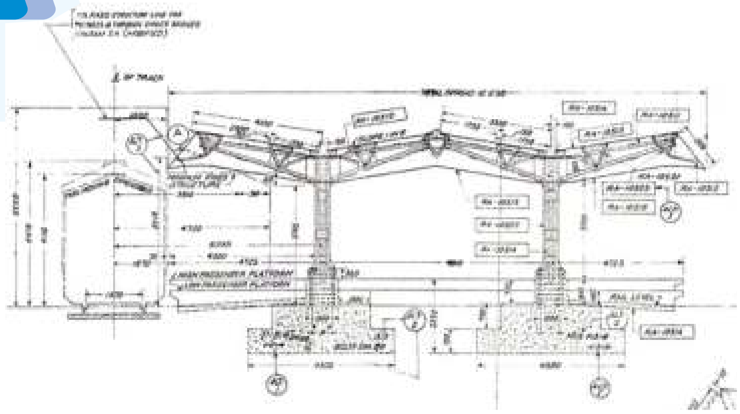
b. To provide arrangement for providing electrical fixtures like fans, lights etc.

c. To provide arrangement for signages – for passenger information as well as advertisements etc.

d. To provide flat surface on which the solar panels can be erected.

e. To be aesthetically pleasing.

4. Existing COP Designs : The most commonly used design on Indian Railways is based on RDSO drawings. It consists of columns consisting of channels, the cantilever arms fabricated from angles and purlins fabricated as triangular elements with angles and rods. These designs are available with structure spacing of upto 16 m and the length of cantilever arm upto 10.80m. For platform width of approx. 16.5m, the existing COP at Habibganj consisted of COP to RDSO drawing no RDSO/B-10409 with two columns and 4.5 m cantilever arm.



RDSO Drawing and actual photograph of existing COP at Habibganj platform no 1.

5. **Why Redesign? :** The Existing RDSO design is robust and time tested, but suffers from a few limitations which were sought to be addressed in the fresh design.

   a. There are lots of spaces allowing birds to sit, which creates problems for passengers in lots of stations.

   b. Due to large number of members, the cleaning and maintenance of the structure is slightly difficult.

   c. Modern aesthetics in malls/airports that are being preferred these days require cladding to conceal elements.

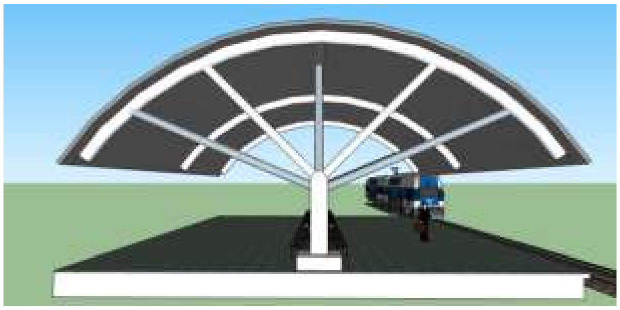
   d. The cladding is not a good solution since the members get concealed and the structural inspections are difficult. Even locating the source of leakages is difficult in clad systems.

   e. The platform width at Habibganj required total span of 18.5 m and it was architecturally desirable to have single column. Single column also required footing at center of platform which left enough space on either side for the passengers to move.

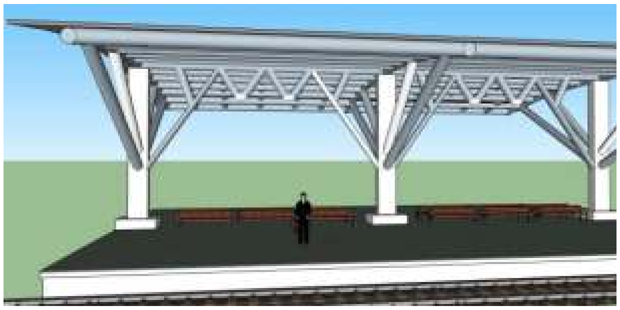
Cladding done to conceal the members of RDSO design Cover on Platform at Chandigarh Railway Station

Design done by Northem Railway with Fewer members and sheefing below the centiliter arms to provide better aesthelics.

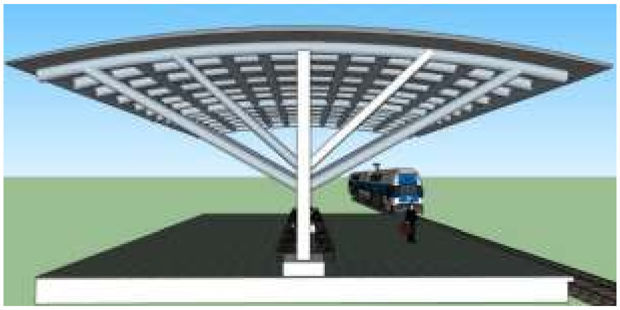
6. **Options considered :** The redesign had the following objectives: Safety, Elegance, Bird Menace Free, Ease of Construction and Innovation. The last objective was added since the Habibganj project is first redeveloped station and innovative design would inspire passengers as well railway people. Having an experienced firm like AECOM on board meant that structural and architectural aspects both could be taken care of in design. The redesign started with a clean slate and different team members came up with different options - over 20 suggestions actually came in and were considered. Few innovative and promising options are given below:



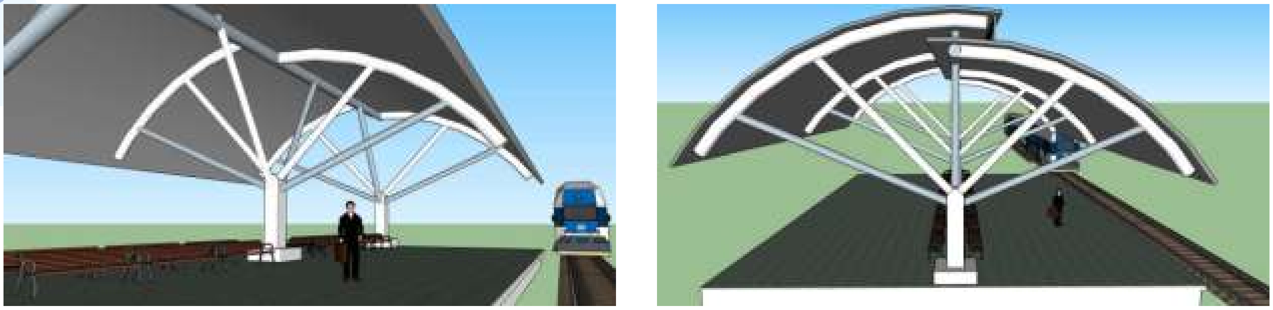
Option 1



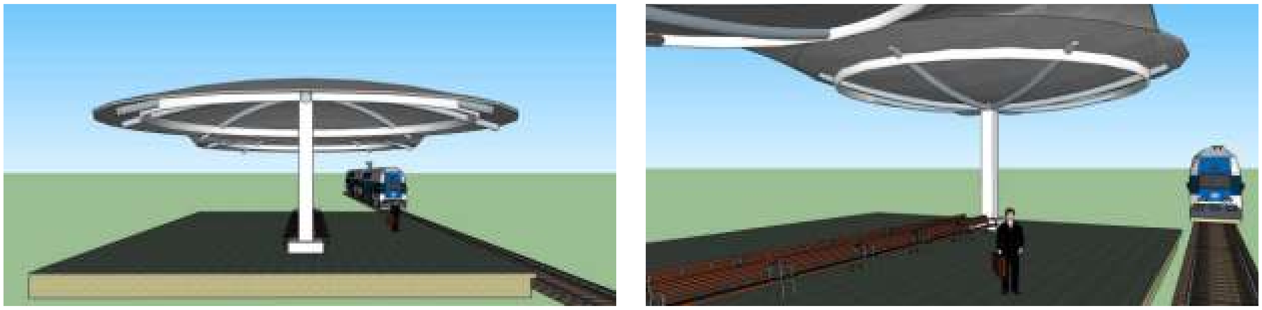
Option 2



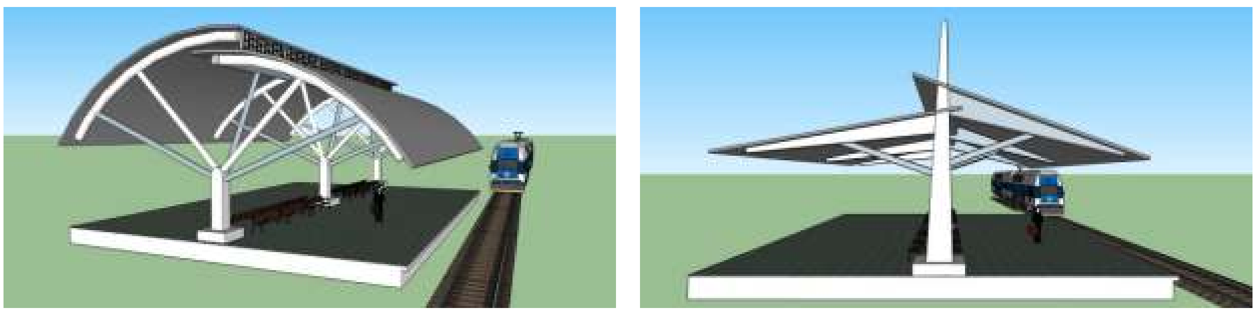
Option 3



Option 4

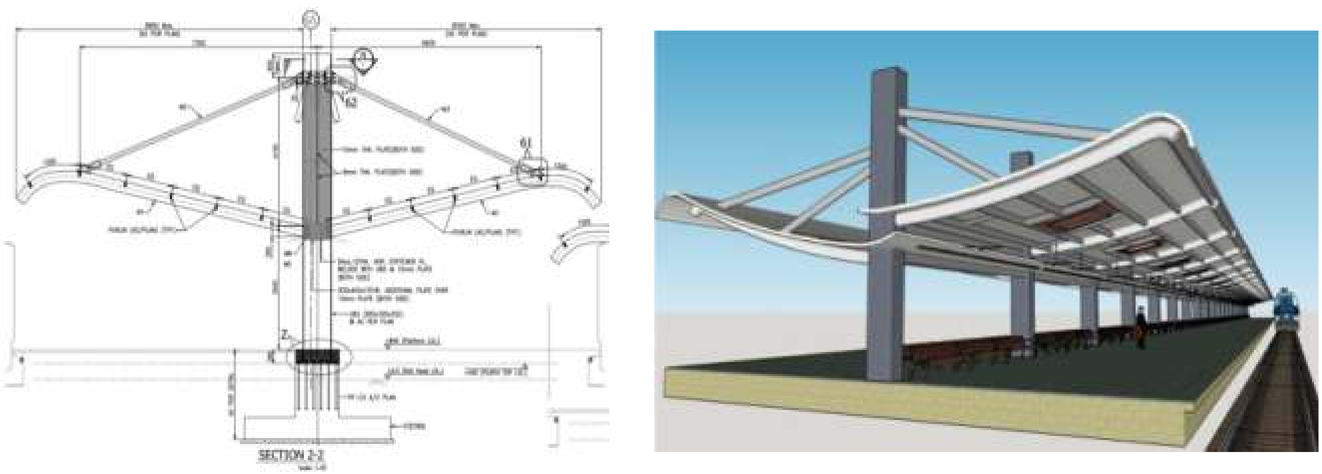


Options 5 & 6



Options 7 & 8

7. **Final Option Chosen :** As the pictures above indicate, the designs submitted were quite innovative and had different strengths. The final option chosen was primarily based on option 8, modified with option 7. The influence of option 4 is also there in the final option chosen. The option chosen was:



The final option with steel I section column, Rectangular closed section cantilever arms and Rectangular closed section stay tubes

This option had the following strengths:

a. The design is structurally robust and architecturally elegant. The lighting in this COP is very effective and pleasant due to absence of too many members.

b. There is no need for cladding and the closed members provided as cantilever arms provide natural elegance. c. There is no space for birds to sit and hence the design shall avoid problems to the passengers on this account.

d. The signages, electrical fixtures, coach indicators, advertisement screens/panels etc can be easily hung with the cantilever arms for which small rings were already provided in the cantilever arms.

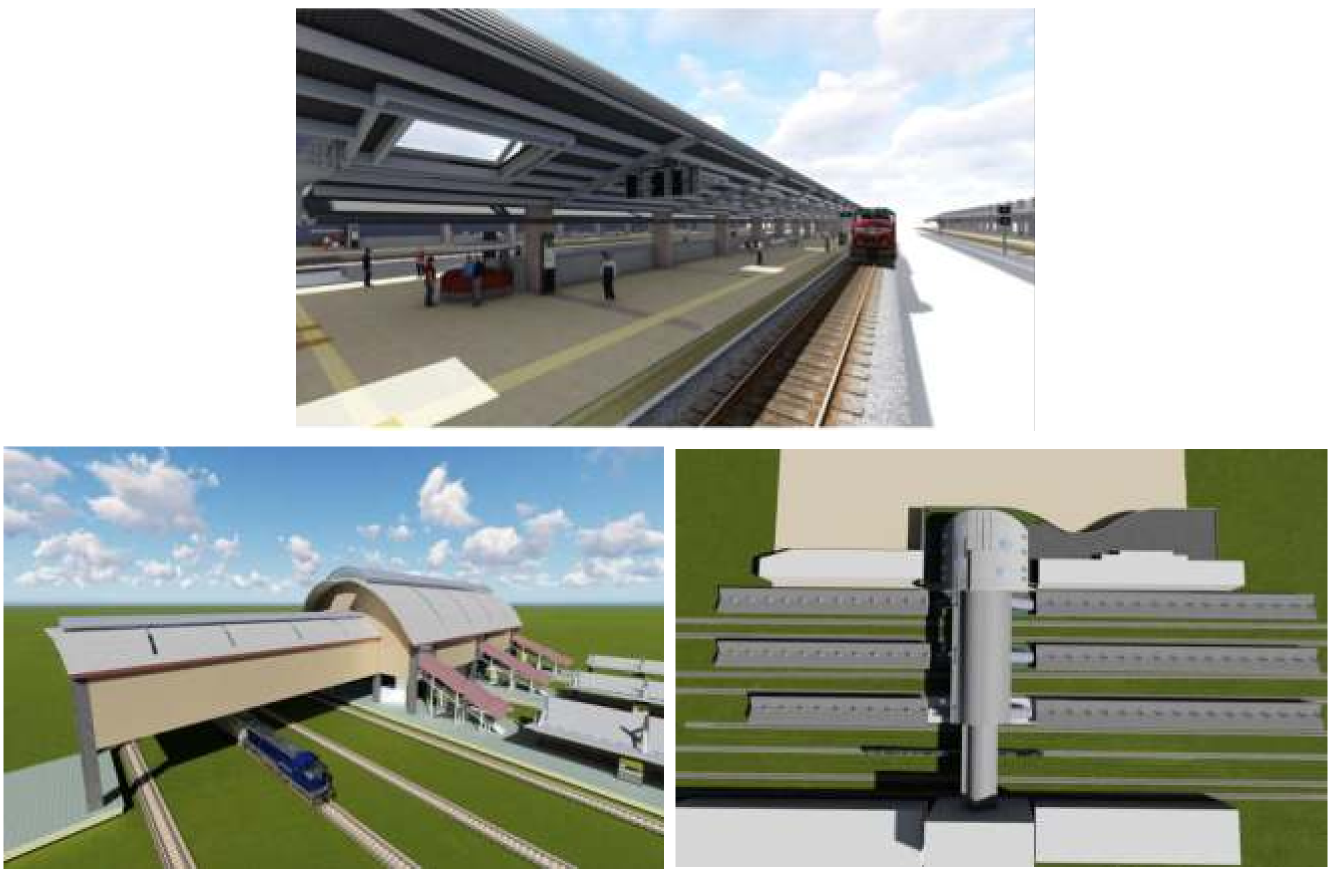
e. The profile of sheeting, which is quite similar to the RDSO design, is ideal for COP. The downward slope towards the extremities provided good advantage of increasing the protection against rains without need for increasing the span.

f. The gap between edge of COP and coach on platform is quite less and this minimises the splatter of water falling on to the coaches.

g. The curved shape matched the architectural language chosen for the covering on the concourse. The curved shape adds elegance to the structure, and at the same time is not difficult to fabricate and erect.

h. Valley gutter could be provided at the center, without any obstruction. Cable trays can be integrated with the design so that the cables can provided without disturbing the platform surfacing and also without becoming eyesores.

i. The design is quite optimized and economical on capital cost. The rolled sections are used which are sealed at ends, minimising the chances of corrosion and there shall be overall savings during maintenance.



Views of COP with concourse

8. **Implementation of New COP Design :** Lots of iterations were done with materials. The cantilevers and purlins etc were to be constructed in steel only as the erection is easy with lighter steel sections. For columns, there was option of providing steel or concrete columns. Casting of concrete columns was not preferred by the Developer. The complete design is done in E350 grade steel. The stays were initially proposed only in the direction perpendicular to track to hold the cantilever arms in place and reduce deflection. However, the at detailed design stage, deflection control for the column required stays had to be provided parallel to track as well. Optimisation was done with lots of structural options and upto 12 options were analysed to reach to optimum configuration. The curved cantilever members were also straightened to the extent possible without compromising with the architectural theme to simplify construction.

The erection of COP was done in simple steps given below:

a. First the concrete footing was cast, with holding down bolts.

b. Steel columns were erected manually and held in place by temporary stays. Holding down bolts were provided.

c. The stay elements were hung on the columns.

d. Cantilever arms were erected. These elements were held in position with small hydra crane till these were supported by stays. This work was done when there was no train on platform.

e. Sheeting was provided except in last 2 m portion affected by OHE. The sheeting was provided in last 2 m after taking shutdown of OHE.

f. The appurtenances like electrical fixtures, signages, cable trays etc were erected.

9. Comparison of the new design with the existing RDSO design at Habibganj is as follows:

S No	Item	RDSO Design	Habibganj COP Design
1	Maximum Cantilever span	10.80 m	18.60 m
2	Spacing of columns along track	16 m	9m
3	Members, and ease of fabrication	More members, more fabrication	Few members, easier fabrication especially since rolled members are used
4	Bird menace free	No	Yes
5	No of columns for 16.5 m span	2	1
6	Integration with OHE possible	No	Yes
7	Concrete per sqm plan approx. for equivalent designs	0.095 cum	0.08 cum
8	Steel per sqm plan area approx. for equivalent designs	35 kg/sqm	39 kg/sqm

10. Improvements suggested : The COP design adopted at Habibganj is quite elegant and economical and is generally being liked by all users. The design can, however, be further improved in following areas:

a. Integrating the OHE masts/portals with the supports for the COP: OHE masts/portals on platforms create problems as these puncture the sheeting which is a source of water leakage during monsoons and the TRD people also find it difficult to maintain the OHE since the person cannot climb the mast/portal. OHE masts/ portals also clutter the platform and create hurdles for passengers in hurry to catch the train. The COP design at Habibganj was modified to integrate the OHE portals at Habibganj with the columns of the COP. A beam connection between columns was designed so that the portal upright can be supported on the same. This arrangement is feasible and WCR had promised to take up this work. However, the same has not yet been taken up. Wherever this COP design is adopted, the OHE masts/ portals must be integrated so that full benefits of the design are utilised by railways.

b. Providing more durable materials for the exposed surfaces: The steel column and stays projecting above the sheeting shall always be exposed to sun and rain. The corrosion of these members may adversely affect the life of the structure. Habibganj in Bhopal is low to moderate corrosion area with low humidity levels for most part of the year. The mild steel coated with epoxy paints provided at Habibganj is deemed durable enough for this exposure condition. However, if the COP is to be adopted in variety of exposure conditions, it will be preferable to use more durable materials such as stainless steel for the exposed portions.

c. Height of COP above platform level may be increased: The height of COP at lowest point near valley gutter is 3m from platform level, which is the same as RDSO design. However, due to compactness of the cantilever section, the vertical space below COP near column appears to be slightly less and this height may be increased by 0.3m to 0.45m in future projects.

11. **Conclusion and Acknowledgement :** Excellent work has been done in the redesign of the COP at Habibganj. M/s AECOM are to be congratulated for coming up with good design, which has been beautifully brought to reality by BPHPL. Special personal thanks are due to Mr K Josh Bhalla, Ms Charu, Mr Mohinder Kumar Gandhi and Mr Pavan Polisetty from AECOM, Mr Sunil Bansal and Mr Abu Asif from BPHPL. Mr Sanjeev Kumar Lohia, MD & CEO IRSDC is an inspiration who has enabled the team to deliver this elegant solution.

Dream - Taking shape at Habibganj

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Indian prime minister opens first two Dedicated Freight Corridors

INDIA's prime minister, Mr Narendra Modi, opened the first 351km section of the 1873km Eastern Dedicated Freight Corridor (DFC) from Bhaupur to Khurja on December 29 2020, followed by the first 306km New Rewari - New Madar section of the 1504km Western DFC on January 7. The world's first doublestack long-haul container train on broad-gauge electrified infrastructure was also flagged off on its maiden journey from Ateli, Haryana, to Kishangarh, Rajasthan.

The Eastern DFC will run from Ludhiana in Punjab to Dankuni in West Bengal, while the Western DFC will connect Mumbai with Dadri in Uttar Pradesh. Dedicated Freight Corridor Corporation of India (DFCCIL) says the 350km section of the Eastern DFC from Madar to Palanpur will be operational by March along with the 45km section connecting Khurja to Dadri. The 120km Rewari - Dadri line is scheduled for completion by December. India's plan to build the two DFCs has witnessed several time and cost overruns since its conception in 2006. The cost of the project was estimated at Rs 290bn ($US 4bn) in 2007, but rose to Rs 600bn by 2010 and Rs 815bn by 2012, excluding the cost of land acquisition. The total cost is currently estimated to be above Rs 1 trillion. Completion deadlines for the two lines have similarly been extended from 2012 initially to 2018, with final completion now planned for 2022. Frequent changes in top management and complications over land acquisition have been the main cause for the delay. For example, since DFCCIL was set up in 2007, it has had 13 managing directors. Four more dedicated freight routes are planned: Delhi - Chennai (2327km); Kolkata - Mumbai (2328km); Kharagpur, West Bengal - Vijaywada, Andhra Pradesh east coast corridor (1114km); and Tamil Nadu - Goa.

(Ref: IRJ Feb 21)

Re-girdering of 45m open web through girder by Road crane

B.K. Kushwaha* / Devesh Sharma** / Prashant De*** / Devendra****

1. Introduction :

The Bridge No 65 consisting 17 Nos 47.85m Open Web Girder over Mahi River at Kms. 52/25 – 53/26 between Sevaliya - Timba stations in Anand - Godhra section of Western Railway. This bridge was under distress category due to cracks in various members and speed restriction was imposed since 2000. The re-girdering of OWG girders of 45.75 m spans was first time carried out on in Western Railway by set of crawler cranes.

2. Salient feature of Bridge No. 65 (MAHI)3.

Name of River	Mahi
Location	Km. 52/25-53-26.
Section	Anand- Godhra.
Between Station	Sevaliya- Timba
Type of girders	Open Web Through type girders
Span No (Overall)	17x47.850m
Span No (Effective)	17x47.420m
Depth/ Height of Girders	8111 mm
R. L. to Bottom of girder	1200 mm
R.L. to Bed Block	2100 mm
R.L. to River Bed	20.00m Average
R.L. to danger Level	3.875m
Details of H.F.L.	4.97m (year 1973)
Type of Bearing	Rocker and Roller
Loading Standard	25 t loading 2008
Type of Decking	Open
Type of Bed Block	RCC
Piers/Abutments	RCC
Foundation	OPEN
Condition of River Bed	Perennial flow in Span Nos.2and3 only.
Painting Area	Total=34000Sq.m.
Weight of Each Girder	139.5 mt

3. History of bridge & section

There was Low level B.G Bridge on Mahi River with 18.3m 42 spans plate girder on brick masonry sub structure. This bridge used to submerge during monsoon. This bridge was re-builded on diverted alignment with 45.75 m Open Web Girder in year 1953. As per General arrangement drawing number CEN/107516/78-D with clear span is 45.75m and overall length is 47.88 m. and girders manufactured by M/s Braithwaite Burn and Jessop Construction Co. Ltd. Calcutta.

All girders of Open Web Through type originally floor system was steel trough decking supported on bottom chord on which track had been laid directly with loose jaws and keys.

Due to impact of train running, steel trough plates started developing cracks since October-1967 and over the period of time number of cracks increases and repaired time to time by welding. Also speed restriction has been imposed in several occasions due to Cracks. Speed restriction of 10 KMPH continued most of time.

In 1994, pone crack was noticed in diagonal L4-U5 of span no.17 at G2 side on 4/8/94 and repaired by splicing and welding.

In the year 2000-2001, all trough decking plates have been replaced by Cross girders and Stringers with provision of steel channel sleepers. After completion of this work SR relaxed to 50 kmph from 10kmph.

*Professor/IRICEN, **DyCE/Br/BRC, ***Dy.CE/ Br/ADI, ****SSE/Br/BRC

In 2002, second crack was noticed in diagonal L4-U5 of span no. 1 at G2 side on 24/09/2002 and repaired by splicing and welding.

Bridge was declared distressed category II. Another six cracks were noticed in diagonals and verticals from 2011 to 2013. Again SR reduced from 50 kmph to 20 kmph. 110

4. Planning and Fabrication of girders.

On account of condition basis regirdering work of this bridge has been sanctioned in two part for total cost of aprox. 57 crores.

All girder members fabricated at Engineering workshop Sabarmati All 17 nos. girder members fabricated and received at site in the year 2018.

Work of re-girdering of all 17 spans (17x45.75m) awarded to agency M/S Dynamic Infra Engineers Limited Kota at total cost of 17.98 cr.

5. Site conditions

Out of 17 nos spans perennial water depth about 2 meters remains in span no 2, 3 & 4. Span no 1 has no perennial water but bed level has differential ups & downs of range of 4 to 6meters. Span no 16 to5 has comparatively uniform bed level without perennial water but sandy and rocky base. Height of pier no-14 is highest at 20 metres.

6. Selection of scheme of regirdering-

The weight of girder is 139 MT, along with Rails, track fitting OHE cantilevers, bearings it comes out to be 180 MT.

Considering above site conditions and weight of girders to be handle, there was following three options to carry out re-girdering in running line.

a. By conventional slide slewing scheme

b. By tyre mounted cranes scheme.

c. By Crawler mounted crane scheme.

a. **By conventional slide slewing scheme -** This method was discussed in length and found not feasible due to very slow, cumbersome, laborious and time consuming process. In addition to above no. of span required to be dealt are more and height of bridge is also excessive.

b. **By tyre mounted cranes scheme -** This scheme was discussed in length and found not feasible due to limitation of working radius and boom length and movement of crane under load.

c. **By Crawler mounted crane scheme -** The weight of girder is 139 MT, along with Rails, track fitting OHE cantilevers, bearings it comes out to be 180 MT.

Though on running lines up till no re-girdering was carried out on OWG girders of 45.75 m spans by set of crawler cranes in Western Railway. Due to ability of moving crane under the load, as such it maintaining required working radius and boom length.

The minimum working radius for crawler crane was calculated 14 meters and maximum height for boom for this bridge comes out to be 41 meters (as pier no 14 height is 20 meters) and height of old girders is 8.10 meters. These requirements fulfilled in crawler crane hence this scheme was proposed.

For re-girdering of these girders, total weight 180 MT at 14m radius requirement of two cranes was of 265 MT capacity. As per Railway Board guideline, the capacity of crane at required radius should be minimum 150% of load. So two 400 MT capacity cranes used. Total three nos. of cranes planned, two working at each end of girder and one standby as spare crane. All scheme of re-girdering planned and checked by Design office under the guidance of Dy.CE/Design. Accordingly TAD submitted by agency and approved by CBE-WR and CRS sanction obtained.

7. Assembly of girders.

All the metalized members of girders assembled in river bed by preparing uniform and sturdy level by keeping RCC blocks at panel points.

Complete assembly of girders done as per IRS -B1. Bottom chord and flooring system assembled first with drift and service bolts. Level is kept 0-0 at all panel points on lifted jacks. Vertical diagonals erected from centre towards end on drifts & service bolts and finally with HSFG bolts, torque on HSFG bolts provided in two stages up to 600 N-M as advised by manufacturer. Initial camber of 42 mm at centre panel point provided by lowering the adjacent jacks.

Now top chord is erected from centre to outside and holes are matched in its splice and with verticals and diagonals, other members and HSFG bolts provided in all joints. All joints are made perfect with proper torque in HSFG bolts.

8. Arrangement for matching rail level

There was 370 mm height difference between old and new girder to match the existing Rail level so 370 mm height stool was to be provided below new bearing.

9. De-launching and Launching of Girders-

Normally in re-girdering by crane sling are tied at bearing portion to increase stability but here it was decided to launch bearing, stool along with girder to minimise number of blocks at later stage, so it was decided to tie the sling at end cross girders. To avoid bending of top and bottom flange of cross girder a temporary iron strut provided at all the sling points. Launching and delaunching work carried out in five and half hours trafic and power block.

The activities carried out during block are as under –

S.N.	Activities	Duration
1	Arrival of tower wagon and disconnection of OHE wire	90 Min
2	Removal of existing girder, crawling of crane with girder to place at nominated location	30 Min
3	Providing slings to new girder	30 Min
4	Lifting of new girder,crawling of crane to place new girder	30 Min
5	Alligning and linking of fish plates	30 Min
6	Removing of slings	30 Min
7	Arrival of tower wagon and connecting OHE wire	90 Min

Sleepers, running rail, guard rails, tie runner angles, chequered plate, OHE cantilever arrangement fixed to new girder prior to lifting so that after block immediately train can be passed.

Re-girdering work planned/carried out in two phases –

Phase I- Re-girdering work commenced from 31 March 2019 to 13 June 2019 & 10 span re-girdered (74 Days). To carry out re-girdering of span 1 to 4 which has perennial flowing water, working platform were prepared by providing four rows of 1200 mm dia RCC Hume pipe and filling by local river material for movement of crane and placing old and new girders

Phase II- Re-girdering work commenced from 28 Dec- 2019 to 18 Jan-20 (21 Days) and balance 7span re-girdered.

In last block two girders of span 5 & 6 were replaced in 7.30 hours block.

The alignment and leveling of new girders were done by innovative tool, which is fabricated at site using rollers and plates which reduced much times and blocks after re-girdering.

Concreting on pier top done for embedding steel stools. It was a tedious job as pumping of concrete was not possible without supporting the pipe line of concrete either to be done by boom placer or crane with a bucket of 1cum capacity. Method of crane adopted for concerting.

SR 20 Kmph relaxed to 45 Kmph on 19.02.2020 after aligning and leveling the girder and grouting of HD bolts.

SR relaxed to 75 Kmph on 24.02.2020 and S.R relaxed to 100 Kmph on 27-02-2020.

10. Conclusion - Though the adopted scheme was new for re-girdering work of 45.75m open web girder in Western Railway. The re-girdering work of bridge no. 65 was carried out with this scheme in a record time and SR relaxed to normal which was imposed since 2013.

It has benefited over conventional slide slewing scheme as it would have required large number labor, T&P, tussles. The conventional method is also very slow it would have taken at least 17 months for completing re-girdering, more ever there would have obstruction of water way in multiple spans for longer period of year. More number of blocks would have required for various activities along with re-girdering. Thus scheme of re-girdering using crawler crane made to success safely and economically.

In another land mark of this work simultaneously with re-girdering, the auction of released scrap girders carried out. Eevery girder delivered within two months of re-girdering by auction, and CRRM about 6.5 crores obtained.

All departments work whole heartedly for this landmark work of Western Railway.

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Restructuring brings difficulties for Indian Railways

INDIAN Railways' (IR) operating ratio shot up alarmingly in the third quarter of 2020 ending in September. With IR rapidly running out of funds to meet expenses due to the effects of the Covid-19 pandemic, the Ministry of Railways was forced to solicit additional funds from finance minister, Ms Nirmala Sitharaman, to help to pay this year's pension bills.

IR has 1.27 million employees to run 22,678 passenger and freight trains on its 67,415km network, making it the country's biggest employer. In 2018-19, IR's payroll was a whopping Rs 1,343.6bn ($US 18.25bn) an increase of Rs 56.49bn over the previous year. Salaries and pensions account for approximately half of operating costs, while fuel bills make up 40%. This means limited funds are available for modernisation and development works.

Freight revenue has continued to be used to cross-subsidise the passenger business. IR reportedly spent Rs 505.79bn to meet its social service obligations such as providing concessionary fares and running uneconomic branch lines and suburban services, as railways minister, Mr Piyush Goyal, informed parliament in February. The urgency of IR's rail managers to take bold reform measures - such as the decision in December 2019 to merge the eight existing cadres into a single IR management service and cut the IR board from eight to four members, is understandable.

Last year, IR's chairman and CEO, Mr V K Yadav, held out the promise of "capacity building and efficiency enhancement" through a structural reform plan. However, the results of the transformation plan have yet to materialise. IR's current challenges are largely seen as the outcome of the failure by political leaders and rail managers to plan or execute ideas to their logical conclusion.

The streamlining of IR's board and management was aimed at breaking down silos and unencumbering unwieldy rail bureaucracy. Issues relating to future recruitment and the chain of command remain unclear. Niti Aayog, the Indian government's think tank, has questioned the ministry's earlier decision to entrust the 17 zonal railway general managers with administrative and financial powers on a par with IR board members.

Rather than giving the decision a green signal on a piece-meal basis, Niti Aayog, in a recent letter to the IR board, has sought clarity about the complete restructuring plan. Meanwhile, several top positions, including those of board member, rolling stock, and additional members, have remained vacant. "Officers are highly demoralised and apprehensive about future prospects because of the arbitrariness with which the reform measures are being pushed through," a senior ministry official said on condition of anonymity. "In such a climate, it is only logical to assume that big-ticket plans will be putoff by some years," says former IR board member, Mr Rajesh Agarwal. Such assumptions are not off the mark. Highly publicised projects such as the Mumbai - Ahmedabad high-speed project, station redevelopment schemes, and the Dedicated Freight Corridors, have remained on pause in recent months, while production of coaches and locomotives has been slashed, as passenger services have remained suspended since June 2020, with just a handful of premium-fare trains allowed to run during the Covid-19 pandemic.

The private train initiative has been embroiled in disagreements between the IR board and private train operators on the proposed terms of the contract. And, after three rounds of tenders were floated, it has also been one step forward and two steps back regarding the plan for the import/indigenous manufacture of 160km/h passenger trains.

(Ref: IRJ Jan. 2021)

Easy Calculator For Extra Clearance On Curves

By **R. Sudharsan**

Abstract : *One of the aspects for safe running of trains is provide clearances between fixed structures & the vehicle. This becomes critical in case of infringements of fixed structures to IRSOD coupled with vehicles / loads exceeding MMD. Similarly in case of structures situated in curves clearances play a vital role and any lacunae on this area would prove highly risky. Field engineers face difficulties in working out the correct clearances of these structures and in order to mitigate their hardship a calculator to calculate the "Extra Clearances" is brought out. Though it is in the form of an excel sheet it can be converted as a standalone app for use in mobiles.*

1.0 Introduction

Maintenance of right clearances of the fixed structures from the centre line of track is an issue requiring constant vigil and turns ticklish when it is on a curve. Both during initial setting and routine maintenance the importance of ensuring the correct clearance need not be over emphasized.

2.0 Stipulations

IRSOD specifies the clearances to the fixed structure on straight and the amount of "Extra Clearance" that needs to be worked out for structures situated in curves.

3.0 Methodology

The horizontal clearance is measured from the CLT whereas the vertical clearance is to be measured from the plane passing through the top of rails on curve.

4.0 Tools & Tackles

The work load of field engineers though humongous they can neither refrain nor remain slack in maintaining the clearances and absence of tool, inspite of too many for other needs, especially to arrive at the extended plane over top of rails is no excuse.

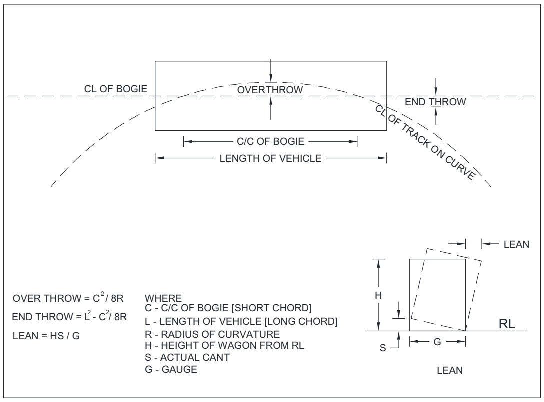
5.0 Need to ascertain clearances regularly

The need is on account of loss of alignment of curved track becomes more serious with respect to clearances and to aid in movement of vehicles/loads that are way beyond MMD, especially lengthy ones.

6.0 Perspective of field engineer's

The need to maintain the stipulated clearances even in the absence of right tools over a large span of geographical area at all times compels to seek for aids that would consume less time & resource to complete the task.

7.0 Theory



Apart from the above parameters that are used to arrive at the clearances specified in the sketch one more allowance termed as additional sway on curves is also considered, which is one fourth of lean due to SE and is only for inside of curve.

8.0 Quick Formulae

The formula is deduced as 27330/R for clearance at centre of vehicle & as 29600/R for end of vehicle for vehicle length of 21340 with bogie centre at 14785.

9.0 Allowances at specified locations

Inside

For structure = OT + Lean + Sway

For PF = OT + Lean + Sway – 51mm

Outside

For structure = ET

For PF = ET – 25mm

In-between tracks = ET + OT + 0.5 Lean

10.0 Solution

"Easy Calculator for EC" (EC4EC) is a simple calculator to arrive at the extra clearances at site with very few inputs.

SSE/D&D/PCE/O/MAS

11.0 Feature

The calculator accepts bare minimum inputs and produces results for various aspects. Parameters of vehicle are provided with default values and are also accepted as inputs if the user wishes to change it depending on need.

12.0 Advantage

The advantage is instant data and large amount of inputs for varied natures.

13.0 Silver lining

The vertical allowances are provided with respect to the inner rail as reference and not the plane passing through the top of rails on curve.

14.0 Ease of work

Field engineers can easily obtain the requisite clearances by using a leveling instrument or total station or even the latest laser enabled distance measurer. No more worry about the extension of the plane.

15.0 Working of EC4EC

The calculations are made using analytic geometry and counter verified with plane geometry drawn in AutoCAD. The variation between results is to the tune of 0.001 to 0.003mm.

16.0 Input

Though the above mentioned parameters are sufficient as inputs on the module, it has been designed to accept vehicle data as input in order to ascertain the exact clearances for differing vehicle conditions.

17.0 Output

The output lists out all the requisite clearances namely for structures, PF, FB & between tracks for both inside and outside of the curve.

18.0 Extra output

For the use of R&D professionals a separate output on clearances is also made available that lists out the clearances between PF&FB to that of the vehicle.

19.0 Assumption

The PF height is reckoned as a line parallel to the inclined plane passing through top of rails. Another possibility in fixing the height of PF is to consider it as exactly vertical. The difference between the two is 4.051mm.

20.0 Prompt for EC4EC

The “Easy Calculator for EC” was developed when (i) a news item highlighted about large gap at PF on curve & (ii) reference was made as to whether clearance needs to be calculated afresh for LHB coaches.

21.0 Conclusion

It is concluded that this calculator is a boon for field engineers.

It can be migrated as a mobile app so that the entire fraternity would reap its benefit with least of inconvenience at field. No more hassle of working with paper and pen.

22.0 Reference

Indian Railway Schedule of Dimensions 2004

23.0 Gratitude

My sincere thanks to Sri. R. K. Bajpai Sr. Professor Track – I for encouraging me in presenting this article.

Mumbai - Ahmedabad HSL could now open in 2028

INDIAN Railways (IR) awarded contracts to a pair of consortia led by Nippon Koei and Tata Consulting Engineers on March 22, which cover the provision of project management consultancy services for 13 civil works packages on the project. The contracts will run for eight years, indicating that IR expects construction of the 508km Mumbai - Ahmedabad high-speed line to overshoot its 2023 completion deadline by approximately five years.

When asked for comments on expected project completion delays, National High Speed RailCorporation Limited (NHSRCL) spokesperson, Mr Sushma Gaur, said the 96-month tenure for project consultants would “include a number of post construction activities” and that their work “would go well beyond contract closure.” However, former railway board member, Mr Subodh Jain, disputed this, saying that “activities of project consultants can be extended for a maximum period of six months and not years.”

Gaur responded that “it was too early to comment on project costs, as this could only be calculated after all tender packages were finalised and awarded.” The Nippon Koei-led consortium includes Oriental Consultants Global and Rail India Technical and Economic Services (Rites). The Tata-led consortium includes the Consulting Engineers Group, Aarvee Associates ArchitectsEngineers and Padeco. The project has been delayed due to issues concerning revised costs and problems relating to land acquisition in Maharashtra state. However, NHSRCL has continued to proceed, awarding contracts for the construction of two sections in Gujarat to Larsen & Toubro in November 2020. **(Ref: IRJ April 2021)**

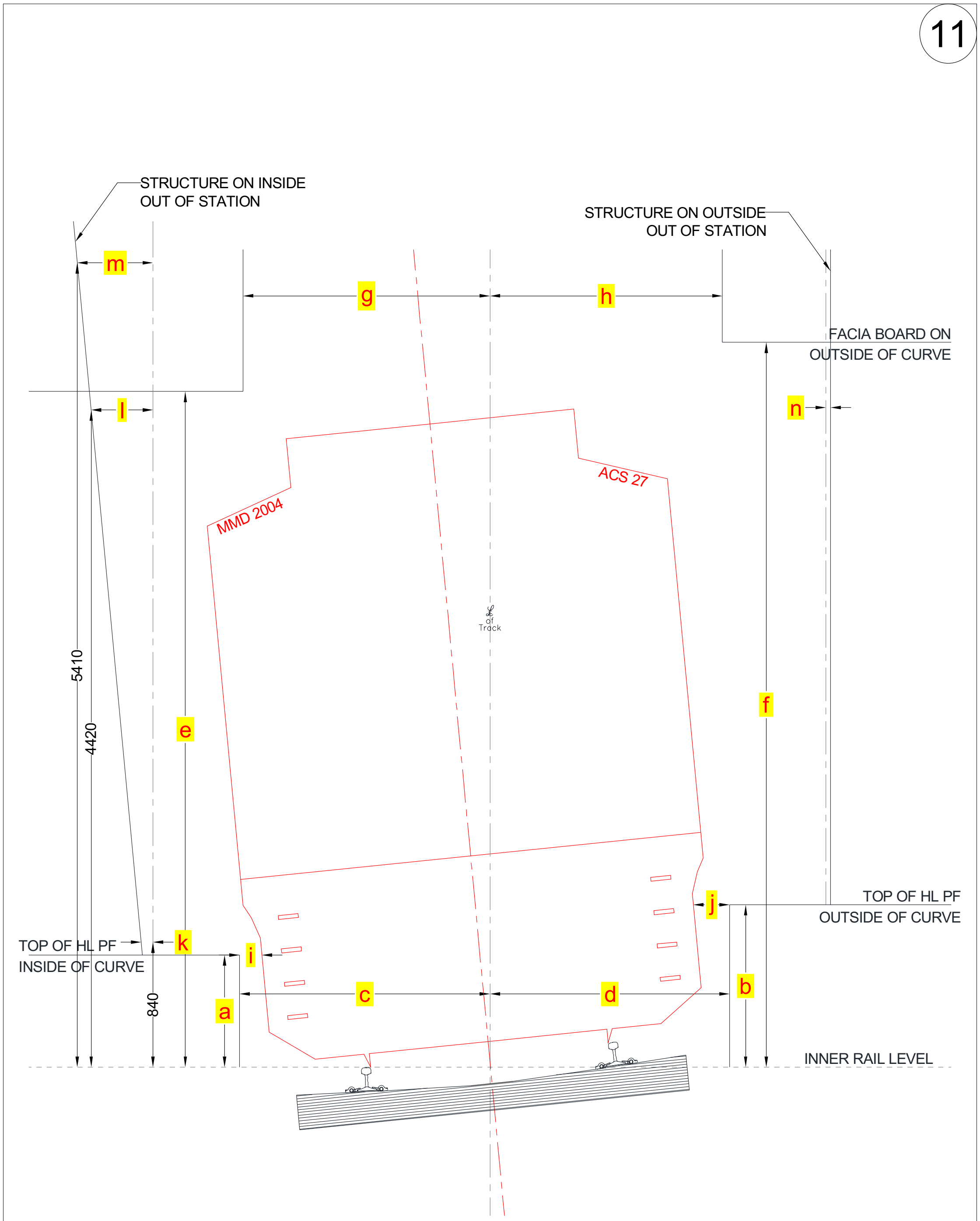
Input/output screen:

CALCULATION SHEET FOR ARRIVING CURVE ALLOWANCE & ACTUAL CLEARANCE AT PLATFORM

DATA:

Degree of curve, D	:	1.0°			
Radius of curve in, R	:	1750.000 m			
Cant, S	:	050 mm			
Height of PF, HPF	:	840 mm			
Wheel base, C1	:	14.785 m			
Length of bogie over buffers	:	22.3 m			
Length of body or roof, C2	:	21.34 m			
C/c distance between doors, CD	:	17.059 m			
Height of floor of vehicle, HV	:	1345 mm			
Width of floor of vehicle, WV	:	3250 mm			
Width of vehicle at PF level	:	3150 mm			
Height of step	:	1077 mm			
Distance of step from CL	:	1385 mm			
Facia Board - horizontal distance	:	1600 mm			
Facia Board - vertical distance	:	4610 mm			
Vehicle top side	:	3735 mm			
Vehicle hood - horizontal distance	:	1015 mm			
Vehicle hood - vertical distance	:	4265 mm			
Extra Clearance required					
for structures situated on Inside					
@ 840 from RL	:	141 mm	**k**		
@ 4420 from RL	:	243 mm	**l**		
@ 5410 from RL	:	280 mm	**m**		
for structures situated on Outside	:	85 mm	**n**		
In-between tracks	:	213 mm			
dimension to be provided					
Location		Inside		Outside	
Height of PF from inner RL	:	787 mm	**a**	996 mm	**b**
Horizontal distance of PF from CLT	:	1766 mm	**c**	1736 mm	**d**
Height of Facia from inner RL	:	4565 mm	**e**	4770 mm	**f**
Horizontal distance of Facia from CLT	:	1741 mm	**g**	1685 mm	**h**
Horizontal clearance between PF & Vehicle @ PF Level					
At bogie centre	:	142 mm	**i**	216 mm	**j**
At Mid Door	:	64 mm		302 mm	
At End Doors	:	168 mm		189 mm	

Reference diagram



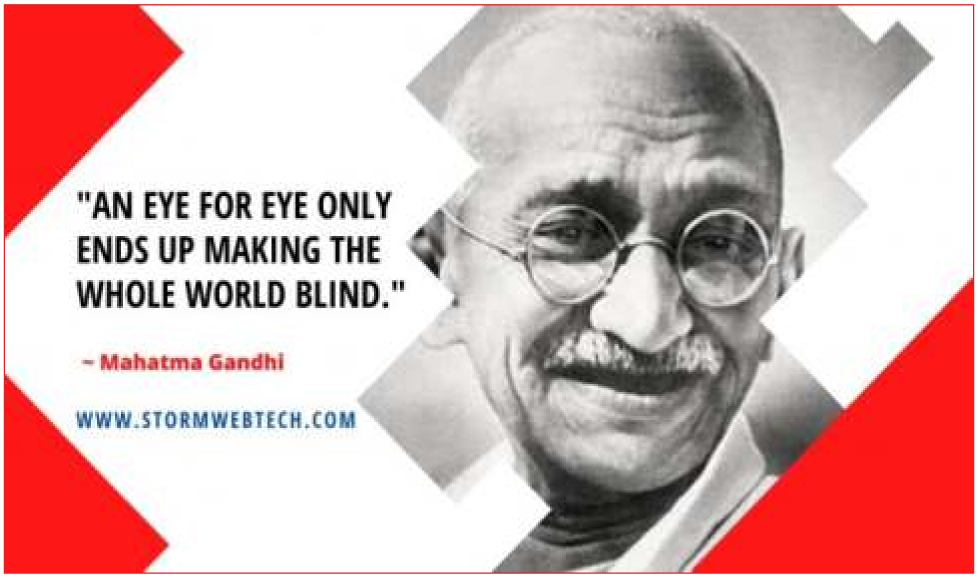
SKETCH OF MMD 2004 ACS 27 SHOWING THE LOCATIONS TO BE PROVIDED WITH EXTRA CLEARANCE FOR STRUCTURES ON CURVE

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			
2. LWR Manual – Merged with IRPWM			
3. Track Machine Manual – New w.e.f. Sept. 2019			
4. Manual for Ultrasonic Testing of Rails & Welds			
01.	01	Nov. 2014	Para No 8.15.1 replaced
02.	02	Dec. 2014	Para No 8.14, 8.15.1, Annexure IIA and IIB replaced
03.	03	Mar. 2016	Para No 4.1.1(c), 5.1.2, 8.6.4, 8.7.2, 8.10, 8.14, 8.15.1, Figs. 3 & 22 replaced. New clause b)(iii) below para 8.16 added, New para 6.3.1 & 6.3.2, 10.6 added
04.	04	Sept. 2018	Para 6.6, 8.14, 8.15, 8.15.1 & 8.15.2 modified,
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)

S.NO.	ACS NO.	DT OF ISSUE	REMARKS
23.	23	23.08.2011	Replace existing Chapter-VIII by revised Chapter-VIII
24.	24	14.09.2011	Para 714(2), 1005(1), 1005(3), 1104, 1104(2), 1104(5), 1106(2), Page No xi(Index)1104 modified
25.	25	17.12.2012	New sub para 3 may be added to existing para 311
26.	26	23.08.2013	Para No 217.2(a)(ii), 217.2(c), 217.4(c), 217.4(d), 217.4(e), 217.4(l), 615 to be replaced
27.	27	03.01.2014	New para 1107 5 i), 215 A added
28.	28	20.03.2014	Chapter-X, Part B – Title of Deep Cuttings replaced and para 1010 to 1015 & Annexure 10/2 replaced by Para 1010 to 1017 and Annexure 10/2 attached.
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
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

S.NO.	ACS NO.	DT OF ISSUE	REMARKS
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),
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
7. IRS Steel Bridge Code 2017 (incorporate CS 1-21)			
01.	22	25.09.2019	Para 7.1.1 replaced
WORKS			
1. Indian Railways Code for 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



Statement of Courses IRICEN CoC-2021 (Revision - 9, dated-15.06.21)								
COURSE NO	Course Name	FROM	TO	DURATION	TIMING	Eligibility	CD	ACD
JUNE 2021								
21304	SPARE SLOT	04.06.21	05.06.21	2 DAYS	CAMPUS			
21227	WEBINAR: Construction and maintenance of FOBs – including quality control aspects.	04.06.21	04.06.21	1 DAY	ONLINE	All officers	PB1	PB2
21014	Appreciation Course G-4	07.06.21	11.06.21	1 W	ONLINE	IRAS PROBATIONERS	SPT2	SPB1
21305	PCE SEMINAR	07.06.21	08.06.21	2 DAYS	CAMPUS	ALL PCEs OF RAILWAY	DN	SPT1
21431	Advance Track Maintenance	07.06.21	18.06.21	2 W	ONLINE (B/N)	JS, SS, JAG	SPT1	SPT2
21735	Dispute resolution and arbitration	07.06.21	11.06.21	1 W	ONLINE (A/N)	SS,JAG,SAG	SPW	SPB2
21228	WEBINAR:Laying of Turnouts taking off from curve.	11.06.21	11.06.21	1 DAY	ONLINE	All officers	SPT1	SPT2
21737	Construction of PSC bridge super structure	14.06.21	18.06.21	1 W	ONLINE (A/N)	All officers	PB2	PT2
21013	Appreciation Course G-3	14.06.21	18.06.21	1 W	ONLINE	IRSEE PROBATIONERS	SPT2	SPB1
21501	COURSE FOR MES Engineers	14.06.21	18.06.21	1 W	CAMPUS	PSU TRAINEES	PW	PP
21306	CAO(C) Seminar	16.06.21	16.06.21	1 DAY	ONLINE	ALL CAO(C) OF RAILWAY	SPW	SPB2
21229	WEBINAR:HSFG Bolts.	18.06.21	18.06.21	1 DAY	ONLINE	All officers	SPB1	SPB2
21406	BRIDGE DESIGN	21.06.21	09.07.21	3 W	ONLINE	Officers and Design Assistants	PB2	PB1
21736	Formation constrtuction and ground improvement	21.06.21	2.7.21	2 W	ONLINE (B/N)	All officers	SPP	SPW
21436	RAIL WELDING and USFD	21.06.21	02.07.21	2 W	ONLINE (A/N)	All officers	SPT1	SPT2
21760	Rail Grinding for RGM Cell	23.06.21	25.06.21	3 Days	ONLINE(F/D)	Officers of RGM Cell	SPTM	SPP
21230	WEBINAR: Clearing of bridges for higher speed and higher loads.	25.06.21	25.06.21	1 DAY	ONLINE	All officers	PP	PW
21007	IRSE Probationers-2019,Phase-II,Part-II	28.06.21	23.07.21	4 W	ONLINE(F/D)	IRSE 2019 (P)	SPP	SPTM
JULY								
21224	WEBINAR: Track Monitoring by TRC	02.07.21	02.07.21	1 DAY	ONLINE	All officers	SPT2	SPT1
21011	Appreciation Course G-1	05.07.21	09.07.21	1 W	CAMPUS	PROBATIONERS	SPW	SPTM
21738	Bridge Planning and bridge foundations	05.07.21	16.07.21	2 W	ONLINE (A/N)	All officers	SPW	PP
21232	WEBINAR- Case study of bridge failure	09.07.21	09.07.21	1 DAY	ONLINE	All officers	PB2	PT2
21405	Mechanised Track Maintenance,Track Monitoring.	12.07.21	23.07.21	2 W	ONLINE (F/N)	All officers	SPTM	SPT2
21201	SR. PROF. P. WAY	12.07.21	06.08.21	4 W	CAMPUS	JAG, Selection Grade, SAG	SPT1	SPT2
21102	INTEGRATED	12.07.21	01.10.21	12 W	CAMPUS	GR. B OFFICERS	PB2	PB1
21233	WEBINAR- Aspects of high tractive effort locomotives on bridges	16.07.21	16.07.21	1 DAY	ONLINE	All officers	DN	PP
21012	Appreciation Course G-2	19.07.21	23.07.21	1 W	CAMPUS	PROBATIONERS	SPTM	SPT2
21761	Rail Grinding for RGM Cell	26.07.21	28.07.21	3 Days	ONLINE(F/D)	Officers of RGM Cell	SPTM	SPP
21751	Contract Management	26.07.21	30.07.21	1 W	ONLINE (F/N)	All officers	SPW	SPT2
21743	Steel fabrication and Inspection (Bow String Girder)	26.07.21	06.08.21	2 W	CAMPUS	Officers and SSEs of Bridge Inspection Unit	PB1	PB2
21744	AT and FBW	26.07.21	30.07.21	1 W	ONLINE (A/N)	All officers	SPT1	SPT2
21234	WEBINAR- Quality and durabilty of concrete structures	23.07.21	23.07.21	1 DAY	ONLINE	All officers	SPB2	SPB1
21502	PSU COURSE SLOT	26.07.21	13.08.21	3 W	CAMPUS	PSU TRAINEES		
21235	WEBINAR- Retrofitting of bridges	30.07.21	30.07.21	1 DAY	ONLINE	All officers	PT2	PB2
AUGUST								
21753	LWR	02.08.21	06.08.21	1 W	Online (F/N)	All officers	SPT2	SPT1
21742	Conc Tech- mix design, RMC, and durability	02.08.21	06.08.21	1W	ONLINE (A/N)	All officers	SPB2	SPB1
21236	WEBINAR	06.08.21	06.08.21		ONLINE			
21741	T/Out and layout calculations	09.08.21	13.08.21	1 W	ONLINE (F/N)	All officers	SPT1	SPT2
21746	Modern surveying	09.08.21	13.08.21	1 W	ONLINE (A/N)	All officers	APT1	PP
21439	Course for Construction Engineers	09.08.21	20.08.21	2 W	CAMPUS	All officers	SPW	SPB2
21202	SR. PROF. BRIDGE	09.08.21	03.09.21	4 W	CAMPUS	JAG, Selection Grade, SAG	SPB1	SPB2
21762	Rail Grinding for RGM Cell	11.08.21	13.08.21	3 Days	ONLINE(F/D)	Officers of RGM Cell	SPTM	SPP
21308	CBE SEMINAR	16.08.21	17.08.21	2 DAYS	CAMPUS	ALL CBEs OF RAILWAY	SPB2	SPB1
21747	Inspection and maintenance of bridges	16.08.21	20.08.21	1 W	ONLINE (F/N)	All officers	PB1	PB2
21748	Curves- speed, laying, maintenance and Realignment.	16.08.21	20.08.21	1 W	ONLINE (A/N)	All officers	SPTM	SPT1
21237	WEBINAR	13.08.21	13.08.21		ONLINE			
21309	CE/TP SEMINAR	19.08.21	20.08.21	2 DAYS	CAMPUS	ALL CE/TP OF RAILWAY	SPT2	SPT1
21238	WEBINAR	20.08.21	20.08.21		ONLINE			
21412	Tunneling	23.08.21	03.09.21	2 W	CAMPUS	All officers	SPP	SPTM
21411	BENTLEY	23.08.21	27.08.21	1 W	CAMPUS	All officers	PB2	PB1
21763	Rail Grinding for RGM Cell	25.08.21	27.08.21	3 Days	ONLINE(F/D)	Officers of RGM Cell	SPTM	SPP
21239	WEBINAR	27.08.21	27.08.21		ONLINE			
21310	EPC / PPP	30.08.21	31.08.21	2 DAYS	CAMPUS	JAG/SG Officers	SPW	PW
21749	Laying and Maintenance of turnouts taking of from curves, special layouts and vertical curves	30.08.21	03.09.21	1 W	ONLINE (F/N)	All officers	SPT1	SPT2
21750	Const. of PSC bridge superstructures	30.08.21	03.09.21	1 W	ONLINE (A/N)	All officers	PB2	PB1

Statement of Courses IRICEN CoC-2021 (Revision - 9, dated-15.06.21)								
COURSE NO	Course Name	FROM	TO	DURATION	TIMING	Eligibility	CD	ACD
SEPTEMBER 2021								
21307	CTE SEMINAR	02.09.21	03.09.21	2 DAYS	CAMPUS	ALL CTEs OF RAILWAY	SPT1	SPT2
21240	WEBINAR	03.09.21	03.09.21		ONLINE			
21203	SR. PROF. P. WAY	06.09.21	01.10.21	4 W	CAMPUS	JAG, Selection Grade, SAG	SPT1	SPT-2
21414	Mechanised Track Maintenance,Track Monitoring	06.09.21	17.09.21	2 W	CAMPUS	All officers	SPTM	PTM
21241	WEBINAR	09.09.21	09.09.21	1 DAY	ONLINE			
21407	MIDAS	13.09.21	17.09.21	1 W	CAMPUS	AEN/Design, Design Assistants	PB1	PB2
21413	STAADPRO	20.09.21	24.09.21	1 W	CAMPUS	AEN/Design, Design Assistants	PB2	PB1
21242	WEBINAR	17.09.21	17.09.21	1 DAY	ONLINE			
21312	SPARE SLOT	20.09.21	21.09.21	2 DAYS	CAMPUS			
21503	PSU+COURSE SLOT	20.09.21	22.10.21	5 W	CAMPUS	PSU TRAINEES		
21313	CE - TMC SEMINAR	23.09.21	24.09.21	2 DAYS	CAMPUS	CE/TMCs ALL RLY.	SPTM	PTM
21243	WEBINAR	24.09.21	24.09.21	1 Day	ONLINE			
21438	PSC BRIDGE CONSTRUCTION + CONCRETE TECHNOLOGY & DURABILITY	27.09.21	08.10.21	2 W	CAMPUS	JS,SS,JAG	SPB2	SPB1
OCTOBER								
21244	WEBINAR	01.10.21	01.10.21		ONLINE			
21204	SR. PROF. BRIDGE	04.10.21	29.10.21	4 W	CAMPUS	JAG, Selection Grade, SAG	SPB1	SPB2
21103	INTEGRATED	04.10.21	24.12.21	12 W	CAMPUS	GR. B OFFICERS	PB1	PB2
21245	WEBINAR	08.10.21	08.10.21		ONLINE			
21403	STAADPRO	11.10.21	15.10.21	1 W	CAMPUS	AEN/Design, Design Assistants	PB2	PB1
21246	WEBINAR	14.10.21	14.10.21		ONLINE			
21419	MIDAS	18.10.21	22.10.21	1 W	CAMPUS	AEN/Design, Design Assistants	PB1	PB2
21247	WEBINAR	22.10.21	22.10.21		ONLINE			
21248	WEBINAR	29.10.21	29.10.21		ONLINE			
21314	IRICEN DAY	31.10.21	02.11.21	3 DAYS	CAMPUS	95 BATCH PROBATIONERS		
NOVEMBER								
21005	IRSE 2019 (P) PHASE - II,PART-III	08.11.21	03.12.21	4 W	CAMPUS	IRSE 2019 (P)	SPP	SPTM
21249	WEBINAR	12.11.21	12.11.21	1 DAY	ONLINE			
21250	WEBINAR	19.11.21	19.11.21	1 DAY	ONLINE			
21251	WEBINAR	26.11.21	26.11.21	1 DAY	ONLINE			
DECEMBER								
21252	WEBINAR	03.12.21	03.12.21	1 DAY	ONLINE			
21432	Geotechnical Investigation & Modern Survey	06.12.21	17.12.21	2 W	CAMPUS	JS, SS, JAG	SPB1	SPB2
21433	Contract and Arbitration	06.12.21	17.12.21	2 W	CAMPUS	JS, SS, JAG	SPW	SPT2
21253	WEBINAR	10.12.21	10.12.21	1 DAY	ONLINE			
21254	WEBINAR	17.12.21	17.12.21	1 DAY	ONLINE			
21255	WEBINAR	24.12.21	24.12.21	1 DAY	ONLINE			
21205	SR. PROF. P. Way	27.12.21	21.01.22	4 W	CAMPUS	JAG, Selection Grade, SAG	SPT1	SPT2
21316	SPARE SLOT	27.12.21	28.12.21	2 DAYS	CAMPUS			
21317	SPARE SLOT	30.12.21	31.12.21	2 DAYS				
21256	WEBINAR	31.12.21	31.12.21	1 DAY	ONLINE			

Statement of Coures SSTW CoC-2021 (Revision - 9, dated-15.06.21)

COURSE NO	COURSE NAME	FROM	TO	TIMING	Duration Weeks	ELIGIBILITY	CD	ACD
JULY								
21616	**Referesher Course Works**	05.07.21	16.07.21	ONLINE(F/D)	2	SSE/JE/Works	APW	PW
21617	**Referesher Course USFD**	19.07.21	23.07.21	ONLINE(F/D)	1	SSE/JE/USFD	APT2	APW
21813	**Geotechnical engineering and construction of formation**	19.07.21	30.07.21	ONLINE(F/D)	2	SSE/JE/Works	APW	APT2
21618	**Referesher Course P-Way**	26.07.21	13.08.21	ONLINE(F/D)	3	SSE/JE/P-Way	PT1	PT-2
AUGUST								
21816	**Concrete technology RCC/PSC FOR BRIDGES.**	02.08.21	13.08.21	CAMPUS	2	SSE/JE/Works	APW	APT2
21810	**Rail wheel interaction and Derailment investigation**	16.08.21	27.08.21	CAMPUS	2	SSE/JE/P-Way	PT1	PT-2
21620	**Referesher Course Works**	16.08.21	27.08.21	CAMPUS	2	SSE/JE/Works	PW	APW
21831	**Contract Management.**	30.08.21	03.09.21	CAMPUS	1	ALL Jes/SSEs	PW	PP
21619	**Referesher Course P-Way**	30.08.21	17.09.21	CAMPUS	3	SSE/JE/P-Way	PT2	PT1
SEPTEMBER								
21832	P & C, Curve & LWR	06.09.21	17.09.21	CAMPUS	2	SSE/JE/P-Way	PW	PP
21622	**Referesher Course P-Way**	20.09.21	08.10.21	CAMPUS	**3**	SSE/JE/P-Way	PT1	PT-2
21623	**Refresher Course for BRI**	20.09.21	08.10.21	CAMPUS	**3**	SSE/JE/BRI.	PP	PW
OCTOBER								
21833	USFD, Welding, Rail Grinding	18.10.21	29.10.21	CAMPUS	2	SSE/JE/P.WAY	APT2	APW
21817	**Rail wheel interaction and Derailment investigation**	18.10.21	29.10.21	CAMPUS	2	SSE/JE/P-Way	PT1	PT-2
NOVEMBER								
21624	**Referesher Course P-Way**	08.11.21	26.11.21	CAMPUS	3	SSE/JE/P-Way	PT2	PT1
21625	**Referesher Course Works**	08.11.21	19.11.21	CAMPUS	2	SSE/JE/Works	APW	PW
21626	**Referesher Course USFD**	29.11.21	03.12.21	CAMPUS	1	SSE/JE/USFD	APT2	APW
21821	**SURVEY & LAND MANAGEMENT**	22.11.21	03.12.21	CAMPUS	2	SSE/JE/Works	APT1	APT3
DECEMBER								
21627	**Referesher Course P-Way**	06.12.21	24.12.21	CAMPUS	3	SSE/JE/P-Way	PT2	PT1
21822	**Concrete technology RCC/PSC FOR BRIDGES.**	06.12.21	17.12.21	CAMPUS	2	SSE/JE/Works	APW	APT2
21628	**Referesher Course Works**	20.12.21	31.12.21	CAMPUS	2	SSE/JE/Works	PW	APW
21824	**Rail wheel interaction and Derailment investigation**	27.12.21	07.01.22	CAMPUS	2	SSE/JE/P-Way	PT1	PT-2

Proposed IRICEN Hostel Building

DG/IRICEN AT INSPECTION MEETING OF SECOND SUB - COMMITTEE OF PARLIAMENT ON OFFICAL LANGUAGE

Calendar Of Courses IRICEN 2021. Revision - 9 dated-15.06.21

Month & Year	July.2021				Aug.2021					SEPT.2021				Oct.2021				Nov.2021			
Date (Monday)	5	12	19	26	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22
IRSE 2018/19	21011 G-1		21012 G-2 (IRTS)															DIPAWALI	21005 IRSE PHASE-II,Pa		
Trainees																			70	70	70
AWARENESS COURSES																					
Trainees																					
Integrated courses		21102 INTEGRATED												21103 INTEGRATED							
Trainees		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25		25	25	25
Sr.Prof. courses		21201 Sr. Prof. P.Way				21202 Sr.Prof.Bridge				21203 Sr. Prof. P.Way				21204 Sr.Prof.Bridge							
TRAINEES		15	15	15	15	15	15	15	15	15	15		15	15	15	15					
CAMPUS COURSE				21743 Steel fabrication and Inspection (Bow String Girder)		21439 Course for Construction Engineers		21412 TUNNELING		21414 Mechanised track maint. Track monitoring			21438 PSC BR. CONST.+ CONC TECH								
TRAINEES				25	25	25	25	35	35	25	25		25	25							
ONLINE COURSE FD				21761 Rail Grinding for RGM Cell		21762 Rail Grinding for RGM Cell		21763 Rail Grinding for RGM Cell													
ONLINE COURSE BN		21405 Mechanised track maint. Track monitoring.		21751 Contract Management	21753 LWR	21741 T/Outs and Layout calc.	21747 Inspection and maintenance of bridges		21749 Laying and Maintenance of turnouts taking of from curves, special layouts and vertical curves												
ONLINE COURSE AN	21738 Bridge Planning and bridge foundations			21744 AT and FB welding of Rail	21742 Conc Tech-mix design, RMC, and	21746 Modern surveying	21748 Curves- speed, laying, maintena		21750 Const. of PSC bridge superstructures												
Software courses								21411 BENTLY			21407 MIDAS	21413 STAADPRO			21403 STAADPRO	21419* MIDAS					
Trainees	25							25			25	30			30	30					
WEBINARS	21232 WEBINAR	21233 WEBINAR	21234 WEBINAR	21235 WEBINAR	21236 WEBINAR	21237 WEBINAR	21238 WEBINAR	21239 WEBINAR	21240 WEBINAR	21241 WEBINAR	21242 WEBINAR	21243 WEBINAR	21244 WEBINAR	21245 WEBINAR	21246 WEBINAR	21247 WEBINAR	21248 WEBINAR		21249 WEBINAR	21250 WEBINAR	21251 WEBINAR
Courses for PSU				21502 PSU COURSE SLOT								21503 PSU COURSE SLOT									
Trainees				20	20	20						20	20	20	20	20					
HAG/SAG SEMINARS							21308 21309		21310 21307			21312 21313						21314 IRICEN DAY			
Trainees							25		25			25									
							CBE/ TP CE-		EPC-PPP/CTE			SLOT/ CE-TMC									

Calendar Of Courses SSTW 2021. Revision - 9, dated-15.06.21

Month & Year	July.2021				Aug.2021					SEPT.2021				Oct.2021				Nov.2021				
Date	5	12	19	26	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29
Institute																						
Track courses							21810 RWI		21619 Refresher Course (P WAY)			21622 Refresher Course (P WAY)				21817 RWI		NO TEACHING ACTIVITY. IRICEN DAY, DEEPAWALI	21624 Refresher Course (P.Way)			21626 Refresher (USFD)
Bridge/ Works courses					21816 CONC TECH RCC/PSC		21620 Refresher Course (Works)		21831 Contract Mgmt.			21623 Refresher Course (Bridges)							21625 Refresher Course (Works)		21821 SURVEY & LAND MGMT.	
Track courses										21832 P & C, Curve & LWR						21833 USFD, Welding, Rail Grinding						
Online Full Day			21617 Refresher (USFD)	21618 Refresher Course (P WAY)																		
Online Full Day	21616 Refresher Course (Works)		21813 GEO. ENGG/FORM ATION																			

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