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ज्ञान ज्योति से मार्गदर्शन

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Release of IRICEN Publications by Member Engineering during IRICEN Day

Indian Railways Institute of Civil Engineering, Pune

ज्ञान ज्योति से मार्गदर्शन

To impart world class training in Rail technology and Railway specific civil engineering through competent faculty & personnel and state-of-art training infrastructure.

We shall ensure continuous improvement in both technical and managerial areas to play a significant role in finalization of prevailing practices and help in achieving overall vision of the Indian Railways

OUR QUALITY POLICY

1. We will impart quality training in the fields of rail technology and railway specific civil engineering to develop competence amongst engineering fraternity of railways
2. We will focus on customer satisfaction through identification, control and improvement of all key processes. For this, we will continuously endeavour to deliver to deliver quality services through constant interaction with RDSO, Railway Board and Zonal Railways.
3. For ensuring overall development of trainees, we will also emphasis on Improvement of their managerial skills.
4. For achieving above, we will deploy competent faculty & personnel and state-of-art-infrastructure.
5. We will create conducive working environment where every employee is motivated to contribute his best.
6. Our motto is to " Beam as a Beacon of Knowledge"
7. This Quality Policy shall be reviewed periodically for its continuing suitability and communicated to all employees.

From director's desk

Dear Readers,

I wish all the readers of this journal and the entire engineering fraternity a very happy and prosperous new year 2017.

IRICEN Day was celebrated with a huge enthusiasm and fervour. The IRICEN Day celebrations were graced by presence of Member Engineering, Railway Board. He also facilitated the officers, who has excelled in various training programmes of IRICEN during last one year and officers of the silver Jubilee (IRSE-1990) batch.

This edition of IRICEN journal includes paper on design of "U" shaped steel composite girder bridges, its applicability, further scope of economizing bridge cost with faster construction. The other paper includes the challenges in design of railway track for heavy haul and semi-high speed trains. Another paper elaborates the norms for setting up divisional permanent way training institutes for training of P.way staff involved in the day to day maintenance of track and improving their own safety and their awareness for the safety.

I hope that readers would find the content in this journal informative and useful. I also invite suggestions and contributions for the forthcoming issue of this journal.

Pune
April 2017

(N. C. Sharda)
Director

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Suggestion for improvement of **IRICEN Journal of Civil Engineering** are welcome from the readers. Suggestions may be sent to mail@iricen.gov.in

Guidelines to contributors

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

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

Railway Ministry Working on $5 Billion Fund to Finance Projects

Railway Ministry is in advanced stages of finalizing a proposal to create a $5 billion fund to finance its infrastructure projects.

According to Railway Minister, Suresh Prabhu, once the proposal for floating Railways of India Development Fund (RIDF) is finalized, it will be placed before the cabinet for its nod. He also mentioned, there were certain hurdles that were to be cleared for the proposed $ 5 – billion Railways of India Development Fund before they seek Cabinet approval. He further said they are almost done the structuring of the fund and hope they will be able to take it to the Cabinet soon, Mr. Prabhu said at a seminar organised by Indian Merchants' Chamber.

The proposed fund, which will be anchored by the World Bank, will be of seven years.

The proposed fund will mainly invest in major infrastructure projects of the transport behemoth. Mr. Prabhu said, pension funds are keen to put money in the Railways as it is a long term investment destination for them with assured long term returns and capital safety assurance.

He added that due to insufficient capital, expansion of infrastructure and capacity augmentation did not happen for a long time. LIC has agreed to invest Rs.1.5 trillion in various commercially viable railway projects last yar and out of the total, it has already invested Rs.10,000 crore so far.

He further said that Railways will continue to explore the public private partnership (PPP) model for various plans.

It can also be noted that, the Japan International Cooperation Agency has also agreed to provide loan of around Rs.1 Trillion at 0.1 per cent interest for a 50 year tenure with a 15-year moratorium for the Mumbai-Ahmedabad bullet train project.

Mr.Prabhu also informed the government has also proposed an integrated development model for the PSU.

Ref: Construction Technology Today, Oct 2016, Pg. 18

Sustainable Materials --Life Cycle Thinking in Building Materials

Although the present energy consumption per capita in India is a fraction of that of most developed nations, but with its projected growth, unless enough measures are taken, it may lead to acceleration of environment degradation, contributing to increased carbon footprint that would lead to global warming and climate change, resource scarcity and inequitable development.

Building materials play a major role in evaluating the energy efficiency of buildings. Currently, it is estimated that contemporary building designs in India consume about 25 % to 30% of total energy, and up to 30% of fresh potable water.

At present, when we consider the environmental effects, we often look narrowly, focussing on one or two concerns, and we are often guided by generic labels like "recyclable"," recycled content", "biodegradable. "

Life Cycle Assessment (LCA) is a tool used to identify the net impacts of a product's life cycle from raw materials extraction through manufacturing, use and disposal.

The national Building Code of India is introducing a new section "Approach to Sustainability" in which the concept of LCA (Life Cycle Assessment) is introduced: "LCA of building materials intends to assess the potential environmental impacts at every stage in the life cycle of a material.

Many LCA programmes have been developed to create an environmental product declaration (EPD) schemes, and a number of national approaches for construction products currently exist.

Ref: Construction Engineering & Construction Review, Sept 2016, Pg. 114 & 116

Introduction of Rustonil FZ105™

1. RUSTONIL can easily remove the rust from any type of oldest iron and it protects iron for a long time. It removes the rust.
2. There is no need of applying any primer or sand paper, after application of RUSTONIL.
   It save time, money and labor.
3. It is pollution free and has no side effect .
4. It's a water based chemical and can be used very easily.

Why Rustonil FZ105 is essential INDIAN Railways?

1. Since Primary Problem for Indian Railway is rust i.e. reoccurrence of rust even after regular painting. This is due to non clearance of 100% rust.
2. Thus RUSTONIL FZ105 Comes into action as it removes 100% rust as well as gives paint its full life resulting in, increase of maintenance interval.

RUSTONIL FZ105 has wide range of application in Indian Railways. As Indian Railways is facing tremendous problems in opening & cleaning of various. Rusted parts like: 1. Pan droll (ERC) 2. Railway Track nuts 3. Plate screw 4. Chakar Plate 5. Rail Track 6. Bridge Girder 7. Steel Bar 8. Pipes 9. Engine Parts 10. Coach & Wagon Parts etc. Thus RUSTONIL FZ105 proves to be a boon as we can easily remove above mentioned rusted parts whose pictures are shown below.

Application of RUSTONIL 105

RUSTONIL FZ 105™ needs single step application as it requires minimal or no surface preparation before application on the surface to be treated (Iron & steel).Put the liquid in a plastic or PVC container.

1. Clean the steel surface or Parts from Dust, Rusty Particles, Grease or Oil and allow the surface to dry.
2. Thoroughly shake RUSTONIL FZ105™before application.
3. Wait for 10 minutes for completing the Reaction process and leave for 24 hours for curing before any other application.
4. Any skilled or Un-skilled person can apply the "RUSTONILFZ 105 ™."
5. It can be applied by any of the following process with coverage Area.

   By Brush 185 sq. ft./Ltr. By Spray 213 sq. ft/Ltr. By Cotton 200 sq. ft/Ltr.Through Dipping 300 sq. Ft/ Ltr.

Precautions

1. Shake well before use. Object to be treated should be free from dust or paints or any other kind of external covering as these external layers prevent RUSTONIL FZ105™ to get in contact with the rustedIron surface which results in poor performance. 2 .Avoid contact with water until the treated surface gets dried off atleast for a period of 24 hrs. 3.Apply only on dry Iron surface.5.Keep away from children's reach. 6. Refer MSDS for technical & safety measures.

Utility of Rustonil FZ 105™In

1. Opening of rusted jammed nuts on rail track.
2. Removal of rusted jammed ERC/ pandrol clip of rail track.
3. Derusting of fish plate/ chakar plate.

Results achieved a year's span

1. Successful opening of nuts with photos & certificate from different divisiouns of Railways.
2. Successful derusted fish plates /chakar plates.

S.No.	Property	Result
1	Colour	Dirty Black
2	Solubility In Water	Soluble
3	Density	1.2gm/cc
4	Flammability	Non Inflammable
5	Viscosity	0.16 stock
6	Polar Formation	No polar formation found
7	Electro- Static Effects	No electro-static Effect found
8	Vaporization	Non evaporative
9	PH Value	0.34
10	Specific Gravity	1.2
11	Dry Film thickness (through XRF Spectrometer / Elcometer)	Nil: After 1st coating for 5 minutes. 1.1 Micron: After 2nd coating for 5 minutes 5.8 Micron: After 3rd coating for minutes
12	Flash Point	Not Applicable
13	Skin Contact	Causes mild dryness
14	Rust remover	Removes rust within 5-10 min. (Tested through IS:13515)
15	Rust Conversion into iron, % by mass:	(A)In 5 min.: 1.98% (B) In 10 min.:6.08% (Tested through IS:13515)
16	Protection form rusting	Positive (Tested through IS: 13515)
17	Weight per litre	1.2 kg
18	Acidic Content	13.30 gm/Lt. (as equivalent to NAOH)

Release of IRICEN Journal by Member Engineering

Member Engineering Sh. A. K. Mittal Addressing to Gathering

Cultural programme by IRSE Probationers during IRICEN Day

Glimpses of “High Speed seminar held at IRICEN on 10th & 11th March 2017.
Delegates from Govt. of Japan & Indian Railways.

Design and Construction of Bridges with 'U' Shaped Steel Composite Girder

By
*V.Thavamani Pandi**

Synopsis

Indian Railway is planning to eliminate level crossings by construction of Road over/ Road under bridges. Road over bridges are constructed with PSC/RCC and Composite steel Girder decks. Composite steel Girder decks are extensively used due to ease of handling and further insitu construction of concrete.

Construction of depth play's an important role on bridge and approach cost. Normally Girders are placed at 2.5m c/c and with a depth of construction of 2.16m for a typical 24m span. In order to economize the cost of construction of bridge and approach, 'U' shaped light weight composite steel girder is proposed with depth of construction of 76.5cm, 99cm respectively for two and three lanes. The approach length reduces by 75 to 90 m resulting in reduction of overall cost of about Rs.9 crores, Rs.12 Crores per two, three lane respectively (construction of bridge on trestles).

'U' shaped steel composite girder bridge can be constructed over RUBs and for water way bridges to increase vertical clearance and also for reducing load on substructure. Designs developed, applicability, further scope of economizing bridge cost with faster construction is also discussed in this paper.

1.0 Introduction: Indian Railway is planning to eliminate level crossings by construction of Road Over/ Road Under bridges. Road over bridges are constructed with PSC/RCC and Composite steel Girder decks. Composite steel Girder decks are extensively used due to ease of handling and further in citu construction of concrete.

Construction of depth play is an important role on bridge and approach cost. In order to economize the cost of construction of bridge and approach 'U' shaped light weight composite steel girder with lesser depth of construction is proposed.

The design aspects, case studies adaptability for multi lane construction, economy in using 'U' shaped composite girders are discussed hereunder.

2.0 Design Aspects of 'U' Shaped Composite Girder ROB/RUB

a. **Selection of span:** Span can be selected keeping the future requirement. Smaller the span lesser the cost of bridge. As the bridges are being constructed on cost sharing basis, the span above track alone can be constructed by Railways or up to next spans in consultation with highways to avoid non standard spans just to construct up to railway boundary.

b. **Provision of supports between tracks:** Wall supports as slender as 0.5m is possible between tracks. In order to avoid difficulties in construction between tracks, precast piers can be done.

c. **Optimum structural layout of super structure**

   I) Normally Girders are placed at 2.5m c/c and with a depth of construction of 2.25m for a typical 30m span. In order to economize the cost of construction of bridge and approach 'U' shaped light weight composite steel girder is proposed. The number of girders reduced to 2 against 5, 7 for two and three lane ROBs respectively..

   II) Cross Girders: cross girders are placed at 3m c/c. Optimum cross girder depth is selected to have less depth of construction. Camper is provided in top flange by varying depth of web .Uniform thickness of RCC slab and wearing coat is provided.

   III) Crash barrier cum foot path: separate crash barrier is not required in the Unshaped girder and foot path plays an important role in load/moment transfer.

   IV) Provision of intermediate stiffeners: Intermediate stiffeners are not required due to the configuration of bridge.

**CE/WS/MAS*

V) Bracings: No bracing is required as the shape of girder takes care. However, inclined struts are provided to support top flange during construction.

3.0 Designs Developed and Applicability

A- Widening of existing ROB no 36 (3 x30.5 Truss +1x7.6mA) near Loco works Perambur.

I. Existing bridge is a truss bridge . Widening/ provision of additional lane is proposed by Chennai Corporation as a deposit work. The vertical clearance is to be raised from 5.4m to 6.525m. Road is existing parallel to track which also restrict the raising of road level. For easy merger of road with approach, 'U' shaped composite girder bridge is suggested and developed by me.

II. The existing span of 30m is divided to 15, 18m spans taking advantage of space availability and availability of platform.

III. The depth of construction of 68 cm . The maximum weight of steel girder handled is 11T.

IV. There is a saving of the bridge and approach cost by more than Rs.4.5 Crores. The concrete is cast in situ without SR. The drawings are given in Annexure II.

B- Bridge No.1136 in TPJ yard

I. The existing Bridge is to be reconstructed with increased VC after commissioning of four lanes of new bridge (1X48m clear span). One approach of new existing bridge is crossing the alignment of the up direction bridge. Railway land is to be transferred for re construction of Existing ROB. In order to reduce the cost of construction of Bridge and transfer of land, the 'U' shaped Composite steel girder bridge is suggested by me.

II. In order to reduce construction depth, bridge and approach cost and reducing land transfer, U" shaped girder bridge of 2x 24m span is suggested.

III. The soil type is soft rock. Mid support is proposed with RCC piers of 0.72m. Isolated foundation can be isolated 4.5m x6m can be precast and launched by crane ensuring level base.

IV. Approaches are planned with earthen embankment with RE wall/RCC retaining wall. One additional opening is needed on either side for movement of Railway vehicles. One box of 6m span is proposed on either side to function as supports for 2x24m span ROB as well as for the railway vehicles. Bottom slab to over hang for 2m towards track side.

V. The proposed road level is 7.575m from existing track against 10.28m. The construction depth is 0.99m. The construction depth is reduced by 2.01m (3-0.99). By keeping 6.525m VC as against existing 7.28m, the road level can be reduced by 2.7m. The approaches are reduced for a length of 162m.

VI. The weight of the deck reduces from 602MT for 48m to 164MT for 2x24m span . The reduction in weight is 438MT.

VII. The bridge proper cost reduces by ₹6.18 crores due to reduction in steel. The overall cost including approaches is around ₹ 15.9 crores.

VIII. The connection to rest house/second entry is made easier apart from reduction in transfer of land and the gradient is flatter.

IX. Adoptability for six lanes: Two numbers three lane ROB can be constructed. There will be overall saving in bridge cost by about ₹12crores/three lane totaling to Rs.24 crores. (with bridges on trestles)

C- Bridge No.129A in TVR yard

I. The bridge in TVR yard is the only bridge linking Tiruvarur and Tanjore. It has inadequate VC for RE work of Lifting the bridge or reconstruction (min ₹15 crores) is not possible. I have inspected and given design solution to increase Vertical clearance for RE work without changing the road level.

II. The Span of Bridge covering Road 2,3 and 4 is 24m. It is made of 3 I girders supported on RCC trestle is 1.42mx 0.6mx8m over columns centered at 3m;

III. The existing VC is 4.83 m. The construction depth is 2.28 mt (road level to bottom of girder)

IV. In order to increase the Veridical clearance 'U" shaped girder bridge is suggested. The 'I' girders are connected át the bottom flange with cross girders.

V. The trestle is not adequate to cover the 'U' shaped girder and also it is to be raised. Hence steel trestle of 115 cm to be provided and supported in existing columns at 6 m c/c.

VI. As the Superstructure loads are transferred in cantilever portion of trestle only two columns are loaded. Two columns requires strengthening. In order to have monolithic action three columns can be tied together with cross beams of 30cm and 15cm jacketing columns up to 3m from trestle.

VII. The depth of construction reduced from 2.28m depth of PSC Girder to 0.765m i.e reduction of 1.515m. The VC increased from 4.83m to 6.35m adequate for RE and no condonation is from CRS.

VIII. The weight of deck is around 63 T which is around 51% of deck with girders spaced at 2.5m C/C i.e five girder arrangement.

IX. Adoptability for Four lane: Two numbers two lane ROB can be constructed. There will be overall saving in bridge cost by about ₹ 9 crores/two lane totalling to ₹18 crores. (with bridges on trestles)

D- Suggested use For RUB 2/3 lane: For construction of RUB of 2 to three lanes, two small boxes of 3mx3m can be constructed by cut open method to serve as support cum foot path and 'U' shaped girder to be laid over the small boxes. The depth of construction is 72cm. The span can be longer to up to 24m to have earthen slope by the side of road and also provides for future expansion.

E- Suggested use For RUB multi lane: For construction of RUB of four or six lanes two small boxes of 3mx3m can be constructed by cut open method to serve as support cum foot path and 'U' shaped girder to be laid over the small boxes. The depth of construction is 72cm. 24m span is adequate and 30m can be used to have partly earthen slope.

F- Suggested use for Railway Bridges: The weight of steel composite deck considerably less compared to PSC deck . The PSC deck can be replaced with U shaped composite Girder which will inturn reduces the load on substructure. For increasing Vertical clearance U shaped steel composite girder can be used. The depth of construction can be kept at 72cm for various spans upto 30m.

4.0 Further Scope for Economizing Cost

a. Provision of Pre camper: The bridges are designed satisfying the codal provisions without pre camber. By providing pre camber the member sizes can be reduced or the same girder can be used for longer spans.

b. Additional supports during construction: By provision of additional supports during construction , the dead load stresses and deflection can be contained which will benefit reduction in self weight of girder or using same girder for longer spans.

c. Using light weight concrete: more than two third of moment and forces are due to dead load. The structural light weight concretes are available from 1350kg/cum to less than 2000 kg/cum against normal concrete of about 2400kg/cum. By reducing dead load considerable saving can be achieved on cost of girder and substructure and foundation.

d. High strength Steel: The design is done using mild steel using Fe 540 grade steel the weight of girders can be reduced by nearly 40 %.

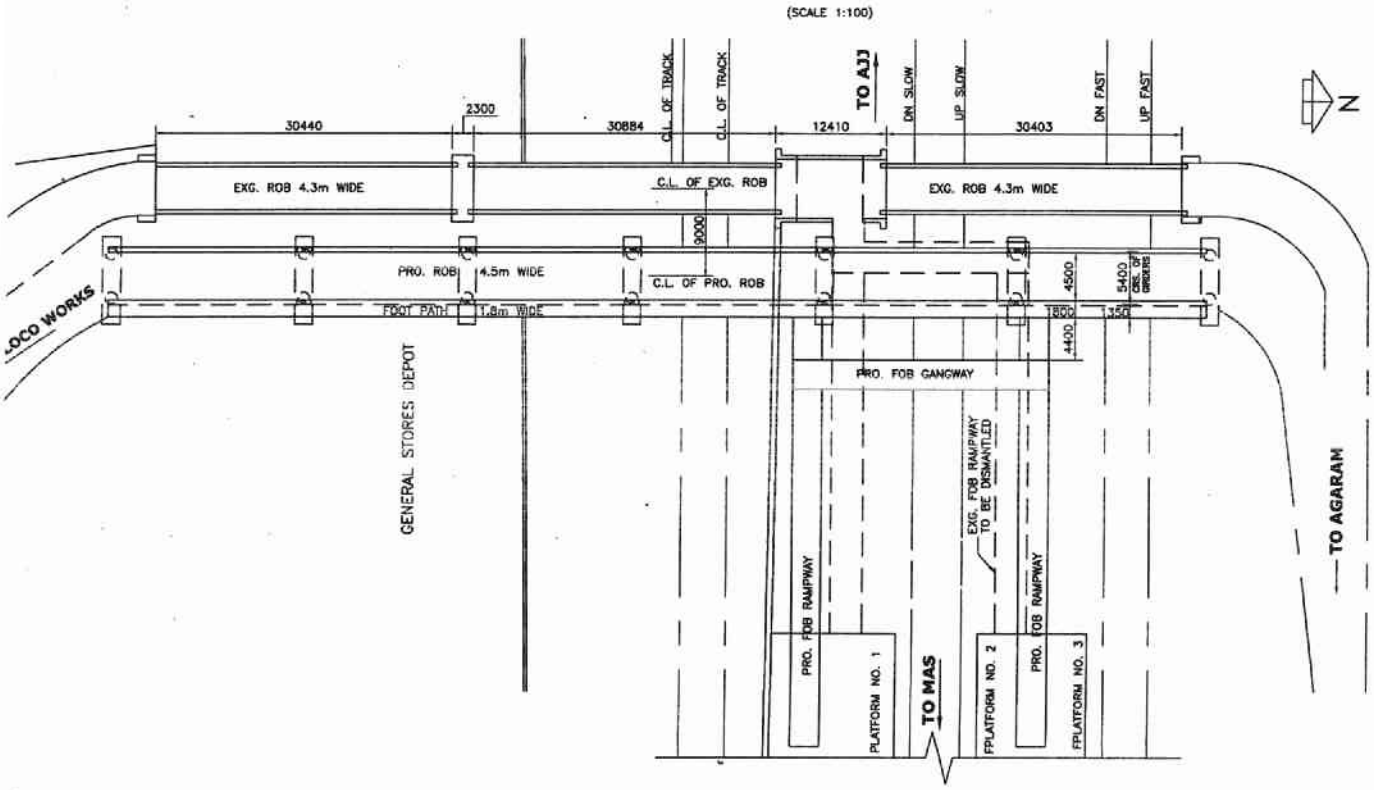
e. Using high strength steel girder and light weight concrete: Using high strength steel girder and light weight concrete advantages of both steel and concrete can be derived to get lighter and economical structure.

f. Construction Techniques : The supports/ piers and retaining walls can be precast and launched. This will reduce the overall construction time substantially and help in selection of smaller span 'U' shaped composite girders

5.0 Indian Railway Scenario

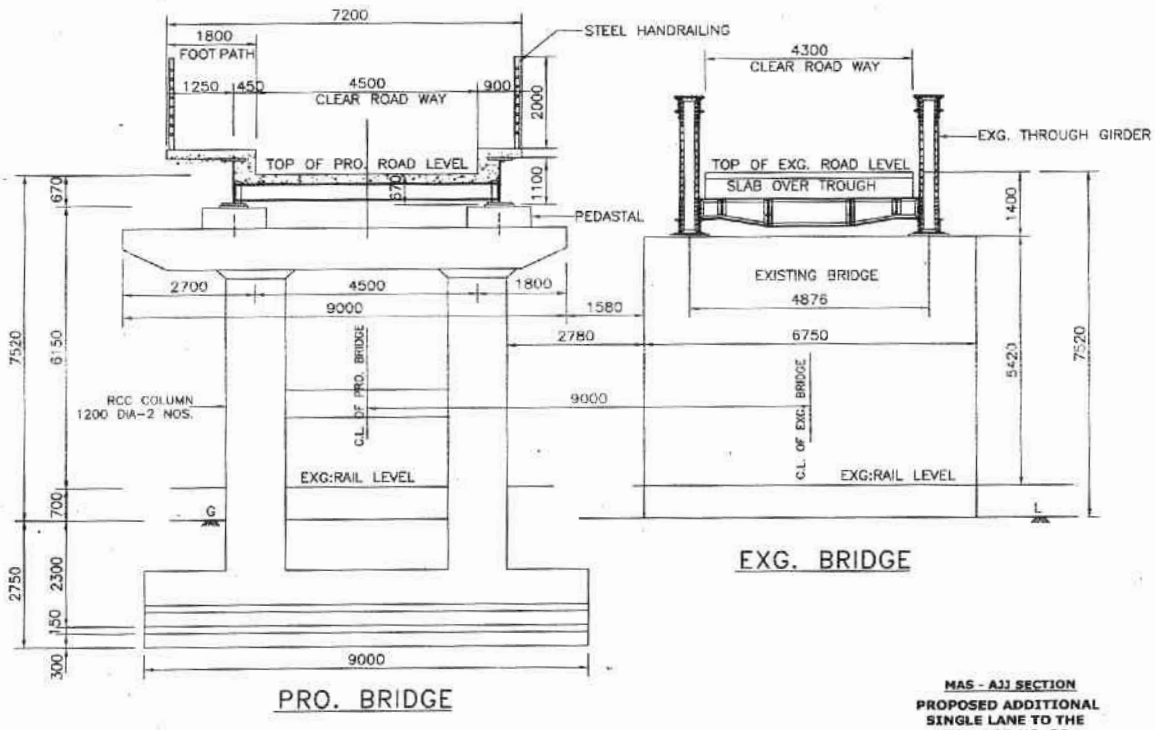
Indian Railways is commissioning around 150 ROBs of 2, 3 and multi lane. Construction with lesser depth U shaped Girdres as suggested for all bridgescan save around Rs 1800 crores considering around ₹9Crores to ₹12 crores per 2,3 lane width of bridge.

6.0 Conclusion: Lighter and economical bridges saves cost of the bridge and construction time. 'U' shaped composite girder can be extensively used for saving around Rs. 1800 Crores for Indian Railways considering 9 to Rs. 12 crores per 2, 3 lane width of bridge in addition to saving in cost of land acquisition and also for easy merger with the existing roads.



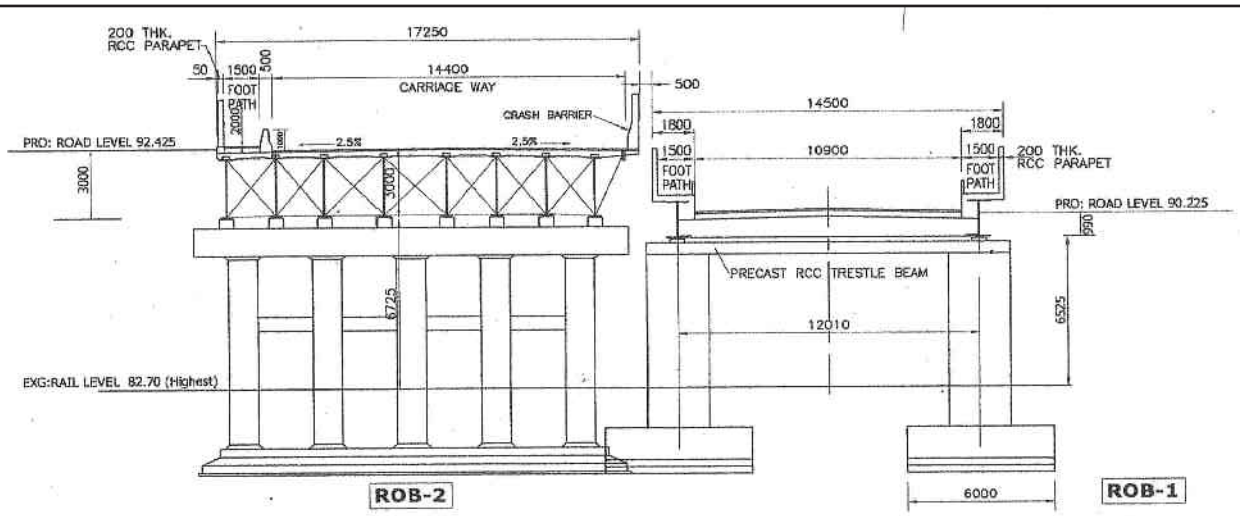
LOCATION PLAN

MAS - AJJ SECTION
PROPOSED ADDITIONAL SINGLE LANE TO THE EXG. ROB NO. 36



CROSS SECTION

MAS - AJJ SECTION
PROPOSED ADDITIONAL SINGLE LANE TO THE EXG. ROB NO. 36



CROSS SECTION

SOUTHERN RAILWAY

TIRUCHCHIRAPPALLI DIVISION

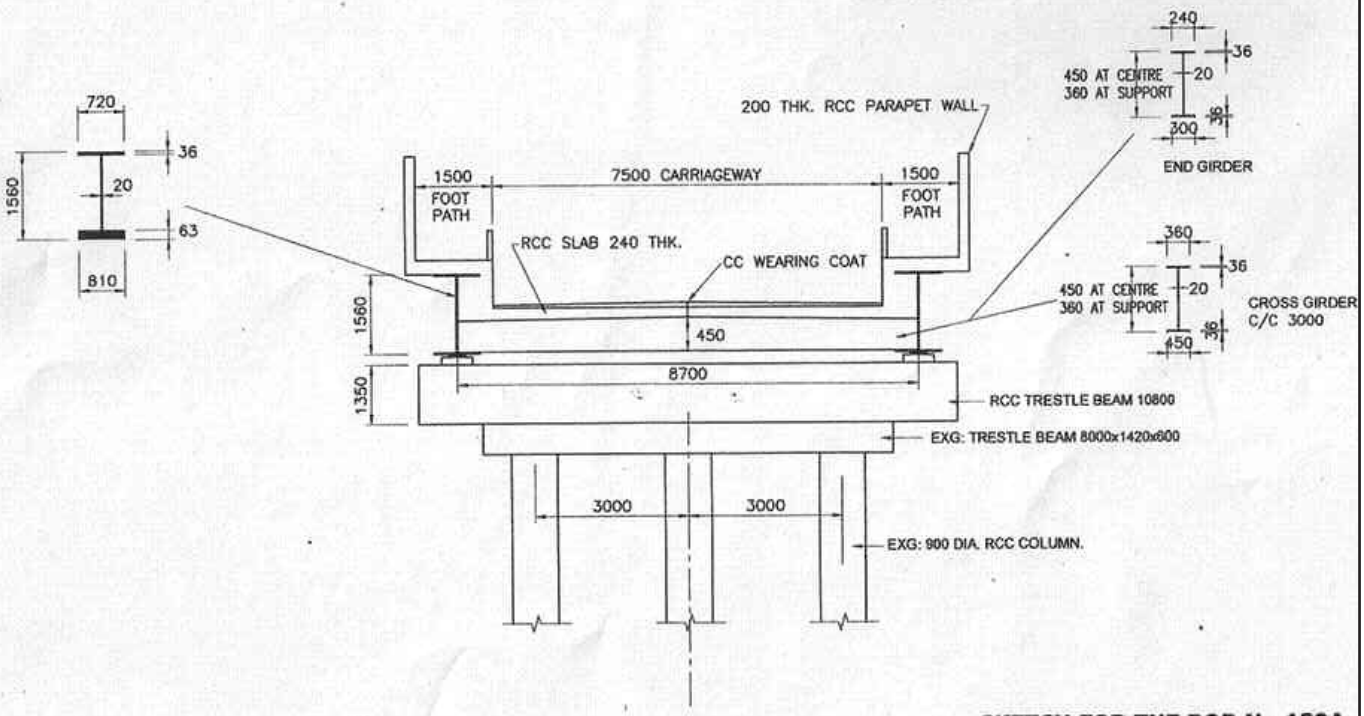
TIRUCHCHIRAPPALLI–DINDIGUL SECTION

TIRUCHCHIRAPPALLI JN.

PROPOSED RECONSTRUCTION OF EXISTING ROB No.1136 AT km:340/600-700.

(2x24000 EFFECTIVE SPAN)

KETCH AS PER GAD No. CBE/GT1/286/2016



SKETCH FOR THE ROB No.129A @ THIRUVARUR JUNCTION

PROPOSED INCREASED IN VC OF EXISTING 1x25.4m PSC DECK.

Pre and Post Retrofit Behaviour of an Existing Railway Open Web Steel Girder Bridge

By
*Sitesh Kumar Singh**
*Nirjhar Dhang***

1.0 Introduction & Objective: Indian Railways have total 1,38,912 bridges on various routes (Broad Gauge, Meter Gauge & Narrow Gauge). There are 35,437 bridges which are more than 100 years old. Amongst 17 zonal railways, Eastern Railway (the then East Indian Railway) is one of the oldest zonal railways of Indian railways in which the first train ran on 15th August, 1854.

There are 94 permanent speed restrictions (PSRs) and 124 temporary speed restrictions (TSRs) imposed on these bridges for various reasons from structural safety considerations.

Maintenance of Important & Major bridges is of prime concern as any failure in such bridges causes serious traffic disruption apart from cost & time required for restoration of these bridges.

In view of the above, there is a continuous need for detailed study on structural health assessment of these bridges for damage detection, corrosion, fatigue etc. so that necessary repairs or strengthening can be carried out to increase service life of the bridge. Further the suitability of existing bridges for running of high axle loads as well as high speed trains needs to be studied. In the present study, the objective is to compare the behaviour of Railway Open web steel girder bridge after retrofitting work.

Keeping the above objective in mind, an instrumentation study has been conducted on Banka Nallah Bridge (Bridge No. 209) situated between Gangpur & Barddhaman stations of Up Main & Chord lines of Howrah Barddhaman busy quadruple route at km 104/13-17 from Howrah station of Howrah Division (Eastern Railway) (Fig.1). The span of this through steel truss bridge is 4x24.40 metres each simply supported on supports. From the records, it is found that this bridge was built in 1914 for the East Indian Railway (E.I.R.) by the Contractor, P. & W. MacIellan Limited, Clutha Works Glasgow (U.K.). The steel has been manufactured by 'Skinningrove-England'.

Fig.1: View of Bridge No. 209

This bridge has served for more than 100 years in one of the busiest & oldest routes of Indian Railways. So far it has carried about 1267 Gross Million Tonnes (GMT) of traffic. The load bearing members (Stringers) have been badly corrodedand as such a speed restriction of 50 kmph has been imposed on this bridge for the safety of running traffic due to distress.

The stringers have been planned for renewal. Therefore, to study the behaviour of this bridge in pre-retrofitting & post retrofitting conditions after changing the stringers is of utmost importance not only from the point of view of residual life but its adequacy to cater to increased future loadings including higher speeds. The study on this bridge can further throw light on behaviour of other old through steel truss railway bridges.

2.0 Literature Review: This study provides a review on the structural health assessment work carried out on various bridges in India and abroad with basic focus on railway bridges.

Alves et al. (2015) presented a methodology for damage detection using genetic algorithm to numerical model of a railway bridge. The railway bridge was modelled as 2D finite

*Chief Engineer/Construction, Eastern Central Railway, Patna
**Professor,IIT, Kharagpur

element model including railway track. The test damage was introduced based on preselected numerical parameters. The response of test damage was compared with the reference damage. The genetic algorithm was applied to minimise residue of the objective function in each iteration. The methodology showed potential to detect location & quantity of damage.

Beck and Yuen (2004) presented a Bayesian probabilistic approach for selection of a model by utilizing the response data. They used this approach on multi-storey frames under seismic response.

The work by Beven and Binley (1992) described methodology for calibration of distributed models with likelihood parameter values.

Boulent et al. (2007) presented a study on identification of most fatigue-critical locations of stringer to cross-girder connection of a riveted railway bridge. The finite element (FE) model was developed and analysed under the passage of a goods train. Rivet holes, angle fillet, loss of rivet, rivet clamping stress and clearance between the rivet shank and the hole were identified as the critical locations for fatigue damage.

Brencich and Gambarotta (2009) did a case study on 90 years old the Campasso riveted railway bridge to assess its residual fatigue life. Steel was tested chemically & mechanically at critical points and severe reduction in resisting cross section in several parts of the bridge was found. Validation of theoretical model with field measurement data showed that the 3D truss was better represented as 3D frame. Residual fatigue life was estimated to be more than 20 years.

Caglayan et al. (2009) studied residual fatigue life of existing steel bridges in Istanbul to ascertain their fitness to be used in the proposed augmented infrastructure. Field measurements were done and analysed for the existing train traffic. Statistical method was used to project future traffic demand. Residual fatigue life was reassessed based on the projected future demand. To enhance fatigue life, strengthening scheme was proposed.

Constantine et al. (2004) presented a study on an in-service old steel railway bridge to ascertain its condition by conducting static & dynamic field measurements as well as lab tests. Validated numerical method was developed to ascertain bridge capacity to carry earthquake & wind loads as per the relevant codes as well as for heavier axle loads. Retrofitting measures were suggested. Residual fatigue life of the pre & post strengthening measures was also suggested.

Fontan et al. (2014) investigated by carrying out many tests on two case studies, the sources of errors affecting the quality of identification of unknown parameters using particle swarm optimization (PSO) algorithm.

Goel (2006) presented a study of behaviour of stringer to floor beam connection in riveted railway open web girder bridges. It was concluded that double-angle stringer-to-floor-beam connection act as shear connection and is capable of developing appreciable moments due to rotation of stringer ends. This results into high secondary bending moment at these connections.

Goulet and Smith (2013) identified unknown uncertainty dependency on a structure by comparing measured response using optimization techniques & statistical inferences.

Goulet et al. (2014) quantified the effects of modelling simplifications for structural identification of bridges. They did case study on long-span, early pre-stressed segmental box girder Grand-Mere Bridge (Canada), affected by substantial long-term vertical deflections. Model simplifications have vital effect on error prediction. Assessed errors are used in the analysis of the ambient vibration acceleration data measured on the structure. The interpretation approach employed is based on error-domain model falsification. The study provides series of parameter values that can be used consequently to depict more precise aspects such as long-term creep and shrinkage behaviour.

Hendrik et al. (2009) presented improved bridge evaluation through finite element model updating using static and dynamic measurements. The possibility of relating finite element (FE) analysis with on-site measurement through finite element model updating is irrefutable. However, abridged initial models and inadequate measurements can lead to updated model parameters which hide incorrect modelling assumptions rather than reflect actual structural parameters. Therefore, they proposed methodology to remove inaccurate modelling simplification by manual model fine-tuning before parameters are estimated by non-linear optimization. They also introduced multi-response objective functions combining various kinds of measurements to arrive at a concrete basis for parameter assessment. The methodology was validated on new Svinesund Bridge, and revealed a necessity to use a non-linear model to assess the structural parameters more precisely. The subsequent model could replicate the measurements with better precision.

Johansson et al. (2014) carried out preliminary assessment of existing railway bridges in Sweden for high speed traffic i.e.

from 200 km/h to 250 km/h. Swedish code required that the bridges be examined with dynamic simulations to avoid excessive vibrations. Dynamic models were based on analytical equations for slab-frame bridges and analysis based on probabilistic approach was done. The method gives a preliminary assessment of upgrading a bridge network. However, they concluded that more detailed studies were needed for final assessment.

Klinger et al. (2014) have presented a case study on steel components and joints of a railway bridge over the Elbe River at Lutherstadt Wittenberg, Germany. The study was needed due to detection of 240 mm long fatigue crack through 80% of the cross section near butt weld of one of the longest hangers. It was found that wind-induced caused unexpected vibrations of the hangers which reduced their fatigue life. Additional bracings were provided to reduce wind-induced vibrations. The butt weld heat influenced zone which was affected by high cyclic stresses was renewed.

Leander and Karoumi (2010) presented a case study on cracks found in the web of the primary steel beams of a railway bridge in Sweden. Theoretical studies showed that the cracks developed mainly due to poorly designed connections of the cross beams and out-of-plane bending of the web. Residual fatigue life of stringers and cross beam was also found to be alarming. They presented a residual fatigue life based on monitoring of bridge behaviour and theoretical studies.

Marques et al. (2014) presented analysis of dynamic and fatigue effects on old metallic railway bridge under European Research Project FALDNESS. Both numerical (FE model validation) and experimental approaches have been used to find fatigue assessment. The main steps taken for fatigue evaluation have been described in their paper. One and half years of strain measurement data have been used.

Pasquier and Smith (2016) applied new iterative framework for structural identification for condition assessment of old bridge structures. They carried study on an existing ageing bridge in Wayne, New Jersey (US) and concluded that such a framework is able to support structural identification with measured field results jointly with engineering judgement.

Pasquier and Smith (2015) presented a case study on International Bridge in New Jersey regarding sources and types of modelling uncertainties for structural identification & the methods to evaluate them.

Pasquier et al. (2014) presented study on improving fatigue evaluations of structures utilizing field measurement data and then comparing model-based data interpretations. Due to uncertainties in modelling & measured data, many models may represent actual structural behaviour. They applied a model falsification approach to improve predicted stresses in structural members, from which the residual fatigue life is assessed. They studied on a circular hollow-section truss.

Pipinato et al. (2009) presented a case study on 12.4m span 90 years old decommissioned railway bridge. Riveted connections of the shear diaphragms were identified as the critical locations.

Eastern Railway has permitted plying of increased axle load of goods train from 20.32 tonne to 22.82 tonne (for Carrying capacity + 8 tonne + 2 tonne) on some of the broad gauge (BG) routes. There is further planning to permit 25 tonne axle load on these routes. Dedicated Freight Corridor (DFC) is separately built with connection to existing yards for which feasibility for allowing 32.5 tonne axle load needed to be studied. Eastern Railway assigned the job to the India Branch of Cintec International Ltd. for monitoring and assessment of 5 arch bridges. Cintec commissioned some of this work to Ramboll (2012) which included static load tests, dynamic in-service monitoring and structural analysis. Strength assessments of these bridges were carried out (2012-2014) using ELFEN and the Finite/Discrete Element (FDE) analytical techniques. The linear working stress approach required by the Indian Railway Arch Bridge Code and Ultimate Limit State (ULS) strength assessment as per British Network Rail Guidance has been used. The results of the studies are as follows:

1. The ULS assessment has found the bridges to be capable of carrying the proposed 25 tonne and 32.5 tonnes axle loadings.

2. The working stress assessment has found that permissible stresses in the masonry have been exceeded under the proposed 25 tonne wagon axle loading. In reality the stresses are working within sustainable limits under existing live load as the bridge is not showing signs of distress. For this the most likely reason could be simplifying assumptions made in the type structural analysis done when permissible stress limits were set. Permissible stresses given in the Indian Railways Bridge Code for masonry are intended to be used with far simpler calculations where forces, derived from force equilibrium or linear elastic analysis, are averaged over whole

numbers. They are not intended for compared with peak stresses within non-uniform distributions, as calculated in arch barrel using FDE analysis. In these circumstances their use to limit load carrying capacity is likely to result in an overtly conservative bridge rating.

Ribeiro et al. (2012) validated the mathematical model of a bowstring-arch railway bridge based on modal parameters such as natural frequencies, mode shapes and damping coefficients. Based on enhanced frequency decomposition method, the vibration test was done to find modal parameters. Genetic algorithm was used to find optimal values of 15 parameters of mathematical model. A new technique based on the modal strain energy was used for the mode pairing. The mathematical model was validated based on an experimental test of the concrete and a dynamic test under railway traffic. The results showed agreement between mathematical and experimental results.

Rocha et al. (2015) have presented a case study carried out on 6x12 m simply supported span composite ballasted track bridge. Load has been taken as TGV-double high speed train. The effects of bridge & train parameters and track irregularities have taken considered for analysing safety criteria. Probabilistic approaches like Monte Carlo & Latin Hypercube have been combined to augment effectiveness of the appraisal. The analysis has been done from two safety considerations: loss of rail-wheel contact and instability due to excessive deck vibrations. They have found the results extremely promising and can be applied in practice due to reasonable computational costs.

Wallin et al. (2011) investigated 2 different methods for strengthening of a through truss railway bridge in Sweden. In one of the methods, arches were added on underside of the truss and in the other, floor beams were pre-stressed to strengthen the structural system. As a result, tension in the bottom chord was changed to compression. 3D FEM model was created for dynamic analysis concerning fatigue study as well as changes in vertical bridge deck acceleration for high speed traffic.

Xia et al. (2012) established a dynamic analysis model for a coupled high-speed train and bridge subject to collision load. A case study was carried out on 7x32 m simply supported high speed box girder Railway Bridge. The time history curve of a drifting floe collision force was obtained from the field experiments. Such an excitation load was introduced on bridge piers to study dynamic response of the coupled train-bridge system. Thereafter, derailment causing factors such as derailment factor, offloading force component, lateral rail-wheel interaction forces were also investigated. They found that the dynamic response of bridges subjected to crash load is much greater compared to that without a crash. They have proposed critical speed curve for running safety of a train on a bridge for crash load with varying intensities. However, there are other design forces such as wind, earthquake, vessel etc., combined effect of which is quite complicated.

Xiao et al. (2015) presented Multi-direction bridge model updating using static and dynamic measurement. Sensors were installed on the bridge to record static & dynamic data for structural health monitoring.A portable accelerometer system was installed to record the ambient loading test and 15 force-balanced accelerometers were installed along bridge centre to record the bridge global response. The original model was built according to the drawing. The bridge model was updated using multi-level test data. In every stage, the uni-direction members were updated in local-global level. Multi-direction model updating can reduce the number of objective functions and variables in each step. They concluded that it is essential to update steel girder bridge's FE model in the multi-direction in order to ensure the model's precision.

3.0 Methodology Adopted for Field Measurement: For field measurements of superstructure, the state of the art Structural Testing System (STS) manufactured by Bridge Diagnostics Inc. (BDI), USA, has been used. The sensors were fixed to the members with the help of quick hardening epoxy/adhesive e.g. Loctite etc. These sensors were connected to STS WiFi Nodes through Ethernet cables. Each WiFi Node accommodated four sensors. Through the antenna of WiFi Node, the signal was transmitted to the antenna of WiFi Mobile Base Station. Then these signals were further transmitted through WiFi to the Laptop as shown below (Fig.2):

Sensor ⟷ STS WiFi Node ⟷ WiFi Mobile Base Station ⟷ Laptop

STS-WIFI: HOW IT WORKS

Fig.2: Working of Structural Testing System

The range of Strain transducer was +/- 4000 micro-strain, sensitivity = 500 micro-strain/V_{out}/V_{ext} with accuracy < +/- 1%.

Based on theoretical analysis of the bridge using MATLAB, sensors such as strain gages, accelerometers, LVDTs, temperature gage etc. were place at critical locations as shown in Fig.3 below.

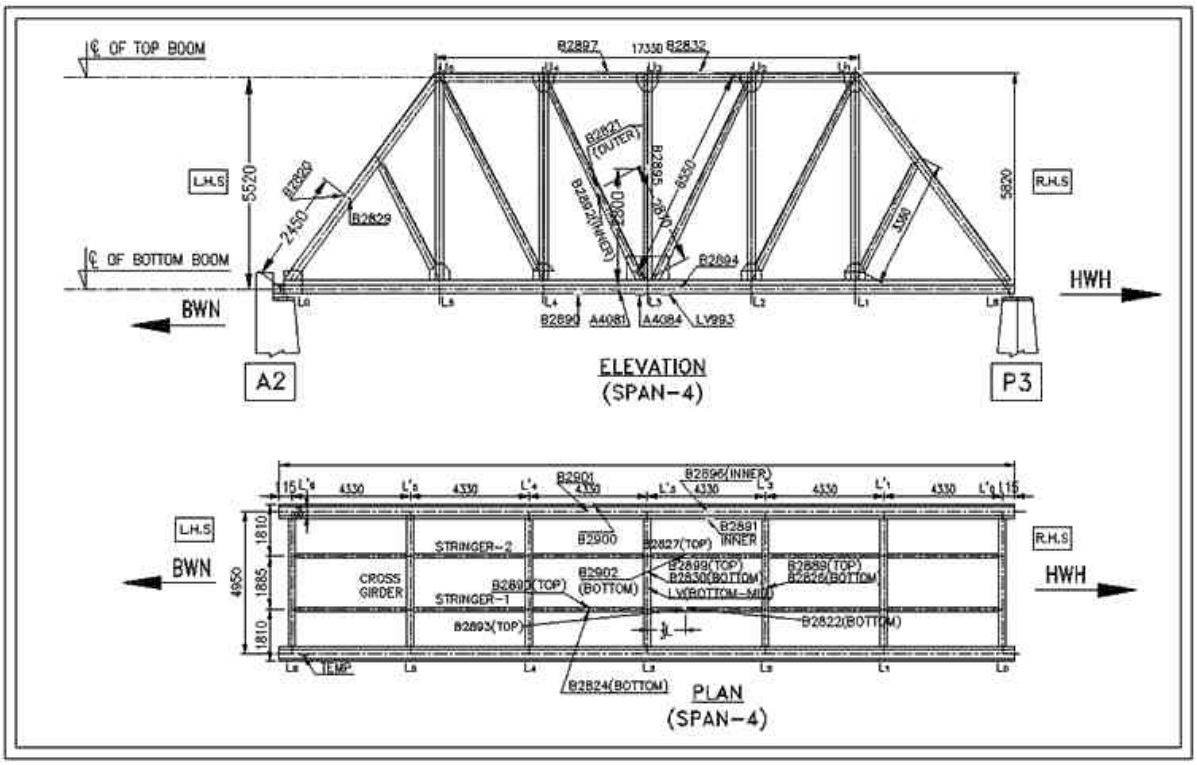


Fig.3:Location of Sensors

Pre-retrofitting measurements were taken on 3rd March, 2016 under moving load of coupled two WAG9+WAG7 locomotives (6 axles each and weighing 123 metric tonnes per loco) with 3 coal loaded BOXN wagons (weighing 75 metric tonnes each) at different speeds of 5 kmph, 15 kmph, 38 kmph & 50 kmph.

After replacement of all corroded load bearing members (stringers), post-retrofitting measurements were taken on 19th June, 2016 under moving load of coupled two WDG4+WDG4 locomotives (6 axles each and weighing 126 metric tonnes per loco) at different speeds of 5 kmph, 15 kmph & 30 kmph. Load formations during pre and post measurements has been shown in Fig.4 below.

Fig.4: Load formations

4.0 Observations

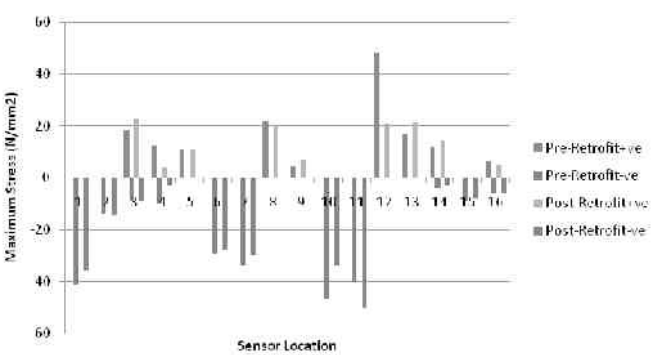
The Pre & Post measured values have been summarized in the Table-1 below:

Table-1: Comparison of Stresses and Deflections at identical locations

Sensor Loc.	Location	Measured Values				%age Change	
		Pre-retrofitting		Post-retrofitting		W.r.t. Pre -retrofitting	
		Avg. Stress (MPa)		Avg. Stress (MPa)		Avg. Stress (MPa)	
		Max +ve	[illegible]	Max +ve	Max -ve	Max +ve	Max -ve
1	Top chord U3-U4 Flange at mid span	0	-41.17	0	-35.83	0	-12.97
2	Top chord U2-U3 Flange at mid span	0	-14.08	0	-14.4	0	2.27
3	Diagonal member L3-U4 @2.87m from L3 on inner side	18.62	-8.68	22.91	-9.16	23.04	5.53
4	Diagonal member L3-U4 @2.87m from L3 on outer side	12.49	-9.85	4.12	-3.14	-67.01	-68.12
5	Vertical member @2.80m from L3	11.06	0	10.62	0	-3.98	0
6	LHS End raker U5-L6 Flange @2.45m from L6	0	-29.38	0	-27.93	0	-4.94
7	LHS End raker U5-L6 Web @2.45m from L6	0	-33.9	0	-29.99	0	-11.53
8	Bottom chord Web near L3 on inner side of Outside Channel	21.61	0	20.87	0	-3.42	0
9	Bottom chord Bottom Flange at L2 - L3 mid span Inside Channel	4.79	0	7.08	0	47.81	0
10	Cross Girder L3 Top at Mid span	0	-46.93	0	-33.85	0	-27.87
11	Cross Girder L2 Top at mid span	0	-40.45	0	-49.94	0	23.46
12	Cross Girder L2 Bottom at Mid span	48.25	0	20.92	0	-56.64	0
13	Cross Girder L3 Bottom at Mid span	17.22	0	21.29	0	23.64	0
14	RHS Stringer L2-L3 Bottom at 1/3rd from L3	12.19	-3.64	14.75	-2.91	21.00	-20.06
15	Vertical Deflection (mm)		8.8		7.9		
16	Lateral Deflection (mm)	6.6	5.8	5.2	5.8		

Note: Pre & Post-retrofit deflection values have been indicated at 50 kmph & 30 kmph respectively.

The above values have been compared graphically in Graph-1shown below.



Graph-1: Comparison of Pre & Post retrofit stresses at identical locations

After replacement of corroded girders, the important observations have been listed below:

1. Compressive & tensile stresses in the diagonal member L3-L4 on outer side have reduced considerably by 68%. However, there has been 23% increase in compressive stress for this member on inner side.
2. Tensile stress in cross girder L2 bottom has reduced by 57% whereas there is 23% increase in compressive stress at top for this member.
3. Tensile stress in cross girder L3 bottom has increased by 24% whereas there is 28% reduction in compressive stress at top for this member.
4. In the replaced Stringer, there is 21% increase in tensile stress and 20% reduction in compressive stress.
5. In the Top chord, there is 13% reduction in compressive stress.
6. In the End raker, there is 12% reduction in compressive stress.
7. In the Bottom chord bottom flange, tensile stress has increased by 48%, though actual increase in the tensile stress is from 4.8 MPa to 7 MPa.

In addition, some typical observations have been made as listed below:

8. Inner side of the diagonal member carries substantially more compressive and tensile stresses than the outer side of the same member.

9. End raker web carries substantially more compressive stress than the flange at the same location.

10. Stringers experience reversal of stresses.

5.0 Conclusion: From the above observations, it is concluded that:

1. The diagonal members are redundant members in the truss structure and hence due to distress in the load bearing members or Stringers, Diagonal members carry considerably more stresses.

2. In the replaced stringer, there has been increase in induced tensile stress but reduction in induced compressive stress.

3. Since Stringers and cross girders are mutually connected as part of the floor system, change in load carrying pattern in Stringers affect compressive and tensile stresses induced in the cross girders as well.

4. There has been reduction in compressive stresses in Top chord and End Raker members i.e. Compression members.

5. In bottom chord member, i.e. tension member, there has been increase in tensile stress after retrofitting. This may be due to increase in tensile stress at bottom in stringers.

6. In the prismatic built-up sections, stress distribution is non-uniform at flange/web at the same location.

6.0 Future Scope of Work: Based on the above observations, the structural parameters need to be determined that produce the measured responses. With these measurements, an iterative analysis process may be used to develop a "calibrated" bridge model from which load ratings can be calculated.

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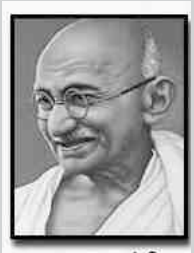
क्रोध को जीतने में
मौन सबसे अधिक सहायक है!
मुर्ख मानुष्य क्रोध को जोर-शोर से प्रकट करता है
किंतु बुद्धिमान शांति से उसे वश में करता है!



– महात्मा गांधी

Constraints and their Solutions for Increasing Speed of Passenger and Goods Trains

By
*Pradeep Kumar**

1.0 Introduction: The vast majority of railway networks worldwide practice mixed operations, i.e the passenger and goods trains share the same track. This practice on one hand seems to achieve economics of scale, as more trains use the railway infrastructure, on the other hand, however, it causes problems in the network operation and maintenance as trains with different axle loads and characteristics circulate on the same track. Many features of the freight wagons/trains differ substantially for those of the passenger coaches/trains. As a result sharing the same track affects directly or indirectly the design, construction , operation and maintenance of a railway system.

The need to have passenger and freight trains sharing the same track has significant impact to the design, construction and maintenance of railway track. For example, the alignment is determined by the design speed defined for passenger trains, track maintenance policy considers the daily traffic load made up of all trains and mixed network satisfy passenger train transportation. This priority usually leads to resource inadequacy for freight trains which are further delayed in favour of passenger trains. This seems to enforce the progressive segregation of network for passenger and freight traffic and it would be ideal to lay separate track for high speed trains and heavy axle load trains as being done for bullet trains and dedicated freight corridor. However, laying separate tracks would require lot of time, resources and investments. Hence to optimize the use of existing track, the need of the hour is to go for semi high speed trains on existing track.

Best way to achieve the semi high speed would be to increase the speed of both passenger and goods trains and minimize the differential speed of these trains as it would be easier to design, construct and maintain the track for one semi high speed. However the same may not be feasible at many sections due to various constraints like track geometry, power of locomotives, design of bogies of both passenger and good trains, track layout and ruling gradients. The aim of this article is examine the various options available to remove the above constraints in existing railway system.

The following constraintsare existing in the operation of high speed in the present track structure.

1) Sharp horizontal curves
2) Sharp Vertical curves
3) Level Crossings
4) Trespassing along the track
5) Ruling Gradient

Let's discuss the constraints and the options available to remove them one by one.

2.0 Sharp Horizontal Curves: The centrifugal forces generated on the curves vary with the square of the speed. The curves are therefore required to be eased out to keep the centrifugal forces within the manageable limit. One of the requirement of track geometry of high speed trains is that Raddi of the curve is to be larger. For example, requirement of cant for two degree curve for speed of 200 Kmph is as follows.

$$\text{Cant} = G*V^2/127*R$$

$$\text{Cant} = 1750*200*200/127*875$$

$$= 630 \text{ mm}$$

Thus the value of cant required is very high. The same will be further higher for more sharp curves. Cant is maximized with respect to stationary condition and slow running trains. A maximum value is set for cant because the following problems which arise if a train is forced to stop or run slowly in a curve.

I) Passenger discomfort at standstill or at low speeds

II) Risk of derailment of freight trains in sharp curves due to

**Dy. CVO/Engg/ECoR/BBS*

combined effect of high lateral and low vertical load on the outer wheel at low speed.

III) Possible displacement of wagon loads

The maximum cant on curve track permitted is 165 mm as per para 406(d) of IRPWM. As the requirement of cant for sharp curves is very high, Flattening of sharp curves is required to bring the cant within the permissible limit.

In Fig-1, there is one two degree curve for length of 500 m. If this curve is to be flattened to one degree keeping the deflection angle same, the maximum shifting of the curve is 37 m at summit point and it is less at other locations. Hence flattening of curves can be done at locations where land is available. Acquiring small patches of land to ease out the curves may also be examined. Construction of retaining walls where land is restricted can also be planned. A detour may also be planned at locations having sharp curves coupled with steep gradients to remove both the constraints. However, there may be some obligatory points like built up areas, rivers, pondswhich have to be avoided in any case and flattening may not be possible at those locations.

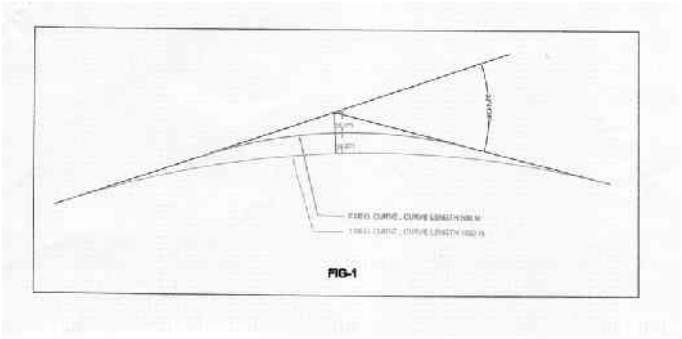


FIG-1

The second option to increase the speed on curves while keeping the cant same is to increase the cant deficiency. The cant deficiency allowed in real train operations is determined by the following factors

i) Track construction(with respect to its ability to resist high speed)

ii) State of the track components

iii) Track alignment(i.e Magnitude and shape of geometrical irregularities)

iv) Type of vehicle

v) Axle loads and unspring masses

vi) State of maintenance of rolling stock

vii) Passenger comfort

Maximum permissible cant deficiency as per para 406(2) of IRPWM is 100mm for group A and B routes. If high values are allowed for cant deficiency, the track components must be designed accordingly. With improved running gear and carbody tilting system, permissible cant deficiency of the vehicles can be permitted up to 245mm(As per BANVERKET[1]).Tilting system is developed by adopting a control device that has springs. Maximum speed permitted can be 228and 161kmph for one and two degree curves respectively with cant deficiency of 245 mm. Hence speed of the passenger trains can be increased by adopting this system.

3.0 Sharp Vertical Curves: A vertical curve provides a smooth transition between successive tangent gradients in the railway profile. In changes of gradients, a suitable radius must be used. If the vertical acceleration on a crest is too great, the loads on the vehicle wheel may cause the wheels to climb the rails and thus cause a derailment. It is also important that passenger comfort is being ensured.

As per para 419 of IRPWM, a vertical curve shall be provided only at the junction of grade when the algebraic difference between the grades is equal to or more than 4 mm per metre or 0.4 percent. The minimum radius of vertical curve should be 4000m for Group 'A' route. However As per BANVERKET[1], the recommended minimum radius for vertical curve for 200 kmph is 6400m. However changing vertical curve may not be a major problem because enhanced radius does not have very severe effect on the top level of rail profile. For example, it requires the maximum lowering of 120 mm at summit point of 1in 100 rising gradient followed by 1 in 100 fall. The amount of lowering/raising can be adjusted in ballast.

4.0 Level Crossing

Level crossings constitute a significant safety concern. The same may act as serious constraint in increasing the speed of passenger trains. Thus the level crossings are required to be eliminated to the maximum extent possible. The following action may be taken when converting existing routes to high speed routes.

i) All unimportant LCs with low TVUs should be closed down by diverting traffic to nearby level crossing.

ii) All major LCs should be eliminated by constructing ROB/RUB/LHS wherever feasible.

iii) All LCs to remain on the route should be manned and interlocked with provision of colour light signals.

With the present emphasis of elimination of level crossing, the same may be completed shortly in phased manner and this

constraint can be eliminated.

5.0 Trespassing Along the Track: Trespassing of track by public and cattles can be a serious safety hazard. Though it is debatable to provide fencing throughout the track for speed up to 200 Kmph, it is recommended to provide fencing throughout the high speed track to avoid trespassing and ensure safety of the passengers.

6.0 Ruling Gradients: The topographical conditionusually require some kind of vertical longitudinal gradients along the way. However steeper gradients constitute a major constraint in increasing speed of goods trains. The speed of goods trains on steeper gradients can be increased by using high speed wagons, high power locomotivesor multiple locomotives. Another however difficult option is to flatten the steep gradients. Stretches of steeper gradients may be identified to plan a detour and flatten the gradient. However the same may not be practicable due to various constraints already discussed above.

Thus it can be concluded that speed of both passenger and goods trains can be increased by removing the above constraints existing in the track. Speed of passenger trains can be substantially increased by better track geometry, use of tilting system for bogies, elimination of level crossings and advanced track maintenance practices. Speed of goods trains can be increased by using high speed wagons,high capacity powerful engines and flatting of steeper gradients wherever possible. Goal should be to increase the speed of passenger and goods trains and minimize their differential speed to ensure that available resources are used in best possible way to achieve best economics in operations and provide speed and safety to the passengers and customers.

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Vadodara Moving Closer to House Country's First Railway University

The initial project report for setting up the national railway university has been prepared and RITES Limited, a Government of India enterprise, has been engaged to prepare the blueprint for the project.

Minister of state for railways Rajen Gohain said this in a written reply to a question in Rajya Sabha.

According to Gohain, the university would benefit not only the Indian Railways but also the growing railway sector including the metro railway, private manufacturers of railway equipments, port railways and consultancy among others.

"The university will act as a centre for conducting interdisciplinary research on railway engineering and management," the minister said in his reply.

It was earlier reported that 100 acres land to set up the railway university has already been identified at Piparia in Waghodia taluka. The railway university is expected to come up at the cost of at least Rs 865 crore in two phases over a period of ten years excluding the land cost.

It was in December 2015 that the railway ministry had declared its intention to set up the railway university. Later, union minister of state for railways Manoj Sinha during his visit to the National Academy of Indian Railways (NAIR), Vadodara had declared that the university will come up in Vadodara. Land parcels at Padra, Desar and Piparia were surveyed after which Piparia was finalised as location for the railway university.

It is proposed that while Vadodara will act as headquarters for the university which will have multi campus, the six colleges of railways located at Secunderabad, Nashik, Pune, Jamalpur in Bihar and Lucknow will become its constituent schools.

On October 22, last year, when Prime Minister Narendra Modi had visited the city to inaugurate new integrated terminal building of Vadodara airport, he had said that the city will contribute immensely to the development of railways in the country through the railway university.

"Government of India has taken this decision whose impact will be felt throughout the century," Modi had said, adding that if the entire world has reached at 100th place in railways, India stands at tenth position.

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

Moving Towards Sustainable Development

By
*Harsimran Singh**

Abstract: *With the increase in global warming and the climate change, sustainable development is no-doubt the prime focus the world over. This paper talks about the implementation of the sustainable development while focusing on Indian scenario. The requirements of a good sustainable construction particularly from the perspective of civil engineer are explained in a systematic manner.*

1.0 Introduction: Sustainability means fulfilling the need of the present generation without compromising with needs of the future generation. Brundtland report (1987). Conventionally the prime focus of a civil engineer is building strength and lifespan, but with present changing scenario, awareness and responsibility toward environment, the characterization of civil engineer has changed from "The one who directs nature's great power source to convenience and use of man" to "the guardians of built and natural environment" (J.A. Ochsendorf, 2005 Sustainable Engineering: The future of Structural Design). From the inception, engineers have focused on economy, strength and long life span of the construction and the sustainability of the construction has been overlooked. Planners & Engineers must start to take care not to build on prime farmland, in a floodplain, on threatened animal habitat and too close to wetlands so as to preserve the ecological balance. They must always remember the 3 Re's while taking decisions big & small during planning a construction project - Reduce, Re-use and Recycle.

2.0 Disturbing Global Figures: So far we have raised average temperature of the earth by 0.8 degree Celsius and that has caused far more damage than most scientists expected. The increase upto 2 degree Celsius is said to be devastating.

3.0 Global Picture: The top 4 emitting countries/regions accounting for 61% of the total global CO2 emissions are mentioned below :

I. China (30%),
ii. United States (15%),
iii. European Union (EU-28) (10%)
iv. India (6.5%)

China as well as US increased CO2 emissions by 0.9% in 2014 compared to 2013, while the rate of reduction in emissions in the EU-28 increased in 2014 to 5.4%. It is interesting to know that the per capita emissions of US are twice as high as those of China and EU.

4.0 Indian Scenario: India`s position is also not good as emissions have increased in India by 7.8% to 2.3GT in 2014 vis-à-vis 2013. The increase in CO2 emissions in 2014 was mainly caused by an 11.1% increase in coal consumption, which accounted for 56.5% of its total primary energy consumption.

5.0 Micro-level Steps: In her INDC (Intended Nationally Determined Contributions) contribution to the UNFCCC (United Nations Framework Convention on Climate Change), India's power generation target for 2030 is to have 40% energy from renewable sources (Solar & wind) and other low-carbon sources, compared to the current 19%, 3% of which is now in nuclear power (UNFCCC, 2015). India has further, planned to ramp up the production of solar energy from 20GW currently to 100GW by 2022. India would create an additional carbon sink of 2.5 to 3 billion tonnes of carbon-dioxide through extra forest and tree cover by 2030.

6.0 Need of Comprehensive Approach: There is urgent requirement Of Comprehensive Approach In the country for a lifetime analysis than a mere patch work point system. For comprehensive plan for sustainable construction, every structure should be considered based on the parameters as mentioned below:

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a) Planning, designing and preparing specifications based on performance and service life
b) Construction Methods
c) Conservation and Selection of material
d) Dismantling and Recycling
e) Conservation of Energy

a) **Planning, Designing and Specifications:** We design the structures well however so far in most of the specifications, we make no reference to any service life or calculations thereof. Deeper study of various service life prediction models and calculations is essential. Specifications must be performance based as opposed to their present form of being prescription based.

b) **Construction Methods :** Wastage in the construction industry is as high as 30%. Wastages are activities that absorb resources, man hours and materials but create no value. In most of the developed countries, there are various forums / institutes / academic institutions for seeking solutions to mitigate these wastages and lean construction practices that emerged have yielded encouraging results.

Lean construction is a way to design production systems to minimize wastage of materials, time and efforts in order to generate the maximum possible value. It is said that you can be lean without being explicitly green, but it is nearly impossible to be as green as is possible without being lean. It helps in minimization of resource depletion; which in turn minimizes pollution and hence helps achieve business and environmental excellence. In India, Initiatives are being taken only by some large private companies to adopt leaner construction practices, though mainly with objective of maximizing profit. We need to have a fully focused lean construction forum to go ahead in a comprehensive way to reduce wastage and have sustainable structures.

c) **Conservation and Selection of Material :** Concrete is the largest manufactured material which has a large per capita consumption of about 1.5 ton per annum in India. While concrete is not as big of an energy consumer as structural steel, aluminum and glass; concrete and particularly cement still remains major energy 'sink' due to its sheer volume of production and is also environmentally unsustainable due to large quantities of CO_2 emissions associated with its manufacture.

Raw materials for cement manufacture include non-renewable natural resources like lime stone, aggregates, clay, shale, sand and so on. Hence Indian concrete industry has following challenges to meet in this regard.

i) **Increased Use of Fly Ash and other Cement Substitutes:** Studies indicate that by 2020 the economically feasible stocks of prospective lime stone will become scarce. However, India has a reasonable availability of by-products like fly ash and GGBFS, which can be added to cement and help to an extent to lengthen the period of smooth supply of lime stone. Flyash which is considered as pollutant also gets consumed in this way, which is big added benefit. India produces approximately 130 million tons of fly ash out of which only 35-40% is being utilized at present. In another ten years, this production is likely to rise to about 250 million tons.

ii) **Use of Manufactured Sand :** Aggregate scarcity is the biggest concern today in India. One solution is to use manufactured sand which is artificially produced from rock such as by using a vertical shaft Impactor (VSI). It provides consistently good quality sand having uniform gradation and shape; with less organic and inorganic impurities and lesser Chlorides and Sulphates; and lower levels of silt, clay and crusher fines, resulting in reduction in water cement ratio. As a result of less cement, fines and water in the concrete, shrinkage cracking is reduced and durability and sustainability are enhanced. There is a direct substantial environmental benefit as the natural terrains of river basins are not disturbed.

iii) **Use of Lightweight Aggregates:** In India, natural lightweight aggregates are not available but light-weight aggregates can be produced by sintering waste products like fly ash. These aggregates have been used in structural lightweight aggregate concrete, with compressive strengths ranging from 20-50 MPa (Clarke J B, Structural lightweight aggregate concrete, Chapman & Hall, 1993 U.K.). These aggregates reduce the self-weight of various structural elements of a building, bridge and other structures, and thus reduces earthquake forces.

d) **Demolition and Recycling :** The use of recycled aggregates has not been adequately explored in India. The construction and demolition waste has substantially increased as new super structures are being built on land after tearing down the smaller structures that previously existed.

Fig. 1 Demolition of old structure

Recycling of aggregate material from C&D waste may reduce the demand-supply gap in both these sectors and also solve problem of acute shortage of dumping grounds and landfills particularly in metropolitan cities. It has now been determined that recycled aggregates can be readily used in construction of low rise buildings, concrete paving blocks & tiles, flooring, retaining walls, approach lanes, sewerage structures, sub base course of pavements, drainage layer and dry lean concrete(DLC) layer in highways, etc.

6.0 Energy Conservation: Since sources of good quality aggregates are fast depleting, it is becoming increasingly necessary to use locally available 'marginal' aggregates. The use of local materials also helps reduce the carbon footprint associated with transport. Use of locally available aggregates should be encouraged even if marginally inferior, as desired properties of concrete can be obtained by intelligent blending of available aggregates of inferior quality with crushed sand, inert fillers, supplementary cementitious materials and chemical admixtures. Rail and Water transport systems should be preferred which are more energy efficient vis-à-vis Road. India has vast Railway network and also very large network of Rivers.

7.0 Review of Standards & Polices vis-à-vis Construction & Demolition (C&D) Waste: We need to look into the standards for promoting the use of recycled material as aggregates. We have millions of tonnes of C&D waste generation (about 530 MT as per some field study) as well as 2.2 billion tonnes of annual aggregate requirement, but the recycled aggregate market in India does not exist because the IS: 323-1970 states that aggregates should be 'naturally sourced'. The concern is that some of the recycled materials may not be structurally viable for re-use, but with proper channels for processing and grading of waste, these hurdles can be overcome. This way two issues would be solved at the same time: waste disposal as well reduction of fresh mining of aggregates.

C&D waste is largely concentrated in urban areas where a majority of the new construction would be taking place, and this would also reduce the transport costs and emissions involved in mining and transporting.

The following are required in this regard:

i. Specific rules for segregation and grading of C&D Waste, and standard guidelines for re-use of C&D waste

ii. Rules for checks on land filling and disposal of only the portion of C & D waste which cannot be re-used

iii. Guidelines for promotion of 'Deconstruction' and curb on 'Demolition'. (Deconstruction : Planned breaking of structures with the aim that majority of the components can be reused.)

iv. The government must aim to develop a market for recycled aggregates by giving tax breaks.

8.0 Transportation Engineering: The Transportation sector is one of the largest contributors to emissions producing about one-third of all greenhouse gasses.

As seen from the table below, the scenario is really critical, and further, transportation sector is so diverse, that there is need to tackle this sector at different levels and through great research. Engineers have the great obligation to plan the transportation system such that people use more sustainable means of transport.

Table : 1

Year	Vehicles in India (In Million)
1991	20
2011	140
2030	400 (expected)

9.0 Urban Transport : Alternative modes of transportation like cycling, walking, etc, must be extensively implemented in public transportation system. We can have separate lanes for pedestrians and cyclists should be to encourage walking and cycling. Bike share stations can be opened in the commercial downtowns.

Fig.2 New Cycle Highway planned in Uttar Pradesh, India

On policy fronts, increasing the cost of car ownership and fuel taxes through increased parking fees and tolls can be implemented. This way, personal cars can be controlled in city and people encouraged to use public transport which should be improved by providing more mobility & accessibility.

10.0 Highways and Railways : India has one of the largest road networks in the world, 33 lakh kilometers at present, though the National Highways, measuring 65,590KM carry over 40 percent of the total traffic. India has set for herself an ambitious target of laying 14600 KM Highways in 2016-17 which is more than double the current pace. Indian Railway is spread over 63028 Route KM (1,08,706 Track KM). Target for 2016-17 is 3310 Track KM.

Construction on such huge scale is very energy & resource intensive and requires great caution for ensuring sustainability. This involves cutting of trees and rehabilitation of residents as well as use of huge amount of cement, steel, aggregates, fuel, bitumen, soil, etc. Keeping these in view tree plantation has been integrated with road construction by the Ministry of Road Transport and Highways, Govt of India. This should be made mandatory in all infrastructure projects and monitored strictly. For land acquisition and rehabilatation, new Act has been passed by the Indian Parliament which takes into account the social aspect of the project, though there may be hiccups to the speed of the projects initially but these will soon be over.

Another important aspect is that carbon foot print of the Railway is much less than the Road sector. Annual consumption of fuel by the Railways is just about 7% of the annual fuel consumption by the Road sector. The energy consumption is about 75%- 90% less for freight traffic when compared to road. The Carbon Dioxide emission is about 80% less than Road. The AITD's report on Environmental and Social Sustainability of Transport-Comparative Study of Rail and Road (2000), made the following conclusions in context of Indian Railway and Highways:

a) **Energy Requirement** – For transporting one Net Ton KiloMeter (NTKM), Railway consumes 0.12 to 0.39 Mega-Joules compared to 1.13 to 1.58 Mega-Joules consumption by Road. To transport one Passenger KiloMeter(PKM), Railway requires 0.16 to 0.20 Mega-Joules compared to 0.19 to 0.22 Mega-Joules required by Road. Thus Railway sector consumes 75% to 90% less energy for freight traffic and 5% to 21% less energy for passenger traffic in comparison to Road sector.

b) **Monetary Costs** – In the base year 2000, unit cost of Rail transport was lower than Road transport by Rs 2.09 per NTKM and Rs 1.62 per PKM.

c) **Accident Costs**- Accident costs on Road are significantly higher than those on Railway. In the case of freight transport, Road accident costs are 8 times that of Railway and in case of passenger transport, they are 45 times higher.

d) **Health Damage Costs**- On an average, the health damage cost of Railway freight traffic is lower than that of Road by a factor of 7, while in case of passenger traffic it is lower by a factor of 5.

e) **Social Costs (all- inclusive costs)** – In terms of all-inclusive costs or social costs, Railways have a huge advantage over Road transport. The advantage is more pronounced in case of freight traffic. For urban areas, the cost advantage of Railway in the base year 2000 is as much as Rs 2.81 per NTKM and Rs 1.72 per PKM, while for non – urban areas, the cost advantage is as much as Rs 2.47 per NTKM and Rs 1.68 per PKM.

International Union of Railways (UIC) have also stated that Railway transport emits 17 gram equivalent CO_2 equivalent per Passenger Kilometre (PKM) compared to 84 gram in case of Road transport and 113 gram in case of Airplanes. M/s Mckinsey in their study – "Transforming the Railway's logistics infrastructure, 2010" have indicated the emission per ton-km of freight as 28 gram equivalent CO_2 for Railway vis-à-vis 64 gram equivalent CO_2 for Road transport and over 1000 gram equivalent CO_2 for Air transportation.

There must therefore an extra effort to build more railway infrastructure and plan well integrated railway networks so that consumers are more attracted towards it. Compatibility of Railway with Roads, Waterways and Airports should also be improved. Also while constructing, green aspects and carbon foot print must never be ignored. We must aim towards solar powered stations and trains. This year Indian Railway has decided to procure 1000MW of solar energy over a period of 5 years which will be part of the 100GW solar power planned to be produced by India by 2022.

11.0 Integrated Planning for Green Buildings : Architect as well as the Engineer must aim for efficient use of energy and water when planning the building.

Fig. 3 Deciduous trees

Surroundings of the building should be planted with deciduous trees on the east and west sides. The leaves would provide shade in the summer and they fall off in the autumn, sunlight would filter through and warm the building during winter. The fallen leaves should be composted to reduce the load on the garbage landfills.

Installing skylights, solar panels and photovoltaic energy systems should be well integrated in the building. When large vacant roof space is available, the same can be used for installing solar power cells.

Fig. 4: 1MW Roof Top Solar Power Plant at Katra Railway Station

The solar energy tapped, can be fed either directly to the electric sub-station (if there is one) for on-line grid feeding, or can be stored and used for electrification. On line grid feeding system uses the generated power first and thereafter the balance required power is drawn from the main grid of substation. When no power is required in the installation, the generated power will feed back the grid. (See Fig.4)

12.0 Conserving Water: Packed gravel or permeable concrete should be used instead of conventional concrete or asphalt to enhance replenishment of ground water. The rain water harvesting systems for recharging ground water table should be adopted wherever permissible as a policy. Grey water irrigation by using the water from wash rooms etc. is another simple and effective sustainable way of reusing waste water.

Fig. 5 Online Grid Feeding System

Fig.6 Rain Water Harvesting

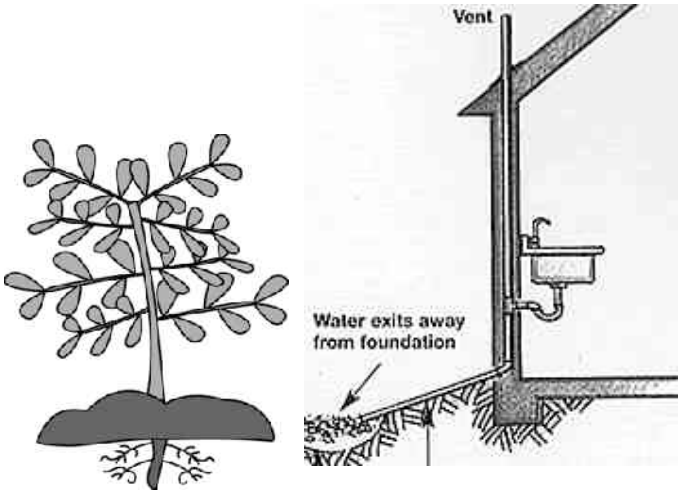

Fig.7 Grey water irrigation

13.0 Reuse : Provision of space for storage and collection of recyclable material should be built in the planning and design stage itself. This is important as the sustainable building is designed for the complete life cycle including dismantling and reuse for material.

14.0 Green Building Materials: These materials are generally more expensive than traditional building materials. The trade off is that green buildings are more energy efficient and definitely make up for the initial greater cost in the long run. Some examples of green building materials which should make part of the plan and design are presented below.

a) Bamboo Flooring : Bamboo takes only three years to mature and the North-east India is abundant in bamboo which can be used as building material.

b) Cork Flooring - Cork is harvested from the bark of the tree, so the tree itself is not cut down and the bark grows again in about three years. Cork is also naturally hypoallergenic and anti-microbial.

c) Reclaimed Wood - The wood is salvaged from demolished buildings and is reused.

d) Linoleum – It's made from items like linseed oil, jute and flax. Another benefit of linoleum flooring is that it does not release toxic Volatile Organic Compounds (VOC's) unlike vinyl tiles.

Insulation is very important for energy efficiency by reducing heating & cooling requirements. Some of the eco- friendly insulation options are as follows**.**

a) Homasote fiberboard made from the recycled newsprint.

b) Cotton insulation made from the recycled cotton materials like denim. It doesn't contain Formaldehyde like traditional fiberglass insulation.

c) Hemp based products which are naturally resistant to pests like moths and beetles.

d) Blown insulation which is comprised of recycled newsprint and is professionally blown in.

Roofing not only protects from inclement weather but also insulates the building. Roofing materials which are designed to reflect heat and therefore help to prevent heat transference from the sun rays should be used where the building is to be kept cool inside. Bamboo can also be used as efficient roofing material for parking sheds, roofing for workshops, etc.

Fig.8 Bamboo Mat roofing for Parking Shed

Autoclave Aerated Concrete(AAC) Blocks : These are made from the steam-cured mix of sand or pulverized fly-ash (PFA), cement, lime, anhydrite (gypsum) and an aeration agent. These are very energy and resource efficient when compared to Clay-fired bricks. Their average density is only one fifth of normal concrete and hence there is reduction in dead weight leading to savings in steel and concrete.

AAC comprises numerous tiny non-connecting air bubbles which give AAC its diverse qualities and makes it an excellent insulating material. There is as much as about 30% saving in cooling and heating requirement when AAC blocks are used in place of clay fired bricks.

Manufacture of AAC blocks does not consume soil but flyash which is itself a waste, an consumes about 1/8th of the fuel (Coal) as consumed by clay fired bricks and hence less CO_2 Emission.

Fly Ash : There is generally requirement of large amount of filling for land development in construction projects, which can be done by using waste materials like fly ash if available locally. Fly ash can be filled in lower layer and in the top layer, good earth or sand should be filled so that the flyash gets covered and does not create pollution. Also good earth at top helps in turfing and planation.

Fly ash bricks are also good alternative to clay fired bricks. These are also cost effective and have good compressive strength and other properties.

Fig.9 Filling fly ash for land developmen

Fig.10 Fly Ash Bricks

PSC & PPC : The cements like Portland Slag cement (PSC) and Portland Pozzolana cement (PPC) which use waste material of industry should be used wherever permissible. Infact PSC is good for foundation work as it is resistant to Sulphate attack. Now-a-days PPC has confirmed its credentials and come up as one of the better cements. Doubts about its strength and durability have been removed.

PPC(Portland Pozzolona Cement): It commands a 67% share of the cement market in India. Current PPC policy of Govt of India, allows only 35% mixture of flyash in cement, whereas the global limit is 65%. If this limit is enhanced, more flyash can be used and more PPC produced.

PSC(Portland Slag Cement): It accounts for 8% share of the cement market in India. While PSC is much less energy and water intensive than OPC as well as PPC, its manufacturing in India is limited by the slag production capacity. India's current slag production capacity is about 10 MT per annum at existing steel plants and the Indian cement industry consumes almost all the granulated slag produced.

Energy Efficient Windows **:** Big windows that provide plenty of fresh air and natural light should be adopted, and in air conditioned space, double walled windows should be used so as to prevent loss of energy.

Mineral Fibre false Ceiling & Bamboo false ceiling provide good interior finish. While the first one makes use of waste material the latter uses raw material with little processing.

Fig.11 Mineral Fibre False Ceiling

Fig.12 Bamboo Mat False Ceiling

15.0 Conclusion: Development must take place in a sustainable manner so that the future generations are able to meet their requirements without difficulty. This requires who listic approach, policy initiatives and urge to maintain and improve the environment. Reduction of carbon foot print should be the objective in various small activities as well as large projects.

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Challenges in the Design of Railway Track for Heavy Haul and Semi High Speed Trains Mixed Traffic on Indian Railways

By
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Synopsis: *Indian Railway succeeded in increasing axial load of goods trains and increasing speed of express trains to supper fast trains. The success was combined with lot of input to keep the track fit to carry the traffic requirements. Even after large inputs maintaining integrity of track assets continue to be problem. There are cases of track asset failure causing derailments. There are cases of rail surface defects needing pre matured renewal of assets. To overcome these problems the track for mixed traffic of heavy haul and semi high speed have to be designed with technological improvements so that Indian Railway can be prepared to handle heavy haul and Semi high speed trains in single net work. This technical paper is an attempt to improve existing track design to sort-out problems of design of railway track on mixed traffic of heavy hall and semi high speed on our railway. Construct ability, maintainability, and reliability are the factors considered in the design.Standardisation, in track design and track works reduces cost and possible mistake. Enhancedrail strength at design stage willavoid premature renewal and failure during service and easy to meet new operational requirements.*

1.0 Introduction: Existing track on Indian railway were initially designed to follow natural alignment, Gradient of the topography, formations built with locally available materials. All these factors resulted in Sharper curves, Steep gradients and yielding formations. Restrictions on speed of goods trains restrict speed of express trains on curves on limiting SE considerations. All these factors resulted in thinking of independent track for DFC, and high speed trains. But now with the advent of latest design and technology and knowhow on heavy haul railway track and semi high speed railway trackit is possible to run heavy haul trains and semi high speed trains in same track net work. This technical paper is an attempt to design track for mixed traffic for heavy haul and semi high speed in India.

2.0 Identification of Problem Areas: Following problems are identified in the initial design of railway track.

2.1 Local material used for formation

Use of local soil for construction without considering its suitability for usage was fit for running conventional traffic. But now it proved its inability to coup up to the present day requirement. Bad soil Caused settlement of formation needing PSR when we increase the axle load and speed.

2.2 Track gradient followed the terrain gradient

Track gradient following topographyof the land results in steep gradient Most of the surface defects in rail were due to steep gradient.

Steep gradients caused Strain on track assets needing pre matured replacement.

2.3 Curve alignment followed the local alignments making the curves sharp Sharp curve need PSR and restricts the speed of trains.

2.4 Problems are attended rather than solved

As the existing deign is not adequate for present day traffic defects are attended and defects do generate after some time.

The main disadvantage of initial track design is that we are not able to grantee 100% safety of track assets. There were pre matured track asset failures.

3.0 Present Study

3.1 Our aim shall be the best design and zero assets failures.

4.0 Design Requirements

4.1 Flat gradient on Level track

**ADEN/N/SA/SR*

4.2 Straight alignments

Flat gradient on level and Straight track is ideal for new construction as it is fit for all types of operation at least maintenance effort at maximum speed.

5.0 Methodology

5.1 Quality Material for construction.

Quality material for construction may be taken from available locations and transported to needy location instead of using locally available fully fit materials.

5.2 PSC technology to be adapted with advantage in present day track design.The advancements inPSC construction can be elevated or lowered or can cover valley at the same elevation fit for running mixed traffic at maximum potential.

5.3 For semi high speed operation and heavy haul operation joint less track with parent rail 20RP to be used.

5.4 Geo grid walls to be adopted in embankments instead of side slope of embankment.

5.5 Fencing requirements are taken care in elevated track and the effect of week formation isavoided.

6.0 Infrastructure Requirements for Semi Speed Operation as per UIC Infrastructure Guidelines

6.1 60 kg rails

6.2 1660 PSC sleepers

6.3 Elastic fastenings

6.4 Ballast cushion 300mm

6.5 Provision of thick web switches

6.6 Flatter gradients

6.7 Minimum Curve radius 2500m

7.0 International Heavy Haul Association Recommended the Following for 30-34 T Axle Load.

7.1 Rails 60 kg on straight

7.2 Premium rails on curve

7.3 PSC sleepers 1660 per km

7.4 Elastic fastenings

7.5 Ballast cushion 300 mm

7.6 Switches made of premium rails

8.0 Track Design

Track structure and alignment requirements are tabulated for different traffic conditions as per the UIC guide lines.

Requirements	Heavy haul	Semi high speed	Existing BG track
1. Rails	60 kg UIC	60 KG UIC	52 kg/60 KG UIC
2. Sleepers	PSC 1660	PSC 1660	PSC 1660
3. Gradient	1 in 100	1 in 100	Steep gradients exists
4. Curves	Flat curves	Straight	Sharp curve exists
5. 300 mm ballet	300 mm ballast	300 mm ballast	300mm ballast
6. Formation	Embankment	Embankment	Embankment
7. LWR	LWR	LWR	LWR
8. Welding	FB	FB	SKV
9. Length of rail	20RP	20RB	Free/3RP/10RP
10. Track special locations	Premium rails	Premium rails	60 KG/52KG

8.1 Rails

Rails 60 kg UIC is recommended rail section for high speed as well as heavy haul traffic. In actual practice in the existing BG track the 60 kg rails not provided desired results. There were asset failures, surface defects were generated in the existing track. Hence it can be stated that the existing 60 kg rails are not adequate for the proposed design of mixed traffic of heavy haul, semi high speed even though it is recommended rail section.

UIC guide lines provide minimum requirements for rail section. Based on the experience gained it is recommended that the next higher section of 68kg rails is recommended for the mixed traffic of heavy haul and semi high speed track. It is also brought out that surface defects do generate in existing track. Head hardened rails will be ideal for the mixed traffic of heavy haul and semi high speed traffic.

Based on this discussion 68 kg head hardened rail are recommended for mixed traffic of heavy haul and semi high speed track.

8.2 PSC sleepers

PSC sleepers to accommodate 68 kg rails are recommended. Existing PSC sleepers design for 68 kg rails is suitable can be adopted for mixed traffic of heavy haul and semi high speed track with Sleeper density 1818 sleepers per KM.

8.3 Gradient

Present experience suggests that one of the reasons for surface defects on rails is track on gradients.

Initially the only way to lay track on gradient was to follow the gradient. Now with advent of PSC technology the gradient can be avoided by viaduct technology. If we avoid gradients surface defects on rails can be countered. If gradient is unavoidable it can be 1 in 400 or flatter with provision for doubling of maintenance frequency and 50% of renewal criteria of straight track.

8.4 Curves

Speed potential of the curve is computed based on formula

Considering SE 165 mm and Cd equal to 75mm for a speed of 160kmph radius of the curve can be computed.

$R=(V^2)/\{(0.27)^2(Ca+Cd)\}$

$R=(160x160)/\{(0.27x0.27)(165+75)\}$

$R=25600/(0.0729x240)$

$R=25600/17.496$

$R=1463$

$D=1750/1463$

D=1.19 degree

It is brought out that for the heavy haul and semi high speed mixed traffic straight track is recommended. If unavoidable curve less than 1 degree can be permitted with doubling of attention frequency and 50% renewal criteria with respect to straight track.

In the case of curve Cd 165mm and Cd 75 mm at design stage so that upgrading is possible when required.

8.5 Ballast

Initial Ballast cushion of 300mm is recommended with increasing cushion to 350 mm during maintenance.

8.6 Formation

Embankment laid with Geo grid wall for slopes to protect cess and providing barrier for that stretch of track. Tested fill material to be used.

8.7 LWR

Entire track to be laid with LWR with SEJ at excluded locations.

8.8 Welding

Welding with flash buts welds only.

As the design is with 'zero' failures need for failure welds will not arise. Maintenance welds can either be Flash butt or gas pressure technique.

8.9 Length of rails

Advantage of using 20 RP is already established hence it is recommended that parent rail to be 20RP.

8.10 Special locations

All locations rails are proposed with head hardened rails so that rail visible damages can be avoided.

9.0 Basic Equations on Design

Q= Wheel load= (Static Axle load)/2 +(Dynamic wheel load)

Static axle load for design purpose is known. The unknown factor is Dynamic wheel load.

The dynamic wheel load is divided in to

9.1 Normal dynamic load

9.2 dynamic loads due to imperfections in the wheel

9.3 dynamic loads due to imperfection in track

9.4 load transfer mechanism of the Rolling stock and track.

The main un known factor causing set back to the design of railway track is thedynamic load due to imperfections in the wheel, imperfection in track and load transfer mechanism of the wagon and track.

EI= Flexural strength of rail. It increases with increase in cross section of the rail.

Hence when existing strength if found to be inadequate for the load carried increased strength of rail will meet the requirement for the load to be carried.

U= Track modulus is the measure of resistance to deformation. All aspects of track structure and track maintenance contribute to elastic track modulus. One of the reasons for premature damages to the rail is destruction in track modulus.

As the rail wheel contact mechanism is complex initial design is based on

Track as continuously supported elastic beam and wheel load as single wheel load. Bending movement at the point of application is

$BM= (Q/4)(4EI/U)^{1/4}$

$Z=\text{depression in track}=(Q/(64EIU^3)^{1/4}$

Track stiffness K depends on flexural strength of rail and track modulus. This suggests that increase in flexural strength and track modulus gives superior track.

The factor what should be kept in mind is the design load Q depends on axle load.

In addition to axle load dynamic wheel load getting added

It is an agreed fact that dynamic wheel load is depends on many unknown factors.

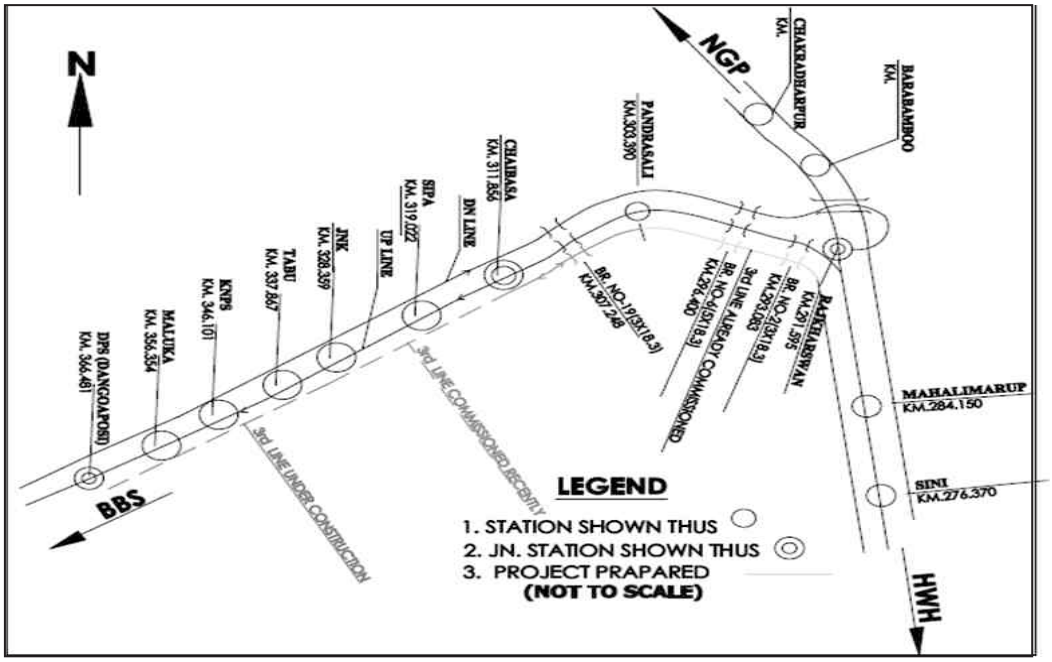
It is to be kept in mind that the actual dynamic load can be more than the axle load for which the track is designed. Presently rail defects like Scabs, squat, are developing needing premature rail renewal or the rail vulnerable for multiple fractures. Considering this higher section rail is recommended.

Construction of New 3rd BG Line from RKSN-PRSL of CKP Division

By
*Anil Kumar Puran**

Salient Features

- One of the highest GMT route (UP 26.52 GMT & DN 69.25 GMT) of Indian railways.
- Expected ROR of 32.11%.
- Work sanctioned in the year 2010.
- Estimate sanction in the year 2011.
- Construction started in the April 2012.
- Construction of formation for 25T axle load and all bridges for 32.5T axle load (DFC)
- Introduction of Absolute Block Signaling on Bi-directional single line from RKSN-PRSL.
- Regulated OHE with swiveling type cantilevers.
- Distance between CSB of RKSN to CSB of PRSL is 10.41KM
- Section commissioned on 19th August 2015.
- Track designed for a maximum speed of 100 KMPH.
- Ruling gradient 1 in 100. Steepest gradient provided 1 in 100.
- Maximum degree of curve is 4°
- 1.876 Km section is on curves out of 10.41 Km.
- 02 Nos major bridge and 20 nos minor bridges in the patch.
- Linear water way is 18.742m per Km and % of water way is 1.80%.
- 06 nos manned level crossings, Out of which 05 nos are of 'C' class & 01 no is 'Spl' class.



*AXEN/Con/II/CBSA

1.0 Preamble

The section between Rajkharswan - Dangoaposi under Chakradharpur Division is double line electrified section covering of 75 KM. length. The section is having 8 block sections. The existing workable capacity of Rajkharswan-Dangoaposi section is 32 trains as per Line Capacity statement 2005-06 against which 33.70 trains are running each way per day, resulting in capacity utilization being 104 %.

Considering the saturation of line capacity and future projection of traffic, the necessity of 3rd line between Rajkharswan-Dangoaposi tremendously being felt.

Section	Charted Capacity with maintenance Block	Utilization					
		2005-06		2013-14		2018-19	
		No of trains per day in each way	% age	No of trains per day in each way	% age	No of trains per day in each way	% age
Rajkharswan-Dangoaposi	32	33.70	104	48.768	152	63.836	199

As per the above statement, it reveals that the capacity utilization on the Rajkharswan-Dangoaposi section has already crossed saturation point and the projected traffic is far in excess of the present line capacity of the section from Rajkharswan to Dangoaposi. To cope up with the future traffic it was required to augment the line capacity in the whole section between Rajkharswan to Dangoaposi.

Considering the PET survey report the Rajkharswan-Dangoaposi 3rd line appears in the Pink Book 2010-11 vide item No.23 with an anticipated cost of Rs.309.44 Crore with an outlay of Rs.4 Crore.

The ROR of the above work worked out to 32.11%.

The detailed estimate with a value of Rs.407.74 Crore (gross) was sanctioned vide Railway Board letter No. 2011/W-2/SER/DL/05 dated: 18.11.2011.

Presently, Out of 75 km of proposed 3rd line 25 km has been completed and commissioned further work is in progress.

2.0 Description of New Line: The third line work from Rajkharswan - Pandrasali section covering the part of Rajkharswan - Dangoaposi project has been constructed on left hand side of UP existing line and from centre line of station building(CSB) of Rajkharswan station(Ex.) km: 292.700 from Howrah to Pandrasali station km.303.110 from Howrah having a track centre of 6.0m to 20.0m in mid section. The above section is targeted for opening of passenger and goods traffic. No intermediate station exists in between the section. The construction of earthwork has been done for 25T axle load and all bridge works for 32.5t axle load DFC loading standard. The section will work with the absolute block working system.

3.0 Land

a) The third line has been accommodated within the existing Railway boundary. No new acquisition of land has been done.

b) The newly constructed BG line is unfenced throughout.

4.0 Formation: The entire section is partly on embankment and partly in cutting having height of bank up to 7.81meter in filling and up to 5.81m in cutting. Adequate formation width in bank (8.10m) and in cutting (7.50m) has been provided to accommodate BG line. Side slope of bank have been kept as 2:1 and in the cutting side slope of 1:1 have been provided. The height of embankment more than 6m has been provided with horizontal berms. The earthwork in formation has been done with suitable local earth as per RDSO Guide lines for Earthwork and mechanically compacted with optimum care and 1.00m thick blanketing materials has been provided as per guideline issued by RDSO. The side slopes in embankment has been protected by providing turfing.

5.0 Curves: There are 11 nos. curves in the present alignment with a maximum degree of curvature of 4.0^0. The percentage of curve track is 18.02%. All the curves have been provided with transition length and super elevation for a maximum permissible speed of 100KMPH. Maximum super elevation has been kept as 115 mm. Curve reference posts have been provided at all the curves as per curve list.

I) Curves Abstract

Length :- 10.41 Km (Km 292.700 to 303.110)

Sl No	Radius in metre	Degree of Curve	Number of each	Length in Km of primary curve
1	5250	0.33	1	0.1105
2	1167	1.50	3	0.3873
3	1000	1.75	2	0.168
4	875	2.0	3	0.4688
5	790	2.21	1	0.4149
6	437.50	4	1	0.3268

TOTAL 11 1.876 km

Ratio of Curve to total length = 18.02%

Curve details enclosed as Annexure 1

6.0 Gradients: The ruling gradient of the section is 1 in 100. The section is mostly on gradient. Gradient post has been provided at every required location. Percentage of gradient is 0.41%.

7.0 Kilometer and Gradient Posts

(a) Standard Kilometer post have been fixed showing the Kilometerage between the section. Kilometerage has been reckoned with 0.00 at centre line of Howrah station building.

(b) Standard type of Gradient post have been provided at every change of gradient all along the section.

8.0 Bridges

All the bridges have been constructed with 32.5t axle load DFC standard. Total Nos. of Minor bridges are 20. There is Two nos. major bridges in the section. Total linear waterway is 195.10m. The waterway per Km. is 18.742 m per km. and percentage of waterway is 1.80%.

List of major bridges

Sr. No	Br.No.	Between Station	Location (In Km.)	Description	Type	Clearance		Completion Plan No.	Loading Standard	
						Available	Required		Sub Structure	Super Structure
1	2	RKSN - PRSL	293.083	3x18.30m	Steel plate girder	2.346	1.5	CAO/C/GRC'S DRG. NO: 7164/2015	32.5 T	32.5T
2	6	RKSN - PRSL	296.4	5x18.30m	Steel plate girder	2.657	1.5	CAO/C/GRC'S DRG. NO: 7169/2015	32.5T	32.5T

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एक ही तरीका हैं
असंभव से भी आगे निकल जाना!

स्वामी विवेकानंद

Abstract of Bridges

Length : 10.410 Km.(Km. 292.700 to Km. 303.110) **Gauge : 1676 mm**

Class of Bridge	Clear span in metre	Total No. of span	Waterway in linear metre	Loading Standard for which designed	Reference to type plan in case of Girder Bridge
Minor Bridge					
R.C.C Box	1.20	16	19.200	32.5 t axle load	
	2.300	1	2.300	32.5 t axle load	
	3.600	2	7.200	32.5 t axle load	
	4.000	5	20.000	32.5 t axle load	
Total		24	48.700		
Major Bridge					
Plate Girder	18.30	8	146.400	32.5 t axle load	
Total		8	146.400		

CLASS OF BRIDGE	TOTAL WATERWAY	TOTAL WATERWAY PER KM.	
Minor Bridge	48.70	4.678	
Major Bridge	146.40	14.063	
Total	195.10	18.742	
Percentage of water way per Km:	**1.80%**		

9.0 Rainfall

The section falls in seismic Zone No.III .The average rainfall is around 2684.31 mm. Mostly rain occurs from the month of June to September.

Average Rainfall of the section in MM

Sl. No.	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1	2010	0.00	0.00	0.00	24.00	67.00	293.00	268.00	813.00	365.00	217.00	0.00	54.00	2101.00
2	2011	0.00	62.00	34.00	160.00	239.00	694.00	462.00	653.00	1466.00	81.00	0.00	6.00	3857.00
3	2012	108.00	58.00	0.00	66.00	13.00	385.00	174.00	980.00	560.00	216.00	58.00	49.00	2667.00
4	2013	9.00	20.00	20.00	149.00	211.00	305.00	811.00	686.00	644.00	418.00	0.00	0.00	3273.00
5	2014	0.00	29.99	77.13	31.00	147.26	172.29	426.84	371.23	180.98	86.85	0.00	0.00	1523.57
													TOTAL	**13421.57**

Total Rainfall of this section (For 5 years) = 13421.57

Avg. Rainfall per year = 2684.31

10.0 Road Crossings

(a) There are 06 Nos Road crossings in between Rajkharswanstation(Ex.) to Pandrasali station. Five nos. are of 'C' class manned and one no is Spl. class. **The details have been enclosed at Form-IX.**

(b) Visibility statement& TVU for level crossings is as follows

Sl. No	Level crossing No.	Chainage of the L-ing (In KM)	TVU	Kilometerage	Visibility from a distance of 5 m away from the centre line of the track				Remarks
					Left hand Side		Right hand Side		
					Towards UP	Towards DN	Towards UP	Towards DN	
1	RBK-3	293.248	3510	293/9-11	above 600m	above 600m	above 600m	above 600m	Manned
2	RBK-4	294.621	1760	294/17-19	above 600m	above 600m	above 600m	above 600m	Manned
3	RBK-6	298.414	62818	298/11-13	above 600m	above 600m	above 600m	above 600m	Manned
4	RBK-7	300.662	6566	300/21-23	above 600m	above 600m	above 600m	above 600m	Manned
5	RBK-8	301.292	1960	301/7-9	above 450m	above 600m	above 600m	above 600m	Manned
6	RBK-9	302.751	6370	302/23-25	above 600m	above 600m	above 600m	above 600m	Manned Presently LHS provided

11.0 Permanent Way: This route is classified as 'D Special'. The section has been provided with new 60 Kg. 90 UTS rail with 60 Kg PSC sleepers with sleeper density of 1660 nos. per Km with provision of LWR on main line. Single rails are welded by Flash butt welding to make SWR/LWR. An average ballast cushion of 350mm has been provided. All the rails and welds have been tested ultrasonically and the defective rails / welds have been replaced/protected.

1) Fish plates

The new track has been laid with LWR track. However 0.61m./1m long fish plates with 4/6 bolts to suit 60Kg. Rail have been used at each joint as per RDSO Drg. No. T-1898/T-1899, wherever required.

2) Fish bolt and nuts

5mm dia. fish bolts with hexagonal nuts as per RDSO's drawing No T-1899 have been used.

3) **Sleeper and Fastenings**

60Kg.PSC sleepers vide RDSO's drg. no.: T-2496 has been provided with sleeper density of 1660 on main line and loop line. SEJs are provided as per LWR diagram. For B.G PSC sleepers, elastic rail clip, mild steel /GFN liner and 6 mm thick Grooved rubber pad have been provided.

4) **Points and Crossing**

1 in 12 Point and Crossing of fan shaped layout manufactured out of 60 Kg. rail having curve switches resting on PSC sleepers have been provided for passenger running lines. 1 in 8.5 Derailing Switch with PSC sleeper has been provided for isolation purpose.

5) **Ballast**

The track has been provided with minimum 350 mm ballast cushion of 50 mm. size hard stone ballast. For point and crossing also 50mm machine crushed stone ballast has been provided.

The newly constructed track has been thoroughly packed manually as well as by tie tamping machine.

12.0 Signalling & Interlocking Arrangement: The station of Rajkharswanis special class, Standard-III with rute relay inter locking with MACL signals, and Pandrasali is "B" class, Standard – III provided with Pannel Interlocking with MACL signals.

13.0 Tation Building & Passenger Aminities

Pandrasali station:-One foot over bridge of span 23.50m has been newly constructed for 3rd line . Existing low level up platform has been converted in to high level platform and extended for 160.0m towards CBSA end . Now total length of up platform is 415.0 m. Existing DN low level platform is also extended up to 120.0m towards CBSA end. Now total length of DN platform is 420.0 m. Existing waiting hall has been renovated and heightened. Rest existing facilities at Rajkharswan and Pandrasali will continue to be used.

14.0 Locomotive & Rolling Stock: The existing Electric Locomotives and Diesel locomotives which are at presently running on the existing track will also run on the newly constructed third line at their respective permissible speed or as speeds permitted from time to time or the sectional speed whichever is less.

15.0 Operation

The new line will work as third line between Rajkharswan to Pandrasali station on "Absolute Block Working System".

16.0 Infringment: There is no infringement to the Standard Schedule of Dimensions in Rajkharswanstation outer to Pandrasali station.

17.0 Means with Dealing with Accidents

a) Accidents Relief Train is stationed at Chakradharpur and Dangoaposi station.

b) Accident Relief Medical Equipment is available at Chakradharpur and Dangoaposistation.

As Regard Medical Facilities

There is a Main Railway Hospital headed by CMS at Chakradharpur. One Railway health center runs at Rajkharswan station.State run Hospitalis at Chaibasaabout 20 km from Rajkharswan and about 8 km from Pandrasali.

18.0 Gang Strength: Maintenance staff required for the section is being arranged by Open line organization as per vetted ETKM submitted to them by construction organization.

19.0 Gang Hut: The existing Gang hut / Quarter is available at Rajkharswan and Pandrasali station and also one unit new type-II quarters for gang is constructed at L.C. no-RBK-6.

20.0 Kilometerage, Bridge No & Level Crossing Nos:

The Kilometerage has been reckoned with "0.00" at centre line of Howrah Station building. The

Bridge No has been reckoned with 0 from Rajkharswan Station.The level crossingNos. have been numbered from Rajkharswan Station from Km 293/34-36.

21.0 Description Of Work

i) **Setting of Alignment in the field**

Approved L-section is studied and first of all, Co ordinates of existing up line in every 20.0m chainage has been taken throughout with the help of total station. And its plotted by autocad software. Again all works as per approved L section setting out of curves, alignment of entire section including major bridges of new line has been exercised through auto cad. The new coordinates of new line worked out by software is noted for each chainage and it is again it is transferred in to the field with the help of total station.

ii) **Formation**

Other than major bridges soil exploration was not conducted only visual survey was done. In filling zones borrow soil as well as cut soil also used as per availability.

FIELD COMPACTION TRIALS
(As per table-6 of RDSO/2007/GE: 0014)

i)	Whether field trials conducted		:	Before execution of works soil samples sent for laboratory tes ts to Geo Labs. Accordingly field tests are conducted to achieve minimum 98% of the MDD by using 10 ton vibratory roller. It is observed that 98% of the MDD is achieved after 8 to 10 passes of vibratory roller.
ii)	Details of field trial (indicate)		:	
	a)	Classification of soil	:	SC, GC, SM, GM, GP,CI,CL
	b)	Type of roller used and its weight	:	10 ton capacity vibratory roller.
	c)	Optimum thickness of layer achieved	:	30cm
	d)	Optimum number of passes of the roller used		8-10 passes
	e)	Field moisture content		8% to 14.5%
	f)	Maximum attainable field dry density (in %age of MDD)		98% of Lab MDD at the prescribed OMC has been followed.
iii)	Whether field compaction trial taken into account in execution		:	Laboratory tests taken as reference.
iv)	Reference of record of field trials		:	Details are available in registered maintained.
v)	Reference of record of field compaction trials (maintained as given in Annexure - IV)		:	yes.

Borrow Material

(As per table-6 of RDSO/2007/GE: 0014)

i)	Type o f fill material (indicate classification as per IS-1498) used in the earthwork		:	SC, GC, SM, GM, GP,CI,CL
ii)	Is soil suitable of embankment (As per table-6 of RDSO/2007/GE: 0014).		:	Yes,
iii)	Frequency of testing at site to assess the suitability of fill materials (As per 7.2.1.1.a of GE.G.1)		:	
	a)	Total quantum of earthwork involved.	:	176200cum (approx)
	b)	Minimum number of test required (at least one test at every change of soil strata subjected to minimum of one test per 5000 cum).	:	25 nos.
	c)	Number of tests actually done.		29nos.
iv)	Maximum size of material used in the bank in case of cobbles/boulders/rock etc. (As per para 5.2. &5.2.3 of GE:G-1).			N.A.
v)	It is certified that record of quality of fill material has been maintained in the office of AXEN/CON/II/CBSA.			

Blanket Material

(As per para 8 of RDSO/2007/GE: 0014)

i)	Source of blanket material		:	Moorum from Local Quarry
ii)	Type of blanket used (Natural/ mechanically crushed/blended)		:	Blended. 90:10 (moorum : sand)
iii)	Whether quality of blanket material selected is conforming to specification as given in para 8of RDSO/2007/GE: 0014 (Blanket Material should be coarse, granular, well graded material having non -plastic fines not more than 12% & not more than 5% in case fines are plastic. On greater than 4 preferably more than 7, Cc should lie between 1 & 3 and the Grain size distribution should lie within appropriate enveloping curve as shown in sketch "B" enclosed)		:	Yes. Results are available.
iv)	Thickness of blanket layer		:	
	a).	Type of sub-grade (in top 1m).	:	Blanket with moorum and sand
	b).	Thickness required (8.2 of RDSO/2007/GE: 0014).	:	1.05 m.
	c).	Thickness actually provided	:	1.05 m.(appox.)
	d).	Deviation from prescribed thickness, if any.	:	No
v.	Frequency of testing to assess the liability of blanket material (As per 7.2.1.2, a of GE:G-1)			
	a).	Total quantum of blanket material involved in cum.	:	87600 cum.
	b).	Minimum number of test required (at least one test per 500 cum).	:	175 Nos.
	c).	Number of tests actually done.	:	154 Nos. (Since the quarry of moorum& sand were same for the whole work).
vi)	Reference of record of testing where quality of blanket material has been maintained and records are available at the office of Dy.CE/C/CKP.			

Preparation Of Formation At Km 301/21-23

Preparation of Formation at Km 302/17-19

Preparation of Formation at Km 301/23-25

Quality Control Checkes on Finished Earth Work

(As per para 7.2.2. of GE: G-1) For Soil:

i)	Frequency of tests for degree of compaction.(As per para7.2.2.1b of GE:1)		:	
	a)	Total area of earth work involved (commutative for every layer in sqm.).	:	387200Sqm.
	b)	Minimum number of density test check required (at least one per 200 sqm. For top one metre of sub -grade and one per 500 sqm. for balance)	:	775 Nos.
	c)	Number of density test check actually done	:	3681 Nos.
	d)	Number of test where degree of compaction is less than 98% of MDD	:	175 Nos.(Re rolling done and 98% compaction achieved.)
	e)	Action taken in case of (d):	:	Watering and rolling done to achieve 98% of MDD.
ii)	Reference of record where report of checking of degrees of compaction has been preserved.		:	Yes, In the field compaction testing registers which are available.

For Blanket.

i)	Frequency of tests for degree of compaction/Relative Density done... (As per para 7.2.2.1,b of GE: G-1)		:	
	a)	Total area of blanket involved	:	89100 m^2
	b).	Minimum number of density test required (at least one per 200 sqm. For every blanket layers).	:	1782 Nos.
	c).	Number of density test check actually done.	:	2015 Nos.
	d).	Number of test where degree of compaction is less than 98% of MDD or 70% of Relative Density (Relative Density should be calculated if fines in the soil are less than 5%)	:	350 Nos.

	e).	Action taken in case of (d).	:	Watering and rolling done further to achieve 98% to 100% of MDD.
iii)	Reference of record where report of checking of degree of has been maintained as given in format in Annexure VII(D).		:	Yes, results are available i n the field compaction registers available.

Formation Level (as Per Para 7.2.2.2 Of Ge:g-1)

i)	Has it been ensured that finished top sub - grade level is within +25mm of designed level and finished top of blanket layer is within +25 mm from designed lev el and top of formation is level without ruts or low pocket.	:	Yes.
ii)	Reference of level book maintained to ensure item (i) above	:	Yes

Cross Slope

(As per SOD for DFC loading para no-1.11). : 1 IN 30

Side Slope:

(As per table-6 of RDSO/2007/GE: 0014) : Up to 6m ht. = 2:1.Beyond 6m = one berm of 3m width at 6MT & with 2:1 side slope.

Formation Width:

(As per SOD for DFC loading para no-1.11). : 8.10m. (min).

Slope Stability for Embankment/Cutting

(As per para 4.4 of GE:G-1)

i)	Maximum height of bank (at chianage).	:	7.81 m. (at chainage 295940)
ii)	Maximum depth of cutting (at chainage	:	5.81m between chainage 301540 to 301940 M.
iii)	Designed side slope in bank/cutting as per slope stability analysis (attach profile duly approved.	:	2:1 in bank. 1:1 in cutting.
iv)	Agency which carried out slope stability analysis.	:	Slope provided as per RDSO guide lines.
v)	Actual side slope provided in bank/cutting as site (attach profile duly approved)	:	Side slope of 2:1 in bank and 1:1 in cutting have been provided. Berm of width 3m have been provided for bank and 2m from cutting having height more than 6m.

Erosion Control Measures
(As per para 6,6 GE:G-1).

a)	Type of soil used in earth work.	:	SC,GC, SM, GM & GP
b)	Chainage where erosion control measures required.	:	Entire length of bank.
c)	Chainagewhere erosion control measures taken..	:	Entire length of bank.
d)	Type of erosion control measures adopted, Chainage wise..	:	Turfing on side slope on entire bank.

Back fill behind Bridge Abutment/Wing Walls/Return Wall

(As per para 6.4 of GE:G-1 and para 605 of bridge Manual)

i)	Details of back fill behind bridge approach as per Annexure-II enclosed	:	600mm thick boulder filling has been provided behind bridge abutments and return walls followed by back fill of suitable materials in triangular portion.

GE Cell At Site;
(As per para 7.1 of GE:G-1).

i)	Organization		:	
	(a)	In charge	:	Concerned SSE/Con/Works,and JE/Works/Con
	(b)	Total staff strength with particulars	:	SSE/CON/Works, Two JE/Con/Works and Three Khalasi.
	(c)	Qualification and training of personnel.	:	Qualification –SSE & JE – B.E,DCE in Civil. Training - Training has given in field by AXEN/Con/II/CBSA
ii)	Period for which lab at site was in operation.		:	From starting of the project to end of the project.
iii)	Total number of tests carried out at site		:	3681 nos. for earthwork 2015 nos. for blanketing
iv)	Reference of record of tests		:	Available in field registers.
v)	Equipments (As per Annexure VIII, attached).		:	Core cutter, balance, moisture meter, sieve set were available at site.
vi)	Relevant IS Codes (As per Annexure IX).		:	Available

General Site Details.

i)	Pond/Ditches/Borrow pits along the alignment (distance from toe of bank).	:	Nil
ii)	Rain cuts on slope	:	Nil.
iii)	Cracks on formation and slope	:	Nil.
iv)	Details of benching in case of third line.	:	Benching 30 cm vert ical & 60 cm horizontal done on existing side slope.
v)	Minimum center to center distance between tracks.	:	6.0m. except yard.

iii) Major Bridge No:- 2

General Details of Bridge

1. Name of river :- Kuchainala
2. Span :- 3x18.30 M (Plate Girder)
3. Location :- 293/1-5, Chainage :- 293083.47 M (Between- RKSN –PRSL)
4. Type of Foundation :- Open
5. Concrete grade :- M-35
6. Loading :- 32.5T Axle load (DFC)
7. Type of girder:- Plate girder (Welded type) RDSO Drg No: 16018
8. Girder fabricated at :-Engg. Workshop Sini, South eastern railway.
9. Max bearing pressure:- 350KN/M (Approx)
10. Safe bearing capacity of soil :- 40T/Sqm
11. Induced max pressure at foundation :-
    For Abutment = 260KN/Sqm
    For Pier = 330 KN/Sqm

Excavation of open foundation

Raft reinforcement binding & preparation of concrete

Assembling of girders at site

Launching of girders

Girders Launched

steel channel sleeper & rail linked

Linked track over br no 2

iv) Major Bridge No:- 6

General Details of Bridge

A. Name of river :Sanjay

B. Span: 5x18.3M (Plate girder)

C. Location : 296/11-15 , Ch:- 296400.00M (Between RKSN – PRSL)

D. Type of foundation: Open (For Abt-2 & Pier-4), Pile (For Abt-1, Pier-1,Pier-2 & Pier-3)

E. Concrete grade: M-35 & M-20

F. Loading : DFC , 32.5T axle load.

G Type of girder : Plate girder (Welded type) RDSO Drg No: 16018

H Girder fabricated at :Engg. Workshop Sini, South eastern railway.

I For Open Foundation:-

i) Max bearing pressure below structure foundation = 350KN/sqm (approx)

ii) Safe bearing capacity of soil = 40T/Sqm

iii) Induced max. soil pressure at foundation (For abutment) = 380KN/Sqm

iv) Induced max soil pressure at foundation (For Pier) = 230KN/Sqm under normal condition as per design calculation.

J. For Pile Foundation

i) Type of piles : Bored cast in situ piles (IS -2911 Part 1/Sec-2 & IRC:78-2000)

ii) Length of piles – Abutment -1 = 19.50m

Piers = 15.50m

i) Dia of piles : 1200 MM

ii) Lap length : 60D

iii) Working load on top of pile

For Abutment :- Vertical = 2850KN (Normal)

2850 KN (Siesmic)

Horizontal = 300KN (Normal)

375 KN (Siesmic)

For Piers :- Vertical = 2100KN (Normal)

2400 KN (Siesmic)

Horizontal = 110KN (Normal)

130KN (Siesmic)

iv) Initial & routine load test on pile of abutment :-

Initial load test : For vertical load = 2.0 times of working load That is 2x2850KN = 5700KN = **570T**

Routine load test : For Vertical load = 1.5 times of working load

For horizontal load = 2.0 times of working load

v) Initial load test (For vertical load) at Site

Total Settlement = 6.638mm

Settlement = 2.868mm

Rebound = 3.770 mm

Excavation for open foundation for Abutment -2

Completed Substructure of Abutment-2 and Pier -4 with open foundation

Reinforcement binding& concreting through pump for RCC raft

Preparation of concrete through portable Batch mixing plant at site.

Casted Raft for Abutment 1

Problem faced during the execution of bridge:-

Initially, the drawing was approved for open foundations for all components. Accordingly, the work started and abutment-2 and Pier-4 was completed by open foundation but when abutment-1 excavated up to its desirable founding level (RL 188.0) as per design the soil strata did not found satisfactory. And adjacent bank slip was started due to excessive depth and was likely to be executed impossible with open foundation. However, it was restored by providing rail piling/sand bags etc and again in view of its excessive foundation depth of Abut -1, Peir-1, 2 & 3 again a soil exploration has been done and redesigned for rest components with pile foundation.

Fig shown slippage of existing bank and restoration done by rail piling and sand bags.

Site during monsoon.

Density check by hydrometer for pouring of tremie concreting.

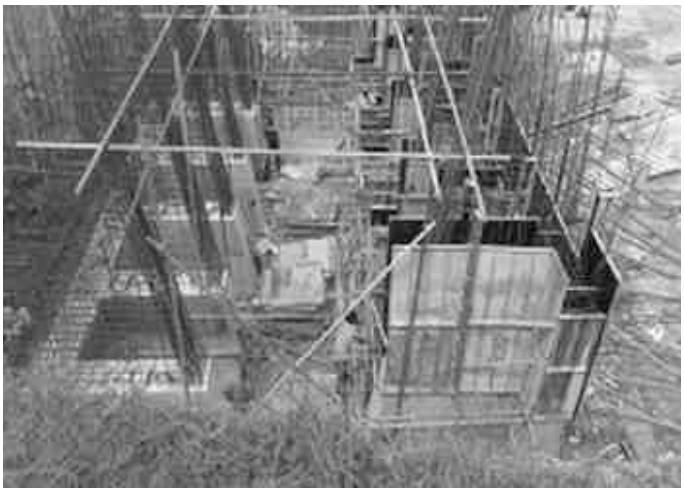
Piling started with rotary rig machine

Piling with conventional rig for piers.

Tremie concreting for pile foundation.

Integrity testing of piles.

Exposing & dismantling of contaminated part about 1.0m



Subsequent lifts casting & preparation.

reinforcement binding for pile cap in abutment-1

Testing of Cubes.

Cap Casted in Abutment 1

Sand Blasting & Metalizing of girders at site

The standard girders RDSO drg no 16018 were fabricated at S.E. railway Sini workshop inspected by RDSO and transported at site. Again girders assembled with riveting sand blasting, metalizing and painting were done at site.

Painting thickness measurement by Alco meterZinc chromate applied

Launching of girdersn Placement of steel channel sleeper

Girders components were assembled over CC cribs in zero level and sand blasting done with the help of compressor machine by pressure of 7.0 kg/Sqcm to achieve smooth surface and to remove rust over it. Again metalizing work had been done with aluminium wire (conforming to IS:2590, IS 739 material I-B(99.5%) by ejecting with metalizing gun with pressure 6.0kg/Sqcm over the entire girder surface in two to three stages up to 150 micron thickness. Then one coat of etch primer conforming to IS :5666 applied whose thickness is not countable. Afterwards one coat of zinc chromate conforming to IS 104 applied up to thickness of 20-30 micron. Again, two coat of aluminium paint conforming to IS: 2339 had been applied over it up to achieving of (15+15) = 30 micron. Thus, total coating thickness is up to 200 micron had been achieved over the girder surface.

Launching of girders :- The ready girders had been launched with the help of two nos 50T capacity mechanized crane in each span.

Steel channel sleepers of 200mm height (Drg No RDSO/B-1636/7 32.5TAxle load) had been placed over the girders with C/C spacing of 600mm and in rail joints 200mm and tighten through hook bolts.

Linking of rails over the girders:- 26.0 m flush butt welded panel rails (60 Kg) and guard rails (52Kg) were linked over the channel sleepers by standard fittings .

Linking of rails over Channel sleepers.

i) Minor Bridges

All twenty nos minor bridges were extension and constructed as RCC box type for 32.5T axle load of RDSO standard. The backfill material behind the bridges were provided as per clause 7.5.A and C.S. No 3 of IRS bridge substructure & foundation code.

Minor Bridge No 5

Minor Bridge no 8

Vi) Drain

Entire cutting stretches is provided with RCC drain of adequate cross section to easy deliver of rain water.

Vii) Trolley Refuges :-

Trolley refuges of size 3.50m x 3.50m has been provided at every 100.0 m interval throughout the section. In embankment it is of earth with RCC retainers, old released sleepers are also used as retainers. In cutting locations it is made by RCC slab.

Viii) Km & Gradient posts:-

Km & gradient posts are of precast RCC slab provided in every kilometer and each terminating points of gradient.

ix) Ballasting , Sleeper laying & rail linking over the section.

The track center were marked at every 20.0m interval over the new formation as per proposed alignment and machine crushed hard stone ballast supplied by the contractor (duly tested by railway laboratory) were spreaded uniformly up to initial depth up to 200mm and sleepers for PSC 60 kg were placed with proper spacing (1660nos/km) and squaring over it. 60 kg single new rails were placed over the sleepers. Again during lifting and packing another 150mm cushion is added by providing extra ballast to achieve 350mm cushion.

X) In Situ welding by Mobile flush butt welding plant:-

Newly single rails laid over the sleepers were weld by using mobile flush butt welding plant followed by grinding and USFD testing. Tolerances has been maintained as per guidelines of F.B. manual. It is done by agency Indo project pvt ltd Hyderabad.

xi) LWR Track : The section Rajkharswan – Pandrasali from Ch 292720 to 303110 entire length is LWR track excluding major bridges. The major bridge portion were isolated with provision of improved SEJ at either ends of bridges. The LWR is provided as per approved LWR plan.

The LWR track has been laid as per criteria laid down in the LWR manual.For B.G elastic rail clip, mild steel /GFN liner and 6 mm thick Grooved rubber pad have been provided as per standard RDSO drawing. At Pandrasali yard the 3rd line has been connected to existing up loop line by 1 in 12 points &xing with provision of 120m over run line with dead end.

Three round packing were done manually and two round packing done by tamping machine with stabilized by DGS.

xii) Level Crossings

All six level crossings road surfacing are provided with 80mm thick

Interlocking pavers/bituminous carpet up to gate posts. Concrete/ bituminous surfacing has been provided beyond gate posts.

Check rails of 52kg (SH) are provided in every level crossings with standard fittings.

All level crossing are provided 15.0 m steel fencing either side and all warning boards, height gauges, lifting barriers, speed breakers etc are provided as per CE circular no 254 of south eastern railway.

xiii) Platform raising & extension

The existing up low level up platform has been converted in to high level platform and extended up to 162.0m towards CBSA end.

Converted in to low level to high level platform at Pandrasali

xiv) Provision of Foot over bridge

A new foot over bridge of span 23.50m has been constructed across the 3rd line to up platform at Pandrasali station. The standard CE's drawing no 22510 of s.e. railway is adopted for its structural design. The all steel members used in the structure are of brand SAIL.Fabrication work has been done at site.

Di Penetration test of weld joints of FOB members

Launching of gallery of FOB

Foot over bridge at Pandrasali station.

Newly constructed FOB at Pandrasali station

xv) Gang strength

GANG STRENGTH

Length : 10.410 Km.(Km. 292.700 to Km. 303.110) RKSN - PRSL **Gauge : 1676 mm**

GANG No.	Between KM.		Between Station	Gang beat in Km.	Gang H.Q	Chainage	Track man	Keyman	Mate	LR	Total Gang Strength	Remarks
	From	To										
1	2	3	4	5	6	7	8	9	10	11	12	13
1	292.480	301.020	RKSN-PRSL	6.5	RKSN	301.020	25	2	1	Nil	28	For Existing Track
2	301.020	307.411	RKSN-PRSL-CBSA	6.5	PRSL	307.411	22	2	1	Nil	25	For Existing Track

Gang strength as per modified special committee formula is enclosed as annexure V

22 Conclusion: The line capacity utilization has been augmented partly by commissioning of this line. However, at the time of commissioning on Aug 2015 it was opened for unidirectional traffic but at present after yard remodeling of Pandrasali station and commissioning of next block section between Pandrasali – Chaibasa this line is being utilized as bi-directional traffic (Joint line). As this section is convergent section of south eastern railway especially identified for freight traffic. The section handles 05 pairs mail express/passenger trains and around 95 nos goods trains per day. Consequently, this line will ease congestion in the section it will be possible to run additional goods as well as passenger/mail express trains with punctuality, safety and undue detention.

23 References

1. Guideline for earthwork in railway projects RDSO GE:G-1
2. Indian railway permanent way manual
3. Indian railway works manual
4. Indian railway bridge manual
5. Indian railway manual & instruction for long welded rails
6. Indian railway concrete bridge code
7. Bridge substructure & foundation code
8. Bridge Rules
9. Available office documents & photographs during execution.

■ ■ ■

Drilling of 7 Km Mumbai-Ahmedabad Undersea Route Begins to Ascertain Soil Condition of Bullet Train Path

Drilling of the seven-km undersea route of the Mumbai-Ahmedabad rail corridor is underway to ascertain soil condition of India's first bullet train path. Passengers will get the thrill of riding under the sea, a first in the country, near Thane at a maximum speed of 350 km per hour in the upcoming high speed train project connecting two major metropolis.

"Soil and rocks below the 70-metre-deep see are being tested as part of the geo-technical and geo-physical investigation undertaken for the entire project," said a senior Railway Ministry official, adding "the test will also cover the 21-km-long underground tunnel between Thane and Virar." Barring the 21-km-long tunnel, most part of the 508-km- long corridor is proposed to be on the elevated track while there will be a stretch after Thane creek towards Virar which will go under the sea as per the detailed project report by JICA, the funding agency of the project.

Railways opted for an elevated corridor to avoid land acquisitions and the need to build underpasses. The tunnel was necessitated to protect the thick vegetation in that area, said the official. The geo-investigation is crucial for the project as it would ascertain the bearing capacity of the soil below 70 feet at the sea.

Estimated to cost about Rs 97,636 crore, 81 per cent of the funding for the project will come by way of a loan from Japan. The project cost includes possible cost escalation, interest during construction and import duties.

The survey is likely to be followed by the final location survey to mark the alignment and exact spots for the pillars on which trains will run at higher speed to reduce the travelling time between Mumbai and Ahmedabad drastically.

Currently it takes about seven hours to travel between the two cities and the bullet train aims to reduce it to about two hours.

Construction of the corridor is expected to start in 2018 and is estimated to be completed by 2023.

JICA agreed to fund 81 per cent of the total project cost through a 50-year loan at an interest rate of 0.1 per cent and a moratorium on repayments up to 15 years.

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

Norms for Divisional Permanent Way Training Institutes

By
*Rajeev Saxena**

1.0 Introduction: Training of Gate Keeper, Track men has been long felt need of the Railways which was introduced in the 1984-85. Railway Board published the approved Modules for stage wise training of Group 'C' and 'D' staff of Civil Engineering Department in 1994-95.

In pursuance of above, all the Divisions on Northern Railway were instructed to open Divisional Training Institute for imparting training to Track men, Gatekeepers, Key man, Mate and other Artisan staff.

Accordingly Ambala, Delhi, Firozpur, Lucknow and Moradabad divisions of Northern Railway opened Divisional Training Institutes at Jagadhari Workshop, initially at Shamli and later at Ghaziabad, Jallandhar City, Lucknow and Hardwar respectively.

These training institutes have served their purpose by upgrading the skills of Permanent Way staff involved in the day to day maintenance of track and in improving their own safety and their awareness for the system.

However, it is found that there is a variation in the standards of the training being imparted due to absence of norms for academics, logistics, infrastructure and facilities available at present in the institutes.

Norms for Divisional Permanent Way Training Institute aims to achieve following objectives :

1. To provide uniformity in Designation, Administrative and Organizational set up among Training institutes.
2. To place all instructions issued from Railway Board/Headquarters etc. at one place.
3. To bring uniformity in standards of Academics, Training Infrastructure, Boarding and Lodging facilities.
4. To bench mark the performance among the Institute and from other similar Training Institutes.
5. To establish procedures and documentation-thereof to achieve ISO Certification.
6. To bring continual improvement base on regular feedback, discussion & dissemination of information.
7. To introduce new concepts and training on fire fighting, first aid, disaster management and to manage situations like gas leakage etc.

For smooth implementation of above objectives, the yardsticks have been specified under the following headings :

1. Safety Module
2. Administrative & Organizational Set up
3. Training Courses & Calendars
4. Academic Infrastructure & Facilities
5. Boarding & Lodging Facilities

2.0 Safety Module

2.1 Personal Safety

Every year there are causalities/injuries to the track men from running trains while they are performing their legitimate duties of patrolling, gang work in the mid section and / or in the yards etc. With the induction of new track men from Railway Recruitment Cell, it is important that they should be made aware of their personal safety before being inducted at site. Dy. Director (MPP) Railway Board vide letter no. CE(MPP)/2009/3/17dtd. 2.12.2010 has circulated the revised training module for Civil Engineering Permanent Way Staff which includes the module on Safety. While the course wise contents as advised by Railway Board should be followed, First session of every induction course and Refresher course must cover following even at the cost of repetition?

i. Knowledge on Railways Signaling system.

**Sr.Den/G/Moradabad/NR*

ii. Methods of knowing the arrival of trains at site.

iii. The practical method of knowing speed, distance, visibility, sound and other aspects of train movement.

iv. Safe distance from track and adjoining track.

v. Importance of wearing shoes and uniforms.

vi. Precautions to be observed while crossing bridges/tunnels

vii. Precautions to be observed during night patrolling.

viii. Pit falls of being under alcoholic influence.

ix. Snake biting.

2.2 Audio visuals/Posters on Safety

i. Every day first few minutes should be devoted on personal safety.

ii. Trainee should be sensitized on different aspects of safety through audio visuals as an educational tool.

iii. "Memorable experiences" of participating Gateman / Trackman should be asked in class and discussed. The posters related to safety should be provided. The indicative list of such posters is given at Annexure 'A'.

iv. Dealing the critical situation on level crossing such as passing of Ambulance on closed gate. Agitation of mob etc. should be discussed with Gateman / Trackman.

2.3 Mandatory Safety Examination

There should be a mandatory examination on personal safety in each course. It will be compulsory for every trainee to pass this examination. In case someone does not clear in this exam, he should be detained and being given a repeat training.

In terms of Railway Board orders dated 10.08.2000 (Annexure L-8), all Apprentices/Trainees have to be given one repeat course or 2nd chance without any stipend or any other remuneration.

Any one not passing in the repeat exam should be relieved with the remark for information to his Sr. Subordinate that he should be sent for repeat course, till he acquires the required knowledge to ensure personal safety.

3.0 Administrative and Organizational Setup

3.1 Standard Organization and Duty list

All heads of the Divisional Permanent Way Training Institute should be designated as Principal irrespective of the substantive Grade of the incumbent. There should be a standard organizational setup consisting of Principal, Co-Instructor and six School Assistants. The indicative duty list of Principal, Co-Instructor and that of School Assistants are given at Annexure-G1 to G3 respectively.

The administrative setup of institute shall consist of an immediate in charge ADEN/DEN & the overall in charge shall be Sr.DEN/Co-ordination of the division. The concerned sectional Sr.DEN/DEN shall be responsible for its maintenance and its structural repairs.

3.2 Duty Roster and Leave Arrangements

There should be a duty roster of Principal and that of Co-instructor as per the provision of Hours of Employment Regulation (HOER Rules). Every institute will draw duty roster for principal and Co-instructor based on the indicative duty list. The immediate charge ADEN/DEN shall notify the standing leave gap arrangement. The standing arrangement should also specify the reliever when both the persons namely instructors as well as standing leave reserve are on leave.

3.3 Schedule of Inspection

All the training institutes must be inspected by the respective in charges as per following schedule :

Officers	Frequency
ADEN/DEN (In Charge of Training Institute)	Once in two months
Sr.DEN/Co-ordination	Once in four months
Dy. CE/Incharge in Hd. Qrs.	Once in six months
CE/Genl.	Any Two in a year
GM	Any one in a year

3.4 Annual Meeting cum Seminar

There will be two annual meeting cum seminar of Principal and the administrative in charges of training institutes. One such meeting will be organized by Dy.CE/TQM at Head Quarters in the month of February/March to take stock of the progress of the current year and finalizing the planning for the next year. The other meeting shall be organized by the institute in the month of September/October by rotation in the Alphabetical order of name of division. In this seminar all the Institutes will share their experiences on best practices, effective communication, issues of documentation, innovations and will suggest improvements. Concerned Sr. DEN/Co-ordination will host the meeting and will be presided over by Chief Engineer in charge of training of Head Quarters.

3.5 Training of the trainers

Sr. DEN/Co-ordination in consultation with Head Quarters office should send the Principal and other Sr. Subordinate of the Division for attending the "Training of the Trainer" programme.

3.6 Class Time Table

There should be a standard class time table in every training institute. The class interval should be in the unit of one hour. The tea and lunch break maybe suitable planned.

A sample time table is as under:

S.N.	Days	Time (Hours)			Total Hours
		From	To	Hrs.	
1	Monday to Friday	08.30	10.30	2 hrs.	**7 × 5 hrs./day = 35 hrs.**
		11.00	13.00	2 hrs.	
		14.00	17.00	3 hrs.	
2	Saturday	08.30	13.30	5 hrs.	5 hrs.
Total					**35 + 5 = 40 hrs.**

3.7 Display Boards

The organizational setup, class time table should be displayed in standard board along with their details as per format given at Annexure-C &D.

3.8 Consignee Code

All the training institutes need to maintain the inventory for items to be display in the model room, on the sample track and keep stock of tools and plants needed for track maintenance and for practical training apart from consumables like paint, oil etc. In absence of a separate consignee code, principals are dependent on adjoining Sectional Engineers for transfer/issue of material. Therefore a Separate Consignee code needs to be allotted to the Training Institutes to facilitate the material transaction from/to Railway stores.

3.9 Imprest

Uniform cash imprest of Rs. 10,000/- should be provided to Training Institute for day to day upkeep and contingencies to cover the expenditure on monthly bill cycle basis. The list of activity and purchase of consumables which will be covered in imprest should be prepared and be available with Training Institute. Hiring of vehicle in case of emergency should also be arranged from imprest. Any other work as decided by Sr. DEN/Co-ordination should also be included in the list. This imprest should increased @ 10% every year to take care of General inflation and change circumstances/requirement of the institute. An indicative list of activities to be covered through imprest is enclosed at Annexure-E.

3.10 Uniform

All trainees should be encouraged to attend the training in proper uniform. They should be sensitize about the importance and utility of uniforms. The Divisional Office, while intimating the calendar of course to the sub divisions should mention in the letter giving a foot-note that the entire trainees will attend training course in their respective uniforms issued from the Railway.

4.0 Training Courses and Calendar

4.1 Calendar of Courses

Railway Board vide letter dated 02.12.2010 specified the duration & course content of various training modules for Trackman/Key man/Mate and Gatekeeper. Based on the details provided in the Railway Board letter dated 02.12.2010 and the training requirement of the division, every training institute must draw and publish a calendar of courses as per the format given below in the beginning of the year. The name of the course should correspond to the numbering scheme given in the Board's letter stated above. The format is as under :

S.N.	Name of Course	Eligible Participants Category/Designation	Duration (In Weeks)	Nos. of Seats	Frequency in Year	Period	
						From	To

This should include details of induction, promotional, refresher, foundation and/or any other special course planned during the year and should duly notify the nos. of seats, frequency and calendar dates on which it will be held. This exercise should include the planning for the month of April of the next financial year to take care of the time taken in planning the course for the current financial year. Railway Board vide letter no. 2010/CE-I Spl) /GNS/15(pt.) Dated 17.08.2012, has circulated that the category of Trackman/Trolley man/Gateman/Watchman/Key man in Civil Engineering Department (P.Way) in PB-1 Gr. Pay 1800 be clubbed & given the designation of Track Maintainer Gr.-IV (PB-1, Gr. Pay 1800).....(Annexure 'L-9').

4.2 Duration and Frequency of Training.

The duration and frequency of different type of training has been circulated vide Railway Board letter dated 02.12.2010. Same is to be followed and at present it is as under :

Category	Induction	Training period (in days)		
		Promotion	Foundation	Refresher once in five years
Trackman	24 days	NA		12 days
Key man	NA	NA	18 days	12 days
Mate	NA	18 days		12 days
Gatekeeper	18 days	NA		06 days

4.3 Nomination of Trainees and Standby

Sr. DEN/Co-ordination should issue necessary instructions to all ADENs and Unit in charge of the division to ensure nomination of the trainees and standby to the courses planned by Divisional Training Institute at least three months in advance. All units in charges should maintain the training records of employees under their control and ensure its entry in their service records/books. The nominations should invariably be based upon the training record of individual employee.

4.4 Course Module

Management Services Directorate of Ministry of Railways (Railway Board) in August 1994 had published the 'Approved Modules' for stage wise training of Group-C & D staff of Civil Engineering Department. The booklet contains 34 modules numbered CE01 to CE34. These modules are designed for different category of staff namely unskilled worker, trackman and artisans for their induction, promotional and refresher courses. For every course number of days to be spent for each and every topic to be covered under a particular module has been specified.

The above modules have been reviewed at Railway Board level and modules for some of the category of staff have been modified and approved by Member Staff & Member Engineering. The revised modules have been circulated by Dy. Director (MPP) Railway Board vide letter No. CE (MPP)/2009/3/17 dt. 02.12.2010 (Annexure L-10). The numbering scheme of various modules have now been modified which should be used by the training institute while drawing the calendar of course for the year.

An updated version of above publications should always be available with the Principal of the training institute. All the Principals must be thoroughly aware about the content of various course modules provided in these booklets.

The division may frame their own course content of such of those training modules for which course contents are not available in these booklets. Sr. DEN/Co-ordination of the division concerned shall be responsible for arranging an updated copy of these publications to the training institute through the Headquarter Office.

4.5 Visiting Faculty

Other Section Engineers of the division should also be motivated to deliver training sessions as visiting faculty which will help in exploiting the expertise and talent of the Sr. Subordinate of the division apart from developing the pool of instructors for future. A suitable honorarium for visiting faculty may needs to be arranged.

A Calendar of other SSE/SE/JE (P.way)should be issued to conduct the training sessions as visiting faculty on particular subjects such as safety of track, General maintenance of LWR, patrolling or personal safety.

4.6 Sample Track, Model Room and Field Training

Railway Board in its letter dated 02.12.2010 has emphasized to provide practical knowledge rather than theoretical knowledge to the trainees. Board specified the list of minimum items to be provided in the model room and/or model yard in the training institute. Board further specified that a minimum of one day per six days of training should be devoted on field training.

Visit to sample track, model room and field should not be planned for less than two hours. Every such visit should be organized by dividing the class into sub groups. These sub groups should suitably interchanged their locations and timing so as to ensure that all sub groups cover all areas of training. Trainees should be instructed to move along with their sub group only.

The job work should also be done in the subgroup form in the nearby yard and/or on sample track under proper supervision once in a week preferably on Saturdays.

As the new recruiters in category of trackman are highly qualified, hence elementary training of Track Management System should also be given to them. It will be beneficial to both i.e. Railways as well as staff as the staff will be multi skilled towards need of the time.

4.7 Other Training Activities

As per Railway Board orders dated 23.08.2002, 03.08.2012,14.08.2012, 13.12.2012, (Annexure L-1 to L-3 & L-7), all training institutes should endeavor to impart other activities like Yoga, Disaster Management, Moral Education, First Aid and Fire Fighting, Field work contribution (Shram-dan) in maintaining the institute clean and green etc. should be arranged for at least 2 hours in a week for every batch.

5.0 Academic Infrastructure and Facilities

5.1 Principal Chamber cum Office

Office of the Principal is the main center of the institute which will act as the face of the institute for the trainees and for visitors including higher dignitaries. This has to be well

equipped and well maintained with an ambience of an open office and that of a modern training institute. The Principal Office should have following minimum facilities :

- Office Furniture for the Principal
- Sofa & Center Table for visitors
- Computer with Internet connection
- Digital Camera
- Books (as per list enclosed) and Bookshelf
- MFD Printer cum Scanner cum Fax
- Railway and P&T Telephone
- White Board and Soft Board for Display of information
- Crockery with Electric kettle

There should be a separate work station in the office cum chamber of Principal for the co-instructor to facilitate proper discharge of office functions.

The digital camera can be used for taking photographs of all the trainees of every course for records.

5.2 Class Rooms

All the classrooms should have blackboard, space for display of charts, white background area in one of the wall for projections, chairs with tables or combined chair cum table to facilitate the training.

All rooms should have proper ventilation, natural light and of size approximately @ 1.26 sq m per trainee {As per guidelines for Whole School Development planning Under SarvaShiksha Abhiyan, March 2010, (Annexure-II (B)}. All the rooms should be provided with wire-mesh doors and windows, electrical fixtures including coolers and fans. Layout plan of Class Room (Typical) and Model Lay Out Plan of P.Way Training Institute are enclosed at Annexure 'M' & 'N'.

5.3 Projections Facilities and Conference Room cum Library

There should be a small Library housing the Audio visual films/documents on various aspects of track management working during accidents, crowd management, Big posters depicting the action to be taken in case of fire, gas leak, water pipe bursting, rail fracture, deep rain-cuts due to floods, obstruction on the track etc.

There should also be in housed the various technical material published by CAMTECH Gwalior, books and references received from HQ and Railway Board, latest circulars, one local newspaper and display of photographs highlighting the function and achievements held/made by the institute. A Laptop with the facilities of portable projector and screen to display various educational films on Tracks, works, safety, documentaries and power point presentation should also be provided. Wherever possible about 20 chairs around a conference table should also be provided in this room for periodical review cum progress meeting of the Institute. This can also be used as a venue for training of trainers programme by rotation. Extra chairs be provided, to meet with the increase requirement.

5.4 Sample Track

Board in its letter dated 02.12.2010 in Annexure-'C' has specified the list of items to be displayed in the model yard. Sample Track should be provided in the campus of the institute covering following minimum items :

- Different Rail Section with Junction Fish Plates.
- Rail Weld Joints with Joggled Fish Plate.
- Emergency repair in case of rail fracture.
- Different Type of Sleepers with corresponding fittings.
- Standard cross section of the track in cutting and embankments.
- Points and crossings with Turn-In-Curve.
- Level crossing sleeper with check rail and LC Number display.
- Bridge sleepers with guard rail, pathway and number plate.
- Part of the track should be in Curve with station marking and cant.
- Switch Expansion Joint (SEJ) and Glued Insulated Rail Joint.

A schematic diagram of sample track is at Annexure-F.

5.5 Model room To make the trackman aware about the local names and physical feel of various track components, tools and plants, measuring and safety devices etc., the articles should be displayed in different groups as given below. The details of such equipments have been specified by Railway Board in Annexure 'B' of its letter dt.02.12.2010.

(a) Equipments related to safety - {Annexure-B1(I)}

(b) Rail, Rail Joints and Rail defects

(c) Sleeper & Elastic fittings

(d) Different Track Fittings (Turnouts)

(e) Different Track Fittings (Level crossing)

(f) Different Track Fittings (Bridges)

(g) Tools and plants

(h) Measuring Tools

(i) Regular Track Maintenance Tools

(j) Other Tools

(k) Small track machines

(l) Other structures

The Drawing No. and name of each article should be displayed on wall by providing boards of uniform size.

5.6 Progress Reporting Principal of the Institute should submit the training statistics and information to the divisional HQ on monthly basis, as per Performa already in vogue. A list of Performa is enclosed at Annexure-H.

5.7 Issue of Training Certificate

After the completion of training, all the trainees should get a certificate. It should preferably be signed by the Principal and Co-Instructor both. The format of the certificate is enclosed at Annexure-I. As far as the Gate Keepers are concerned, Training cum Competency Certificate should be issued as per Performa given in chapter XVI of General and Subsidiary Rules. Its format is enclosed at Annexure-J. As regard to period of validity is concerned, it should be for a period of five years.

6.0 Boarding and Lodging Facilities

All the courses to be conducted shall be residential. Trainees who are nominated from the station where the Institute is located can only be permitted to become a day boarder if they wish so. Therefore, adequate and comfortable arrangements for the stay of the trainees need to be ensured. Availing of messing facilities shall be compulsory. All trainees have to pay as per the rates prescribed from time to time. Accordingly, following facilities need to be arranged and maintained :-

6.1 Accommodation

Each trainee should be provided with individual bed in the dormitories. The dormitories should preferably consist of not more than 6-10 beds each. With each bed, bed sheet, pillow, pillow cover, one sheet with blanket, mosquito net and one locker should be provided. The linen i.e. bed sheet and pillow cover should be replaced on weekly basis. Additional blankets should be arranged as per temperature and be provided on request.

Each dormitory should have proper natural ventilation and lighting. All doors and windows should be equipped with wire mesh panels. Each dormitory should have proper fans, lights, coolers and sockets for mobile chargers and mosquitos' repellents etc.

Each dormitory should be provided with posters displaying Etiquette of group living. Do's and Don'ts for habits and conduct.

6.2 Toilet Facility

For every 20 trainees or part thereof, a neat and clean tiled block consisting of following should be provided:

i. Four nos. water closets preferably 3 Indian and 1 Western style.

ii. Four nos. urinals with water flushing.

iii. Four nos. baths with hot water facilities.

iv. Two counter type washbasins with soap dispensers and mirror.

v. The toilets should be in neat and clean condition. This is the responsibility of trainees as well as school that cleanliness should be clearly vision able in the school premises.

6.3 Messing Facility

As per Railway Board orders dated 16.08.2005 & 01.07.2010 (Annexure L-4 & L-5), the infrastructure for mess shall be provided by the institute. The mess will be run through outsourcing, by the Mess Committee consisting of trainee representative under the overall superintendence of the Principal. The Mess infrastructure shall be as follows :-

6.4 Kitchen Room

It should be provided with :

- Cooking platform, overboard & under counter storage
- Gas connection with hot plate
- Good ventilation with wire mesh panels on doors and windows

- Electrical lights, fan and noiseless exhaust fan
- 300 liters capacity refrigerator
- Supply of normal water and water cooler with potable water from Ro
- Sink with drain board, ground platform for cleaning of utensils
- Proper drainage.

6.5 Dining-cum-Common TV Room

It should be provided with :

For every 10 trainees, one set of Dining table and chairs with capacity of 6 persons should be provided. These should be arranged in such a manner that proper space for circulation is provided.

The endeavor should be made to provide a 32" LCD dish TV at a height of 6 ft. with musical system. This room shall also be used as common Reading, TV and music room for trainees at other times, so extra chairs should be provided.

The peaceful environment should be maintained in Dining room while meal time.

6.6 Sports facilities:

All the trainees should be encouraged to play outdoor and indoor sports during the evening hours within the campus. The facility of Badminton, Volley ball, Football, Kabbadi & Kho-Kho should be provided as per availability of space. In the common TV room Chess board, Carom board etc. should be provided.

Sports activities have been recognized as the key feature to meet the challenges in life. It enhances the physical capacity as well as mental power to break down the difficulties in work time and life. Hence, sufficient time should be spared for trainees for sports activities.

6.7 Yoga Classes:

All the trainees should be encouraged for attending Yoga classes for keeping them mentally and physically fit. Yoga classes be arranged in the morning preferably 5.30 to 6.30 hrs. and in the evening 18.00 to 19.00 hrs. Under the guidance of yoga instructor. Yoga instructor may be managed from local yoga institutes on payment basis, through imprest.

Spiritual attendance is also required in this era of competition and hectic life style. Yoga has been recognized by science for minimizing the stress. So, the trainees should be encouraged to attend the Yoga Classes so that they may be encharged to handle the challenges in job.

6.8 Proving of Mobile training cum demonstrator car. One training car approved with models & audio video documents on various subject on AT welding patrolling day to day maintenance work, utilisation of various work protection equipments & methods. On site/yard short term lectures may also be arranged in mobile training car for particular P.way units.

6.9 A short introduction of carriage & wagon defects like flat wheel, hot axle defect, loose shunting etc. may also be given to Trackman. Some operating rules & regulation regarding shunting rules, signals may also be explained to them to understand better train working in yards.

6.10 Accident & derailment restoration activities must also be added in the initial training program of Trackman. Impact of bad workmanship in the field must also be explained to this category. This must be in the same manners as in RED CROSS organization. Some first aid training may also be imparted to Trackmen to enable them to meet with any unusual injury during work or in extreme hot & cold season any time.

6.11 Upgrading the status of Trackman to the level as skilled worker/constable/Sainik as these people have the close activities with the similar staff as RPF constable, GRP constable and these people harassed them time to time treating them as illiterate labour &when they approach to them for many reason. They must be well dressed and well disciplined worker of Engineering department.

6.12 All the Trackman must be well educated. A separate course must be initiated for these illiterate Trackmen to make them literate. There must be no illiterate Trackmen in Engineering department.

■ ■ ■

Provision of Indirect Braking System on Machines

By
*Prasad Rao**

1.0 Introduction Track Machines are a visualization of industrially advanced economies, conceived and built to their needs. Indian Railways, have introduced these machines with the purpose of upgrading technology and to keep pace with other railways. These machines use highly sophiscated technology, easily adaptable to the mindset and work culture of those nations.

RDSO has been suggesting change in many of the specifications and incorporated many modifications for the easy and quick adaptability of technology by our work-force. In-spite of the best efforts at various levels, down the line, the field executives always have some additional requirements.

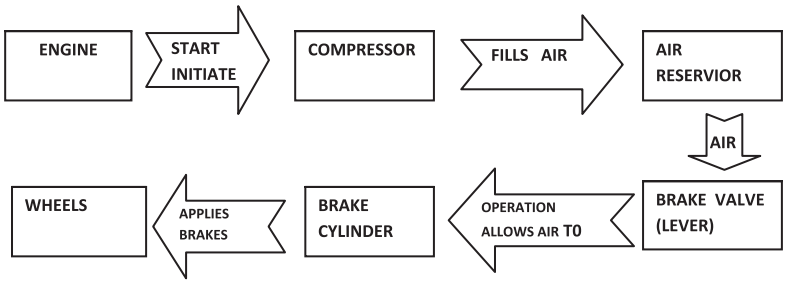
Central Periodical Over-Hauling Depot, Rayanapadu, has a regular interaction with these men on the front-line. Their requirements are the main concern during the POH of machines.

2.0 Indirect Braking System on Track Machines (I.B.S):

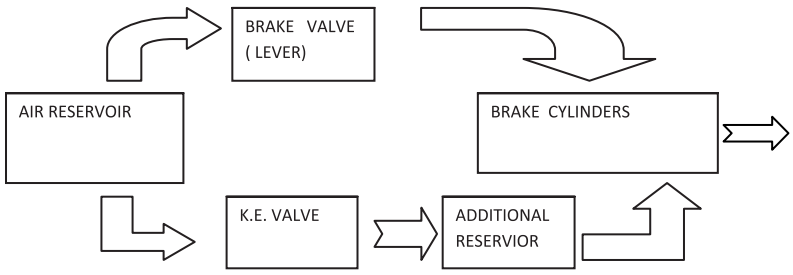
All over Indian Railways, cases of machines coupled with Rest vans colliding with stabled trains, machines, etc were being reported. The brake power of the Track Machine was found to be inadequate when coupled with the Rest Van. Instructions were received to provide proper braking system on track machines to ensure safety. The limitation with machines is that they cannot tow camping coach or any other rolling stock as per G&S rules in un-braked condition.

The braking mechanism of the Track Machine is limited to applying brakes only to the machine. This mechanism had to be extended to the coach/Rest van also. This has been achieved by introduction of a K.E.Valve.The responsibility was thrust on to the CPOHs to comply with the indirect bracking system. The first circuit was developed at Rayanapadu. Compatible indirect braking circuits have been developed for various type of track machines and are being provided on all track machines of SCR as a project in a phased manner. Machines of other Rlys which come for POH are updated as part of POH. This work is taken up without depending on OEM of the machines to ensure safety and economy.

3.0 Flow Chart: Start Initiates: The existing braking system on the Track Machines can be explained in the simplest form as follows.



4.0 Modification Done



*Dy.CE/CPOH/RYP

4.0 Line Diagrams (Drawings):

1) DUOMAT -- Annexure - A.
2) CSM -- Annexure -B.
3) UNIMAT -- Annexure - C.
4) DGS -- Annexure - D.

5.0 Additional Spares Required:

S.No	DESCRIPTION	PLASSER PART NO	QTY in Nos
1	Indirect Brake Valve	90366	02
2	Pressure Regulator	90188/90189	02
3	Non return valve	90382	02
4	Pressure Gauge	90184	02
5	Air Reservoir Tank-100 Lts	90157	01
6	K.E.Valve	90350	01
7	2-Way Valve	90362	02
8	Container (Dust Collector)	90356	02
9	Hose Coupling		02
10	BP Hose pipe		02
11	Adopters/Pipes		As reqd.

Initially 25 machines demanded were commissioned and later in an phased manner all the 72 machines on S.C.Rly have been provided/re-commissioned with indirect braking system.

As part of POH, all older version Track Machines available with-in the circuit of CPOH/RYP have been provided with I.B.S. even some of the new machines have been provide with I.B.S. the last machine being CSM-3X-3963 of C.RLY (Nagpur Division). Till date a total 98 machines have been provided with I.B.S.

2 WAY Valve Fixing

Additional Air Reservoir

Ke Valve Fixing

Dust Collector Fixing

Indirect Brake Valve

Air Regulator

6.0 Advantages:

1) In steep down gradients the ability to control the speed of Machine and coach will be adequate.

2) Application of both machine (Brake Lever) and Coach brake (KE Valve) will ensure lesser braking distance due to lack of pushing force.

3) The spares used are compatible with spares available with mechanical dept.

■ ■ ■

Australia's Monash University Institute of Railway Technology Enters into Agreement with Indian Railways

A Railway research centre in Australia has entered into an agreement with the Indian Railways to support future research and technology development, related to critical infrastructure in India.

Representatives from Monash University Institute of Railway Technology (IRT) and Indian Ministry of Railways corporation DFCCIL (Dedicated Freight Corridor Corporation of India Limited) signed an agreement in New Delhi.

IRT with partners - Balaji Railroad Systems Ltd (BARSYL), leading railway consultants in India, PwC, and Indian Institute of Bombay (IITB) were selected as the preferred supplier from a competitive global selection process.

They will provide guidance on the establishment of a new applied research and development institute in India known as SRESTHA (Special Railway Establishment for Strategic Technology & Holistic Advancement).

SRESTHA will be locally engaged, but have a global reach with the aim to become a world leader in the advancement of rail.

Significantly, the project will provide guidance to the Indian Railways on international models that will be adapted to the Indian railway environment.

IRT Director Ravi Ravitharan said the partnership will help advance railway technology both in India and around the world.

"I am extremely pleased to be invited with our partners to assist with this significant project, which will support future research and technology development related to critical infrastructure for India. Indian Railways is one of the largest employers in the world and this is a very important project not only for IRT but also for Victoria and Australia," Ravitharan said.

IRT is the premier track and vehicle railway research centre in Australia.

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

IRICEN'S CALENDAR OF COURSES 2017 (Rev. 04)					
Course No	From	To	Name of the Course	Duration	Eligible Group
PROBATIONARY COURSES					
17003	10-04-2017	13-04-2017	IRSE Posting Exam	1 Week	IRSE (P) 2014 Exam.
17004	05-06-2017	09-06-2017	Orientation	1 Week	IRSE (P) 2014 Exam.
17005	05-06-2017	04-08-2017	IRSE Ph.II (Gr.P)	9 Weeks	IRSE (P) 2015 Exam.
17006	05-06-2017	04-08-2017	IRSE Ph.II (Gr.Q)	9 Weeks	IRSE (P) 2015 Exam.
17007	17-07-2017	21-07-2017	IRSE Joining	1 Week	IRSE (P) 2016 Exam
17008	08-08-2017	18-08-2017	IRSE M.Tech, Sem-II	2 Weeks	IRSE 2015 Exam.
17009	30-10-2017	15-12-2017	IRSE Ph. I (Gr. P)	7 Weeks	IRSE (P) 2016 Exam
17010	30-10-2017	15-12-2017	IRSE Ph. I (Gr.Q)	7 Weeks	IRSE (P) 2016 Exam
17011	04-12-2017	08-12-2017	IRSE Posting Exam	1 Week	IRSE (P) 2015 Exam.
17012	18-12-2017	29-12-2017	IRSE M.Tech, Sem-I	2 Weeks	IRSE 2016 Exam.
18001	15-01-2018	19-01-2018	Orientation	1 Week	IRSE (P) 2015 Exam.
INTEGRATED COURSES					
17101	02-05-2017	20-07-2017	Integrated	12 Weeks	Gr.B officers
17102	11-09-2017	30-11-2017	Integrated	12 Weeks	Gr.B officers
17103	11-12-2017	01-03-2018	Integrated	12 Weeks	Gr.B officers
SR. PROFESSIONAL COURSES					
17201	02-05-2017	02-06-2017	Sr.Prof(P.Way)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
17202	24-07-2017	24-08-2017	Sr.Prof(Br &General)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
17203	11-09-2017	13-10-2017	Sr.Prof(P.Way)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
17204	11-12-2017	12-01-2018	Sr.Prof(Br &General)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
PCE/HAG/SAG/SEMINARS/WORKSHOPS/MEETINGS					
17302	05-11-2017	12-05-2017	Workshop on PPP&EPC	2 days	HAG/SAG of Civil Engg & Accounts
17304	20-04-2017	21-04-2017	CE/TMs' Seminar	2 days	CE/TMs
17305	27-07-2017	28.-07-2017	Workshop on PPP&EPC	2 days	JAG/SG of Civil Engg & Accounts
17306	15-06-2017	16-06-2017	CTEs' Seminar	2 days	CTEs
17307	06-07-2017	07-07-2017	CAOs' Seminar	2 days	CAOs
17308	03-08-2017	04-08-2017	CE(W)/CPDEs' Seminar	2 days	CE(Works)/CPDEs
17309	31-08-2017	01-09-2017	Trg Mgr/CGE Seminar	2 days	CGEs/Pr.CETCs
17310	21-09-2017	22-09-2017	CBEs' Seminar	2 days	CBEs
17311	05-10-2017	06-10-2017	PCEs' Seminar	2 days	PCEs
17312	01-11-2017	02-11-2017	IRICEN Day Seminar	2 days	IRSE 91' Batch
17313	07-12-2017	08-12-2017	Workshop on PPP&EPC	2 days	HAG/SAG of Civil Engg & Accounts
17314	17.04.2017	18.04.2017	Workshop for CRS/Dy.CRS	2 days	CRS/Dy.CRS Central& State
17317	24.04.17	25.04.2017	State JVs	02 Days	Government Officers

Course No	From	To	Name of the Course	Duration	Eligible Group
SPECIAL COURSES (TRACK/BRIDGES/WORKS)					
17408	31.07.2017	08.08.2017	Course for Bridge Design Asstt	3 Weeks	AEN/XEN(Design)/ Bridge Design Asstts of OL/Constr.
17410	24-04-2017	25-04-2017	Special course on Crane Working	2 Days	JAG/SAG
17411	24-04-2017	28-04-2017	Land Management	1 Week	SS/JAG
17412	12-06-2017	16-06-2017	Points & Xings and Yards	1 Week	JS/SS/JAG
17413	17-04-2017	22-04-2017	Rail Wheel Interaction & derailments	6 days	JS/SS/JAG/SG of OL
17414	08-05-2017	19-05-2017	Mechanised Track Maint & Renewals, RG, USFD &TMo	2 Weeks	JS/SS/JAG
17415	15-05-2017	24.05.2017	Steel Structure	10 Days	JS/SS/JAG
17416	22-05-2017	02-06-2017	Contracts & arbitration and Project Management	2 Weeks	SS/JAG
17417	29-05-2017	02-06-2017	Modern Surveying	1 Week	JS/SS/JAG of Const.Org.
17418	19-06-2017	30-06-2017	Special course for Open Line Engineers	2 Weeks	JS/SS/JAG
17419	14-08-2017	18-08-2017	Points & Xings and Yards	1 Week	JS/SS/JAG
17420	21-08-2017	22-08-2017	Special course on Crane Working	2 Days	JAG/SAG
17421	21-08-2017	29-08-2017	PSC construction	9 Days	JS/SS/JAG
17422	28-08-2017	08-09-2017	Construction Engineers	2 Weeks	SG/JAG/SS of Const.Org.
17423	28-08-2017	01-09-2017	Rly. Formation and Geo.Tech. Invest.	1 Week	JS/SS/JAG
17424	28-08-2017	01-09-2017	Land Management	1 Week	SS/JAG
17425	04-09-2017	07-09-2017	TMS	1 Week	JS/SS/JAG
17426	04-09-2017	12-09-2017	Steel Structure	9 Days	JS/SS/JAG
17427	11-09-2017	16-09-2017	Rail Wheel Interaction & derailments	6 days	JS/SS/JAG/SG of OL
17428	11-09-2017	22-09-2017	Mechanised Track Maint & Renewals, RG, USFD &TMo	2 Weeks	JS/SS/JAG
17429	25-09-2017	06-10-2017	Contracts & arbitration and Project Management	2 Weeks	SS/JAG
17430	03-10-2017	07-10-2017	Points & Xings and Yards	1 Week	JS/SS/JAG
17431	09-10-2017	13-10-2017	Special course for NTPC Engineers on Rly Sidings	1 Week	NTPC Engineers
17432	06-11-2017	17-11-2017	Mechanised Track Maint & Renewals, RG, USFD &TMo	2 Weeks	JS/SS/JAG
17433	20-11-2017	25-11-2017	Rail Wheel Interaction & derailments	6 days	JS/SS/JAG/SG of OL
17434	11-12-2017	15-12-2017	Special course for NTPC Engineers on Track & Br.Maint.	1 Week	NTPC Engineers
17437	24-04-2017	12-05-2017	Spcial Course MRVC's Project Engineer	3 Weeks	MRVC Project Engineer
			AWARENESS COURSES		
17705	10-04-2017	13-04-2017	Awareness course	1 Week	Prob of other Dept
17706	17-04-2017	21-04-2017	Awareness course	1 Week	Prob of other Dept

Course No	From	To	Name of the Course	Duration	Eligible Group
17707	02-05-2017	05-05-2017	Awareness course	1 Week	Prob of other Dept
17708	22-05-2017	26-05-2017	Awareness course For IRSME	1 Week	Prob of IRSME
17709	19-06-2017	23-06-2017	Awareness course For IRTS	1 Week	Prob of IRTS
17710	09-10-2017	13-10-2017	Awareness course For IRSME	1 Week	Prob of IRSME
17711	27-11-2017	01-12-2017	Awareness course	1 Week	Prob of other Dept
IRICEN SSTW (SR. SUPERVISORS TRAING WING) COURSES					
17826	03-04-2017	13-04-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17827	03-04-2017	06-04-2017	Track Monitoring(Tmo)	1 Week	SSE/P.Way
17828	03-04-2017	11-04-2017	Fabrication of Steel Bridges (FSB)	9 Days	SSEs/Bridges
17829	10-04-2017	13-04-2017	Contract Management (CM)	1 Week	SSE/Works
17830	17-04-2017	27-04-2017	Mech.Track Maintenance & Renewals (MTMR)	2 Weeks	SSE/P.Way
17831	17-04-2017	20-04-2017	Building Maintenance (BM)	1 Week	SSE/Works
17832	24-04-2017	28-04-2017	Land Management (LM)	1 Week	SSE/Works
17833	24-04-2017	04-05-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE/P.Way & Inst. of ZRTI& DTI
17834	02-05-2017	12-05-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17835	08-05-2017	11-05-2017	Yard Maintenance(YM)	1 Week	SSE/P.Way
17836	08-05-2017	12-05-2017	Insp.& Maint. of Bridges (IMB)	1 Week	SSE/Works
17837	15-05-2017	24-05-2017	Points, Xings & curves (PXC)	2 Weeks	SSE/P.Way
17838	15-05-2017	18-05-2017	Safety at Track work sites & Crane working (S&Cr Weekg)	1 Week	SSE/P.Way
17839	15-05-2017	01-06-2017	Training of Trainers(W&B)) TOT(W&B)	3 Weeks	Inst. of ZRTI& DTI(Works&Bridges)
17840	22-05-2017	25-05-2017	Track Monitoring(Tmo)	1 Week	SSE/P.Way
17841	29-05-2017	08-06-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17842	05-06-2017	09-06-2017	Management of Land & stores (MLS)	1 Week	SSE/P.Way
17843	05-06-2017	15-06-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE/P.Way & Inst. Of ZRTI& DTI
17844	12-06-2017	22-06-2017	Mech.Track Maintenance & Renewals (MTMR)	2 Weeks	SSE/P.Way
17845	19-06-2017	23-06-2017	Formation (FMN)	1 Week	SSE/Works
17846	19-06-2017	23-06-2017	Insp.& Maint. of Bridges (IMB)	1 Week	SSE/Works
17847	27-06-2017	06-07-2017	Points, Xings & curves (PXC)	2 Weeks	SSE/P.Way
17848	27-06-2017	05-07-2017	PSC Construction	9 Days	SSE/Works
17849	03-07-2017	06-07-2017	Track Management System (TMS)	1 Week	SSE/P.Way
17850	10-07-2017	20-07-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17851	10-07-2017	13-07-2017	Concrete Technology (CT)	1 Week	SSE/Works
17852	17-07-2017	21-07-2017	Survey (SRVY)	1 Week	SSE/Works
17853	17-07-2017	27-07-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE/P.Way & Inst. of ZRTI& DTI

Course No	From	To	Name of the Course	Duration	Eligible Group
17854	24-07-2017	28-07-2017	Long Welded Rail (LWR)	1 Week	SSE/P.Way
17855	31-07-2017	04-08-2017	Track Monitoring(Tmo)	1 Week	SSE/P.Way
17856	31-07-2017	03-08-2017	Building Construction (BC)	1 Week	SSE/Works
17857	31-07-2017	08-08-2017	Fabrication of Steel Bridges (FSB)	9 Days	SSEs/Bridges
17858	08-08-2017	17-08-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17859	08-08-2017	11-08-2017	Yard Maintenance(YM)	1 Week	SSE/P.Way
17860	14-08-2017	18-08-2017	Land Management (LM)	1 Week	SSE/Works
17861	21-08-2017	30-08-2017	Points, Xings & curves (PXC)	1 Week	JS/SS/JAG
17862	21-08-2017	24-08-2017	Building Maintenance (BM)	1 Week	SSE/Works
17863	21-08-2017	24-08-2017	Insp.& Maint. of Bridges (IMB)	1 Week	SSE/Works
17864	28-08-2017	31-08-2017	Water Supply ,Sewarge & Water Audit	1 Week	SSE/Works
17865	28-08-2017	07-09-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE/P.Way & Inst. of ZRTI& DTI
17866	04-09-2017	14-09-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17867	04-09-2017	08-09-2017	Contract Management (CM)	1 Week	SSE/Works
17868	11-09-2017	15-09-2017	Management of Land & stores (MLS)	1 Week	SSE/P.Way
17869	18-09-2017	28-09-2017	Mech.Track Maintenance & Renewals (MTMR)	2 Weeks	SSE/P.Way
17870	18-09-2017	20-09-2017	Safety at Track work sites & Crane working (S&Cr Weekg)	1 Week	SSE/P.Way
17871	25-09-2017	03-10-2017	PSC Construction	9 Days	SSE/Works
17872	03-10-2017	13-10-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17873	03-10-2017	06-10-2017	Track Management System (TMS)	1 Week	SSE/P.Way
17874	09-10-2017	12-10-2017	Concrete Technology (CT)	1 Week	SSE/Works
17875	09-10-2017	13-10-2017	Insp.& Maint. of Bridges (IMB)	1 Week	SSE/Works
17876	06-11-2017	09-11-2017	Track Monitoring(Tmo)	1 Week	SSE/P.Way
17877	06-11-2017	10-11-2017	Long Welded Rail (LWR)	1 Week	SSE/P.Way
17878	06-11-2017	16-11-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE/P.Way & Inst. of ZRTI& DTI
17879	13-11-2017	23-11-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way
17880	13-11-2017	17-11-2017	Formation (FMN)	1 Week	SSE/Works
17881	20-11-2017	24-11-2017	Survey (SRVY)	1 Week	SSE/Works
17882	20-11-2017	28-11-2017	Fabrication of Steel Bridges (FSB)	9 Days	SSE/Bridge
17883	27-11-2017	07-12-2017	Mech.Track Maintenance & Renewals (MTMR)	2 Weeks	SSE/P.Way
17884	27-11-2017	30-11-2017	Concrete Technology (CT)	1 Week	SSE/Works
17885	04-12-2017	08-12-2017	Contract Management (CM)	1 Week	SSE/Works
17886	11-12-2017	15-12-2017	Long Welded Rail (LWR)	1 Week	SSE/P.Way
17887	11-12-2017	14-12-2017	Building Construction (BC)	1 Week	SSE/Works
17888	11-12-2017	21-12-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE/P.Way & Inst. of ZRTI& DTI
17889	18-12-2017	28-12-2017	USFD,Welding & Rail Grinding (USFD)	2 Weeks	SSE/P.Way

Damage Effect on Concrete Columns Confined with Carbon Composites

Five experimental cyclic tests were carried out on reinforced concrete (RC) rectangular columns with rounded corners, different conditions (new and damaged), and different strengthening systems, which included confinement through carbon fiber-reinforced polymer (CFRP) jackets, anchor dowels, highstrength repair mortar, and external longitudinal stainless steel bars. Lateral load-displacement relationship, energy dissipation, ductility, and curvature results were analyzed with two different damage assessment classifications. The overall evaluation concludes that confining RC columns with external CFRP is both viable and improves performance by itself and combined with other techniques. Damaged columns that were retrofitted showed an increased load capacity up to 20% along with good ductile behavior within the limits of the United States, European, Canadian, and Japanese codes, with minor/moderate degree of damage at 1% drift ratio and moderate degree of damage at 2% drift ratio.

By: Pedro Faustino and Carlos Chastre

Ref: The ACI Structural Journal, Sept./Oct. 2016

Strength and Serviceability Performance of Self-Consolidating Concrete Bridge Girders

Self-consolidating concrete (SCC) is commonly used in all types of reinforced concrete construction. The use of SCC mixtures allows for simpler, more cost-effective fabrication techniques and provides the ability to cast structural shapes and architectural finishes that were previously impracticable. The widespread use of this material has led to numerous research efforts in looking at mixtures, rheological properties, hardened properties, and integration into structural systems. Research reported in this paper is aimed at contributing to a better understanding of the major concerns with regard to the use of SCC concrete in pretensioned bridge girders: 1) end region cracking; 2) long-term deformations; and 3) ultimate strength performance. The work conducted in this research highlighted the impact of the stiffness of SCC mixtures (compared to conventional concrete [CC] mixtures) on both long-term deformations and ultimate strength performance.

By:David B. Garber, José M. Gallardo, Dean J. Deschenes, and Oguzhan Bayrak

Ref: The ACI Structural Journal, Sept./Oct. 2016

Modeling Steel Concrete Bond Strength Reduction Due to Corrosion

Reinforcement corrosion in reinforced concrete (RC) structures induces concrete cracking and leads to a reduction in both steel cross section and steel-concrete bond strength. In this paper, a new model is proposed based on a scalar damage parameter Dc that depends on the loss of cross-sectional area of steel due to corrosion. The model predictions are plotted against experimental data from the literature based on both accelerated and natural corrosion processes and compared to other existing empirical models. The proposed new model significantly improves the prediction of the bond strength of corroding steel bars and is valid for all diameters ranging between 10 and 20 mm (0.39 and 0.79 in.). Moreover, two additional parameters have been implemented in the model, allowing for the consideration of natural (localized) corrosion and the presence of stirrups. A stirrups confinement coefficient st and a pit penetration depth coefficient α have been successfully calibrated using experimental results from the literature.

By: Arnaud Castel, Inamullah Khan, Raoul François, and Raymond Ian Gilbert

Ref: The ACI Structural Journal, Sept./Oct. 2016

Optimal Rail Profile Design for a Curved Segment of a Heavy Haul Railway using a Response Surface Approach

To determine the optimal design of the rail profile for a curved segment of a heavy haul railway, an optimization method that considers the extent of rail wear over the entire design cycle was developed. The approach is based on wheel–rail rolling contact theory, vehicle–track dynamic theory and nonlinear programming theory. The changes in the rail profile were analyzed using an updating strategy that considers random irregularities in the railway track. The minimum average metal loss from the vehicle in terms of wear and grinding for the whole design cycle was regarded as the design objective, and discrete point coordinates on the rail were regarded as the design variables. A radial basis function was used to establish an approximate model, which formed an explicit function between design variables and design objectives. The optimization model was established on this basis, and a genetic algorithm was used to solve the optimization model for the optimized profile. The maximum passing gross load for the whole design cycle reached 150.74 x106 t, an increase of

139.73% compared with the standard profile, which achieved the purpose of prolonging the service life of the rail.

By: Jianxi Wang, Siyi Chen, Xiangguo Li, Yanjie Wu

Ref: Journal of Rail Rapid Transit, August 2016

Predictive Modeling of the Rail Grinding Process using a Distributed Cutting Grain Approach

High-density railway lines experience a high rate of deterioration on the running surface of the rails; it can be addressed by rail grinding in order to reduce the frequency of rail replacement. Rail grinding includes additional complex features beyond what is usually considered in conventional grinding. Although extensive empirical experience exists to describe rail grinding, it can still be considered to be an emerging field that is in need of predictive theoretical guidance. This paper presents a newly developed modeling approach that is intended to provide a theoretical understanding of the rail grinding process and allow the prediction of rail grinding behavior and performance. The modeling is a bottom-up approach that starts from individual cutting grains and builds up to the rail grinding train level. First, grain distribution modeling is used to build a uniform template for the grinding simulation, based on the assumption of spherical grains with normally distributed sizes. Second, one representative slice is extracted as a grinding surface with stable grains. Protrusion heights and spacing distances of the cutting grains are analyzed to obtain the features of the grinding surface. Then the spherical grains are transformed into decahedrons with arbitrary poses, so as to closely approximate the actual surface of a grinding wheel. Third, the interactions of the cutting grains are combined into a model of a single grinding wheel and compared to test results from a single-wheel test. This allows for the connection between the utilized grinding parameters and the grinding results to be isolated, which is validated with supporting experiments performed on a single wheel. The individual wheel relationships can be combined into a full multi-wheel grinding pattern for estimating the simulation results of a multi-wheel grinding train. Eventually, the comparison between the simulations and grinding tests is used to show the effectiveness of the predictive rail grinding modeling at the level of a rail grinding train.

By: Shaodan Zhi, Jianyong Li, Allan M Zarembski

Ref: Journal of Rail Rapid Transit, August 2016

Load Transfer and Arching Analysis in Reinforced Embankment

In a previous study, a series of 9 model tests performed on embankment models resting on soft clay treated with and without ordinary stone columns (OSC), encased stone columns (ESC), and with horizontal layer of geogrid at interface and at 0·1 h height has been carried out to investigate the behaviour of piled (stone columned) and geogrid reinforced embankments. In this paper, these tests are simulated numerically by the finite element method using the program Geostudio (SIGMA/W). Firstly, reanalysis was done of experimental work of embankment models constructed on soft clay treated with OSC and ESC. Secondly, embankment models reinforced by a horizontal layer resting on soft clay strengthened with OSC and ESC were analyzed. A horizontal layer of geogrid is embedded at different levels of embankment height. It was concluded that in the embankment models constructed on soft clay treated with stone columns at a spacing s = 2·5 d with length to diameter ratio L/d ratio = 8, the maximum bearing improvement ratio (qt/qunt) equals 1·33 for the ordinary stone columns and 1·59 for the encased stone columns and about 1·13 and 1·23 when one layer of geogrid is embedded at interface or at 0·1 h height, respectively.

By: Mohammed Y. Fattah, Hadeel A. Mohammed Hanan A. Hassan,

Ref: Ice proceedings Structures and Buildings, November 2016

Experimental Evaluation of Transfer Length in Pretensioned Concrete Beams Using 2,400-MPa Prestressed Strands

Prestressed (PS) strands are widely used to develop prestressed concrete (PSC) and are stronger than other types of structural steel used in the construction industry. Because of their high strength, PS strands are more effective for use in structures than other materials. Recently, high-strength 2,400-MPa PS strands have been developed and are being considered as an alternative to conventional 1,860-MPa PS strands. However, there have been no reports of research or proposed regulations for pretensioned 2,400-MPa strands in PSC. In this study, 28 PSC beams were fabricated by using 2,400-MPa PS strands, and the transfer length of the PSC was measured. Experiments were performed to evaluate several parameters such as the compressive strength of concrete, steel–fiber volume ratio, and stirrup reinforcement along with different de-tensioning methods in order to determine their effects on the transfer length. In addition, the transfer length with the 2,400-MPa PS

especially longitudinal stresses throughout the structure were altered by the repeated application of thermal gradients. The different creep and shrinkage strain rates through the depth of the section, driven by the temperature and stress differences from the applied thermal gradients, induced residual stresses. The presence of these residual stresses implies that time-dependent stress changes from a creep and shrinkage analysis at a constant temperature cannot be linearly superimposed with the stresses caused by thermal gradients computed using an independent elastic analysis.

By: Brock D. Hedegaard, Catherine E. W. French, and Carol K. Shield,

Ref: Journal of Structural Engineering, October 2016

Shear Design and Assessment of Reinforced and Prestressed Concrete Beams Based on a Mechanical Model

Safe and economical design and assessment of reinforced (RC) and prestressed concrete (PC) beams requires the availability of accurate but simple formulations which adequately capture the structural response. In this paper, a mechanical model for the prediction of the shear-flexural strength of PC and RC members with rectangular, I, or T sections, with and without shear reinforcement, is presented. The model is based on the principles of concrete mechanics and on assumptions supported by the observed experimental behavior and by the results of refined numerical models. Compact, simple, and accurate expressions are derived for design and verification of the shear strength, which incorporate the most relevant shear transfer actions. Excellent agreement between the predictions of the model and the results of the recently published ACI-DAfStb databases, including more than 1,287 tests on RC and PC beams with and without stirrups, has been observed. The theory behind the model provides consistent explanations for many aspects related to the shear response that are not clearly explained by current code formulations, making it a very helpful tool for daily engineering practice.

By: Antonio Marí; Jesús M. Bairán; Antoni Cladera; and Eva Oller

Ref: Journal of Structural Engineering, October 2016

Behavior of Tendons with Multiple CFRP Rods

Research works related to the fiber-reinforced polymer (FRP) tendons have focused on the anchor system, but the anchor is not the only contribution to performance. Since civil structures require tendons consisting of multiple rods (e.g., cables, suspenders in bridges, or rock bolts in ground anchors), the characteristics of multirod tendons require targeted research. This paper presents a study on the behavior of tendons with multiple carbon FRP (CFRP) rods. Four specimens including two cable-type assemblies (TA12-9 and TA12-20) and two ground anchors (GA12-9 and GA12-20) with large-tonnage capacities were built and tested. Using strain gauges set along individual rods, the nonuniform force distribution among individual rods was observed and is discussed. The test results showed that nonuniformity is a recurring feature of a multirod tendon, with the variation in the initial length of the rods caused by installation error as its main reason. Based on the premise that tension in multiple rods obeys a normal distribution, the relationship between the nonuniformity coefficient, η and a corresponding capacity reduction coefficient, λ , was established. The tendon consisting of nine CFRP rods in TA12-9 (GA12-9) shows a capacity reduction factor of 0.83 (0.89), while the capacity reduction factor of the tendon consisting of 20 rods in TA12-20 (GA12-20) decreases to values of 0.79 (0.87).

By: Kuangyi Zhang; Zhi Fang; and Antonio Nanni,

Ref: Journal of Structural Engineering, October 2016

Hybrid Model for Railroad Bridge Dynamics

Railroads carry approximately 40% of the ton-miles of the freight in the United States. On the average, a bridge occurs every 2.25 km (1.4 mi) of track, making them critical elements. The primary load on the railroad bridges is the train, resulting in numerous models being developed to understand the dynamic response of bridges under train loads. However, because the problem is time-dependent and coupled, developing adequate models is challenging. Most of the proposed models fail to provide a simple yet flexible representation of the train, bridge, and track. This paper proposes a new hybrid model that is effective for solving the track–bridge interaction problem under moving trains. The main approach is to couple the finite-element model of the bridge with a continuous beam model of the track using the assumed modes method. Both single-track and multitrack bridges are considered. The hybrid model is validated against field measurements for a double-track bridge. This model is then used to predict critical train speeds. The results demonstrate that the hybrid model provides an effective and fundamental tool for predicting bridge dynamics subject to moving trains. The flexible feature of the model will allow

strands was measured and compared with the transfer length predicted by previously proposed models.

By: Jin Kook Kim; Jun Mo Yang; and Hong Jae Yim

Ref: Journal of Structural Engineering, November 2016

Combined Bearing and Shear-Out Capacity of Structural Steel Bolted Connections

This study is concerned with the strength limit state of serial bolted connections in structural steel plates. It points out that the ultimate load capacity of a serial bolted connection failing in combined bearing and shear-out cannot be computed as the simple sum of the respective ultimate bearing and ultimate shear-out capacities, which is implicitly permitted in design specifications worldwide. Based on the laboratory test results of 10 hot-rolled steel plate specimens composed of three different grades with nominal thicknesses ranging from 5 to 8 mm, the paper first establishes the ultimate bearing coefficient of a 20-mm bolted connection in a structural steel plate to be 3.5. Coupled with the shear-out equation previously derived, a design equation where the shear-out capacity of the downstream bolt varying quadratically with the end distance is then proposed to determine the combined bearing and shear-out capacity. The proposed equation is demonstrated through verification against independent laboratory test results involving 5-mm plates of three different grades to be significantly more accurate than the simple sum. Explanation for the unexplained results obtained by another researcher using his own equation is provided in this paper.

By: Lip H. Teh, and Mehmet E. Uz

Ref: Journal of Structural Engineering, November 2016

Systematic Calibration of Model Parameters Based on Large-Scale Experiments on Hybrid Masonry Walls

Hybrid masonry is a relatively new type of structural system that benefits from the ductility and ease of construction of steel frames and from the in-plane strength and stiffness of reinforced masonry panels. Finite element analyses of hybrid masonry systems employ complex models, such as the two-scalar continuum damage model, to capture the propagation of damage through the masonry panels. Such formulations rely on several constitutive parameters but no simple experiments exist that can be used to decouple their effect and calibrate them independently. This paper proposes a method to calibrate the masonry parameters using experimental data from global system testing. Steel components are described by an elastoplastic model with kinematic hardening whose constitutive parameters are easily calibrated. A parameter calibration procedure for the damage model parameters based on the behavior of the base wall of a two-story hybrid system in global testing is proposed. In order to reduce the number of calibrated parameters, two constraints are applied to the compressive range of the constitutive law, requiring that for that range the stress-strain curve is similar to that of concrete. The effectiveness of these two constraints in finding an optimized set of parameters more efficiently is then verified by using uniaxial compression test data. An automatic calibration procedure of the remaining parameters is proposed based on the Nelder-Mead simplex method. It is demonstrated through numerical experiments that the models with calibrated parameters can accurately capture the behavior of hybrid masonry systems.

By: Zhenjia Gao, and Ilinca Stanciulescu,

Ref: Journal of Structural Engineering, October 2016

Effects of Cyclic Temperature on the Time-Dependent Behavior of Post-tensioned Concrete Bridges

Typically, measurement and analysis of concrete time-dependent behaviors such as creep and shrinkage are performed under the assumption of constant temperature conditions. However, many structures in the field are subject to variable seasonal and daily temperatures. This paper explores how changes in temperature affect the time-dependent behavior of concrete structures, with a particular focus on post-tensioned concrete bridges. Temperature-dependent creep, shrinkage, aging, and relaxation models were incorporated into structural finite-element analyses examining a post-tensioned concrete beam under variable thermal loading. The impacts of uniform temperature changes on the time-dependent deflections, strains, and stresses were accounted for using an Arrhenius-adjusted age based on the structure temperature. However, nonuniform temperature changes, such as thermal gradients through the depth of the cross-section, caused time-dependent behavior that could not be accounted for using the Arrhenius-adjusted age based on the average structure temperature. Time-dependent vertical deflections and

accommodating more sophisticated vehicle models and track irregularities.

By: Robin E. Kim; Fernando Moreu, and Billie F. Spencer,.

Ref: Journal of Structural Engineering, October 2016

Widening of Existing Bridges on State Highway 16 in Auckland

The State Highway 16 Causeway upgrade project is one of the packages in the Waterview Connection project portfolio, which forms the final section of the 48 km Western Ring Route in Auckland, New Zealand. The project improves, widens and raises an approximately 4·8 km long section of the existing motorway, to provide additional capacity and to safeguard it against coastal erosion and flooding. Two existing bridges on the motorway, Whau River Bridge and Causeway Bridge, are being widened and upgraded to extend their usable lives. Both bridges are a mix of structural forms, presenting many technical and logistical challenges for design and construction, in terms of the integration of further widening work and the assessment of the existing structural elements. This paper discusses the innovative approach taken towards the complex bridge widening, how durability, constructability and traffic management have been taken into consideration and how the results of assessments, including non-linear seismic 'pushover' analyses, have been used to confirm the functionality of the bridges in the final scheme.

By: Paul William Corbett and Timothy John Watterson,

Ref: Ice proceedings Bridge Engineering, September 2016

Futuristic Composite Bridges

Three futuristic composite bridges viz. Bridge in a backdrop [using FRP tubes filled with SCC (self Consolidating Concrete) as the main load bearing element], Hybrid-Composite Beam (with a FRP shell housing as arch of SCC which is tied at its ends by high strength galvanized pre-stressed strands) and ProCoBeam [with a shear composite dowel connecting bottom steel T-section (with a specially profiled web) with the top concrete T-section] are described, which result in accelerated construction as well as sustainable solutions.

By: Gaithersburg,

Ref: The Bridge & Structural Engineering, June, 2016

Seismic esponse Analysis of Train-Track-Bridge Interaction System to Evaluating Safety of Train in case of High-Speed Railways

The study is intended to evaluate the seismic response of a train-track-bridge interaction system along with assessing the running safety of train. In regards to this, a rather simplified approach of introducing a complex , realistic bridge model into the coupled system is suggested and the system responses are found out with the co-simulation of MATLAB and ANSYS. Thereafter, in order to investigate the dynamic behavior of the system, first a single span simply supported bridge of composite section made of concrete deck over steel box girder is taken and the effect of seismic excitation, train speed, bridge vibration and striking time of earthquake on the system responses are shown. Moreover, the running safety of train is also investigated with the help of a safety index, called derailment factor. Finally, a 3 span simply supported and a 3-span continuous bridge model are taken in order to show the effect of different status of train motion simultaneously with earthquake on train-bridge responses in case of two different bridge model. In addition to that, the effect of those two bridge models on the safety index of running train are also shown. Some useful conclusions are drawn thereafter, indicating the dynamics of bridge-train interaction system in seismic design.

By: Biswajit Pal, and Anjan Dutta

Ref: The Bridge & Structural Engineering, June, 2016

In-Plane Shear Performance of Masonry Walls after Strengthening by Two Different FRPs

This experimental study was aimed to investigate the in-plane shear performance of externally strengthened masonry walls using two types of fiber-reinforced polymer (FRP) sheets, namely, carbon FRP (CFRP) and polyethylene terephthalate-FRP (PET-FRP) sheets. Among these two, PET-FRP has a low tensile strength but possess a higher fracturing strain than CFRP. Twelve masonry walls made from clay brick were tested for static lateral loading under constant compression, after bonding CFRP and PET-FRP sheets onto their surfaces in three different configurations. The ultimate shear strength and deformation at peak load were the two important observations. The mechanisms by which load was carried were observed, varying from the initial uncracked state to the final, fully cracked state. The results demonstrate that a significant increase in the in-plane shear capacity of masonry can be achieved by bonding these two

FRPs to the surface of the walls but ductility is compromised when CFRP is used. Walls retrofitting with PET-FRP in a crossdiagonal fashion show a good ductile behavior in both prepeak and postpeak regimes. The experimental data were used to assess the effectiveness of the strengthening of one FRP over the other. PET-FRP in diagonal configuration was found to be the most effective way of strengthening without compromising the two most essential aspects of masonry, that is, strength and ductility.

By: Ataur Rahman, S.M.ASCE; and Tamon Ueda

Ref: Journal of Composites for Construction, Sept. / Oct., 2016, Volume 20, Issue 5

Load-Strain Model for Steel-Concrete-FRP-Concrete Columns in Axial Compression

A load-strain model for a steel-concrete-FRP-concrete (SCFC) hybrid column section in compression is proposed. The section layout has a square steel tube as the outer layer and a circular fiber-reinforced polymer (FRP) tube as the inner layer, and concrete is filled between these two layers and inside the FRP tube. Thus the section can be regarded as a concrete-filled steel tube (CFST) with a FRP-confined concrete core (FCCC), in which the FCCC is essentially a concrete-filled FRP tube (CFFT) in sectional configuration. However, the mechanical behavior of a SCFC is superior to the simple superposition of CFST and CFFT without consideration of the interaction mechanisms among the different materials. The load-strain behavior of a SCFC differs from that of a CFST or CFFT in that it includes an initial parabola portion, a second linear portion, and a postpeak portion. The model is established by superposing four load-strain models of the constituent layers and attempting to reveal the mechanical responses of the SCFC sections under axial compression. In the modeling, several mechanical characteristics, namely yielding point, peak strain, peak load, and postpeak residual bearing portion, are investigated and the effects of three parameters, FRP thickness, steel thickness, and concrete strength, are examined. Comparisons between the modeling results and experimental results show good agreement in terms of yielding strain, yielding load, peak strain, and peak load. Furthermore, a set of predictions for peak load covering a greater range of parameters than the experiments is developed according to this load-strain model.

By: Shi Cheng; Peng Feng; Yu Bai; and Lie Ping Ye

Ref: Journal of Composites for Construction, Sept. / Oct., 2016, Volume 20, Issue

Analysis of FRP Shear Strengthening Solutions for Reinforced Concrete Beams Considering Debonding Failure.

In this paper, a fiber beam model previously developed by the authors for the nonlinear analysis of strengthened elements, including the effects of shear, is used to predict the response of reinforced concrete (RC) beams strengthened in shear with fiber reinforced polymers (FRP) sheets. In the previous version of the model, debonding failure of FRP was not included; hence, its application was limited to the simulation of wrapped configurations. The model is now extended to account for debonding failure in order to allow for its application to beams strengthened with U-shaped and side-bonded configurations. Existing experimental tests on RC beams strengthened in shear by FRP sheets in both wrapped and U-shaped configurations were numerically simulated. The model reproduces, with reasonable accuracy, the experimental failure loads, the load-deflection behavior, and the strains in FRP and stirrups with increasing load. The advantages of this proposal are related with the simplicity and straightforwardness of the beam models to be applied in practical engineering problems.

By: Denise Ferreira; Eva Oller; Antonio Marí, M.ASCE; and Jesús Bairán

Ref: Journal of Composites for Construction, Sept. / Oct., 2016, Volume 20, Issue

Experimental Investigation of GFRP-Reinforced and GFRP-Encased Square Concrete Specimens under Axial and Eccentric Load, and Four-Point Bending Test

This paper presents the results of an experimental study on the axial and flexural behavior of square concrete members reinforced with glass fiber-reinforced polymer (GFRP) bars and embedded with pultruded GFRP structural sections under different loading conditions. The main parameters investigated in this study were the influence of the type of internal reinforcement (steel bars, GFRP bars and pultruded GFRP structural I-sections and C-sections) and magnitude of load eccentricity on the flexural and compressive behavior of square concrete members. To fulfil the objectives of this study, 16 reinforced concrete specimens were tested, of which 12 were tested as columns under compression loading and 4 were tested as beams under flexural loading. The concrete specimens were square in cross section with a side dimension of 210 mm and a height of 800 mm. The

experimental results have shown that the steel-reinforced specimens have a higher load-carrying capacity than specimens reinforced with GFRP bars for all loading conditions. In addition, for concentrically loaded specimens, steel-reinforced specimens have a better ductile performance than specimens reinforced with GFRP bars. In terms of eccentric loading, specimens reinforced with GFRP bars experienced similar ductility as compared to the corresponding steel-reinforced specimens. However, the eventual failure mode of specimens reinforced with GFRP bars was sudden and brittle in nature. However, specimens encased with GFRP structural sections have a higher load-carrying capacity but considerably lower ductility than the steel-reinforced and GFRP bar–reinforced specimens.

By: Muhammad N. S. Hadi, F.ASCE; and Jim Youssef

Ref: Journal of Composites for Construction, Sept. / Oct., 2016, Volume 20, Issue

Experimental Study on Dynamic Behavior of CFRP-to-Concrete Interface

Carbon fiber–reinforced polymer (CFRP) sheets/plates are widely used to strengthen deficient RC structures. Existing studies show that the effectiveness of externally bonded CFRP materials generally depends on the bond between the CFRP element and concrete. Most of the research studies developed so far have focused on the bond behavior of the CFRP sheet-concrete interface under static loading. In this work, the bond behavior was experimentally investigated from the dynamic standpoint, through the drop-mass impact test method, with the aim of highlighting the effect of the loading rate on the bond strength. The test results show that the strain distribution gradient of the CFRP sheets under impact loading was larger than under static loading, and that the loading rate significantly influences the bond strength, while only moderately affecting the effective bond length. A practical bond-slip model is proposed to simulate the CFRP-to-concrete interface bond behavior under dynamic conditions, which considers the strain-rate effect based on the recommendations for the strength of concrete under impact loading. Furthermore, starting from the equations given in some existing guidelines, a design proposal is developed to accurately predict the effective bond length and the bond strength of the CFRP-to-concrete interface under impact loading.

By: Jingsi Huo; Jingya Liu; Xiaoqing Dai; Jin Yang

Ref: Journal of Composites for Construction, Sept. / Oct., 2016, Volume 20, Issue

Axial Compression Behavior of Fire-Damaged Concrete Cylinders Confined with CFRP Sheets

This paper presents the axial compression behavior of standard Ø150×300 mm concrete cylinders after exposure to elevated temperatures of 300, 500, and 700°C for heating periods of 2 h (for all temperatures) and 3 h (only for 700°C). A total of 192 specimens were tested in static compression to investigate the stress-strain relationships and failure modes of fire-damaged concrete before and after strengthening with carbon fiber–reinforced polymer (CFRP) wraps. The test results showed that the exposure temperature and duration, unconfined concrete strength, and cooling method (air or water cooling) influence the postfire compressive strength, strain at compressive strength, and modulus of elasticity of concrete. Low-strength concrete is more susceptible to the loss in residual properties caused by fire than high-strength concrete. The CFRP wrapping can significantly enhance both strength and ductility of concrete after exposure to elevated temperatures. The level of strength enhancement by CFRP confinement for fire-damaged concrete is higher than undamaged concrete. The confinement effectiveness increases with an exposure temperature, especially for the lowest-strength (20-MPa) water-cooled concrete. In contrast, the level of ductility enhancement on fire-damaged concrete is lower than undamaged concrete. The application of an equation to predict the compressive strength of CFRP-confined fire-damaged concrete is also discussed. It was found that the equation conservatively predicts the ultimate strength of CFRP-confined fire-damaged concrete. However, the prediction becomes less accurate as exposure temperature increases.

By: Akhrawat Lenwari; Jaroon Rungamornrat; and Supanat Woonprasert

Ref: Journal of Composites for Construction, Sept. / Oct., 2016, Volume 20, Issue

Shear Capacity of RC Beams with Carbon Fiber-Reinforced Polymer Stirrups with Rectangular Section

Experimental observations were made for the shear capacity of reinforced concrete beams with carbon fiber-reinforced polymer rectangular stirrups (CFRPRS). In total, 12 concrete beams were tested under three-point loading. Each beam measured 1,400 mm long, 150 mm wide, and 250 mm deep. For comparative studies, different parameters were considered: different sectional shapes (circular and

rectangular CFRP stirrups), material types (steel and CFRP), and reinforcement ratios of stirrups (0.0038 and 0.0096). All beams were subjected to three-point loading. Test results indicated that concrete beams reinforced with CFRPRS stirrups could maintain shear behavior comparable to that of the concrete beam reinforced with steel stirrups. Compared with the beams with conventional CFRP stirrups with circular sections, superior shear behavior was observed for the beams reinforced with CFRPRS stirrups in terms of shear strength and crack width.

By: C. Lee; S. Lee; and S. Shin

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Experimental Investigations on Circular Concrete Columns Reinforced with GFRP Bars and Helices under Different Loading Conditions

Glass-fiber-reinforced polymer (GFRP) bar has emerged as a preferable alternative to steel bar in reinforced concrete (RC) members in harsh, corrosive, coastal environments in order to eliminate corrosion problems. However, only limited experimental studies are available on the performance and behavior of concrete columns reinforced with GFRP bars under different loading conditions. This study investigates the use of GFRP bars and GFRP helices (spirals) as longitudinal and transversal reinforcement, respectively, in RC columns. A total of 12 circular concrete specimens with 205-mm diameter and 800-mm height were cast and tested under different loading conditions. The effect of replacing steel with GFRP reinforcement and changing the spacing of the GFRP helices on the behavior of the specimens was investigated. The experimental results show that the axial load and bending moment capacity of the GFRP-RC columns are smaller than those of the conventional steel-RC columns. However, the ductility of the GFRP-RC columns was very close to the ductility of the steel-RC columns. It is concluded that ignoring the contribution of the GFRP bars in compression leads to a considerable difference between analytical and experimental results.

By: Muhammad N. S. Hadi, F.ASCE; Hogr Karim; and M. Neaz Sheikh

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Design-Oriented Stress–Strain Model for Concrete under Combined FRP-Steel Confinement

Extensive research has been conducted on fiber-reinforced polymer (FRP)-confined plain and RC columns, leading to a large number of stress–strain models. Most of these models have been developed for FRP-confined plain concrete and are thus applicable only to concrete in FRP-confined RC columns with a negligible amount of transverse steel reinforcement. The few models that have been developed for concrete under the combined confinement of FRP and transverse steel reinforcement are either inaccurate or too complex for direct use in design. This paper presents an accurate design-oriented stress–strain model for concrete under combined FRP-steel confinement in FRP-confined circular RC columns. The proposed model is formulated on the basis of extensive numerical results generated using an analysis-oriented stress–strain model recently proposed by the authors and properly captures the key characteristics of FRP-steel-confined concrete as revealed by existing test results. The model strikes a good balance between accuracy of prediction and simplicity of form and is shown to provide close predictions of test results and perform significantly better than existing stress–strain models of the same type.

By: G. Lin; T. Yu; and J. G. Teng

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Experimental and Numerical Investigation of Elephant Foot Buckling and Retrofitting of Cylindrical Shells by FRP

Abstract Large and small cylindrical shells have long been used as tanks and silos to store materials such as oil and its derivatives. The radius-to-thickness ratio of these shells is 500 2000; as a result, buckling collapse of these thin-walled structures is of major concern for designers. The present study examined inelastic buckling behavior of cylindrical shells near the base, known as elephant foot buckling. This form of buckling occurs under high internal pressure exerted simultaneously with axial compression. The buckling of cylindrical shells subjected to combined axial loads and internal pressure was experimentally studied and tested and a new method of strengthening steel cylindrical shells using fiber-reinforced polymer (FRP) composite materials is presented. The proposed method was studied by numerical methods using a nonlinear algorithm, and the results were evaluated for resistance to buckling of cylindrical shells. The results provide effective and useful information for use in retrofitting cylindrical shell tanks.

By: Morteza Vakili and Hossein Showkati

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Use of CFRP to Maintain Composite Action for Continuous Steel–Concrete Composite Girders

The loss of composite action at the negative moment region for a continuous composite girder reduces the girder's strength and stiffness. This paper presents an experimental investigation into the use of carbon fiber–reinforced polymer (CFRP) to maintain the composite action at the negative moment region of continuous composite girders. This is achieved by bonding CFRP sheets to the top of a concrete slab at the negative moment region. Six two-span continuous composite girders were tested. CFRP sheet thickness was varied to assess its effect on girder behavior. The girders were designed to have full composite action between the concrete slab and the steel girder. Moment capacity at the positive and negative moment regions was evaluated experimentally and theoretically. A plastic analysis was conducted to evaluate the ultimate capacity of the girders. Finite-element modeling evaluated girder performance numerically. The experimental results confirmed the effectiveness of CFRP sheets in maintaining composite action at the negative moment region and in preventing crack initiation in a concrete slab under service load. The use of CFRP improved the strength and stiffness of the continuous composite girders. The plastic analysis safely estimated the girders' ultimate capacity. The developed finite-element model yielded satisfactory results.

By: Alfarabi M. Sharif; Mohammad A. Samaaneh; Abul K. Azad; and Mohammed H. Baluch

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Evaluation of Damaged RC Columns with GFRP-Strip Device

Damage of reinforced-concrete (RC) structures commonly occurs during major earthquakes, and becomes worse because of aftershocks. For these reasons, repair technology for seismic damage is needed to prevent possible collapse of damaged RC structures before aftershocks. In this paper, a seismic retrofitting device is proposed to improve the seismic performance of damaged RC columns using glass fiber–reinforced polymer (GFRP), which can be easy to install and quick to repair. The proposed GFRP-strip device consists of a GFRP-composite strip and aluminum clip connectors, used to increase the shear strength of the damaged column. Three RC specimens were constructed with reference to existing RC structures. Two of the specimens were damaged before installing the GFRP-strip devices. After the pretest damage was done, the GFRP-strip devices were installed along the plastic-hinge regions on both ends of the test columns. A comparison of the experimental results indicates that the seismic performance of the damaged RC columns with the GFRP-strip device was improved, and that the shear-failure mode of the RC columns was changed to ductile-flexural-failure mode. According to these results, the maximum strength, accumulated-dissipated energy, and displacement ductility of the retrofitted specimens was increased. Therefore, the proposed GFRP-strip device can be used to improve the seismic performance of damaged RC columns.

By: Hyunsu Seo; Jinsup Kim; and Minho Kwon

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Fiber-Element Modeling for Seismic Performance of Square RC Bridge Columns Retrofitted with NSM BFRP Bars and/or BFRP Sheet Confinement

This paper presents an analysis of the seismic performance of square RC bridge columns retrofitted with near-surface-mounted (NSM) basalt fiber-reinforced polymer (BFRP) bars and/or BFRP sheet confinement based on fiber element modeling. An axial stress versus loaded-end displacement model of NSM FRP bars, including both elastic elongation and bond-slip effects, is proposed to account for the significant slippage of FRP bars in the plastic hinge region of strengthened columns. The simplified FRP bar model is then converted into the equivalent stress–strain relationship for easy implementation in fiber-based analysis. Moment-curvature analysis is performed based on the proposed FRP bar model, and the analytical moment versus fixed-end rotation relationship of a strengthened column is calculated and assigned to the rotational spring in the fiber element model. The proposed method avoids the nested iterations in sectional analysis that require force equilibrium and deformation compatibility. Comparisons between the numerical simulations and experimental results indicate that the proposed method is appropriate for predicting pushover curves and the hysteretic response of strengthened columns. Furthermore, the mechanism of the hybrid effect of combining NSM FRP bars with externally bonded FRP sheets can be interpreted after the analytical study; that is, confining the column with FRP sheets improves the bond conditions for NSM FRP bars, while the bond-slip effect

mitigates the premature fracturing of the FRP bars, leading to more effective utilization of the NSM reinforcement and a more ductile column behavior.

By: Liu-Zhen Yao and Gang Wu

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

New Shear Connector Design for Insulated Concrete Sandwich Panels Using Basalt Fiber-Reinforced Polymer Bars

In this study, 38 push-through tests were performed on a precast concrete insulated sandwich panel design using combined angled and horizontal connectors. Basalt fiber-reinforced polymer (BFRP) and steel connectors were tested and compared. The key parameters were various inclination angles and diameters of connectors; orientation of the diagonal connector relative to loading (i.e., tested in tension or compression); and panels with or without an active foam-to-concrete bond. Steel connectors failed by yielding in tension and inelastic buckling in compression. Larger-diameter BFRP connectors usually pulled out under tension and crushed in compression. Smaller-diameter BFRP connectors ruptured in tension and buckled in compression. Strength and stiffness increased with the connector angle and diameter. The insulation foam bond was found to contribute similarly regardless of connector material. An independent theoretical model accounting for material, bond, and stability failure modes, as well as geometric distortion attributable to relative slip, was developed. It provided an average test-to-predicted value of 1.15 with a standard deviation of 0.25 for the strength of the shear connection system.

By: Douglas G. Tomlinson; Nathan Teixeira; and Amir Fam

Ref: Journal of Composites for Construction, July/Aug., 2016, Volume 20, Issue 4

Evaluation of Railway Track Safety with a New Method for Track Quality Identification

A new method for track inspection is developed to complement traditional geometric methods. An inertial measuring system and a specialized data treatment method is proposed to evaluate railway track safety, observed from the vehicle dynamic performance point of view. System equations for the inverse vehicle dynamic problem, augmented with the suspension torsion equation, are solved to estimate the wheels driving forces that are directly correlated with the vehicle safety traveling over an irregular track. Results of a measuring campaign on a railway wagon are used to evaluate the present system by direct positional comparison with lateral and vertical contact forces (L/V)safety ratio measured with two instrumented wheelsets (IWS) installed on the leading bogie of the wagon. Also, data collected and treated are compared with track geometry measurements. The results of quantified track safety present good agreement with those found using traditional measuring methods. This confirms the ability of the new method to detect the location of the highest potential hazard region, for optimized track maintenance purposes. The new system proves to be a promising method for track safety evaluation.

By: Roberto Spinola Barbosa,

Ref: Journal of Transportation Engineering, Sept., 2016, Volume 142, Issue 11

Modeling Human Learning and Cognition Structure: Application to Driver Behavior in Dilemma Zone

In transportation studies, modeling human learning and decision-making processes plays a key role in developing realistic safety countermeasures and appropriate crash-mitigation strategies. In this study, a human learning model was created that captures the cognitive structure of human memory. The relationship between long-term and short-term memories was incorporated into a reinforcement learning technique to construct the human learning model. The model was then applied to dilemma zone data collected in a simulator study. Dilemma zone is an area of roadway ahead of the signalized intersection in which drivers have difficulty deciding whether to stop or proceed through at the onset of yellow. Driver choice behavior and learning process in dilemma zones was modeled, taking into account drivers' experiences at the previous intersections, and was compared to a pure machine learning model. The results of the model revealed lower and faster-merging errors when human learning was considered in training agents. The human learning model for dilemma zones presented here could be used to evaluate dilemma zone mitigation algorithms by considering their effects on driver agents.

By: Sahar Ghanipoor Machiani and Montasir Abbas

Ref: Journal of Transportation Engineering, Sept., 2016, Volume 142, Issue 11

Silver Jubilee Batch (1990)

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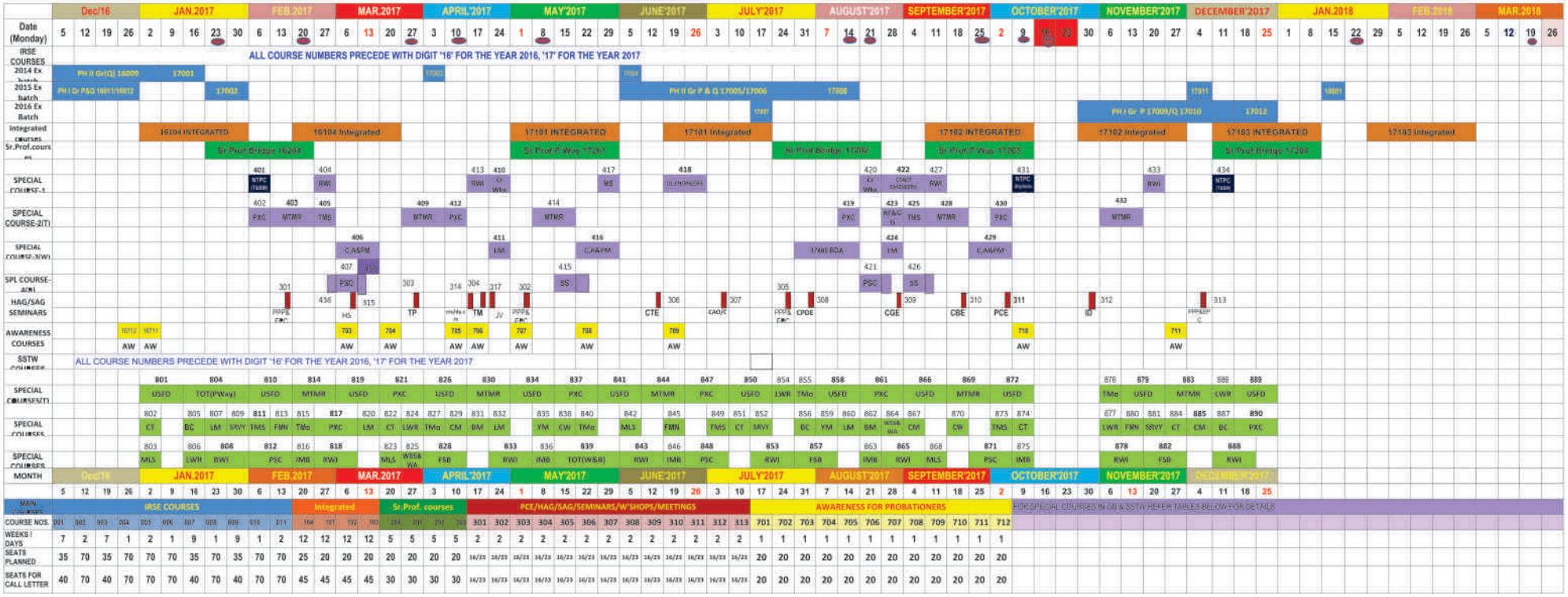
CALENDER OF COURSES 2017 CHART (Rev. 04)



No	Start date	End date	Details	Duratio	Eligibility	CD	ACD
301	2/16/2017	2/17/2017	Workshop on PPP&EPC(JAG/SG)	2 D	JAG/SG of Civil Engg & A/C	SPW	SPP
302	3/2/2017	3/3/2017	Workshop on PPP&EPC(HAG/SAG)	2 D	HAG/SAG of Civil Engg & A/C	SPP	SPW
303	3/30/2017	3/31/2017	Seminar for CE/TP	2 D	CETPs	DN	SPB-2
304	4/20/2017	4/21/2017	CE/TMs' Seminar	2 D	CE/TMs	SPT-2	SPT-1
305	5/4/2017	5/5/2017	Workshop on PPP&EPC(JAG/SG)	2 D	JAG/SG of Civil Engg & A/C	SPW	DN
306	6/15/2017	6/16/2017	CTEs' Seminar	2 D	CTEs	SPT-1	SPT-2
307	7/6/2017	7/7/2017	CAOs' Seminar	2 D	CAOs	SPP	SPW
308	8/3/2017	8/4/2017	CE(W)/CPDEs' Seminar	2 D	CE(Works)/CPDEs	SPW	SPP
309	8/31/2017	9/1/2017	Trg Mgr/CGE Seminar	2 D	CGEs/Pr.CETCs	SPT-1	SPT-1
310	9/21/2017	9/22/2017	CBEs' Seminar	2 D	CBEs	SPB-1	SPB-2
311	10/5/2017	10/6/2017	PCEs' Seminar	2 D	PCEs	SPT-2	SPT-2
312	11/1/2017	11/2/2017	IRICEN Day Seminar	2 D	IRSE 91' Batch	SPW	DN
313	12/7/2017	12/8/2017	Workshop on PPP&EPC(HAG/SAG)	2 D	HAG/SAG of Civil Engg & A/C	DN	SPW

Course code	Course name	No	No	No	No	No	Total	Dur/course	Total weeks
OLE	Open Line Engineers	418					1	2	2
RWI	Rail Wheel Interaction & derailments	404	413	427	433		4	1	4
TMS	TMS (T-5)	405	425				2	1	2
LM	Land Management	411	424				2	1	2
MTMR	Mechanised Track maint & Renewal	403	409	414	428	432	5	2	10
PXC	Points, Xings & Curves	402	412	419	430		4	1	4
C.A&PM	Contract, Arbitration & Proj. Management	406	416	429			3	2	6
RF&GTI	Rly Formation & Geo Tech Investigation	423					1	1	1
PSCC	PSC Construction	407	421				2	2	4
SBC	Steel Bridge Fabrication	415	426				2	2	4
BDA	Bridge Design Assistant	408					1	3	3
CE	Construction Engineers	422					1	2	2
MS	Modern Surveying	417					1	1	1
CW	Spl course on Crane Working	410	420				2	1	2
NTPC	Special course for NTPC Engineers	401	431	434			3	1	3
							34		50

Course code	Course name	No	No	No	No	No	No	No	No	No	No	No	No	Total	Dur/course	Total weeks
TOT(P.Way)	Training of Trainers(P.Way)	804												1	3	3
CT	Concrete Technology	802	822	851	874	884								5	1	5
BC	Building Construction	805	856	887										3	1	3
TMo	Track Monitoring	815	827	840	855	876								5	1	5
FMN	Formation	813	845	880										3	1	3
RWI	Rail Wheel Interaction & Derailment Inv.	808	818	833	843	853	865	878	888					8	2	16
LM	Land Management	807	820	832	860									4	1	4
SRVY	Survey	809	852	881										3	1	3
MLS	Management of Land & stores	803	823	842	868									4	1	4
PXC	Points, Xings & curves	817	821	837	847	861	890							6	2	12
PSCC	PSC Construction	812	848	871										3	2	6
FSB	Fabrication of Steel Structure	828	857	882										3	2	6
TMS	Track Management System	811	849	873										3	1	3
LWR	Long Welded Rail	806	824	854	877	886								5	1	5
USFD	USFD,Welding & Rail Grinding	801	810	819	826	834	841	850	858	866	872	879	889	12	2	24
IMB	Inspection&Maintenance of Bridges	816	836	846	863	875								5	1	5
MTMR	Mech.Track Maint. & Renewals	814	830	844	869	883								5	2	10
TOT(W&B)	Training of Trainers(W&B)	839												1	3	3
CM	Contract Management	829	867	885										3	1	3
BM	Building Maintenance	831	862											2	1	2
YM	Yard Maintenance	835	859											2	1	2
CW	Safety at Tr. Worksite &Crane Wkg	838	870											2	1	2
WSS&WA	Water Supply,Sewer & Water Audit	825	864											2	1	2
														90		131

Indicates a holiday in the week

Indicates Monday being holiday

1 Week at RDSO for BDA course

To IRTMTC / RDSO

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