IRICEN JOURNAL OF CIVIL ENGINEERING

ज्ञान ज्योति से मार्गदर्शन

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BDI Auto Clicker Fitted to Wheel of The Vehicle



Piers eccentric over well foundation



Indian Railways Institute of Civil Engineering, Pune - 411001

Important Recommendations of CBEs' Seminar at IRICEN

16th -17th May, 2013

1. **Norms for 2 years for sanctioning of new works :**
   It is recommended that norms for 2 years for sanctioning of new works is restored back to 3 years as was existing previously and also ceiling limit should not include works between 1-2.5 crore as these are already sanctioned at Board's level.

2. RDSO should train few officers & supervisors of different railways in engineering workshop in the inspection of welded plate girder for composite construction ROBs and issue them certificates. RDSO should also issue a clarification that check list for plate girders is applicable to composite girders of ROBs also.

3. It is recommended to review the policy of provision of ROBs on National Highways to facilitate construction of ROB with four lanes irrespective of TVUs.

4. It is recommended that Railway Board may clarify in case of ROBs on deposit terms what charges are to be levied if there is a pier or any other obstruction due to construction of ROB in railway land in case (a)ROB leads to closure of level xing and (b) does not lead closure of level crossing.

56th IRICEN Day Celebration - 1st Nov. 2013

1. Silver Jubilee batch of IRSE 1987 exam shall be felicitated on 1st Nov. 2013.
2. Outstanding probationary officers and Gr.'B' Integrated Course officers will also be awarded.
3. Theme for the seminar for Silver Jubilee batch of IRSE 1987 exam shall be as below.
   (i) 2nd Phase Track Modernisation on IR
   (ii) Ethical Conduct & Experience Sharing
4. We shall be starting our activities on this date from the new building which is slated to get a top rating in green building construction.

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

Guidelines to contributors

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

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

From director's Desk:

Dear Readers,

New IRICEN building at Koregaon Park is ready & will be commissioned on 1st Nov'2013, to be observed henceforth as 'IRICEN DAY' every year. It's a unique structure slated for certification as green building of platinum rating by LEED and five star rating by GRIHA.

Welcome to this issue of IRICEN Journal of Civil Engineering. Bridges are an important structural component of the Railway System. Substantial numbers of bridges on Indian Railways are very old. In view of this, bridge monitoring, rehabilitation and maintenance assume added importance. With the advancement in monitoring technology, it has now become possible to monitor the condition of bridges in real time. We will have to reinforce this front and use the current available technological advancements. There are several papers on this subject in this issue.

It is also essential to ensure that important structures like bridges and tunnels are constructed to high standards of quality and least maintenance requirements so that they serve the purpose fully and last well beyond their design life, thus leading to reduction in life cycle costs. Layouts of turnouts and crossover may appear to pose complexities when it comes to putting theory into practice. A paper on real life example on this subject finds a place in this issue.

I hope you find this issue an interesting, relevant and enjoyable read, and trust it will encourage you to prepare and submit a paper on your own project or research in

(C.P. Tayal)
Director

DMRC to Construct 74 Tunnels in Phase III

Tunneling work for the phase III appears to be the most challenging job for Delhi Metro. It is gearing up efficiently to construct 74 tunnels tin phase III of its network. For this work, a record number of 33 tunnel-boring machines will be deployed. The use of 33 tunnel-boring machines will be among the highest number TBMs ever used in any urban project at the same time in any part of the world.

In phase II for 34.89km of underground corridor, it had used 14 TBMs. In pahse III, it will have underground corridor of 53 km with 34 underground stations. These tunnels will go through challenging terrains from corridors going under railway tracks and highrise buildings to flyovers, all posing many engineering and structural challenges. Apart from this, four different tunnel stretches will pass below/though existing underground portion. The tunnels will also cross existing corridors at 14 different points, including four points where it will cross elevated viaducts, said a DMRC official explaining the complicated tunneling work going on for phase III.

Ref. : New Building Materials & Construction World July 2013, pg 28

Metro Rail Company For Noida

For expediting the work on the Metro network in Noida and Greater Noida, a new company- Noida Metro Rail Company(NMRC) is to be formed. The company would be formed on the lines of DMRC with an initial capital of Rs. 1000 crore. A special purpose vehicle is to be formed for undertaking construction of the proposed Metro project, said Noida Board chairman. The first project of NMRC will be 29 km long, after this it will take other metro extension work.

Ref. : New Building Materials & Construction World July 2013, pg 28

Jaipur Metro

In terms of pace of construction, Jaipur's Metro is being described as the world's fastest project next to Mecca's metro project. But in terms of commuting speed, it will possibly be the slowest when it opens in August this year.

With a partly finished signaling and telecommunication system, the upcoming 9.5km corridor will be operated as single train system with line side signals. The train will do the full journey forward and back. The coach borrowed from Delhi, will be limited to a maximum speed of 45 kmph when run under the safety cutout mode. According to the Jaipur Metro Rail Corporation (JMRC) chairman and managing director Nihal Chand Goyal, the trains will run at slow speed only for the first few months. We want to ensure the benefits of the project to commuters at the earliest. In such a big project, it is not possible to have it completely ready at the first go he added.

Ref. : New Building Materials & Construction World, July 2013, pg 28

Fast Track Master Plan for Industrial Corridor

The outcome of discussion between the visiting Prime Miniser of India and his Japanese counterpart Shinzo Ae in Tokyo has resulted in expediting work on the master plan for development of the Chennai-Bangalore Industrial corridor by fiscal year 2014. The joint statement at the end of the summit-level meeting between the two Prime Ministers highlighted the importance of development of this corridor, while reviewing their commitment to reinforcing their cooperation including Tokyo pledge to render financial and technical assistance to India's major infra projects. In addition, both the countries have decided to conduct a joint feasibility study on a high speed railway network between Mumbai and Ahmedabad, having already completed a joint feasibility study on upgrading the speed of passenger trains on Delhi-Mumbai route to 160-200 kmph.

Ref. New Building Materials & Construction World, July 2013, pg 38

India Funded Rail Line Commissioned in Sri Lanka

The first phase of Sri Lanka's northern railway project funded by India was successfully commissioned as coaches chugged. According to IRCON, tracks along the 43 km stretch were reconstructed as part of the $800 million project executed by it, this restoring the 252 km railway line that would connect different parts of the country.

Ref. New Building Materials & Construction World, July 2013, pg 38

DFCC Awards Rs. 6700 cr. Corridor Contract.

The Dedicated Freight Corridor Corporration of India (DFCC) has recently awarded a contract worth Rs. 6700 crore to L&T-Sojitz for the construction of 640 km twin track line between Rewari and Palanpur, a portion of the Wester Dedicated Freight Corridor. With the awarding of the contract the Indian Railways has entered into a long term engagement with Japan as L &T spjitz, is a joint venture comprising L & T of India and Sojitz Corporation of Japan and contract has been lauded as one fothe country's biggest contract through international bidding.

According to sources, the project is funded by Japan International Copoperation Agency (JICA) which is also DMRC's lending agency and is the Japanese government arm for providing technicaland financial aid to developing countries. Prior to this, the Dedicated Freight Corridor Corporation of India (DFCCiL) had awarded the Rs. 3300 crore contract for 343 km long Khurja-Kanpur section of the Eastern Dedicated Freight Corridor, funded by the World Bank. The length covered under the new contract is more than 40% of the entire western corridor for which land has already been acquired and all the other statutory clearances have also been obtained. The Western Dedicated Freight Corridor, which will Cover a length of about 1500 km for Dadri to Jawarharlal Nehru Port (Mumbai) for which jICA has pledged a Special Terms for Economic Partnership loan of 677 billion yen for the entire Western Dedicated Freight Corridor.

Ref. New Building Materials & Construction World, July 2013, pg 38

Jaipur Metro to be Functional this August



Jaipur Metro project is soon expected to kick start its function from this August. The information was confirmed after the first lot of four coaches has been arrived at Bangalore.

Confirming the project update, Mr. Nihal Chand Goel, Managing Director, Jaipur Metro Rail Corporation said that after system testing and trial, the train from Mansarovar to Chandpole section under the first phase will be introduced for public in August.

He further added that the process of necessary checks and trial runs is expected to take around one and half month, after which the train of four coaches will be ready for the public. Ten train sets of four coaches each are to be commissioned and hopefully all the trains will arrive here from Bangalore by October.

Ref. Construction Technology, Month: July, 2013 , pg 14

Noida Authority Allots Rs 2,000 cr for Metro Extension

The Noida Authority has sanctioned Rs2,000 crore for the extension projects after gaining the approval for two proposed routes of the Metro project in Noida from Uttar Pradesh government.

The Authority had attained clearance from the government for 3.9 km route between Kalindi Kunj and Botanical Garden and for the 6.7km network on City Center Sector 62 link.

However, the proposal for implementing the two routes is awaiting the Center's approval. The proposed project involves six stations at Sector 34, 52, 59, 61, 62 and Electronic City.

The work on the extension of the Metro from Botanical Garden to Kalindi Kunj is scheduled to be completed by 2016 and construction of the City Center to Sector 62 link is expected by 2017.

Ref. Construction Technology, Month: July, 2013, pg 16

Construction Work Kick-Starts on Kochi Metro Rail.

Construction work over the much awaited Kochi Metro has finally kick started with the state's Chief Minister Oommen Chandy flagging off the initiative. The Chief Minister flagged off the initiative at the function held at Jawaharlal Nehru Stadium, wherein the piling work was soon commenced at Edapally.

Commenting during the launch function,Shri Chandy said that Delhi Metro Rail Corporation (DMRC) Principal Advisor,E Sreedharan had promised that the project would become a reality in 1095 days. He further added that they also anticipate that the metro work should not be affected even a single day.

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The 25-km Kochi Metro route, which will have 22 stations from Aluva to Petta, is expected to be completed in about three years time.Shri Chandy said the government has decided to ask the Kochi Metro to study the demands and submit a report in six months on

Japanese Companies Show Interest to Construct Third Phase of Metro

A few Japanese companies have shown an interest to build a fully-underground metro corridor from Colaba-Bandra-Speez, which has so far considered a financially and technically risky project. The Japanese companies assured the Mumbai Metropolitan Region Development Authority (MMRDA) that they would complete the project within the stipulated time, according to a source.

In a meeting with the MMRDA on Monday, Japanese companies Kawasaki, Mitsubishi, Hitachi and Nippon expressed their interest in the project. According to Mr. UPS Madan, MMRDA commissioner these companies gave the presentation for the project and said they were capable of building the fully-underground corridor within the stipulated time. A representative of Japan's external affairs ministry was also present at the meeting. Japan International cooperation Agency (JICA) is providing a loan for the construction of the Rs. 24,500-crore project, and Japanese companies have been emerged as the main contenders for the project. The MMRDA is planning to invite only multinational companies for the construction of the underground metro corridor.

The planning authority's decision to build this corridor on a cash-contract basis reportedly came after its previous unpleasant experience with existing metro corridor in the city, which are being developed on a public-private partnership.

Mumbai's first metro corridor, the Versova-Andheri-Ghatkopar, which was supposed to be operational in 2010, has missed its deadline several times and does not seem ready to start before early next year.

Construction on the second Charkop-Bandra-Mankhurd metro corridor has not begun, as though the contract was awarded in 2010, there was a clash between the concessionaire and the MMRDA.

MMRDA officials said JICA will provide 56% of the project cost, while the rest of the cost will be borne by the state and central government. The MMRDA has sent a proposal to the public investment board for a final approval.

According to Mr. Madan, they have received a positive response from the public investment board and the final approval to the finance model will be given by this month. This will be later approved by a cabinet committee. We anticipate that an agreement will be signed with the JICA in May this year

Ref. Construction Technology, May, 2013, pg 22

Renewed Focus on PPP Projects

Realising the facts that its earlier track record of promoting PPP rail projects has not been inspiring for the private sector's participation, the Railway Board has decided to make its entry in PPP space through two important rail projects, worth Rs 32000 crore. These are expected to take off by this year end. Under this, two locomotive factories are to be set up in Bihar, Global players like GE, Chinese locomotive company CSR and EMD have evinced great interest in these projects, while five companies – GE, CSR, Bombardier, Alstom and Siemens have taken part in pre-bid meeting for electric locomotive factory. PPP in railway would be happening for the first time in a massive scale with these two projects. The selected private partners would set up manufacturing facilities under a guarded annual scale. Apart from this, 26 stations are proposed in the Mumbai elevated project another PPP project, estimated to cost Rs 21000 crore.

Ref: NBM&CW, Aug 2013, Vol. 19, Issue 2, pg 28.

Work on Udhampur-Katra Rail Link

Work on Udhampur-Katra rail link is on fast track. The route is to be completed soon at an estimated cost of Rs 950 crore passes through hostile terrain, making it an extremely challenging project. On the route, there are 30 small and big bridges and seven tunnels spanning over 10 km of 25 km stretch.

Ref: NBM&CW, Aug 2013, Vol. 19, Issue 2, pg 28.

Rapid Rail Link in NCR

There is a big transit plan for NCT with its boundaries constantly expanding. It is proposed to create a transport corporation specifically to facilitate transit to the NCR. The new corporation will manage three major rail corridors, which together amount to 381 km with a daily ridership of nearly 18 lakh people by 2016. The proposed corporation will be funded jointly by the Centre and state government. The three corridors will be Delhi-Sonipat-Panipat line covering 111 km. Delhi-Gurgaon-Alwar line covering 180 km and Delhi-Ghaziabad-Meerut line covering 90 km.

Ref: NBM&CW, Aug 2013, Vol. 19, Issue 2, pg 28.

Railways Fast Tracks Port Link Projects

Buoyed by the investors' interest in the public private partnership (PPP) projects in the rail sector, the Indian Railways has finally opted for the model ensuring fast tracked growth in the port connectivity projects involving an investment of `6000 crore explained sources adding that barring port-connectivity, there is little investor interest in other PPP projects from private players and this has again become crystal clear with the interest shown by some of the country's leading infrastructure players for lucrative port-connectivity projects. Under the participative policy, there is a model that says 95% of the net apportioned revenue after deducting the operation and maintenance costs will be shared with the private party. The concession period of 25 years is also extendible to 35 years. Prior to this, Dhamra Port, a joint venture (JV) of Tata Steel and L & T, Reliance Industries' Rewas Port, Balaji Infra Projects' Dighi Port and Navayuga Engineering's Astaranga are names having received the railways' nod to build rail links under a participative policy of rail connectivity.

Ref: NBM&CW, Aug 2013, Vol. 19, Issue 2, pg 28.

Delhi Metro Phase 4 to Start Soon

Having completed the detailed project report for the proposed phase 4 corridor covering 94.24 km, DMRC could start construction of this corridor much before the ongoing phase 3 is completed. This was disclosed by Mr. Sharma, executive director, business development, DMRC. By the end of this month, DPRs for all corridors proposed in phase 4 will be ready for submission to get approval. After that we will be able to start civil work, any time, the government wanted, he said. In this phase, DMRC has revised its coverage from 115.94 km as planned earlier to 94.24 km. construction work of phase 3 is expected to be completed by 2016 and phase 4 is scheduled to be completed by 2021, added Mr. Sharma.

Impressed by the international technical standard of the work being done in Phase 3 and in earlier phases Japan International Cooperation Agency (JICA) has given in-principle approval to extend soft loan for the expansion work of phase 4. At home DDA has also extended financial support to DMRC for its phase III and Phase IV, providing `1500 crore.

DMRC has been undertaking critical engineering work for the phase III to construct record number of sharp curves with uneven twists and turns in a 25 km long elevated corridor in East Delhi. Work of constructing sharp curves requires a great deal of engineering skills with advanced design for spans and special segments. Elsewhere, it is building linkages along flyover with little margin on either side where viaduct available is 10 m wide. Several Metro stations will have pedestrian linkages, making not just the station but also Ring Road accessible. Construction of complicated tunnels has been one of high points of phase III. Recently, a 96 metre long tunnel boring machine (TMB) began tunneling work in old Delhi. This, according to DMRC is the longest TMB being used in Delhi Metro phase III project weighing around 500 tonnes. Construction work in phase III is an exercise on precision engineering. DMRC has formed specially dedicated beds in its casting yards for special segments which will be extensively used in phase III.

Ref: NBM&CW, Aug 2013, Vol. 19, Issue 2,pg 30.

DMRC Takes Over Airport Line

DMRC technical team has taken over the operation of 22.7 km Delhi Airport Metro Express following R-Infra pulling out from the project. The developer has been struggling for long to run the line which was started in February 2011. Shut down for a while, restarted in 2013 with developer sending termination notice, stating that it would not operate the line from July 2013. The Airport Metro Express has been in the eyes of storm again and again as it was conceptualized not on the basis of ridership survey but on many vague insistences.

Ref: NBM&CW, Aug 2013, Vol. 19, Issue 2, pg 30.

Ahmedabad-Gandhinagar Phase -1 Metro to be Operational by 2017

Gujarat Government's much anticipated Ahmedabad and Gandhinagar metro rail project is close to veracity with the phase-1 is ready for completion in 2017.

Metrolink Express for Gandhinagar and Ahmedabad (MEGA) a state-formed special purpose vehicle (SPV) for the project execution, expressed that the first phase of the Rs19,000-crore metro rail project between

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Delhi Metro Rail

Delhi Metro rail Corporation (DMRC) has awarded Bombardier a contract worth around Rs 2.5bn (US$47m) to supply its Cityflo 350 integrated train control and signaling system for three metro extensions in the Indian capital. The system will be installed on the 9.4km northern extension of Line 6 from Central Secretariat to Kashmere Gate and the 14km southern extension from Badarpur to YMCA Chouk in the satellite city of Faridabad, together with the 11km western extension of Line 5 from Mundka to Bahadurgarh City Park.

Ref. : Indian Railway Journal, May, 2013, pg 13

Indian Group PCM Acquire German Track Specialist Rail. One

THE PCM Group, India, has acquire Rail. One, Germany, bringing to an end the letter's search for a strategic investor.

Rail.One specializes in the design and production of concrete sleepers and ballastless track including Rheda 2000 concrete slab track for high-speed lines, Rheda City for light rail applications, and getrac asphalt track. Last month, rail.One announced plan to invest €15m to set up a concrete sleeper plant in Clinton, Iowa, and a US subsidiary. PCM also produces concrete sleepers for the Indian market, where it has three plants, while it has a heavy-haul concrete sleeper plant in Saudi Arabia which has supplied sleepers for the North-South Railway project. The company also produces turnouts and level crossings, and conducts flash-butt welding of rails.

"This is a giant step for PCM Group and this acquisition has made us the world's leading conglomerate in railway infrastructure," says Mr. Kamal Kumar Mittal, Chairman of PCM Group

Ref. : Indian Railway Journal, May, 2013, pg 16

HS Grinding Debuts in China

CRM-Vossloh track Maintenance, a joint venture of Vossloh Rail Services and CRM, China, has secured a contract with the operator of the Beijing-Shanghai high-speed line to provide its High Speed Grinding (HSG) service. Vossloh says a HSG-2 train spwcially built for operation in China is now en route and will begin operations in the second quarter of this year.

Vossloh says HSG's ability to grind rail at speeds of up to 80km/h, compared with the 5-15km/h of conventional grinding equipment, and operate in between timetabled traffic was particularly attractive to the Chinese operator which wants to minimize disruption on the line which carries the equivalent of 400 million tones of traffic per year on some sections.

Ref. : Indian Railway Journal, May, 2013, pg 18

Series of Accidents at SBB

Derailment Near Schwerzenbach

At about 1:20 a.m. on Saturday, 16 Februarly, the night S-Bahn train 20051 Zurich – uster _ Plaffkon SZ derailed on the open line between Schwerzenbach and nanikon Greifensee. The cause of the derailment appeared to have been several rail fractures. The right hand rail in the direction of travel literally fragmented into pieces 30 to 40 cm long over a length of more than ten metres. Even experienced experts had never seen damage of this kind before.

Personnel on the ground see a possible explanation in construction work and repairs carried out over the winter. In order to prepapre rails for continuous welding in the cold season, they first have to be heated up to a temperature of 25 deg C. This is usually done with a series of gas burners 30 to 40 cm apart. If the rails are heated up too much, there is a danger that the metal structure will be affected. In the weeks prior to the accident it would appear that repairs had been necessary on the directly adjoining track section.

What was not made public officially was that an empty train consisting of two coupled double deck push-pull trains (DPZ) had travelled along the same track as the accident train in the other direction about 20 minutes earlier. The driver noticed impacts and reported the incident to the control headquarters immediately. In a case such as this, headquarters should have ordered the next train to run at sight, but failed to do so. The DPZs of the empty train remained in S-Bahn operation the following day. Later, they were located, taken out of service and inspected. This revealed considerable damage to the under carriages of the DPZ that had been coupled in second position. This damage shows that the Class Re 450 locomotive pushing the front DPZ must have already caused initial rail fractures. As a result, a 70-cm gap was created in the right hand rail

Series of Accidents at SBB

Derailment Near Schwerzenbach

At about 1:20 a.m. on Saturday, 16 Februarly, the night

Series of Accidents at SBB

Derailment in Bern

The front bogie of an unfinished low-floor double-deck coach derailed in Bern Weyer mannshaus. The sight of an Re 4/4 II with the usual round buffer plates and two new low-floor double deck coaches (NDW) still under construction with a length of 26.8 meters might suggest that overriding of the buffers occurred on the 40 km/h points at bern Weyer mannshaus. The Re 4/4 IIs for Zurich S-Bahn's LION trains are being converted to square buffers. However, the traces on the track indicate that overriding of the buffers was more likely the consequence than the cause of derailment.

The two NDW coach bodies for the Zurich S-Bahn still with empty interiors, were travelling from the Wien Simmering Siemens production facility to Villeneuve where Bombardier completes the interior fittings. Without their weight the coach body during these transfer runs is too light for the suspension, which is already installed. On the first transports of this kind siemens had loaded sandbags on board to make up the weight, but not in this case. In addition, the anti-roll supports on each bogie were only mounted on one side. Brake and air suspension were not yet operating, so the coach bodies were therefore resting on the emergency-operation supports. Clarifying this incident is likely to prove highly complicated as the coaches are not officially certified vehicles with clearly defined characteristics.

Ref. Railway Update 5-6/2013, pg 85

Collision of Trains

On 21 January 2013, trains 20595 and 20592 both travelling on tack 1 Vo of route 120 collided head-on between Wien Penzing and Wien Hutteldorf stations, on sub urban section of Vienna Metropolitan Railway. Both trains were EMUs, each travelling with about 100 passengers on board.

On a previous journey, a fault had occurred in the track vacancy detection system (red closed) in the points 41 and 42 area. In the telephone train-acknowledgement procedure (standard procedure in such cases) train 20595 was "offered" to Penzing station by Hutteldorf station and "accepted" by Penzing station. The train departed and accelerated to about 80 km/h. In the meantime, train 20592 departed in the opposite direction from Penzing station twoards exit signal R 6.

Owing to the fact that the "automatic" route setting" mode was switched on, exit signal R 6 was consequently set to the "Clear" position in the direction of track 1 Vo.

The two tains travelling at speeds between 75 and 80 km/h collided head-on. Both drivers initiated emergency braking when they saw the oncoming train. The speed on impact was 26 km/h in the case of train 20595, and 49 km/h for the train in the opposite direction.There were serious injuries to passengers. Catenary incurred no damage and there was only minor damage to track.

Cause of the accident may have been operator error at the "accepting" Penzing station in initiating the train substitute signaling procedure. According to operating regulations, all systems for automatic route setting must be deactivated immediately on changing over to the telephone train-acknowledgement procedure.

Ref. Railway Update 5-6/2013, pg 90

Upgrading the London Underground, and North of England Programme

Upgrading the Underground, "Deep Tube project" is currently in the feasibility stage. This is the next major programme of work for London Underground (LU), which is following on from the completion of the Victoria line upgrade and the ongoing delivery of new trains, signalling and infrastructure to re-equip the Sub-Surface Railway. Learning from these projects, LU is planning for the future development of the next generation of line upgrades for the Bakerloo, Piccadilly, Waterloo & City and Central lines – the Deep Tube Programme. The aim is to provide much needed extra capacity to meet forecasts of continued rising demand in the 2020s. The approach being adopted represents a unique opportunity for LU to apply a whole railway system approach and harness developments in technology to aim for a truly world class metro with greater reliability, energy efficiency and higher levels of automation. In the North of England geographical area, covered by the North West, there has been an increase in traffic since privatisation, 40% in passenger numbers and 60% in freight. The demand for travel is still increasing and is expected to have incrased by possibly a further 66%.

Various work streams which become known as the North of England Programme are North West Electrification, Northern Hub and the Trans Pennine Electrification. These plans are to provide better connections across the region. All the elements are to be delivered between Decemeber 2013 and December 2018.

Ref.The JOURNAL, PWI, April 2013/Volume 131 pg 19, 20

Complete Structural Testing System
New system for Monitoring Bridges on Indian Railways.

By
V B Sood*
Sanjeev Kumar Garg**
Mukesh Kumar Meena***
M Z A Sheriff****

SYNOPSIS

Indian Railways has procured a new Complete Structural Testing System (CSTS) for monitoring of bridges. This paper describes the components of the system and discusses ways in which this system is different from the existing monitoring methods. Also, the paper describes ways of deploying this system so as to meet the objectives of reliability of the bridges and ensuring safety while running higher axle loads on existing bridges.

1. Introduction

Indian railways have procured eight nos Complete Structural Testing System (CSTS), which are also known as STSWiFi (Wireless Structural Testing System), which have been supplied to NR, NER, NFR, SCR, SR, SER, CR and ER.This equipment has been used earlier for testing of bridges in western railway as part of Pilot Project through Railway Board. These systems are manufactured by M/S Bridge Diagnostics Inc, Boulder, Colorado, USA and supplied through COFMOW. The contract for supply included two rounds of indigenous training and a round of foreign training for 4 officials in operating the equipment. Indigenous training was given in RDSO in April 2013in which setting up of the equipment for testing and viewing the results using softwarewere explained to 27 nos officials from RDSO/ zonal railways were trained in this training. The authors of this paper attended foreign training in Boulder/New York in May 2013during which the modeling of the structure and drawing conclusions from the field data were covered.

2. Equipment: The equipment supplied has the following components:

a. STS-Wi-Fi Base Station: This main communication hub, which is ruggedized equipment that can connect



with up to 4 nodes with Ethernet cables (up to 50 with additional Ethernet switches) and upto 25 nodes wirelessly. The wireless communication is 802.11 b/g with 100m line-of-sight range. Multiple base stations can be used during the same test to allow structures longer than 100m to be tested.If line of sight is not clear, Ethernet cables (standard LAN cables) can be used to connect the nodes with base station.

b. STS-WiFiNode : Nodes are used to connect sensors to the testing system and are of modular ruggedized design. Each node can connect to up to four sensors through instrumentation grade cable. These cables

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**DyCE/D/N Rly
***Sr.DEN/ASN, E Rly
****XEN/Br/GTL, SC Rly



are connected to the sensors at one end and the other end consists of waterproof military specification circular bayonet snap-lock connector, which can be quickly connected to the STS-WiFi node.Up to 100 nodes can be connected together (i.e., the system is expandable to up to 400 channels of data). The hardware accuracy is ±0.2%, sample rate is 1 to 500 Hz software selectable. Power input is 9-48 Volts DC, current: ~0.45 Amps at 12Volts DC nominal. The STS-WiFi nodes can work in wireless as well as wired modes. The wireless communication is on 802.11 b/g while the wired communication is through standard Ethernet cables. The nodes have 520 MHz Marvel Xscale PXA270processor with 64MB SDRAM (32-bit)which is used for signal conditioning, filtering, and A/D conversion which are performed by each STS-WiFi node.

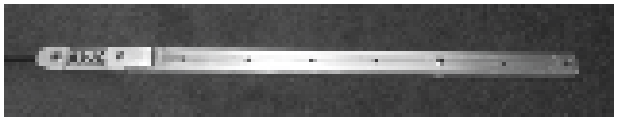
c. Sensors/Intelliducers: The data acquisition equipment works with most sensor types but is best used with Intelliducers manufactured by BDI. The Intelliducers have built in memory chips so that each sensor can identify itself to the system so there is no need for tracking which sensor is wired into which channel or feeding the sensor number and calibration information into the system. Due to this, these sensors can be connected to any node at any position. This Intelliducer system also enables each sensors individual calibration factor to be stored in a “cal” file, which allows these factors to be automatically applied, with no need for separately entering these factors for each bridge test. All BD Isensors have integrated Intelliducer plug that can be used to connect the sensor to the nodes.

Different type of gauges available include:

i.) BDI Strain Gauges: These sealed/water proof strain gauges are designed for high-speed live-load measurements. Working temperature range is -50°C to +120°C. These sensors have a range of ±4000με



with a sensitivity of ~500 με/Vout/Vext and an accuracy of <0.2%, individually calibrated to N.I.S.T. standards. These consist of four fully active 350Ω foil gages in a Wheatstone bridge configuration. These are suitable for steel as well as masonry/concrete structures. For use in the masonry/ concrete, the gauge length can be increased by attaching a strain transducer attachment. The nominal length of the gauge is 3 inches (76.2 mm), which can be increased with the attachment in steps of 3 inches (76.2 mm) upto 24 inches (610 mm).



The strain gauges are reusable and are bolted on studs which are either fixed with adhesive or welding on the bridge.The tabs too can be removed after use and reused afterwards on other location/ bridge. This feature makes the use of these gauges extremely cost effective.

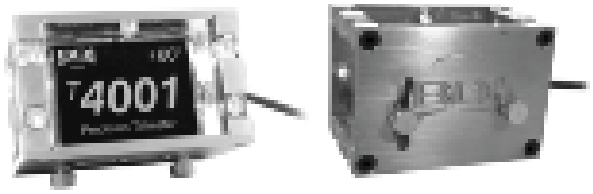


ii.) BDI Accelerometers: These 350 Ω MEMS type accelerometers are designed for live-load vibration



measurements with ±2g, ±5g, ±10g, ±20g, ±50g and ±100g range. The excitation voltage is +5 VDC and a sensitivity of 1000 to 20 mV/g. Operating temperature range is -55°C to +125°C and F.S. Non-Linearity is ±0.5%.

iii.) BDI Precision Tiltmeters:These electrolytic gravity based tilt sensors are used to monitor live-load and



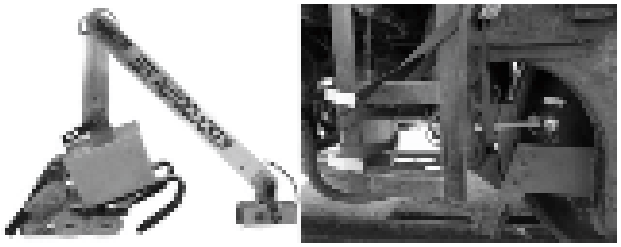
long-term rotations on beam ends, piers, columns and towers etc. Normal models have linear range of ±0.5° to ±60°, with resolution <0.0001 to <0.001 arc degrees and < 2% F.S. accuracy. These can work in temperature range of -54°C to +125°C, with temperature coefficient of 0.1%/0C.

iv.) BDI Temperature Sensors:The temperature sensors are a thermistor reading and generally used to track the temperature of the structure during live-load testing or long-term monitoring. The standard operating range is from-20°C to +80°C and have an accuracy of ±0.5°C.

v.) BDILVDTs:BDILVDTs or Linear Variable Displacement Transducers are used to monitor live-load and long-term deflections and are ideal for measuring bridge deflection. These have spring-loaded return pistons and have a linear range of ±25.4mm. The resolution is <0.0025mm and operating temperature range of -58°C to +158°C. These have a temperature coefficient of ±0.006%F.S./0F.



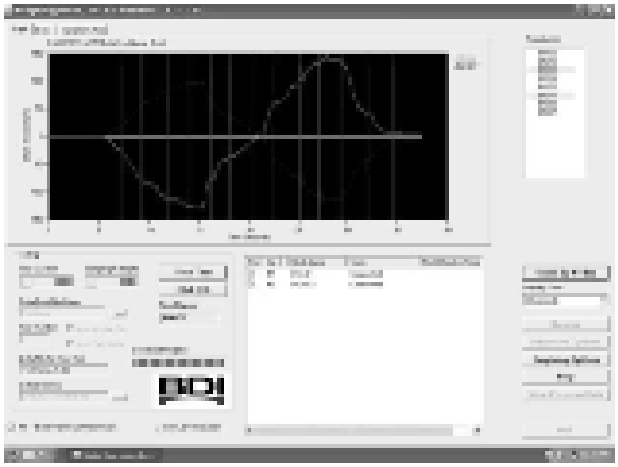
d. BDI Auto Clicker : This sensor is used to record the testing vehicle's position during an entire live-load



test. The structural response data collectedby the STS-WiFi nodes is synchronized with data coming from the BDI AutoClicker so that the structural responses can be presented as a function of load position rather than an arbitrary point in time. The AutoClicker is attached near one of the wheels of the vehicle and is used to give the precise location of the vehicle at different instances of time. Ituses a reflective surface fitted on the wheel which reflects the infrared rays back onto a sensor on the AutoClicker and thus counts the wheel revolutions by inputting a marker into the data file for every reflection. With the knowledge of wheel circumference, the distance traversed between each markeris known and can be used to indicate the position of the vehicle knowing the initial starting position. This event of passing of the reflective surface in front of the infrared rays is called a "Click" which is transmitted usingradio.It has a range of 1 km and uses two 900MHzradios to wirelessly transmit the signal back to the one of the input channels on an STS-WiFi node.

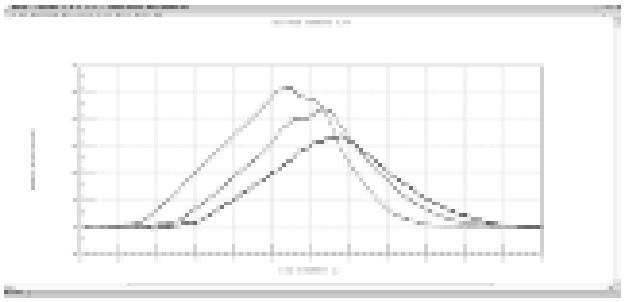
e. Software : The equipment becomes "complete" with custom-made software which is used for viewing the results from testing, for comparing the trends from different strain gauges, for generating a numerical model and for optimization of the numerical model etc. In short, the system handles all activities related to testing of a bridge from field work to drawing conclusions. There are three components of the software:

i.) WinSTS:Data AcquisitionSoftware,developed for operating and collected data from the STS-WiFi equipment.



This software is the computer interface for the STS-WiFi hardware. This software allows the user to control all functions associated with the STS-WiFi system, collected data, and perform a preliminary data review. This software has been expressly designed for use with STS-WiFi and no other Data Acquisition equipment.

ii.) WinGRF: Graphing Utility Software, tailor-made for the needs of the STSbridge testing equipment.

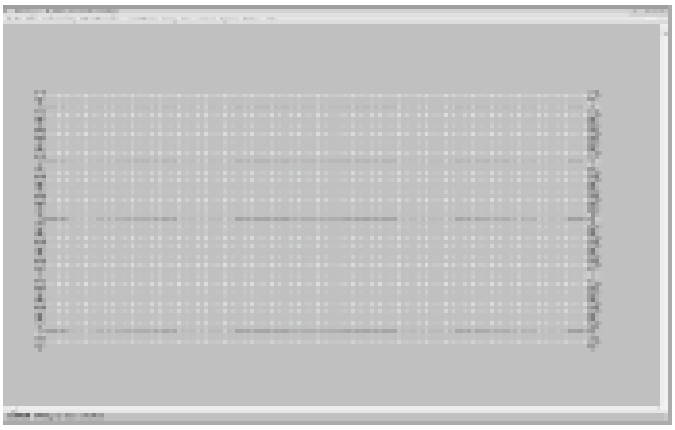


This user interactive graphing program was specifically designed for viewing data obtained from the BDI Structural Testing System (STS). It enables the user to view field data quickly and efficiently, saving the need for dealing with spreadsheets. Raw data files from the STS can be imported directly into WinGRF and viewed with respect to time, load position or load event. In addition, WinGRF is used to view computed responses from BDI's WinSAC structural analysis software, and allows an engineer to visually determine the validity of their finite-element optimization procedures.

The software has a capability for comparing the lateral distribution of the loads shared by the various girders as the position of load changes. This is a very good option and any improper distribution can identify whether some sensor is not behaving properly or the structure itself has some peculiar behaviour.

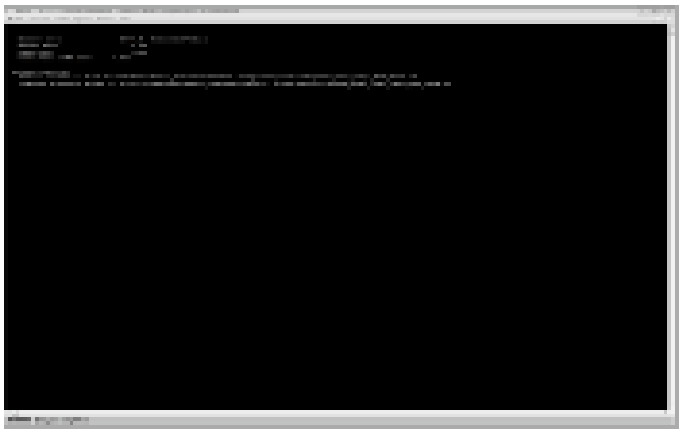
Other various tools for extracting and processing data have also been incorporated into the WinGRF software. The user has the ability to generate envelope files to determine the minimum and maximum responses from each sensor, extract data at specific load position increments, and decimate or filter data to either reduce file size or eliminate noise in the field data. The user can also easily combine or average multiple data files; this is extremely useful when working with multiple STS systems or multiple rounds of testing.

iii.) WinGEN:Linear Elastic Finite-Element Modeling Generation Software, tailor-made to create models that can be used by WinSAC to compute structural response for comparison, calibrate the model, or rate the structure. The calibration of model in WinSAC is automated iterative process which optimizes the convergence of model with actual field data.



This GUI based software allows the user to create a 2-D or 3-D finite-element (FE) model quickly and efficiently. The available FE element types that can used are frame (beam), shell (plate and membrane), and spring (6 degrees of freedom) elements. Using the software's mesh generation feature, window based group creation, group assignment, gage location definition, and test vehicle definition; the user can quickly create a FE model to simulate the load test conditions and make direct comparisons between the model and the collected test data.

iv.) WINSAC: A Linear-Elastic Structural Analysis And Correlation Software that performs the analysis for model files created by WinGEN.



This software strictly performs the structural analysis necessary to evaluate the WinGEN model, including: computing and comparing strains at the instrumented locations; calibrating the FE mode based on user's defined parameters and their limits; and load rating the structure based on input rating information. Once the analysis is complete, this software saves different types of results in various files that can be reviewed or used in WinGRF.

3. Basic theory of CSTS : The CSTS was developed around the concept called "integrated approach". In simple terms this approach involves collecting high quality structural data quickly and efficiently, and integrating this data into the structural analysis in order to evaluate the structure as accurately as possible. First, this approach involves taking continuous recording of the strains and other parameters at a high sample rate as the load crosses bridge at slow speed. The high sample rate of the continuous data enables the CSTS to capture a complete set of structural response behavior, which is often missed using static testing techniques. The type of information provided by complete response histories include: composite action or the loss thereof; end-restraint and continuity behavior near supports; effects of secondary elements such as sidewalks and curbs; effects of damage or deterioration, and a more complete picture of WHY the

structure was behaving a certain way instead of just how large the beam stresses were. The STS-WiFiis testing system developed to capture the live load response of the structure quite accurately and quickly and can be used to accurately predict the behaviour of a structure under different loads. Using the collected data, the model is calibrated against the live load only and hence a limitation of CSTS is that it cannot necessarily predict the behavior of structure under effects of wind, earthquake, temperature effects, etc. The effects of dead loads can be predicted by extrapolating the results obtained for live loads as long as the structure is found to mostly behave linearly under dead and live loads. However the effects of the lateral loads and occasional loads have to be approximated or modeled separately.

4. Capabilities and advantages of CSTS : The CSTS has the following basic capabilities which bring about major advantages for the users:

a. Fast testing : It can be set up very fast because it has wireless transmission between the nodes and the base station. The cables from nodes to the sensors are not typically very long. This makes the task of setting up a test very fast.

b. Lessmistakes : The sensors used in CSTS have Intelli ducersi.e. they have their own chip in-built in each sensor and each sensor identifies itself to the base station. Any sensor can be connected to any node and any channel on the node without affecting the data collected and the operator only needs to note down which sensor no is installed at which location on the bridge. The sensor calibration factor also applied to the data automatically. This reduces the chances of making a mistake to a considerable degree.

c. Lesser errors: The strain gauges supplied with CSTS have a gauge length of 75 mm (3 in.) which is higher than the gauge lengths normally available for bondable strain gauges. For use of concrete and masonry structures, the gauge length can be increased by using strain transducer extension upto 610 mm (24 in.). Due to the large length of the gauge, it captures data from a longer area of the structure and hence the data obtained is much less susceptible to local changes in material properties, minor cracks on surface, mistakes due to fixing the gauges slightly oblique to the axis of the structure etc.

d. Versatility: The CSTS can be used to monitor a variety of parameters on a bridge, such as: strains, tilts, accelerations, displacements, temperature etc. A modified version of the equipment can be used for long term monitoring of behaviour of bridges which is useful for the fatigue life computations. The system can be used with its own sensors as well as sensors manufactured by other manufacturers.

e. Easy Visualization: The data acquisition with CSTS can be viusualized very easily using the proprietary software called WINGRF which can show upto 32 channels after testing and any number of channels in post processing mode. It is easy to see the patterns of changes in values coming in with the changing load positions which can tell if the data coming in is 'good' i.e. as per trends expected or not.

f. Lesser Cost of Testing: The strain gauges used in CSTS are reuseable. These are fixed with tabs glued to the girder components in which the gauges can be screwed. The tabs can be removed after testing and the same gauges can be used repeatedly over long periods of time with periodical calibration. This reduces the overall cost of testing considerably.

g. Accuracy: Each BDI strain gauge takes the reading of four strain gauges installed in Wheatstone bridge configuration. This increases the output from a typical ¼-arm foil gauge by approximately 3.5 times, so the signal to noise ratio is much better then typical ¼-arm foil gauges. The gauges being installed in rugged casing have proven to be very accurate over considerable periods of time even though calibration through recalibration is recommended periodically.

h. Complete Package: The CSTS is a complete integrated package, from testing to load rating. The job of theoretical analysis of the bridge components through Finite Element Modeling is not left to some other software. The software is written specifically for bridge testing and has neat features which help modeling of typical bridges very easy. For difficult layouts, there is a facility for importing the geometry from AutoCAD, which can be used for difficult bridges such as curved bridges or bridges with a unique 3-D geometry. Visual comparisons of the modeling results and the instrumentation results can be done through the software which makes the comparison convenient. The adjustment of the different parameters such as stiffness of members, support conditions, fixity of supports etc can be controlled manually and then optimized using the optimization engine built-in in the software. The integrated approach helps perform all the tasks required for instrumentation and testing of a bridge and the software which is specially developed to make the entire task convenient.

i. Load Rating: The software is programmed to give load rating of the bridge. Load rating is a simple parameter

which determines the ratio of load carrying capacity and the actual load coming on the most critical component of the bridge with an acceptable factor of safety. This ratio is considered a load rating factor. Larger a load rating factor value is,the better it is, and a value less than 1 indicates that the rated load cannot cross the structure with an acceptable factor of safety, as it leads to possible overstressing and potential member failure. The software WinSAC gives the load rating of the components using any of thestandard methods given by AREMA/ AASHTO etc and can be customized for IR's needs. The load rating takes into account the actual stresses, various load and material factors which are considered in design and then assesses the critical load rating. In short, the field verified load rating provided by the integrated approach is a factor which conveys the load carrying capacity of the most critical component of bridge based on actual field data. This load rating can be used to plan repairs/ rehabilitation as the load rating of entire bridge can be increased if the most critical component is strengthened/ replaced or structural behaviour of the bridge altered.

5. Usage of Equipment on Railways: The equipment can be used for a variety of purposes on bridges:

a. **Assessing Damaged Components:** Quite often we come across the situation where some bridge component is deteriorated to considerable degree either due to corrosion or due to other damage such as accidental hitting etc. In such cases the decision cannot readily be taken on the basis of theoretical analysis and often the engineers are left to take the decisions based on their 'judgment' or 'gut feeling'. Mostly the engineers decide to err on safe side and overly-conservative decisions are made, often creating problems in operations. However, if the engineer decides to take measurements around the damaged area, they can typically make a more informed, much better and more accurate decision. The damaged component and some other component in reasonable condition on same or different bridge can be instrumented and measured under the same train load. The absolute readings of the stresses under load will give a very good idea on the magnitude of stresses under live load and tell the engineer if the damaged component is stressed to a significant extent as compared to the allowable stresses. Comparing the results from damaged and good components will help compare the effects of damage on the strains and tell the engineer the effect of the damage on the load distribution. Since the tests can be performed quickly, the tests can be performed on more than one damaged/good component to quickly draw up the trend and informed decisions can be taken. Another interesting use of this equipment is in comparing the efficacy of repairs/ retrofitment planned. Before committing large investments for the repairs, a few prototype repairs/ retrofitment can be done and this equipment can be used for noting down the 'before' and 'after' parameters and indicating the efficacy or otherwise of repairs/ retrofitment planned. The choice of appropriate method can be made on the basis of the measurement results.

b. **Predict structural behaviour:** The structures are designed assuming idealized/simplified behaviour or certain assumptions. Normally all these idealizations/ assumptions are on the conservative side and the structures can typically take slightly more loads than assumed in the design. During usage, the structure undergoes various deteriorations due to ageing and environmental /usage factors which leads to reduction in load carrying capacity. The structures are also modified in field during repairs/ retrofitment operations arising out of different exigencies in use. The assessment of effect of corrosion, repair of components etc on load carrying capacity/ residual life of the bridge is very difficult as these may be accompanied by redistribution of the stresses also. In order to predict the structural behaviour of the bridge taking into account all the various changes in the bridge as constructed is very important, especially in case of major/ important bridges where the replacement of components is not easy. As per Indian Railways Bridge Manual Para 1107 (16), Health Monitoring of very important bridges is to be carried out once in five/ten years include corrosion monitoring, deterioration of material, system damage, retrofitting, etc. This equipment can be used for this exercise. This equipment can also be used where investment decisions for repairs/ replacement of major bridge components is involved. \

c. **Load rating:** An important use of the equipment is in load rating of the bridge components. Whenever there is need for enhancing the loads on any particular stretch of track, the load rating of representative bridges on the section can be undertaken. The bridges can be tested under the existing loads and the results can be extended to predict the load rating if the higher loads are run on the section. The load rating concept will indicate not

just the suitability of the bridge as a whole for the loads to be carried but also indicate the members whichmaybe required to be strengthened/ replaced before/after the higher loads are allowed.

6. Action Plan for Technology Absorption and Use of CSTS on Indian Railways: As with any new technology/ technique, it requires lot of hand holding to ensure that the same is adopted by the 'system' and the usage percolates to the field level. The following are steps which authors feel are important that this equipment and technique is used fruitfully for the bridges on Indian Railways:

a. Procurement of additional Systems: looking at the various advantages of the CSTS, the procurement of the system shall be done for the balance eight zonal railways, RDSO and IRICEN. This equipment shall be the basic equipment to be used for assessing health of bridges, especially those that have suffered some damage and for all major repair / rehabilitation / replacement proposals.

b. Training: Present contract through COFMOW visualizes two indigenous training rounds and one round of foreign training out of which one indigenous training and the foreign training have been completed. Having attended the trainings, the authors are of the opinion that the equipment shows its potential in first training but since IR's engineers are not used to working with such equipment before, the actual usage will require many more rounds of training.The authors are of the opinion that using the equipment has two prerequisites, viz, proper field testing and in-depth knowledge of the post analysis engineers. Further, the importance of field notes, proper methodology to be followed for testing etc cannot be overemphasized. The proper testing in field is not a matter of classroom training but needs to be experienced in field. Before meaningful work is started using the equipment in India, there is a need to know the methodology being followed by M/S BDI for testing. The in-depth knowledge requires experience which will come by doing the same job over and over and experiencing the complexities thrown up by actual field conditions.It is felt that the following action plan will go a long way in percolation of technology in the IR's bridge organizations:

i.) Hands on Training: At the moment, there is none in India who can impart training in this equipment. It is, therefore, proposed that training be imparted to staff from RDSO, IRICEN and zonal railways in the actual field testing and post testing analysis separately in the premises of M/S Bridge Diagnostics Inc, USA and their actual testing sites to get the idea of actually how the work is being done. A critical mass of engineers of Indian Railways must be created through the hands on training so that they can use this equipment through their own knowledge and through interaction with other trained engineers.

ii.) Refresher Training: After the initial hands on training, the further training shall be imparted on annual basis by IRICEN and RDSO so that new engineers requiring training can be trained and the existing engineers who are using the equipment can clear their doubts through discussions and classroom training.

c. Analysis Training and Support: The analysis of testing being done in field requires not just training but also hand holding initially. It is recommended that the testing done as part of hands on training shall be analysed by the design engineers of IR jointly with BDI's engineers at Boulder so that the IR's engineers gain an idea of the methods involved and the techniques used by BDI engineers in the analysis. Further, the work done in India shall be analysed jointly by the IR's design engineers and BDI's engineers initially so that the work done is reviewed and actual work done in IR's conditions is available to serve as reference for future.

d. Spares and Hardware support: The hardware equipment requires support from OEM and it will be better if an Annual Maintenance Contract (AMC) incorporating the rates for spares and important components is available.

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High Strength Concrete – Some Influencing Factors

By
B. Rama Rao*

SYNOPSIS

With the advent of new admixtures and cementitious materials, it became possible to produce highly workable concrete with superior mechanical properties and durability. This emerging concrete is being called as High Performance Concrete (HPC). One of its offsprings is High Strength Concrete. HSC can be delineated as the concrete with characteristic strength beyond 55 N/mm2. The salutary impact of HSC can be seen in the saving of size of members in high rise buildings and prestressed concrete structures that need 'intelligent designing'.

Conventional Cement Concrete (CCC) has inherent weaknesses in the form of numerous voids, micro-cracks in transition zone between aggregate and cement paste. Thus enhanced performance is directly proportional to the degree of reduction in these intrinsic flaws. This can be achieved mainly by reduction of w/c ratio to a value around 0.3. In this program the influence of size of specimen, dosage of superplasticiser, time of compaction and age of M60 concrete were studied.

1. Test Program

First step was mix design in which target strength higher than characteristic strength was aimed so that the required strength could be achieved in the field. HSC mix design involved the process of fixing the proportion of cementitious materials (cement), coarse and fine aggregates, water and chemical admixture (superplasticiser) to get the desired properties in both fresh and hardened state.

ACI mix design method was used to achieve a mix for a characteristic strength of 60 N/mm2. After assiduous attempts with various mix trials for different w/c ratios, a w/c ratio of 0.25 was adopted as it yielded the required target strength. The final mix proportion implemented was 1:0.94:1.35 with w/c ratio of 0.25.

2. Materials

Cement:

Portland pozzolana cement

28 days compressive strength	: 58.8 N/mm2
Initial setting time	: 160 minutes
Final setting time	: 220 minutes
Specific gravity	: 3.14

Fine aggregate:

River sand

Fineness modulus: 2.30

Specific gravity: 2.60

Zone: II

Purely dried sand was utilized to avoid the problem of bulking.

Coarse aggregate:

Grading of coarse aggregate with 12.5mm and 10mm was done to get the optimum density.

* *ADEN/Kadapa, South Central Railway*

Fineness modulus: 6.57

Specific gravity: 2.63

Water:

Potable water with PH value of 7.65 was used in this work.

4. Test Variables

Influence of the following factors on compressive strength was studied.

Dosage of plasticizer	:	400ml, 500ml, 600ml/50 kg of cement
Time of compaction	:	20 to 120 seconds in steps of 20 seconds
Size of specimens	:	100mm & 150mm cubes and 150mm dia. cylinders
Age	:	1, 3, 7, 28, 56 and 91 days

5. Casting

All the constituent materials were put into the concrete mixer and water was added during rotation. 80 percent of needed water was added initially and mixed for 75 seconds. In the meantime, superplasticiser was mixed with the left over 20 percent water and this mixture was in turn added to the concrete in the mixer. Mixing was continued further for another 45 seconds. After mixing, test-specimens were cast in moulds of 100mm & 150mm-cubes and 150mm diameter cylinders. Individual batches were cast for each age. Specimens were kept under water in a tank immediately afterremoving them from the moulds. This curing was continued till the time of testing.

Altogether 387 specimens were tested in the present study. Allocation of these samples to various test-variables is given below.

Test variable	No. of specimens
To find optimal dosage of super plasticiser	45
To arrive at the best time of compaction (100mm & 150mm cubes)	36 +36 = 72
To study age-effect on compressive strength (100mm & 150mm cubes, 150mm dia. cylinders)	90+90+90 = 270

6. Discussons

a. *Effect of dosage of plasticizer*

Fig. 1a & 1b depict the variation of compacting factor and compressive strength with dosage of superplasticiser. It can be observed from Fig.1a that there is no pronounced influence on workability with the increase of dosage of

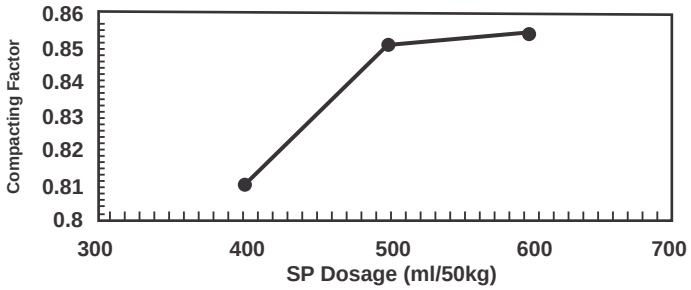


Fig. 1 a SP Dosage VS compacting factor

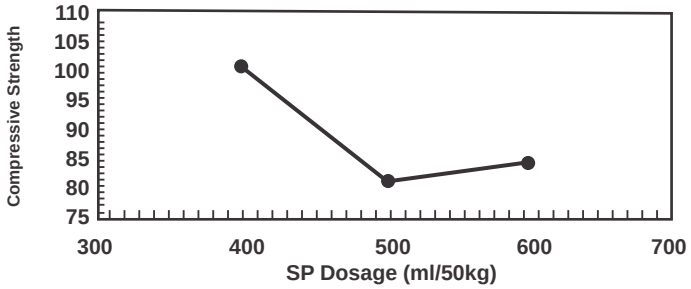


Fig. 1b SP Dosage VS % Compressive Strength

superplasticiser. It can also be inferred from these figures that workability enhancement is peripheral i.e. only 5% while decrease in strength at higher dosages is around 15-20% of the strength corresponding to 400ml/50kg dosage. Thus the higher dosages have a violent effect on strength. Hence the lowest dosage of 400ml/50kg of cement is adopted for further studies as the desired workability is achieved at this dosage.

b. Effect of time of compaction

Dependence of compressive strength on time of compaction can be seen from Fig.2. In this figure compressive strength is almost consistent in the range of 40 to 100 seconds of compaction-time with the lowest value observed at 20 seconds and the highest value at 40 seconds. Moreover compressive strength at 40 seconds touched target strength of the mix. Hence 40 seconds time was considered as adequate.

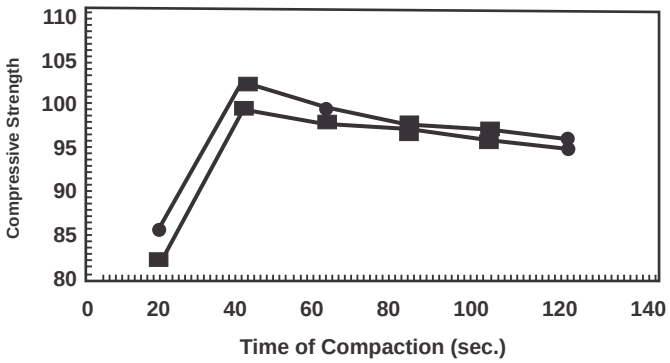


Fig. 2 Time of compaction vs compressive strength as % of 150 mm cube strength (40 sec.)

c. Influence of size of specimen

Compressive strength of concrete is the most trusted property to investigate its quality.Cubes (100mm & 150mm) and cylinders (150mm dia., 300mm height) were utilized for the tests. Usage of 100mm cubes along with 150mm cubes is justified since maximum size of aggregate has been restricted to 12.5mm in this study.

The variation of compressive strength with age of all sizes of specimens is demonstrated in Fig.3. In this figure, %compressive strength means compressive strength as percentage of 28-days strength of 150mm cube. HSC exhibited high early strength and it is clear from this figure.

It is difficult to say whether cube strength or cylinder strength gives a better picture of strength of concrete. However, cylinders seem to give more uniform results than cubes do as the end restraint caused by platens of testing machine is less on cylinder.Moreover, cylinders are cast and tested in the same direction. But direction of testingis perpendicular to that of casting in case of cubes. Thus cylinder, with respect to direction of loading, simulates filed conditionsin a better way. However, shape of cube reflects shape of structural members adopted in general.

The percentage compressive strengths of different specimens for different ages are tabulated below.

Specimen	Age	Compressive strength as % of 150mm cube 28-days strength
150mm cube	1	37.49%
	3	46.22%
	7	68.80%
	28	100%
	56	100.38%
	91	101.89%
100mm cube	1	42.32%
	3	49.17%
	7	77.72%
	28	103.20%
	56	105.82%
	91	106.71%
150mm cylinder	1	31.35%
	3	39.28%
	7	54.79%
	28	81.99%
	56	82.60%
	91	84.57%

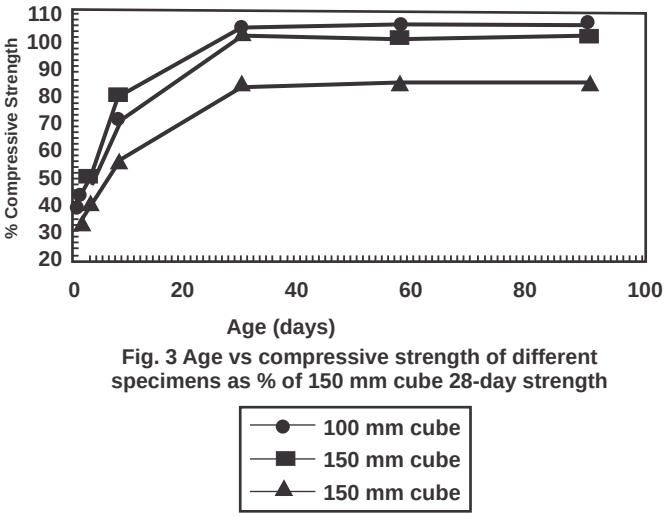


Fig. 3 Age vs compressive strength of different specimens as % of 150 mm cube 28-day strength

d. Failure pattern

Specimens of age 56 days and 91 days burst into pieces i.e. brittle failure was observed while testing for compressive strength. Whereas normal mode of failure took place at earlier ages i.e. up to 28 days.Failure surface of specimens of 56 days and 91 days showed “breaking up of coarse aggregate”. This can be attributed to the fact that for HSC, hardened cement paste and transition zone are no longer strength limiting and it is mineralogy and strength of coarse aggregate itself that control the ultimate strength of concrete.

7. Inferences

The following practical conclusions were arrived at in the present study.

1. In terms of strength, compatibility of superplasticiser with cement was found to be the best at a dosage of 400ml/50 kg of cement among other dosages.
2. The pattern of influence of time of compaction on compressive strength indicated that the compaction period of 40 seconds was optimum.
3. High strength concrete exhibited high early strength and the rate of increase became smaller at later ages.
4. Smaller specimens i.e. 100mm cubes gave higher strength than that of 150mm cubes which in turn developed higher strength than cylinders did. This conclusion is in conformity with the behavior of normal strength concrete.
5. The specimens tested for compressive strength at later ages exploded in contrast to the failure of specimens of conventional concrete. Hence it is advisable to provide cage around testing machine while testing HSC for compressive strength.

Optimum Design of Prestressed Concrete Slab for Railway Bridges

By
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Prof. N. G. Gore**
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SYNOPSIS

A computer approach to the optimal design of prestress concrete slab for Railway loading is presented. The resulting optimum design problems are constrained non-linear programming problems and have been solved by SUMT. Parametric study with respect to different type of spans and grade of concrete combinations of PSC slab sections have been carried out. The result of optimum design for PSC slabs have been compared and conclusions drawn. For the minimum weight and cost design of the PSC slab unit the following design variables are chosen: 1-Depth of PSC slab unit at center, 2-Depth of PSC slab unit at end, 3-Eccentricity of prestressing cable at center, & 4-Total prestressing force. The computer program is written in MATLAB.

1. Introduction

The prestressed concrete slab for Railway bridges extensively used for clear span 6.1m to 12.2 m. The design of prestressed concrete slab for Railway bridges is done based on Concrete Bridge code (CBC) of Indian Railway Standards. The code requirement is generally concerned with the safety of the structure in its lifetime. RDSO issued standard drawings for simply supported pre cast slabs for 6.1m, 9.15m, 12.2m, span Bridges for pre tensioned and post tensioned both methods. These precast slabs are replaced in short duration traffic blocks. The lightness of precast slabs is economical not only by material cost but also more economical for launching cost and cost of traffic block.

Apart from satisfying the code requirement, the slab may be designed economically from RDSO Drawings. For a given condition, there might be a large number of alternatives that satisfy the requirements imposed by codes. But the designer must be in position to choose the one, which is optimal against certain measure of optimality. Therefore, the designers have to do some optimization to arrive at such design. The objective of this Project is to achieve the optimal design of a prestressed concrete Slab for Railway Bridge. It will establish a general relationship among different design variables at optimum and will recommend a simple procedure to identify the optimum design.

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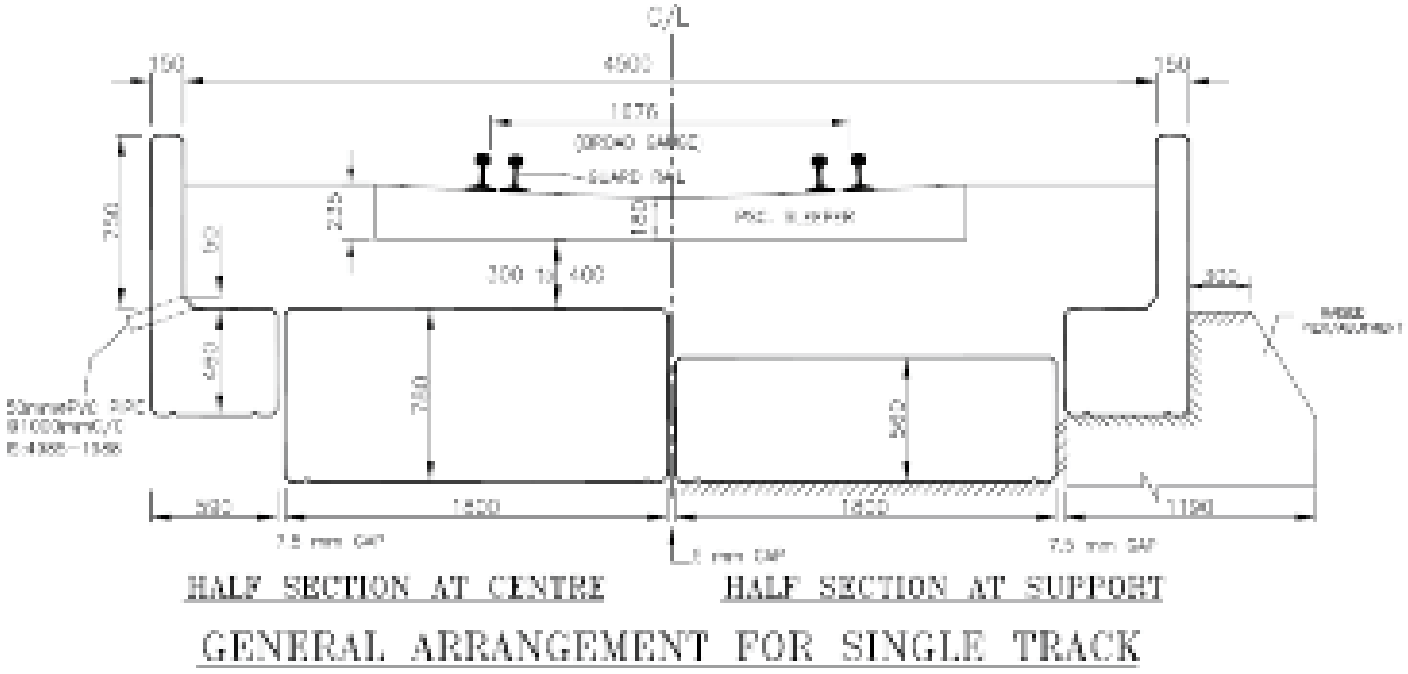


Fig.1: Cross section of 9.15m span PSC slab arrangement with RCC ballast retainer

2. Structural optimization

Optimization is the act of obtaining the best result under given circumstances. It can be also stated mathematically as "the process of finding the conditions that gives the maximum or minimum value of the function".

The optimum cost design of PSC slab formulated in is nonlinear programming problem (NLPP) in which the objective function as well as Constraint equation is nonlinear function of design variables. The Sequential Unconstrained Minimization Technique (SUMT) is on of the Methods for the solution of the NLPP.

In SUMT the constraint minimization problem is converted into unconstraint one by introducing penalty function. In the present paper the function f (X, r) is the penalty function f (X) and the objective function r is the non negative penalty parameter, and m is the total number of constraints. The penalty function (X, r) is minimized as an unconstrained function of X and r, for a fixed value of r.

The present optimization problem is solved by the interior penalty function method. DFP method is used for solving successive unconstrained minimization problems coupled with cubic interpolation methods of on dimensional search. The program developed by S.S. Rao for SUMT is used for the solution of the problem. The program is written in MATLAB language.

3. Formulation

3.1 Design Variable

The design variable in optimal design problem of prestressed concrete elements includes concrete dimensions, prestressing force and the tendon eccentricity.

X1 = h = depth at center

X2 = h1 = depth at end

X3 = e = eccentricity of prestressing cable at center

X4 = p = Total prestressing force.

Span L, slab width b and nos. of voids are taken as pre-assigned parameters.

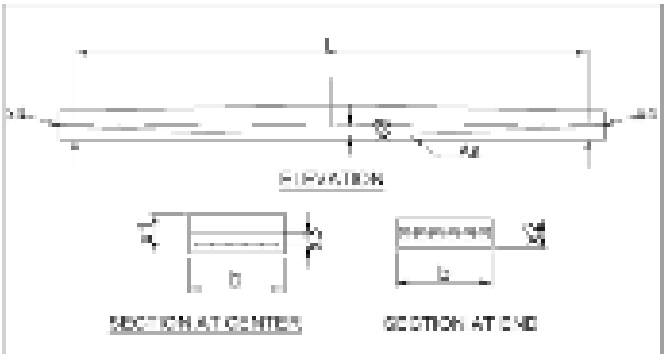


Fig:2

3.2 Constraints

The restrictions that must be satisfied in order to produce an acceptable design are collectively called design constraints and formulated as below.

Normal Stress Constraint

G1= Stress in top fiber at transfer $= \frac{\left(\frac{P}{A} - \frac{Pe}{Zt} + \frac{Mg}{Zt}\right)}{ftt}$ -1≥0

G2= Stress in bottom fiber at transfer $= \frac{\left(\frac{P}{A} - \frac{Pe}{Zt} + \frac{Mg}{Zt}\right)}{fct}$ -1≤0

G3= Stress in top fiber at service $= \frac{\left(\frac{P}{A} - \frac{Pe}{Zt} + \frac{Mg}{Zt} + \frac{Mq}{Zt}\right)}{fcw}$ -1≤0

G4= Stress in bottom fiber at service $= \frac{\left(\frac{P}{A} - \frac{Pe}{Zt} + \frac{Mg}{Zt} + \frac{Mq}{Zt}\right)}{ftw}$ -1≤0

Ultimate strength, shear constraints

G5= Ultimate Strength $= \frac{Mu}{Mult}$ -1≤0

G6= Ultimate shear $= \frac{Vu}{Vco}$ -1≤0

G7= Maximum shear capacity = Vu/Vm -1 =0

Deflection Constraints

G8= Deflection check $= \frac{D}{Du}$ -1 =0

Design Constraints

G9= Minimum depth at center $= \frac{h}{2(e+c)}$ -1 ≥0

G10= Minimum depth at end $= \frac{h1}{2F}$ -1 ≥0

G11= Maximum eccentricity $= \frac{X3}{(.5x1 - c)}$ -1 ≥0

G12= Maximum prestressing force $= \frac{X4}{(0.8 cable\ no * uts)}$ -1≤0

G13= Minimum section modulus $= \frac{Zc\min}{Zc}$ -1≤0

3.3 Objective Function

The objective function in the present optimization problem is the cost of PSC slab which main components are cost of concrete, and pre stressing steel. It is assumed that cost of steel, launching and casting formwork etc are directly proportional to volume of concrete, hence all these cost are included in the rate of concrete. It is also assumed that cost of anchor, sheathing etc are directly proportional to volume of prestressing steel, hence all these cost are included in the rate of prestressing steel. Objective function can be expressed as:

COST = (wt. of Pre stressing steel x Rate) + (Vol of Concrete x Rate) or

Z = Vp x Rp + Vc x Rc

4. Results and discussion

A computer code developed in MATLAB7 based on above design variables, constraints and objective functions to find minimum weight and the minimum cost of a Railway PSC slabs. After validating this computer code by comparing the results with analytical results, it is planned to carry out the economical and safe design. The active constraints calculated by this computer code for the various grade of concrete and various spans.

Sr. No.	Span (in mm)	fck	Weight of slab unit (KN)				Cost of slab unit (Rs.)			
			As per RDSO DRG	Opt. wt	RDSO vs opt. wt	variation from opt. M60	As per RDSO DRG	Opt. cost	RDSO vs opt. cost	variation from opt. M60
1	3050	M40	57.74	51.69	11.7%	7.98%	78670	73508	7.0%	1.86%
2	3050	M50	57.74	51.57	12.0%	7.73%	79593	74235	7.2%	2.87%
3	3050	M60	57.74	47.87	20.6%	0.00%	80979	72167	12.2%	0.00%
4	6100	M40	178.61	146.04	22.3%	9.58%	243868	216093	12.9%	2.64%
5	6100	M50	166.79	134.21	24.3%	0.71%	236460	208140	13.6%	-1.13%
6	6100	M60	166.79	133.27	25.2%	0.00%	240463	210526	14.2%	0.00%
7	9150	M40	315.88	279.91	12.9%	7.12%	401028	370341	8.3%	1.48%
8	9150	M50	315.88	265.44	19.0%	1.58%	406080	362250	12.1%	-0.73%
9	9150	M60	315.88	261.31	20.9%	0.00%	413663	364930	13.4%	0.00%
10	12200	M40	593.8	414.92	43.1%	9.43%	732476	579896	26.3%	2.72%

11	12200	M50	593.8	387.37	53.3%	2.16%	741977	562588	31.9%	-0.35%
12	12200	M60	593.8	379.17	56.6%	0.00%	756228	564561	33.9%	0.00%
13	15300	M40		610.31		10.85%		915859		3.26%
14	15300	M50		569.69		3.47%		890324		0.38%
15	15300	M60		550.58		0.00%		886926		0.00%

Table 1: Variation of slab cost and weight for different span and grade of concrete

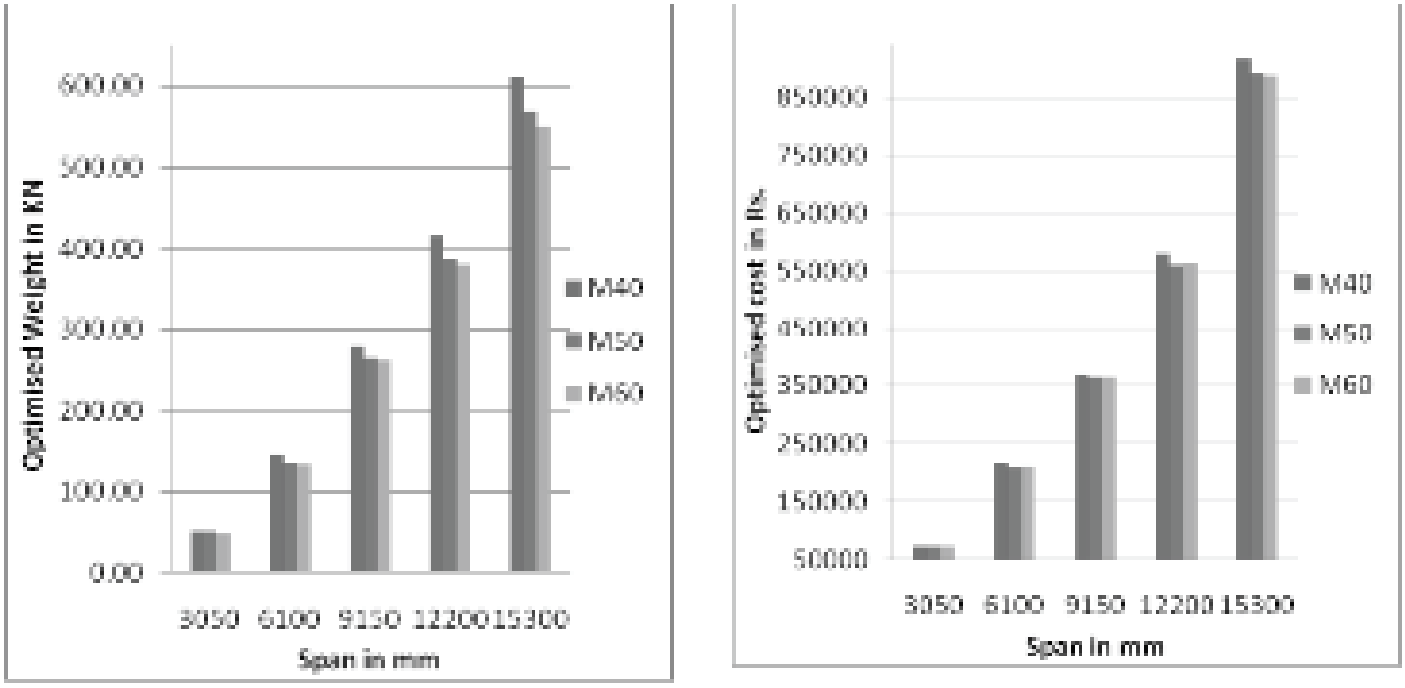


Fig.:3: Optimized weight and cost for various span and concrete grade

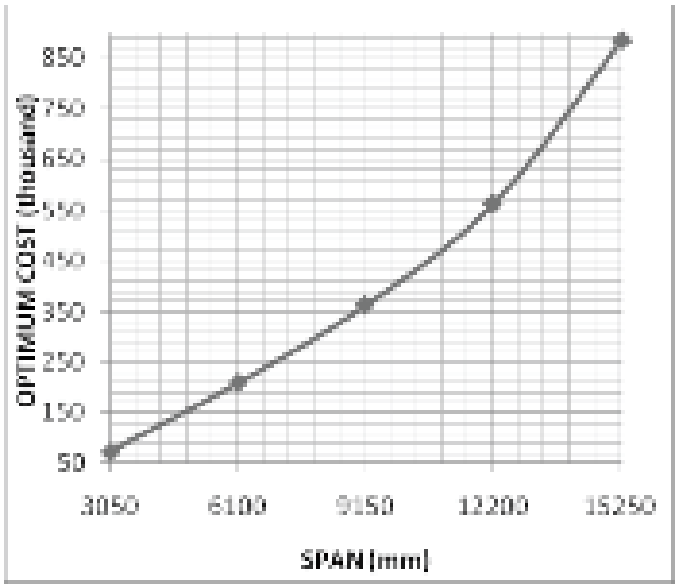


fig 4: Optimum cost v/s span

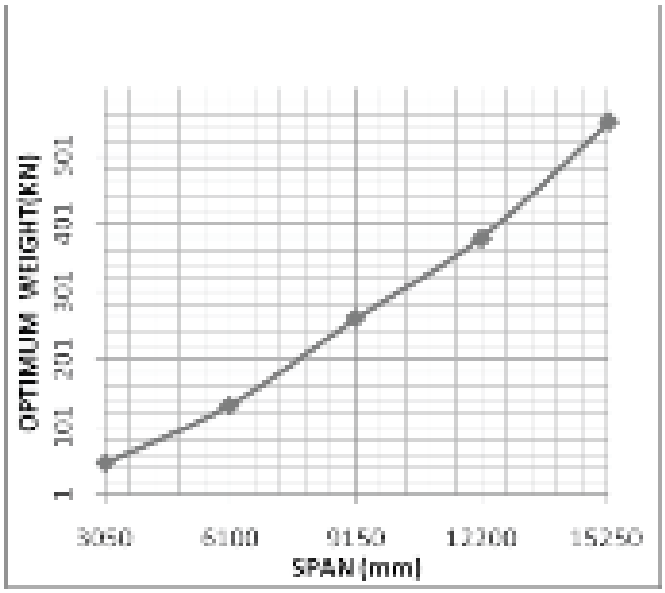


fig 5: Optimum weight v/s span

The results of various illustrative examples are presented as per Table 1 and graphically analysed in fig. 3,4&5. The weight and cost of optmised PSC slab calculated based on post tensioned design. The weight and cost of RDSO PSC slab calculated based on available RDSO drawings irrespective of grade of concrete and pre/post tensioned design for illustration purpose.

The conclusion drawn from the results of the illustrative examples are presented as below.

- It is possible to formulate and obtain solution for the minimum weight and cost design for PSC slab.
- Interior penalty function method can be used for solving resulting non-linear optimization problems. The chosen values of initial penalty parameter r0 and reduction factor C worked satisfactorily.
- It is possible to obtain the global minimum for the optimization problem by starting from different starting points with the interior penalty function method.
- The minimum weight and cost design of PSC slab is fully constrained design which is defined as the design bounded by at least as many constraints as there are the design variables in the problems.
- Significant savings in weight and cost over the normal design can be achieved by the optimization. However the actual percentage of the saving obtained for optimum design for PSC slab depend upon the span of slab, prestressing tendons and grade of concrete (refer Table1).
- Maximum cost savings of 26.30% over the RDSO standard design is achieved in PSC slab unit of 12200mm of M40 grade concrete. Maximum weight reduction of 56.6% over the RDSO standard design of PSC slab unit of 12200mm span of M60 grade concrete(refer Table1).
- The optimum cost for a PSC slab is achieved in M50 grade of concrete which is the average of M40 and M60 grade of concrete, but optimum weight for a PSC slab unit reduced with increase in grade of concrete (refer fig. 3).
- The cost of PSC slab unit increased exponentially (refer fig.4) with respect to span where as weight of PSC slab unit increased linearly (refer fig.5) with respect to span.

5 Conclusion

The PSC slab is very important structure for small span Railway Bridges. Indian Railway replacing steel girders by PSC/RCC slabs on programme basis due to low maintenance and economical cost. PSC slabs are most suited for Railway Bridges of span 3m to 12m.

The main drawback of PSC slab is that PSC slabs are three times heavier than steel plate girders. The launching of PSC slab is more expensive due to its heavy weight. Hence, it is necessary to optimise the design of PSC slab to get the light design and minimum launching cost for such important structure.

The objective of this study is to investigate the appropriate optimization method to find minimum weight and the minimum cost of a Railway PSC slabs. In view of achieving this objective it is decided to develop a computer code in MATLAB7. After validating this computer code by comparing the results with analytical results, it is planned to carry out the economical and safe design of PSC slab.

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Appindix II- Notations

The following symbols are used in this paper:

ftt - allowable tensile stress at transfer,

fct - allowable compressive stress at transfer,

fcw - allowable compressive stress at load combination (DL+ super imposed load +LL),

ftw - allowable tensile stress at load combination (DL+ super imposed load +LL),

P - effective pre stress force,

A - Area of the section,

Ic - moment of Inertia of the section,

Mg - Dead Load Moment at the critical section,

Mq - (Live Load + Impact),

c - minimum cover.

F - minimum anchorage edge distance.

Mu - ultimate design moment due to dead load, and live load with load factor,

Mult - ultimate moment capacity of the section under consideration.

Vco - ultimate shear resistance of a section untracked in flexure,

Vm - Maximum shear capacity,

D - deflection of the girder under load,

Du - upper bound to deflection,

Zc - section modulus,

Rp - Rate of prestressing steel / Kg

Rc - Rate of concrete / m3

Vp - Weight of prestressing steel in Kg

fck - characteristic cube strength of concrete.

Vc = Volume of concrete in m3

Elimination of Long Persisting Problem of Misalignment of Track over Bridge No. 77 of Howrah Division- An Experience of Eastern Railway

By
Goutam Bhattacharyya*

SYNOPSIS

Bridge No. 77 (Up line, SP-12x18.3 m plate girder) in Khana- Rampurhat section of Howrah Division of Eastern Railway was having the problem of misalignment on track and thereby requiring imposition of TSR for last 10 years. This route is CC+8+2 T route of Eastern Railway and removal of TSR and subsequent increase in throughput was the need of the hour. This paper tries to depict the nature, diagnosis and analysis of problem, its solution, execution scheme and the final achievement in this work.

1. Introduction

Bridge no. 77 (12 x 18.3 m plate girder) at km 164.35 from Howrah near Bolpur on the heavily loaded section of Howrah Division, Eastern Railway was having the problem of misalignment of up line track for last 10 years. The track was on channel sleepers and the problem of poor alignment of track was continuing thereby making imposition of speed restriction of 10 kmph as inevitable. Other details of this bridge are as under:

- Bearing: Centralized articulated Bearing.
- Substructure: Masonry circular pier on well foundation
- Year of construction: 1906

2.0 Problems Faced:

The defect was so acute that the TSR was continuing for almost last 10 years. Poor alignment in the track was visible in the naked eye and the defect was mainly from SP-2 to SP-5. SP-7 to SP-11 was also having some minor alignment defects. The ends of the channel sleepers also formed a false curve on the bridge.

3.0 Diagnosis of Defects:



Fig. 1: Misalignment in Bridge No. 77 before execution of work

The defects were found in three places- track i.e. channel sleeper, Bridge i.e. girders, and Masonry i.e. sub structure level. The defect was in fabrication of channel sleepers but actually it was not wrongly fabricated but was made wrong

*Dy. Chief Engineer, Eastern Railway

intentionally to accommodate rails on the sleepers and the bridge, by shifting the J hook location plate and canted bearing plate in each sleeper for a length of 100 sleepers between SP-2 to SP-5 and at other locations to compensate the defects of other parts. The maximum affected stretch for those which influenced the alignment was from sleeper 36 to 127 between SP-2 and SP-4 again from sleeper number 344 to 386 between SP-11 and SP-12. This was done while



Fig. 2: End of channel sleepers forming false curve on Bridge No. 77

replacing wooden sleepers by channel sleepers some time in 2002.

While analyzing the reason behind such defect in channel sleepers, it was seen that the girders were heavily misaligned. Measurements were taken for quantification of such misalignment which is produced below:

Abutment /Pier no.	Misalignment in Girder	
	HWH End Girder(mm)	JMP End Girder (mm)
A-1	0	--
P-1	5	13
P-2	96	91
P-3	118	98
P-4	27	22
P-5	12	17
P-6	30	15
P-7	10	10
P-8	0	0
P-9	22	27
P-10	2	2
P-11	45	50
A-2	--	5



Fig. 3: Piers eccentric over well foundation at Bridge No. 77

t can be seen that the maximum misalignment is 118 mm in SP-3 (JMP end) and 98 mm in SP-4 (HWH end) on pier no. 3, 96 mm in SP-2 (NJP end) and SP-3 (HWH end) on pier no. 2, 45 mm in SP-11 (NJP end) and 50 mm in SP-12 (HWH end) on pier no. 11. In other spans also, misalignments persisted to a smaller magnitude as compared to these.

While such misalignment in major bridge girders over IR is not common, it was found that some masonry piers were having eccentricities with respect to the well foundation. This defect is in place since construction i.e. 1906. The defect actually started here in substructure and reflected in track after replacing wooden sleepers by channel sleepers. Rather it can be said that wooden sleepers compensated the defects in substructure and girders.

4.0 Reasons of cropping up such defects:

The conversion of Flat Bearings to Centralised bearings was done some time in 1996. Therefore, it is understood that while doing conversion of flat bearings to centralised, wooden sleepers were on the bridge. Wooden sleepers compensated the misalignment by placing the rail in an eccentric manner with respect to the girders.

This defect could have been rectified either at the time of replacement of wooden sleeper by channel sleepers by

slewing the girders or, at the of conversion of flat bearings into centralised with slewing the girders. In both the cases requirement of huge number of wooden sleepers for replacement was a crisis in the year 2002, aligning the girders could not be done at that time. Moreover, inadequate space on the circular piers did not allow the required slewing of girders as well. Therefore, this defect could have been rectified only if jacketing of piers were done but since there was no sanction that did not take place in 1996 and 2002.

5.0 Proposed Solution:

One and only solution which was available to eliminate these deficiencies was to replace the sleepers of SP-2 to 4 and slewing of all the four ends of girders on two piers, at a time, in one Power and Traffic Block. In 2nd block, removal of sleepers on SP-11-12 along with slewing of SP-11 (JMP End) and SP-12 (HWH end) and slewing of other spans on piers in small blocks subsequently. Prior to this, RCC jacketing was to be completed in all piers with priority on pier no 2,3,4,6,9,11.

5.1 Sequence of Execution:

- RCC Jacketing: RCC jacketing of thickness 300mm was done in all the piers.
- Replacement of channel sleepers and slewing of girders.
- Channel sleepers and New Bedplates of required numbers were fabricated and brought at site. After fabrication of channel sleepers and bed plates and procurement of fittings, programme of block was made. It was considered that a block of 9 hours will be required. Break up is given below:

SN	Items of Work	Time
1	Lifting and Slewing of Girder of 4 ends of 3 spans on 2 piers	3.30 Hrs
2	Replacement of Channel Sleepers 100 numbers minimum on 3 spans	4.00 Hrs
3	Fixing of Rails and Fittings on 3 spans	1.30 Hrs
	Total	**9.00 Hrs**

5.2 Pre- block Activities:

All pre-block arrangements were made like removal of guard rails, loosening of fittings of rails etc. All lifting brackets fitted and jacks were placed and set below the lifting brackets and kept ready for lifting. All markings on piers and girders were given.

5.3 Activities during the block:

Traffic block of 9 hours was granted and the activities were taken up as below-

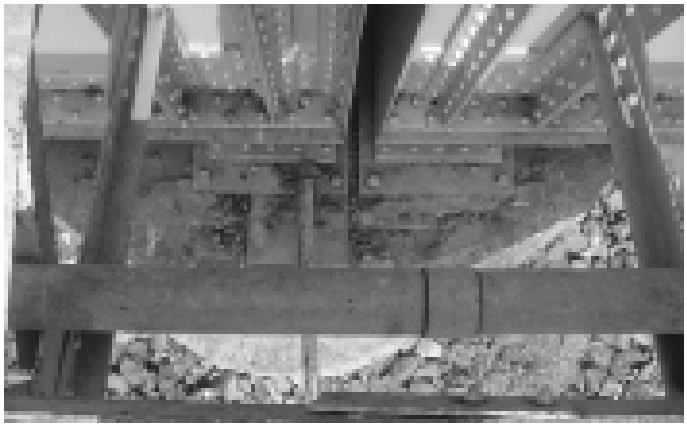


Fig. 4: Inadequate space on pier

1. Rails were loosened and lifted from the girder from span-2 & 3.
2. Girders of span 2 and 3 were slewed to the desired location by 96 mm and 92 mm on pier no. 2.
3. Removal of the existing channel sleepers was started and placing of new channel sleepers in position on SP-2 taken up after lowering the rails.
4. SP-3 and SP-4 are now made free of rails by lifting of rails.
5. Girder ends of span 3 and 4 were placed to the desired location by slewing by 120 mm and 98 mm at pier no 3 and lowered.



Fig. 5: Work in progress

6. Replacement of old channel sleepers by newly fabricated channel sleepers continued in span 3 and 4.
7. Next placing of rails and fixing of cleats were continued from one end so that trains can pass safely at restricted speed.
8. Work Completed safely with the achievement of

replacing 104 no. sleepers, slewing of four ends of three girders to true alignment.

9. Subsequently, two more blocks were taken for other spans and works executed with the same sequence.

5.4 Post-block Activities:

1. All fittings including guard rails were fixed.
2. 192 nos holes were drilled for HD Bolts of 20 mm diameter in new locations and grouted.
3. Rails were changed due to heavy side wear and true alignment of track was achieved.



Fig. 6: Newly laid channel sleepers

6.0 Achievements:

- Both the slewing of four ends of girders on two piers and changing of channel sleepers were done at one go in one block. Most importantly, changing of a minimum number of channel sleepers was mandatory for running the traffic after cancellation of block.
- Since the pier was of circular shape and the bridge was on a height, inadequate working space for placement of jacks, movement of workers and placement of channel sleepers. This made the execution very difficult.
- Being on a busy section availability of required block was a problem.
- Being heavier than the wooden sleepers, handling of channel sleepers required more manpower and time. Due to space constraint, utilisation of manpower was difficult.
- The lead for placement of channel sleepers was more than 50 m in cases and it was extremely difficult to handle heavy channel sleepers during the block.
- Finally, precision of work was the key in achieving the end result.



Fig. 7: Bridge No. 77 after work



Fig. 8: Rectified misalignment and no false curve on Bridge No. 77

7.0 Conclusion:

After the completion of work following improvements were noticed:

- The alignment on the bridge found straight and correct.
- Both the track and the spans of the bridges are concentric.
- No vibration on the piers after jacketing.
- Most importantly, the TSR was relaxed in phases to normal speed. Presently, there is no temporary speed restriction on this bridge after time period of 6/7 years thus contributing in the increase of sectional throughput.
- A Long persisting defect has been eliminated finally for long from the system.

■ ■ ■

Precast PSC 'I' Girders – An experience and Overview in Connection to Execution of Dakshineswar Metro

By
Rajesh Prasad*

SYNOPSIS

The existing Metro from Noapara is getting extended from Dumdum to Dakshineswar with Baranagar as intermediate junction station and Dakshineswar as terminal station. The total length of the elevated corridor from Noapara is 4 Km out of which 2.2 Km is on the viaduct and 1.5 Km is on the Railway embankment. The construction Metro requires diversion of 1.8 Km of National Highway (Expressway). For the purpose of construction of viaduct pre-cast PSC girders are being used where the maximum length of PSC girder is 33 m. Presently road crane having capacity 272 tonne is being used for erection of girders. In this paper efforts have been made to elaborate and give emphasise on execution of precast PSC girders being used for construction of Metro viaduct.

1. Introduction

Construction of Metro corridor from Noapara to Dakshineswar is being executed through a design and built contract. The contract has been awarded based on the various tender drawings and IIT/Delhi is the Proof Consultant for clearing the various drawings submitted by the Designer on behalf of the design and built contractor. For the viaduct, PSC Girders of M50 grade are being used. PSC girders are not new to the context of Railways. For the said purpose a casting yard near Dakshineswar has been developed and after casting and curing, the same is transported through long trailers and by using road crane of 272T Capacity, erection is done over the piers. The I-Girders of M50 grade are post-tensioned type and prestressing is carried out in two stages i.e. first stage after 7 days of curing and second stage after 28 days of curing or alternately when full cube strength is achieved. In exceptional cases second stage of prestressing is done after casting of the deck slabs as per the designs submitted by the designer and cleared by IIT/Delhi.



Expressway Diversion for Construction of Viaduct

2.0 Sequence of execution :

For casting of the precast I-girders, following flow chart has been considered:

- I-girder soffit bed preparation.
- Providing reinforcement as per drawing with proper cover on bottom and sides.
- Laying & profiling of HDPE sheathing pipe and HT strands with anchorage set fixing.
- Assembly of stressing end, dead end and side shutters with proper supporting system.

* *Chief Project Manager(M)/RVNL/Kolkata*



Casting of I-Girders with pump concrete

- Concreting of the I-girders after above steps are completed.
- De-shuttering of the side shutters, after final setting of the concrete and curing of the same by wrapping with Hessian cloth and sprinkling of water on the surface of the I-girder.

3.0 Work procedure :

The work procedure for the execution of the precast I-girder as mentioned in 2.0 shall be elaborated as follows:

3.1 I-girder soffit bed assembly :

I-girder soffit bed is prepared with concrete and structural channel, plates etc.

3.2 Fabrication of reinforcement :

- Bar Bending Schedule (BBS) is prepared from approved drawing.
- Cutting of reinforcement steel is done by bar shearing machine. Bending of the bars is done in bending machine. Laps, chairs and spacer bars are provided



Shuttering & Gantry Crane in Casting Yard

for proper positioning of the reinforcement. Cover blocks are provided sufficiently to maintain cover as per approved drawings..

- Rebar cage is assembled including dowels for cross beam portion along with sheathing profile arrangement.

3.3 Sheathing & guide cone fixing :

- HDPE sheathing ducts profile is done by fixing with support bar and joining one sheathing pipe to another sheathing pipe by push-fit couplers.
- Profiling (layout of HDPE ducts) is carried out according to the co-ordinate (x,y) given in the approved drawing.

3.4 Steps on cable profiling :

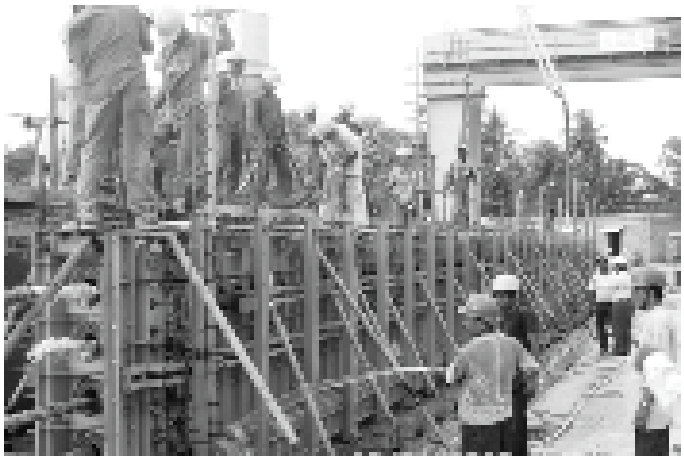
- HDPE duct is fixed as per the X, Y co-ordinate available in the approved drawings.
- Cone boxes are fixed at required locations. Fixing of guide cones (anchorage cones) to cone box shutter is done by using nut and bolt.
- Cable support/ chairs are firmly tied to the girder reinforcement and duct which is tied by binding wire, so as to avoid displacement of cable during concreting. Care is taken to make profile for the HDPE pipes.
- HDPE pipe is fixed over supports. At the ends of the cables, HDPE duct is connected with the guide cone and the joint sealed with masking tape to avoid ingress of slurry during the concreting.
- HT strands are inserted into the sheathing ducts one by one from any one end side of I-girder. After completion of threading, it is ensured that sufficient grip lengths are kept at the anchorage side for stressing.

3.5 External side shutter assembly :

All shutter panels are connected with nut and bolt arrangement, ensuring alignment by turn buckle and tie rod tightening with wingnut.

3.6 Casting of I-girder :

- After reinforcement placing and shutter fixing and alignment is complete, once again is checked if all supporting system and cover block of rebar cage placed properly.
- All necessary gaps are filled by putty, foam & masking tape (whichever is applicable) to arrest slurry leakage during fixing the shutter panels.
- Lifting hook arrangement is provided inside the girder to be embeded in concrete.



Form work, Gantry & Casting arrangement

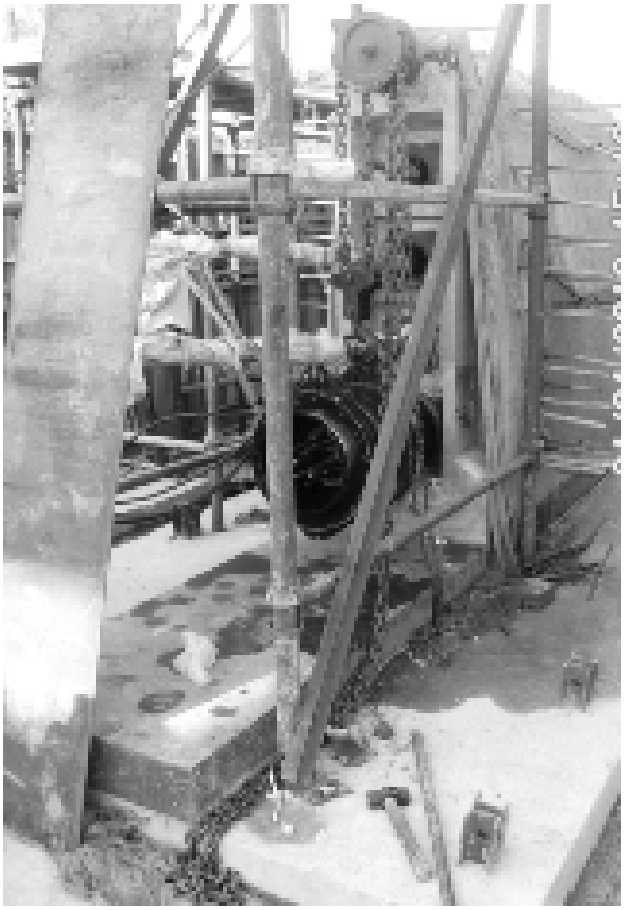
- Placing of concrete is normally done by crane bucket or through pumping. While inserting the vibrator, care is taken that it does not damage the sheathing of tendons. Concreting is started from bottom slab, and then moved to web. On completion of web concreting upto 900 mm, final pouring is done upto top of I-girder shutter. Finishing of concrete is leveled rough surface.

3.7 De-shuttering and curing :

- After final setting of concrete, the de-shuttering of stressing end shutter, dead end shutter and side shutters is carried out. This is followed by curing by sprinkling water with the help of Hessian cloth laid over it.
- For each I-girder 'ID' is marked by suitable paint on any one side of the I-girder so that during erection it can be easily identified for type of length, inner or outer girder.

3.8 Stressing of the Cables :

- Before commencement of stressing, grip lengths are to be cleaned. Then permanent wedges are to be fixed with strand to keep the bearing plate along with the anchorages.
- 4000MG hydraulic jack with electrically operated hydraulic pump is placed by inserted LRPC strand at one end. Other end strands are locked by permanent wedges.
- Jack is connected with pump by means of hydraulic hosepipes and Pressure gauge is fitted with pump. After giving electrical connection to pump, it is operated with levers. Required pressure is applied for all strands together and the elongation is measured at stressing jack end by measuring ramp coming out at jack end and noted down. Applied pressure is certain



First Stage Prestressing after 7 days of casting

interval as per stressing format and final pressure is applied as per approved design load. During application of load codal provision is followed and final guiding factor is considered on elongation length of strand. After applying required load, permanent wedge is locked with the strand inside the bearing plate.



Stacking of I Girders in Casting Yard

- The tensioning force applied to any tendon is determined by direct reading of the pressure gauges elongation with the calculated elongation. The calculated elongation is invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer. The difference between calculated and observed tension and elongation during pre-stressing operations are regulated as per specification.
- First Stage and Second stage Stressing are done as per approved drawing detail.
- After completion of stressing, Excess grip length of strand is cut leaving 20mm projection beyond the locked permanent wedge.

3.9 Grouting of the Tendons:

The extra length of strands, leaving 20mm projection beyond the wedge is cut. The cable ends are sealed by 1:3 Cement Sand mortar. All sheathing ducts are washed fully and then grouted as follows.

- Grouting of the tendons are carried out as per approved non-shrink grout mix.
- Once the concrete is set, we can start the grouting operation. Grouting is done by using electrically operated Grout pump. The grout pump is fitted with a pressure gauge.
- After Pump is connected electrically, required water is poured on the top drum and cement is then added with water. Then non-shrink compound is added with the mix. Once the grout mix is ready, it is pumped in to the cables through the inlet vent fixed with anchorage cone. Grout mix will travel inside the cable duct by water displacement method and coming out from other end outlet vent. After the original grout comes out from the other side of the cable, it is blocked by attached valve and pumping is continued till the pressure increases to 5 kg/cm² and is maintained for 1minute. This operation is repeated for all cables.

3.10 Recess filling at both end :-

- After completion of grouting operation, Recess filling is to be done by putting necessary reinforcement, plain supported ply-shutter.
- Top portion of 200mm is to be kept open from end face shutter and required grade of concrete to be poured manually.
- Once recess concrete pouring is complete then top 200 mm portion to be packed by less slump concrete.
- After setting of concrete, deshuttering is to be done and necessary finishing to be done by (1:3) cement sand mortar mixed with sika latex as non-shrink compound.
- If required carborandum stone can be rubbed on concrete surface to appear straight and leveled finish but any rectification by means of repairing the concrete is not permitted.

3.11 Finishing of girder surface :-

- To achieve the best possible finish, we use best quality steel shutter, proper needle vibration, layer wise concrete pouring and outside the shutter, wooden maleting is done during casting to remove trapped air bubble.
- After de-shuttering, if there are visible for big air bubble impression or honey comb type surface then following finishing process only with the approval of the Project Director under exceptional circumstances can be done but cement wash is strictly not permitted.

  i) Cleaning the surface by wire brush.

  ii) Applying cement sand mortar (1:3) with lime powder and sika latex mixed water as non-shrink material on the required concrete surface area.

  iii) Water curing or locally curing compound of approved brand to be applied.

  iv) Carborandum stone is rubbed to get smooth concrete surface.

Checklist for I-Girders is enclosed as Annexure-I. This is strictly followed at site.

4.0 Erection of I-girders :

The scope of erection basically comprises of the followings:

- Installation bearing pads on pedestals
- Transporting of I-girder from casting yard to site.
- Lifting of I-girder from trailer by crane
- Placing of I-girder by crane over pedestal bearing of Metro viaduct piers.



Cros

SN	Description	Type/ Brand	Remarks
1	Trailer 100 feet	As per requirement with supports.	Fitness certificate, to ply on road, is provided
2	Crawler/wheel crane 272 MT	Manitowoc 2250	Load chart attached. Fitness certificate is provided.
3	2 Nos. 50 m gantry crane	As required in precast yard	Already using in precast yard.
4	Spreader/ lifting beam/ strong back	As required	As per approved drawing
5	Shackles, wire rope slings	As required	
6	Survey instrument	1. Total station with accessories 2. Auto level	
7	Welding machine	As required	
8	Adhesive/ other equivalent brand	As required	
9	Elastomeric bearing and seismic pad	As per approved drawing	

5.1 Materials :

1	Adhesive/ other equivalent brand	As required
2	Elastomeric bearing and seismic pad	As per approved drawing

6.0 Work methodology :

6.1 Fixing of elastomeric bearings and seismic arrester.

- After the curing is done for pedestals, the elastomeric bearings & unreinforced neoprene pad are fixed in position on the padestals and seismic arrester as per the approved drawing.
- Position of the bearings shall be accurately marked on pedestal and the area where bearings is seated accurately leveled.
- Bearings are placed between true horizontal surfaces and at true plan position of their control lines marked on receiving surfaces. Concrete surfaces are made free from local irregularities.
- Bearing are placed on pedestal after applying of adhesive like other equivalent brand in between bearing & pedestal surfaces.
- Bearings are placed in a recess as shown in the relevant drawings.
- For doing so a team of surveyor constantly supervises and ensures the proper fixing of bearing as per approved scheme. The presence of the same surveyor from start of the project till completion is being ensured.
- For further details please refer to the IRICEN publication and clause No. 2005.6 of MORTH specification.

6.2 Transporting and shifting of I-girder from casting yard to site :

Initially, the route from casting yard to site are assessed prior to commence the transportation of I-girders from stocking yard. Before shifting of I-girders from stacking yard, first required girder is identified at the casting yard and 100 ft trailer is placed at the end of the platform of stacking yard. By using of 2 Nos. of 50 MT gantries at present yard identified girder is lifted and placed properly on the 100 ft trailer. For doing safe operations, a team comprising of competent gantry crane operator, banksman, Safety Officer, Mechanical Engineer and Electrical Engineer etc are available all the time during lifting, loading, transporting and other activities related to I-girders.

6.3 Transportation and reaching erection site :

After ensuring proper placing & locking of girder with 100 ft trailer, the trailer will move slowly towards the site where the particular span of girder is erected. 100 feet trailer is positioned based on the available space as per the

requirement.

6.4 Positioning of crane :

The dimensions of cranes and the positions of crane are shown in the various stages of erection of girders in the approved method statement. The boom length of the crane and capacity of drane is desired based on the position of cranes from unloading and lifting to the erection level of girders including weight of girders.

Once banksman is available for signaling operations and to direct the crane operator in lifting and placing of girders in position. Crane operator shall follow only the signaling of banksman directions during the erection process. For doing safe operations, a team comprising of competent gantry crane operator, banksman, Safety Officer, Mechanical Engineer and Electrical Engineer etc are available all the time during lifting, loading and unloading and other activities related to I-girders launching. The various operations of the process has been shown in Annexure-II.

6.5 Erection and placement :

The I-girders are placed directly on top of already placed elastomeric bearings. Different stages at erection procedure has been described with schematic sketches at Annexure-III. While placing the girder on ground, minimum bearing area has to be provided. Also, verticality is to be maintained with utmost care while lifting the girder to avoid crack.

7.0 Environment, Health and Safety :

- Working area is to be barricaded and display boards are to be provided.
- Sufficient lighting is to be provided in the working zone at night times.
- Only certified plant and machineries are to be put in operations.
- Operators shall have sufficient relevant experience and valid license to operate the machineries.
- Safety stewards are to be engaged for monitoring to avoid unsafe conditions and unsafe acts.
- All the staff and workmen are to be provided with personal protective equipments like safety helmets, safety hand gloves, safety shoes, safety goggles, retro reflective jackets and ear plugs as per the requirement.
- All the persons involved are given the task briefing before start of the erection activity.
- First-Aid box is to be made available at site office, at casting yard and at worksite.
- Safety cones and flags are to be used to control the traffic
- Along with the methodology the crane, Traveler, Spreader/ Lift beam documents, Third party certificate and lift plan are made available.

8.0 Check list for the quality and the safety at the worksite on behalf of the Contractor:

- Project Manager – Responsible for monitoring of project and co-ordination with client and consultant.
- Site in Charge – Responsible for the correct and safe execution of the works falls within the execution department, and shall report to Project Manager.
- Safety Manager – Responsible towards SHE requirements at site and shall report to Project Manager.
- QA/QC Manager – Responsible for maintaining and fulfilling all related documentation and responsible for quality control and shall report to Project Manager.
- QA/QC Engineer – Responsible for verification/ inspection of all the activities in accordance with Specification/ checklists.
- Site Engineer – Ensures the construction activity as per approved work procedure, correct quality & safety and monitoring all records and shall report to Project Manager.

9.0 Check list for work :

- Survey Protocol for placing of elastomeric bearings, neoprene pad for seismic arrester and other related works are to be obtained for position of girder before erection.
- Safety Protocol related to all activities for launching of I-girder are to be issued before starting of launching of girder.

10.0 Conclusion

Pre Cast I-Girders are generally economical way of executing the viaduct and also it is faster provided the erection procedure is not complicated. For handling of such girders, a lot of space (of the order of 1-3 hectares) are required. The method statements and procedure orders of various micro activities in handling of PSC girders have been deliberated in this paper so that this can be helpful in execution for similar nature of work at some other places all over the Indian Railways.

Annexure-I

CONSOLIDATED CONSTRUCTION CONSORTIUM LIMITED

Checklist for I-Girder

I-Girder ID:-

Date :

Drawing no.:-

Casting Bed no.:-

Grade of Concrete:-

For Reinforcement:-

1) Reinforcement cage fabrication as per dtg. :-

2) All Dareting rebar at end anchorage portion placed :-

3) Cross beam dowel rebar placed :-

4) Cover block properly placed :-

For HDPE Sheathing Profile :-

1) Sheathing profile properly done :-

2) HDPE sheathing pipe with coupler arrangement properly tied :-

For Shuttering :-

1) All Panel side shutter fixed and aligned :-

2) Both end shutter fixed with anchorage cone :-

3) Cross beam shutter panel fixed :-

4) Threads and Turn Buckles properly tight and fixed :-

For Anchorage Cone and LRPC Strand :-

1) All Tube unit / Anchorage cone fixed with end shutter :-

2) All Tube unit / Anchorage cone connected with respective sheathing pipe :-

3) LRPC strand inserted to all Cable position as per dtg. :-

For Lifting Hook :-

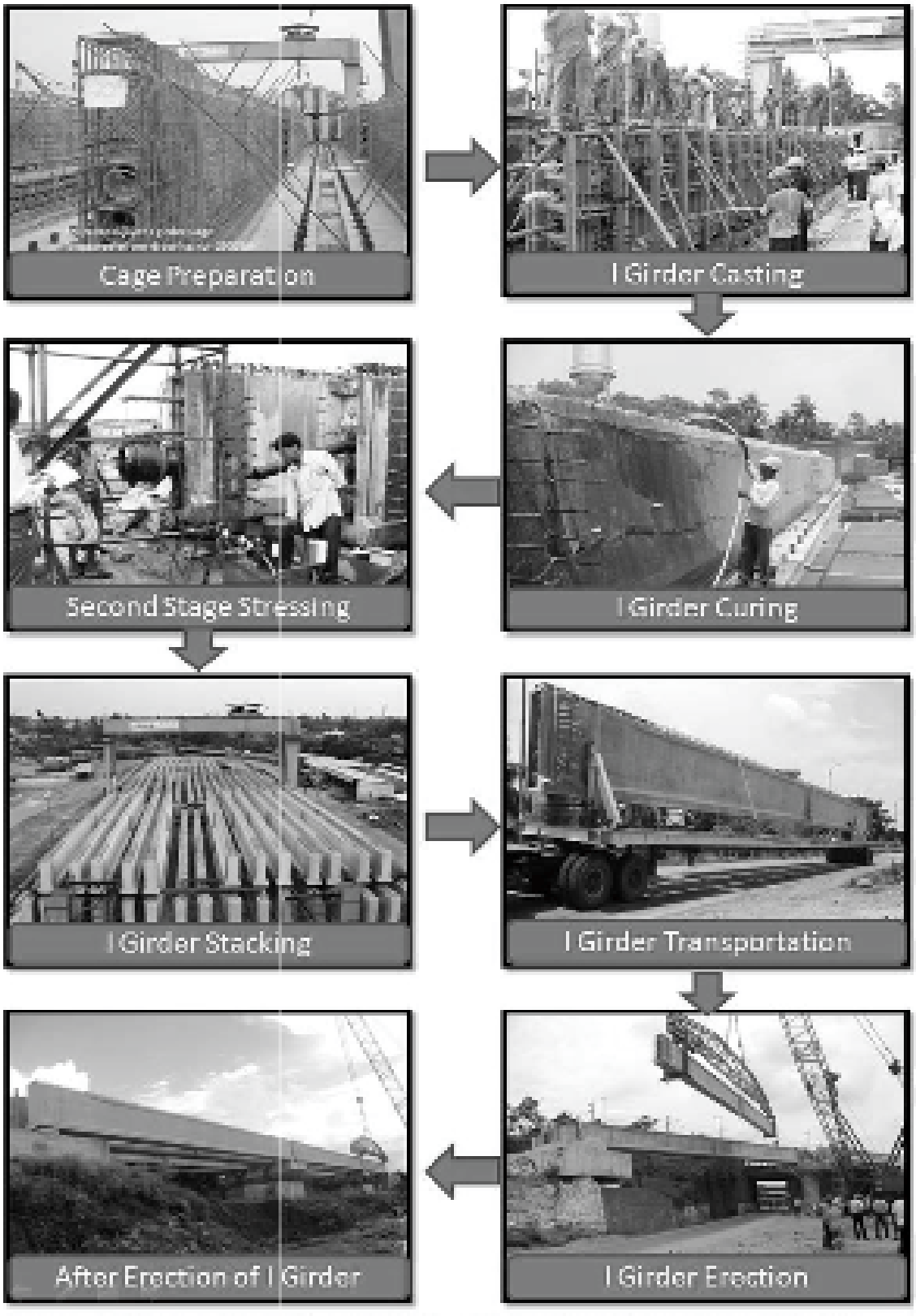
1) Lifting hook arrangement properly placed at both end :-

CCCL Representative

RITES Representative

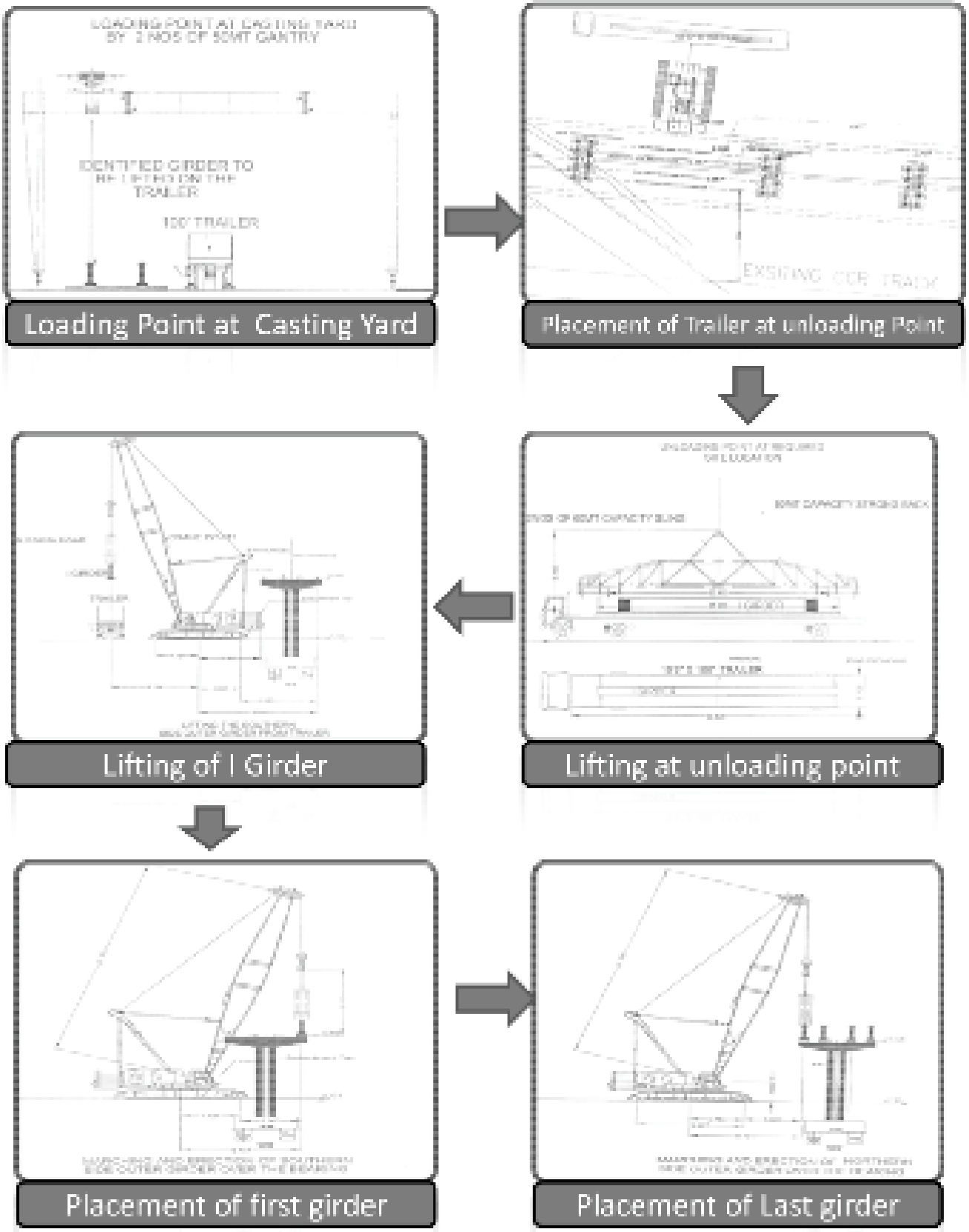
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Annexure-II



Execution of PSC Girders in Dakshineswar Metro

Annexure III



Sequence of handling of I Girders and road Crane operation

Laying of Crossover Between Straight & Curve

By
Arun Kumar Singh*
Shambhu Kumar**
Masood Ahmed***

1. Introduction

Available software for laying out crossovers does not incorporate examples for cross over taken out of a curve to connect a straight track. Examples shown in the relevant books also do not incorporate it.

But, the field conditions do require laying out of such crossovers, which is more cumbersome.

The software designed for 'Layout calculations for cross over' deals with various conditions pertaining to the parallel tracks only, as shown herein.



Convention ways in practice:

The following methods are generally adopted in field for laying out of curved for non-parallel tracks:

- By THEODOLITE

It involves more time and wastage of man days.

- HIT & TRIAL method:

Sometimes hit & trial method is applied at site to suit the field conditions. It becomes strenuous especially in busy yards. Accuracy is also at stake, practically.

Necessity for the method under discussion:

DRAWING is the language of Engineers.

With the help of AutoCAD, a drawing is easily generated to the scale. All sorts of dimensions (including aligned length, included angle, etc.) are then automatically read and marked over the drawing with the finger tips.

So, AutoCAD is resorted to as a good solution here.

With the help of AutoCAD drawing, the field/ yard condition gets appeared exactly over the paper to a desired scale and so, necessary trials/ corrections may be done without strain.

Brief description of the case:

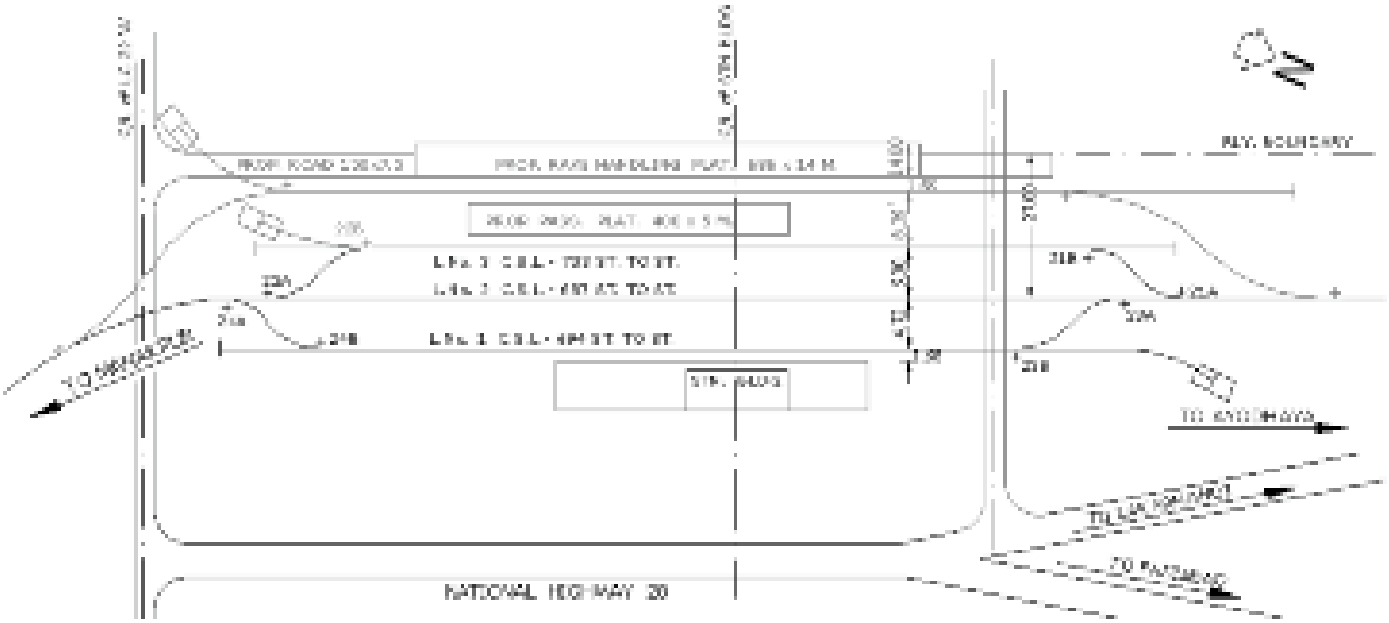
- KATARA is a 3-line crossing station providing route to 'AYODHYA', the holy pilgrim.

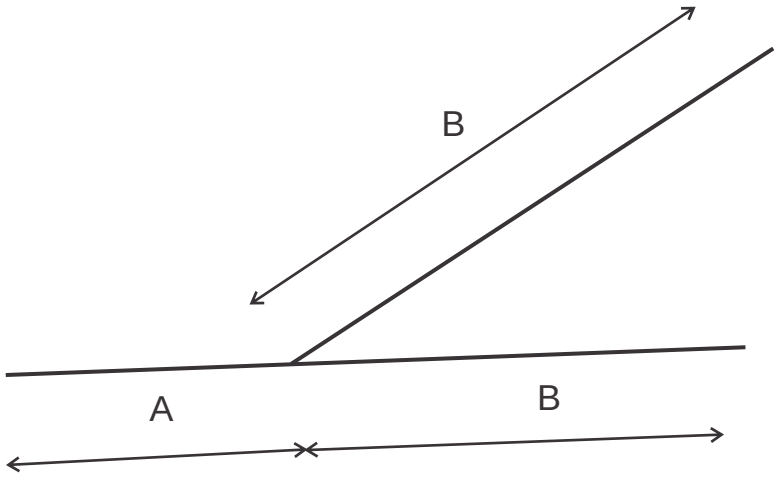
*DEN/LJN/N.E.Rly
**AEN/NWD/E.C.Rly
***XEN/IZN/N.E.Rly

Integrated Course No. 13102

- Provision of Rake handling siding along with two new platforms was proposed there to accommodate heavy Goods and Passenger traffic.
- At Manakapur side of the yard, main line lies on 3° curve which initiates just after S.J. of point no.24'a'.
- Within the yard limit, LC No. 22A falls at the curve for National Highway-28 with huge road traffic.
- The Rake handling line (straight) was required to be connected with the curved main track coming from Mankapur side through a Point & Crossing of 1 in 12 (in main line) and 1 in 8 1/2 (symmetrical split) point & crossing in rake handling line.
- Since the distance between Main line and proposed rake handling platform line is 13.66m. and NH-28 is very close to the S.J. of 1 in 8 1/2 (symmetrical split), there was every possibility of passing the cross over through NH-28.
- Since, it was presumed that cross over is passing through NH-28, the layout should be precise, because any further alteration of track alignment falling in NH-28 portion was very tedious.
- Due to NH-28 constraint (heavy traffic) , layout by Theodolite was also very cumbersome and non practical approach; resorting to try and error method was illogical.
- Due to the above limitations, a way out was being explored which have feasibility for trying most suitable and feasible option for laying the curve there, that too without exploring ways at site. For this, Auto-CAD was resorted as a reasonable solution which gives precise layout of the cross over.

Miniature plan of the Yard is shown below (not to scale) for general assessment of the field conditions.





Here, the objective is to set out cross over at the enlarged location at 'A'

Our perception for laying out of Curve:

For laying of a 52Kg CMS crossing over B.G., nodal 'A' & 'B' lengths are specified.

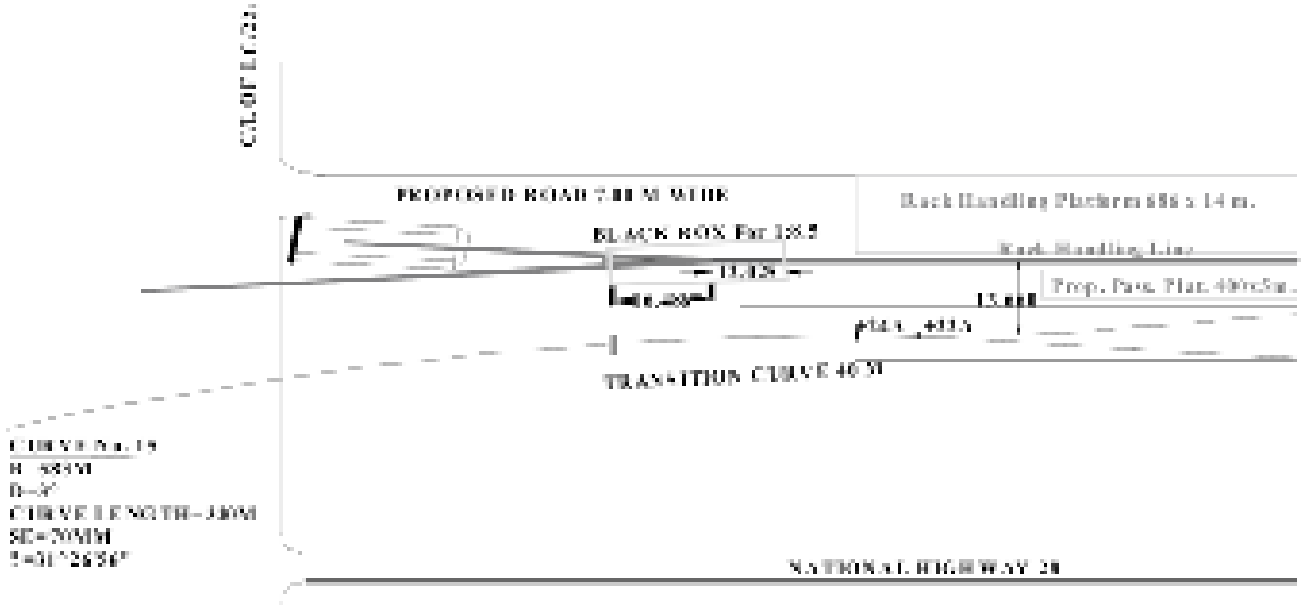
it is 12.025m. & 16.486 m. respectively for 1 in 81/2 and 16.989m. & 22.914 m. for 1 in 12 pt. & X-ing.

It is shown in the 'Black box' above.

Method adopted in this project for dealing with the situation:

Here, our perspective is to draw the field and field conditions at paper along with all the constraints prevailing at field. The Yard drawing is prepared in Auto-CAD at suitable Scale.

The field condition for the location in concern is as below at suitable scale:



Laying out of curve is done using Black box for a specific type of cross over. Here Black box for '1 in 8.5 T/O for S.S' and '1in 12 T/O for 3° curve' is required, so these are drawn over Auto-CAD to a suitable scale.

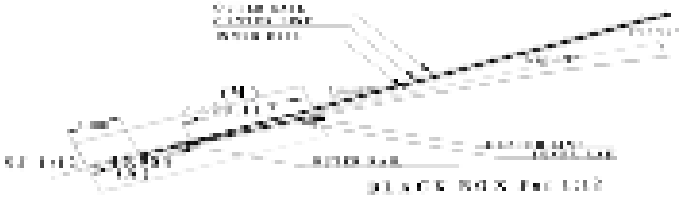
Black box for '1 in 8.5 T/O for S.S'



Method for drawing:

1. As per laid down procedure and as depicted in the Black box, 12.025 m long line (equal to 'A') is taken along the center line .
2. For taking alignment of 1 in 8.5, line segment of 17m is drawn along the C/L and from there, 1m. Long lines are drawn at both sides of line for drawing symmetrical lay out for 1 in 8.5 T/O.
3. Line segment of 16.486m. (equal to 'B') is drawn from end point of line offset (of 1m.) from the line of 12.025m. It forms Black box for 1:8.5 SS.

Black box for '1in 12 T/O for 3° curve'



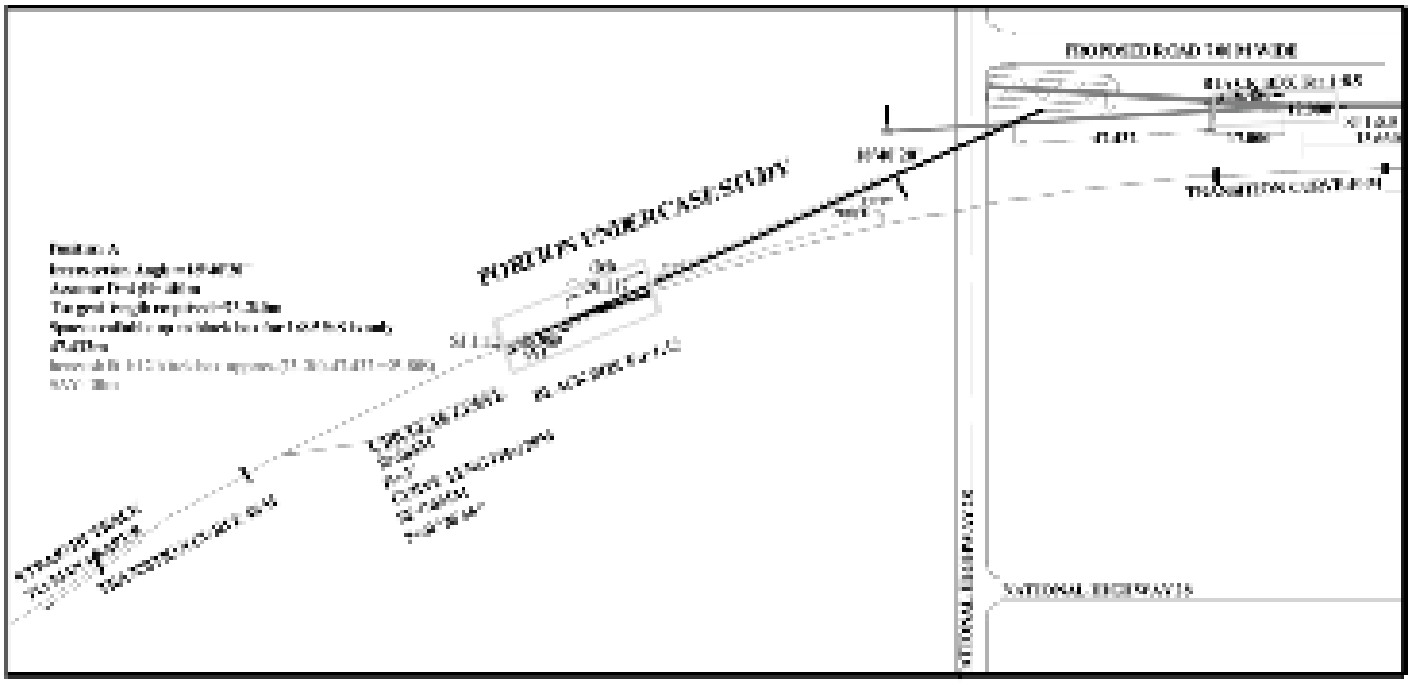
Method for drawing:

1. Line segment of 19.989 m. is drawn along C/L of the curved track: this is 'A' from proposed S.J.
2. From this, 20.111m. long line is drawn along the C/L (this is M). From end of this line (A+M distance), alignment for outer & inner rail is drawn. Tangent is drawn from the outer Rail.
3. Angle F (= 4°45'49") is then drawn from tangent. This will be the inner rail for cross over portion. C/L of the cross over is drawn with respect to this inner rail.
4. C/L of the crossover where crosses the C/L of 8.5 Black box provides the Angle of intersection.

Now, different trials are made over the Auto-CAD drawing for laying out the curve in Auto-CAD which suits the prevailing site conditions along with all the constraints.

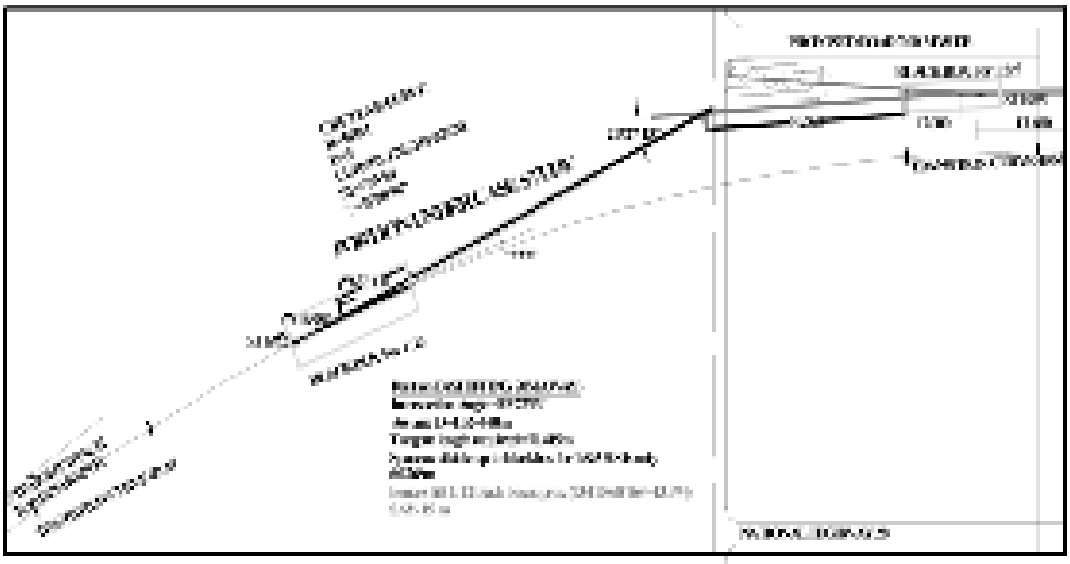
Trial-1

- An arbitrary point is selected over the main line curve.
- Tangent is drawn from end point of 1:12 Black box cross over leg. It intersects at 18°40'20" with cross over leg of 1:8.5 Symmetrical Split.
- Distance bet. Point of intersection to 1:8.5 Black box is found only 47.432m., which is not enough to accommodate the required tangent length of 73.240m. for 4° curve.
- Hence, it is proposed to shift the S.J. of 1:12 T/O by further 15m.



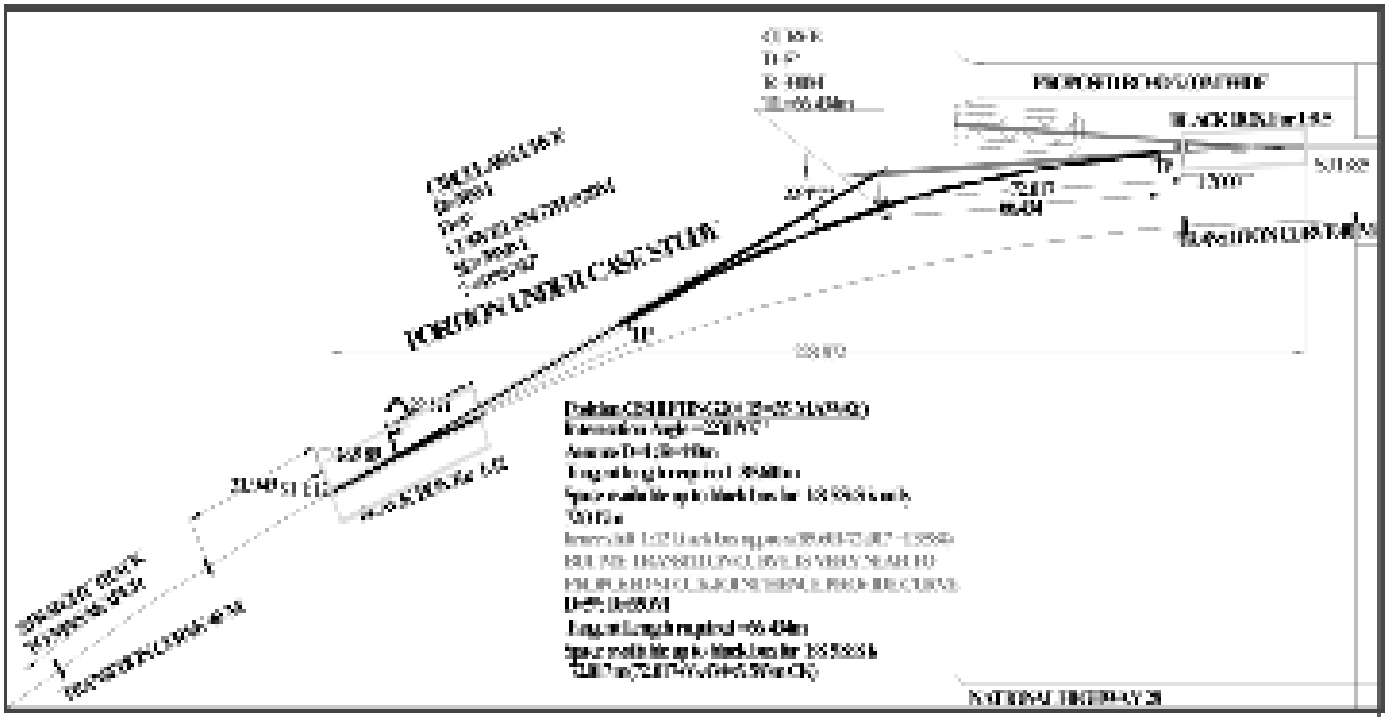
Trial-2

- Next point was selected 15m. away from the S.J. of 1:12 T/O .
- Again, tangent is drawn from end point of 1:12 Black box cross-over leg. It intersects at 20°27'13" with cross over leg of 1:8.5 Symmetrical Split.
- Distance bet. point of intersection to 1:8.5 Black box is found only 60.768m., which is not enough to accommodate the required tangent length of 76.415m. for 4° curve.
- Hence, it is proposed to shift the S.J. of 1:12 T/O by further 15m.

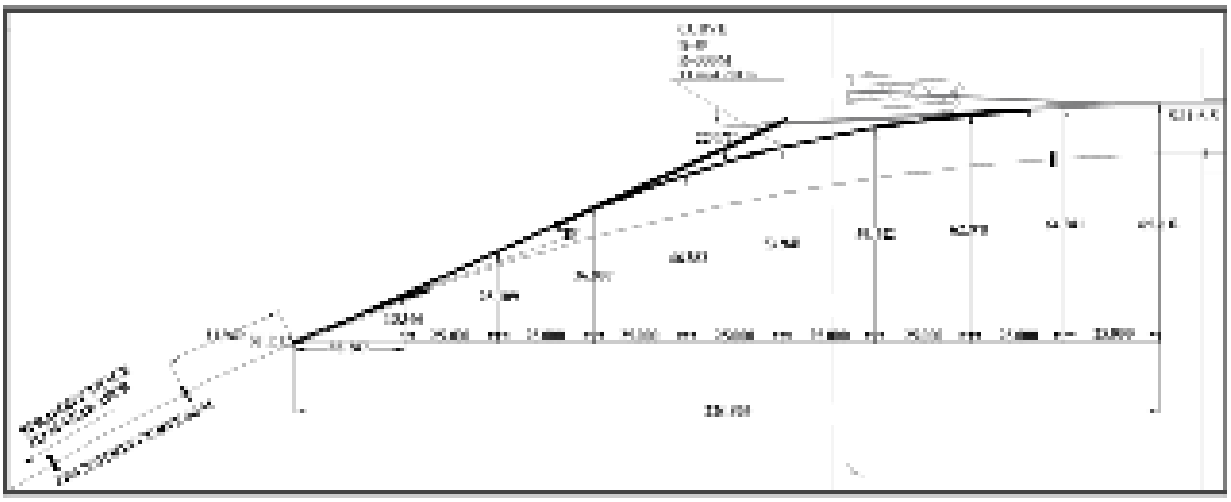


Trial-3

- Next point was again selected 15m. Away from the S.J. of 1:12 T/O .
- Again, tangent is drawn from end point of 1:12 Black box cross over leg. It intersects at 22°01'07" with cross over leg of 1:8.5 Symmetrical Split.
- Distance bet point of intersection to 1:8.5 Black box is found only 72.017m., which is not enough to accommodate the required tangent length of 85.601m. for 4° curve.
- By these trails, it is observed that if we move further, angle of intersection going on increasing. So, 4° curve will not accommodate there.
- So, 5° curve is provided in cross over portion. It gives tangent length of 65.478m. Which is well accommodating in the available space of 66.434m.
- Now, the total cross over length comes to 228.872m.
- Thus, the desired solution for accommodating the cross over with the prevailing field conditions were achieved. It led to setting out to curve in the field with all the desired parameters at X-Y axis, as shown further under heading of 'Detailed dimensions".



Detailed dimensions for laying out of curve in field, as derived from the above methods are summarized in the sketch below:



Tunneling In Soft Ground Conditions

By
S. D. Patil*
D.D.Joshi**
R.B.Maharshi***

1. Introduction

1.1 Tunneling through soft ground conditions coupled with ingress of water is a challenging task for the construction engineers. In such fragile and unstable geological conditions, the tunneling by conventional method with the rigid supports viz. steel ribs (made up of ISMB/ISHB), alongwith RCC lagging and plum back fill concrete is critical. It is also experienced that the rigid supports are likely to deform under the high squeezing pressure acting on the supports due to high over burden. The rectifications of such deformed sections and maintaining the correct tunnel profile is also critical, time consuming and costly affair. Moreover, in spite of deploying costly construction equipments and expert manpower, the rate of progress is also not commensurate with the deployed resources. Hence, the conventional system of tunneling is not found appropriate system for the tunneling through soft ground conditions.

1.2 The New Austrian Tunneling Method (NATM) is basically appropriate methodology for the execution of tunnels in soft ground conditions having high over burden, leading to high squeezing pressure etc. This project report covers NATM along with basic principles, excavation methodology, tunnel support systems which are deliberated in the foregoing paras.

2.0 New Austrian Tunneling Method (natm):

2.1 History:

The term "New Austrian Tunneling Method" popularly known as NATM got its name from Salzburg (Austria). It was first used by Mr. Rabcewicz in 1962. It got world wise recognition in1964. This method has been evolved as a result of experience gained in Austrian Alpine tunnelling condition. The first use of NATM in soft ground tunneling is done in Frankfurt metro in 1969. The basic aim of NATM is for getting stable and economical tunnel support systems. This method has also been very useful in complex diversified geological condition where forecasting of the rock mass is difficult due to rapidly changing geology.

2.2 It consists of providing flexible primary lining viz. shotcrete, wire mesh, rock bolts, lattice girder etc. In case of weaker rock mass the use of pipe forepole/pipe roofing is also used for crown support. This in turn lead to less overbreak and safety during the execution. The main aspect of the approach is dynamic design based on rock mass classification and in-situ deformation. Hence, appropriate methodology and economy in the tunnel support system is achieved along with the rational approach of execution.

3.0 Broad Principles of NATM:

3.1 NATM broadly based on the following principles:

3.1.1 Mobilization of the strength of rock

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**SEN/KRCL
***ADEN/SW

Integrated Course No. 13102

mass: The method relies on the inherent strength of the rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.

3.1.2 Shotcrete protection: Loosening and excessive rock mass deformation should be minimised by applying a layer 25-50mm of sealing shotcrete immediately after opening of the face.

3.1.3 Measurements: Every deformation of the excavation must be measured. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground such as load cells, extensometers and reflectors.

3.1.4 Primary Lining: The primary lining is thin. It is active support and the tunnel is strengthened not by a thicker concrete lining but by a flexible combination of rock bolts, wire mesh and Lattice girders.





3.1.5 Closing of invert: Early as far as possible closing the invert so as to complete the arch action and creating a load-bearing ring is important. It is crucial in soft ground tunnels.

3.1.6 Rock mass classification: The participation of expert geologist is very important as the primary support as well as the further designing of supports etc during the excavation of rock requires the classification of the rock mass.

3.1.7 Dynamic Design: The deigning is dynamic during the tunnel construction. Every face opening classification of rock is done and the supports are selected accordingly. Also the design is further reinforced based on the deformation as noticed during the monitoring.

4.0 Classification of Rock Mass type:

4.1 Rock mass encountered during excavation cannot be said to be favourable or unfavourable only on the basis of the type of the rock. Several other factors also play part in the rock mass behaviour. The excavation in the rock is dependent on the rock class based on several factors such as compressive strength of rock, water condition, number of cleavages, condition of cleavages, dip and strike of the rock etc. There are various approaches of classification of the rock mass and most predominantly are RQD, RMR and Q factor of the rock mass.

4.2 Rock Quality Designation index (RQD)

4.2.1 The Rock Quality Designation index (RQD) was developed by Deere (Deere et al 1967) to provide a quantitative estimate of rock mass quality from drill core logs. RQD is defined as the percentage of intact core pieces longer than 100 mm (4 inches) in the total length of core. The core should be at least NW size (54.7 mm or 2.15 inches in diameter) and should be drilled with a double-tube core barrel.

4.3 RMR Value:

4.3.1 RMR value depends upon the following factors:

1. Uniaxial compressive strength of rock material.
2. Rock Quality Designation (RQD).
3. Spacing of discontinuities.
4. Condition of discontinuities.
5. Groundwater conditions.
6. Orientation of discontinuities.

RMR Value	100-81	80-61	60-41	41-20	<20
Rock Class	I	II	III	IV	V
Description	Very Good	Good	Fair	Poor	Very poor

4.3.2 Q Factor : It depends on the following:

1. Block size
2. Inter block shear
3. Active stress
4. Reduction for joint water flow
5. Presence of weakness zones

Q factor varies from 0.01 to 1000 i.e. from exceptionally poor rock to exceptionally good rock.

4.3.3 Rock Mass Behaviour Types (RBT)

A general indication of tunnelling conditions is described by means of Rock Mass Behaviour Types. Following RBT (according to "Conventional Tunnelling – The Austrian Draft", Austrian Society for Geomechanics, 2003):

Sl	Behaviour Type (BT)	Description of potential failure modes/mechanisms during excavation of the unsupported rock mass
1	Stable	Stable rock mass with the potential of small local gravity induced falling or sliding of blocks
2	Stable with the potential of discontinuity controlled block fall	Deep reaching. discontinuity controlled, gravity induced falling and sliding of blocks, occasional local shear failure
3	Shallow shear failure	Shallow stress induced shear failures in combination with discontinuity and gravity controlled failure of the rock mass.
4	Deep seated shear failure	Deep seated stress induced shear failures and large deformation
5	Rock burst	Sudden and violent failure of the rock mass, caused by highly stressed brittle rocks and the rapid release of accumulated strain energy
6	Buckling failure	Buckling of rocks with a narrowly spaced discontinuity set, frequently associated with shear failure
7	Shear failure under low confining pressure	Potential for excessive overbreak and progressive shear failure with the development chimney type failure, caused mainly by a deficiency of side pressure
8	Ravelling ground	Flow of cohesion less dry or moist, intensely fractured rocks or soil
9	Flowing ground	Flow of intensely fractured rocks or soil with high water content
10	Swelling	Time dependent volume increase of the rock mass caused by physical-chemical reaction of rock and water in combination with stress relief, leading to inward movement of the tunnel perimeter
11	Heterogeneous rock mass with frequently changing deformation characteristics	Rapid variations of stresses and deformations, caused by block-in-matrix rock situation of a tectonic melange (brittle fault zone)

5.0 Components and Sequence of Execution in NATM:

5.1 **Excavation in Soft Ground / Poor Rock Mass Tunneling:**

5.1.1 The excavation can progress in full face when the rock mass class is excellent, very good, good and then de pending upon the inferior rock mass class the excavation can be resorted to heading, benching. For further poorer and very poor class of rocks the excavation can further be divided into the sub-segments. Based on the studies Rabcewicz (1965) proposed that the excavation face may be divided into small cells that will help the ground stand until completion of the lining.

The excavation is carried out in six or more steps depending on the size and the geometry



of the tunnel.

Definition of Excavation Profile:

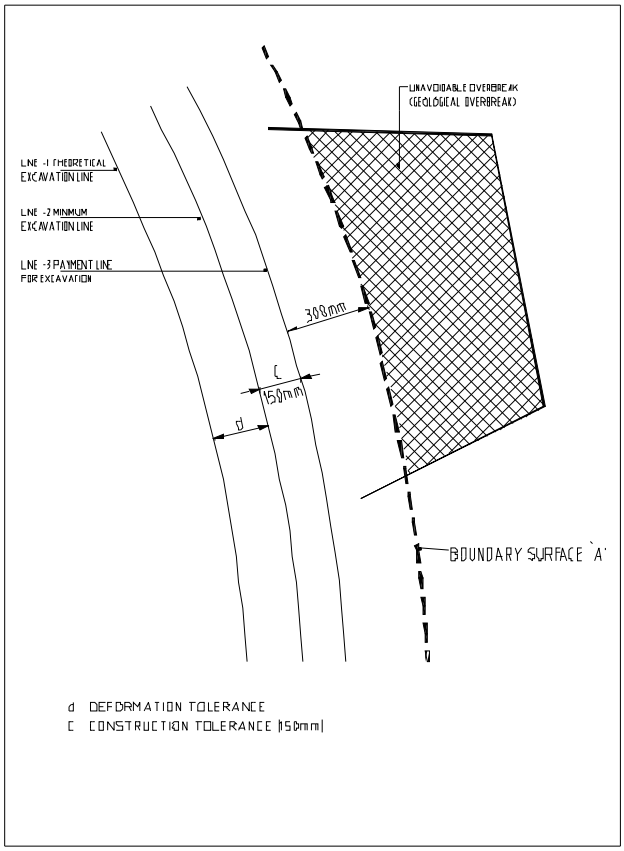


Fig. 1

5.1.2 The excavation profiles as shown on the cross section drawings refer to the theoretical excavation lines (Line No.1 as shown in the Fig.1).

5.1.3 Depending on the quality of the rock, an appropriate enlargement of the theoretical excavation profile is made in order to provide enough space for radial deformations. The minimum excavation line (Line No.2 as shown in Figure 1) is the line taking into consideration the radial deformations above theoretical excavation line. No rock materials will be permitted to remain protruding the minimum excavation line under any circumstances.

5.1.4 An additional allowance of 150 mm over and above minimum excavation line is provided for construction tolerances and excavation undulations (Line No.3 as shown in Figure 1). This line is the payment line.

5.1.5 Deformation tolerances are estimated to be:

Rock Classes I, II	:	d = 50 mm
Rock Classes III	:	d = 100 mm
Rock Class IV	:	d = 150 mm
Rock Class V	:	d = 250 mm

5.1.6 Overbreak:

5.1.7 Overbreak is the space created when the ground breaks beyond the pay line for the various rock classes. Occurring overbreak may be caused by improper workmanship and careless working technique (avoidable overbreak). Unavoidable overbreak is overbreak caused by unfavourable geological conditions.

5.2 Machinery Used:

5.2.1 Apart from the general machinery used in tunneling like Excavators, loader, tippers following machines have advantage of using:



- **Boomer:** it is a versatile machine having three arms machine. Its two arms are used for drilling and one arm has the bucket for the movement of the men for work. It is useful in fixing of Wire gauge, Lattice Girder, Pipe Forepoling, rock bolting. For rock bolting separate machine Tam

Rock can also be used.

- **Shotcrete Machine with Robotic arm:** This may be used for spraying of shotcrete rather than manual spraying so as to avoid human errors.



5.3 Drilling and Blasting:

The drilling pattern is decided based on the rock mass classification of the strata encountered.

The blast design is prepared for each cross section or subdivided cross section, containing the following information:

- Drilling pattern, hole diameters, spacing, depth and inclination
- Type, strength, amount in terms of weight and cartridges of explosives to be used in each hole, on each delay and the total for the blast
- Distribution of the charge in the holes and priming of each hole
- Type, sequence and number of delays, delay pattern; wiring diagram for blast; size and type of hook-up lines and lead lines; type and capacity of firing sources; type of condenser discharge blasting machine
- Stemming of holes and matting or covering of blast area
- Written evidence of the qualifications of the persons who will be directly responsible for supervising the charging and firing of the round

5.4 Protection of Portal Face:

Especially in soft rocks and cracked rocks the face of the tunnel portal should be secured

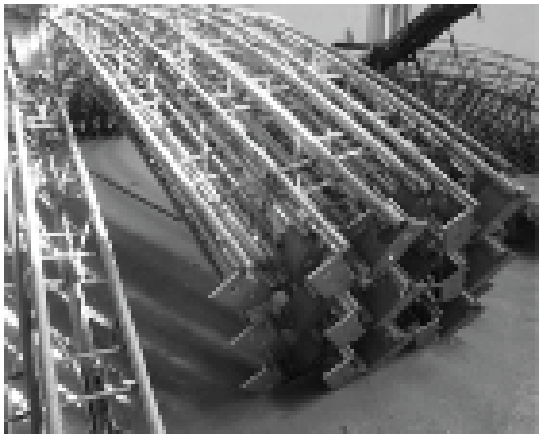


nicely to avoid any fall out and closing the way of the tunnel.

5.4.1 Sealing Shotcrete: Shotcreting with designed mix cement concrete M25 grade of 25-50mm generally used. Shotcrete Machine with Robotic arm is normally used for spraying of shotcrete.

5.4.2 Fixing of Lattice Girder: lattice girder is 3 Bars of steel reinforcement placed at three corners of triangle with 8mm steel bar for connection. Easy to handle as compared to steel ribs.





5.4.3 Fixing of wire mash: generally 6mm thick wires used. It can be fixed with boomer.



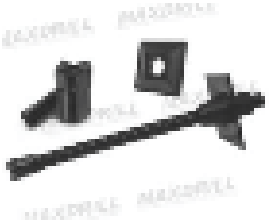
5.4.4 Primary Lining with Shotcrete: Shotcreting with designed mix cement concrete M25 grade in layers each not thicker than150mm shall be used.

5.4.5 Rock Bolting:

Types of Rock Bolts:

There are various types of the rock bolts may be used. Based upon the type of rock mass encountered during tunnelling i.e. rock mass classification, following rock bolts are being are being used:

1. **SN Type:** Normal steel tor steel bars of dia 28mm and above (generally used as 32mm) with cement grout, sometime the resin pouches can be used for better anchorage.
2. **SDR:** These are self-drilling type of Rock bolts with sacrificial bit at start, suitable for rapidly collapsing soils where the drilled hole collapses when drill bite is withdrawn.



3. **Expansion Rock Bolts (Swellex type):** The rock bolt is inflated after insertion with the water pressure for better anchorage.



Wire mesh is not used for Fibre Reinforced Shotcrete

5.4.6 Allowances for Settlement and Construction:

It has been observed that if the allowances are not given for the settlement or execution perfection then at later stage it may sometime cause problem in SOD especially in curves. Sometimes, the speed considerations in the tunnel are adversely effected. So during tunneling due allowance should be taken into the consideration for the excavation for allowing the settlement and construction tolerances to avoid any complication at the later stage. Generally 100mm for construction and for settlement it depends on rock mass classification.

6.0 Conclusion:

1. NATM approach of design and execution of the tunneling in varied geology and especially in soft ground tunneling is advantageous and scientific way of tunneling in comparison to the old /conventional way of tunneling.
2. This system monitors the rock mass deformation and designs the support system with reference to the rock mass type and deformation.

References

Indian Standards:

a. IS: 4756:- 1978 – Safety Code for Tunnelling work
b. IS: 3764 –1966 – Safety Code for Excavation work
c. IS: 4081-1967 – Safety Code for Blasting and Related drilling operations
d. IS: 4138-1977 – Safety Code for Working on Compressed Air
e. IS: 7293-1974 – Safety Code for Working with Construction Machinery
f. IS: 5878 (Various parts) – Codes of practices relating to tunneling and underground excavations
g. Indian Explosive Act -1988
h. Indian Explosive Rules -1983

i. IS: 823 -1964 – Code of procedure for manual metal Arc welding of mild steel

j. IS: 816-1969 – Code of practice for use of Metal Arc welding for General Construction in Mild steel.

CASE Study:

CONSTRUCTION OF TUNNELS T- 6, T10, T11 , T-12 & T9 BETWEEN KAURI AND DUGGA (KM 51.9 TO KM 61.0) ON KATRA- DHARAM SECTION OF UDHAMPUR – SRINAGAR - BARAMULLA NEW BG RAILWAY LINE PROJECT, J&K STATE EXECUTED BY KRCL.

Name of Contractor: M/s ITD Cementation (India) Ltd.

Approx Cost of Work: Rs. 189 crs (approx).

Tunnel wise length for Tunnels T6, T9, T10, T11 & T12:

Tunnel	From	To	Total length of tunnel (m)	Cross Section & Methodology
T6	51.935	55.418	3483.35	Elliptical shape with NATM.
T9	55.538	56.110	571.690	Elliptical shape with NATM.
T10	56.239	57.249	1010.00	Elliptical shape with NATM.
T11	57.296	58.126	830.00	Elliptical shape with NATM.
T12	58.198	60.336	2138.00	Elliptical shape with NATM.

The tunneling is being executed by NATM. So far, tunnels T10 & T11 are made through, tunneling lining works for above tunnels are in progress.

Geology

T6P1 side: Strata so far encountered are sandstone, siltstone of Sabathu formation for a length of 400m, thereafter, entire tunnel length i.e. upto RD 1177m has been excavated through major silt stone and minor clay stone and sandstone bands. Both sandstone and siltstone are generally fresh and hard. At places, clay filling was recorded along joints planes. Clay shale is generally soft.

Water seepage: Minor seepage was noticed from Ch 52.1291 to Ch 52.264 and heavy water inflow was encountered around Ch 52.750 which continued upto Ch 53.112. However, initial seepage of 5-6 lit/sec was got reduced to 2-3 lit/sec later on. Due to the presence of hard siltstone, heavy water seepage did not pose construction problem. Except for some over break which ranges from 20cm to 1.85m and few cavity formations, tunneling generally remained smooth.

At the tunnel portal 5-6 cm thick slope debris followed by thickly bedded siltstone alternating with sand stone and clay stone are seen.

T6P1A side: Strata encountered is clay stone/silt stone with occasional sand stone bands. Rock mass remained dry as such no tunneling problems has been encountered so far. Overbreak varies from nil to 0.50m.

T6P2A side : Strata encountered is sandstone, silt stone and occasional clay stone band. In the absence of sub-surface water tunneling has been done smoothly. Overbreak varies from nil to 0.75m.

Tunnel T9

Tunnel starts at chainage 55/538.35 through portal designated T9P1. Tunnel ends at chainage 56/110.04 at portal T9P2. Total length of this tunnel is 571.69 m. Portal T9P1 & T9P2 has yet not been developed. Land acquisition at the location of T9P1 & T9P2 is in process. Feeder road for both the portals T9P1 & T9P2 is yet to be constructed. Land acquisition for the feeder road has been completed. For this tunnel no work has been carried out till now. Dumping location is available just adjacent to portal T9P2 and T9P1. These dumping location are having adequate capacity though certain protection work shall need to be carried out to realize full capacity. Dumping location near T9P1 is also available though approach road up to dumping location needs to be constructed.

Geology

Alignment of this tunnel has been modified slightly. So far Geotechnical investigation of modified alignment has not been carried out. However, modified alignment is in close vicinity of earlier alignment of T9 for which geotechnical investigation was carried out. Therefore, some idea of geology can be made by looking at geology of earlier alignment.

In the earlier alignment strata encountered was siltstone, sandstone and occasional clay stone bands. Rock mass in general is classified as good. As such, tunneling problems was not encountered so far due to the presence of good rock and in the absence of water seepage.

Tunnel T10

Tunnel starts at chainage 56/239.67 through portal designated T10P1. Tunnel ends at chainage 57/249.67 at portal T10P2. Total length of this tunnel is 1010 m. Land acquisitions at the location of T10 P1 & T10 P2 is completed. Feeder road up to both the portals is constructed and motorable even during Monsoon. Portal developments on both the faces have been completed. Total 474.33 meter of tunnel excavation (Chainage

56/239.67 to 56/714) is completed from T10 P1 side. Total 125.75 meter of tunnel excavation (Chainage 57/249.67 to 57/123.25) is completed from T10 P2 side. Invert concerting has been completed from chainage 56/239.67 to chainage 56/565.67. Presently, only 150mm thickness of Invert concreting has been completed against total planned thickness of 300 mm. Wherever excavation has been done structural support ribs (ISHB 150 in the arch portion and ISHB 200 in the vertical portion) has been provided. Laggings slab of 50 mm thickness, consisting of M-20 concrete has been provided between arch ribs. Backfilling with M-10 concrete has been done between laggings & excavated face of the rock. Approximately 52.0 m length of this tunnel (From Ch 57/249.67 to Ch. 197.67) needs rectification as supports at this location are infringing to moving dimensions. Due to poor strata, RCC box has been provided at T10 P2 for portal protection. Construction of RCC box and other protective measures are still in-complete though major portion of RCC box has been completed. Not much water discharge is noticed in the tunnel and presently there is no water discharge from excavated portion. The shape of excavated tunnel is 'D' type. Dumping location is available just adjacent to portal T10P1. This dumping location is having adequate capacity though certain protection work shall need to be carried out to realize full capacity. Dumping location is available for portal T10P2 also.

Geology

Towards T10P1 side strata encountered was sand stone, siltstone and occasional clay stone. Except some wetness or minor seepage, rock mass remained dry and has been behaving as good tunneling media. However, towards the T10P2 side rocks are highly fractured, shattered and sheared and appear as overburden at places. The slow progress remained due to presence of poor rock mass. Besides, presence of poor rock mass in the tunnel, rocks between tunnel portal and road above the tunnels are highly crushed and mixed with surface clay and are slide prone. To prevent slide above the tunnel portal, heavy retaining work along both sides of the false portal in the form of RCC walls, beams has been done as per the recommendations of NHPC. Over break along tunnel from P1 side varies from 5cm to 1.40m whereas towards P2 side it varies from 20cm to 2m. Minor water seepage between Ch 57.491 to Ch 56.112 was recorded from crown and left half of the tunnel.

Tunnel T11

Tunnel starts at chainage 57/296.67 through portal designated T11P1. Tunnel ends at chainage 58/126.398 at portal T11P2. Total length of this tunnel is 830.0 meter. Land acquisition at the location of T11P1 & T11P2 has been completed. Feeder road for both the portals is constructed. Feeder road for both the portals is motorable even during Monsoon. Total 303.0 meter (Chainage 57/296.67 to 57/599) of tunnel excavation has been completed. Elliptical section has been provided for the excavated tunnel. Invert concerting has been completed from chainage 57/296.67 to chainage 57/511.67. Presently only 150mm thickness of Invert concreting has been completed against total planned thickness of 300mm.Through T11P1 portal, 303.0 m tunnel excavation has been completed from chainage 57/296 to 57/599. Portal T11P2 has yet not been developed fully. Dumping location is available just adjacent to portal T11P1. Dumping location is also available for portal T11P2.This dumping location is having adequate capacity though certain protection work shall need to be carried out to realize full capacity.

Geology - T11P1

During the construction of false portal, rock fall from top of the slope took place and buried the false portal. However, after sometime, slided material was removed and false portal found intact. About 310m tunnel length has been excavated through sandstone, silt stone and occasional thin bands of clay stone. Rock mass encountered in this is much better than rock mass encountered in the previous tunnel. Rock mass are generally free from sub-surface water and can be classified as good to very good and can stand without support for many days / months. No water seepage has been encountered so far. Both the portals are located in Muree formation i.e. sand stone, silt stone and clay stone. The general trend of bed suggests favourable condition for tunneling.

Tunnel T12

Tunnel starts at chainage 58/198.67 through portal designated T12P1. Tunnel ends at chainage 60/336.70 at portal T12P2. Total length of this tunnel is 2138.0 meter. Land acquisition at the location of T12P1 is completed. Feeder road upto portal T12P1 is also available. Portal development of T12P1 has been done and total 104.75 meter (Chainage 58/198.67 to 58/302.75) of tunnel excavation has been completed from this side. Invert concerting has been completed from chainage 58/198.67 to chainage 58/235.92. Presently only 150mm thickness of Invert concreting has been completed against total planned thickness of 300mm. Land acquisition for portal T12P2 and feeder road upto T12P2 is still under process. Cross section of excavated tunnel is "D" shape. Dumping location is available for T12P1. This dumping location is having adequate capacity though certain protection work

shall need to be carried out to realize full capacity. Dumping location near for T12P2 is also available though approach road up to dumping location needs to be constructed and protection works for development of dumping location needs to be done.

Geology

Excavation of the tunnel has been taken up from P1 side, i.e. Katra end portal after providing false portal. Fresh, massive and blocky sand stone, siltstone and thin clay stone bands have been encountered in the tunnel upto excavated length of 110.25m. Rock mass can be classified as good. Same rock types shall continue to encounter in the remaining tunnel length. Water seepage of 3- 4 lit/sec and wetness is recorded along the benching portion of tunnel between km. 58.823 and km 58.625. Over break in excavated length ranges from nil to 60cm. Both the portals are located in Muree formation i.e. sand stone, silt stone and clay stone. The general trend of bed suggests favourable condition for tunneling.

Cycle time of operations:

TIME CYCLE FOR FULL FACE i.e HEADING & BENCHING IN TUNNELS T6, T9 & T12

S. N.	Activity	Class II/III Pull = 2.5 m	Class IV Pull = 1.5 m
1	Survey & Profile Marking	1.00 Hr	1.00 Hr
2	Drilling	3.00 Hr	2.50 Hr
3	Charging & Blasting	3.00 Hr	2.00 Hr
4	Defuming	1.00 Hr	1.00 Hr
5	Face triming & Scaling	1.00 Hr	1.00 Hr
6	Mucking	5.00 Hr	3.00 Hr
7	Face logging	0.50 Hr	0.50 Hr
8	Profile check	0.50 Hr	0.50 Hr
9	Sealing Shotcrete	1.00 Hr	1.00 Hr
10	Laying of Wire Mesh	3.00 Hr	2.50 Hr
11	Erection of Lattice Girder		4.00 Hr
12	Rock-bolting	2.00 Hr	2.00 Hr
13	150mm/100mm & Final shotcrete	3.00 Hr	3.00 Hr
	Total	24.00 Hr	24.00 Hr
	Total Cycle time per metre	10.00 hrs	16.00 hr







Haldia DEMU Factory – State of Art of Technology Implemented on Fast Track by RVNL

*Rajesh Prasad**



Features: - The main feature of the project is pre-engineered buildings for faster execution over a shed area of more than 13000 sqm. The total area of factory is 1,85,000 sqm. Latest state of the art design, techniques have been employed for setting up of the DMU factory and it covers design, fabrication and erection of pre-engineered building sheds covering furnishing & assembly shops with two 35 T and one 15 T EOT cranes, store ward and electric sub-station covered with sandwiched panels of galvalume sheet, 20% sky light with polycarbonate sheet roofing and 300 mm dia turbo vents.

The salient feature of the factory:-

• Pre-Engineered Buildings & Sheds	:	13110 sqm	• Railway track	:	4.5 TKm
• Porta Blocks for Canteen, Administrative Building, Toilet Blocks etc.	:	678 sqm	• Hume pipes (750 mm & 450 mm dia) for drainage system.	:	1350 m
• Flyash filling for Land development	:	185000 cum	• EOT crane 15 T	:	1 No.
• Coarse sand filling for road	:	40000 cum	• EOT crane 35 T	:	2 Nos.
• Silver sand/earth filling over flyash	:	100000 cum	• Traversers	:	2 Nos.
• Earthwork filling for track	:	37000 cum	• Load test box	:	1 No.
			• Electrical sub-station	:	1 No.

Timelines followed by Rail Vikas Nigam Limited (RVNL) :-

Work Transferred to RVNL	:	August,2010	Costing and Productivity :-		
Contract Awarded for Factory at Sankrail	:	Dec,2010	Cost of Phase-I	:	115 Crore
Factory Shifted to Haldia due to Land Problems	:	02.02.2011	Output of Phase-I	:	1Rake/month
Turnkey Contract Awarded For Factory At Haldia	:	20.07.2011	Cost of Phase-II Being planned by Railway in PPP model	:	179Crore
Completion of the Project	:	Feb, 2013	Output of Phase-II	:	Rakes/month
Handing over to S.E. Rly	:	Apr, 2013			

**CPM/RVNL/KOLKATA*

Shimla Chosen for International Project to Lower Greenhouse Gases

The Queen of the Hills, as Shimla was fondly called by the British, has been shortlisted for a global project to lower greenhouse gas emissions on the pattern of European cities, a municipal official said. The Shimla Municipal Corporation is one of six Indian cities selected for implementing the "Promoting Low Emission Urban Development Strategies in the Emerging Economy Countries" project, said, Omesh Bharti, Municipal Health Officer.

He said the project, is to be executed by International Council for Local Environmental Initiatives (ICLEI) South Asia, with support from the European Commission, in collaboration with UN–Habitat. Besides India, the project is also being implemented in Brazil, Indonesia, and South Africa. Bharti said the civic body would enter into a memorandum of understanding (MoU) with ICLEI once it gets approval from the corporation's elected members.

Terra Green, July, 2013, pg 4-5

60,000 sq km of Western Ghats to be Green Zone

The Union environment ministry is expected to approve the K Kasturirangan panel report on Western Ghats and declare around 60,000 square kilometers of the southern hills—spanning across six states—as no-go area for mining, thermal power plants, and heavily polluting industries. Sources in the ministry said, the process has begun to finalize the decision after receiving comments from public and state governments on the panel report.

The panel—headed by the Planning Commission member K Kasturirangan—had been set up by the Central government after an earlier report of a team of ecologists, headed by NAC member Madhav Gadgil, had suggested for almost 75 per cent of the Ghats to be put under various levels of restrictions much to the opposition of the states and other interest groups alike. The Gadgil committee had suggested a blanket ban on mining and pitched for the powerful Western Ghats Authority to be the final arbiter of development activities in the region.

India will be World's 3rd Largest Construction Market by 2025

According to a study India will become the world's third largest construction market by 2025, adding 11.5 million homes a year to become a $1 trillion a year market.

The study also predicts that while India's infrastructure market is expected to grow at around 8%, the fastest among its sector, India is unlikely to achieve its plan target of $1 trillion investment in infrastructure, given the shortage of financing. However, while factors like high commodity prices, inflation and currency volatility affect its short term growth prospects, the writers feel that in the medium to long term, once global financial volatility passes, India is poised for a construction boom.

Ref. Construction Technology, August, 2013, pg 22

JNPT Outlines RS 2,000 Cr to Develop New Marine Terminal

Jawaharlal Nehru Port Trust (JNPT) has outlined an investment plan of Rs 2,000 crore to set up a marine terminal. Besides, the Port Trust also plans to enhance the capacity of its already existing twin berth liquid cargo terminals to 30 MTPA. The twin terminals of BPCL and Indian Oil Corporation presently at JNPT have a capacity of 5.5 MTPA.

The new marine terminal is expected to meet the demands for liquid cargoes like oil, acids and cleaning compounds. L&T Ramboll is involved in the designing and project management consultancy service of the project. The company has already submitted the detailed project report draft to the Port Trust.

JNPT had earlier invited bids for developing a container terminal worth Rs9,000 crore. Last week, JNPT signed a concession agreement with the subsidiary Dubai based DP World to develop a standalone container handling facility.

Ref. Construction Technology, August, 2013, pg 26

Bangalore to Get First Blast-Proof Building by 2014

Bangalore Data Centre building which will be resistant to blasts, floods and earthquakes will be ready by early 2014 in Banglore. It will house a vital data hub of the Unique Identification Authority of India (UIDAI).The building will get CISF cover, and house the primary data both demographic and biometric centre for the entire country. (The data relates to generation of Aadhaar cards.)

The data centre is coming up next to Tatanagar Main Road, off NH-4, near Sahakarnagar. Spread over 6,245

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The data centre is coming up next to Tatanagar Main Road, off NH-4, near Sahakarnagar. Spread over 6,245 sqm, the centre has a storage capacity of 6 peta bytes with 4,000 servers is built by Engineers India Ltd (EIL)

According to a senior EIL engineer, the building is blast proof with category 'C' rating. The data storage won't be impacted in explosions. The 500-mm-thick wall makes it a tough structure. In all likelihood, no structure in Bangalore has such safety specifications.

The building is also green building and a can withstand floods and quakes too.



According to UIDAI official, since Bangalore is under Zone-2 on the quake-sensitive scale, the data centre is being built for the next level - Zone-3 - to make it safer. The building is at an elevation of 2.1 metres from the road level, staying free of flood threats.

According to UIDAI deputy director general Mr. Ashok

Important Recommendations of CE/ TP Conference

on 25th-26th July, 2013
at IRICEN, Pune

1. Recommendations of SAG Committee relating to Changes in Special Standard Conditions of Contract on Security deposit, Cost of tender document, Validity of offer, Quoting of different PVC formula etc. and Modified PVC formula for ERC, GRSP and Metal/ GFN liner should be accepted by Railway Board.
2. Purchase Orders are being uploaded in the TMS portal by Zonal Railways. Name of some the P.Way items are not compiled in the portal which lead to uploading the P.O in some other name. Complete list of P. Way items is to be provided in the portal by CE/ TMS /N. Rly.
3. Uploading of PO & LOA with clear details of PVC should be done by all Zonal Railways.
4. Suitable mechanism should be built in IREPS to ensure confidentiality of vendors taking part in tender, which is not available at present.
5. For Composite GRSP and Improved SEJ, it is recommended that (1) There should be a warranty for 300 GMT traffic or 4 years, whichever is earlier, and (2) There should not be any provision of submission of Performance Guarantee
6. Powers for dealing with tenders should be modified as- HAG-Rs 25 Cr to Rs 50 Cr, SAG-Rs 5 Cr to Rs 25 Cr, JAG-Rs 1 Cr to Rs 5 Cr, SS- Upto Rs 1 Cr
7. RDSO should approve vendors for combination items which can't be used individually, such as combination liner, for the set as a whole.
8. PSC sleeper contract –Condition for Liquidated Damages (para 10.4 of the Agreement for PSC sleeper) may be suitably modified by Railway Board, linking it to availability of stacking area.

Lakshmi Brand Gasoline Impact Wrench

INTRODUCTION: - The GT-3500GE portable impact wrench is a powerful and sturdy tool for spot maintenance of way requirements. The one-man portable machine can be used for running on/off of rail bolts, tightening of threaded rail fastenings, fitting or extracting of coachscrews and drilling of wooden sleepers/ties. It can take a variety of standard 1-in sockets and augers.

Features

- Powerful 2-stroke gasoline engine
- Easy to maneuver, one-man operation for vertical and horizontal applications
- Capable of applying bolts up to 1-1/4 in diameter
- Standard 1-in square drive Standard Impact Wrench



End View



Top View



Side View

Average: 5.32 (m/s2)

Engine	Type	Two Stroke, Forced, Air Cooled, Single Cylinder
	Displacement	46.5cc. Ø 43X32 mm (Inner bore size X stroke)
	Fuel Tank Capacity	1 liter
	Fuel Mixture Ratio	1:25 (gasoline:2 cycle oil)
	Revolution (idling)	2,700 rpm ±250
	Revolution (loaded, impact)	7,120 rpm
	Revolution (non loaded, max)	9,880 epm
Ignition	Type	Electric
	Spark Plug Type	NGK BPMR6A
Carburetor	Type	Diaphragm
Impact	Square Driver Size	25.4 mm (1")
	Fastening Torque Range	1030 N.m (Full Throttle: 760 ft.lbf)
	Free Speed	800 N.m (Half Throttle: 590 ft.lbf)
Capacity	Bolt Diameter	1,200 rpm
Weight	Without Fuel	32 mm (1-1/4")
		19.50 kg (42.99 lbs)

E-mail: railwaymachines@gmail.com www.lakshmirailwaymachines.com

Navman Wireless Introduces GPS Tracking Device for Construction Equipment

Navman Wireless has introduced Qtanium 300, a GPS



tracking device for construction equipment. Qtanium 300 features an IP67 rated waterproof enclosure and connecting cables designed to withstand the dirt, weather and vibrations suffered by bulldozers, excavators, cranes and other off road assets. With the size of an external hard drive, the device can be installed anywhere on any make or model of construction equipment, monitors each vehicle's location in real time via GPS, and transmits the data to Online AVL2, the company's flagship fleet tracking and management software for analysis and reporting.

Qtanium 300 also offers various benefits for construction equipment. It allows dispatchers to see the actual location of all construction assets in their fleet on a desktop map in real time. Different map icons can be assigned to different types of assets to enable authorized users to differentiate vehicle types at a glance. Information provided by Qtanium 300 enables fleet managers to track real-time vehicle usage, minimize fuel and other operating costs, and identify other opportunities for increasing productivity and profits.

Ref. TIMES JOURNAL OF CONSTRUCTION AND DESIGN, July-December, 2013, pg 49

Pipe Ramming Hammer

HammerHead Trenchless Equipment offers its pneumatic pipe ramming hammer. The 34-inch hammer can install casing 48 inches to 180 inches in diameter in drainage culvert and washover applications and can be used for pipe assist or pipe extraction, guided pilot bore ramming and horizontal directional drilling assist. The hammer was recently used in an Ontario, Canada, washover casing job and installed 185 feet of 72-inch diameter steel casing.

RT&S, March 2013, pg 48

Rail Grinding - Whittling it Down to PREVENTION

To help railroads achieve optimal rail performance, equipment suppliers aim to provide optimum preventative grinding options. The article describes the latest in grinding tools and practices and the products and services that are available for railroad maintenance.

Vossloh Rail Services' (VRS') newest grinding equipment offerings include a next generation High Speed Grinding (HSG) series offered in two formats: the heavy haul system, which can operate at speeds upto 50 mph; and the HSG City system, which can operate upto 35 mph and offers enough clerance to operate in most metro systems and tunnels. The heavy haul system was introduced to the North American market last year and the city system is being introduced this year. The city model also featurs a 100 percent spark and dust collection system to address environmental concerns in populated areas, and overhead structure and tunnel applications.

To help railroads address rail that reaches the point of needing corrective action, VRS offers a High Performance Milling system, a heavy haul application designed to return a rail profile to an original specification in a single pass. The system generates no sparks or dust and generates little noise so that it can be used in any environment, such as on bridges and/or main lines near highly populated areas, and when traditional grinding is not allowed due to potential fire hazards.

In an effort to help railroads curtail infrastructure maintenance related traffic disruptions, VRS has begun working with some clients to schedule a grinding operation as if it were part of regular traffic.

Loram's newer offerings include the RG400 series for production mainline grinding, which incorporates higher stone counts, quality assurance tools and higher operating speeds. For the specialty rail grinding market, the company offers its RGS series fleet. Combined, the RG400 and RGS – introduced in 2010 and 2011, respectively – help minimize track time disruptions.

The RGS grinds switches and crossings in fewer passes with pinpoint precision and can be effective grinding open rail, while achieving speeds upto 12 mph. The machine is " a natural supplement" to any production grinding program since it can grind problem spots as it travels between switches, crossings and other

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The Asset-Tracking Evolution

Rail-car and locomotive owners have an array of AEI/GPS (Automatic Equipment Identification reader systems and Global Positioning System) technology options at their monitoring disposal. They have always expected to know where their rail cars and locomotives are, the condition they are in and when they'll get to their final destination. But with the evolution of monitoring technology, rail-car and locomotive owners have more product and service options available – and a better shot at pinpointing, in real time, where their assets are – than ever before.

The article discusses products/ solutions by Industrial Networks Ltd., Lat-Lon, Comet Electronics, Railinc Corp., Softrail and Wi-Tronix.

By: Walter Weart

Ref. Progressive Railroading, Issue July, 2013, pg 41-44

Leica Launches Nova Measurement System

The flagship of the new solution is the Leica Nova MS50 MultiStation, which combines scanning, total station, imaging, and GNSS positioning in one instrument to deliver fast and reliable results. Leica Nova uses advanced measuring technology that provides accuracy and quality, yet is easy to use for an unprecedented range of applications. Whether users measure objects on a construction site, quickly calculate volumes, monitor a dam or a bridge, capture an accident scene with digital imaging or scan a façade, Leica Nova integrates all these capabilities in one compact, flexible solution.



The Leica nova MS50 MultiStation combines every significant measuring technology in one device for first time. The new merge TEC technology fuses hardware capabilities with comprehensive data management solutions. Images are synchronized with scans, and scans are tied into total station measurements, making it easy to manage complex 3D data. The Leica nova MS50 also integrates 3D point cloud measurements into regular survey workflows.

Ref. : GPS World, July 2013, pg 16

Data Collector

The Nexteq T8C is a multi-functional GIS data collector that integrates voice recording, photo, cellular voice and



data, Bluetooth, and MicroSD slot into a lightweight and durable package. Combined with a long lasting battery, an outdoor-readable three inch color LCD touch screen, and waterproof/dustproof protection, the T8C offers users a solution for field work. Equipped with NexGeo data collection software running on Windows Mobile 6.5, the T8C provides users with an open, flexible, and scalable solution application. T8C also supports third-party Windows Mobile applications.

The built-in high-sensitivity SIRF Star IV GPS receiver provides real-time positions for applications in harsh environments with better than 2-meter accuracy with SBAS coverage. An external GPS antenna can further improve the positioning capability.

Ref. : GPS World, July 2013, pg 31

Evaluation of Concrete Drying Shrinkage Related to Moisture Loss

Drying shrinkage, defined as volumetric change of concrete induced by moisture loss, can change characteristics of concrete such as durability, stress distribution, and deformation.Considering the importance of shrinkage effects and the absence of any comprehensive method to estimate shrinkage value, this paper attempts to integrate numerical and experimental methods to predict shrinkage strain based on internal moisture loss.

The hypothesis of volume changes being proportional to internal moisture loss is used to evaluate the shrinkage strain, where the proportionality coefficient, called the "shrinkage factor," is to be determined experimentally and is a function of the material properties and humidity conditions. Results show that the proposed method has acceptable accuracy for estimating the shrinkage and evaluating the shrinkage strain distribution.

By : Reza Abbasnia, Mohammad Shekarchi, and Jamal Ahmadi

Ref : ACI Materials Journal, Vol. 110, No. 3, May-June 2013, pg 269

Effect of Curing Water Availability and Composition on Cement Hydration

Curing can help concrete reach its full strength and durability potential. The effect of sealing the concrete with plastic or formwork, use f a liquid curing compound, wet curing, and internal curing with saturated lightweight aggregates on the cement degree of hydration (DOH) development with time was examined using isothermal calorimetry. Curing water amount, curing water ionic concentration, and sample thickness were varied. Finally, curing application timing was studied by comparing strength development of concrete cylinders sealed, placed in a moist room after 24 hours sealed, and immersed in a water bath immediately after finishing. Increasing the height of curing water decreased the height of heat of hydration rate peaks. Curing water ionic concentration affected the setting time and heat of hydration rate peak heights. Strength results show delay curing can result in significant strength loss because of the difficulty for water to penetrate in the already-hardened concrete.

By : Md. Sarwar Siddiqui, Wesley Nyberg, Wilson Smith, Brett Blackwell, and Kyle A. Riding

Ref : ACI Materials Journal, Vol. 110, No. 3, May-June 2013 pg 315

Detection and Characterization of Early-Age Thermal Cracks in High-Performance Concrete

Streicker Bridge is a new pedestrian bridge built on the Princeton University campus. Structural health monitoring (SHM) is applied with the aim of transforming the bridge into an on-site laboratory for various research and educational purposes. Two fiber-optic sensing technologies are permanently deployed: discrete long-gauge sensing technology based on fiber Bragg gratings (FBG) and truly distributed sensing technology based on Brillouin optical time domain analysis (BOTDA). The sensors were embedded in the concrete during construction. This paper describes the real time detection and characterization of early-age thermal cracks in the high-performance concrete deck of Streicker Bridge. The deployed monitoring strategy and monitoring systems, which successfully detected cracking, are described. The observed crack propagation trajectories are presented. Details of a simple finite element model (FEM)of the bridge are given, and the analysis procedure used to demonstrate the formation of thermal cracks using this model is outlined.

By : David Hubbell and Branko Gilsic

Ref : ACI Materials Journal, Vol. 110, No. 3, May-June 2013, pg 323

Alkali-Activated Natural Pozzolan Concrete as New Construction material

In the near future, geopolymers or alkali-activated cementitious materials will be used as new high-performance construction materials of low environmental impact with a reasonable cost. This material is a good candidate to partially replace ordinary Portland cement (OpC) in concrete as a major construction material that plays an outstanding role in the construction industry of different structures. Geopolymer materials are inorganic polymers based on alumina and silica units; they are synthesized from a wide range of dehydroxylated alumina-silicate powders condensed with alkaline silicate in a highly alkaline environment. Geopolymeric materials can be produced from a wide range of alumina-silica, including natural products-such as natural pozzolan and metakaolin or coproducts-such as fly ash (coal and lignite), oil fuel ash, blast sustainable development. Using lesser amounts of calcium-based raw materials, lower manufacturing temperature, and lower amounts of fuel result in reduced carbon emissions for geopolymer cement

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Effects of Two-Wheelers on Saturation Flow at Signalized Intersections in Developing Countries

Two-wheelers (TW) constitute a major proportion of urban traffic in developing countries and therefore their effect on the saturation flow at signalized intersections could be substantial. This paper attempts to study and analyze the effect of two-wheelers on the saturation flow of signalized intersections by collecting data at a few signalized intersections in Bangalore, India. A strong correlation is observed between the measured saturation flow and the proportion of two-wheeler traffic, which suggest that two-wheelers have significant impact and should be considered in the capacity analysis of signalized intersections. In this paper, the effect of two-wheelers on saturation flow rate is incorporated in a previous model by calibrating and introducing a new adjustment factor for two-wheelers. Results show that saturation flow measured using the modified HCM equation is closer to observed saturation flow values. DOI 10.1961(ASCE)TE.1943-5436.0000519. © 2013 American Society of Civil Engineers.

By : C. S. Anusha; Ashish Verma and G. Kavitha

Ref : Journal of Transportation Engineering, May 2013, Vol 139, No. 5 pg 448

Relationship between Pavement Roughness and Distress parameters for Indian Highways

The present study demonstrates the relationships between pavement roughness and distress parameters like potholes, raveling, rut depth, cracked areas, and patch work. The pavement distress data collected on four national highways in India using a network survey vehicle (NSC) are used to develop linear and nonlinear regression models between roughness and distress parameters. Analysis of variance of these models indicated that nonlinear relation is better than a linear model. R2 value, root mean square error (RMSE), and mean absolute relative error (MARE) also supported non linear models. An artificial neural network (ANN), which is an advanced technique of modeling, is also used in the present study to model pavement roughness with distress parameters. A network with five input nodes, 15 hidden nodes, and one output node is considered. The network was trained with 90% of the data and tested with remaining 10% data. Results of R2 and MSE showed that the neural network performed highly significantly in both training and testing phases. Finally, the performance of the ANN model is compared with that of linear and nonlinear regression models. The mean absolute error (MAE) for the ANN model is around 18% less than that for the linear model and 11% less than that for the nonlinear model. MARE values are also 12.5% lower in the case of ANN modeling, indicating that the ANN model yields a better forecast of road roughness for a given set of distress parameters. DOI 10.1961(ASCE)TE.1943-5436.0000512. © 2013 American Society of Civil Engineers.

By : Satis Chandra; Chalmuri Ravi Sekhar; Anish Kumar Bharti; and B. Kangadurai

Ref : Journal of Transportation Engineering, May 2013, Vol 139, No. 5 pg 467

Mode Choice Behavior of Commuters in Thiruvananthapuram City

Travel behavior plays an important role in transportation planning. Mode choice analysis is the process of arriving at a decision about which mode to use under a set of circumstances. Choice of a particular mode by commuter affects the general efficiency of travel within the city. Various techniques are available in the literature for mode choice modeling. Among these, multinomial logit models are found to be efficient in estimating the different mode shares in a scenario where more than two choices of modes of travel are available for commuter. The present study used multinomial logistic regression to analyze the mode choice behavior of commuters in Thiruvananthapuram, a typical Indian city. The findings from the study revealed that as age increases preference to car increases and preference to two wheelers decreases in comparison with public transport. Increase in time per distance and increase in cost per distance cause the commuters to switch to car and two wheelers from public transport.

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Numerical Modeling of Load and Stress on the Contact Surface of a Turnout and Railway Vehicle

In operating conditions, railroads are subject to abrasive and fatigue wear. Their durability period spends on the properties of the materials from which rail sections are made, the characteristics and value of the load, and the distribution of contact stresses and strain in the places at which wheels contact track and turnout components. Forecasting of the real load and resultant contact stress and strain makes it possible to rationally design railway turnouts and correctly select the material to be used for their component. For these reasons, characteristics of load and, subsequently, distributions of contact stresses and deformations in places of wheel/turnout component contact were determined in numerical calculations using Universal Mechanism and MSC.MARC computer applications, was determined that the distributions of contact and reduced stresses depend on the load value. The highest reduced stresses occur in the contact zone and the right under the rolling surface of the section. DOI 10.1961(ASCE)TE.1943-5436.0000510. © 2013 American Society of Civil Engineers.

By : Krzysztof Aniotek, Ph.D; and Jerzy Herian

Ref : Journal of Transportation Engineering, May 2013, Vol 139, No. 5 pg 533

Track Allocation Optimization in Railway Station: Mean-Variance Model and Case Study

Allocating tracks with operation restrictions for trains in a conflict-free way is known as the basic scheduling problem, and it has attracted much attention, especially at the station bottlenecks. First, this paper presents a mean-variance optimization model for solving the track allocation problem that minimizes the occupation time costs in groups of turnouts at station bottlenecks. Then the simulated annealing algorithm is provided to solve this programming. In addition, a case of a China railway station focused on track allocation is performed that illustrates the application of the proposed model. Also, considering the quality of track allocation program, an evaluation function that tests the results in a balanced allocation is built to further strengthen the allocating results. Finally, to verify the efficiency of the simulated annealing algorithm, the effects of algorithm parameters on an optimizing function have been tested. It illustrates that the algorithm parameters have great effect on the global optimal results. The more cycles the program runs, the better optimization results will be obtained. DOI 10.1961(ASCE)TE.1943-5436.0000530. © 2013 American Society of Civil Engineers.

By : Jianjun Wu; Liujiang Kang; Huijun Sun; and Xiaolei Jia

Ref : Journal of Transportation Engineering, May 2013, Vol 139, No. 5 pg 540

Proposal for Geoid Evaluation from GNSS/Leveling

Data: Case Study along a Railway Line in Greece

A surveying-engineering procedure is presented for gravimetric geoid model verification along selected railway traverse lines using collocated ellipsoid and orthometric heights. The proposed method relies on (1) a tactical-grade, multisensor

[Global Navigation Satellite System (GNSS)/inertial navigation system (INS)} kinematic-surveying system used to measure the ellipsoid heights along the traveled section and (2) the orthometric heights derived from the railway-line construction and/or maintenance works. Compared with the standard static GPS/leveling technique, the proposed approach produces geoid height profiles in a very short acquisition time, with dense point spacing, and in a considerably inexpensive manner. The quality of the final result reflects the accuracy of modern GNSS/INS systems and available railtrack orthometric height information. The method was applied to a long (101-km) railway traverse in central Greece using a custom-built mobile mapping system. Gravimetric geoid model verification was undertaken in an absolute and relative manner fir the Earth Gravitational Model2008 (EGM08) and 1996 (EGM96) geopotential models. Analysis of the result has demonstrated the potential of the method both in terms of efficiency and in terms of the evaluation checks performed. Based on the absolute- and relative-quality tests undertaken, the superiority of EGM08 over EGM96 is clearly evident for the tested line. Also, these results are cross compared and evaluated with the findings obtained from previous studies in Greece.

This paper described a multisensor surveying-engineering technique for estimating the geoid heights along longitudinal railway traverse lines. The proposed approach relies on the kinematic surveying of railway track lines of known orthometric heights. The main contribution of the method is its ability to measure ellipsoid heights with relatively high accuracy in a short

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Impact of Watefproofing Chemicals on the Strength and Durability of Buildings

Given the rapid growth of the Indian construction industry over the last decade, the importance of waterproofing chemicals has become well established. Wateproofing used to be considered as a part of the repair market, being employed only after damage from water caused a water leakage. While water proofing at the time of construction can prevent water leakage and associated damage and certainly used for repair, another important role that has emerged for waterproofing products is one where the use of the appropriate product/s and their correct application can significantly help make the building stronger, more durable, hygienic and safe. Waterproofing can also help to maintain the appearance of newness by protecting against damaging effects of weather and pollutants.

By : Dr. Aparna Kumar

Ref. New Building Materials & Construction World July 2013, pg 206.

State of the Art on Fibre Reinforced Concrete

If the concrete could be made so strong in tension that it would do without the crutches of reinforcing steel, the potential for increased productivity would being enormous benefits, raising construction up to the speed demanded in the twenty-first century. There are situations where fibre concrete can give better technical options. Structural concrete with thinner sections, better crack controls, high toughness is economically possible in fibre concrete. Modern construction practices should utilize fibre concrete. It can be used in repair and strengthening.

By : Deepa A. Sinha, Dr. A. K. Verma, Dr. K. B. Prakash,

New Building Materials & Construction World July 2013, pg 224-232

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This paper described a multisensor surveying-engineering technique for estimating the geoid heights along longitudinal railway traverse lines. The proposed approach relies on the kinematic surveying of railway track lines of known orthometric heights. The main contribution of the method is its ability to measure ellipsoid heights with relatively high accuracy in a short acquisition time, with dense point spacing, and in an expensive manner. Therefore, it can potentially be used to develop a set of geoid calibration lines and to serve as check against geopotential gravity models. Moreover, resurveying of the same traverses over time would yield a direct and independent check of actual geoid change

MOBILE CRANES

An Essential Tool at Construction Jobsites

Cranes represents family of material handlers that are essential tools for many construction projects. Cranes have multiple uses and configurations on projects that range from residential and commercial through heavy industrial, infrastructure and marine construction. They are used for lifting and placing such things as heavy steel beams, pre-stressed concrete sections for building or bridges, materials and supplies to the upper stories of a high rise, unloading trucks, and a host of other essential construction site material handling tasks.

Determining which crane to use for which job comes down to the same parameter we apply to any equipment selection – what is the application? For cranes, the main application considerations are how high do you have to lift the load, how far out must it be placed and what does it weigh. The bulk of the load can also be a factor in that a bulky load may require a larger crane to handle physical dimensions in order to obtain lift height required at a given radius.

Other considerations include the terrain and if the crane will be working on or off road, pick and carry considerations, single or repetitive lifts, travel time and distance, and other factors. A cost consideration also enters into the equation and is viewed differently depending on the end user.

All-Terrain Cranes.



MOBILE CRANES

An Essential Tool at Construction Jobsites

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All-Terrain Cranes.

All terrain cranes have become a very popular construction tool. All terrain cranes have a combination of the mobility of mobile truck cranes and the wheel steering features found in rough terrain cranes. These features enable them to move from site to site effortlessly as well as to allow easy maneuverability at jobsites. Multiple axles – steer drive and tag – distribute the load. Multiple drive axles provide traction to handle tough jobsite conditions and multi-axle steering provides added maneuverability. These are suspension options that can provides added off-road clearance and enhance driving characteristics making a crane that is easy to take on the road from job to job no matter how far the trek. High tonnage cranes are normally all terrain cranes. Capacity on these machines can reach 1,000



tons. Jib tip heights can be measured at 597 feet and boom heights at 344 feet (plus or minus).

Rough-Terrain Cranes

Even with the advances being made by all-terrain crane, rough-terrain cranes remain king of the job site. A rough terrain crane is subclass of a hydraulic crane. A a self –propelled crane mounted on an undercarriage with four rubber tires, rough terrain cranes are specifically designed to operate on off-road and rough applications and surfaces. They handle tough off-road conditions with four-wheeled drive and with various types of steering for maneuverability. They are simple – two-axle configuration and have only one cab from which the operator controls all functions.

They are relatively inexpensive in comparison to other types of cranes. Since they don't have to travel at highway speeds they don't require the horsepower or drive train components. All rough terrain cranes are powered by a single-engine with hydraulically operated winches mounted in the undercarriage. Similar to a crawler crane, the engine powers both the undercarriage and the crane. The two axle configuration is another major cost saver. Their biggest negative comes from the fact that they have to be transported between jobs. Once on the job, they excel at pick and carry operations. They are a sound economic investment where lot of lifting on the job site is required.

Truck-Mounted Cranes

Truck mounted, hydraulic cranes are commonly used un the construction industry to set construction components and equipments. Truck-mounted cranes sit on a commercial truck chassis. The truck engine is used to power the crane operation. These cranes consists of



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Communication Makes a Corporate Code of Ethics Effective: Lessons from Hong Kong

Ethical Behaviour has once again come into focus on Indian Railways in the aftermath of Cash for Post Scam in Ministry of Railways. In this paper the author has studied and analysed the effectiveness of communication of corporate code, what we call Railway Service Conduct Rule on Indian Railways. Author expressed concerns on the deteriorating ethical standards of the Hong Kong construction industry arising from the fact that the number of court cases of corruption and unethical behavior had risen. The government and the general public encouraged the industry to accept the importance of sound corporate ethical behavior and ethics management. Earlier study concluded that the construction company had produced its corporate code of ethics almost as an end in itself. This study did not investigate whether or not the Hong Kong construction industry should adopt a corporate code of ethics as an ethics management instrument, given that such codes are already in place, but instead focused on the operational aspects of communicating a code. The study has looked at the following crucial questions.

i. Is there any relationship between the methods of communicating a corporate code of ethics and attitudes of employees, including site staff, toward such a code?

ii. Which communication methods (formal or informal) are more effective in communicating ethics-related information to employees?

The purpose of this study was to determine which communication methods led most effectively to implementation of a corporate code of ethics.

A corporate code of ethics is the instrument most frequently used for curbing un-ethical behavior and upholding the ethical standards of organizations. Whereas most large companies around the world do have a corporate code, reported ethical malpractices among some of these companies do not appear to be abating. It is sad though but corporate ethics management is traditionally grounded in the 3P approach: "Print a corporate ethics code, post it on the wall and pray people actually read it". To have any impact on employee ethical behavior, the provision of a code of ethics is certainly a necessary but by no means sufficient condition. Much time and energy has been spent revising the contents and examining the effectiveness of codes, but to date there is little empirical evidence on the extent to which the existence of a corporate code actually helps to prevent unethical behavior in the workplace, and under which circumstances this holds true. Many organizations, academics and government have failed to effectively confront the challenge of how to communicate a corporate code and embed the code in the organization's culture. Attitude is "a predisposition to respond favorably or unfavorably toward some attitude object." The recent perspective of attitude is "a summary construct that represents an individual's overall feelings toward or evaluation of an object."

The primary findings of one of the earlier study of a company are following (1) the company developed a corporate code of ethics that become an end in itself, and (2) the company did not communicate the code directly to each of its project site staff. It was left to the discretion of individual project managers as to whether and how to communicate the code.

The study confirmed the existence of an inter-relationship between code effectiveness and communication. They claimed that codes could be effective only if communication channels were effective. Studies show that the usefulness of codes increases with familiarity with content. Study indicates that different methods of communication have different impacts on employee perceptions, knowledge, and actual behaviour in their use of the code respectively.

Employees in general consider that they receive less ethics-related information than they need for dealing with ethical issues irrespective of whether channels of communication and information sources were formal or informal. Information received through formal communication was less than they actually needed to cope with ethical issues. The project site staff received more ethics-related information from formal sources of information (i.e. immediate supervisor, middle management, and top management) than from informal sources (i.e. subordinate, co-workers, and individuals from the company). In general, formal sources of information were rated highly. The employees explained that because of the sensitive nature of ethics-related issues, they held formal sources of information in high regard as a kind of guideline and directive.

Although the employees considered that formal sources of information were more effective in communicating ethics-related information than informal sources, they

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Kentucky Bridge Provides Relief Without Clutter

The Bridge in western Kentucky that carries U.S. Route 60 over the Tennessee River and links the countries of McCracken and Livingston was built in 1931. The superstructure of this 1800 ft long bridge was designed by the San Francisco-based engineering firm URS Corporation after local officials and the public voiced concern about an earlier design that had been approved by the Kentucky Transportation Cabinet (KYTC), which oversees the state's highways. The bridge was designed without vertical members or low hanging sway braces to give it a more open feel. The new design would also need a less cluttered appearance than what was initially planned and would have to be free of the vertical members and low hanging sway braces that critics worried might create too much of a closed-in, tunnel effect for drivers. Construction of the superstructure, the second phase of the project, began in 2010 and is expected to be completed this year, well ahead of the initially anticipated mid 2014 completion date. The bridge is expected to open for two lanes of traffic in June, the completion and full opening coming in the fall.



Ref: Civil Engineering, June 2013, pg 23

GPS Leaves This Earth

At 5:38 Eastern Daylight Time (21:38 UTC) on May 15, the fourth GPS IIF satellite, Space Vehicle Number (SVN)66 built by Boeing, ascended towards orbit aboard a United Launch Alliance Atlas V rocket at from Cape Canaveral Air

Force Station, Florida.

The US's NAVSTAR GPS constellation remains healthy and continues to meet and exceed the performance standards to which the satellites were built. Our goal is to deliver sustained, reliable GPS capabilities to America's war fighters, our allies, and civil users around the world, and this is done by maintaining GPS performance, fielding new capabilities and developing more robust modernized capabilities for the future.

The new capabilities of the IIF satellites will provide greater navigational accuracy through improvements in atomic clock technology; a more robust signal for



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Corrosion Estimation of a Historic Truss Bridge Using Model Updating

Bridge structures are valuable assets for transportation and economy that are to be maintained properly for continuous stable operation. Corrosion is common in steel bridges; severe corrosion may result in significant economic impact and long duration restrictive operations for retrofit. Efficient methods for the evaluation of the structural condition are required for timely maintenance of bridge structures. To date, various corrosion evaluation technologies have been developed such as nondestructive evaluation techniques and analytical model updating strategies. Among them, NDE-technologies are limited in investigating local damage in a small area because of the high-cost and time-consuming procedures required to scan the whole structure.

The impedance-based method is effective for corrosion detection, because structural impedance is sensitive to corrosion; however, the baseline impedance of the undamaged structure is required, which is usually not available for historic bridges where significant corrosion has already developed. Therefore, direct corrosion measurement technology such as various methods in NDE, PZT sensors, or fiber optic sensors may be costly and inappropriate for global assessment. As an alternative to direct inspection, model updating has been seen as a promising technique for damage detection.

In this paper, the degree of corrosion of a historic steel truss bridge has been estimated using finite-element (FE) model updating based on measured data. The target bridge is a 100 year old steel truss bridge that has developed significant corrosion in its structural members. A FE model was built based on the structural drawings when it was retrofitted. Free vibration tests were conducted to measure accelerations, which were then used to identify the natural frequencies and mode shapes of the bridge. To reduce the number of variables in the model updating and hence increase the stability of optimization procedure, the bridge members were grouped based on cross section types, and the thickness of each cross section was selected as a candidate parameter for model updating. The FE model was then updated to match the identified modal properties by adjusting the thickness of each cross section group. The corrosion state, which was represented by the thickness reduction of each element, was obtained from the model updating results. A good match was achieved between the thicknesses from model updating and visual investigation, which indicated the potential of the proposed corrosion assessment strategy based on model updating.

A visual investigation of the status of the bridge was conducted before dynamic tests. In general, the most noticeable damage was steel corrosion. As shown in Fig. 1, the main truss elements, including the horizontal, diagonal, and vertical chords, supports, and connections, were considerably corroded.

Severe pitting corrosion was found in the end post, vertical channels, cross girders, and longitudinal beams as shown in Fig. 2, while the vertical and diagonal members have less severe corrosion.

The detailed strength of the steel elements and exact degree of the corrosion are unknown, because detailed coring tests are not allowed for the in-use bridge. Therefore, the varying degrees of the corrosion of bridge elements were estimated by visual investigation using the ASTM corrosion chart (ASTM 1988). Though a visual investigation, the structure has been categorized into six groups based on the cross sections shown in Fig. 6. The corrosion rate is assumed to be proportional to the cross-sectional area. Based on the observed number, density, and size of pitting holes the thickness loss is estimated as 1.6mm for the severely corroded sections and as 0.8 mm for the less severely corroded sections. The corresponding sectional properties are calculated based on the sectional shape. These corrosion estimation results will be compared with the model updating data as a reference.

By : Shinae Jang, A.M.ASCE; Jian Li; and Billie F. Spencer Jr., F.ASCE

Ref: ASCE Journal of Bridge Engineering, July 2013, Vol. 18, No. 7, pg 678

IMPORTANT RECOMMENDATIONS OF CAO (C) SEMINAR

18th & 19th July 2013
at IRICEN, Pune

Final Location Survey:

- Limit of 1.0 lakh/km in Board's L No.97/W-1/Survey/CR/PT-III dt.21.01.2009 be removed
- Increase the limit of expenditure from 2% to 4% of the estimated cost
- Lower the level of Tender committee from SAG to JAG
- Include the work of forest department approvals and relocation of services etc.

Sanction of Estimates

- Powers of GM and CAO to be enhanced for sanction of detailed estimate to 500 crore and 250 crore respectively
- GM and CAO be delegated power to sanction part detailed estimate for the works for which detailed estimated would be in their competency of sanction

Material Modifications

- Definition of material modification be revised as recommended by CAO forum (WR to frame the revised clauses) and Limit for Material Modification be increased from 5 lakh to 5 crore per item subject to limit of 5% of the sanctioned cost of work

Powers for Single tenders

- The powers for acceptance of tenders by GM and CAO to be enhanced from present limits of 100 and 50 crore respectively to 250 and 150 crore.

Powers for Single tenders:

- Powers be delegated to CAO (C) for New Line and GC Projects permanently instead of giving on year to year basis like that for Traffic facility and doubling works
- Financial limit is recommended to be enhanced to 5 crore from present limit of 2 crore
- These powers should also be for commissioning in addition to completion of the works

Change in statutory levies, taxes and duties

- Definition of material modification be revised as recommended by CAO forum (WR to frame the revised clauses)
- Limit for Material Modification be increased from 5 lakh to 5 crore per item subject to limit of 5% of the sanctioned cost of work

Comprehensive review of functioning of Organization of CAO (Con)

- Railway Board is requested to examine this issue and form a high level Committee for comprehensive review of Construction Organization by including the organization structure & controls, functioning, administrative and financial autonomy to address various issues which are hampering the delivery of the projects.
- Creation of posts for new assets: Railway Board is requested to issue policy instructions for creation of new posts without matching surrender and clarify the responsibility of creation of posts to be of Open Line as was earlier.

CALENDAR OF COURSES 2013 (Rev. 10)

Course No.	From	To	Name of course	Duration	Eligible Group
Probationary Courses					
13005	26.08.13	01.11.13	IRSE Phase-II (P)	10 wks	IRSE(P) 2011 Exam.
13006	26.08.13	01.11.13	IRSE Phase-II (Q)	10 wks	IRSE(P) 2011 Exam.
13007	09.12.13	13.12.13	IRSE Posting Exam	1 wk	IRSE(P) 2010 Exam.
13008	09.12.13	13.12.13	IRSE Introductory	1 wk	IRSE(P) 2012 Exam.
INTEGRATED COURSES					
13104	18.11.13	30.01.14	Integrated	11 wks	Gr.B officers
13105	23.12.13	06.03.14	Integrated	11 wks	Gr.B officers
SR. PROFESSIONAL/SAG REFRESHER COURSES					
13204	14.10.13	22.11.13	SAG Refresher course	6 wks	SAG
13208	30.12.13	21.02.14	Sr. Prof. Dev. Course	8 wks	
HAG/SAG/SEMINARS/WORKSHOPS/MEETINGS					
13309	28.11.13	29.11.13	CE/TMs' Seminar	2 days	CE/TMs
13310	31.10.13	01.11.13	IRICEN Day Seminar for IRSE '87' Exam	2 days	SAG (IRSE '87')
SPECIAL COURSES (TRACK/BRIDGES/WORKS)					
13417	18.11.13	22.11.13	Green Building, Unified SOR & IRPSM	1 wk	SAG/JAG
13418	25.11.13	29.11.13	Rail Wheel Interaction & derailments	1 wk	JS/SS of OL& Instructors(P.Way)/ZTS
13419	02.12.13	06.12.13	Rail Grinding	1 wk	Officers & Supervisors of OL
13421	16.12.13	20.12.13	USFD testing, welding, rail grinding & Track monitoring	1 wk	JS/SS
13422	23.12.13	03.01.14	Contracts & Arbitration for SS/JAG/SG officers	2 wks	SS/JAG
PSU / OTHER COURSES					
13604	25.11.13	20.12.13	Course for ITEC/SCAAP	4wks	ITEC/SCAAP Foreign Engrs.
13605	23.12.13	17.01.14	Course for RITES Engineers	4wks	RITES Engrs.
AWARENESS COURSES					
13715	02.12.13	06.12.13	Awareness for IRSS	1 wk	IRSS (P) 2011
13716	16.12.13	20.12.13		1 wk	

INDIAN RAILWAYS INSTITUTE OF CIVIL ENGINEERING, PUNE-411001

CALENDAR OF COURSES 2013 CHART (Revision - 10)

MONTH / DATE (MONDAY): DECEMBER '12 (3, 10, 17, 24, 31) · JAN.2013 (7, 14, 21, 28) · FEBRUARY (4, 11, 18, 25) · MARCH (4, 11, 18, 25) · APRIL (1, 8, 15, 22, 29) · MAY (6, 13, 20, 27) · JUNE (3, 10, 17, 24) · JULY (1, 8, 15, 22, 29) · AUGUST (5, 12, 19, 26) · SEPTEMBER (2, 9, 16, 23, 30) · OCTOBER (7, 14, 21, 28) · NOVEMBER (4, 11, 18, 25) · DECEMBER (2, 9, 16, 23, 30) · JAN.2014 (6, 13, 20, 27) · FEB.2014 (3, 10, 17, 24) · MAR.2014 (3, 10, 17, 24)

Row	Entries (week beginning Monday)
IRSE COURSES	PE/O (18 Nov)
2010 Exam batch	007 (3 Dec '12); 003 (29 Apr); 004 (27 May); 007 (9 Dec)
2011 Exam batch	13001 Phase-I Group P (14 Jan – 25 Feb); PE (29 Apr); PO (27 May); 13005 Phase-II Group P (2 Sep – 28 Oct); INT (9 Dec)
2012 Exam batch	008 (10 Dec '12); 13002 Phase-I Group Q (18 Mar – 22 Apr); 13006 Phase-II Group Q (2 Sep – 28 Oct); 008 (9 Dec)
INTEGRATED COURSES	12104 Integrated (3 – 24 Dec '12); 12104 Integrated (7 – 28 Jan); 13102 Integrated (6 – 27 May); 13102 Integrated (3 – 24 Jun); 13104 Integrated (18 Nov – 9 Dec); 13104 Integrated (6 – 27 Jan 2014)
	13101 Integrated (11 Feb – 4 Mar); 13101 Integrated (18 Mar – 8 Apr); 13103 Integrated (8 – 29 Jul); 13103 Integrated (2 – 23 Sep); 13105 Integrated (16 Dec – 6 Jan 2014); 13105 Integrated (3 – 24 Feb 2014)
SR.PRO/DEV.COURSES	12204 Ref.Cr.for SAG (3 Dec '12); 201 (7 Jan); 201 (4 Feb); 202 (6 May); 202 (10 Jun); 203 (22 Jul); 203 (26 Aug); 204 (14 Oct); 204 (18 Nov)
	204 (31 Dec '12); 205 SPDP (1 – 29 Apr); 206 SPDP (13 May – 17 Jun); 207 SPDP (5 – 19 Aug); 208 SPDP (30 Dec – 27 Jan 2014)
HAG/SAG/SEMINARS	310 CGE (3 Dec '12); 301CPDE (4 Feb); 302 FD (11 Mar); 303 CTE (22 Apr); 304 CBE (13 May); 306 CAO (1 Jul); 307 TP (22 Jul); 308 CGE (19 Aug); 310 ID (21 Oct); 309 TM (25 Nov)
SPECIAL COURSES	IB (24 Dec '12); 428 (31 Dec '12); PX (4 Feb); RF (11 Feb); 402 (11 Mar); TM (1 Apr); TMS (6 May); 407 CA (13 May); 409 (10 Jun); 410 (17 Jun); 411 CE (24 Jun); 412 (8 Jul); 413 (15 Jul); 414 (29 Jul); 415 (5 Aug); RG (12 Aug); 423 (19 Aug); GB (18 Nov); RW (25 Nov); RG (2 Dec); US (16 Dec); 422 C&A (23 Dec)
	427 (24 Dec '12); RW (31 Dec '12); BD 401 (7 – 14 Jan); 403 (4 Feb); 404 (11 Feb); US (11 Mar); 405 (1 Apr); 406 (6 May); SS (10 Jun); MS (17 Jun); TMS RW (8 – 15 Jul); PS (29 Jul); LM (5 Aug); 416 (12 Aug); RG (19 Aug); 417 (18 Nov); 418 (25 Nov); 419 (2 Dec); 421 (16 Dec)
PSU & OTHER COURSES	601 NTPC (7 Jan); 602 IRCON (14 – 21 Jan); 604 ITEC/SCAAP (18 Nov – 2 Dec); 605 ITEC/SCAAP (16 – 30 Dec)
TRG.FOR TRAINERS	806 PW (1 – 8 Jul)
AWARENESS COURSES	701 (4 Feb); 703 (22 Apr); 704 (6 May); 707 (3 Jun); 708 (24 Jun); 712 (5 Aug); 713 (12 Aug); 715 (2 Dec); 716 (16 Dec)
FIELD CRS.	

MONTH	DATE (MONDAY)	COURSES / WK	OFFICER / WK
DECEMBER '12	3	4	
	10	2	
	17	2	
	24	2	
	31	2	
JAN.2013	7	4	80
	14	4	95
	21	4	95
	28	3	75
FEBRUARY	4	3	100
	11	4	100
	18	4	100
	25	3	95
MARCH	4	3	95
	11	3	70
	18	2	95
	25	3	80
APRIL	1	4	100
	8	3	80
	15	4	100
	22	3	65
	29	3	95
MAY	6	4	85
	13	3	45
	20	3	60
	27	2	60
JUNE	3	4	85
	10	4	85
	17	3	80
	24	4	100
JULY	1	3	80
	8	3	60
	15	3	85
	22	3	85
	29	2	65
AUGUST	5	4	100
	12	4	100
	19	3	100
	26	4	100
SEPTEMBER	2	3	80
	9	3	100
	16	3	100
	23	4	120
	30	3	80
OCTOBER	7	3	80
	14	3	100
	21	3	80
	28	3	80
NOVEMBER	4	0	0
	11	0	0
	18	3	66
	25	4	80
DECEMBER	2	4	80
	9	4	110
	16	4	40
	23	4	80
	30	4	80
JAN.2014	6	3	
	13	3	
	20	2	
	27	1	
FEB.2014	3	2	
	10	1	
	17	1	
	24	1	
MAR.2014	3	1	
	10		
	17		
	24		

MAIN COURSES	COURSE No.	WEEKS / DAYS	SEATS PLANNED	SEATS FOR CALL LETTER
IRSE COURSES	001	8	35	35
	002	8	35	35
	003	1	70	70
	004	1	70	70
	005	10	35	35
	006	10	35	35
	007	1	6	6
	008	1	70	70
INTEGRATED	101, 102, 103, 104, 105	11 each	25	45
REF. SAG	201, 202, 203, 204	6 each	16 / 23	16 / 23
SR.PROF.DEV.PROG.	205, 206, 207, 208	8 each	16 / 23	16 / 23
HAG/SAG SEMINARS	301	2D	60	60
	302, 303, 304, 305, 306, 307, 308, 309	2 each	20	20
PSU/TRG.TRAINERS	601	1	15	15
	602	3	15	15
	603	2	20	20
	604, 605	4 each	15	15
AWARENESS FOR PROBATIONERS	701 – 716	1 each	20	30
SPECIAL COURSES			20	20

Code	Mid-break Spl.Courses	C.No.	C.No.	Wks.
BD	Bridge Design Asstt.	401		3
CE	Construction Engrs.	411		2
CA	Contracts & Arbtrn.	407	422	2
GB	Green Building	417		1
LM	Land Management	415		1
PX	Laying of Points & Xings	403		1
MS	Modern Surveying	410		1
PM	PMCs	408		2

Code	Spl. Courses	C.No.	C.No.	Wks.
PS	PSC Construction	414		1
RF	Rly.form.& GeoTec.Invest.	404		1
RG	Rail Grinding	416	419	1
RW	Rail Wheel Inte.& Der.	413	418	1
SS	Steel Structure & Fabrication	409		1
TM	Tr.M/Cs & Small Tr.M/Cs	405		1
TMS	Tr. Monitoring System	406	412	1
US	USFD	402	421	1

Code	Awareness Courses	C.No.	C.No.	Wks.
AS	Accounts Service	706	709	1x1
EE	Electrical Engg.	704	705	1x2
ME	Mechanical Engg.	707	708	1x2
PS	Personnel Service	702		1x2
SE	Signal Eng. 701 703	711	712	1x4
SS	Stores Service	715		1x1
TS	Traffic Service & RPF	713		1x2

NOTES - MODIFICATIONS

No.	Course	Note
1	13402	Special Course on USFD postponed to 11.03.2013 (Revision-1, 24.12.12)
2	13403	Laying of Points & Crossings, Planng of yards and design of track using MX Rail (Postponed)
3	13405	Spl. Course on Tr.M/c.& STM postponed to 01.04.13 to 05.04.13 (Rev.2)
4	13415	Spl. Course on Land Management will conclude on 08.08.2013 (Rev.2)
5	13712	Awareness Course for IRAS will conclude on 08.08.2013 (Rev.2)
6	13702	Awareness Course for IRPS Cancelled 04.04.2013 (Rev. 3)
7	13711	Awareness Course for IRSSE Cancelled 04.04.2013 (Rev. 3)
8	13406	TMS Eligibility restricted to some div. 04.04.2013 (Rev. 3)
9	13206	Sr. Professional Dev. Course bifurcated in 13206'A', 'B' and 'C' 04.04.2013 (Rev. 3)
10	13408	Spl. Course for PMCs Cancelled due to poor nomination 09.05.2013 (Rev. 4)
11	13705	Awareness Course for IRSEE Cancelled 09.05.2013 (Rev. 4)
12	13710	Awareness Course for IRPS Reallocated to IRSEE 09.05.2013 (Rev. 4)
13	13712	Awareness Course for IRSSE Reallocated to IRSEE 09.05.2013 (Rev. 4)
14	13305	PCE Seminar Postponed, dates will be decided later 06.06.2013 (Rev. 5)
15	13710	Awareness Course for IRPS has been cancelled 10.07.2013 (Rev.6)
16	13714	Awareness Course for IRTS & RPF has been cancelled 10.07.2013 (Rev.6)
17	13706	Awareness Course for IRAS has been cancelled 02.08.2013 (Rev.7)
18	13709	Awareness Course for IRAS has been cancelled 02.08.2013 (Rev.7)
19	13603	Training for Trainers is renumbered as ITTI 13806 02.08.13 Rev. 7
20	13207-A	Sr. Prof. Dev. Course (Part A is cancelled 02.08.13 Rev.7
21	13007	IRSE Posting Examination postponed 02.08.13 Rev.7
22	13605	Course for ITEC/SCAAP allocated to RITES 02.08.13 Rev.7
23	13305	PCE Seminar Postponed 02.08.13 Rev. 7
24	13103	Integrated Course preponed by 1 day 02.08.13 Rev.7
25	13423	Interactive Session on Rail Grinding (New Course in to CoC 2013) 02.08.13 Rev. 8
26	13310	IRICEN Day seminar for IRSE 1987 Exam 31.10.13 to 01.11.13 (Rev.09)
27	13104	Integrated course changed to 18.11.13 to 30.01.14 (Rev. 10)
28	13305	PCE seminar has been cancelled (Rev. 10)
29	13204	SAG Refresher course changed to 14.1013 to 22.11.13 (Rev.10)