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Indian Railways Institute of Civil Engineering, Pune



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

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from director's desk

Dear Readers,

IRICEN is alma mater for all IRSE officers and I am now privileged to be a member of IRICEN faculty since June 2017. It is my pleasure to interact with the vast fraternity of Railway engineers through this Journal.

India's ambitious High Speed Rail (HSR) project is now at the take-off stage, Hon'ble Prime Minister Shri Narendra Modi and his Japanese counterpart His Excellency Shinzo Abe laid the foundation stone for 508 km long India's first bullet train project connecting Ahmedabad to Mumbai. This bullet train is an endeavour to bring economic growth and prosperity in the country.

This edition of journal includes papers on diverse topics; the paper on redesigning of curves on Rajdhani route based on equilibrium speed addresses the problem of severe lateral wear on sharp curves. Another paper elaborates good maintenance practices to be observed for mechanised track maintenance.

I sincerely hope that the readers would find the papers and other articles contained in this journal informative and useful. Readers may send their suggestions and articles/paper etc. for inclusion in future issues of this Journal.

(A. K. Mishra)
Director

Pune
Sept 2017

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

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

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

Indian Railways to Start its Biggest Track Renewal Exercise

Indian Railways will undertake its largest track renewal exercise in the next three months to reduce train derailments. New railway minister Piyush Goyal has asked the Railway Board to identify stretches where tracks have either completed their lifespan or carry heavy traffic and change them all within the stipulated timeline.

The national transporter is expected to renew almost 2,000 km of track by the end of this calendar year, officials said. Goyal has instructed the board to use the available rails for renewals. However, the target for the current financial year for laying of new rails will remain the same and the railways will place fresh orders for tracks. "The minister is of the view that we should get safety in place first and then focus on laying fresh routes or doubling and tripling of lines.

The track renewals would have to be completed by December," a top rail official said. "However, it doesn't mean that we won't meet the target of laying 3,000 km of new track routes. That would be completed as well. This would be a challenge for the zonal railways — to complete both things in record time."

Goyal has also told the board that he's not looking at raising passenger fares or levying any kind of safety cess on rail tickets to raise more resources for maintenance, the officials said. Instead, the focus is on weeding out inefficiency and raising revenue through non-fare avenues.

The minister has also instructed the timely completion of the 3,300 km long dedicated freight corridors by 2019. The corridors will reduce traffic on the existing rail network, giving the railways more resources for better maintenance of rail routes.

India has been hit by several rail accidents in the past few months. At least 200 people have died in 340 small and big accident since 2014.

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

Railways to Install GPS Trackers in Push Trolleys to Monitor Tracks

With repeated derailments mostly due to defective tracks, the railway ministry has decided to install GPS trackers in all hand-pushed trolleys used to inspect the tracks.

"The board has decided that all push trolleys should be numbered and installed with GPS trackers for effective monitoring of safety inspections of track and that the installation should be completed within one month period," said a railway board letter to zonal railways.

The letter also stated that a computer, dedicated to keeping a record of the tracking system, will be installed at divisional engineering controls.

Installation of the GPS will ensure proper monitoring of the track inspection by sector engineering as well as by trackmen.

Physical track maintenance involved around two lakh trackmen and gangmen who carry 15 kg of equipment and walk along tracks checking for defects.

Railway Minister Piyush Goyal, who chaired a high-level meeting on Thursday, also decided to replace all defective tracks on a priority basis.

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

TMS System can do much more than Provide Information if used Optimally: says CR Officials

The Track Management System (TMS) is not just meant to give information, but also solutions. Central Railway (CR) officials conceded that this system is being inefficiently used. In times of a disaster such as the floods on August 29, TMS can ideally do a lot more.

The CR authorities agreed that despite spending crores of rupees on a software system meant to augment the overall operations of smooth functioning of trains, the system was only providing updates on movement of trains. The main objective of TMS is to maximise the benefits of material, equipment and manpower inputs made to track and to optimise the life and utilisation of assets

without impairing the safety and passenger comfort by ensuring the optimum standards of track geometry by web enabling the existing manual system of track inspection.

On September 1, it was reported how the CR's TMS software failed to live up to their expectations on August 29, when the city's suburban rail network was paralysed due to heavy rains.

Sources said that this system can do miracles if used to its optimum and if it is upgraded. TMS Application is used for Asset Management, Rail & Weld Fracture, Track Monitoring by Machines, Maintenance by Machines & USFD Testing, Engineering Control-Caution Orders and Traffic Blocks, Track Renewal & Deep screening, Ballast Supply and Insertion, Patrolling & Accidents Reporting. "It can identify and automatically inform the shortest alternative routes, diversions during rail accidents immediately, plan rail timetable where services can be used efficiently and even allow communication between all motormen/ guard plying in times of disaster," said a CR official.

The officials said that a few months ago they had also discussed the need to upgrade their TMS, but it was ditched on the grounds that it would incur additional cost. A whopping Rs 32 crore has been spent on installing this TMS.

Hardware/System Software Infrastructure is built over IBM Power Systems for RISC Architecture, SAN, Tivoli Back Solution, Tivoli Directory Server, WebSphere Application Server, DB2 database, Edge Component, WebServer, Lotus Expeditor, Lotus Mobile Connect. 2340 number of Netbooks has been delivered in 28 IR divisions for TMS application by CRIS. The Disaster Recovery Site has been set up at IRICEN Pune for recovery of data in case of disaster which is an important feature in TMS. Currently TMS has been implemented on entire Indian Railways.

On August 29, TMS proved to be of little use as the control room could not even inform the motormen and guards about the status of stranded trains carrying thousands of commuters.

The CR installed the TMS at Chhatrapati Shivaji Maharaj Terminus (CSMT) to monitor and keep an eye on train-running in the suburban section.

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

Indian Railways to Rope in Japanese Experts to Avoid Accidents, Derailments

Amid rising incidents of derailments and accidents, the Indian Railways has decided to rope in Japanese experts to grapple with the situation.

A high-level team of experts from Japan comprising of representatives of Japan's ministry of land, infrastructure, transport and tourism (MLIT), JICA (Japan International Cooperation Agency) and railway operators visited India this week and discussed in detail the scope of cooperation between the two countries in the matter of Railway safety.

The Japanese team visited Indian Railway's coach, wagon and locomotive maintenance facilities and also observed rail welding and track maintenance practices bring followed at present, a senior Railway official said on Wednesday.

MLIT had in response to the request from Indian Railways deputed a team of Japanese Railway experts to India to assess incidents of rail breakage and suggest measures to improve safety in train operations. The official said that the first meeting was held in January with Japanese Experts.

After this, a separate memorandum of cooperation (MoC) on Railway safety was signed on February between Ministry of Railways, Government of India and MLIT, Japan to cover area adequately.

The memorandum envisages cooperation in Rail Safety on area such as maintenance of Track (welding, rail inspection, track circuit etc.) and rolling stock maintenance.

Capacity development has been taken as a technical cooperation project under the MoC to develop Indian Railways' capacity in respect of the above identified areas.

These areas have been incorporated in the terms of reference of the cooperation.

Japanese Railways is one of the oldest Rail system in the world. Japan is the pioneer in the High Speed Rail 'Shinkansen'. Japanese Railways has an impeccable record with Safety. Ministry of Railways (GoI) had requested Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) for technical cooperation in Rail Safety.

The cooperation will facilitate exchange of information and visit of experts from both sides. A workshop is proposed to be organised in the first week of Nov'2017 in association with Japanese experts.

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



Director, IRICEN addressing IRSE Probationers 2014 Batch during Convocation



International Yoga Day Celebrated



Unveiling of IRICEN Publication books by Director, IRICEN



Farewell of Sh. N. C. Sharda, outgoing Director, IRICEN and Welcome to incumbent Sh. A. K. Mishra as Director, IRICEN



Flag Hoisting during Independence Day



Sadbhavana Diwas



Engineer's Day Celebration



Rajbhasha Week at IRICEN

Redesign of Curves in Godhra – Ratlam Section Based on Current Traffic Type and Discussion on Trial Run of TALGO

By
*Neeraj Dhamiji **
*Avdhesh Verma ***

Synopsis:
Godhra–Ratlam section is situated in one of the most important Rajdhani routes of IR i.e. Mumbai-Delhi. When one of the authors of this paper was posted as Sr. DEN there, he encountered a problem of severe lateral wear on sharp curves resulting into premature renewals of rails. This paper deals with checking of cant provided in Godhra-Ratlam based on current traffic by calculating equilibrium speed, redesigning of curves and to propose change in maintenance practices if any. This paper also deals with recent TALGO trials in the section, theory available on self-tilting coaches and outcome of trials.

1.0 Introduction and Scope :

Godhra – Ratlam section is situated in one of the most important Rajdhani routes of IR. Being Ghat section, there are numerous sharp curves and steep gradients. During 2012-13, when one of the authors was posted as Sr DEN he had to propose lot of pre mature rail renewals due to lateral wear on outer rails of sharp curves. This excessive lateral wear was of the tune of 6 to 8 mm and was seen mainly on curves with degree three or more. Some of these 3 degree curves were having different cant/super elevation also. Hence it was decided to analyze the issue.

The UP line of Ratlam - Godhra was constructed between1959-1962 and DN line was constructed between1894-1896. This indicates that the traffic pattern must be very different at that time. Hence, the equilibrium speed at that time must be very different from the equilibrium speed based on current traffic. But we could not find the data being very old. Hence, it was decided to, at least analyze the traffic pattern. When we compared the traffic pattern roughly, the main and glaring difference was BLC/CONRAJ traffic which was not there in 1960s and at present is amounting to 40 to 50% of the goods traffic and that to at a sanctioned speed of 100 KMPH. Hence is was decided to find out fresh equilibrium speed and check the cant and redesign if required.

Recently TALGO trials have been done between Mumbai and Delhi at speeds of 130 kmph, 140 kmph and 150 kmph. The Talgo coaches are having the feature of natural tilting while travelling on curves which enable them to achieve approximately 20% higher speed in comparison to the conventional coaches. As the TALGO technology is Patent technology, details of their design and calculation of speed on curves were not available. Hence in this paper we have discussed the trials, basis of trials, success of trials, and future scope of TALGO in IR.

2.0 Available Theories, Provisions and Designs :

Equilibrium speed is the speed on a curve at which the cant provided exactly counteracts the centrifugal force. If all the trains passing over a curve move at same speed, the speed chosen as the equilibrium speed and the curves designed accordingly. However, in a situation most prevalent in Indian Railways, the various trains move at different speeds. The same track is

*Sr.DEN(Co), SUR,CR
**DEN(Central), SUR, CR

shared by Goods train and Express trains. Hence speed for which cant is to be provided has to be decided based on the number of trains and their speeds of travel on the curve.

There are two formulas for calculating the equilibrium speed, namely Schramm's formula and Russian formula. In IRPWM, only equilibrium cant formula is given. In this project calculations are done using Russian formula.

Schramm's Formula:

$$V_{eq} = \sqrt{\frac{\sum_{i=0}^{n} L_i V_i^2}{\sum_{i=0}^{n} L_i}}$$

Where,

L_i : Load of *i*th train,

V_i : Speed of *i*th train,

n : Number of trains

Russian Formula :

$$V_{eq} = \sqrt{\frac{\sum_{i}^{m} n_i W_i V_i^2}{\sum_{i}^{m} n_i W_i}}$$

Where,

n_i : No of trains of type i,

W_i : Weight of such train,

V_i : Speed of such train,

m : Total types of trains

As per IRPWM stipulations (Para *406(b)*), Equilibrium speed is to be decided by **CE** considering:-

The equilibrium speed for determination of cant to be provided shall be decided by the Chief Engineer, after taking into consideration the maximum speeds which can be actually attained by fast and slow trains, the proximity of permanent speed restriction in the route, junctions, stopping places, gradients which may reduce the speeds of goods trains, without appreciably affecting the speed of fast trains and their relative importance. For this purpose the entire section may be divided into a certain number of sub sections with a nominated equilibrium speed for each sub section, fixed on the basis of speeds which can be actualy attained by fast or slow trains over the sub section, so that the need for imposing any speed restrictions for limiting the cant excess for slow trains and cant deficiency for fast trains is avoided. On sections where all trains run at about the same maximum permissible speeds like suburban section, it will be preferable to provide cant for that speed.

Equilibrium Cant :

- Weight Component = W*sinθ
- Centrifugal Force Comp = M*(V^2/R)*cosθ
- *i.e.* W*sinθ = M*(V^2/R)*cosθ
- *i.e.* W*tanθ = M*(V^2/R)
- (for small θ, sinθ ≈ tanθ)
- *i.e.* M*g*SE/G = M*V^2/R
- *i.e.* Equilibrium Cant, SE=G*V^2/(g*R)
- SE=G*V^2/(127*R)

Para 406(a) of IRPWM

- Maximum Cant

(Para *406(1) (d) (i)*)

165 mm for group A, B and C routes
185 MM for locating permanent structures on group "A" routes with speed increase potential (new works and doubling) incl. TL
140 mm for group D and E routes

Self Tilting Coaches : -

The main available reports/sources are mainly International Union of Railways (UIC) [1998, 2005] which has reported on tilting train technology, where tilting trains and known tilting technology are described briefly. The present report covers tilting trains and known tilting technology as well as an analysis of the present situation. The other detailed paper is FACT project, i.e. *Fast and Comfortable Trains* .The FACT-project contained three parts: part 1 is related to track layout, part 2 to the onset of motion sickness and part 3 to how to calculate motion sickness by simulations.

3.0 Concept :

A train and its passengers are subjected to centrifugal forces when the train passes horizontal curves. Car body roll inwards reduces the centrifugal force felt by the passengers allowing the train to pass curves at enhanced speed with maintained ride comfort. Roll may be achieved by track cant, or when the track cant is insufficient, car body tilt. Trains capable of tilting the bodies inwards in curves are often called *tilting trains*. Tilting trains can be divided in two groups: the *passively tilted trains*, called naturally tilting trains in Japan, and the *actively tilted trains* (active tilt is called forced tilt in certain publications).

Passive Tilting / Natural Tilting Trains :-

The passive tilt relies on physical laws with a tilt center located well above the center of gravity of the car body. In a curve, under the influence of centrifugal force, the lower part of the car body then swings outwards and makes the lower part to tilt inward. It should be noted that passive tilt has a negative impact on safety due to the lateral shift of the center of gravity of the car body.

Active Tilting Trains :-

The active tilt relies on active technology, controlled by sensors and electronics and executed by an actuator, usually hydraulic or electric. Tilt as such has normally not an impact on safety of actively tilted train, as the center of gravity does not essentially change its (lateral) position.

Tilting Trains Around the World :

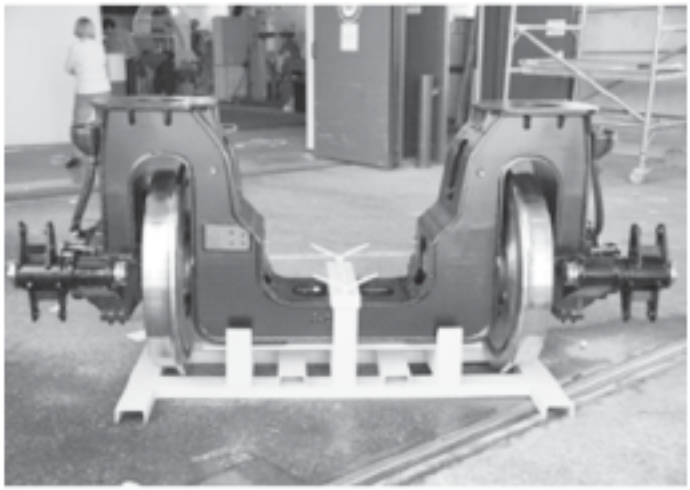


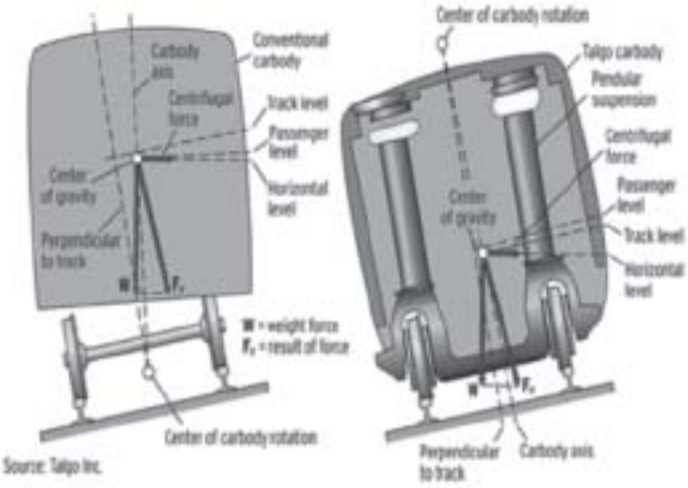
Virgin Trains' Class 390 Pendolino is the flagship train of the West Coast Main Line in the United Kingdom.

4.0 Talgo Salient Features :-

The Talgo coaches are having the feature of natural tilting while travelling on curves which enable them to achieve approximately 20% higher speed in comparison to the conventional coaches. Talgo trains are faster on ***curves*** due to independent stub wheels and natural tilt capacity of the pendular. More the curves, the faster they go when compared with conventional coaches. On straight line they can accelerate faster but the peak speed remains the same. Basically each wheel set supports two coaches at end vis a vis 4 wheel set per coach of LHB. Which means the coaches on a Talgo train set have to be smaller, add to that they are made of Aluminum, i.e., they weigh a lot less. That means that the rolling resistance is sharply down. That means it can accelerate faster.

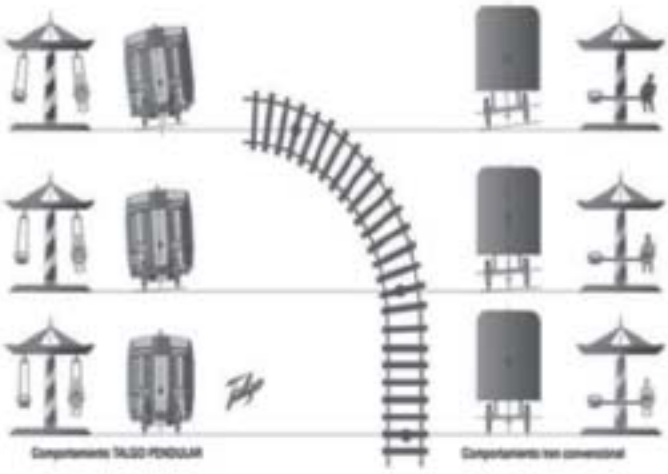
What makes it even better - since the coaches weigh less, they cause less energy transfer to the track under dynamic conditions. What makes it much, much better is that the weight of the wheel sets is sharply down - this weight is the major contributor to the dynamic loading - NOT the weight of the coach body since the suspension causes attenuation to the dynamic movement of





the coach body (the coach body moves very little compared to the wheel sets).

The absolute icing on top of the cake is the fact that the wheel set is actually consisting of 2 stub wheel sets, one left and the other right. What that means is that the left wheel can rotate at a different speed compared to the right wheel. What THAT means is that the much feared angle of attack drops to practically zero! And on CURVES that is a miracle.



The tilt in TALGO coaches is passive tilt, in other words the coach tilts due to the normal action of forces as explained in concept of passive tilting coaches. That tilt is key for the performance of the coaches on curves. Add to that the Z-lever mechanism that keeps the wheel set centered between 2 coaches even on curves. So the angle of attack remains constant and very low even on the tightest curves.

It also makes it very, very comfortable for the passengers. The ride in a Talgo coach, even on Indian tracks, is excellent. That can also be seen by OMS peaks on coach.

5.0 Collection of Data and Analysis :

The Russian formula for equilibrium speed require number of trains of a particular stock, weight of the stock, average speed of a stock in a particular section based on proximity to permanent speed restrictions, gradient, location of signals and traffic operations. We tried to gather data accordingly.

First we searched for chetak studies which could not be found. We then took the average daily stocks from operating and done a week long footplate drive on different stocks and compared it to section charts taken from operating department and average time was found out for different stocks in different sections. Then based on this average time, average speed of stocks for different sections was calculated. From the collected data the equilibrium speed of different peculiar sections was calculated. Based on this equilibrium speed, equilibrium cant was calculated for various 3 degree curves and then comparison was done with existing cant and curves were redesigned. Details of data and detailed calculations are annexed in annexure 1 and 2.

The schedule of Talgo trials are as under:-

August 2, 2016: First Trial of TALGO coaches with electric locomotive of Indian Railways done between Mumbai to Delhi at a speed of 130 KMPH.

August 5, 2016: Second Trial of TALGO coaches was also with electric locomotive of Indian Railways and also done between Mumbai and Delhi at a speed of 130 KMPH. In this run, there were lot of OMS peeks in loco, which was a matter of concern.

OMS PEAKS SUMMERY IN TALGO TRIALS CONDUCTED BETWEEN MUMBAI - DELHI																			
	TRIAL-1, DATE 02/08/16, SPEED = 130 KMPH			TRIAL-2, DATE 05/08/16, SPEED = 130 KMPH			TRIAL-3, DATE 09-10/08/16, SPEED = 130 KMPH			TRIAL-4, DATE 12-13/08/16, SPEED = 130 KMPH			TRIAL-5, DATE 07-08/09/16, SPEED = 140 KMPH			TRIAL-6, DATE 010-11/09/16, SPEED = 150 KMPH		
CPWI	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK
RTM/S	0	0	VERY GOOD	0	2	VERY GOOD	0	2	VERY GOOD	0	1	VERY GOOD	0	0	VERY GOOD	2	7	VERY GOOD
MGN	0	1	VERY GOOD	0	0	VERY GOOD	0	2	VERY GOOD	0	0	VERY GOOD	0	1	VERY GOOD	0	12	VERY GOOD
DHD/N	0	0	VERY GOOD	0	0	VERY GOOD	0	1	VERY GOOD	0	0	VERY GOOD	0	0	VERY GOOD	0	0	VERY GOOD
DHD/S	1	11	VERY GOOD	0	2	VERY GOOD	0	4	VERY GOOD	0	0	VERY GOOD	1	11	VERY GOOD	0	11	VERY GOOD

August 9-10, 2016: Third Trial of TALGO coaches was done with WDP4 locomotive due to lot of peeks in counter in Electric locomotive in last run and its better acceleration properties. This run was also a 130 KMPH speed and in this run also, there were lot of OMS peeks in Engine and Negligible peaks in Coaches.

August 12-13, 2016: Fourth Trial of TALGO coaches was also done with WDP4 locomotive with improved dampers with respect to the last run. This run was also at a speed of 130 KMPH but there was not substantial reduction in OMS peaks in Engine.

September 7-8, 2016: Fifth Trial of TALGO coaches was done with WAP5 locomotive which is having better suspension and Acceleration characteristics. In this run Cd is considered as 100 mm and based on that PSRs were imposed for the trial run. In this run there was substantial reduction in OMS peaks in Engine.

OMS PEAKS SUMMERY IN ENGINE DURING TALGO TRIALS CONDUCTED BETWEEN MUMBAI - DELHI																			
	TRIAL-1, DATE 02/08/16, SPEED = 130 KMPH			TRIAL-2, DATE 05/08/16, SPEED = 130 KMPH			TRIAL-3, DATE 09-10/08/16, SPEED = 130 KMPH, WDP4			TRIAL-4, DATE 12-13/08/16, SPEED = 130 KMPH,WDP4			TRIAL-5, DATE 07-08/09/16, SPEED = 140 KMPH,WAP5			TRIAL-6, DATE 010-11/09/16, SPEED = 150 KMPH,WAP5		
CPWI	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK	VERTICAL PEAK	LATERAL PEAK	TRACK
RTM/S	0	0	VERY GOOD	47	73	AVG	32	86	AVG	8	33	VERY GOOD	0	3	VERY GOOD	1	34	VERY GOOD
MGN	0	3	VERY GOOD	44	59	AVG	32	93	AVG	7	26	VERY GOOD	0	8	VERY GOOD	0	23	VERY GOOD
DHD/N	0	0	VERY GOOD	18	79	AVG	11	68	AVG	6	5	VERY GOOD	0	13	VERY GOOD	0	1	VERY GOOD
DHD/S	0	0	VERY GOOD	29	79	AVG	19	126	AVG	12	45	VERY GOOD	0	8	VERY GOOD	0	30	VERY GOOD

September 10-11, 2016: Sixth and Final Trial of TALGO coaches was also done with WAP5 locomotive. In this run Cd is considered as 125 mm and based on that PSRs were imposed for the trial run. In this run also the OMS peaks in Engine were less.

We have collected the PSR proposed by Western railway HQ for speed trails at 140 KMPH and 150 KMPH. Total six trials were done with TALGO rake, initial trials with 130 kmph and subsequently at speeds of 140 kmph and 150 kmph. In 150 kmph trials RDSO has proposed a Cd of 125 mm. This was analyzed and checked for unbalanced lateral acceleration based on the formula given below:

$Ca + Cd = GV^2/gR$

$Ca*g/G + Cd*g/G = V^2/R$

In this equation, Cd*g/G is unbalanced lateral acceleration and as per UIC recommendations

the limits of unbalanced lateral acceleration should be in between 0.4 to 0.7 m/sq.sec and when we calculate, it keeping Cd = 125mm, it comes out to 0.7 m/sq.sec. This means that RDSO has proposed the Cd based on TALGO claims and supporting documents in claim and must have checked it as per maximum permissible unbalanced lateral acceleration.

We have also collected OMS peaks recorded in the above Trails at 140 KMPH and 150 KMPH. Summary of OMS peaks are given in Tables:

6.0 Conclusion :

The results of redesign of curves based on equilibrium speed show that there are only few curves of degree more than equal to 3 on which cant is required to be increased based on equilibrium speed the result also shows that cant should be increased by 5 to 15 mm and average cant was around 145 mm on 3 degree curves. This is also in the line with our initial observation and may result in reduction in lateral wear. But these changes are for only around 11.26 % of curves of 3 degree or more as the equilibrium speeds calculated came out on lower sides in general. Back calculation was also done to check what was the equilibrium speed taken at the time of laying/ redesign in past. The equilibrium speed for 3 degree curve with a cant of 140 mm came out to be 77KMPH, which is more than most of the equilibrium speeds calculated taking current traffic details.

Apart from design of curve, it was also one of our objective to study the existing maintenance practices and propose improvement if required.

At present, the greasing frequency on curves is once in a month. Based on above study, as increasing cant on most of the curves not desirable considering equilibrium cant required is less than actual cant provided. Hence, if cant cannot be increased then we are left with reducing lateral wear by greasing or preventing premature renewal by timely interchanging of rails. The existing frequency of greasing the gauge face of curves was once in a month which is proposed to reduce to once in every 15 days. It is also proposed to do proper documentation by opening a curve wear register, in which wear shall be recorded every 3 months. Apart from that, it was also seen that interchanging of rails are not being done based on some fracture with kidney on non-gauge face after interchanging of rails and based on some HQ's directions. It is proposed that interchanging of rails should be done and just before interchanging of rails, USFD testing of gauge face should be done after interchanging one cycle of USFD shall be done on non-gauge face side of rail for GFC defects.

7.0 Talgo Trials :-

The TALGO trials can be termed as successful because:-

1) In a three-phased trial conducted in 2016, Talgo trains clocked a top speed of 180 kmph on the Mathura-Palwal route and covered the Delhi-Mumbai distance in 11 hours 48 minutes.
2) There were very less peaks of more than 0.15 g. The peaks per KM was also very less.

But still use of TALGO trains in Indian Railways have following issues:-

Indian Railway cannot invite tender suiting TALGO only or TALGO technology only. It has to invite global tender for tilting coaches only. In this tender any company can participate and take the contract.

a) TALGO offered trials of its coaches on its own to showcase its technology. Indian Railway hence has no obligation to use TALGO coaches only.
b) Three major changes are to be made to current TALGO coaches. These are platform height, toilets and pedestals to ease platform train gap.

Hence, it has been heard that Railway is thinking of leasing 2-5 TALGO rakes, coaches only and running it on existing Shatabdi routes. By doing this travel times may get reduced by 25 % of the existing. As per paper articles currently a 3 member committee is working on this in Railway Board. It has also been learnt from

media reports that Indian Railways is also planning to invite international players to set up an aluminum coach factory for high-speed trains in India under the Modi government's 'Make in India' drive. An international competitive tender for the same will be floated soon. In September this year, Railway Minister Suresh Prabhu had spoken of his dream for Indian Railways – rail connectivity that ensures that a train journey from one part of the country to another does not take more than 12 hours. The Talgo plan also fits in with the NDA government's intent to ramp up average speeds of Mail and Express trains from the existing 65 kmph to 100 kmph. Given the vision of current Government, and the increasing competition that Railways is facing from airlines, Talgo's coaches and other semi-high speed and high-speed trains will go a long way in benefiting the Indian Railways, and of course the common man.

◆◆◆

Railways Signs MoU with Ahmedabad University to Preserve its Heritage

AHMEDABAD: To conserve, preserve and manage the Indian Railways' old and rich heritage, the Centre for Heritage Management (CHM) at Ahmedabad University (AU) has signed a memorandum of understanding (MoU) with the Indian Railways Institute of Civil Engineering (IRICEN).

The MoU aims to establish a long–term partnership in knowledge generation and collaboration. As part of the agreement, the institutes will engage in a series of activities to build the capacity of railway personnel by integrating heritage perspectives in their training and work practices.

The collaboration is also aimed at integrating 'Heritage Management' in the academic curriculum of IRICEN, wherein CHM will actively work towards developing training modules and course components to be imparted to railway officers for creating awareness about railway heritage.

Professor Devanath Tirupati, in-charge of CHM, said, "The MoU provides research opportunities for faculty and students of AU on heritage-related themes associated with Indian Railways."

http://www.railnews.in

Hysteresis Curves of LWR

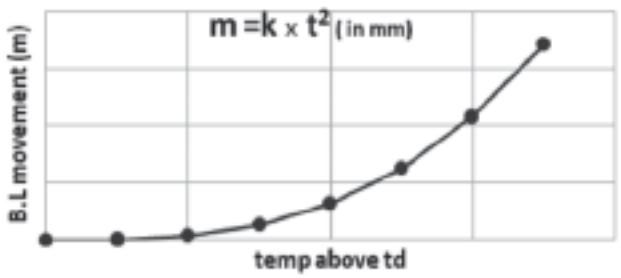
By
*Ramesh Pinjani **

Synopsis:
Indian Railways, LWR manual specify the SEJ's gap based on hysteresis curve with single loop i.e. to take care of temp lowering from td to tmin. Then temp increasing from tmin to tmax & then temp again lowering from tmax to tmin. This paper deals with estimation of SEJ gaps based on 4 hysteresis loops, to cater for situations i.e. when temp increases after destressing &considering effect of destressing in particular range of temp.

1.0 Introduction:

1.1 L.W.R is defined as a long welded rail or a panel in which central portion does not undergo/ exhibit any longitudinal movement due to thermal variations, since the central portion of the LWR does not move, the thermal strains & stress/ force gets induced in central portion equal to P = A E α t. The magnitude of induced thermal force (P) works out 1.638 ton for 52 Kg & 1.903 ton for 60 Kg rail section per degree of temp change.

1.2 The ends of LWR called breathing lengths is subjected to expansion/contraction on account of temperature variations. It is that length of track, from both ends of LWR where ballast resistance gets geared up to generate a force which will create fixed conditions in central portion. The movement of B.L (m) is given by equation = $(L_b \alpha t)/2$ OR $m = AE(\alpha t)^2/2R$



Value of k for diff track str.		
Rail	**S.D**	**K**
60 kg	**1660**	**0.00798**
60 kg	**1540**	**0.00826**
52 kg	**1660**	**0.00684**
52 kg	**1540**	. . . . .

1.3 However in real practice the B.L. does not follow the above curve, because at every reversal of temp, the ballast resistance is doubled, causing hysteresis loops which are discussed here under

2.0 Phenomenon of Hysteresis :

The behaviour of LWR, in terms of SEJ movementis shown in the fig-2, *As the temperature uniformly rises above 'O'(td) , the movement at the SEJ follows the movement — temperature curve oa, where movement of LWR m is calculated as under*

$$m = \frac{E(\alpha t)^2}{2R}$$

At any given temperature t_1 if the temp starts falling, then the movement at the SEJ does not follow the original path but traces out a new curve A_2DB_2. If at B_2 the temp again reverses then the path traced out is B_2EA_2 rather than

**Sr Professor (Bridge - II) IRICEN*

B_2DA_2. The loops in the form $A_2DB_2EA_2$ are called hysteresis loops and are formed whenever there is a temperature reversal. In order to simplify matters, an annual hysteresis loop or curve is plotted which will envelope all the hysteresis loops formed on a daily basis.

2.1 Reason for Hysteresis :

Hysteresis loops are formed due to the behaviour of the longitudinal ballast resistance. A plot of the resistance offered by the ballast vis-à-vis the sleeper displacement is as given in Fig -3. It is seen that:

The ballast resistance first increases linearly as the sleeper displacement, then goes into the plastic zone and finally assumes a constant value R. If at this stage the temperature reverses then the value of the longitudinal ballast resistance drops to zero and then becomes (-R) as shown in the figure-

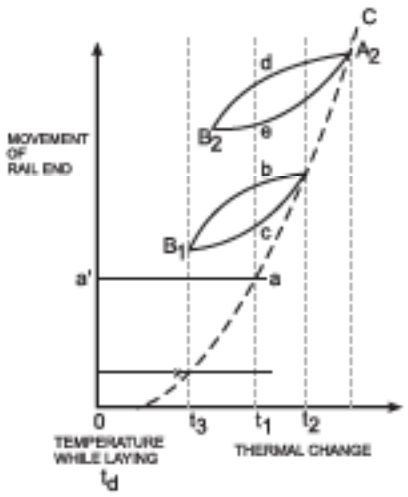


Fig -2 Hysteresis Phenomena

Note :

At the reversal of temperature the ballast resistance has to get mobilised in opposite direction, for this ballast core deformed in one particular direction has to come back to normal & then get mobilised in reverse direction, summing up the ballast resistance + r which existed at the instance of reversal of temperature drops to zero and then develops to - r. Hence to decide the magnitude of ballast resistance opposing the reverse movement, its value is taken as r - (- r) = 2 r for mathematical purpose.

Therefore at the time of reversal of temp the ballast resistance mobilized is 2R. Due to this effect, at every temp reversal the movement in LWR follows a different path leading to the hysteresis phenomenon.

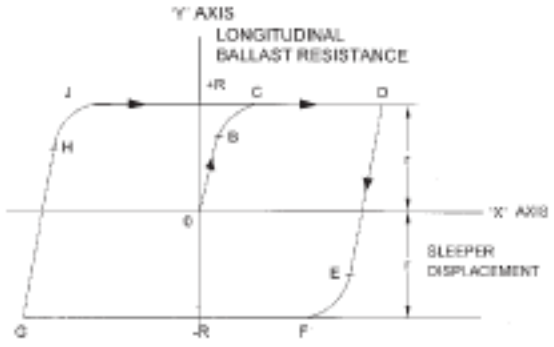


Fig. - 3

2.2 Number of Hysteresis loops:

The hysteresis loop can be traced in two ways:

1) Temp rise from t_d to t_{max}, fall from t_{max} to t_{min} and again a rise to t_{max} from t_{min}

2) Temp fall from t_d to t_{min}, rise from t_{min} to t_{max} and then a fall from t_{max} to tmin

It is however further added that in fact 4 hysteresis loops needs to be considered because destressing temp is a range of temp, where in one loop will form when td is fixed at lower limit & second loop will form when td is fixed at upper td limit.

The present criterion for td is as under:

a) Zone IV 52 kg & higher rail section : tm+5 to tm+10

b) All other sections in zone IV & Zone-I,II,III : tm to tm+5

For example, in zone-IV LWR with 52 & 60 kg rail section, the td can be fixed with in a temp range of tm +5 to tm +10, accordingly the tmax & tmin shall vary as under (Fig-4) :

i) When td is fixed at tm +5, tmin will go up to td – 43 & tmax will go up to td + 33.

ii) When td is fixed as tm +10, tmin will go up to td - 48 & tmax will go up to td + 28.

On over all basis the effective movement can take place in the temp range of td – 48 to td + 33 to take care of td at tm+5 to tm+10, this is additional feature which is under consideration with RDSO.

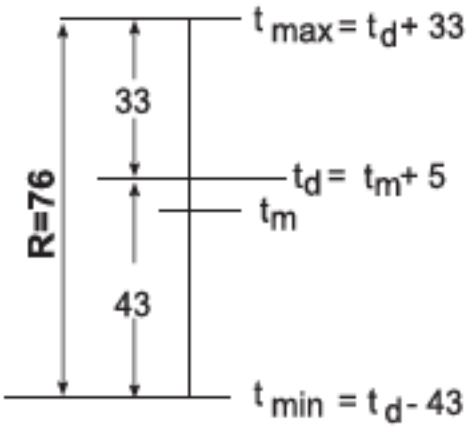


Fig. - 4a

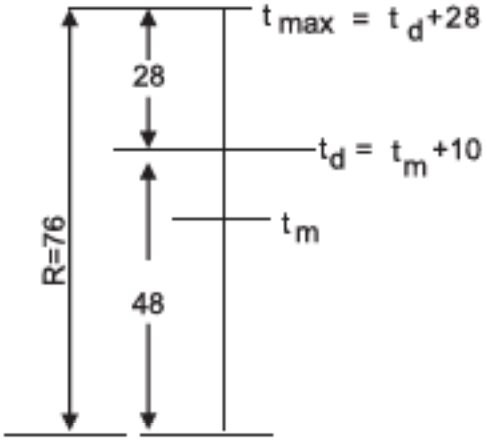


Fig. - 4b

The existing LWR manual annexure-V provides gaps based with an assumption that td is fixed at = tm +10, so as to have tmin = td - 48 & tmax = td + 28, the limitation of this assumption is that if the LWR is destressed at tm +5 (which is lower permitted temp for destressing) then tmax in peak summer shall reach td +33, but gaps indicated in annex-V are up to td +28. Similar problem is encountered for all other temp zones also.

It is therefore concluded that 4 hysteresis loops are to be considered in each case, for example in zone-IV when td is fixed as tm +5 to tm+10, the hysteresis loops shall be considered for following situations.

(Refer Fig-4a & 4b):

1) **Hysteresis loop-1**: with td = tm +5, Temp fall from t_d to td-43 , rise from td-43 to td+33 and then a fall from td+33 to td-43
2) **Hysteresis loop-2**: with td = tm +5, Temp increases from t_d to td+33 , fall from td+33 to td-43 and then increases from td-43 to td+33
3) **Hysteresis loop-3**: with td = tm +10, Temp fall from t_d to td-48 , rise from td-48 to td+28 and then a fall from td+28 to td-48
4) **Hysteresis loop-4**: with td = tm +10, Temp increases from t_d to td+28, fall from td+28 to td-48 and then increases from td-48 to td+28

3.0 Hysteresis Loops for All Temp Zones:

In zone-I,II,III the td is tm to tm+5, where as in zone-IV, td can be tm+5 to tm+10 (52 kg & 60 kg rail section) or tm to tm+5 (for 90R & lighter sections), therefore total 5 cases needs to be considered. These are given here under:

Table - 1

ZONE	Zone-I	Zone-II	Zone-III	Zone-IV	Zone-IV
Max. temp Range	50	60	70	76 76	
td	tm to tm +5	tm to tm +5	tm to tm +5	tm to tm +5	tm+ 5 to tm +10
Max. temp range	When td =tm+5 tmax = td+20 tmin=td-30	When td = tm+5 tmax = td+25 tmin = td-35	When td = tm+5 tmax = td+30 tmin= td-40	When td = tm+5 tmax = td+33 tmin=td-43	When td = tm + 10 tmax = td+28 tmin = td – 48
	When td= tm tmax= td+25 tmin=td-25	When td = tm tmax = td+30 tmin = td-30	When td = tm tmax = td+35 tmin = td-35	When td= tm tmax = td +38 tmin=td-38	When td = tm + 5 tmax = td+33 tmin = td -43
Effective temp range for hysteresis	td-30 to td+25	td-35 to td+30	td 40 to td+35	td-43 to td+38	td-48 to rd+33

ZONE	Zone-I	Zone-II	Zone-III	Zone-IV	Zone-IV
Loop-1: td at lower limit, temp decreasing trend	td → td - 30 → td → 20 →td-30	td → td - 35 → td → 25 →td - 35	td → td - 40 → td+30 →td-30	td -43 td + td + 33 - 43	td → td - 43 → td + 33 → td - 43
Loop-2 : td at lower limit, temp increasing trend	td → td + 20 → td → 30 →td+20	td → td +25 → td - 35 → td + 25	td → td - 30 → td+40 →td+30	td→ td+ 33→ td - 43 td + 33	td → td +33 → td + 33 → td + 33
Loop-3 : td at upper limit, temp decreasing trend	td → td - 25 → td+25→ td-25	td → td -30 → td + 30 → td - 30	td → td - 35 → td+35 →td-35	td→ td- 38 → td + 38 → td - 38	td → td - 48 → td + 28 → td - 48
Loop-4 : td at upper limit, temp increasing trend	td → td + 25 → td-25→ td+25	td → td +30→ td - 30 → td + 30	td → td + 35 → td-35 →td+35	td→ td+ 38 → td - 38 → td + 38	td → td + 28 → td - 48 → td +28

4.0 Detailed Calculations for Hysteresis Loops: Hysteresis calculations have been done to cover all the above 5 cases. One set of calculations based on 4 hysteresis loops is explained below:

Table: 2 - Hysteresis loop-1: Temp variation starts with lowering of temp up to tmin = td - 43, after destressing (when td is fixed at tm+5)

A=	76.86	∝ =	1.15E-05	E =	2150000	r =	13.28	K =	0.00826
60 KG	td = tm + 5 (decreasing temp trend after destressing)								
SD=1540	temp	formula	m1	temp	formula	m2	temp	formula	m3
Temp	td → td - 43			td - 43→ td +33			td + 33 → td - 43		
td + 33				76		8.58	0		8.58
td + 30				73		6.73	3	↓	8.54
td + 28				71		5.54	5	$m = 8.58 - \frac{AE(\alpha t)^2}{2x2R}$	8.48
td + 25				68		3.82	8		8.31
td + 20				63		1.12	13		7.88
td + 15				58		-1.38	18		7.24
td + 10				53		-3.67	23		6.39
td + 5				48		-5.76	28		5.34
td	0	↓ $m = \frac{-AE(\alpha t)^2}{2R}$	0	43		-7.63	33		4.08
td - 5	5		-0.21	38		-9.31	38		2.62
td - 10	10		-0.83	33		-10.77	43		0.95
td - 15	15		-1.86	28		-12.03	48		-0.93
td - 20	20		-3.30	23		-13.08	53		-3.02
td - 25	25		-5.16	18		-13.93	58		-5.31
td - 30	30		-7.43	13		-14.57	63		-7.81
td - 35	35		-10.11	8	↑ $m = -15.27 + \frac{AE(\alpha t)^2}{2x2R}$	-15.00	68		-10.51
td - 40	40		-13.21	3		-15.23	73		-13.42
td -43	43		-15.27	0		-15.27	76		-15.27
td - 45				↑					
td - 48									

Table-3: Hysteresis loop-2: Temp variation starts with increase in temp up to tmax= td + 33, after destressing (when td is fixed at tm +5)

	td = tm + 5 (Increasing temp trend after destressing)								
	temp	formula	m4	temp	formula	m5	temp	formula	m6
Temp	td → td + 33			td + 33→ td - 43			td - 43 → td + 33		
td + 33	33	↑ $m = \frac{AE(\alpha t)^2}{2R}$	8.99	0	↓ $m = 8.99 - \frac{AE(\alpha t)^2}{2 \times 2R}$	8.99	76	↑ $m = -14.85 + \frac{AE(\alpha t)^2}{2 \times 2R}$	8.99
td + 30	30		7.43	3		8.95	73		7.15
td + 28	28		6.47	5		8.89	71		5.96
td + 25	25		5.16	8		8.73	68		4.24
td + 20	20		3.30	13		8.29	63		1.53
td + 15	15		1.86	18		7.65	58		-0.97
td + 10	10		0.83	23		6.81	53		-3.26
td + 5	5		0.21	28		5.76	48		-5.34
td	0		0.00	33		4.50	43		-7.22
td - 5	↑			38		3.03	38		-8.89
td - 10				43		1.36	33		-10.36
td - 15				48		-0.52	28		-11.62
td - 20				53		-2.61	23		-12.67
td - 25				58		-4.90	18		-13.52
td - 30				63		-7.39	13		-14.16
td - 35				68		-10.10	8		-14.59
td - 40				73		-13.01	3		-14.82
td -43				76		-14.85	0		-14.85
td - 45									
td - 48									

Table-4: Hysteresis loop-3: Temp variation starts with lowering of temp up to tmin = td - 48, after destressing (when td is fixed at tm+10)

	td = tm + 10 (decreasing temp trend after destressing)								
	temp	formula	m7	temp	formula	m8	temp	formula	m9
Temp	td → td -48			td - 48→ td +28			td + 28 → td - 48		
td + 33									
td + 30									
td + 28				76	↑ $m = -19.02 + \frac{AE(\alpha t)^2}{2 \times 2R}$	4.82	0	↓ $m = 4.82 - \frac{AE(\alpha t)^2}{2 \times 2R}$	4.82
td + 25		↓		73		2.98	3		4.78
td + 20		$m = \frac{-AE(\alpha t)^2}{2R}$		68		0.07	8		4.56
td + 15				63		-2.64	13		4.12
td + 10				58		-5.14	18		3.48
td + 5				53		-7.43	23		2.64

td	0		0.00	48		-9.51	28		1.59
td - 5	5		-0.21	43		-11.39	33		0.33
td - 10	10		-0.83	38		-13.06	38		-1.14
td - 15	15		-1.86	33		-14.53	43		-2.81
td - 20	20		-3.30	28		-15.79	48		-4.69
td - 25	25		-5.16	23		-16.84	53		-6.77
td - 30	30		-7.43	18		-17.69	58		-9.07
td - 35	35		-10.11	13		-18.33	63		-11.56
td - 40	40		-13.21	8		-18.76	68		-14.27
td -43	43		-15.27	5		-18.92	71		-15.99
td - 45	45		-16.72	3		-18.99	73		-17.18
td - 48	48		-19.02	0		-19.02	76		-19.02

Table-5 : Hysteresis loop-4: Temp variation starts with increase in temp up to tmax= td +28, after destressing (when td is fixed at tm +10)

	td = tm + 10 (Increasing temp trend after destressing)								
	temp	formula	m10	temp	formula	m11	temp	formula	m12
Temp	td → td + 28			td +28 → td - 48			td - 48 → td + 28		
td + 33									
td + 30									
td + 28	28		6.47	0		6.47	76		6.47
td + 25	25	↑	5.16	3		6.44	73		4.63
td + 20	20		3.30	8		6.21	68		1.72
td + 15	15	$m=\frac{AE(\alpha t)^2}{2R}$	1.86	13		5.78	63		-0.99
td + 10	10		0.83	18		5.14	58		-3.48
td + 5	5		0.21	23	$m=6.47-\frac{AE(\alpha t)^2}{2\times 2R}$	4.29	53	↑ $m=-17.37+\frac{AE(\alpha t)^2}{2\times 2R}$	-5.78
td	0		0.00	28		3.24	48		-7.86
td - 5				33		1.98	43		-9.74
td - 10				38		0.51	38		-11.41
td - 15				43		-1.16	33		-12.88
td - 20				48		-3.04	28		-14.14
td - 25				53		-5.12	23		-15.19
td - 30				58		-7.41	18		-16.03
td - 35				63		-9.91	13		-16.67
td - 40				68		-12.62	8		-17.11
td -43				71		-14.34	5		-17.27
td - 45				73		-15.53	3		-17.34
td - 48				76		-17.37	0		-17.37

5.0 Recommended Gap Range Based on 4 Hysteresis Loops Logic:

Based on the above 4 hysteresis loops the minimum & maximum breathing length movement is worked out to estimate the range in which the SEJ gap will lie for the temperatures lying between tmin & tmax.

The breathing length movement is to be

converted in the SEJ gaps, so that it can be measured.

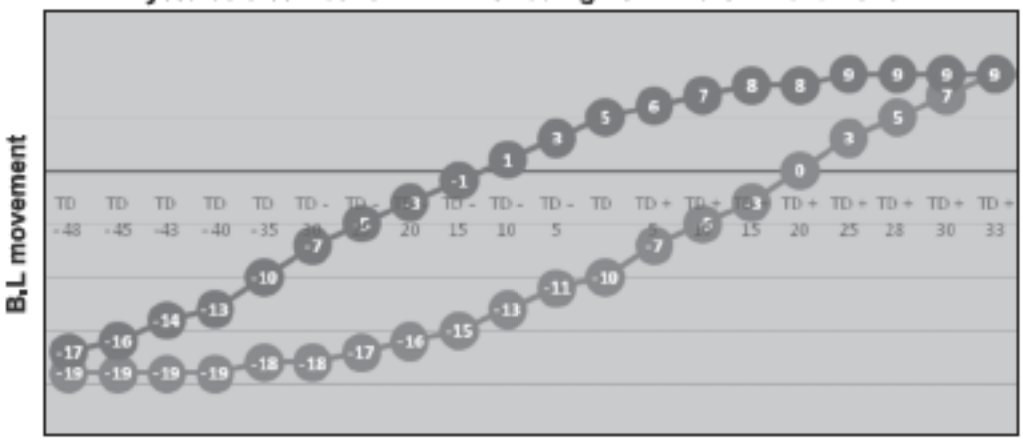
Suppose the B.L movement is in the range of a - b and say a is contraction & b is expansion then the SEJ gap range will be 20 + a, 20 – b, assuming initial SEJ gap as 40 mm (which is fixed for 52 kg &60 kg), If the initial gap is 60 mm (which is fixed for 90 R & lower section) then gap range will be 30 + a, 30 - b.

Based on 4 hysteresis loops as worked out under table-2 to table-5 above, the range for breathing length movement & SEJ gap range is worked out as shown in table-6 below.

Table -6: Recommend gaps based on 4 hysteresis loop concept/logic

RAIL- 60 KG SLD=1540 ZONE-IV	Range for movement (m)		Range of Gap		Rounding off gap		Permitted gap Range
	min (m1)	Max (m 2)					
Temp							
td + 33	8.58	8.99	11.42	11.01	11	11	11 -11
td + 30	6.73	8.95	13.27	11.05	13	11	11 -13
td + 28	4.82	8.89	15.18	11.11	15	11	11 -15
td + 25	2.98	8.73	17.02	11.27	17	11	11 -17
td + 20	0.07	8.29	19.93	11.71	20	12	12 -20
td + 15	-2.64	7.65	22.64	12.35	23	12	12 -23
td + 10	-5.14	6.81	25.14	13.19	25	13	13 -25
td + 5	-7.43	5.76	27.43	14.24	27	14	14 -27
td	-9.51	4.50	29.51	15.50	30	16	16 -30
td - 5	-11.39	3.03	31.39	16.97	31	17	17 -31
td - 10	-13.06	1.36	33.06	18.64	33	19	19 -33
td - 15	-14.53	-0.52	34.53	20.52	35	21	21 -35
td - 20	-15.79	-2.61	35.79	22.61	36	23	23 -36
td - 25	-16.84	-4.90	36.84	24.90	37	25	25 -37
td - 30	-17.69	-7.39	37.69	27.39	38	27	27 -38
td - 35	-18.33	-9.91	38.33	29.91	38	30	30 -38
td - 40	-18.76	-12.62	38.76	32.62	39	33	33 -39
td -43	-18.92	-14.34	38.92	34.34	39	34	34 -39
td - 45	-18.99	-15.53	38.99	35.53	39	36	36 -39
td - 48	-19.02	-17.37	39.02	37.37	39	37	37 -39

Hysteresis curves for LWR with 60 Kg Rail PRC SD=1540-Zone-IV



6.0 Compilation of Results : For a particular track structure having a specific value of **A** (based on cross sectional area of rail) &ballast resistance **r** (based on Type of sleeper-sleeper density) the permitted gap range is calculated for all the 4 temp zones & compiled. This exercise has been done using the excel program.

For track structure 60 kg / 52 kg rail on concrete sleeper with 1660/ 1540 sleeper density (most widely & commonly used track structure on IR today) the permitted gap range is worked out for all the 4 temp zones, which is placed under table 7-10:

Table-7 Gap range for temp zone-I

TEMP	60 KG R = 13.74	60 KG R = 13.28	52 KG R = 13.74	52 KG R = 13.28
td + 25	15-15	15-15	16-16	16-16
td + 20	15-17	15-17	16-18	16-18
td + 15	15-19	15-19	16-19	16-19
td + 10	16-21	16-21	16-21	16-21
td + 5	17-22	16-22	17-22	17-22
td	18-24	17-24	18-23	18-23
td - 5	19-25	19-25	19-24	19-24
td - 10	20-26	20-26	20-25	20-25
td - 15	21-26	21-27	21-25	21-26
td - 20	23-27	23-27	23-26	23-26
td - 25	25-27	25-27	24-26	24-26
td - 30	27-27	27-27	26-26	26-26

Table-8 Gap range for temp zone-II

TEMP	60 KG R = 13.74	60 KG R = 13.28	52 KG R = 13.74	52 KG R = 13.28
td +30	13-13	13-13	14-14	14-14
td + 25	13-15	13-15	14-16	14-16
td + 20	13-18	13-18	14-18	14-18
td + 15	14-20	13-20	15-20	14-20
td + 10	14-22	14-22	15-21	15-22
td + 5	15-23	15-24	16-23	16-23
td	16-25	16-25	17-24	17-24
td - 5	18-26	18-26	18-25	18-26
td - 10	19-27	19-28	19-26	19-26
td - 15	21-28	21-28	21-27	21-27
td - 20	23-29	23-29	22-28	22-28
td - 25	25-29	25-30	24-28	24-28
td - 30	27-30	27-30	26-28	26-29
td - 35	29-30	30-30	28-28	28-29

Table-9 Gap range for temp zone-III				
TEMP	60 KG R = 13.74	60 KG R = 13.28	52 KG R = 13.74	52 KG R = 13.28
td + 35	10-10	10-10	12-12	11-11
td + 30	10-13	10-13	12-14	11-14
td + 25	11-16	10-16	12-16	12-16
td + 20	11-18	11-18	12-19	12-19
td + 15	12-21	12-21	13-21	13-21
td + 10	13-23	12-23	14-22	14-22
td + 5	14-25	14-25	15-24	14-24
td	15-26	15-27	16-25	16-26
td - 5	17-28	16-28	17-27	17-27
td - 10	18-29	18-29	19-28	18-28
td - 15	20-30	20-31	20-29	20-29
td - 20	22-31	22-32	22-30	22-30
td - 25	25-32	25-32	24-30	24-31
td - 30	27-32	27-33	26-31	26-31
td - 35	30-33	30-33	28-31	29-31
td - 40	32-33	33-33	31-31	31-31

Table-10 Gap range for temp zone-IV				
TEMP	60 KG R = 13.74	60 KG R = 13.28	52 KG R = 13.74	52 KG R = 13.28
td + 33	11-12	11-11	13-13	12-13
td + 30	11-13	11-13	13-14	12-14
td + 28	11-15	11-15	13-16	12-16
td + 25	12-17	11-17	13-18	12-17
td + 20	12-20	12-20	13-20	13-20
td + 15	13-23	12-23	14-22	13-22
td + 10	13-25	13-25	14-24	14-24
td + 5	14-27	14-27	15-26	15-26
td	16-29	16-30	16-28	16-28
td - 5	17-31	17-31	17-29	17-30
td - 10	19-33	19-33	19-31	19-31
td - 15	21-34	21-35	20-32	20-33
td - 20	23-35	23-36	22-33	22-34
td - 25	25-36	25-37	24-34	24-34
td - 30	27-37	27-38	26-35	26-35
td - 35	30-38	30-38	28-35	29-36
td - 40	32-38	33-39	30-36	31-36
td -43	34-38	34-39	32-36	32-36
td - 45	35-38	36-39	33-36	33-36
td - 48	37-38	37-39	34-36	35-36

7.0 Comparison with Gaps Stipulated under Annex-V LWR Manual:

i) It is seen that the gaps mentioned in LWR manual does not cover the gaps for extreme temp limit in summer, say in zone IV, when td is fixed at tm+ 5 level, the temp can rise up to td +33, however the gaps in LWR manual are shown up-to td +28 only.

ii) The gaps based on 4 hysteresis loops are generally permitting a wider range of gap for a given temp i.e. by 3- 4 mm extraapprox.., over existing permitted range, and even in some cases 5 to 7 mm extra (60 kg rail with 1540 SD) using 4 hysteresis loops.

The difference in permitted gap range based on 4 hysteresis loops & annex-V of LWR manual for 60 kg/52 kg PRC SD 1540/1660 for zone-IV is placed under table-11, for better understanding of magnitude of change / implications involved.

Table-11 Diff. in permitted gap range based on 4 hysteresis loops & LWR annex-V

TRACK STR.	60 KG PRC SLEEPER SD=1660 R=13.74	60 KG PRC SLEEPER SD=1540 R=13.28	52 KG PRC SLEEP ER SD=1660 R=13.74	52 KG PRC SLEEPER SD=1540 R=13.28
Temp	Diff in Gap Range	Diff in Gap Range	Diff in Gap Range	Diff in Gap Range
td + 33	-	-	-	-
td + 30	-	-	-	-
td + 28	4	4	3	4
td + 25	3	5	4	3
td + 20	4	7	3	3
td + 15	3	7	2	3
td + 10	4	5	3	3
td + 5	3	3	2	2
td	2	3	2	2
td - 5	3	2	2	3
td 10	3	3	2	2
td - 15	2	2	2	3
td - 20	1	2	2	3
td - 25	1	2	1	1
td - 30	1	2	2	1
td - 35	1	1	1	2
td - 40	1	2	3	1
td 43	-	-	-	-
td 45	1	2	2	1
td - 48	1	2	2	1

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Loss in Lateral Ballast Resistance after SBCM working

By
*Anil Choudhary**

1.0 Introduction:

During many discussions it was observed that field officials are of the view that there is a major loss in lateral ballast resistance after working of SBCM. Many times this resulted in non-utilization of SBCM during high temperatures. TMM directorate of RDSO decided to conduct trials so that actual position may be clarified. The terms of reference of the trial was chosen as below:

a) Reduction in Lateral Ballast Resistance after Shoulder ballast screening by SBCM machines.

b) Comparison of loss in Lateral Ballast Resistance after Shoulder ballast screening by SBCM machines and Lateral Ballast Resistance after Tamping.

2.0 Trial Location:

a) The trial, for Effect on Lateral Ballast Resistance after Shoulder ballast screening by SBCM, was conducted between Dhondha Dih- Karimuddinpur in Lucknow Division of North Eastern Railway (NER) having LWR track with 60 Kg Rail on 60 Kg sleeper and sleeper density of 1660/Km.

b) For comparison of loss in Lateral Ballast Resistance after Shoulder ballast screening by SBCM machines and Lateral Ballast Resistance after Tamping results of trial conducted in Moradabad Division of Northern Railway for preparing Report on evaluation of comparative performance of Different types of Dynamic Track Stabilizer working on Indian Railways has been utilized.

3.0 Method of Measurement of Lateral Ballast Resistance:-

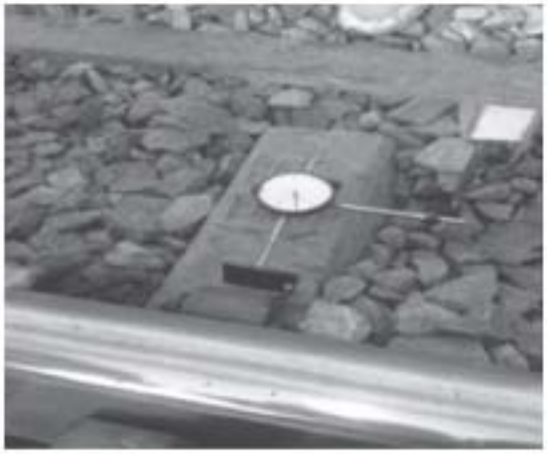
For testing, the sleeper was required to be freed of rail. Thus ERC of 6-7 sleepers on both side of sleeper to be tested was removed and freed Rail lifted to the extent that sleeper can move laterally under the rail. The work was to be conducted in traffic block. Ballast resistance was measured initially before working of SBCM & after working of SBCM. Force was applied laterally through hydraulic jack at the end of sleeper and proving ring provided in between sleeper and jack to measure the load. Some reaction blocks were fitted in between jack and rail post to fill the gap. The sketch of arrangement is shown at Annexure – 5. A dial gauge was placed at other side of sleeper to measure the lateral displacement of sleeper.

Load was applied gradually and max load applied by the jack before sleeper movement started was measured by proving ring as max ballast resistance of that sleeper. Average value of data has been taken for comparison of results. The photograph of measurements being taken is given below.



Photograph-1: Arrangement for taking Reaction

* *Professor (Track Machine), IRICEN*



Photograph-2: Dial gauge for taking displacement



Photograph-3: Proving ring for measuring Load



Photgraph-4: Reaction being taken at site

4.0 Results of Ballast Resistance Measured:-

Initial Ballast Resistance.

Sl No.	Location	Initial ballast resist. (Kg/Sleeper)	Average
1	98/4-5	1680	
2	98/4-5	1650	**1592.5**
3	98/5-6	1510	
4	98/5-6	1530	

Ballast Resist. After SBCM

SL No.	Location	Initial ballast resist. (Kg/Sleeper)	Average
1	99/5-6	1370	
2	99/5-6	1320	
3	99/4-5	1440	
4	98/6-7	1420	
5	98/6-7	1470	**1403.3**
6	98/5-6	1350	
7	98/0-1	1450	
8	98/0-1	1340	
9	98/0-1	1470	

Percentage decrease in ballast Resistance after working of FRM = **11.76%**

5.0 Comparison of Loss in Lateral Ballast Resistance

Comparison of loss in Lateral Ballast Resistance after Shoulder ballast screening by SBCM and Lateral Ballast Resistance after Tamping was made. For the loss of lateral ballast resistance due to tamping, the results of RDSO report No 195 was taken. The result of the report is reproduced below-

S.No.	Item	Value
1	Average Lateral Ballast Resistance of a consolidated track (Before tamping)	1433Kgf/ sleeper
2	Average Lateral Ballast Resistance immediately after tamping	663Kgf/ sleeper

Loss in Lateral ballast resistance is 53.73%. The increase in lateral ballast resistance after one round of DTS (By M/S Plasser M/C) is upto 914kgf/sleeper. This net loss from initial is still 36.22%.

6.0 Observations & Conclusion

1. Trials were conducted in the following limiting condition:
   Trial for measuring loss in lateral ballast resistance after working of SBCM was conducted at only one location and so the sample size is insufficient.
2. Following conclusion may be drawn from the trials conducted under above limiting conditions::

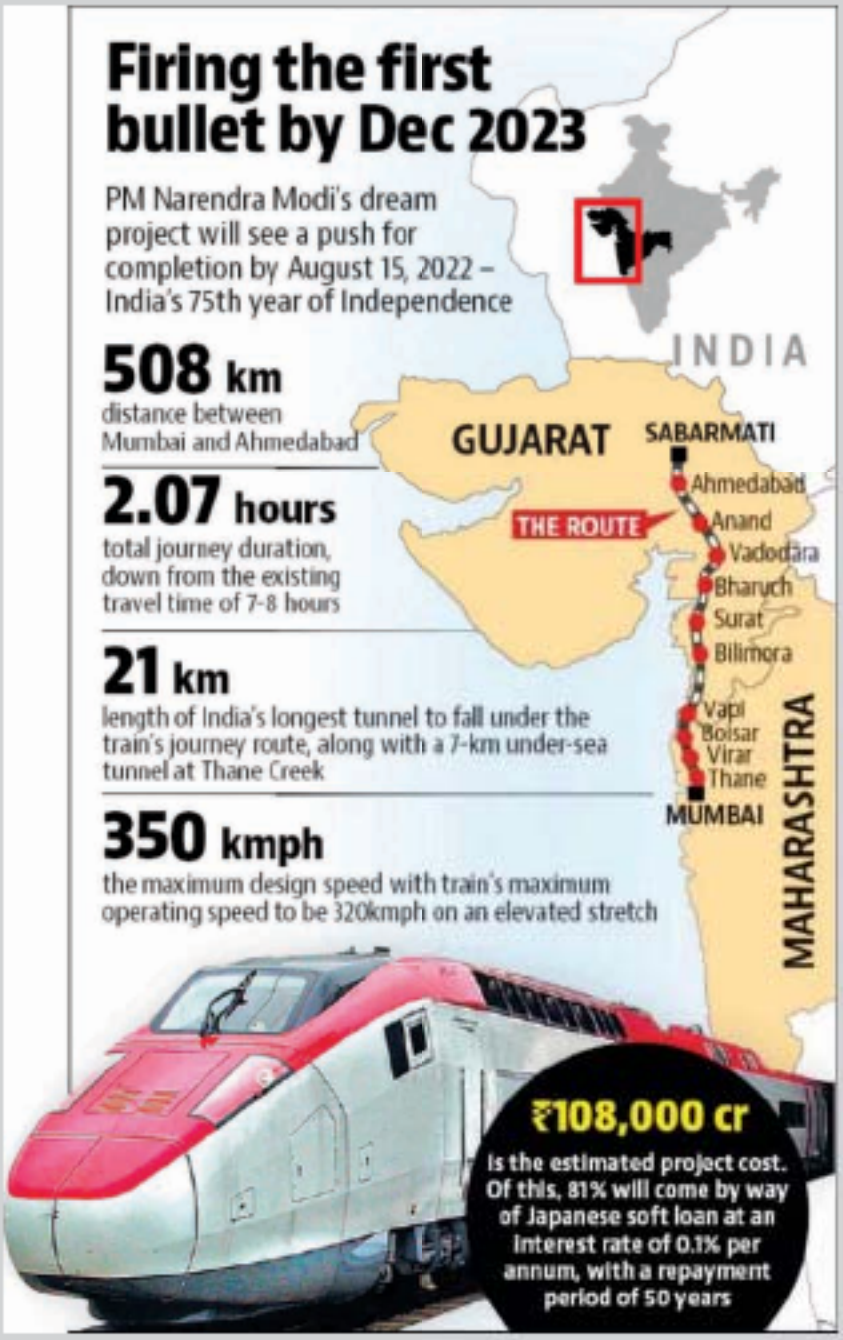
i) Percentage decrease in ballast Resistance after working of SBCM = 11.76%.

ii) The lateral ballast resistance of sleeper is reduced immediately after tamping to approximately 46% (663 Kg/sleeper) of that of consolidated track value(1433 Kg/sleeper) ie the loss is of 53.73%. Even one round of DTS (By M/S Plasser M/C) retains it to 63.78%of initial value ie there still remains a net loss of 36.22%.

Loss of lateral ballast resistance after working of SBCM is therefore very less. Since tamping with DTS is permitted in summer so it is also safe to use SBCM in summer.

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Mumbai-Ahmedabad Bullet Train Project Ready for Takeoff; Modi, Shinzo Abe laid Foundation



https://www.railnews.in

Review of Geotechnical Investigation Guidelines and Suggestions for Framing Tender Conditions

By
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*Kunal Jain***
*Suprit Jakati****

Synopsis :

Geotechnical investigation is the foremost engineering activity that is conducted for any project, which influences the safety as well as economy of the project. Depending upon the type of project and soil condition different methods of geotechnical investigation are involved. In most of the engineering projects, it is observed that due to lack knowledge or an insufficient contract condition, complete geotechnical investigation is not carried out and as a result, the design of the project is either at risk or overdesigned. In this paper, various aspects of geotechnical investigation are reported from standard codes of different countries and an attempt has been made to provide a comprehensive guideline which will help in better assessment of ground strength and also to frame tender conditions so that adequate testing can be done.

Keywords: Geotechnical investigation, Boreholes, Laboratory Testing and Tender Conditions.

1.0 Introduction

Geotechnical Investigations are performed in order to determine the engineering properties of soil and rock at the site. These engineering properties are used to design earthworks and foundations. In a project, the greatest risk lies in the uncertainties in ground conditions. Despite being an important part of a project, it is generally constrained by time and economic considerations. Most of the time the tender document lacks clarity regarding the detail scheme of geotechnical investigation which leads to subjectivity and finally results into inadequate geotechnical investigation.

The Indian Standard Code of Practice for subsurface investigation for foundations IS 1892gives only the broad overview of geotechnical investigation to be carried out. The details about number of undisturbed or disturbed samples, their locations and some other relevant features are missing.

In this paper and attempt has been made to suggest holistic view of geotechnical investigation, guidelines adopted in other countries. Some suggestions regarding framing of tender conditions also suggested so that subjectivity in the quantum of work can be eliminated. The Standard Schedule of Rates for each item has also been mentioned for reference so that contractor can quote their competitive rates.

2.0 Preliminary Geotechnical Investigation or Reconnaissance Survey.

Site reconnaissance helps in deciding future programme of field investigations. A site where detailed geotechnical information is not available site reconnaissance becomes a mandatory investigation. Site reconnaissance helps in determining scope of work, methods of exploration to be adopted, field tests to be carried out and administrative arrangements required for the investigation. The site reconnaissance guides whether the site is suitable for the construction of the proposed structure or not, if

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else some recommendation have to be made for the improvement of the site. Site reconnaissance includes a study of local topography, excavations, behaviour of existing structures at or near the site; water level in streams, water courses and wells; drainage pattern, springs and swamps. Information on some of these may be obtained from topographical maps, geological maps, pedological and soil survey maps, and aerial photographs. The type of vegetation surrounding the site indicates the nature of the soil. The indications of swamps, peats and superficial deposits have to be confirmed during actual investigation. The groundwater conditions may be known by observing the water level in wells in the vicinity of the sites. For the construction of the waterfront structures the flood marks in the river may indicate the highest flood level.

If reconnaissance is not possible then it is essential to carry out preliminary investigation. Preliminary exploration helps in determination of depths, thickness, extent and composition of each soil stratum, location of rock and ground water. During preliminary investigation, geophysical methods and tests with cone penetrometers are carried out.

3.0 Detailed Geotechnical Investigation

Detailed investigation is carried out after preliminary investigation and should be planned on the basis of data obtained during reconnaissance and preliminary investigations. The aim of detailed exploration is to determine engineering properties of strata which are shown by preliminary exploration to be critical. Also, the detailed investigation helps to determine shear strength and compressibility of all types of soils, density, natural moisture content, and permeability. It may also be necessary to determine the pre-consolidation pressure of the strata. The detailed investigation includes boring programme and detailed sampling to determine these properties. The field permeability test and the test for the determination of dynamic properties of soils may also be conducted where necessary. All in-situ tests are to be supplemented by laboratory investigations.

Usually boreholes are drilled in the ground surface to extract the ground samples, which are used in tests to determine the soil or rock properties. A borehole is a narrow shaft bored in the ground, either vertically or horizontally for detailed geotechnical investigation. The common boring methods include Auger boring, Percussion boring, wash boring and rotary drilling, rotary drilling being most common in ground formed by soil and rock. In rotary drilling a heavy string of the drill rod is used for choking action. The broken rock or soil fragments are removed by circulating water or drilling mud pumped through the drill rods and bit up through the bore hole from which it is collected in a settling tank for recirculation. These samples are collected and laboratory test may be conducted on them to determine the required properties.

During detailed investigation, Standard Penetration Test (SPT) is conducted simultaneously during borehole sampling. The test uses a thick-walled sample tube, which is driven into the ground at the bottom of a borehole by blows from a slide hammer with a mass of 65 kg falling through a distance of 75cm. The sample tube is driven 150mm into the ground and then the number of blows needed for the tube to penetrate each 150mm up to a depth of 450mm is recorded. The sum of the number of blows required for the second and third 15cm of penetration is termed the "standard penetration resistance" or the "N-value. The blow count provides an indication of the density of the ground, and it is used in many empirical geo technical engineering formulae. Under the following conditions the penetration is referred to as refusal and the test is halted. a) 50 blows are required for any 150mm penetration b) 100 blows are required for last 300mm c) 10 successive blows produce no advancement. The observed N-values should be corrected as per IS 1892.

4.0 Selection of No. of Borehole Locations

Selection of ground investigation points plays an important role in geotechnical investigation. The properties obtained from a particular borehole represents only that particular location. Therefore, the investigation points must be distributed such that one can certainly determine the properties of the whole project area.

The load distribution of each structure is different hence the criteria for deciding the spacing between two points should be different for each structure.

4.1 For Embankments and Cutting

Embankments and cuts prevents sudden changes in elevation of a road or a railway track by maintaining a certain level.

At least one investigation point should be selected for each cut or embankment.

The investigation points should be selected along the alignment at an interval of 60m to 120m, or wherever there is change in strata. *(FHWA NHI-01-031. Table 2-3)*[2]

Investigation points should be arranged at adequate offsets to the centre line, depending on the overall width of the structure.*(EN 7 2.4.1.3.2)*[3]

4.2 For bridges

Bridges are more sensitive to settlement as unwanted settlement can cause the path to misalign.

If the design is known the for piers or abutments over 30m wide, at least two Investigation points per foundation. For piers or abutments less than 30m wide at least one Investigation points per foundation. If the design is unknown the minimum spacing between two investigation points should be 30m along the alignment of the bridge. *(FHWA NHI-01-031. Table 2-3)*[2]

Investigation points should be arranged at adequate offsets to the centre line, depending on the overall width of the structure.*(EN 7 2.4.1.3.2)*[3]

Apart from the length of bridge, the exploration should be extended by distance B on both sides where B is the Depth of exploration of the respective extreme ends. (*IRC 78- Appendix 2 clause 3.2)*[4]

4.3 For Tunnels

Tunnels require a thorough geotechnical investigation as the tunnelling technique depends on the subsurface profile.

There is no Indian standard for geotechnical investigation of tunnels. Hence the following practise is recommended for borehole spacing along the centreline of the tunnel during the Soil investigation. *(Manual on Subsurface investigation–AASHTO 7.4.3.5)*[5]

Soil Condition	Condition	Spacing
Soft Ground	Adverse Favourable	15m-30m 90m-150m
Mixed Face	Adverse Favourable	8m-15m 15m-23m
Hard Ground	Adverse Favourable	15m-60m 150m-300m

Since no Standard suggests complete arrangement of borehole for tunnelling it is recommended that in addition to above criteria one borehole between two consecutive centreline boreholes with alternate offset of one third of the distance between two consecutive centreline boreholes.

The distance between two consecutive centreline boreholes is L, then location of the offset boreholes is shown in the figure 1.

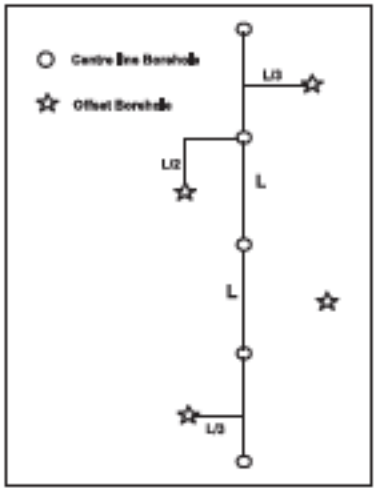


Figure 1 : Location of Boreholes

4.4 For Open Land

The selection of investigation point on a plot depends on the purpose of the plot. There is no investigation necessary for parks or parking areas. But ground beneath the buildings needs to be investigated.

The location of the boreholes of the plots should be as per IS code recommendations mentioned below.

For a compact building site covering an area of about 0.4 hectare, one borehole or trial pit in each corner and one in the centre should be adequate. For smaller and less important buildings even one borehole or trial pit in the centre will suffice.*(IS 1892 2.3.1)*[6]

For high-rise and industrial structures, a grid pattern with points at 15m to 40m distance and for large-area structures, a grid pattern with points at not more than 60m distance.*(EN 7 Annexure B.3)*[3]

However, it should to be taken care that borehole is drilled on the sites where the actual structure rests. The drilling of borehole where no structure is proposed can be ignored.

The plan of a Residential society along with proposed boreholes is shown in figure 2.

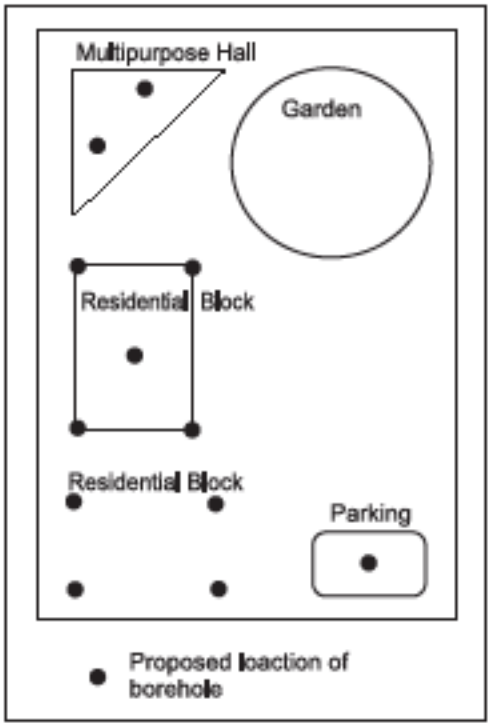


Figure 2 : Location of Borehole for Plot

5.0 Determination of Depth of Exploration

The entire load of the structure is transferred to soil. These loads influence the soil and after certain depth the effect of loads becomes negligible. Hence it is necessary to know the soil properties throughout the zone of influence. The required depth of exploration depends upon type of structure, purpose of structure, the loads transferred by the structure, size and shape of loaded areas, soil profile and site conditions.

If the proposed structure is planned in a developed area, the geotechnical investigation data of existing similar structures should be considered and in such cases the investigation should be carried out to confirm that the soil profile is similar in that area. If no such information is available or inconclusive data is available, then a detailed exploration is required.

If the required depth of exploration is less than 3m then trial pits can be used.

Depending on the type of structure the following guidelines should be followed:

5.1 For Embankments

The exploration depth (from ground level) for the embankment should be maximum of 6m *(EN 7 Annexure B.3)*[3] or 2 x H (where H is the height of the embankment). *(GE G1 RDSO 3.4.2 (c))*[7]

5.2 For Cuttings

The exploration depth (from base of the cutting) for the cutting should be maximum of 5m *(FHWA NHI-01-031. Table 2-2)* [2] or the width at the bottom of the cutting. and *(IS 1892 clause 2.3.2.1 table 1)*[6]

5.3 For Tunnels

The depth of exploration should be at least 1 to 1.5 times B below tunnel (where B is the width of the tunnel). However, it is recommended to explore 2 to 3 times B, considering future modifications in tunnel. (*manual of sub-surface investigation 1988 AASHTO Clause 7.4.4.5)*[5]

5.4 For Foundations

5.4.1 The depth of exploration should be carried out up to a level at which the net increase in the

vertical stress becomes less than 10% of the initial overburden pressure.[8]

5.4.2 If the width of foundation is known the depth of exploration shall be carried out accordingly.

If spacing between two foundations is less than twice the width of the foundation, then the depth of exploration should be 1.5 to 2 times L (L= length of foundation).*(IS 1892 clause 2.3.2.1)*[8]

If spacing between two foundations is more than four times the width of the foundation, then the depth of exploration should be 1.5 to 2 times B (B= width of foundation).*(IS 1892 clause 2.3.2.1)*[8]

If spacing between two foundations is less than four times the width and more than twice the width, then the depth of exploration is obtained by linear interpolation of values obtained bythe above two conditions. *(FHWA NHI-01-031 table 2-2)*[2]

The engineer in charge will decide the multiplier 1.5 to 2 depending on the importance of the structure and site conditions.

5.4.3 If the design of structure is not known at the time of exploration then, the depth of exploration should be based on the type of structure being constructed. In general, the following values can be adopted :

Type of Structure	Depth of exploration (m)
Residential buildings	Number of floors times 2.5*
Institutional buildings	Number of floors times 3.5*
Major bridges	40m - 50m
Minor bridges	20m - 25m

* based on the load of each floor.

5.5 For Piles

The depth of exploration should be the maximum of 5m, or 3times the pile base diameter or the width rectangle circumscribing the group of piles forming the foundation at the level of the pile base. The depth is measured from the bottom of the pile. *(EN 7 Annexure B.3)*[3]

In any case the minimum depth of exploration for black cotton soils should be 3.5m and 1.5m for other soils.

6.0 Sampling

Sampling is the important component of the Geotechnical investigation, the samples of subsurface material are taken at regular intervals. To determine the properties of the subsurface, laboratory tests must be conducted on these samples. The sampling method depends on the nature of the site and the type of engineering project. The two types of soil samples that can be generally taken for an engineering project are Disturbed soil sample and Undisturbed soil sample. Disturbed sample are those in which natural structure of the material is modified or destroyed, though with suitable precautions the natural moisture content can be preserved. Undisturbed soil sample are the one in which the structure and properties of the material are preserved. For a better quality of sample, the minimum diameter of the bore shall be 150mm and boring shall be carried out in accordance with the provisions of IS: 1892.And for the standard frequency of sampling, samples should be taken at any change of stratum and at a specified spacing, usually not larger than 3m.*(EN 7.3.4.3(7))*[3] Similarly, in Rock sampling, the sludge from percussion borings, or from rotary borings which have failed to yield a core, may be taken as a Disturbed sample. Disturbed samples may be recovered from circulating water by settlement in a trough. The rock type may be deduced by examining the material of which the sludge is composed. The undisturbed rock samples shall be taken from rock formation in the form of Block sample, and dressed to a size convenient for packing. The undisturbed core samples of rock shall be taken by means of rotary drills fitted with a coring bit and core sampler.

6.1 Categories of sampling methods and laboratory quality classes of samples

A major consideration during sampling a particular stratum is to ensure that the sample

taken is appropriate for the tests required and that the results obtained from the testing are then relevant to the actual conditions in the field. To ensure accurate and reliable test results, the quality of the sample must therefore be appropriate for that particular test.

The sampling category obtained when a particular sampling method is used on particular type of soil is as found out based on table 1.

The minimum sampling category required for determining a particular property of soil is as follows. [12]

Properties that can be determined	Sampling Category
Sequence of layers	C/B/A
Boundaries of strata - broad	B/A
Boundaries of strata fine	A
Atterberg limits, Particle	B/A
density, Organic content Water content	A
Density, Density index, Porosity, Permeability	A
Compressibility, Shear Strength	A

Table 1 : Quality Classes of Soil Samples[12]

No.	Sampling Method	-	-	-	Soil type	-	-
			Clay	Silt	Sand	Gravel	Organic
1.	Rotary core Drilling	Single- tube Double /Triple tube	B A	C B	C B	C -	B -
2.	Augering		C(B)	C	C	C	C(B)
3.	Thin walled open tube sampler	Pushed Percussion	A B(A)	A -	A -	- -	A
4.	Thick walled open tube samplers	Percussion	B (A)	B(A)	B	B	-
5.	Piston Samplers	 Pushed	- A	A -	- -	- -	A
6.	Large Samplers		A	A	-	-	-
7.	Sampling from trail pit		A	A	A	A	A
8.	Sampling from borehole bottom		A	-	-	-	

The properties of soil that remains unchanged when extracted to obtain a sample of particular sampling category are given in table 2

Table 2 : Unchanged properties[12]

Sampling Category	Properties Unchanged
A	Particle size, Water Content, Density, Density index, Permeability, Compressibility, Shear Strength.
B	Particle size, Water content
C	None

6.2 Mass of Samples

The minimum quantity of disturbed sample that should be taken from field to perform necessary laboratory tests is given in the table 3.

6.3 Water Samples

The water shall be collected into a clean vessel, allowed to settle and more than 1L water is poured out into a clean well-rinsed glass or polythene bottle. The water samples may then be sent to the laboratory for chemical analysis. At least one water sample must be collected for each stratum.

There should be a minimum of 3 piezometers installed preferably in a triangular formation so that the flow of water can be predicted in a plane. All the piezometers should be spread uniformly across the entire area.

Table 3 : Minimum Quantity of soil sample required (IS 1892 clause 6.1 table 2)[8]

Purpose	Soil type	Mass in kg
Soil identification, natural moisture content tests, mechanical analysis, index properties and Chemical tests	Cohesive Sand and Gravel	1 3
Compaction tests	Cohesive and sand Gravelly soil	12.5 25
Comprehensive examination materials including soil stabilization	Cohesive and sand Gravelly soil	25 to 50 50 to 100

7.0 Field Tests

In most of the cases Undisturbed Sampling is not possible or is very difficult, in such situations field test are the only way to determine the in-situ properties of soil. Field test conducted on sites are advantageous, since they represent the natural properties of the soil. Generally, the field tests are of short duration. Hence the time dependent results obtained for the granular soils are much closer to the actual soil parameter when compared to those results obtained for cohesive soils.

Generally, the field tests conducted on the soils include standard penetration test, cone penetration test, pressuremeter test and field density test. The plate load test, permeability tests are specifically conducted on non-cohesive soils whereas vane shear test should be conducted in relatively soft soils. On rocky subsurface the permeability test and in-situ shear test shall be conducted. In addition to above tests, the engineer in-charge should suggest the tests required for the soils of troublesome nature like black cotton soils. All the field tests should be performed as per standard codes.

The field tests for groundwater involve testing of temperature of subsurface water, pore water pressure and regular monitoring of the groundwater level. Due to inadequate guidelines mentioned in Indian standards, the code EN ISO 22475 should be used.

8.0 Geophysical Tests

Geophysical tests are conducted to get information about the soil stratification of the proposed site which helps in planning future investigations. Geophysical tests are part of preliminary investigations. Geophysical surveys make use of differences in the physical properties like electrical conductivity, magnetic susceptibility etc. of geological formations in the area to investigate the subsurface.

The most common types of Geophysical test are given in table 4.

Table 4 : Geophysical Methods

Test	Strata where proposed test to be conducted
Seismic Refraction test Seismic Cone Penetration test	Soil and Rock Soil
Cross Hole Seismic test	Soil and Rock
Electrical Resistivity test	Soil and Rock
Bathymetric Survey	Base profile
Sub Bottom Profiling	Soil and Rock

9.0 Laboratory Tests

9.1 For Physical Properties

The most important part of Geotechnical investigation involves laboratory Testing of the samples. laboratory Tests are used to determine the exact value of soil parameters which are used to determine the Bearing capacity and settlement of the soil. The determination of soil parameters for cohesive soils takes more time than compared to granular soils. Hence performing the laboratory tests on cohesive soil is justified. Based on nature of determination of soil properties, laboratory tests are conducted either on Disturbed or Undisturbed samples. Generally, to determine the index properties of soil disturbed samples are used whereas for determination of engineering properties undisturbed samples are used. Table 6 suggest specific test based on the sample type.

For shear tests

To determine the shear strength, the sample can be tested in three conditions depending on the nature of soil and drainage condition.

Unconsolidated Undrained Test (UU test) - Generally conducted on less permeable soils like clay. The test can be conducted in few minutes, so test is also called Quick test or Q - test.

Consolidated Undrained Test (CU Test) — These tests are conducted on cohesive as well as non-cohesive soils. This test is conducted on the samples which are subjected to sudden drawdown condition.

Consolidated Drained Test (CD Test) — Generally conducted on high permeable soils. This test is conducted on samples whose long-term stability has to be studied. This test takes 2 to 5 days to complete, hence this test is also referred as Slow test or S- test.

The general Laboratory test to be performed on rocks according to Indian standard are water absorption test, Porosity, Specific Gravity, uniaxial compression test for determining Modulus of elasticity and Poisson's ration of rock material and determination of point load strength index of rocks. In addition to above test Triaxial compression test on rocks, Splitting Tensile Strength of Rock core specimens and Slake Durability test should be performed as per ASTM guidelines.[8]

For Chemical properties

It is necessary to check for presence of any substance that changes the performance of the structure; hence chemical testing plays an important role. The common chemical tests used in geotechnical investigation are listed in table 5.

Table 5 : Chemical Tests

Chemical test on	Test	Relevant Codes
Soil	Determination of Organic matter	IS 2720-part 22
	Determination of Calcium Carbonate	IS 2720-part 23
	Determination of Cation Exchange Capacity	IS 2720-part 24
	Determination of Silica Sesquioxide ratio	IS 2720-part 25
	Determination of pH value for soil	IS 2720-part 26
	Determination of Total Soluble Sulphates for soil	IS 2720-part 27
	Determination of Chloride content	EN 1997-part 2
Ground water	Determination of the pH value	IS 3025
	Determination of the Organic matter and Suspended solids	IS 3025
	Determination of Sulphates, Chlorides, Nitrates, Carbonates	IS 3025
	Determination of Turbidity of Water	IS 3025

Table 6 : Test for Physical Properties of Soil

Test	Relevant Code	Disturbed		Undisturbed	
		Cohesive	Cohesionless	Cohesive	Cohesionless
Optimum Moisture Content	IS 2720-part 2	✔			
Maximum dry Density (Proctor)	IS 2720-part 7/8	✔			
Natural Moisture Content	IS 2720-part 2	✔	✔	✔	✔
Natural Density				✔	✔
Liquid limits and Plastic limit	IS 2720-part 5	✔		✔	
Specific Gravity/ Unit weight	IS 2720-part 3	✔	✔	✔	✔
Particle size distribution including Hydrometer analysis	IS 2720-part 4	✔	✔	✔	✔
Triaxial Shear test	IS 2720-part 11	✔	✔	✔	✔
Unconfined Compression test	IS 2720-part 10	✔		✔	
Consolidation tests	IS 2720-part 15	✔		✔	
Determination of free swell index	IS 2720-part 40	✔		✔	
Laboratory Vane Shear test	IS 2720-part 30	✔		✔	
Direct Shear Test	IS 2720-part 13		✔		✔
Relative Density	IS 2720-part 14				✔
Permeability Test	IS 2720-part 17/36				✔

10.0 Examples

Shallow Foundation

Geotechnical Investigation for a G+4 residential building is to be carried out. The total number of floors is 5 hence the minimum depth of exploration should be 2.5m*5 =12.5m from the ground level (based on the load of each floor). All the investigation points should be uniformly spread across the land. The number of boreholes will depend on the size of land. A minimum of 5 points should be investigated of an area of 400m^2. Corners and centre should be given highest priority while selecting the placement of boreholes. The SPT and samples should be taken as shown in figure 3. All the laboratory tests should be performed depending on the type of the soil sample. At least one plate load test and permeability tests should be performed if the soil is sandy.

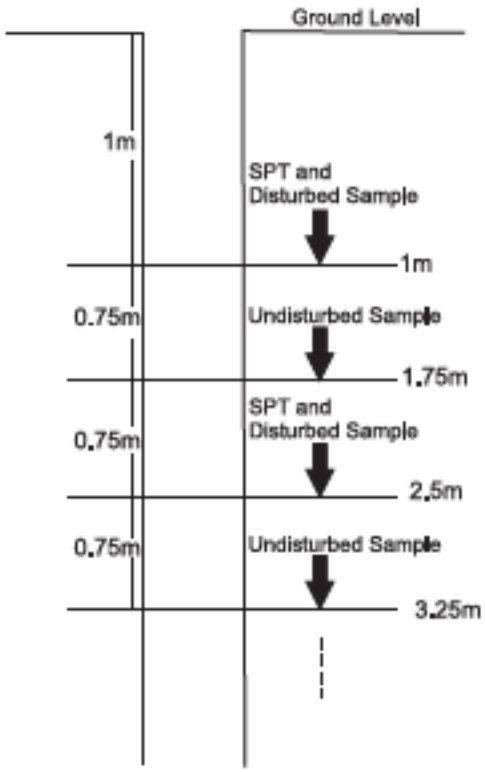


Figure 3 Depth of SPT and Samples

High Railway Embankment

Geotechnical Investigation for 10m high railway embankment is to be carried out, water table is at 10m depth. The height of the embankment is 10m hence the minimum depth of exploration should be 2*10m = 20m from the ground level.*(GE G1 RDSO 3.4.2 (c))*[7] Investigation points should be 60m to 120m apart *(FHWA NHI-01-031. Table 2-3)*[2]depending on the site conditions and should be 5m from the central line alternate on each side of the centre line.*(EN 7 2.4.1.3.2)* [3]The SPT and samples should be taken as shown in figure 3. All the laboratory tests should be performed depending on the type of the soil sample. The water samples should be collected for every stratum. If the undisturbed samples cannot be obtained the Field Vane Shear test should be performed.

Pile Foundation

A high-rise building is proposed on a land of size 100m*150m with piles having 0.4m diameter. Preliminary investigation should be carried out by performing cone penetration test at every 50m by dividing the area into grid pattern and number of boreholes may be decided by observing variation in the penetration curves. (IS 1892 clause 2.3.1)[8] The cone penetration resistance values may be used to find soil parameters using empirical relations. (EN 7 Annexure D)[3] From these soil parameters, a preliminary depth of borehole can be estimated. Boreholes may be drilled in a grid pattern with grid size 25m resulting in total of 5*7 =35 boreholes. The depth of exploration should be width of the rectangle of pile group i.e. 100m. The total depth of exploration becomes 100m + length of pile. The SPT and samples should be taken as shown in figure 3. All the laboratory tests should be performed depending on the type of sample obtained. The water samples should be collected for every stratum. Pile load test should also be performed. If the undisturbed samples cannot be obtained the Field Vane shear test should be performed.

11.0 Cost Estimation

The advance cost estimation helps the client to better manage the resources. The cost should be estimated on the basis of amount of work done (number of boreholes and laboratory tests). It

should be included in the tender along with the specific Schedule of Rates to be followed for the project.

Example: There are total 5 investigation points. The Depth of exploration for each borehole is 15m. SCPT is performed at two locations. The cost can be estimate as follows:

Item per borehole	Quantity
SPT	10
Undisturbed Sample	9
Disturbed Sample	10

A sample of cost estimation is shown in table 7, the similar approach can be extended to full Unified Standard Schedule of Rates, Central Railways [18] or any other Schedule of Rates.

Table 7 :

Item No.	Description of Item	Qty	Unit	*Rate*	Amount
191010	Exploratory drilling of Boreholes down to required depth			0.00	0.00
191011	0m to 10m	50	metre	894.36	44718.00
191012	10m to 20m	25	metre	1138.27	28456.75
191070	Conducting SCPT for soil as per IS - 4968	2	Each	1393.80	2787.60
191100	Taking out 100mm diameter & 450mm long undisturbed samples of soil from bore holes	45	Each	150.53	6773.85
191110	Taking out 100mm dia & 450mm long disturbed samples of soil from bore holes, including provision of air tight containers for packing, labelling and transporting the samples to laboratory. Samples shall be collected as per IS 2720	50	Each	167.26	8363.00
191120	Conducting standard penetration test as per IS 2131 at approximate1.5m intervals in bore holes, as directed by the Engineer in charge	50	Each	232.30	11615.00
191130	Collection of water samples at required intervals	10	Each	40.66	406.60
191140	Conducting laboratory tests on collected soil samples as per relevant IS code			0.00	0.00
191141	Moisture contents/ Dry density	95	Each	81.31	7724.45
191142	Atterberg Limit	95	Each	325.22	30895.90
191143	Specific Gravity	95	Each	40.66	3862.70
191144	Grain size analysis including Hydrometer analysis	95	Each	227.52	21614.40
191146	Natural density	45	Each	174.23	7840.35
191149	Tri-axial test	95	Each	696.90	66205.50
191160	Conducting chemical analysis of ground water samples to determine suitability for concreting and aggressiveness in relation to attack on concrete / reinforcement including determination of pH value	10	Each	813.05	8130.50
191170	Conducting chemical analysis of soil samples to determine aggressiveness in relation to attack on concrete / reinforcement Including determination of pH value	10	Each	1161.50	11615.00
191180	Preparation and submission of final report giving complete and comprehensive record of investigations, laboratory test reports and calculations in approved format	1	Each	11615.00	11615.00

12.0 Conclusion

In this paper, a set of guidelines for framing tender conditions of geotechnical investigation is presented. The guidelines presented were based on reviewing several standards and code of practice used around the world.

The tender document should specify the following for geotechnical investigation:

1. The number and relative position of the investigation points should be decided numerically.
2. The depth of exploration for each borehole. If the design is finalised then the depth of exploration will depend on the foundation size. If the design is not finalized at the time of investigation, then it has to be decided based on the structure and the site conditions and in any case numerical value for the depth of the boreholes should be mentioned.
3. The number of field and laboratory tests to be performed on soils depending on the stratum conditions.
4. The specification and suppliers of laboratory apparatus. Use of modern equipment in geotechnical investigation should be preferred. All the samplers should be as per Indian standards. [8]

The contents of report should be clearly mentioned in the tender to give more clarity to the report. The report should include:

12.1 The topographical map prepared as per IS:15686 and photographs of the site. In case of linear structures, the elevation profile should be included.

12.2 The report must indicate Seismic zone of structure

12.3 If the geotechnical investigation is carried out for the Hydrological structures such as bridges and dams, the hydrological investigation data must be included.

12.4 A map showing location of boreholes and the proposed structure.

12.5 Bore Logs and the cross-section profile (preferably 3D).

12.6 Duly Signed Laboratory reports including observation tables and results.

12.7 Results obtained by Software analysis.

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Government may Open Railway Lines to Private Players

The Union government is open to the idea of giving operations of railway lines to private players for enhancing competition, Railway Minister Piyush Goyal said in an interview.

"It's an exciting proposition. We will be able to generate competition in the process and improve customer satisfaction," Mr. Goyal told on board the Mahanama Express train, launched between Prime Minister Narendra Modi's old constituency in Vadodara and his present one in Varanasi on Friday, ahead of the Gujarat Assembly elections.

Mr. Goyal, who took charge of the Railway Ministry on September 4 after Suresh Prabhu resigned following a string of derailments, said he was studying various models for attracting more private players.

Claiming that he was willing to spend unlimited funds on safety, he said clearing the backlog for track renewal would be the focus, and a zero accident rate would be an aspiration.

"In my working, there is no budget for safety. Whatever (fund) is required we will spend," Mr. Goyal said.

He said the government was engaging with other countries to "rapidly scale up" the bullet train project.

Mr. Goyal is also re-tuning policy to attract private companies for modernising railway stations.

To begin with, the Railways have decided to do away with the 'Swiss Challenge' model of awarding railway stations to private players and taken a slew of measures to lease out at least 100 stations.

The steps include increasing the lease tenure from 45 years to 99 years, allowing private players to sub-lease stations for increasing their investment value and mortgaging assets to allow banks to give low-cost funds, he said.

"We had a meeting with over 150 stakeholders (recently). All were interested in being a part of this journey of station redevelopment and land redevelopment but were constrained by the process being followed," Mr. Goyal said.

http://www.railnews.in

Problems Faced in Maintenance of Point and Crossing and their Innovative Solutions

By

*Avinash Jain**
*Md. Tanveer Khan***
*Sushil Kumar and Rajesh Kumar****

Synopsis :

The vast network of Indian Railway practices mixed traffic operation. Passenger and freight trains share the same track. This practice on one hand seems to achieve economy as same railway infrastructure is shared by both passenger and freight traffic but on the other hand it causes problems for the maintenance engineers. The major problem is the maintenance of Point and Crossing areas which are subjected to high speed passenger trains and heavy axle loads of freight trains. Something beyond the regular maintenance practices and application of some innovative ideas is the need of hour to cope up with these challenges. This paper aims at describing the various innovative ideas which are tried in the Barddhaman subdivision of Eastern Railway and found useful and got appreciation from senior railway officials.

Key words:- Mixed Traffic, High Speed, Heavy Axle Load, Maintenance, Innovative ideas.

1.0 Introduction:

The section of Barddhaman subdivision on grand chord line caters the busy suburban services, high speed trains such as Rajdhani, Shatabdi and Duranto running at 130kmph and heavy loads of freight trains. So the track structure is subjected to all sorts of stresses which can be thought of. In this scenario the maintenance of points and crossings become a typical task for the maintenance engineers as they are the weakest part of track structure which requires baby care, otherwise in long term it will lead to interruptions to normal traffic. In Para no. 237,317 & 1413 of IRPWM the detailed procedure of Inspection, maintenance, renewal & laying of points and crossings are discussed but in the scenario which is discussed above some additional efforts are required to deal with the other special type of problems which are arising due to increased speed and heavy axle load and troubling the P. way engineers. In the subsequent paragraphs of this paper, those problems and there solution using some innovative methods which are tried in the Barddhaman subdivision of Eastern Railway are discussed.

2.0 Problems and Innovative Methodologies for their Solutions

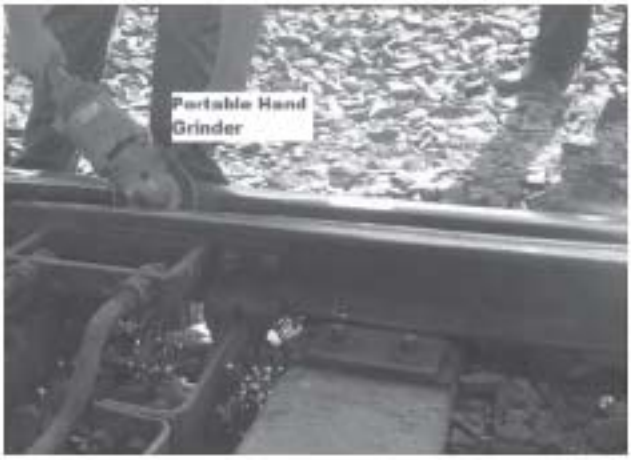
2.1.1 Burr Formation on Stock Rail

Burr is formed due to plastic deformation and flow of metal from gauge face corner, which if not attended within time, leads to non setting of points and breakage/chipping of tongue rail. Existing method of burrs removal in vogue is by using chisel and sledge hammer. This prevalent practice is clear-cut violation of handling instructions for 90UTS rails, and this may leads to development of stresses and consequent fracture of stock rail in long run.

2.1.2 Solution

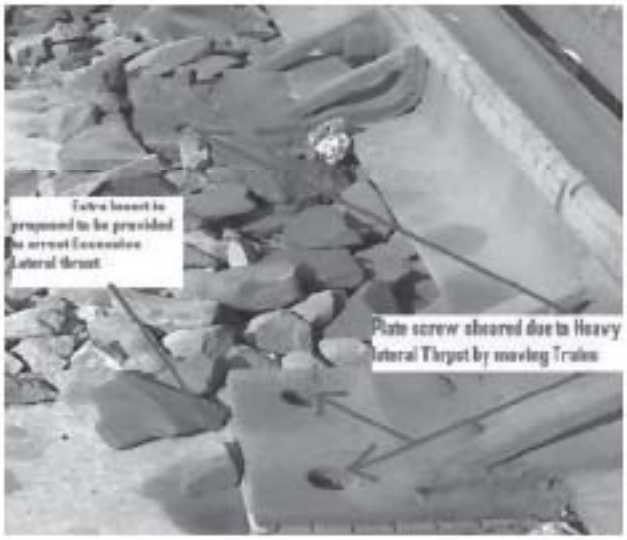
Use of portable hand grinders for removing of the burr as and when required, is the best solution to this problem. It is very much practical, safe and easy as far as its operation is concerned.

**Sr DEN/S/HWH, Howrah Division, Eastern Railway*
***Sr. ADEN/BWN, Howrah Division, Eastern Railway*
****SSE (P.Way)/BWN, Howrah Division, Eastern Railway*



2.2.1 Shearing of plate screws

Plate screws are used to hold the slide chair but due to lateral thrust exerted by rolling stock, the plate screws get sheared off which results in the widening of the gauge and disturbance of alignment. Further it is also very difficult to remove the broken part of the plate screw and replace by the new one every now and then.



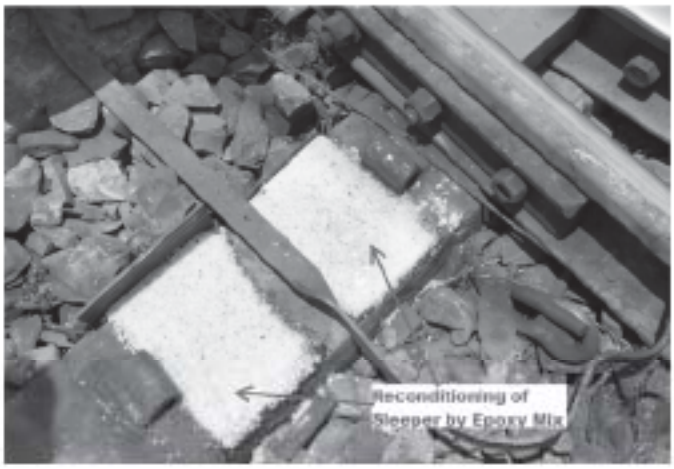
2.2.2 Solution

To bear the lateral thrust of rolling stock wheels flange, Inserts are provided on the outer side of the slide chair up to the heel block. This practice prevents the shearing of plate screws.



2.3.1 Dented sleepers in crossing portion

The sleepers below the crossing body i.e. sleeper no. 66 to 73 in case of 1 in 12 turnout and 43 to 48 in case of 1 in 8.5 gets dented due to hammering impact of rolling stock while negotiating the crossing portion of turnout. This results in the further deterioration of crossing assembly due to loosening of rubber pad and the cross levels also changes and form twist under load thus resulting in bad riding. The fan shape sleepers are available in sets only, so if the dented crossing sleepers are changed by the new ones than the whole set has to be procured and the rest sleepers will be wasted.



2.3.2 Solution

This problem can be solved if the dent/groove developed in the sleepers is filled up by the mortar of epoxy and coarse sand mix. This mixture is a very good and reliable material to be used for filing the groves and dents of the sleepers. It is also highly durable and with stands the dynamic train loads.

2.4.1 Excessive lateral wear of switches near Stock Rail Joint

The problem of excessive lateral wear of switches is common on the turnouts which are laid on the inside of the curves. Due to the lateral wear the renewal of switch is required to be done before its service life or codal life is over and if not changed there is always a chance of fracture of tongue rail or stock rail and may cause serious mishap.

2.4.2 Solution

This problem can be minimised by regular application of grease on the gauge face of the tongue rail and providing a small check rail near the ATS of the switch of opposite side.



2.5.1 Elongation of Insert hole/Eye

The hole/eye of the inserts of the sleeper gets elongated due to wear and tear which in turn reduces the toe load significantly and even the ERC get loose and fall after passing of one train after driving them.

2.5.2 Solution

This problem can be satisfactorily solved by reconditioning of the inserts either by depositing the metal inside the insert hole/eye by the welding electrode or by inserting a metal pipe of suitable size inside the eye/hole of insert.



2.6.1 Fully worn out or corroded insert

Some time in highly corrosion prone areas the inserts in the points and crossings areas gets highly corroded and even breaks during the driving of ERCs. In these cases the PWIs use to change the sleepers and the remaining sleeper of the set is wasted.

2.6.2 Solution

There is a solution for this type of problem. The worn out inserts can be removed and new inserts can be fixed using the epoxy mix if the otherwise condition of sleeper is good. This practice is very economical in comparison to the replacing those sleepers with new one.



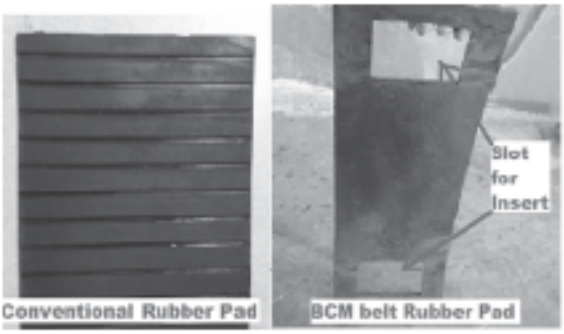
2.7.1 Slipping of the rubber pad under the crossing body from rail seat

The GRSP provided underneath the crossing tends to slip and come out and get dropped which in turn exposes the sleeper directly to the impact of rolling stock and thus damage the sleeper.

2.7.2 Solution

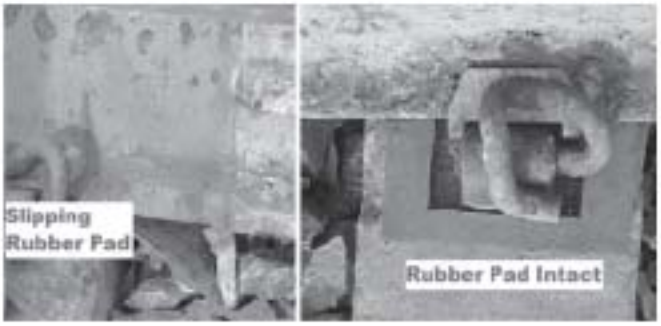
The conventional GRSP as shown in the photograph is not having any slot by which it can be kept attached to the insert and prevent its slipping. In our section we have used the BCM conveyor belt for this purpose by cutting it into

suitable sizes as per requirement and making a slot in them for housing the MCI inserts so that it do not slip and come out. The thickness of BCM belt is also more so it protects the sleeper against impact more and also not easily crushed.



3.0 Conclusion:

Open Line Maintenance work is not just changing and replacing the existing assets by new one but it demands the maintenance engineers to think and apply their knowledge to maintain the asset in working condition by using the available resources and by introducing and enforcing the good maintenance practices. The innovative ideas, maintenance methodologies, and solution to different types of problems as discussed in this paper are very much practical and can be easily implemented over entire Indian Railways.



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18-Coach Delhi-Mumbai Rajdhani to Run at 150 kmph, Cover 1377 Kms in less than 13 Hrs 30 Mins

As a Diwali gift to its passengers, the Indian Railways is planning to run a faster Rajdhani Express on the Delhi-Mumbai line that will cover the distance of 1,377 kms in less than 13 hours and 30 minutes.

The 18 Linke Hofmann Busch (LBH) coaches train will run at the maximum speed of 150 kmph. The train will originate from Hazrat Nizamuddin in Delhi and terminate at Bandra/Mumbai CentraL The train would have a stoppage of 8-10 minutes at Ratlam fir operational purposes only — for change if crew and watering of trains.

The train would run at the maximum speed of 150 kmph between Hazrat Nizamuddin and Mathura and at 130 kmph from Mathura to Bandra/Mumbai Central. The 18 LBH coaches will comprise of an FAC (fuel adjustment component), 3 ACCW, 1 pantry car, 2 power cars and 11 ACCNs.

All the formalities are scheduled to be completed by October 15. The trial would be done in the last week of September

This will be the third Rajdhani on the route. Presently, the route is served by two Rajdhani Express trains– the August Kranti Rajdhani and the Mumbai Central-New Delhi Rajdhani. While the August Kranti Rajdhani takes around 17 hours 05 minutes, the Mumbai Central-New Delhi Rajdhani train takes around 15 hours 35 minutes.

The Mumbai Rajdhani has a sanctioned speed of 130 kmph. But due to numerous curves and speed restrictions on the route, its average speed comes down to about 89 kmph.

http://www.railnews.in

Supply Chain Integrity in the Construction Sector

By

*Sneha Poddar**

1.0 Introduction

Any major construction project is a complex chain of supply of resources, statutory clearances and services. It is capital intensive. Construction, right from the stage of in-principle concept approval, planning & design to final execution, may take few years to decades. And the major infrastructure depreciates slowly, over a longer base period (say 30 to 100 years) unlike any other dynamic system. Thus, its operation & maintenance cost may become prohibitive, if specification of construction material and quality of execution/workmanship is deficient. Apart from it, it may endanger structural integrity of the infrastructure and lives & stocks.

There has been excellent value engineering in the supply chain integrity in various sectors but the construction industry has remained largely insulated. Not much attention has been paid to this aspect as the concerns of project owner are good quality of construction and timely completion with minimal cost whereas the contractor is more worried on profits. Further, the project owner has hardly any control over the supply chain. One direct consequence is substandard construction leading to reduced service life of finished construction projects and newspaper headlines of collapsed bridges & buildings. All these lead to immense loss of costly and scarce resources which the nation or any other project owner needs for many sectors. Supply chain integrity, therefore, assumes paramount importance in the construction sector. "Construction is a $ 1.7 trillion industry worldwide, much of which is linked to publicly financed projects. Government investment in road transport alone can account for between 2-3.5 % of GDP. Outcomes from this financing are frequently sub-optimal. In India, for example, nearly half of all road projects see cost overruns greater than 25 percent, and more than half see delays adding fifty percent or more to completion times. The quality of infrastructure constructed can also leave much to be desired. Press reports suggest that an Indian government survey of a recent rural roads project found one fifths of completed roads to be unsatisfactory."[1]

The supply chain in the construction sector can be broadly divided into two parts i.e. formal sector and informal sector. The formal sector shall include the supply of material and machinery, i.e., cement, steel, TMT bars, heavy construction plants & cranes, etc. On the other hand, the informal sector shall include supply of unskilled and semi-skilled labour, good earth, aggregates, bricks, ready mix concrete, etc. The high level of integrity and attention needs to be established more in the informal sector.

In India, construction industry depends hugely on the informal supply chain because informal industries are able to supply labour and materials at reduced cost. This is achieved through exploitation of labour (at the cost of the poor) and natural resources (environmental degradation and depletion of resources in uncontrolled manner). The informal supply chain systems adopt unethical practices in the procurement of the bricks, sand, etc. On the other hand, swollen demands in construction sector unleash a crisis of supply of sand and other materials. In the case of sand, there is an illegal excessive mining of river beds for hoarding of sand. All these endanger the ecology and economy of the area. The

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frequent government ban on mining and unstable policies of government with political colour too prompt mafia taking over the whole illegal mining of sand, good earth, etc. With the supply chain integrity in place, this predicament can be averted.

The general guidelines of the Supply Chain Management can be used to analyse, re-engineer, coordinate and constantly improve all elements of the construction supply chain. It shall resolve basic problems and control unorganised value chain of the construction industry. The task itself is mammoth and it may not be possible to realize it in the short term. Therefore, initially, the SCM methodology can be deployed at a lower scale addressing partial supply chain problems, involving a limited number of supply chain actors. Since constraints in the SCM shall vary from place to place and from one organisation to another, the SCM methodology needs a continuous improvement in the process based upon experience and expediency. The scope of SCM can be enlarged over time involving an increasing number of areas of application.

Some of the examples of consequence of ineffective supply chain management, along with its adverse impact, are explained below:

2.0 Supply of Substandard Bricks

Brick manufacture generally comes under informal sector. However, permission is required from the Government to set up and operate brick kiln. However, this is followed more in breach than practice. The issue of brick kiln has attracted the notice of the Green tribunal and 'polluter pays' principle has been applied.[2]

The overall quality of bricks depends on various factors like quality of the soil, expertise in managing the heat inside the kiln, weather conditions, etc. In one of the projects, the contractor had quoted a certain cost for the construction project considering locally available bricks. Later on, they found that the quality of bricks required for the project was not available in the area and as such they had to procure the same from faraway location. Sourcing bricks from such faraway place would have increased the construction cost tremendously. Hence, they abandoned the project with the consequence that they lost good amount of money in the shape of the security deposit. In addition, there was delay in the execution of the project leading to cost overrun. Further, the tendering authority suffered huge losses in terms of opportunity cost.

3.0 Supply of Ready Mix Concrete

In big cities, the ready mix concrete is supplied by the ready mix plants which are mostly automatic plants driven through software systems. However, in the smaller cities, it is either made at the site through small or large size weigh batching plant or brought from nearby places. In the case of the computerised ready mix concrete plant, while all reports are generated through the computer but it still does not certify type, brand and quality of cement used. In such plants, the ready mix concrete is also supplied to various construction sites. Hence, the confusion remains unresolved as to which lot was supplied to whom. On the other hand, in small places, it is difficult to establish whether the ready mix concrete manufactured is of required quality.

4.0 Supply of Labour

The supply of labour is always a tricky issue and costly element of construction industry. Effective management of labour is required. The labour engaged are mostly uneducated people who work on daily wages basis. They take upon the work wherever they can find it. Hence, it is not necessary that the labour, who once worked in the construction sector, shall always either get the job there or they shall work with the same contractor. Hence, they are not able to develop dependable skill/expertise in the specific areas of the construction sector. Secondly, they are supposed to be working under the supervision of the engineers who may not be present all the time. Hence, even a small slip up can lead to weak structures. For example, due to defective shuttering, honeycombing occurs which lead to reduced life of structure. Inadequate curing in the pavement construction leads to abrasions and scaling of the top surface. Lately, Govt. of India has launched Skil

Development Programme. This may help in the provision of the skilled trained labour force for the construction industry.[3]

5.0 Supply of Good Earth and Sand

The supply of good earth and sand is crucial to any construction project. Many states may not be having good earth and sand suitable for the construction work. In some of the states, for example Uttrakhand, the digging of good earth and sand for the construction purpose is banned. In other states, there is frequent ban on mining of good earth, sand, gravel, etc. However, it is in the common knowledge of all, including the Government Authority that the river beds are dug up for the sand. There is illegal rampant mining of good earth, sand, gravel, aggregate etc. Further, since digging of good earth or sand is banned, it shall also mean that contractor would procure these materials from the neighbouring states. All these increase the cost of construction manifold.

6.0 Role of the Consultants (Architect, Designer, Site Supervisor)

There is no dearth of the consultants but many of them have been found lacking in professionalism. Some of them abandon the project midway, thereby, putting the whole construction project in jeopardy. Few are found to be working as agents rather than fulfilling the responsibility of ensuring construction as per laid down specifications, Quality Assurance Programme and schedules. Instead of putting in place stringent testing methods and follow the standard operating procedure in letter and spirit, they become a lethargic partner in the project thereby putting the project in jeopardy.

7.0 Importance of Supply Chain Management

Any major construction is a complex activity. It is imperative to identify actors in the supply chain. To simplify it is another task. This can be done by introducing integrity in the entire structure. Tender conditions can be so designed as to identify supply chains in advance, by means of identified supplier of inventories (manufacturing units with their capacities/ subcontractors) and services. Bidders shall be required to disclose the name of their suppliers. Effective management of actors in the supply chain can be ensured through inviting value inputs from the bidders.

A goal is required to be defined and explained in advance to all in the supply chain. Time schedule should be explained and made visible. In order to have clear delineation of messages, a strong Information Technology (IT) based database which can handle storage of inventories and pass on the information for arranging the supplies is required. The central database handling inventories and their distribution logistics should be controlled by the tender floating organization. This IT based database shall ensure smooth flow of information along supply chains. It should be robust enough to prevent leakage of information, remove duplicity, detect crisis and make arrangement for alternate supply chains.

Some areas of application, where there is a strong need for Supply Chain Integrity include the reduction of costs (especially logistical costs), lead-time and inventory in the supply chain. In view of the large share of these costs in construction, these areas need primary focus. Secondly, the emphasis may be on the impact of the supply chain on site activities. Here, the goal is to reduce site costs and duration. In this case, the primary consideration should be to ensure material and labour flows to the site for the sake of avoiding disturbances or say any missing link in the workflow. Thirdly, the focus should be on transferring activities from the site to upstream stages of the supply chain. The rationale behind the whole scheme should be to avoid inferior conditions of site as well as to achieve wider concurrency between activities, which is not possible in site construction with its many technical interdependencies. Here, the goal is again to reduce the overall cost of construction and completion period.

The whole system of supply chain should be monitored and regulated through standard operating procedures and guidelines. It must include possible solutions as well as positive steps in the shape of penalties on detection of delays, frauds and other

abnormal behaviour of supply chains. Various steps are required to be taken for implementing the Supply Chain Integrity in the system.

1. There is a need to fix basic elements of supply chain of the major construction project. These include human resources, sub-contract, procurement, risk mitigation plan, quality assurance programme, time of construction, overall cap on the cost of construction, overall gap in fund, scope of the work, stakeholders, material suppliers, machinery suppliers, method of construction & contracting, billing cycle, digital transfer of document (E-bill, E-Drawings, E-measurements, E payment etc. Any of the missing link(s) of supply chain of construction projects must be avoided or else it would become a hindrance in the commissioning of the project. We may also call missing link as Dead link, Obstructing link or Doubtful Integrity link.
2. Major construction projects are affected due to dynamics of Micro and Macro environment, Technology and Socio-Political-Economic factors. The supply chain management need to do continuous re-shaping of planning, organizing, activating and controlling functions as per the changing external and internal environment of the project ecosystem for its success. They should, at the same time, have capability to convert weaknesses and threats into opportunities through apt interventions and positive problem solving attitude for the timely completion of the construction project.
3. Planning and design is the foundation stone of any major construction project. Detailed Engineering (it includes detailed survey, geotechnical investigations, execution plan required for the approval of government agencies, detailed design, innovations, drawings for the propose of Tender and construction, preparation of tender documents, etc,) land acquisition, hindrances removal & utility shifting, approvals, etc, are important parallel activities of the supply chain management. These are critical activities which add to cost and mismanagement can lead to many complications e.g. time over runs. These should not be left to contractor alone. Role and responsibility of all stakeholders of the supply chain management should be carefully defined.
4. A construction project (100 km new line) in Railways is sanctioned after preliminary engineering and traffic survey, foot survey, study of terrain and all possible detailed engineering, estimation, investigations, data, involvement of many engineers and surveyors. However, when the actual construction starts, many new unforeseen circumstances crop up stalling the project and causing cost and time over runs. Consequently, as expected, shifting responsibility and blame game started leading to court cases and arbitration. First of all, supply chain management should have sufficient robust mechanism to ensure that such eventuality does not take place. Undertakings and affidavit should be taken from engineers for integrity of technical & tender documents, detailing & drawings on the basis of which contracts have been finalised and awarded. This should bring absolute transparency and reduce the uncertainty. Risk, if any, will be known in advance and the same can be mitigated through available means. In the worst scenario, failure on the part of engineers would not be passed on to the contractors. Such act will eliminate disputes & arbitration, ensure timely completion of work and therefore, reduce cost and time overruns.
5. Supply chain management should use digital tools, audit & vigilance for system improvement, etc. and bring transparency in construction project including risk mitigation due to real time decision making and professional approach to the construction project.
6. Recent Amendments to the Arbitration and Conciliation Bill, 2015 aim at ensuring neutrality of arbitrators, declaration of award within 12 months, extension of time for declaration of

award by another six months with mutual consent of parties, option to parties to fast track six months procedure for award, clearly defining the grounds for challenge of an award, disposal of application to challenge the award within a year, no stay on execution of award, appointment of arbitrator by the High Court within 60 days, etc. These will bring significant amount of transparency in the settlement of right dues amicably within a reasonable period.

7. General Conditions of Contract favour the Government agencies by default. It is one sided contract agreement leaving contractors at the receiving end with no compensation for default of Government. On the other hand, the FIDIC (Fédération Internationale Des Ingénieurs-Conseils or International Federation of Consulting Engineers) contract document is a good alternative. It defines role, responsibility and accountability of client and contractor equally, with no ambiguity or one sided clauses. There is a need for balanced general conditions of the contract. It is to be understood that a contractor is an equal partner in the project and they take up the contract with the information available to them through the contract documents. They do not work in isolation. If a contractor has to work under circumstances which are uncertain, they will try to make up their losses through handing over inferior work or leave the works in between. In both situations, there will be cost & time overruns.

8. Positive use of Audit and Vigilance: There is a need to use audit and vigilance, as a positive tool of governance. It should be ensured that these do not become detrimental to the project. Professional management executives ensure that Audits/Vigilance officials are made aware of the importance of projects and working system through orientation and training programme, including visits to sites. All actions are taken keeping in view the success of the project. At the same time, if vigilance or audit becomes a hindrance, there is a need to ensure that defaulting engineers and non-understanding vigilance officers are repatriated. Such actions are required to ensure healthy working atmosphere which will go a long way in reducing cost and time over run. At the same time, audits and vigilance plays significant positive roles. Their findings should be taken seriously for system improvement in all areas. After all we are dealing with public money as such we have to use all financial cannons of proprietary to avoid its misuse at any levels.

One of the great advantages of implementing the supply chain integrity is the benefit which shall accrue to the Micro, Small and Medium Enterprises. At present, most of the supplies to the construction industry come from the informal sector. Because, the supply of sand, bricks, labour etc. comes from the unorganised sector, there is no advance determination of the price of the goods, certainty of the time schedule of the supplies, quality of the materials supplied, etc. If the supply chain integrity is enforced, supplies will come from the Micro, Small and Medium Enterprises in an organised way. It will greatly resolve aforesaid problems.

There is a need for everybody involved in the project to follow principles of Business Ethics which are as follows:

a) Professionalism: All participants of the supply chain process should exhibit a high standard of professionalism. It shall mean that each entity should treat the other with an equal amount of respect and trust and in no way shall intervene or command the other. Classified Information should be guarded safely by all parties involved. Adherence to the laid down terms and conditions should be a pre-requisite for all.

b) Personal Integrity: Personal integrity is a strong sense of commitment towards morality, openness and high standards of ethics that an individual stands by and acts as a role model for their colleagues. Every individual and not just the overall entity should have high personal integrity,

to make sure that entire supply chain process is ethically in place. Behaviour like receiving favours such as gifts, monetary commissions, stakes and preferential treatments should be outside the code of business ethics. The actors in the construction project must declare the gifts they may have given to project sanctioning authorities.

c) Transparency and accountability: All parties involved in the supply chain process have to be open and accountable i.e. certain companies approach or try to manipulate officials of a state/nation to gain advantage over their competitors for their personal agenda rather than proceeding on legally right channels. Public resources are used by different parties in the supply chain which must adhere to fair usage policies.

d) Compliance and continuous improvement: Compliance to law of land is a mandatory pre-requisite. No party shall bypass the laws of the state/nation for their business motives to gain unfair advantage. All entities shall work towards fostering a continuous improvement culture in their supply chain activities and serve as a role model for others to follow. Doing so can lead to earning concessions and credits from government as a token of appreciation.

e) Integrity Pact: The Central Vigilance Commission has approved that all government organisations must sign the integrity pact with contractors. It binds both the parties to adhere to norms of integrity. Any violation may lead to the cancellation of the contract and blacklisting of the contractor. In case of any difficulty in the management of the contract, the contractor does also have the option of going to Independent External Monitors for resolving their issues.

8.0 Advantages:

The supply chain integrity shall result in the following benefits:

- Uncertainty mitigated
- Logistics simplified
- Timely completion of projects
- Efficient inventory management
- Maximization of resources utilization
- Promotion of ethical practices
- Assurance of good quality material
- Avoidance of cost overrun
- Maximize the values for project owner.

9.0 Conclusion:

The CII had formed a Research Team 264 (RT 264)[4] to investigate and provide recommendations on product integrity concerns from low-cost sourcing countries. The team conducted almost 190 face-to-face interviews with industry and government leaders in the People's Republic of China, Taiwan, Hong Kong, the United Kingdom, Pakistan, Canada, and the United States. They concluded that maintaining the integrity of the supply chain is the most effective way to combat the problem. Their suggestions were:

- Confirm and verify that every link in the supply chain is secure and observed.
- Responsible manufacturers have designed and implemented highly reliable and secure distribution networks that ensure product integrity.
- For branded products, trust only manufacturer or their authorized distributors.
- The use of brokers, re-sellers and unauthorized distributors (at any level in the supply chain) are common entry-points for counterfeit products.
- An immediate supplier could be trustworthy but could also be a victim of counterfeit entry points up stream.
- The Chartered Institute of Building (CIOB)[5] had carried out a survey into procurement in the construction industry. The key findings of the Report indicate that construction professionals view procurement (supply of manpower, material and machinery) as absolutely crucial to the delivery of a project on time, on budget and to a high quality. 87% of respondents believe that good

procurement is synonymous with a successful project. 82% of the respondents believe that 'suicide bidding' exists within the industry, a worrying statistic that highlights the dangers of selecting a very low bid at tender stage.

In India, little thought has been given to the issue of the supply chain integrity in the construction sector as yet. The absence of the supply chain integrity has resulted in wastage of immense resources of the nation due to the failed projects. When the nation aspires to be at the highest pedestal and be the best in the world, it is appropriate that suitable measures are taken for the same. The integrity of supply chain in the construction sector is one such step.

1. http://www.constructiontransparency.org
2. http://www.indiaenvironmentportal.org.in
3. http://www.msde.gov.in/background.html

   (Skill India is an initiative of the Government of India which has been launched to empower the youth of the country with skill sets which make them more employable and more productive in their work environment. Our National Skill Mission is chaired by the Hon'ble Prime Minister, Shri Narendra Modi himself.)
4. https://www.construction-institute.org
5. https://www.ciob.org

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Stop Train Mishap, Get Out-of-Turn Promotion Piyush Goyal to Railway Staff

In the wake of a series of recent train accidents in the country, Railway Minister Piyush Goyal has suggested out-of-turn promotions for those railway employees who take timely action to avert mishaps.

Speaking at a review meeting with senior officials of the South Western Railway, he asserted that such schemes will boost the morale of the staff.

Terming the recent train accidents as "unfortunate", Goyal called upon the railway staff to work diligently for ensuring complete safety in running trains, a release by the South Western Railway said.

"The minister suggested various schemes such as granting out-of-turn promotion for the staff who take timely action to avert accidents. He said such schemes will go a longway in boosting the morale of the staff," it said.

The Railway Minister emphasised that safety shall be given top most priority and track renewal works be taken up expeditiously.

He also asked the Railways to develop an action plan for eliminating unmanned level crossing gates in a year's time, instead of 2019-20 as planned earlier.

http://www.railnews.in

Tamping Machine Work Site: Good and Bad Practices

By
*Anil Choudhary**

1.0 Introduction:

On the instruction of Railway Board, an audit Inspection of one working site of Tamping Express and one of CSM in two different Railways (Northern railway and Eastern Railway) was conducted by a team from RDSO. It was a surprise inspection and sites were selected to know the good and Bad Practices being followed at work site. This paper highlights the important observations on the site condition, the pre and post block works done, the condition of machine etc which will help to understand the improvement required at tamping machine work site for getting better result.

2.0 Mode of Working:

a. Good Practice observed (T-Exp site):

- Tamping in 3-Point Design mode.
- DTS was being used behind tamping machine
- Level of track was plotted using dumpy level taking measurement at an interval of 10 meter and the high points were identified.







Fig 1: Alignment Correction using Malkhan Singh System

- Theodolite was used for taking alignment defect in spans of 200 meters. A local made three unit wooden gadget commonly known as Malkhan Singh method was used for the purpose.
- Sh. M.S.Ekbote formula used for re alignment of curve

b. Bad practice observed (CSM Site)

- Tamping in 3-Point Smoothening mode.
- DTS was available but was not working
- No prior survey of site done.

* Professor (Track Machine), IRICEN

3.0 Site Condition and Pre Tamping Activities:

a. Good Practice observed at both sites:

- Spacing and squaring of sleepers was proper. No damaged sleepers observed at both sites
- Ballast Cushion adequate at both sites.
- Obstructions like joggle fish plates, traction bonds etc temporarily removed at both sites.
- No deficient fittings observed at both sites..
- At the site of T-Exp working, ballast heaping in tamping zone done.

b. Bad Practice observed (T-Exp Site):

- Condition of liner was not good and for correcting gauge, 2mm thick steel strips made by cutting grease drum was being used.
- Overhauling of level crossing gate (No117C) not done prior to tamping and was simply opened for tamping.

c. Bad Practice observed (CSM site):

- Ballast was inadequate and Ballast heaping in tamping zone not done.
- Many trespassing locations existed at the location of tamping. Sleeper's edge was naked. The ballast was not dressed before tamping.
- The cess was low all along in the section.



Fig 2: Trespassing Location and Low Cess at Tamping location

4.0 Observations During Tamping:

- The tamping depth, squeezing pressure and squeezing time were within the range prescribed at both site.

a. <u>Bad Practice observed (T-Exp Site):</u>

- While working on transition of the curve, versine value as written on sleepers was modified to accommodate correction value by using thumb rule. The correction value should actually be fed as per chart given by M/s.Plasser India OR by ALC. As ALC was not working the manual feeding as per chart should have been done.
- Where lifting and slewing is not required, nothing was mentioned on sleepers. Zero should be written in such cases to avoid any confusion to the operators.

b. Bad Practice observed (CSM site):

- Super elevation (SE) was being taken on curve stations ie every 10 m. Cross level should have been done ever 5th sleeper for better assessment of improvement in twist track quality.
- The last day tamping was closed in the circular portion of the curve. The whole curve should be tackled at a time.
- The versine value should actually be fed as per chart given by M/s. Plasser India.
- Versine and SE was written on sleepers on transition portion of curve whereas SE was only written on circular portion of the curve. Versine should also be written on sleepers in the circular portion also for guidance of operator.

5.0 Post Tamping Activities :

a. Good Practice observed at both sites:

- Gang of 10 men (Approx.) was deployed behind tamping machine for filling up the void created by tamping tools.
- At T-Exp site, this gang was working ahead of DTS.

6.0 Condition of Machine

a. <u>CSM</u>

- All 32 tools were available in the machine. The size of blade was also proper.

- Proper Greasing and Lubrication of units was done.
- The engine i.e. Greaves Cotton MWMTBD 232 V12 was in good condition. Engine temperature and oil pressure were within limits. Filters were regularly being changed.
- Calibration of lining & leveling unit was done.

Deficiency observed in M/C (CSM):

- POH was not overdue, however, the IOH schedule after 2000 ERH was not done. Other maintenance schedule was completed.
- Minor oil leakage was observed in some of the cylinders (Driving Axle support cylinder, Satellite axle support cylinder).
- Gauges for Hydraulic temperature, Hydraulic level, ZF pressure & Satellite Brake pressure were out of order.
- Cap of opening for filling Hydraulic oil in tank was missing and was closed with polythene.



Fig 3: Cap of hydraulic tank covered by polythene

- Return filter choke indication switch missing.
- Engine air dirt indicator indication not provided.
- Interlocking proximate switch/limit switch feeler rod is missing.
- Bush of middle feeler rod relocated.
- Middle position galvanometer out of order and lining galvanometer need adjustment.
- Pneumatic pressure is less (5bar) against 6-7 bar while working.
- Brake shoes gap not proper and needs replacement.
- Height of lining roller needed adjustment
- Speedometer in front tower was out of order
- Automatic safety System (interlocking of ZF) with brake system not working
- Maggie spring was damaged.

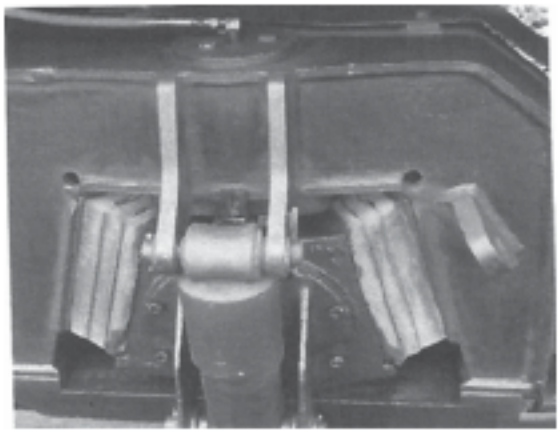


Fig 4: Maggie Spring damaged

- LHS cabin glass of working cabin broken.
- Main panel box broken and supported by wooden plank



Fig 5: Main panel supported on wooden plank

- Loose wiring at satellite channel. It should have been properly fixed.
- The tamping bank has worked for 600km with no major breakdown reported. However, following deficiencies were noted in the bank:
- Tamping depth control transducer is not properly fixed

b. T-Exp

- The Maintenance Schedule VII (POH) done by CPOH/ALD and was not overdue. Engine Running Hours of KTA 1150L was 3744 while that of NTA 855 L was 1786.
- Maintenance Schedule V and Schedule VI (IOH) of the machine to be done after 1000 & 2000 ERH respectively. The IOH is overdue by ERH of KTA 115OL, however in absence of clarity on ERH to be taken in IRTMM-2000, when two engines are there, Zonal Railway mentioned that they are taking working engine running hours ie of NTA 855L by which IOH is not overdue. Other maintenance Schedule I, II, III & IV done as per provision in IRTMM, 2000.
- All 48 Tamping Tools were available

Deficiency observed in M/C (T-Exp):

- In-charge of M/C was due for refresher training at IRTMTC/ALD. The safety training certificate issued by Zonal Training centre was up to date and competency certificate of operator was valid.
- Machine was working without ALC (Defective).
- CCTV camera used for viewing position of lifting/lining units was not working.
- Audio-visual warning system was out of order.
- Hole provided in the machine for lifting in the case of derailment, has been used in re-routing the cable.
- Calibration of lining & leveling unit was done during schedule-III maintenance. However, tamping unit up and down calibration was not proper
- Satellite lateral movement sensor out of order.
- Limit switches for safety of front feeler rod, middle feeler rod & rear feeler rod was out of order.
- System pressure and Servo Valve Filter Choking Indicators was defective.
- Color code of wires during wiring of different panels was not followed at CPOH. Fixing of wiring needs improvement.

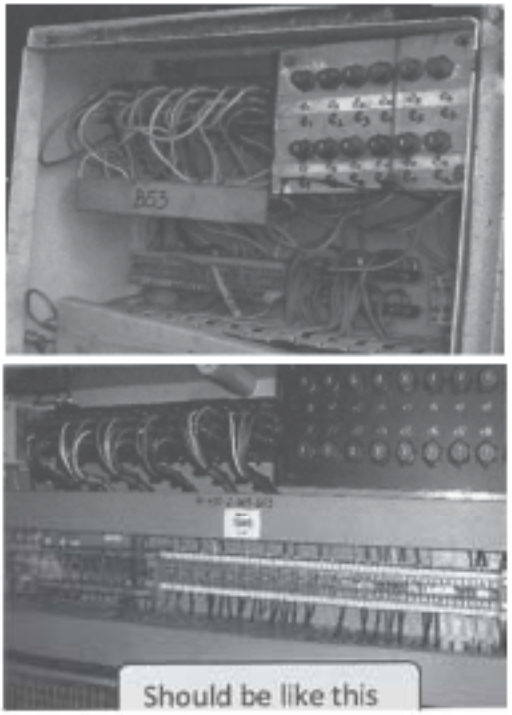


Fig 6: Colour Code of wiring not followed at CPOH

- Leakage of oil from one of the suction pipe suction pipe (4 inch). Crimping of suction pipe was not proper.
- Maggie spring in the rear bogy was damaged.

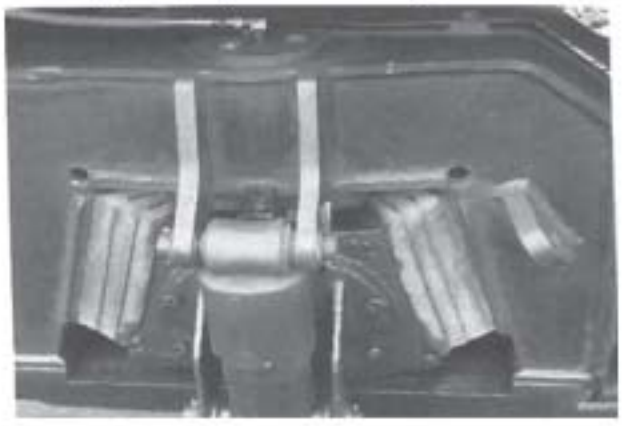


Fig 7: Damaged Maggie spring

- The tamping bank overhauled at CPOH had worked for 314km with no major breakdown reported. However following deficiencies were noted:
- Leakage of oil from elbow due to mismatch of elbow and connector. While the connector was of OEM, the elbow was of other company.
- Shank of one of the tamping arm was defective and tamping tool came out during tamping.
- The locking arrangement of lifting units was not proper and the lifting clamp wheel was only 85 mm above rail level infringing the SOD (102 mm above Rail level).
- The RHS middle filler rod was also infringing SOD (75mm above Rail level).



Fig 8: Lock Clamp infringing SOD

- The RHS middle filler rod was also infringing SOD (75mm above Rail level).

7.0 Comparison of Results

a) CSM Site:

Parameters	Before Tamping	After Tamping
Cross Level in Track varied between (Design SE 25 mm)	9R to 32R	22R to 32R
Maximum Twist	1.9 mm/m	1.1 mm/m
Max. stn to Stn variation of versine	17 mm	10 mm
Average versine of circular portion curve (design versine-15 mm)	14.67 mm	12.37 mm
TGI recorded	-	97/110

The curve was found to have been flattened after tamping and average versine of circular portion reduced from 14.67 mm before tamping to 12.37 mm after tamping. The design versine was 15mm. Transition length also increased at exit side of curve. It is seen that the curve versine correction was not satisfactory. Tamping in design mode would have given better result.

b) T-EXP Site:

Parameters	Before Tamping	After Tamping
Cross Level in Track varied between Design SE 45 mm	5L to 9R (St) 26 R to 50 R (curve)	2L to 4R (St) 37 R to 51 R (curve)
Maximum twist	2.34 mm/min	0.67 mm/m
Maximum station to station variation variation	13 mm	3 mm
Average versine of circular portion of curve (design versine -15 mm).	15.94 mm	15.81 mm
TGI recorded in this Km	163	173

Cross level before tamping varied between 5L to 9R in straight track which was brought between 2L to 4R. Maximum twist before tamping was 2.34 mm/m and after tamping was 0.67 mm/m. The alignment defect on straight track measured on cord of 10m length varied between +10 to 0 which was reduced to +3 to 0. In general the alignment was made 0 at most of the locations.

DGS was working in leveling mode. The cross level after tamping was retained after DGS working. Track quality as indicated by Track Recording Car measurement after tamping shows considerable improvement.

8.0 Conclusion:

The result obtained by tamping Express was far superior than that by CSM, primarily due to following reasons

a. 3-Point Design mode tamping was used at T-Exp site and proper survey was done for getting the front offset values. At CSM site 3-point smoothening mode tamping was used instead.

3- Point Design mode with proper front offset value is going far better result than 3 point smoothening method of tamping.

b. DTS in Constant settlement mode was used behind Tamping express while DTS was not used behind CSM.

c. The pre-block work particularly like heaping of Ballast in tamping Zone, Cess repair and attention to trespassing locations were not done in advance at CSM site.

d. The datas to be provided to operator's ie super elevation versine etc were not properly written at CSM site.

e. The curve at CSM site was partly attended in one block and partly in another block.

The result at T-Exp site could have further been improved if the versine data from manufacturer's manual instead of thumb rule have been used. Also ALC of tamping express was not working and that could be directly used for feeding versine values.

In addition, the condition of machine maintenance was not proper and lot of essential instruments and safety related components were out of order. I feel that all Dy CE/TM should develop a system of audit inspection of each machines at regular interval to properly appreciate the deficiencies in m/c and accordingly its rectification. No By passing of any safety circuit or instruments should be allowed. This will also help in developing proper system of maintenance for keeping machine in good health.

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Japanese Firm Mitsui Wins Bid for Supply of Rail Tracks for Ahmedabad Metro Rail Project

Japanese firm Mitsui Co. Ltd. has won the bid to supply 10,600 metric tonne of Head Hardened Rails (HH-Rail) for the track work of the 37-km-long Phase-1 of the Ahmedabad metro-rail project at the cost of Rs 59.32 crore.

"Mitsui has been selected from a group of five bidders which included Voestalpine, Jindal Steel, British Steel, East Metals," said IP Gautam, Managing Director of Metro-Link Express for Gandhinagar and Ahmedabad (MEGA) Company Ltd which is constructing the Rs.10,700 crore Phase-I of the project.

Mitsui is the first Japanese firm to win a bid out of the 27 contracts that have been awarded.

The tender notice for procurement of the HH-rail was published on July 8, 2016 and the tender was awarded on June 15.

According to metrorail officials, the 1,080 grade HH-rail being procured for Ahmedabad metro has greater durability than the normal rail of 880 grade. The use of 1,080 grade HH-rail will dispense frequent rail checks on main lines.

"We will be using the HH-rail only for laying the metro tracks, while normal rail will be used in the depots," an official added. Two depots — one at Apparel Park on the East West Corridor and the other at Gyaspur on the North-South Corridor is being built.

http://www.railnews.in

Successful Design of Wet Mix Shotcrete - Five Common Misconceptions and Corresponding Facts

Relative to conventional concrete, Shotcrete is now capable of providing similar performance at a lower cost and it can be placed in challenging areas where application of conventional "poured" concrete is not convenient. Although wet-mix Shotcrete has proven to be an ideal alternative to conventional concrete in numerous applications, its further success is sometimes hindered by a few common misconceptions. The article discusses some of those fallacies and presents corresponding facts.

Misconception 1: Shotcrete is not concrete

Fact 1: Shotcrete IS concrete

Shotcrete is composed of cement, water, aggregates and chemical admixtures. Therefore, from a materials perspective, shotcrete is certainly concrete. Similarly, it should be noted that other special concrete types such as pervious concrete, self-consolidating concrete, lightweight concrete and ultra-high-performance concrete - regardless of their different mixture designs or application types - are all considered to be concrete, and shotcrete is not an exception. As a matter of fact, shotcrete is termed "sprayed concrete" in many parts of the world.

Perhaps the confusion about how to categorize shotcrete comes from the facts that: (i) Shotcrete has a different placement method than conventional "poured" concrete; and (ii) The spraying application requires mixture designs that are different than conventional concrete. The mixture design has to be selected based on the desired fresh and hardened concrete properties, which are determined in accordance with the intended use of the concrete structure, exposure condition, the size and shape of the building elements, and the selected placement/spraying equipment.

Misconception 2: Strength is most important parameter of shotcrete

Fact 2: Strength is important, but it is NOT the only parameter affecting performance

Although compressive strength is the most commonly specified parameter for the acceptance of concrete, and although a minimum strength is generally required to ensure the structural performance of concrete, strength has little direct correlation with durability. Considering that durability is what determines the service life/longevity of a concrete structure, strength cannot be solely relied on to assess shotcrete performance.

Analysis of data from more than 60 shotcrete mixtures, to determine the correlation between compressive strength and boiled absorption at 7 and 28 days (Boiled absorption is commonly used indicator of durability – the higher the boiled absorption, the less durable the concrete), indicates that mixtures with nearly identical compressive strength could have a wide range of absorption values. This confirms that compressive strength is not sufficient to presume a mixture having good durability characteristics. In fact, durability is influenced by factors such as water-cementitious material ratio, total binder content, type and amount of supplementary cementitious materials, aggregates, consolidation, curing, and external environmental conditions.

Misconception 3: Alkali-free accelerators reduce the 28-day strength

Fact 3: Alkali-free accelerators have a minor impact on the 28 days strength

In shotcrete applications, it is not uncommon for mixtures containing accelerators to have a lower 28-days strength than similar mixtures containing no accelerators. However, this does not necessarily mean that such behavior is caused by the presence of accelerators. For shotcrete applications, the strength is affected by the mixture design, the constituent materials, and the quality of spraying. Because these factors affect each other as well as the "finished product", it can be difficult to isolate the primary cause of compromised performance. A placement issue, such as inadequate compaction resulting in high voids content, probably will have a more detrimental effect on compressive strength than the presence of an accelerator. Therefore, if strength test

results obtained from cores (with an accelerator) are significantly different than strength test results from cylinders (without an accelerator), cross-sectional disks of specimens should be examined to determine the quality of the spraying.

Analysis of data of 130 shotcrete mixtures, with samples taken before and after addition of an alkali-free accelerator at various dosage rates, shows that compressive strength of samples produced before addition of accelerators tend to be about 3.45 MPa greater than the strength of samples produced after addition of accelerators. The magnitude of difference is small enough to be tolerated. Other research have also shown that the impact of alkali-free accelerators on later-age strength is relatively minor.

Misconception 4: Concrete slump dictates the rebound rate

Fact 4: While slump does provide an indication of the ease of flow, rebound rate is determined using more complex rheological properties.

While the slump test is a simple test method for evaluating the yield stress (ease of low) of concrete, it is not a reliable indicator of the overal quality or suitability of shotcrete mixtures. First of all, there is no direct correlation between a mixture's slump and its thixotropic properties. Furthermore, modern chemical admixtures make it possible to have two mixtures with the exact same slump values but with completely different rheological properties. Slump test results actually provide limited guidance despite the commonly held misconception that they can be used to judge the sprayability, placeability, finishability, and rebound of shotcrete mixtures.

During the spraying process, large aggregates particles tend to segregate from the mixture after hitting and bouncing off the receiving surface. Thus, a high volume of rebound material primarily consists of aggregate particles. If the quantity of paste is sufficient to fill the voids between the aggregate, paste quality and aggregate gradation plays more important role than the amount of cementitious materials.

The quality of paste is affected by the mixture's rheological characteristics such as: (i) Stickiness (adhesion to substrate surface–allowing large thickness buildup); (ii) Cohesiveness (adhesion to self-providing resistance to segregation under pressure); and (iii) Viscosity (resistance to gradual deformation-reducing sagging on vertical walls).

Therefore, instead of relying solely on the slump, these three rheological parameters should be evaluated and optimized to reduce the rebound rate. Until a sufficiently thick paste layer accumulates on the substrate, thus creating a "sticky" viscoplastic surface, rebound of the aggregate particles is inevitable. Therefore, although it is not feasible to completely eliminate rebound, it is possible to reduce the rebound rate by changing the mixture's rheological characteristics. However, the ideal mixture for a given project should draw a delicate balance between these rheological characteristics, as they also influence other aspects of shotcrete quality such as compaction, consolidation, and encasement.

Pumpability and sprayability are two other key properties that need to be taken into account when shotcreting, and it is important to understand the differences between these two parameters. Pumpability characterizes the stability and mobility of a mixture under pressure. For Pumpability, it is desirable to have a mixture with low viscosity and high flowability (usually associated with high slump). Sprayability characterizes the efficiency of a mixture to stick to the applied surface (adhesion) and to itself (cohesion). For sprayability, a stiff and sticky mixture with low slump and high cohesiveness is desired to minimize rebound and increase thickness buildup.

Adequate rheological properties are also essential for proper placement, consolidation, and compaction. Because, shotcrete is consolidated by high-velocity placement rather than mechanical vibration, mixture should provide sufficient fluid properties to accomplish consolidation around reinforcing bars. If mixture lacks cohesion and is not fluid enough, voids will occur within the shadow areas behind the bars.

However, while satisfying the needs for consolidation, it should be noted that highly flowable mixtures are prone to sagging if they do not possess a certain degree of viscosity, allowing the material to remain on the applied surface and resist the effect of gravity. Therefore, mixture components should be selected to provide adequate viscosity and yield stress for minimizing

sagging while not increasing the pump pressure.

Unlike cast-in place concrete, shotcrete must stick or adhere to a surface, as there is no formwork. Therefore, "sticky" mixtures are desirable for the shotcrete process, as they allow larger buildup thicknesses on walls and overhead applications. "Stickiness" also contributes to enhancing safety, productivity, and cost-efficiency, as material that do not stick or adhere cause fallouts that raise a safety concern and become costly waste.

Slump is only one parameter, and the rheological behavior of shotcrete is too complex to be oversimplified with one test. Rather selecting, a shotcrete mixture requires a delicate balance between flowability, cohesiveness, viscosity, and "stickiness". Considering that different phases of shotcreting require conflicting rheological properties, it is ideal to maintain the highest possible fluidity (lowest yield stress) while providing the desired viscosity, cohesiveness, and "stickiness" to satisfy all needs.

Misconception 5: Prescriptive-based specifications are necessary to control quality

Fact 5: Prescriptive-based specifications can result in mixture overdesign, and they do not assure performance

Currently, many concrete mixtures are proportioned based on recipes that have been used before or on prescriptive-based specifications. While prescriptive specifications may appear to conservatively define limits on the type, amount, and proportions of the mixture components, they do not necessarily ensure that performance requirements are met. They also typically put constraint on the minimum compressive strength, maximum water cementitious material ratio, replacement level for supplementary cementitious materials, and minimum cementitious material content. In effect, these constraints promote overdesign of mixtures by forcing the producer to use cement content as a safety factor. Even so, mixtures designed using prescriptive specifications do not always provide the desired end results.

Although more than 60% of shotcrete volume is composed of aggregates, many prescriptive-based specifications for shotcrete neglect to provide information regarding aggregates. It is not ideal to specify cementitious material content without considering aggregates, as the required paste content is heavily dependent on the size, type, and gradation of aggregates. According to a study conducted by Dhir et al., aggregate properties have a greater impact on many aspects of performance than changing cement content at given water cementitious material ratio. This is especially true for shotcrete mixtures because a high volume of rebound material consists of mainly aggregate particles, and as long as there is a sufficient amount of paste to fill the voids between the aggregate particles, paste "stickiness" and aggregate gradation play more important roles in rebound reduction than the amount of cementitious materials.

Every application is subject to different environmental conditions, locally available materials, and performance requirements. Therefore, for high-performance shotcrete mixtures, mixture designs should be selected based on the project requirements instead of simply following an existing recipe that was found to be successful on a previous job.

Conclusions

Shotcrete has advanced significantly over the years; however, the discussed misconceptions often limit many benefits it offers to the construction industry. To broaden the area of shotcrete applications and to improve its performance, it is essential to understand shotcrete as a material and its demands as a placement method. There is a very delicate balance between the mixture constituents and their impact on shotcrete performance. This is especially true considering that pumping, spraying, and placement require conflicting rheological requirements that may cause sacrificing one property while improving another. Consequently, understanding rheological behavior with a simple slump test or overdesigning a mixture to meet prescriptive-based specifications might do more harm than good. Therefore, for successful shotcreting, it is ideal to consider all the desired performance criteria and find an optimum that could satisfy all the project needs.

By : Ezgi Yurdokul, Klaus-Alexander Rieder and Diego Grannel Nebot.

Ref.: Published in Concrete International, Vol. 39, Issue 4, April 2017

Experimental Evaluation of Slender High-Strength Concrete Columns with GFRP and Hybrid Reinforcement

The behavior of slender high-strength concrete columns reinforced with glass fiber-reinforced polymer (GFRP) bars and spirals subjected to concentric and eccentric axial loads was evaluated. Large-scale tests were conducted for nine circular concrete columns (three short and six slender) reinforced with internal GFRP-spirals and either steel, GFRP, or a combination of steel and GFRP longitudinal bars. The short and slender columns had slenderness ratios equal to 10 and 49, respectively. Axial load tests were conducted with loads placed concentrically (short columns) and at two eccentricities (slender columns) to observe the general behavior associated with different geometric and loading conditions. The behavior of slender columns with small eccentricity (8.3% of the column size) was governed by material failure, while that of slender columns with large eccentricity (33% of column size) was governed by a buckling failure. The research shows that GFRP spirals and GFRP longitudinal bars are a viable method of reinforcement for slender concrete columns subjected to eccentric axial loads.

By : Thomas A. Hales, Chris P. Pantelides, Lawrence D. Reaveley

Ref. Journal of Composites for Construction, Month: Nov./Dec. 2016 Vol. 20 Issue 6

Fatigue Performance of Ballastless Track Slabs Reinforced with BFRP and SFCB

The main objective of this research was to evaluate the behavior of fiber-reinforced polymer (FRP) bar-reinforced ballastless track slab subjected to a fatigue loading. Five ballastless track slabs were experimentally tested, which were reinforced with steel fiber–reinforced polymer composite bars (SFCBs), basalt fiber–reinforced polymer (BFRP) bars, and traditional steel bars, respectively. All slabs were loaded in three-point loading and designed to have the same initial stiffness of cross section. To simulate the wheel cyclic load, different maximum loads were selected, but the minimum load was the same for all slabs. At the same maximum load of 1.76 static wheel loads, the stiffness degradation and crack width in the SFCB slab were similar to those of the traditional RC slab and survived 3,000,000 fatigue cycles, showing good fatigue performance and a residual strength reduction of only approximately 3%. At the maximum load level of 60% of the ultimate load static capacity, both the SFCB slab and RC slab could satisfy the requirements of 2,000,000 fatigue cycles, whereas the stress in SFCB was only approximately 66% of the steel bar, and the crack width in the SFCB slab was 1.15 times greater than that in the RC slab. After 2,000,000 fatigue cycles, the maximum load level was increased to approximately 65% of the ultimate load static capacity. The stiffness of the RC slab decreased by 21% and was close to failure, whereas the SFCB slab only decreased by 6%. Finally, the BFRP slab had the shortest fatigue life (only 1,600,000 cycles) with a maximum load of only 52% of the ultimate load static capacity owing to the possibly reduced bond strength between concrete and BFRPs.

By : Yang Yang, Gang We, Zhi-Shen We

Ref. Journal of Composites for Construction, Month: Jan./Feb. 2017 Vol. 21 Issue 1

Preliminary Study to Enhance Ductility of CFRP-Strengthened RC Beam

A Fiber-reinforced polymer (FRP) strengthening systems are widely accepted in engineering practice as means to enhance the flexural strength of RC members, but resulting in decreased ductility. Brittle failure, i.e., FRP rupture, FRP delamination, or concrete cover separation, impairs the reliability of FRP strengthening system. A near surface–mounted (NSM) FRP strengthening system has similar drawbacks. As a possible solution, a design philosophy is proposed to enhance the ductility of the NSM-FRP system by triggering a global slip at the FRP–adhesive interface. The corresponding design method is developed to induce the ductile failure and predict the ultimate strength of NSM FRP–strengthened RC member in flexure. A series of experimental tests were conducted to verify the effectiveness of the proposed method. The designed RC beams strengthened with NSM–carbon FRP (CFRP) outperformed the externally bonded CFRP systems both in ductility and flexural strength. Additionally, the proposed design method was

experimentally validated by precisely predicting the ultimate strength of tested specimens.

By: Jiangtao Yu, Yanning Xu, Kequan Yu, Thomas L. Attard

Ref. Journal of Composites for Construction, Month: Jan./Feb. 2017 Vol. 21 Issue 1

Rehabilitation of Tunnel No.-10

Introduction :-

Construction work of tunnel no. 10 on katra-reasi section of USBRL project was started in june 2003. The total length of this tunnel is 970 m. The alignment of tunnel lies on a curvature of 4 degree. There is a maximum overburden of 190m .This tunnel has been constructed in the holytown of katra. This tunnel passes through highly unfavourable geological formations, due to which tunnel work was extremely difficult strata from 28/578 to 28/840 involved loose soil containing pebbles compounded with seepage of water due to which tunneling was extremely difficult in such a strata. Though, the tunneling work progressed without problem from katra end i.e. 28/280-28/578. Thereafter the work of tunneling could be continued with great difficulties. During initial construction, squeezing of tunnel and heaving of tunnel invet was observed at many locations. Tunnels collapses and cavity formations were also encountered. The initial tunnel excavation work was completed in 2009. The problem of squeezing/heaving and cavity formation necessitated intensive rehabilitation work in this tunnel.

Description of Geology Encountered :-

The tunnel probably passed through sheared dolomite/crushed dolomite i.e. part of reasi thrust. Dolomite pieces are mixed with clay (yellow in colour). Topgraphy of the area also indicates that the collapsed tunnel portion is below southern slope of tarakot hil which is madeup of jointed and sheared dolomite. Reasi end of tunnel has been excavated through dolomite mixed with reddish clay band charged with water. The examination of the area indicates that tunnel is located along with reasi thrust and due to curve in tunnel the present collapsed portion may be passing through sheared and crushed dolomite charged with water.

Causes of Tunnel Failure Leading to Squeezing/heaving And Cavity Formation/ collapse :-

Due to extremely poor geology coupled with 'D' shape of the tunnel, problem if tunnel failure leading yo squeezing/heaving and cavity formation/collapse was encountered.

Rectification Work :-

Squeezing/heaving of tunnel occurred in the account of extremely poor geology and adaption of 'D' shaped profile which is less efficient to encounter lateral forces. Further in tunnel 'D' shaped, SPL beam is the weaker part for transmitting the compressive forces come from the crown. The SPL beam ISHB-150 buckling at many places. The remedy measure for this is eliminate the provision of SPL beam during profiling. It was proposed to provide bottom beam every rib during profiling. Since, original 'D' shape was able to withstand the squeezing effect was decided to adopt much stable profile in elliptical section with permanent support system comprising of ISHB-150 at 500mm c/c instead of ISHB-150 at 750mm c/c.

Exavation work was started to rectify the collapsed 'D' shaped tunnel by reprofiling with elliptical shape. Due to very poor strata , the standup time of the excavated profile was very less to increase the standup time, method of pipe roofing waqs adopted using 114mm dia seamless pipe at a spacing of 300mm c/c. ,micro-piling rig machine was used for forepoling the seamless pipe for creating an umbrella.The working space required for micro-piling machiene about 10m length with 750mm extra clearance at sides in a 'D' shaped tunnel. For creating this extra working space for micro-piling machine excavation was done in cycle of 50m length,sealing shortcreate of 50mm thickness was applied after every cycle of excavation.

In order to increase the standup time of exavation profile pipe roofing methodology was adopted to provide umbrella roofing below which the work of re-profiling/excavation for tackling cavity was executed.

Re-Profiling Work :-

In locations where re-profiling was required, first of all efforts were made by doing re-profiling,tackling

one rib at a time. Re-profiling in heading was done first followed by benching. Rib-spacing while profiling was reduced from 750mm c/c to 500mm c/c. After fixing ribs, RCC laggings (450*200*50) were provided and back filling done with M-20 concrete with the help of concrete pump. Contact grouting was done to consolidate the surrounding area beyond excavation line with pressure pump applying pressure upto 5-10 kg/sqcm. Back filling thickness was also increased 150 to 350mm. The X-section is changed from 'D' shaped to elliptical shape with haunch arrangement (elephant foot) at SPL level to increase stability, thereby eliminating SPL beam.

In locations where standup time of exavated earth was very less on account of poor geology, re-profiling as above was carried out after providing protection in the form of pipe umbrella using pipe roofing methodology.

Rectification Of Cavity Zone Between Ch. 28.724 To 28.862 :-

In order to rectify and making through the tunnel in the cavity zone following action were taken.

A. Back filing of the voids in the collapsed material in the tunnel section and upper zone over the crown with colgrout (sand cement grout).

B. Install pipe roofing with colgrout/neat cement grout before taking up heading and benching.

The length of collapsed tunnel was divided in segments of about 12m length for effectiveness of treatment. The detailed methodology and sequence of operation are as under :-

1. Drilling
2. Colgrouting
3. Pipe roofing and grouting/colgrouting
4. Exavation

Conclusion :-

Elliptical shape tunnel is round and safe by providing rib spacing of re-profiling reduced 750mm c/c to 500mm c/c with RCC lagging (450*200*50) instead of 'D' shaped tunnel.

Reference :- Him Prabhat Vol. II issue V

Feb. 2015 USBRL Technical News Magazine

Reinforced-Concrete Beam Hinge Joint Fatigue Assessment

A major highway underbridge has been subjected to a complex fatigue assessment to determine its present and future serviceability. Similar to approximately 100 other structures within Great Britain, reinforced-concrete deck hinge joints are positioned within longitudinal beams providing rotational flexibility. Concerns were raised as to the fatigue condition of the hinge joints considering repetitive rotations applied by traffic loading and pitting corrosion found on reinforcement bars. This paper describes the assessment work and associated research relating to this structure including finite-element analysis, laboratory models and space frame modelling of the structure. Comments are made on the applicability of current codes of practice for fatigue assessment of reinforced-concrete deck hinge joints.

By: David Peter Cousins

Ref: Ice Proceedings, March 2017, Vol. 170

Transverse Assessment of a Concrete Box Girder Bridge

This paper looks at the beneficial effects of geometric arching from haunches, web continuity and compressive membrane action in the design and assessment of box girder top slabs. The paper initially reviews tests relevant to arching action in box girders and then analyses recent tests on box girder slab strips. Finally, using the assessment of an existing box girder bridge as an example, a series of computer models is developed to illustrate a method for transverse analysis of a box girder top slab in which some of these arching effects can be utilised. For the analysis of tests and the assessment example, a three-dimensional frame model that considers the in-plane strength enhancement of the restrained slab is used. This simplified approach was verified by finite-element modelling and the results show good agreement. The analysis methods including arching action significantly reduce the required amount of reinforcement for the deck slab. The paper concludes that arching action from geometrical arching of haunches and frame action are significant and must be considered for any accurate analysis at both serviceability and ultimate limit states. It is also concluded that compressive membrane action may occur and can be used in the design and assessment of box girder structures within certain geometric parameters.

By: Abdullah Zaid, David Collings

Ref: Ice Proceedings, March 2017, Vol. 170

Structural Capacity Assessment of Corroded RC Bridge Piers

A new numerical model is developed that enables simulation of the non-linear flexural response of reinforced concrete (RC) components and sections with corroded reinforcement. The numerical model employs a displacement-based beam–column element using the classical Hermitian shape function. Material non-linearity is accounted for by updating element stiffness matrices using the moment–curvature response of the element section considering uniform stiffness over the element. The cover concrete strength is adjusted to account for corrosion-induced cover cracking and the core confined concrete strength and ductility are adjusted to account for corrosion-induced damage to the transverse reinforcement. The numerical model is validated against a benchmark experiment on a corroded RC column subject to lateral cyclic loading. The verified model is then used to explore the impact of corrosion on the inelastic response and the residual capacity of corroded RC sections. The results show that considering the effect of corrosion damage on RC sections changes the failure mode of RC columns.

By: Mohammad M. Kashani, Adam J. Crewe, Nicholas A. Alexander,

Ref: Ice Proceedings, March 2017, Vol. 170

Assessment of an Existing Fully Prestressed Box-Girder Bridge

The N.S. da Guia Bridge is a 250 m-long post-tensioned box-girder bridge built in the late 1970s using the balanced cantilever method. During a routine inspection, a systematic cracking pattern that exhibited both longitudinal and transversal symmetry was detected in the webs and bottom slab, which raised concerns about the condition of the embedded post-tensioned cables. The working programme that was devised to perform the condition examination of the bridge is described. Besides a detailed visual inspection campaign and a short-term monitoring programme, non-destructive testing was also employed, most notably gamma-ray imaging of the internal tendons. Special attention is devoted to the numerical studies developed to explain the origin of the observed crack patterns. This information was crucial in order to decide on the best rehabilitation strategies. The crack pattern could be satisfactorily reproduced by taking into account the local stress conditions around the tendon anchorages, and the concerns related to the condition of the prestressed steel could be ruled out. The applied methodology constitutes an example of how detailed analysis techniques can be used in practice to help bridge owners evaluate the condition of special bridges and plan the rehabilitation intervention in a cost-effective way.

By: Mário Pimentel, Joaquim Figueiras,

Ref: Ice Proceedings, March 2017, Vol. 170

Waterloo Bridge – Structural Behavior and Strength

Waterloo Bridge, carrying the A301 road across the River Thames in London, was completed in 1942. It comprises twin multi-cell reinforced-concrete box girders of variable depth with connecting transverse slab, supported on caisson foundations. The paper describes the analysis and load assessment using modern techniques of a structure originally designed without the use of computers. The original articulation system incorporated stops to restrict longitudinal movement, and dynamic damping devices. The assessment has taken account of the actual behaviour of the structure determined from movement measurements. The centre suspended span is supported by hinge joints, which comprise steel roller bearings attached to concrete with pre-stressed vertical and diagonal bars. These bearings and their associated supports were subject to detailed analysis to determine their ultimate strength. The assessment has led to a much better understanding of bridge performance and residual life, which will enable the bridge owner to plan future maintenance interventions.

By: David Astin,

Ref: Ice Proceedings, March 2017, Vol. 170

Bridge Model Updating using Distributed Sensor Data

One of the challenges of managing bridge infrastructure is developing numerical models that can be used to accurately assess highly redundant bridge systems. One way to refine the model is to use sensor data to perform model updating. However, conventional sensors provide limited

data with which to update the model, given the many degrees of freedom associated with indeterminate structures, resulting in a large potential error. Distributed sensing technologies such as digital image correlation and fibre optic strain sensors have the potential to provide more extensive data sets for model updating. This paper presents a case study of a reinforced concrete bridge that was modelled numerically to predict the bridge performance. The bridge was then load tested, and distributed sensor data were acquired. Using the sensor data, the numerical model was updated and refined estimates of the bridge behaviour were obtained. The initial and final models produced estimates of bridge behaviour that differed by an order of magnitude, illustrating the importance of sensor data for some bridge assessments. Additionally, the model indicated that the stiffness of the bridge had increased with time owing to an increase in the elastic modulus of the concrete and the development of compressive stresses.

By: Evan C. Bentz, Neil A. Hoult,

Ref: Ice Proceedings, March 2017, Vol. 170

Capacity of a Nineteenth Century Iron-Arch Bridge in Leeds, UK

Leeds Bridge crosses the River Aire in the city centre of Leeds, UK. Built in 1871, this grade II-listed iron-arch structure is currently restricted to vehicles over 7·5 t (other than buses and fire engines) due to a weak deck. A proposed trolleybus system was planned to go over the bridge, requiring it to be reassessed. The single 32 m skew span bridge is made up of ten arched ribs – two external ribs made from cast iron with the eight internal ribs, plus all the cross-girders and bracing, made from wrought iron. This paper describes the assessment of the bridge using a three-dimensional space-frame model supplemented by a three-dimensional finite-element model of one rib. The assessment concluded that the strengthening requirements to carry the required vehicle loading would be limited to replacement of the mass concrete infill.

By: Aaron Okorie, Peter Clapham, Bowen Ndlovu,

Ref: Ice Proceedings, March 2017, Vol. 170

Identification of Cracks in Box-Section Beams with a Cracked-Beam Element Model

Box-section steel members are widely used in different types of engineering structures. Identification of cracks in box-section members poses a particular challenge because of the section geometry. This paper presents a crack identification approach for box-section beam-column members based on a cracked-beam element model and using a finite-element (FE) model updating procedure. The cracked-beam element model is established by involving an additional local flexibility due to the crack, which is formulated using the fracture mechanics principles. To calculate the additional local flexibility, the stress intensity factors for cracks in box sections need to be established and this is achieved using an empirical approach combining FE simulation, parametric analysis, and regression. The cracked-beam element model is verified in terms of its predictions of the dynamic properties of cracked box-section beams against both FE simulated and experimentally measured modal data. Both thick-walled and thin-walled box-section beams have been considered in the FE simulated examples, while several box-section beams with different numbers of cracks have been tested in the experiment. Subsequently, the model is incorporated in the crack damage identification procedure. Results indicate that cracks can be identified correctly for beams with both single crack and multiple cracks and the identified crack parameters are of good accuracy.

By: Chuanchuan Hou and Yong Lu

Ref: Journal of structural Engineering, June 2017, Vol. 143

Hinging Mechanisms of Masonry Single-Nave Barrel Vaults Subjected to Lateral and Gravity Loads

This paper investigates the limit states of a circular masonry arch supported on rectangular buttresses when subjected to lateral inertial loading in addition to gravity loading by employing the principle of stationary potential energy. Depending on the slenderness of the arch compared to the slenderness of the buttresses, the study identifies two lower failure mechanisms: (1) a four-hinge mechanism within the arch alone; and (2) hinging of the arch in three locations together with a hinge

at the base of the downstream buttress. In this analysis, radial ruptures are assumed for the arch, while the buttresses may rupture either horizontally or develop an oblique elongation failure along which the compression-free portion of the buttress separates. It is concluded that the hinging mechanism that triggers an oblique elongation failure of the downstream buttress is the most critical and initiates at a lower value of the seismic coefficient than the value associated with the mechanism that involves a horizontal fracture at the buttress. Finally, it is shown that the discrete-element method (DEM) captures the results of the proposed variational method with remarkable accuracy.

By: Haris Alexakis and Nicos Makris,

Ref: Journal of structural Engineering, June 2017, VoL 143

Serviceability Performance of Steel–Concrete Composite Beams

The use of steel–concrete composite beams in which wide-flanged steel beams act compositely with a concrete or steel–concrete composite slab above is well established in building construction. However, for composite beams with low degrees of shear connection between the beam and slab, significant additional deflections can occur due to slip in the shear connectors. A design formula is presented for the effective stiffness of composite beams taking account of the stiffness of the shear connectors, which is compared to measured deflections of six symmetric composite beams and an 11 m span composite beam of asymmetric profile. It is shown that the comparison is good when using a shear connector stiffness of 70 kN/mm for single shear connectors and 100 kN/mm for pairs of shear connectors per slab rib. The results of push tests on a range of slab profiles confirmed these initial elastic stiffnesses. To ensure that the slip at the serviceability limit state does not lead to permanent deformations of the composite beam, it is proposed that the minimum degree of shear connection should not fall below 30% for unpropped beams and 40% for propped beams of symmetric cross-section.

By: R. Mark Lawson, Dennis Lam, Eleftherios S. Aggelopoulos, Sebastian Nellinger,

Ref: Ice Proceedings, Feb 2017, Pg 81

Mix Model for Self-Compacting Concrete with Recycled Aggregate

Self-compacting concrete has become a common material in the current scenario of construction of large and complicated structures with heavy reinforcement and complex shapes. Using normal concrete in such situations can often result in inadequate compaction affecting the performance and long-term durability of structures. Also, the use of recycled-aggregate concrete is gaining importance throughout the globe owing to the depletion of natural aggregate sources and the disposal problem of demolished waste. Although there are different particle packing theories to optimise the aggregate proportions for binary and ternary combinations, the compressible packing model seems to be best suited for poly-dispersed mixes. In the present work, three grades of recycled-aggregate self-compacting concrete mixes without and with steel fibres were developed using the compressible packing model. To qualify the mixes developed, fresh properties such as slump flow, J-ring, V-funnel and L-box tests were conducted and checked for the satisfaction of European Federation of National Associations Representing for Concrete specifications. Validation was also done for other intermediate concrete grades, namely, M25, M30, M35, M45, M50 and M55. It was noted that the compressible packing model optimisation of aggregates considers important parameters such as wall effect, loosening effect and perturbed volume, which are important in deciding aggregate portions of self-compacting concrete.

By: Madduru Sri Rama Chand, Kontham L. Radhika, Pancharathi Rathish Kumar, Siempu Rakesh,

Ref: Ice Proceedings, Feb 2017, Pg 115

Beam-to-CFT High-Strength Joints with External Diaphragm. I: Design and Experimental Validation

The paper presents the outcomes of an experimental program developed and carried out with the aim of characterizing the behavior of two types of moment-resisting joints in multistory frames of concrete-filled high-strength steel rectangular hollow section (RHS) columns and mild carbon steel beams. The paper describes the design approach and displays the specific detailing

for the two joint typologies: with reduced beam section (RBS) and with cover plates (CP). In spite of the various past and recent studies which were focused on the evaluation of full-strength welded beam-to-concrete-filled-tube (CFT) column joints, particular design procedures are missing at the European level. The objectives of the current research were to (1) development a design procedure for welded beam-to-CF-RHS joints, (2) experimental validation of the of the design procedure, and (3) assessment of the seismic performance. The monotonic and cyclic tests evidenced a good conception and design of the RBS and CP joints. In particular, the current study proved the feasibility of using higher steel grades in columns and joint components, and the use of an external diaphragm for the transfer the loads from the beam to the side walls of the RHS steel tube. The seismic performance of the joints was proved adequate, the joints sustaining rotation capacities larger than the 40 mrad at the significant damage performance level.

By: Cristian Vulcu; Aurel Stratan; Adrian Ciutina; and Dan Dubina

Ref: Journal of structural Engineering, May 2017, VoL 143

Beam-to-CFT High-Strength Joints with External Diaphragm. II: Numerical Simulation of Joint Behavior

The paper presents the outcome of a finite-element numerical investigation program developed and carried out in connection to a set of experimental investigations performed on welded beam-to-column joints, with columns realized as concrete-filled tubes (CFT) with rectangular hollow sections (RHS). The current study was aimed to calibrate a set of numerical models, to conduct a parametric study, and to validate the proposed design procedure. Joint models were calibrated, and additional parameters were investigated numerically, such as: influence of the concrete core, influence of the axial force in the column, response of one-way and two-way joints. It was shown that (1) the influence of concrete core was proved to be low for the single sided RBS or CP joint assemblies, but significant corresponding to joints with strengthened beam, (2) the response of the joint assembly was not affected by the presence of the axial compression force in the column, and (3) the connection solution with external diaphragms was characterized by an adequate response considering one-way and two-way joints. The current study evidenced a good conception and design of the reduced beam section (RBS) and cover plate (CP) joints. In particular, the study proved the feasibility of using higher steel grades in columns and joint components, and the use of an external diaphragm for the transfer the loads from the beam to the side walls of the rectangular hollow section (RHS) steel tube.

By: Cristian Vulcu; Aurel Stratan; Adrian Ciutina; and Dan Dubina

Ref: Journal of structural Engineering, May 2017, VoL 143

Long-Term Mechanical Properties of Different Fly Ash Geopolymers

Geopolymer concrete is a sustainable construction material with the potential to act as a replacement for portland-cement (PC) concretes. A detailed investigation of the mechanical properties of four different fly ash geopolymer concretes was carried out up to 1 year of age. Compressive, flexural, and splitting tensile strengths, elastic modulus, and Poisson's ratio of four geopolymer concretes at 1 year ranged between 28 and 88 MPa (4.06 and 12.76 ksi), 3.92 and 6.3 MPa (0.568 and 0.914 ksi), 1.86 and 4.72 MPa (0.27 and 0.684 ksi), 10.3 and 29 GPa (1493.5 and 4205 ksi), and 0.16 and 0.28, respectively. The results show an increase in performance observed between 90 and 365 days for all concretes depending on the fly ash properties. Tarong displayed the highest increase while Gladstone had the least, although Gladstone did display the best performance throughout. The nature of the gel matrix formed, in terms of uniformity and compactness, was observed to determine the mechanical properties. The nature of the interfacial transition zone formed between coarse aggregate and mortar and its density was observed to govern the tensile strength. An increase in porosity and microcracks was seen to negatively affect the compactness of the gel matrix, which in turn affected the elastic modulus.

By: Chamila Gunasekara, Sujeeva Setunge, David W. Law,

Ref: ACI Structural Journal, May-June 2017 VoL 114 No. 3

Calendar of Courses

Course No.	From	To	Name of the Course	Duration	Eligible Group
Probationary Courses					
17009	06-11-2017	29-12-2017	IRSE Ph. I (Gr. P)	7 Weeks	IRSE (P) 2016 Exam
17010	06-11-2017	29-12-2017	IRSE Ph. I (Gr.Q)	7 Weeks	IRSE (P) 2016 Exam
17011	11-12-2017	15-12-2017	IRSE Posting Exam	1 Week	IRSE (P) 2015 Exam.
17012	18-12-2017	29-12-2017	IRSE M.Tech, Sem-I	2 Weeks	IRSE 2016 Exam.
18001	15-01-2018	19-01-2018	Orientation	1 Week	IRSE (P) 2015 Exam.
Integrated Courses					
17102	11-09-2017	30-11-2017	Integrated	12 Weeks	Gr.B officers
17103	11-12-2017	01-03-2018	Integrated	12 Weeks	Gr.B officers
Sr. Professional Courses					
17203	11-09-2017	13-10-2017	Sr.Prof (P.Way)	5 Weeks	JAG-SS officers with minimum 6 years of Service in Gr.'A'
17204	11-12-2017	12-01-2018	Sr.Prof (Br &General)	5 Weeks	JAG-SS officers with minimum 6 years of Service in Gr.'A'
PCE-HAG-SAG-Seminars-Workshops-Meetings					
17310	07-12-2017	08-12-2017	CBEs' Seminar	2 days	CBEs
17311	05-10-2017	06-10-2017	PCEs' Seminar	2 days	PCEs
17312	31-10-2017	01-11-2017	IRICEN Day Seminar	2 days	IRSE 91' Batch
17313	28-12-2017	29-12-2017	Workshop on PPP&EPC	2 days	HAG-SAG of Civil Engg. & Accounts
Special Courses (Track-Bridges-Works)					
17426	20-11-2017	01-12-2017	**PSC & Steel Structure including crane working**	2 Weeks	JS-SS-JAG Officers
17429	25-09-2017	06-10-2017	Contracts & arbitration and Project Management	2 Weeks	SS-JAG Officers
17430	03-10-2017	07-10-2017	Points & Xings and Yards	1 Week	JS-SS-JAG Officers
17431	11-12-2017	15-12-2017	Special course for NTPC Engineers on Rly Sidings	1 Week	NTPC Engineers
17432	06-11-2017	17-11-2017	Mechanised Track Maint & Renewals, RG, USFD & TMo	2 Weeks	JS-SS-JAG Officers
17433	18-12-2017	23-12-2017	Rail Wheel Interaction & derailments	6 days	JS-SS-JAG-SG of OL

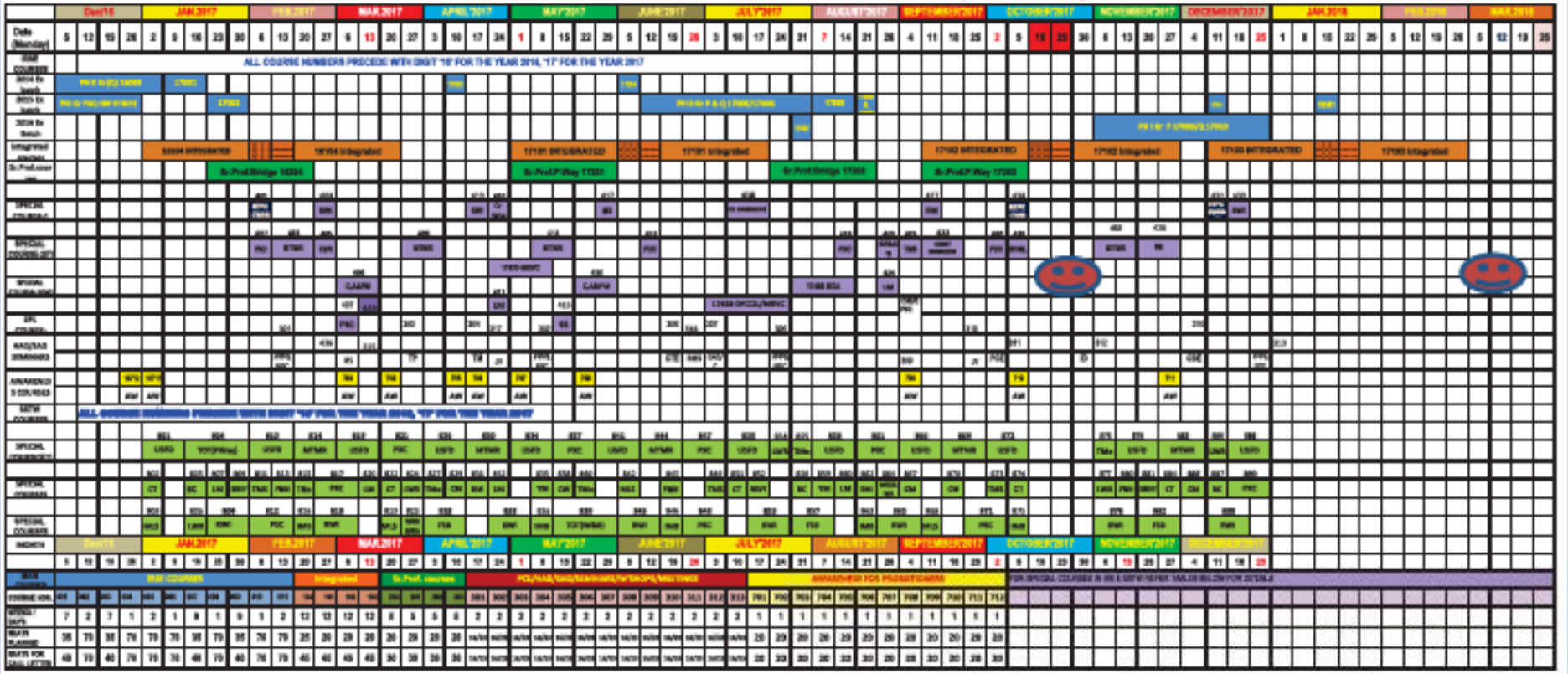
17434	09-10-2017	13-10-2017	Special course for NTPC Engineers on Track & Br.Maint.	1 Week	NTPC Engineers
17439	09-10-2017	13-10-2017	Special Course for, RVNL Officers of middle management level	1 Week	RVNL Officers of middle management level
Awareness Courses					
17710	09-10-2017	13-10-2017	Awareness course For IRSME	1 Week	Prob of IRSME
17711	27-11-2017	01-12-2017	Awareness course	1 Week	Prob of other Dept
IRICEN SSTW (Sr. Supervisors Training Wing) Courses					
17872	03-10-2017	13-10-2017	USFD, Welding & Rail Grinding	2 Weeks	SSE-P.Way
17873	03-10-2017	06-10-2017	Track Management System	1 Week	SSE-P.Way
17874	09-10-2017	13-10-2017	Concrete Technology	1 Week	SSE-Works
17875	09-10-2017	13-10-2017	Insp.& Maint. of Bridges	1 Week	SSE-Works
17876	06-11-2017	09-11-2017	Track Monitoring	1 Week	SSE-P.Way
17877	06-11-2017	10-11-2017	Long Welded Rail	1 Week	SSE-P.Way
17878	06-11-2017	16-11-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE-P.Way & Inst. of ZRTI & DTI
17879	13-11-2017	23-11-2017	USFD, Welding & Rail Grinding	2 Weeks	SSE-P.Way
17880	13-11-2017	17-11-2017	Formation	1 Week	SSE-Works
17881	20-11-2017	24-11-2017	Survey	1 Week	SSE-Works
17882	20-11-2017	28-11-2017	Fabrication of Steel Bridges	9 Days	SSE-Bridge
17883	27-11-2017	07-12-2017	Mech.Track Maintenance & Renewals	2 Weeks	SSE-P.Way
17884	27-11-2017	30-11-2017	Concrete Technology	1 Week	SSE-Works
17885	04-12-2017	08-12-2017	Contract Management	1 Week	SSE-Works
17886	11-12-2017	15-12-2017	Long Welded Rail	1 Week	SSE-P.Way
17887	11-12-2017	14-12-2017	Building Construction	1 Week	SSE-Works
17888	11-12-2017	21-12-2017	Rail Wheel Interaction & Derailment Investigation	2 Weeks	SSE-P.Way & Inst. of ZRTI & DTI
17889	18-12-2017	28-12-2017	USFD, Welding & Rail Grinding	2 Weeks	SSE-P.Way
17890	18-12-2017	27-12-2017	Points, Xings & curves	2 Weeks	SSE-P.Way

Group Photo of IRSE Probationers (2014 batch) with
Hon'ble Shri Pranab Mukherjee,
President of India at Rashtrapati Bhavan, New Delhi





CALENDAR OF COURSES 2017 (REV. 09)



Sr.	Start date	End date	Details	Levels	Eligibility	CE	AED
201	16/01/2017	21/01/2017	Workshop on PPP&EPC(JA&SSC)	2/3	JA(SSE) of Civil Engg & allied	BPM	BPP
202	16/01/2017	19/01/2017	Workshop on PPP&EPC(HAG/SA)	2/3	HAG/SAG of Civil Engg & allied	BPP	BPM
203	16/01/2017	21/01/2017	Seminar for CE/TP	2/3	CE/TPs	TPI	BPM-II
204	23/01/2017	31/01/2017	CE/Bridges Seminar	2/3	CE/Brs	BPT-II	BPT-I
205	16/01/2017	19/01/2017	Workshop on PPP&EPC(JA&SSC)	2/3	JA(SSE) of Civil Engg & allied	BPM	CPI
206	16/01/2017	19/01/2017	CTEs' Seminar	2/3	CTEs	BPT-II	BPT-II
207	16/01/2017	17/01/2017	CAOs' Seminar	2/3	CAOs	BPP	BPM
208	23/01/2017	24/01/2017	CE(W)/CE(P)CEs' Seminar	2/3	CE(Works)/CE(P)Cs	BPM	BPP
209	31/01/2017	31/01/2017	Trg.Mgr/CQE' Seminar	2/3	CQE's/Pr.CTTCs	BPT-I	BPT-I
210	31/01/2017	31/01/2017	CBEs' Seminar	2/3	CBEs	BPM	BPM-II
211	30/01/2017	30/01/2017	PCEs' Seminar	2/3	PCEs	BPT-I	BPT-II
212	31/01/2017	02/02/2017	WCE/N Day Seminar	2/3	WCE/ WT Mahim	BPM	CPI
213	30/01/2017	03/02/2017	Workshop on PPP&EPC(HAG/SA)	2/3	HAG/SAG of Civil Engg & allied	CPI	BPM

Course code	Course name	Bhs	Kor	Mlv	Nas	Kor	Total	Days/course	Total weeks
OLF	Open Line Engineers	418					1	2	2
RWI	Rail Wheel Interaction & Derailments	404	413	421	430		4	1	4
TMS	TMS (T-5)	405	429				2	1	2
LM	Land Management	411	428				2	1	2
MTWR	Mechanised Track maint.& Renewal	403	406	414	430	432	5	2	10
PSC	Points, Kings & Curves	402	412	419	430		4	1	4
C,AM,PM	Contract, Arb/Mediation & Proj. Management	405	416	426			3	2	6
RFMDT	Rly Formation & Geo Tech investigation	420					1	1	1
PSCC	PSC Construction	407	427				2	2	4
SSC	Steel Bridge Fabrication	415	426				2	2	4
BDA	Bridge Design Assistant	405					1	2	2
CE	Construction Engineers	420					1	2	2
MS	Modern Surveying	417					1	1	1
CW	Sp course on Crane Working	410	426				2	1	2
NTPC	Special course for NTPC Engineers	401	407	424			3	1	3
							54		98

Course code	Course name	Bhs	Kor	Mlv	Nas	Kor	Mar	Pan	Ses	Pun	Ahm	Bar	Total	Days/course	Total weeks
TOT(P.Way)	Training of Trainers(P.Way)	504											1	2	2
CT	Concrete Technology	503	512	517	513	514							5	1	5
BC	Building Construction	508	509	507									3	1	3
TMe	Track Introducing	513	517	510	502	516							5	1	5
FMN	Formation	511	510	509									3	1	3
RWI	Rail Wheel Interaction & Derailment Inv.	508	510	505	511	503	506	509	502				9	2	18
LM	Land Management	507	511	512	502								4	1	4
SRVY	Survey	502	502	507									3	1	3
MLM	Management of Land & assets	503	511	510	504								4	1	4
PSC	Points, Kings & curves	517	511	517	517	501	502						6	2	12
PSCC	PSC Construction	513	510	511									3	2	6
FSB	Fabrication of Steel Structure	520	517	502									3	2	6
TMS	Track Management System	511	510	515									3	1	3
LWR	Long Welded Rail	504	514	504	517	506							5	1	5
GRT	GRT(Grinding & Rail Grinding)	501	512	513	503	514	512	505	504	503	510	505	10	2	14
BDS	Inspection&Maintenance of Bridges	513	520	510	503	513							5	1	5
MTWR	Mech.Track Maint. & Renewals	514	501	514	508	503							5	2	10
TOT(M&S)	Training of Trainers(M&S)	508											1	3	3
CM	Contract Management	503	507	505									3	1	3
RM	Building Maintenance	501	502										2	1	2
PM	Plant/Maintenance	508	503										2	1	2
CW	Safety at Sr. Workable &Crane Mtg	504	510										2	1	2
WSS&RM	Water Supply,Sewer & Water Audit	501	504										2	1	2
													80		121

Indicates a holiday to the week

Indicates Monday being holiday

1 Week at KSG for IOA course

To IRIMTE,Vadodara

MAHAVIDA PROJECT

Design at Kalyani Corporation, Pune - 30. Tel. 24486080