IRICEN Journal of Civil Engineering

ज्ञान ज्योति से मार्गदर्शन

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09-3X Dynamic Tamping Express (Made in India)
Under Make in India Initiative

Indian Railways Institute of Civil Engineering, Pune

ज्ञान ज्योति से मार्गदर्शन



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

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



OUR QUALITY POLICY

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



from director's desk

Dear Readers,

I wish all the readers of this journal and entire engineering fraternity a very Happy and Prosperous Samvatsar 2075.

I am happy to announce that from March 2018 edition onwards this journal will be published in e-format which is user friendly, easy to refer and eco friendly a lot.

60th IRICEN Day was celebrated with huge enthusiasm and fervour. This celebration was graced by Shri Mahesh Kumar Gupta, Member Engineering, Railway Board. He also facilitated the officers, who had excelled in various training programmes during last one year and officers of Silver jubilee, IRSE 1991, batch.

In this edition, papers on wide ranging topics are included. The contribution of papers from retired officers to share their knowledge and wisdom is laudable.

A few papers focus on track monitoring methodologies. One paper elaborates calculation of rail stresses on the concept of average track modulus. Another paper enlightens on concrete mix design and quality control in production of concrete. One interesting paper is on e-procurement on Indian Railways.

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

(A. K. Mishra)
Director

Pune
April 2018

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Guidelines to contributors

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

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

Railways Inducts New Machine 09-3x Dynamic Tamping Express for Improved Mechanised Track Maintenance



Indian Railway has inducted three numbers of 09-3X Dynamic Tamping Express machines, the state of the art integrated track maintenance. These machines were inaugurated and flagged off by Shri M.K. Gupta, Member Engineering, Railway Board at Faridabad.



Seven number of such machines are planned to be procured and inducted within next six months in the present fleet of 874 track maintenance machines over IR for deployment on heavy density Routes.

The New 09-3X- Dynamic Tamping Express costing about 27 Crore each is a latest high output integrated tamping machine having multiple functions, so far being carried out by different machines. It can measure pre & post track geometry, correct the track to required geometry, can tamp three sleepers simultaneously, stabilize and measure post tamping track parameters under load to ensure quality of work done. This eliminates the need for a separate stabilisation machine which reduces operating costs and track possession time. This machine will vibrate & compact the loose stone ballast after tamping for safe movements of trains. These machines have been manufactured in India under MAKE IN INDIA initiative with imported components. 42 more such machines have been planned to be included in Indian Railway maintenance fleet over next three years. This will further improve the safety, reliability and economy in maintenance of tracks over Indian Railways. This will also eliminate manual measurement of track quality after maintenance.

Three operations including manual interface is now combined in one machine.



For practical hands-on training to operate such advanced track maintenance machines a new 3D state-of-the-art tamping simulator has been installed and commissioned at Indian Railway Track Machine Training Centre Allahabad (IRTMTC) recently. This type of advanced technology simulator is presently available only in five countries including India. India Railway has planned complete mechanisation of inspection, monitoring, relaying and maintenance of track by 2024.



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

Green Clearance must for Rail Projects on Forest Land: MoEF & CC

Railway projects passing through forest lands, national parks and eco-sensitive zones will not be exempted from the forest clearance process, the Ministry of Environment, Forest and Climate Change (MoEF&CC) told the Railways Ministry and state forest departments. The Environment Ministry's clarification on the matter comes after the Railways had argued that Railways Act, 1989, gives it the power to acquire land, including forests, falling in its right of way. MoEF&CC clarified its position on the issue after referring the matter to the Ministry of Law and Justice, who seconded the Environment Ministry's opinion.

The MoEF&CC told Railways, that as per the Law Ministry, despite provisions of the Railways Act, 1989, allowing Railways to acquire any land for its projects, forest land falling in the right of way attract provisions of the Forest Conservation Act, 1980. MoEF&CC added that even if the forest land is under the possession of the Railways, it will need to seek forest clearance for non-forestry work. Further, projects passing through protected areas would need the approval of the National Board for Wildlife.

"Railway projects passing through wildlife sanctuaries, national parks, and tiger reserves amount to destruction of habitat within the meaning of various sections of Wildlife Protection Act, 1972. The need of seeking approval for railway projects passing through a wildlife sanctuary is in pursuance of Supreme Court order of 2002," the MoEF&CC said.

The Railways had raised the issue of applicability of Forest Conservation Act, 1980, and Wildlife Protection Act, 1972, for its projects citing the upcoming conversion of Akola-Khandwa railway line from metre gauge to broad gauge. The railway line passes through a reserve forest, Wan sanctuary and the Melghat Tiger Reserve in Maharashtra. Of the 176-km track, 40 km passes through forested areas and of that 18 km lies inside the tiger reserve. According to government documents, the project would require diversion of 160.94 hectares of forest from the critical tiger habitat of Wan Sanctuary, a part of Melghat Tiger Reserve.

Overruled

The Railways had argued that Railways Act, 1989, gives it the power to acquire land, including forests, falling in its right of way. MoEF&CC clarified that Railway projects passing through forest land, national parks, eco-sensitive zones will not be exempted from forest clearance process.

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

Indian Railways to Launch Android/iOS App to Maintain Online Records of Inspections

All records of inspections conducted by the railways will now be maintained online through an App exclusively developed for the purpose.

The "E-inspection App", which will be launched on the Android and iOS platforms later this week, will make the records of all the inspection activities online, especially those pertaining to safety and passenger amenities.

This would be for all types of major inspections carried out periodically by the railway staff, which include track inspections, running-room inspections, station inspections, train inspections, coaching stock inspections etc., officials said.

"This will do away with many shortcomings in the manual way of inspection reporting and record keeping," the railways said today.

The App can be installed by all the stakeholders concerned in their mobile phones or computers. It would ensure a speedy reporting and help send instant alerts to the field via text messages or e-mail for timely corrective measures, officials said.

The other advantages of the app include real-time tracking, data mining, analytics, transparency and ensuring the availability of data across organisations.

"It will be a proper checklist for inspections, development of scorecard to digitise the trends, prioritise the issues on a fact-based analysis, availability of historical data prior to inspection," an official said.

The app will have an in-built software, which will generate various graphs and analytical data automatically. It will also have an option of reporting a matter through actual photographs taken at the time of inspection.

While the App will be formally launched in the Delhi Division this week, it will be extended all over the country in a month's time.

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

CCTV Cameras in Locomotives to Track Loco Pilots

For the first time ever, Southern Railway has installed CCTV cameras in a WAP 7 locomotive to monitor loco pilots during train operation. Highly placed sources told that as a pilot project, two CCTV cameras and voice recorders have been installed on a WAP 7, a third generation passenger locomotive, a month ago at Royapuram AC Electric Loco shed.

"Initially, the surveillance cameras will record the tracks and a portion of the cabin. A voice recorder has also been installed in the loco cabin. The loco will be monitored closely for three months on parameters such as loco pilot behaviour, difficulties in navigating the operating tools and troubleshooting process. If it works well, it would be replicated in more locomotives. Passenger train locos will be given top priority," said an official.

Sources said installing CCTV cams were part of the recommendations made by a task force in June this year. The panel was constituted to improve the safety of train operation in the wake of repeated rail accidents.

"Monitoring the loco pilots is essential for safe operation of trains. It has been found that a majority of safety violations, including signal jumping, derailment and non-adherence to speed restrictions happen mostly when drivers are taking calls on their mobile phones. Now, they will exercise more vigil while on duty," the official said.

Predictably, the loco pilots association is upset. The cams, it said, would only put the loco pilots under pressure and not improve rail safety.

All India Loco Running Staff Association general secretary V Balachandran said removing loco pilots from service for jumping the red light has not reduced train accidents in any part of the country. "Railways should install cell phone jammer at loco cabins, besides providing train protection warning system, a technology that stops the train automatically if the loco crosses the red light. Also, the location of brakes, accelerator and monitoring screen should be standardised and kept in the same location in all types of locomotives," he said.

At least 10 drivers have been removed from service in Southern Railway in the last two years for jumping red lights. There are about 4,600 drivers working in six divisions of Southern Railway. Of them, more than 15 percent of loco pilots were involved in safety violations, said sources. The railway passengers association welcomed the move and urged railways to install CCTVs in all locos as early as possible.

T Mohammed Mubeen, a member of the divisional rail users consultative committee (DRUCC), Chennai division, said unlike buses, flights and trucks, trains carry more than 2,500 passengers in one go. "Hence, it is essential to monitor loco pilots for the safety of passengers. Railways should install CCTV cameras at the earliest," he said.

According to official records, Arakkonam AC electrical loco shed is one of oldest loco sheds in the country housing about 130 freight electrical locos, while Erode and Royapuram totally hold about 270 passenger locomotives of several types including WAP 4 and WAP 7.

Tiruchy Diesel Loco Shed, one of the premier sheds of Southern Railway accommodates around 130 locomotives of different types. Around 350 locomotives are maintained at Tondairpet, Erode and Ernakulam Diesel Loco Sheds.

In August 2017, Vellore JM Court awarded 10 years imprisonment and imposed penalty on a 47-year-old motorman for causing an accident near Arakkonam in 2011 in which 12 passengers died and 86 were injured. He was found guilty of talking over mobile phone when the tragedy occurred.

Pilots want sound-proof, air-conditioned cabins

The All India Loco Running Staff Association has urged the Railways to fulfil their long-pending demands, including sound-proof, air-conditioned cabins and toilets for pilots

In a memorandum sent to the Railway Board, the association said high noise levels inside the cabins had caused hearing loss to thousands of loco pilots and assistant loco pilots after retirement. "Hearing level of many loco pilots has come down even before the age of 45," alleged the association's south zone general secretary V Balachandran.

The control cabinets of the LHB power generator are noise proof and such provision should also be made for locomotives, he

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

तभी बोलो जब वो मौन से बेहतर हो.

महात्मा गाँधी

Indian Railways to Increase Efficiency via Skill-Based Training in Core Sectors

"Indian Railways has decided to send its staff members for "skill-based training" to enhance their productivity and efficiency levels.

Under the direction of Minister of Railways & Coal, Shri Piyush Goyal, a comprehensive plan for imparting training to all employees of Indian Railways is being prepared with a view to upgrade skill & knowledge. This comprehensive training programme named as Project Saksham will help boost productivity and efficiency.

The massive exercise for all its employees – Project Saksham – will continue for the next one year. Employees in each zone will be put through a week's training in skills and knowledge relevant to their work area.

In a letter to the zonal General Managers on October 30, Railway Board Chairman AshwaniLohani emphasised that "there is a need to do a concentrated capsule of training for all employees in a short period of time to boost their efficiency".

Under this plan, all employees in each zone will be put through a week's training in skills and knowledge relevant to their work area over next one year. A communication to this effect from Chairman Railway Board, Shri Ashwani Lohani, has been sent to all General Managers of zonal railways and railways production unit.

With the growing rail network, new trains, different high-quality services, the growing expectation of passengers for better amenities and services – and the promise of the government to deliver superior and safe rail travel — there is a need to rise to the occasion to deliver the promise, Lohani said.

"While continuous learning and educational training has been an integral philosophy and approach of the Railways, there is need to do a concentrated capsule of training for all employees in a short period of time to boost their productivity and efficiency.

"So it has been decided that all employees in each zone will be put through a week's training in skills and knowledge relevant to their work area over next one year," Lohani said. He also asked the General

Managers to ensure that the training requirement is quickly identified for each category of employee in their specific zones and asked them to formulate a schedule by December 31, 2017.

"The training shall be a five-day-on-the-job or classroom training in railway training centres depending on the nature of the training," he said.

Lohani also asked the General Managers to ensure that the reporting managers of all employees are actively involved in the training processes and the focus should be on "making a difference" on the job.

He instructed the General Managers to complete the training within nine months and asked them to personally monitor progress by devising metrics to ascertain the impact of the Project Saksham.

Following the stampede at the Elphinstone Station in Mumbai on September 29, in which 23 people were killed and over 150 injured, Railway Minister Piyush Goyal had announced a series of steps, including decentralisation of power, to carry out safety-related work.

On October 25, the Railways said that General Managers had been given full powers to sanction out-of-turn safety-related work without any ceiling "within the financial limit set out by Ministry of Finance".

The Divisional Railway Managers (DRMs) and Chief Workshop Managers can now re-engage retired railway employees up to 62 years to take care of safety and maintenance related work wherever there are vacancies.

Enhanced powers for repairs of track machines were also given to the field officers for faster track safety work.

The Railways had substantially simplified the procedures for procurement of material like spare parts for locomotives, coaches and the like.

Junior field officers and supervisors in charge have been provided multi-utility vehicles and may hire vehicles for up to Rs.5,000 per case for rushing to breakdown sites without loss of time. This will lead to faster restoration of train services and improve punctuality/safety of trains.

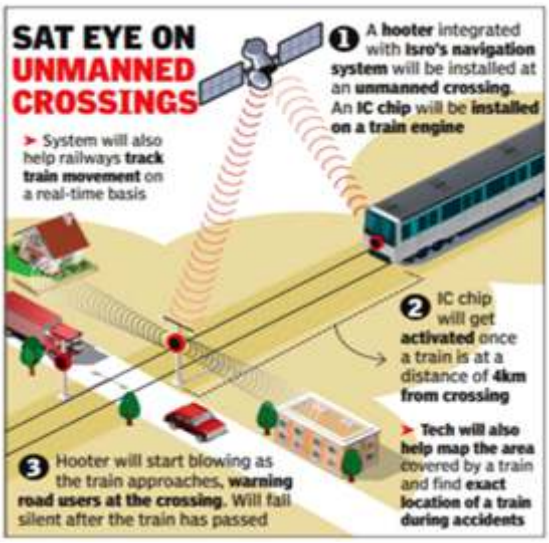
DRMs were also given full powers to undertake projects on Build Own Operate Transfer (BOOT) basis like setting up of laundries and to enter into Annual Maintenance Contracts (AMCs) for critical equipment with the OEMs to ensure uninterrupted services.

Meanwhile, Station Directors in large stations had been given the powers of the Branch Officers in the divisions to enable them to take decisions for smooth operations. Instructions were issued to post young and dynamic officers as Station Directors at 75 important stations.

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

उठो जागो और तब तक मत रुको
जब तक लक्ष्य की प्राप्ति न हो जाए
स्वामी विवेकानंद

Railways using ISRO Tech to Avoid at Accidents Unmanned Crossings



Indian Space Research Organisation (ISRO) is helping the Indian Railways use its satellite-based system to check accidents at unmanned railway crossings and track train movements on a real-time basis.

Working on a pilot project with Isro, the railways has installed space agency-developed integrated circuit (IC) chips on some train engines. The Indian Regional Navigation Satellite System (or NaVIC) will be used to warn road users of approaching trains through hooters installed at unmanned road crossings. TapanMisra, director of Ahmedabad-based Space Applications Centre (SAC), confirmed that "ISRO and the Indian Railways have been working together on this pilot project since June". Explaining the functioning of the satellite-based system, Misra said, "A hooter will be activated as soon as it gets signal from the IC chip installed on a train when its engine is at a distance of 500 metres to 4 km from the crossing. The hooter, linked to the navigation system, will thus warn road users about the approaching train. It will become louder as the train comes near the crossing and will fall silent after the train has passed." The SAC director said, "Under the pilot project, IC chips have been installed on five engines of trains on different routes. The testing on the satellite-based hooter system has been going on since June to check if it is reliable and can function under different climatic conditions."

He said, "ISRO is using its constellation of seven navigation satellites (IRNSS or NaVIC) for the railway safety system as the technology, once the pilot project is over successfully, will be installed on all trains across the country in phased manner."

Misra said, "The satellite-based system will also be used for tracking trains for disseminating information about their movement on a real-time basis." He said, "The system will also help the railways map the area covered by trains. The technology will come in handy at the time of a railway accident when it can be used to ascertain the exact location of a train."

The push for using the space technology for the railway safety system came after PM Narendra Modi, during a national meet on September 7, 2015, asked all central ministries and state governments to make the most of the ISRO technology to provide good governance.Safety at unmanned level crossings is a cause for concern for the railways as these crossings witness maximum accidents. The national transporter had explored various ways to address the issue before settling for the Isro system. There are about 7,254 unmanned railway crossings in the country which account for around 40% of accidents involving the railways. There are about 18,000 manned level crossings.

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

No Shortage of Fund in Railways for Projects Related to Passengers Safety: Piyush Goyal

Rail Minister Piyush Goyal said that there is no shortage of fund in railways for projects related to passengers' safety and security. The rail minister said that PM Narendra Modi and Finance Minister ArunJaitley has given railways full liberty to use funds on safety. He said that General Managers have been given full powers to sanction out of turn safety related works without any ceiling.

Addressing a press conference, the rail minister said that procedures have been substantially simplified for procurement of material in the Railways. Piyush Goyal told the media that the government is doing transformational changes in the Railways and for faster implementation, those changes will have a defined time span. He said that in every rail division now there would be two ADRMs instead of one to ensure a smooth operation. The railway will categorise its station on the basis of passenger footfall and will accordingly increase the facilities at these stations. For the benefit of specially-abled and senior citizens, the railway has identified 3000 spots where escalators would be built. The railway has decided to increase the number of CCTVs across trains and stations.He especially took the name of Mumbai rail network, one of the biggest suburban rail networks in the country for this purpose.

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

Glimpses of IRICEN Day










भारतीय रेल सिविल इंजीनियरिंग संस्थान, पुणे
60 वां इरिसेन दिवस






IRICEN

Concept of Average Track Modulus for Rail Stresses Calculations

By

Ramesh Pinjani*

Synopsis: *The present RDSO method for calculation of bending stress in rail is based on double track modulus, i.e. it involves 2 values of track modulus namely value for initial 4 t load & for balance wheel load (elastic load). Since characteristic length & bending moment depends upon the value of track modulus, therefore the BM is to be calculated twice based on initial track modulus value & for elastic load value, this makes the calculations unnecessary lengthy & complex.*

In real time the total wheel load moving over the track acts instantaneously and it is not applied in 2 parts i.e. initial load 4t and balance elastic load. It is also a fact that the response of track is different for first 4t and balance wheel load (based on RDSO studies). Therefore the response of track can be averaged out by considering the effect/deflection for first 4t and balance elastic load. This paper deals with method of calculating BM based on concept of average track modulus.

1. General:

Track modulus (U) is defined as load per unit length of track, required to cause unit deflection in track. Vide 76th TSC Jan 2006, item No. 1078, the following values of track modulus (U) have been approved.

Sleeper density in Nos/km	Track module in kg/cm/cm	
	Initial (4t load)	Elastic load (beyond 4T load)
1540	125	425
1660	135	540

Based on theory of "Rail supported on elastic foundation": The Characteristic length is worked out by formulae $\left(\frac{4EI}{U}\right)^{0.25}$

The bending moment at any point, distance x from the wheel load is worked out as under

$BM_x = (QL/4)\, e^{-x/l}\, (\text{Cos } x/L - \text{Sin } x/L)$

2. Existing RDSO method:

1. Since there are 2 values of track modulus, to work out $B.M_x$ at any point, requires calculations as under:

i) L_i (Characteristic length for initial 4 t load) = $\left(\frac{4EI}{U_i}\right)^{0.25}$

Than $BM_i = \left(\frac{Q_i' L_i}{4}\right)\left(e^{-\left(\frac{x}{Li}\right)}\ (Cosx/L_i - Sinx/L_i)\right)$

where Q_i^1 is net wheel load, considering effect of adjacent wheel loads on the same bogie/wagon/coach within 1.25 Π L_i distance

ii) $L_e = \left(\frac{4EI}{Ue}\right)^{0.25}$ for balance wheel load (Q_e) i.e. total wheel load including impact effect - 4 t

$BM_e = \left(\frac{Q_e' L_e}{4}\right)\left(e^{-\left(\frac{x}{Le}\right)}\ (Cosx/L_e - Sinx/L_e)\right)$

where Q'_e is net balance wheel load, considering effect of adjacent wheel loads on the same bogie / wagon / coach within 1.25 Π Le distance

Total $BM = BM_i + BM_e$

3. Proposed method based on average track modulus:

It is suggested to calculate BM based on average track modulus as under –

Suppose the axle load is 25t and dynamic factor is say 0.6

So total wheel load = $25(1 + 0.6)/2) =$ $20\ t$

S.D = 1660 therefore $U_i = 135$ $U_e = 540$

$U_i = 135$ means for initial 4t load track modulus is 135 kg/cm/cm

Step- 1 Calculation of Average track modulus:

Suppose wheel load acts on cm length of track

U_i=135 kg/cm

135 kg/cm is required for 1 cm deflection

1 kg/cm is required for $1/135$ cm deflection

4t/a will cause deflection = $d_i = \frac{4t}{135\ a} = \left(\frac{Qi}{Ui}\right)$

U_e = 540 kg/cm/cm

Balance elastic wheel load = 20t – 4 t = 16 t

540 kg/cm is required for 1 cm of deflection

1kg/cm is required for = 1/540 cm deflection

16 t/ a will cause deflection $de = (16\text{ t} /540\text{ a}) = (Q_t - Q_i)/U_e$

Total deflection = $\frac{Qi}{Ui} + \frac{(Qt - Qi)}{Ue}$

In this particular example

Total deflection = 4000/(135 a) + 16000/ (540 a)

= 29.62 + 29.62/ a = 59.26/a cm

Therefore (59.26/a) cm deflection takes place due to load intensity of 20t / a

1 cm deflection requires ⇒ load intensity per unit length / total deflection

⇒ (20000 kg/ a) / (59.26/a) cm = 337 kg/cm/cm

$\Rightarrow U_{av} = \left(\frac{Qt}{4/Ui + (Qt - Qi)/Ue}\right) \Rightarrow$ 20 000 kg / 59.26 cm

= 337 kg/cm/cm

*Sr Prof. / Bridges -2 IRICEN

Step-2: Calculation of Characteristic Length (L_{av})& B.M

i) $L_{av} = \left(\frac{4EI}{U_{av}}\right)^{0.25}$ &

ii) $BM_t = \left(\frac{Q_t L_{av}}{4}\right) e^{-\left(\frac{x}{Lav}\right)} \left(Cosx/L_{av} - Sinx/L_{av}\right)$

Where Q_t is net wheel load, after considering effect of other wheels within 1.25 L_{av}

4. Calculations of maximum BM by proposed & existing RDSO method

a) Based on average track modulus

Axle load – 25t, Dynamic factor = 60%

Wheel load = $\frac{25 \times 1.6}{2} = 20t$

SD = Suppose 1660, Rail = 52 kg

Uav = 337 kg/cm/cm,M. I= *1942.2*

$L_{av} = \left(\frac{4EI}{Uav}\right)^{0.25} = \left(\frac{4 \times 2.11 \times 10^6 \times 1942.2}{337}\right)^{0.25} = 83.5\ cm$

Effect of adjacent wheels within distance of 1.25 Π L_{av} = 1.25 x3.14 x 83.5 cm = 3.27m

Suppose Bogies with 3 axles have configuration as under

	WHEEL-1	WHEEL-2	WHEEL-3	WHEEL-4	WHEEL-5	WHEEL-6
INTER SPACING	170.2				170.2	
		210.8		210.8		
			521.4			
DISTANCE FROM WHEEL-1	0	170.2	381	902.4	1113.2	1283.4

Therefore only one adjacent wheel 2 @ 170.2 cm will affect the leading wheel 1, the effect will be by factor

$e^{-\left(\frac{x}{Lav}\right)} \left(Cosx/L_{av} - Sinx/L_{av}\right)$

For L_{av} = 83.5 cm & x as 170.2 cm the above factor works out as (–) o.17

Considering 10% extra for leading wheel effect the maximum BM works out as

$Netwheelload = 1.10 \times 20 \times (1 - 0.17) = 18.26t$

Maximum BM = $\left(\frac{Q_t L_{av}}{4}\right)$ =18.26 X 83.5 /4 =381 ton-cm

b) Based on Existing RDSO method:

The maximum value of bending moment calculated based on existing RDSO method is as briefly indicated as under:

Load	U	L	1.25 L	Net Wheel Load	With Leading Effect	BM	Total BM
4t	135	104.97	412cm	3.24	3.57	93.59	396 t-cm
16t	540	74.23	291cm	14.83	16.31	302	

It is seen that in this particular case the % difference between existing RDSO method & based on average track modulus is 3.8%

5. Average Track modulus for different SD & Wheel load:

Based on the above logic/ concept the value of U_{av} for Q_t i.e. total wheel load including dynamic augment for 20 t to 50 t @ interval of 5t for S.D value of 1540 & 1660 is worked out using excel sheet, which is placed here under

Total wheel load↔ S.D↓	20t	25t	30t	35t	40t	45t	50t
1540	287	307	322	334	343	350	357
1660	337	365	386	402	415	426	435

Suggestions:

(i) In real time the total wheel load moving over the track acts instantaneously and it is not applied in 2 parts i.e. initial load 4t and balance elastic load = total load – 4t. It is also a fact that the response of track is different for first 4t and balance wheel load (based on RDSO studies). Therefore the response of track can be averaged out by considering the effect/deflection for first 4t and balance load.

Accordingly, working out of characteristic length and maximum bending moment based on average response/track modulus appears to be more realistic approach and it also makes the calculation procedure simplified.

Therefore average track modulus as worked out in para-3 step-1, i.e.

$U_{av} = \left(\frac{Qt}{4/Ui + (Qt - Qi)/Ue}\right)$ can be used for calculations for bending stresses in rail.

(I) There is a need to consider/work out track response (track modulus) for varying formation and ballast conditions, as the track response depends upon physical condition of track components. RDSO can take up necessary studies/trials by involving IITs or by creating instrumented track.

Track Monitoring System on Indian Railways Need for a Complete Overhaul

By
J.S. Mundrey*

Synopsis

Indian Railways with its long history of over 150 years has a well established system of Track Inspection and Monitoring. The System heavily relies on its Manual Input, although it is being supplemented with the outcome obtained from Track Recording Cars, Rail Flaw detectors, OMS etc. With the increased traffic density and higher operational speed, the present system is failing to provide the necessary safeguards, as reflected in the increased number of Derailments occurring on Track account. It is also responsible for causing heavy casualties among Track Men, while they are patrolling the Track in an unprotected environment.

German Railways, with a similar Track Structure, as on IR, did not have any accident on Track Account in the last 10 years. This has been possible by exercising better quality control during Track Laying and by switching over to Mechanised Track Monitoring System. The paper analysis the problems being faced by Indian Railways, and the methodology of Track Monitoring as adopted on German Railways. It also suggests the steps that are required to be taken by I.R. for improving their Track construction & Maintenance Standards, before they can switch over to Mechanised Monitoring System, in the form, now prevalent on the Advanced Rail Networks.

1. Introduction:

Track Structure & Track Monitoring System on Indian Railways. With a history of over 150 years, Indian Railways have been continuously evolving their Track Structure, its Maintenance and Monitoring System to meet the challenges of change. The changes have been occurring in respect to, heavier axle loads, higher speeds, and increased traffic density. Till the middle of the last century, although the Track Structure on Indian Railway consisted of comparatively lighter rails of 90 pounds, laid as single rails of 13 Metre length, on wooden /cast iron/steel sleepers, there was hardly any accident related to Track deficiencies. The frequency of Track Inspections, right from Key Man to the higher levels, was well tuned to ensure the safety & integrity of Track.

The situation however started changing from 1960 onward. To meet the increased demands of Goods and Passenger traffic, higher axle load wagons were introduced, diesel / electric traction adopted in a big way, and additional passenger trains introduced. They not only caused additional strain on Track, but also reduced the availability of time needed for Track Maintenance and Track Inspection, considerably.

Over the years although many important steps have been taken to strengthen the Track Structure (Heavier higher UTS, Long Welded rails laid on Concrete Sleepers) and the Track Monitoring System has been strengthened, they have not been able to match the onslaught of heavier axles loads, greater traffic density and high speed operation.

The recent spate of derailments causing loss of many precious lives, attributed to the deficiencies in Track, have posed a big question mark on the present system of Track Inspections/ Track Monitoring, on Indian Railways.

2. Present Day, Track Inspection and Monitoring System on Indian Railways.

Broadly the Track Inspection and Track Monitoring System On Indian Railways have the following constituents.

- Key-man daily patrol, Gang Patrolling during abnormal rainfall, night Patrolling during Monsoon, Security Patrolling, Hot Weather Patrolling of LWR ,Early morning Patrolling to detect Rail /Weld fractures, Stationary Watchmen at Vulnerable Locations.
- Push Trolley /Motor Trolley Inspection by Permanent Way Inspectors and officials at higher levels
- Footplate/Rear window Inspections.

Track Conditions are also monitored through Track Recording Cars, OMS, and Rail Profile Measuring Equipment.

A large fleet of Rail Flaw Detecting equipment have been deployed to weed out defective rails and Welds.

Manual Patrolling and Trolley Inspections are anachronistic at the present level of railway operation, and in prevailing socio economic environment. It is inhuman to expect the Gang man to get up at midnight hours in extreme cold weather conditions and, patrol the track to find out if any Rail/Weld fracture has occurred and make him answerable if he failed to detect.

The very fact that on an average one track man gets

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killed every day on IR Tracks While Patrolling brings out the dangerous situations to which, the Track Men are exposed to.

High incidence of track defects in service, some of the them leading to dangerous consequences, indicate that Track Monitoring System on Indian Railways is in a dire need of a major overhaul.



Fig No. 1 Key Man Patrolling on Indian Railway (an Unprotected Environment)

3. Track Monitoring System on Advanced Railways (German Railways)

On German Railways, the Track Standards are generally the same as have been adopted on Indian Railways. But there has been NO fatal Derailment on Track Account in the last decade or so. The Inspection / Monitoring System as adopted on German Railways consist of:

· **Foot Inspection by Track Team Leader,** the frequency of Inspection varies from 2 months to 12 months depending upon the permitted speed on the line. With the high speed operation these foot Inspections are replaced by Inspection journeys by Motorised Cars.

· **Track Recording Cars.** They measure all the important track Geometry parameters having a frequency of Two to Eighteen months depending upon the permissible speed on the line.

▪ **Ultrasonic Rail testing Trains also equipped with Eddy current measurement system**. The Inspection frequency depends upon the need of the line. Although internal Rail flaws have come down considerably with the installation of sophisticated Flaw detection equipment at the Rail Rolling Mills, the incidence of rail surface and gauge corner defects have increased, on account of more aggressive rail/wheel interactions .More frequent Rail Grinding is therefore resorted to.

· **Ground Penetrating Radar**. Track Sub-Structure is being completely mapped with the help of Ground Penetrating Radars. This is becoming very useful in proper diagnosis of Track Geometry Defects.



Fig No. 2 - Ground Penetrating Radars

Geo Rail Xpress measuring system, the latest track monitoring system as adopted by German Railways, combines all the functions hitherto being performed by Track Recording Cars, Ground Penetrating Radar and Visual Inspections. With powerful digital cameras it automatically checks the defects in Rail running surfaces, sleepers and the Track Fastenings. Geo Rail Xpress, has made the foot Inspection System quite redundant, all information about track integrity and Track Geometry, being available at the desk top, of the railway officials.

One can not find any maintenance staff on track, during Train Operation, all Track Maintenance activities carried out in the Nominated Track possession time, and In a planned manner.



Fig No. 3 - Geo- Rail Xpress – Track Recording Car on German Railway

• **Monitoring of Turnouts**. European Railways are increasingly adopting electronic Recording system for

monitoring Turnouts conditions. One such System is VA Road master 2000.

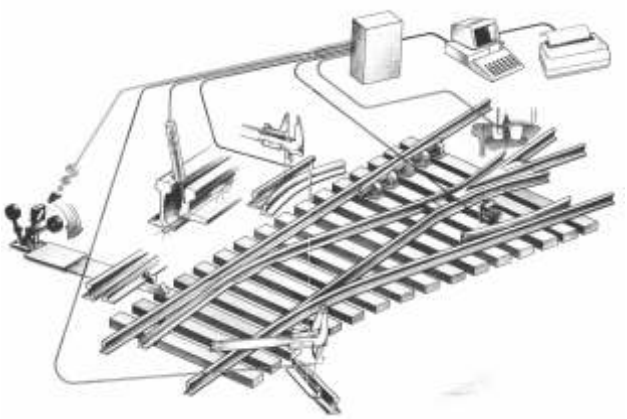


Fig No. 4 - Road master 2000.

In this System measuring values at critical locations of Turnouts are obtained by electronic measuring methods and recorded via specially designed sensor. Measurements are recorded, with respect to:

- Working of the switch setting mechanism,
- Condition of the switch rails
- Condition at the Crossing,
- Measurement of critical clearances
- Bolting conditions at important locations.

A computer system is used for the acquisition of digital and analogies data. The measurements are fed into a graphic system. When the limiting values are exceeded, an alarm is activated. A well planned maintenance operation to rectify the defect is then undertaken.

· **Measurement of Track Stiffness.:** The abrupt changes in track Stiffness are encountered at approaches to Bridges, Level Crossings and at Turnouts, on account of changes in ground conditions/track Structure. Dynamic Simulation Modelling of the Bridge approaches indicate that a combination of Stiffness change and running surface defects can generate dynamic loads two to three times the static loads at normal train speeds. They can become dangerous at high speeds. Fig. No. 5a & 5b

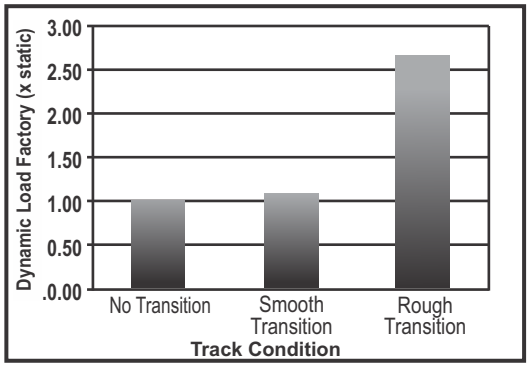


Fig No.5a - Track Stiffness Profile

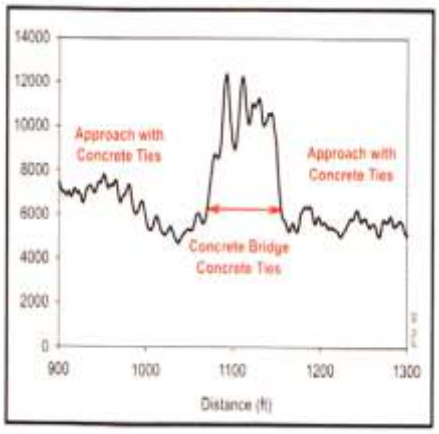


Fig No. 5b Dynamic Load Factor

Periodic measurement of Track Stiffness is carried out and where abrupt changes are noticed, measures to achieve acceptable stiffness gradient are taken. For that purpose Track Recording Cars are equipped with Stiffness measuring equipment.

· **Train Speed Control During Heavy Rains**

The railway lines are classified into different zones depending upon the vulnerability of the zone under different rainfall conditions. Speed restrictions are imposed when rainfall per hour exceeds predetermined threshold values.For example on JNR the limit values of rainfall are as under:

Conditions for trains to be stopped.:

Trains are stopped when the rainfall per hour exceeds 50 mm or when the continuing rainfall in a day exceeds 150 mm with an hourly rate of more than 40 mm. Trains are also stopped when the water level of a river comes to a dangerous height. After train stops, the first train runs at the speed of 70km / hour. On this train, PWI travels with the driver to inspect the Track.

Speed restrictions at various levels are imposed based on the vulnerability index of each of the section under various intensity of rainfall.

Customised Monitoring Systems have now been developed to detect motion that may occur in Railway Structures and adjacent features. Timely warnings can be given to control train movements, if any dangerous situation is like to occur.

Manual patrolling of track during rainy season is thus no longer required.

· **Deployment of Track Safe Release (RAIL SCAN) equipment.**



Fig No. 6 Rail Scan Equipment

Longitudinal stresses in LWR have been a cause of concern to Track men on Indian Railways. Hot weather/Cold weather Patrolling is resorted to take Timely action for ensuring safety of Railway Operation. RAIL SCAN equipment can determine the Thermal Stress Level in LWR Tracks and equipped with that information measures can be taken to avoid building up of Rail Stresses to dangerous level. Hot weather/Cold weather patrolling is thus no longer required.

· **Deployment of Drones as a Substitute to Security Patrolling.**



Fig No. 7 Drones on Indian Railways

Drones are being successfully used to monitor the safety of Railway Tracks against loiterers, intruders and other unscrupulous elements, which could endanger the safety of Railway Operations. This Technology is getting upgraded every day, and is poised to provide dependable information on Track Components. Fig No. 7

4. Adoption of Advanced Monitoring Technologies on Indian Railways

For the adoption of Advanced Monitoring Technologies On Indian Railways, it is necessary to bring up the Track Construction & Track Maintenance Standards to the Global Level, where Track Degradation behaviour of Various Track Components can be reasonably assessed. Here it may be mentioned that the Track Standards on I.R. are not much different from German Railways, the difference lies in poor quality control in procuring Track Components including RAILS and in poor execution of Track Works. Measures required to be taken to prepare the Track for the adoption of Advanced Monitoring Technologies, are as follows:

• **Strict Quality Control in the Construction of Railway Embankments.** Old existing formations are to be monitored with Ground Penetrating Radars and any deficiency in Track drainage, and Ballast quality/quantity is made up. Fig. 8a & 8b



Fig No. 8a Poor Track drainage

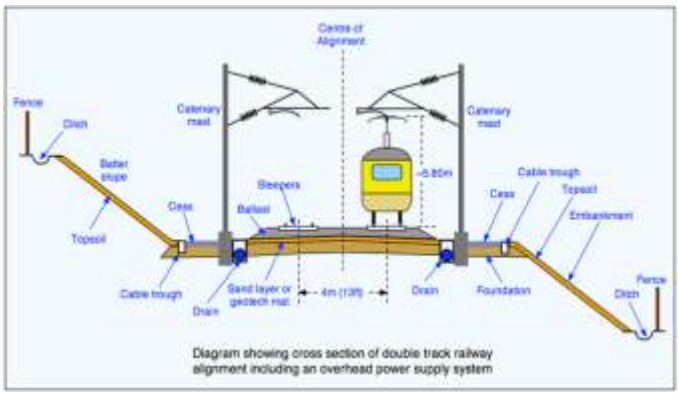


Fig No. 8b Well planned track drainage

Track to be Fully Fenced. The integrity of unfenced track can not be maintained. On I.R theft of the Fastenings is not uncommon creating unsafe conditions. Unscrupulous elements getting access can tamper with the Track causing train accidents. Tracks should thus be provided with un-assailable fencing. Fig 9a & 9b



Fig No. 9a Public loitering on Track



Fig No.9b Properly fenced track

• **Track Construction should be fully Mechanised.**

Present-day 90UTS Rails are brittle and suffer irreparable damages during handling and transport. To avoid such damages ,Rails in modern Rail Rolling Mills, are rolled into longest possible lengths, welded into longer panels in integrated Flash Butt Welding Plants, transported in roller mounted rakes, and laid at Construction sites using specialised end unloading equipment. On German Railways to avoid damage to rails, the Rail Suppliers have been given the single point responsibility of delivering the Long Rails at Construction Sites. This System has produced good results and should be adopted on Indian Railways. Fig. 10a & 10b



Fig No. 10a Manual handling of Rails on IR



Fig No. 10b Rail down loading on German Railway

Jindal Steel & Power Limited, who are rolling long rails in 120 Metre length, in their Raigarh Mill, are in a position to take the responsibility of delivering Long Rails at Track Laying sites, similar to the system adopted on German Railways.

· **Insitu Welding.**

Site welding, with its inherent limitations, can not match the quality standards that are achievable in a Stationary Welding Depot. They are therefore to be minimised to the extent possible. Where ever inescapable, Site Welds should be carried out with Mobile Modern Robotic Flash Butt Welding Machines. These Machines automatically ensure full compliance with the Welding parameter and the Welds produced are almost equal to the Welds produced in Stationary Plants, in their quality standards.

Thermit Welding with its comparatively lower fatigue strength, should be reduced to the bare minimum. Where ever unavoidable, latest technology of Digital Welding should be adopted. This system ensures that during welding all necessary steps in producing Flaw less Welds have been taken. Welding procedure is well recorded and transmitted to the Controlling Authorities, to be seen and reviewed at any time. Fig No. 11a &11b



Fig No.11a APT 1500 RA Robotic Flash Butt welding Machine



Fig No.11b Digital Thermit Welding

• **Technology Up-gradation in Elastic Fastening System.** Advanced Railways are procuring the Complete Elastic Fastenings, from one source, with a single point responsibility of assured service life from each Fastenings Component. With assured service life, the Fastening Components are routinely replaced at the end of their service life. Presently, on German Railways, while elastic clips have a service life equal to the Rail, Rail Pads have a life of over 10 years. Steps are being taken to bring better Technologies, where all Fastening Components will have life equal to the RAILS. The same system should be adopted on Indian Railways.

• **Turnouts To Carry CWR.** To bring down the frequency of attention to Turnouts, their technology on IR needs urgent Up-gradation, to be brought at par, with what is being adopted on DFCC Tracks. Their Turnouts design, apart from general strengthening of Switch and Crossing portions, has the arrangements for the continuation of canted rails through the turnouts. Indian Railways should upgrade their turnout technology to International level.

• **Up-gradation of Technology in Switch Expansion Joints.** CWR should be continued as long as possible, through, bridges and Turnouts. To bring down the need of Switch Expansion Joints, where required its technology needs Up-gradation to have its service life equal to the rails.

One such design is shown in Fig No. 12



Fig No. 12 Modern Switch Expansion joint

• **Stress Free Temperature (SF*T*) to be monitored through Rail Scan Equipment.**

To ensure that the rails are installed at the right temperature, it is necessary that the SFT is verified with Rail Scan Equipment after a de-stressing work is carried out. Similar verifications are needed when any repair work is carried out on CWR for the rectification of Rail/Weld fractures. With these checks, the Thermal Stresses in Rail can be better controlled and there may be no need of any Hot/Cold weather Patrolling.

Track Maintenance work only to be carried out, under Complete Track Block in a planned manner, with full weather protection .Track Maintenance vehicles being adopted on German Railways is shown at Fig. No.13

Similar Equipment is needed to be provided to Track Maintenance units on Indian Railways, to achieve the desired qua



Fig. No. 13 Mobile maintenance units on German railways

5. Summing Up.

· Manual Monitoring of Track On Indian Railways, under present day Operating Environment, is failing to provide the necessary safeguards against accidents attributable to Track. In addition it exposes the Track Men to hazardous environment causing heavy casualties among them.

· On Advanced Railways, manual track monitoring has been replaced with remote sensing technology, with far better results. Digitization of Monitoring data, is playing an important role in this change over.IR has to adopt this technology to ensure the safety of Railway Operation, and for the safety of Track Men.

· Track Construction and Maintenance Standards on IR shall have to be upgraded, to the International Level, to get the desired benefits from the Modern Track Monitoring Systems.

Strategies & Field Assessment of Track Subgrade for Semi-High Speed 160kmph Routes

By
Jogesh S. Sondhi*

Abstract *Rational design approach for track subgrade is required to assure best suited track substructure with low maintenance for increased axle loads, and/ or for semi- high speed lines. Indigenous effort made for state of the art Track subgrade suited for 160 Kmph on IR is presented in this paper.*

Design issues includes assessment of stress on subgrade layer, dynamic amplification factor, critical speed issues on soft soils; and adequate subgrade layer as regards strength and stiffness. Important factor in design of track subgrade layer, supporting the granular ballast/ sub-ballast layer, is to check against shear failure limit excessive plastic deformation.

Available design approaches for track subgrade, and practices on World Railways have been covered. Geotechnical issues for subgrade design has been covered. Lab and field in-situ tests adopted to assess strength and stiffness of the subgrade layer in the field are mentioned. Latest development of in-situ methods, including rail mounted systems have been outlined.

Draft specifications for Track Formation for semi high speed on IR is suggested, on similar lines of GE-14: RDSO Report on Subgrade Design for Heavy Axle Load, as developed during 2008-09 at RDSO with guidance & review at Rly. Board level including the author.

A case study of a Double Track High Speed (160 kmph) Meter Gauge (MG) Project in Malaysia has been presented. Correlation of field test, and laboratory tests on field samples were done to conclude and predict assured behavior of track subgrade for higher speed upto 160kmph.

1. Introduction

Railway tracks were earlier built with empirical design approach for track formation. With resurgence of Railway Projects with heavier axle loads, and higher speed passenger trains (160 kmph) on existing routes, attention is required for appropriate design of track formation with field assurance tests.

High quality track is characterized by long term track stability, with low maintenance efforts for high GMT, higher sectional speeds and heavier axle loads. Track formation supporting the track structure, properly design and provided with good material can fulfill the need for mixed traffic, with heavy axle load trains and high-speed train service.

2. Formation Issues

Formation comprises of granular ballast, blanket (protective) layer laid over subgrade layer, supported on underlying soil embankment layer. Formation also includes slopes, longitudinal drains and any embedded structure (viz. sub soil drain) within them.

Track formation function is to resist stresses due to axle loads, provide stability, and retain track structure within narrow tolerance range, without degradation over pre-defined service period. Subgrade layer, acting as the stress bearing layer, need to provide sufficient strength, stiffness, and reflect reasonable settlement; in addition to good drainage for rain water from the ballast layer.

To understand, with passage of each loaded train, a series of stress bulb wave (stress contour to an average depth of 2m) sweeps at train speed, through the formation: ballast, subgrade layer subjecting the constituent soil to repeated stress application, resulting in degradation with multiple load cycle application, resulting in accumulation of plastic deformation.

Signs of insufficient bearing capacity of track formation are reflected in field by way of:

- Recurrent tack defects requiring frequent attention
- Wet spots- subsoil material rising and contaminating ballast layer
- Wet soil being pressed out to the sides, and
- Deformation of earth formation by ballast pockets and trough formation with water retention.

2.1 Resilience, Track Stiffness, Track Modulus & Subgrade

On conventional track, approximately half the resilience needed to absorb dynamic forces is provided by the ballast bed and the other half by the subgrade, Ref. (1) TTCI. Ideally, the stiffness of the overall track structure is of the order of 100 kN/mm, which implies the structure deflecting 1 mm under a 20 t axle load.

2.2 Parametric study by Li and Selig (1994), using GEOTRACK model, ref (2), indicate in case of ballasted track, stiffness of the subgrade is the most influential parameter of Track modulus. Secondary influence parameters include the granular (ballast and sub ballast) layer thickness, rail fastener pad stiffness, and sleeper type (wooden or concrete). Sleeper spacing and its dimensions has minimal influence on Track modulus.

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earlier PCE & CAO, WCR.

Whereas, in case of slab track, and track on ballasted deck or open deck bridges the modulus is almost entirely a function of the stiffness and resilience of the elastomeric elements in the rail fastening system or at sleeper deck system; additional resilience must be added to the system to compensate for the absence of ballast.

3. Formation Design Approach

I. Design Methods need to address maximum axle loads, traffic volume (GMT), max. speeds (V), dynamic amplification, (DAF), and soil characteristics of Subgrade layer. Steps involved include:

(i) accurate assessment of loads, maximum stress on the subgrade,

(ii) DAF, critical velocity regime issue, and

(iii) granular layer thickness;

(iv) provide adequate material/ thickness of Track subgrade layer for strength & layer stiffness

(v) check for adequacy of ground bearing layer

II. Test Regime: Finally, validation by appropriate laboratory/ field assessment tests.

3.1 Stress Assessment on Subgrade

Accurate estimation of stress in subgrade soil layers is basically 3D analysis; it being difficult to capture load dispersion under point wheel loads in longitudinal and transverse plane by 2D analysis. Using Winkler model beam approach proposed by Zimmermann (in 1941) and Odemark's Equivalence Method (1984) described in ref (1), the vertical stress on formation is overestimated.

Case Study: MG High Speed Project, Malaysia: Double track High-speed (160kmph on MG) rail line project between Rawang - Ipoh, north of KL, Malaysia, completed in 2006, has a New track constructed adjacent to existing track, also rehabilitated and upgraded to new alignment on raised embankment. Expected trains- freight, Intercity and Rapid Commuter with speeds varying in the categories: 72-90 km/hr, 120, and 160 km/hr. Track Subgrade Study done by NUS, Singapore - analysis results, summarized.

A.1 Geometry and Material Properties

The thickness of ballast and sub-ballast taken as nominal 300mm each, supporting UIC 54 rail on concrete sleepers of dimension 2000x275x250 mm at 600mm spacing on a typical embankment height of 5m.

A.2 Loads (20t axle load) : Trainload comprise heavier axle loads of locomotive with lower trailing wagon axle loads; locos with CO-CO bogie (20t, 3axle each), axle at 1.78m spacing with bogie centers 8.1m apart assumed. Taking advantage of geometry and loading symmetry, a quarter portion of the double track embankment (12m top width) was analyzed. Load from one bogie i.e. 3 axles imposed on one track portion on double line simulates two locos positioned adjacent on two parallel tracks, track centers at 5m.

A.3 Stress Distribution: Embankment modeled FE mesh is shown, max. subgrade stress occurs under middle axle of bogie cluster. The Von Mises stress shown is the deviatoric stress; and is maximum directly under the rail seat of central axle of 3-axle bogie; separate stress bulbs are reflected under each rail. Shear failure for low soil strength follow similar pattern.

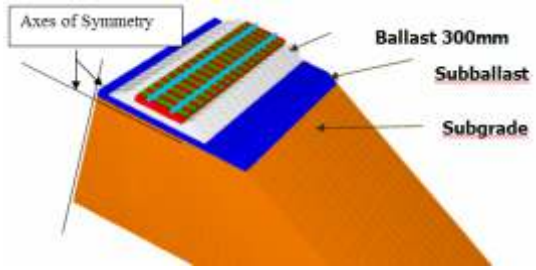


Fig.1 FE mesh for quarter embankment portion under track structure

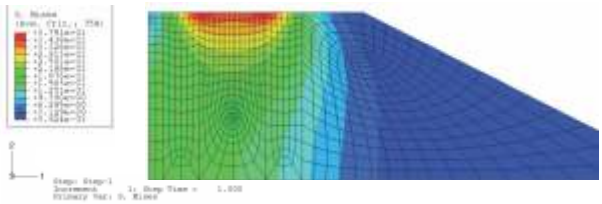


Fig. 2 Cross Sectional View of Embankment showing deviatoric stresses under central 20t 3-axle, only formation shown.

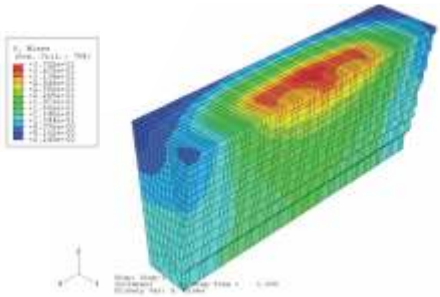


Fig. 3 Deviatoric Stress contours for L–section through center of track for 20t, 3-axle loading

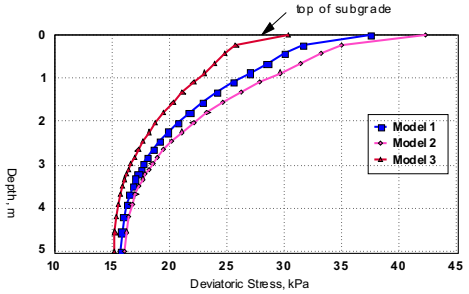


Fig. 4 Distribution of Deviatoric stress with depth in sub-structure embankment

Table. 1 Material Parameters

Material	Model I	Model 2	Model 3
	Young's Mod.,MPa	Young's Mod,MPa	Young's Mod., MPa
Ballast 300mm thick	280	140	280
Sub-ballast 300mm thick	140	70	140
Subgrade/ Embankment 5m thick	25	25	12.5

Table. 2 Deviatoric Stresses at Various Levels

Deviatoric Stress in kPa	Model 1	Model 2	Model 3
Vertical Deflection at Rail Level, mm	4.33	4.73	7.73
Stress below sub-ballast (at subgrade level)	37.5	42.4	30.4
Vertical Deflection at Top of subgrade (mm)	4.12	4.37	7.53
Stress at 1m below subgrade level	25.5	27.9	22.1
Stress at 2m below subgrade level	20.7	22.1	18.8

Maximum deviatoric stress acting on the subgrade is **approx. 37.5 kPa** for Model 1, varying from 30.4 to 42.4 kPa depending on modulus of ballast. The vertical displacement under static wheel load at rail and subgrade level varies between 4 and 7 mm.

The stress acting on subgrade increases marginally with decrease in ballast modulus (effect on degradation).

3.2 Dynamic Amplification Factor (DAF)

Static stress values determined from FE analysis need to be augmented by dynamic amplification factor. This factor takes into account, dynamic effects such as roll, slip, vibration, unequal load distribution and related forces of motion. Dynamic amplification is also caused by impact loads generated by the sleeper distance effect and track irregularities. Extent of stress amplification in subgrade is dependent on several factors like: *train speed, track quality, sleeper spacing and soil stiffness.*

The dynamic forces resulting from low (5-10 Hz) and middle frequency (20-25 Hz) steady state contribution more primarily influence the ballast and subgrade. Empirical formulae based on speed, probability factor, and track conditions have been adopted. Two such empirical relations are:

a. AREA approach (1996): DAF is a function of velocity of trains and D diameter of the wheel., e:g: for wheel diameter of 0.9m, and train velocity of 160 km/hr, DAF = 1.92.

b.Whereas, Eisenmann Formula is dependent on train speed, track quality, and chosen factor t, which is probability factor and depends on the track quality. For good quality track, and probability of 66.7% (=1) at subgrade level, DAF = 1.34.

3.3 Critical Speed: Critical speed issue affects track laid on soft underlying soils, and is governed by:

• Soil Stiffness: Wave Propagation in soil – becomes restrictive in Soft Soils Velocity of shear waves Vs = √ (G/p), where G is shear modulus of soil and r is the density. For operating velocity of 160 kmph, Critical shear modulus is 4 MPa, & Effective Young's modulus 10 MPa.

• The maximum train speed is limited by velocity regime of the surface waves traveling in the supporting soil strata. Rayleigh surface wave speed, slightly dependent on Poisson's ratio ( ) of soil, propagate at speed (Vr) approximately 90% of the shear waves for normal (Vs) values of soil.

• At lower speeds, the deflection below moving load points symmetrical and more or less coincides with the location of load. Approaching critical speed, the deflection below load point exhibit 'bow' effect [3] of track below moving wheel load.

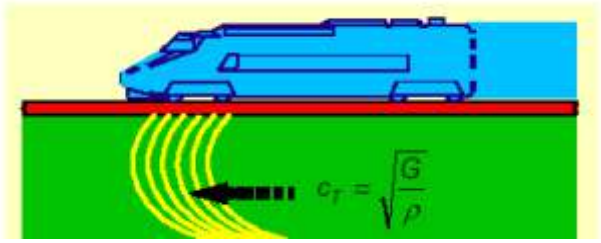


Fig. 5 Critical limiting speed due to Shear Waves in Soft soil layer

Critical velocities for few typical subgrade soils are calculated, shown in Table 3. Allowable train speed is computed as 0.65 times the critical speed. It is must to limit the train speed to the sub-critical zone. Embankments with Soil Modulus E_{v2} ~25 MPa with Value of *DAF* = 1.25 limit Speed V_{max} to 188 km/hr.

Table.3 Critical Limiting Velocities for *Weak to Good* Subgrade

Type of Subgrade Soil	Young's Modulus, MPa	Shear Modulus, MPa	Critical velocity = Rayleigh wave velocity m/sec	Allowable Operational Train speed m//sec (km/hr)	
Poor	10-20	4-8	52-73	33	121
Moderate	50	20	115	74	269
Good	80-100	32-40	146-258	95	341
Suggested minimum value for Track on Soft Soils	35	14	96	62	226

Heelis et al. (2000) derived relation for displacement amplification factor, as function of critical speed and the results are shown in Fig. 6. Increase in displacement need to be checked by limiting DAF to about 1.25. It is also reasonable to assume damping to be about 5%

For Undamped Case:

DAF IS function of V, and Vcr Values

$$DAF = \frac{Wdyn}{Wstat} = \frac{1}{\sqrt{1 - \left(\frac{V}{Vcr}\right)^2}} \quad ..(Eq.1)$$

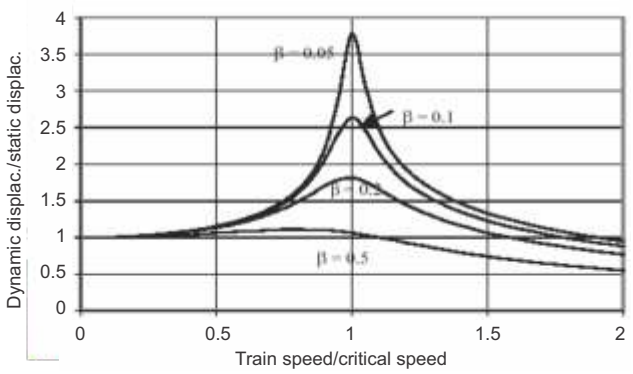


Fig.6 Relation between DAF and Critical Speed (Heelis et al., 2000); ß represents material damping of the subgrade soil.

Graph in Fig. 6 indicate that train speed should be 0.65 times the *critical speed*. In any case, in practice, margin from critical speed should be kept, particularly when anticipating speed increase later on. Accelerating train wheel loads approaching the resonance levels exhibit increased dynamic displacements and forces in the supporting strata, as reported by various researchers.

4. Prevalent Design Approaches for Subgrade Layer

i) British Rail – Threshold stress concept (Heath et al., 1972)

ii) I. Railway Approach– Report on Subgrade Stress and Design of Track Structure (RDSO, June 1993)

iii) UIC- Design Approach: UIC Code – 719 R (1994)

iv) AAR Method- Li & Selig (1998) based approach.

4.1 British Rail – Threshold stress approach: developed by British Rail (Heath et al., 1972), wherein, the stress on subgrade soil layer is limited within the limit of threshold stress value, to protect against failure by excessive plastic deformation. At stress level above the threshold stress value, rate of cumulative plastic deformation of soil is very fast. Threshold stress is determined based on repeated Triaxial load tests, or in practice it is assumed to be 50% of ultimate compressive strength. Threshold stress approach consider the effect of repeated load application on subgrade soil layer. Limitation of this method has been that it does not take in account effect of cumulative tonnage.

Blanket/ Capping Layer on Australian Railways: provides 15 cm blanket/capping material over 0.5 m of subgrade having CBR values more than 8 or over 1 m of sub-grade if its CBR is in range of 3 to 8. a typical case of empirical approach for design.

4.1 **Indian Railways RDSO Guidelines (1993):** similar to BR recommends design of subgrade by keeping stress *below threshold stress level* of subgrade soil by providing suitable depth of well-graded granular (blanket) layer. Due to lack of experimental data for the underlying soil, placement of compacted granular fill of about 1m thick blanket layer directly below the ballast layer was cntinued, later reduced to 60/ 30cm as per various directives. With GE-14 RDSO Design approach, *now this is of historical importance.*

4.2 **UIC Approach**: The relation between ballast thicknesses versus subgrade modulus according to ORE D117 for various Railways is reflected in Fig.7. Relates 2nd step Plate load test (E_{v2}) or CBR values or soil types to granular layer thickness.

UIC 719 (1994) provision specifies thickness of track bed layers; e= (total depth of ballast & blanket), dependent upon axle load, GMT, speed, soil type used as prepared subgrade. Covers axle load in the range 20t to 25t, and prescribes geotextile for soil of QS1 and QS2 class. Blanket material is a well graded sand-gravel layer (Cu > 6 and Cc between 1&3), satisfying Terzaghi filter criteria with prepared subgrade soil.

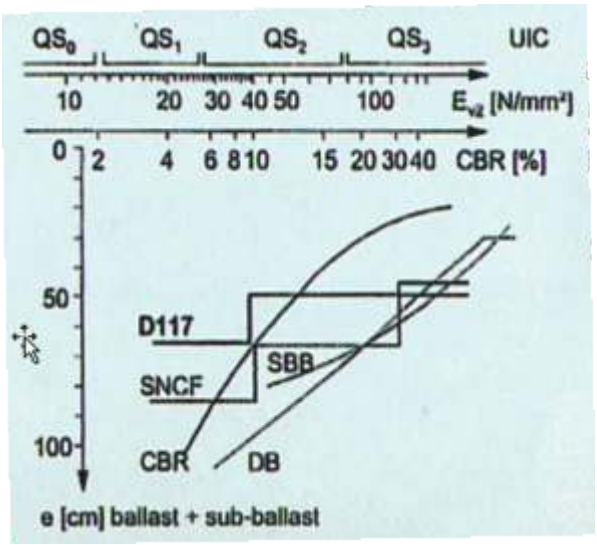


Fig 7 e=(Ballast+Sub-ballast) thickness versus Subgrade CBR/ Modulus (based: ORE D117, Design Handbook RP28)

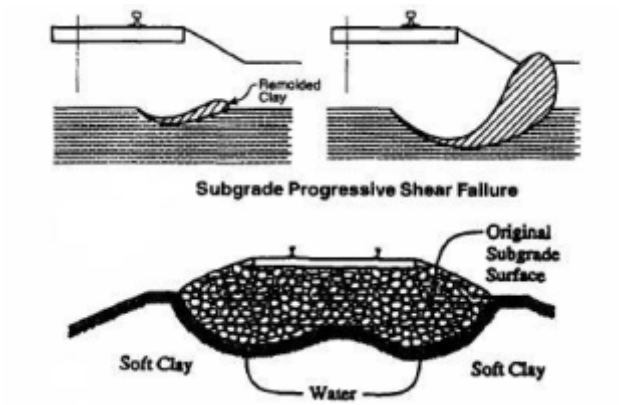


Fig 8 Excessive Subgrade Plastic Deformation (Ballast Pocket)

4.4 AAR Method: Li and Selig (1998), researchers at AAR Test Track Center at Peublo, Colorado, USA based on field testing, presented a rational design method considering two criteria:
(i) progressive shear failure, and
(ii) excessive plastic deformation.

Progressive shear failure criterion makes sure that the design is far from failure, whereas, excessive plastic deformation criterion limits the total settlement due to repeated loading, to a given preset value.
This method is superior to other methods including *threshold* stress concept method; correlates annual rail traffic, axle loads, train speeds and axle effects in terms of dynamic wheel load to the requirement of the total granular layer (ballast + sub- ballast) thickness required for a given soil strength with a predefined design value for plastic deformation acceptable in the embankment.

The AAR method designs track subgrade based not only on maximum wheel load but also the gross tonnage, whereas the *threshold* stress method is based on maximum wheel load only.
The second difference is in the analysis model. The AAR method is based on GEOTRACK (multi-layer 3-D Model) for stress dispersion, whereas British rail method uses the Boussinesq elastic theory; stresses computed by Boussinesq's equation are much higher hence design is on conservative. Hence, for heavier axle loads, AAR method approach is on safer side.

Case Study (contd.): High Speed MG Project, Rawang – Ipoh, Malaysia

Maximum speed specified for the fast train-set with axle load of 16t would be 160 kmph, whereas for freight with 20t axle loads is 90 kmph. Gross annual tonnage was expected to reach peak values of ~40 GMT at final operational stage.
Limiting Values specified by Malaysian Rlys for the ubstructure, included:

(i) Maximum settlement of 25mm, and maximum differential settlement of 10mm over 10m chord, both over first 6 months of commercial service; to sustain maximum design speed of 160 km/hr.
(ii) Vertical stress on subgrade due to axle loads to be less than *threshold* stress (British Method approach).
Technical Specifications/ Criteria adopted, in terms of
1. Loading: 20t Axle Loads cause bearing pressure of 50 kPa on Track Subgrade.
2. Strength: Minimum soaked CBR of 5% correlates to 150 kPa.
3. Stiffness: Assumed E = 25 MPa for subgrade soil indicates static deflection of 6mm, which is acceptable. Shear wave velocity criteria requirement (to avoid resonance at 160 kmph) dictates a minimum value of Resilient Modulus: E = 25 MPa for the soil.
4. Lab. & Field Tests - Cyclic Load tests in Lab & Field Assurance Test for Subgrade Modulus.
Recommendations inputs from **NUS, Singapore Study** were:
a. Limit fines in the range: 15% to 40% for top layer of embankment.
b. Top 500mm layer: better than 95% of measured samples to have soaked CBR 6%, and CBR 5% for 500mm to depth of 2m.
c. Special cross–hole seismic cone tests to assure subgrade/ embankment fill has Soil modulus 25Mpa.
d. **Second step PLT & FWD** (Falling Weight Deflectometer) to check Modulus for subgrade.
On the project, majority of the stretches involve embankment fill above original ground with height varying from 0.5 to 6.0m. Soils for the embankment were of 'suitable' type; *fines* contents generally limited to less than 35%. Subgrade layer constituted by the top 600mm layer of formation, and was compacted to minimum 95% MDD.

Review using AAR method (Li & Selig approach) was carried out for Shear strain failure and total allowable deformation (< 25mm). The required granular layer thickness (ballast + sub ballast) was re-confirmed for two different moduli of subgrade, summarized in Table 4; track maintenance period of 2 years assumed between major track tamping, with the projected annual GMT. Considering allowable cumulative plastic deformation 10mm in 2 years, with subgrade modulus value 26 MPa, the calculated granular layer thickness works out 486 mm, less than 600mm (30+30 cm sub- ballast) provided.
In case of low embankments, where the existing ground may not be stiff enough. It, also indicate that absolute minimum stiffness modulus required for sub-grade and or underlying soil strata is 16 MPa, with total granular layer of 60cm.

Table. 4 Thickness of granular layer (ballast + sub-ballast) related to Subgrade Modulus

Type of Train	Axle load (tons)	Speed Km/hr	Resilient modulus of sub-grade (MPa)	Required thickness of granular layer, mm
Freight	20	90	26	486
Passenger	16	160	26	486
Freight	20	90	16	578
Passenger	16	160	16	578

Based on testing of samples retrieved from subgrade, and tested for 1x 106 cycles, range of plastic deformation for embankment was likely to be 2 to 7mm. Also, 20t Freight trains@ 90 kmph has equivalent effect as Semi-High speed 160kmph with 17t axle load.

Ground Improvement: Existing soils along the alignment ranged from laterite mix, loose sand, clayey sand, clayey silt to organic mixed soils. Generally, the soil stretches with cone tip resistance (qc) less than 1 MPa were subjected to ground improvement.

Apart from surcharge loading, ground improvement methods included:

- Remove and replace poor soil (R&R) with sand - improves bearing and drainage,
- Dynamic replacement, SVC and stone columns - improves bearing & settlement.

These methods strengthen, limit future settlements and also increase soil stiffness.

Brief conclusion: for shallow embankments trainload (dynamic) effect dominates, whereas for high embankments static effect dominates.

5.Standard requirements for Sub-structure under Tracks on Earth formation, according to DS836 (DB AG)

Table 5: Few important values of layer thickness for various Line Types (DB AG) (Track Compendium- Eurail Press)

	Line Type V (kmph)	Formation: (MN/mz) Ev2	Evd	Protective Layer- cm Standard thickness F1	F2 class	Earth Formation (MN/mz) Ev2	Evd	Legend
New Track	Pass / Mixed Upgraded Lines (230)	Ballast 120	50	50	60	60	40	Ballast- Ballast Track Slab- Slab Track Ev2- Modulus of Static Deformation Evd- Modulus of Dynamic Deformation Frost Class F1 – No sensitivity to frost F2 - Low to medium sensitivity to frost.
	Pass Traffic (160) Mixed Traffic (160) Goods Traffic (120) Commuter (120)	Ballast 100	45	40	50	45	35	
	Commuter (80) Goods (50)	Ballast 80	40	30	40	45	30	
Improved Track	Pass/ Mixed Traffic Upgraded Lines (230)	Ballast 80 Slab 100	40 45	30 40	40 40	45 45	30 30	
	Pass Traffic (160) Mixed Traffic (160) Goods (120) Commuter (120)	Ballast 50	35	20	25	30	25	
	Commuter (80)0) Goods (5)	Ballast 40	30	20	25	20	25	

Note: Geotextiles may be inserted below the Protective layer, particularly for low bearing capacities of the soil.

6. Design Approach Strategy# & Specs for Semi-high speeds upto 160kmph on existing IR lines.

Formation on IR for higher speeds (160 kmph), and in mixed traffic scenario (23t Axle load) need to be designed, similar to AAR approach, with: i) trength (CBR) based soil layers for subgrade/embankment, and ii) cumulative plastic deformation criteria. Concept of graded multi-layer system is adopted; which can also checked by Analysis Programs for stresses and deformation settlement.

 # Considering the time tested features of Subgrade provided for Highway system (Ref; Indian Road Congress Code, IRC:37 on 'Guidelines & Design of Flexible Pavements), and foreign Railway practices, strength based approach withCBR value for subgrade, with minimum assured Subgrade modulus for soil layers, is the most appropriate approach.

Steps of Rational design approach can be summarized as:

(i) Compute *stress* on sub-grade: 3D Model for load (max. Axle load) dispersion through Multilayer's

(ii) Determine *critical* velocity and *DAF* value (based on Train Speed)

(iii) Determine *adequate depth* of granular layer with assumed minimum sub-grade modulus expected at site.

(iv) Laboratory and field measurement of sub-grade soil modulus to determine value of sub-grade modulus to validate.

(v) Field control of sub-grade parameters by compaction control with 95% MDD at OMC, soaked CBR soils > 5%, and check sub-grade resilient modulus using 2nd step plate load test

SUGGESTED SPECIFICATIONS on IR for Higher Speeds up to 160 kmph, with Freight traffic of 23t axle load :

Specifications and layer thickness for blanket layer, subgrade, embankment are proposed, as two different systems (Values based on ABACUS analysis & GE-14 Report of RDSO (for Heavy Axle Load), Nov 2009)

A. Conventional blanket layer (30 to 100cm) over Single layer of Subgrade / Embankment Fill

B. Reduced Blanket layer thickness over prepared subgrade layer (s) - good/imported soil in one/ or two layers (inclusive of stiff subgrade layer).

Any of the two system may be considered for adoption in the field based on *good* soil availability and different material cost economics.

These are given for following: *Specification* values (as *higher values)* are specified, in Table 6.

a) Total Granular Layer (Ballast+ sub ballast) thicknes for Higher Speeds, and/or heavy Axle Loads,

b) Blanket Layer of standard specs and thickness specified as per underlying soil type.

c) Specs (CBR values) and thickness of Subgrade Layer, and soil embankment layers below.

Blanket material should have sufficient high CBR value to avoid penetration of ballast particles into blanket layer. CBR value of prepared subgrade as top layer of formation should be minimum 5, and for blanket material minimum 25.

On Indian Railways, CBR value of soil used as embankment fill is recommended as minimum 3, but preferably should be 4 or more.

Subgrade Modulus based Criteria: Rational approach specifies *minimum* Subgrade Modulus, e:g: for top subgrade layer (1) > 35 MPa; and Sub Soil strata > 16 MPa. To achieve these values in the formation layers, soil in terms of CBR need to be specified for the layers, with follow up assurance tests.

Table. 6 Proposed Specs of Subgrade layer (in colour) for Higher Speeds (160kmph).

Assuming minimum Ballast + old ballast layer actig as sub-ballast= 30cm, on top of Blanket Layer

Layer	Specs	Axle Load - Max 22.9 T 17t for Coaches, speeds upto 160kmph	Routes with 25T Freight at 75 kmph
MULTI- 2LAYER System			
Blanket- Well Graded sand gravel layer; graded as per RDSO specs.	Cu >7; Cc 1 to 3 LA Abrasion < 40%, and Filter Criteria with Subgrade layer. Min. CBR 25	Min. Thickness 30 cm / 45 cm/ 60 cm (with Subgrade soil layer below of (SQ3/ SQ2/ SQ1) #Geotextile if SQ1 below, optional for SQ2 Min. Ev2 = 50 MPa	30 cm with SQ3, 45 cm with SQ2, soil below blanket layer. 100 cm with SQ1. Min. Ev2 = 80 MPa
Layer 1: Prepared Subgrade - *T opLayer* (*Good*/ Imported Soil)	CBR >= 6% Limit Fines: 12- 40%, **Only SQ3, SQ2**	Min. 50 cm to 70 cm **CBR >= 6%** 95-97% MDD Min Ev2 =35	Min 60 to 70 cm **CBR >= 6** 95-97% MDD Min Ev2 =45
Layer 2: Formation Soil layers below the TopLayer	CBR >= 4% Avoid SQ1, and limit fines	Layers below **CBR >4%** SQ3, SQ2, 95% MDD SQ1 only in exceptional	Layers below **CBR >5%** SQ3, SQ2 95% MDD, SQ1 avoidable
SINGLE LAYER SYTEM (Soil Formation)			
Blanket	--As above, for Blanket	Blanket min. 60 cm	100cm to 120cm
(with Subgrade/Formation as SingleSoil Layer)	Soil Layers CBR >=4 to 5% Limit Fines: 12- 40%,	**CBR >= 5%** 95-97% MDD Min. Ev2 =35 In soil layers: SQ1 to be avoided	**CBR >5%** SQ3, SQ2 95% MDD Min. Ev2 = 45 SQ1 to be avoided

1. As per IS codes: Fines have size less than 75 micron (c.f. in UIC, fines are below 60 micron)
2. EV2 to be determined in the field as per procedure of German Code DIN : 18134 at ground.Undrained shear strength, Cu of ground soil from Unconfined Compression (UCC) test or Vane Shear Test and Penetratio Number (N–Value) from Standard Penetration Test should also be determined.
3. If EV2 value of Ground layer is less than 20 MPa or Sub-soil strata having (Cu) < 25 KPa (mostly in Marshy area) or N-value < 5 will also require Ground improvement.
4. CBR test is well established and easy to determine in the laboratory as per procedure laid down in BIS Code– IS : 2720 (part 16) – 1979.

Strength: Related issues

The minimum soaked CBR of 5% ensures that undrained shear strength at top of subgrade is about 150 kPa (using Cu=30* CBR). The expected stress level on subgrade is about 50 kPa. This will ensure that the ratio of applied stress / strength of subgrade is about 1/3. Selig and Li (1998) reported that the acceptable threshold stress level ratio (applies stress / strength of subgrade) is about 1/2. The adopted ratio of 1/3 is prudently conservative.

Stiffness

The stiffness of subgrade will influence static deflection and dynamic amplification factor (DAF) due to train loading. Finite element analyses using Young's modulus of 25 MPa for subgrade indicated that static deflection is about 6mm, which is acceptable.

It is important that stiffness of soil should be far from resonance due to train loading. For a 20% amplification i.e DAF of 1.2, the required stiffness of soil is 25 MPa assuming train velocity is 160 kmph (44 m/sec). The undrained shear strength can be related to Young's modulus of soil using E=200Z*Cu The expected Young's modulus of subgrade is about 30 MPa. This will satisfy both static and dynamic requirements.

7. Laboratory & Field Testing, and Assurance

Strength and deformation properties are both important in measuring subgrade performance. Shear Test and CBR value is considered to be the general indicator of strength, while elastic deformation per applied load intensity is represented by the soil modulus. The tests include:

- o Undrained (UU) Triaxial and Direct Shear test,
- to determine strength of soil,
- • California Bearing Ratio (CBR) Tests
- to measure soaked CBR value
- • Cyclic Triaxial tests
- determine resilient modulus, and
- • Field Test for Strength

(i) Field Vane Shear test and/ or PLT (Plate load test),
(ii) SPT, Cone Penetration test (CPT)

- • Field Test for Resilient (Subgrade) Modulus

(i) Second Step Plate Load Test
(ii) FWD- Falling Weight Deflectometer Test or Cross Hole Seismic Test

Methods used should simulate field situation i.e. repetitive axle load applications for the design period.

QA/QC is generally adopted to assure design parameters: (*c.f.* High Speed Project, Malaysia)

- ·# Strength: Top ~500mm layer: better than 95% of measured samples to have soaked CBR > 6% , and CBR > 5% for 500mm to a depth of 2m .
- · Stiffness: Subgrade/ Soil modulus > 35Mpa for top layer
- – Second step PLT & FWD (Falling Weight Deflectometer) to check modulus for subgrade along alignment at regular intervals,
- – Lab Test- Cyclic Triaxial Test for Resilient Modulus.

Properties measured and related attributes of Various tests are summarised in Table below:

Track Modulus: To indicate, representative Track Modulus values required for Track varies between 1200 to 800 kg/cm/cm, value specified in Proposed Track Specs for the Malaysian project was 1000 kg/cm/cm. **Technical literature on High Speed Track indicate correlation values for Soil Types**, Mod of Dynamic Elasticity- Ev2 (Modulus of Elasticity for formation - from the second load step in a Plate Loading Test), Foundation Modulus -C, and permissible compressive stresses σ_z for '**n**' cycle loading, (source: Ref.1).

Soil Classification	E_{v2} (N/mm2)	C (N/mm2)	σ_z (N/mm2) for n = 2x10 E +6	Admissible Comp Strain of the soil, for n=10 E+6
Poor	10- 20	0.03- 0.04	0.011-0.022	1.2 to 2.4
Moderate	50	0.07	0.089	5.8
Good	80- 100	0.09- 0.11	0.089-0.111	9.6- 10.2

$\sigma_z = 0.006\ E_{v2}/(1+0.7\log n)$

Values Range for Clay & Sand Soil Typs:

Soil type	Cone Resistance q_c. N/mm^2	Foundation Modulus,K	Elasticity Modulus,E_{dyn}	CBR values
Clay	0.2- 2.5	0.02- 0.04	15- 60	3- 8
Sand	3.0- 25.0	0.04- 0.10	70- 200	8- 18

7.1 Assessment Methods for Track Subgrade

Repeated Load Triaxial Test (Cyclic Triaxial) (ASTM D3999)

The cyclic triaxial test is used to measure a soil's resilient modulus (Er). The deviator stress applied monotonically in the standard triaxial, is varied in the repeated load triaxial test to produce a cyclic loading. Typical stress-strain behavior can be seen in Figure 9. Correlation of Ev with CBR in reflected in Fig. 10

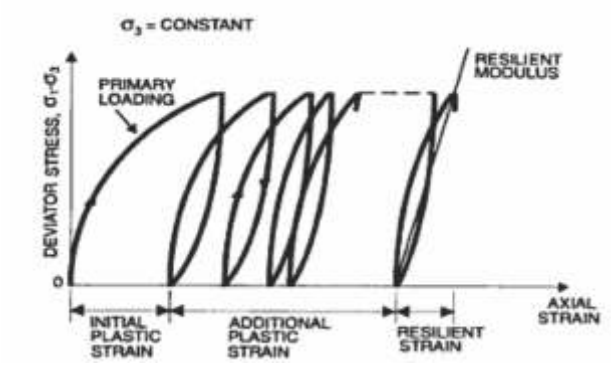


Fig.9 Typical stress-strain behavior of a cyclically loaded soil showing the accumulated plastic strain and resilient modulus

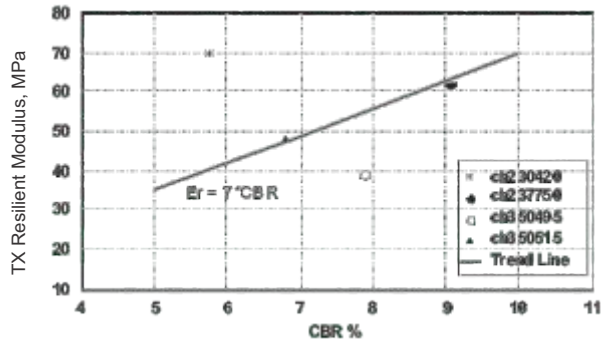


Fig. 10 Relation between CBR and Triaxial Resilient Modulus

7.2 Other In-Situ Tests For Railway Trackbeds

i. **PANDA Penetrometer :** A recently developed, hand-held version of a dynamic cone penetration test called the PANDA Penetrometer has seen increased use on Railways trackbed assessment; is a lightweight dynamic penetrometer developed in France. The penetrometer consists of a rod with a 2, 4, or 10 cm2 cone on its end. The rod is driven into the ground using variable, manual energy supplied from a hammer. Each time the rod is struck, the blow energy and the depth of penetration are measured using a small central acquisition unit. Results used for estimating Elastic modulus for various layers of track bed. Fig. 11 shows the set up, dynamic cone resistance, qd, is calculated using Eq. 2.



Fig. 11 Panda Penetrometer developed for French SNCF Railways

Dynamic Cone Resistance value

$$qd = \tfrac{1}{2} mV^2 . \ 1/Ae . \ m/ \ m+m') \ldots \text{Eq 2}$$

where:

m = mass of the PANDA head
m' = mass of the tube + cone
e = depth of penetration
A = section of the cone
V = velocity of the hammer at impact

- PANDA can penetrate through ballast
- SNCF uses because of its economy, speed and reduced level of disturbance.

i. **DySta Fit (Dynamic Stability Field Test):** Developed by ARCADIS, Netherland, is capable of generating static and cycle –dynamic loading of a train directly on to the compacted subgrade. This 1:1 scale provides more representative measure of subgrade performance, than the scaled down test (Neidhart and Shultz, 2011). Loading cycles can be simulated in one or two days. Mentioned as a verification method in the German Railways guideline on Earth Construction. Field equipment similar to that shown in Fig. 15.

ii. **Portancemetre' Method**: Recently developed continuous means of testing Subgrade soil modulus. Known forces and measured deflection are used to find Mod of Subgrade reaction k value, and then using Eq given (LCPC and CETE, 2007(2)) determines Ev2. Measurement covers 15 km each day, at speed of 3.6 Km/ hr.

Ev2 (kN/mm) = 5.26 * k (in kN/mm)

Both the Portancemètre and the DyStaFiT systems have been developed for direct use on the track (LCPC and CETE 2007(2)). Rolling Stiffness Measurement Vehicles (RSMV) and Track Loading Vehicles (TLV) have been developed and used in Europe as well as the U.S. Now, Asian countries are adopting these for continuous recording.

LCPC and CETE were involved in the recent development of a modified Portancemètre for track stiffness measurements as seen in Fig. 12.



Fig 12 A version of the adapted Portancemètre during its development (LCPC and CETE, 2007)



Fig. 13 Track Loading Vehicle (TLV) at TTCI test track in Pueblo, Colorado (AAR)

iv. The TLV at the TTCI test track in Pueblo, Colorado uses a similar setup(see Figure 13), as the CARS system. University of Nebraska at Lincoln has also developed a continuous track stiffness measurement device using laser to measure track deflection ahead of the rolling wheel (Norman et al., 2004) While these tests are not run directly on the subgrade soil, their results are likely indicative of the subgrade quality and performance. Their main advantage is obviously that they are rail-bound.

8. **Weak Subgrade Strengthening Method:** Adopted when N values <5, and
Possible solutions include: (i) Remove & Replace (R&R), (ii) Soil improvement, grouting, deep mixing, and provision of piles, or stone columns.Stabilization using grouting or deep mixing can be applied mechanically to the soil very precisely. Grouting involves injecting liquid mortar (based on cement or limestone), which then hardens, while deep mixing consists of mixing the material already present with a liquid or dry mortar based on cement, limestone, fly-ash etc.

Piles: In addition to stone columns, Li et al. (2003) indicate that other types of piles, including concrete, timber, and sand columns are accepted methods of stabilizing weak subgrades. Unless the end of the pile is on a firm foundation, skin friction provides most of the load transfer capacity. Therefore, the pile's effectiveness will depend on its length, and different lengths can be used to smooth the stiffness of the embankment approach to a bridge or weak formation stretch



Fig. 14 Installation of Stone Columns (2 methods) in a grid pattern on track bed to enhance bearing.



Fig. 15: SVC Method (sand over Clay strata)

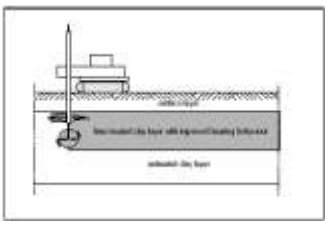


Fig 16. Mechanized Lime Treatment for Stabilization of subgrade

Considerations need to be also given to:

- The use of Stone Columns, Surface Vibratory Compaction (SVC), soil cement, geosynthetic materials, and piles are all techniques ensuring maximum and uniform soil density by performing adequate soil density testing during construction.
- HMA (Hot mix asphalt) layer below ballast provides a flexible semi-impermeable stiff layer.
- Use of Geotextiles and Geogrids to reinforce weak soil layers
- Lowering ground water levels or installing cutoff layers if needed to prevent capillary movement of ground water upward into cohesive soil embankments.
- Allowing for adequate embankment width to accommodate the ballast/subballast depth. Allowing for adequate embankment slope angles or the use of benches, retaining walls, or sheet piles for slope stability and control of erosion.

- Allowing for adequate embankment width to accommodate the ballast/subballast depth. Allowing for adequate embankment slope angles or the use of benches, retaining walls, or sheet piles for slope stability and control of erosion.

Related Observations – Subgrade Issues

1. As per 3D analysis, for 200 kN (20 t) axle loads, the static deviatoric stress on top of subgrade, supporting 30 cm ballast & 30 cm sub-ballast, is in the range of about 40 kPa, and considering dynamic augment is of the order 72 kPa.
2. It has been observed that major part of deviatoric stress due to moving train loads dissipates in the top 2m depth below the ballast layer. Dynamic train loads require high undrained shear strength soil at ground layer for shallow embankments (~2m), for high banks overburden load of embankment height govern the undrained shear strength of supporting ground layer.
3. The AAR design method is a rational method to determine thickness of granular layer based on axle load, speed, GMT, and soil types used in the underlying layers, etc. It requires field determination of soil parameters and design calculations every time when new formation or Traffic scenario is required / changed.
4. In the case study for High-speed Project, with design passenger speed upto 160 Km/hr, DAF is 1.92 based on AAR approach. As per AAR method, for mixed traffic with Freight- 20t axle loads at 90 Km/hr, the granular layer thickness of 300mm ballast and 300mm sub-ballast layer is considered adequate, with resilient modulus of more than 25 MPa; the desired resilient modulus Er for subgrade being ≥35 MPa.
5. Use of Good quality soil for top layer of formation with CBR >= 5 is essential to check excessive cumulative plastic deformation and shear failure. Strengthening of weak formation/ ground may be required particularly for soft clayey soils.
6. Suggested Layers and Thickness on IR for Semi- High Speeds- Similar to AAR, UIC, the total requirements of Semi-High Speed along with heavy axle loads (25 t) can be met with a capping blanket layer (~30cm) laid over prepared subgrade layer of ~70 cm of superior quality soil (CBR >=6%, and min. Ev2 of 35), and the lower formation layers can be of slightly lower specification in terms of CBR value. Ground soil to have min. Ev2 of 25 MPa.
7. Features as Proposed in GE00014 Report of RDSO, Geotechnical Directorate, RDSO, Lucknow for Heavy Axle loads (25t) can be suitably adopted for Semi High Speed (160kmph) with slight modifications, and Field Tess.

Future outlook for subgrade strengthening for Higher speed/ heavy axle load system lies in adopting modified stiff layer or alternate systems.

a. Geogrid and geotextile layers below blanket or sub-ballast layer.
b. Asphalt (HMA) layer 150-200mm thick as subgrade on formation supporting ballast layer.
c. Geo Mats below the sleeper for better stress distribution

9. Summary

This paper covers various design approaches related to track subgrade, including British Rail, UIC, AAR. Design approach involves stress estimation, provision of adequate Subgrade layer with higher strength and stiffness. Weak formation leads to early deterioration and early track maintenance cycle.

Stiffness of subgrade in terms of Resilient Modulus is important and adequate field assurance tests are required to be carried out to ensure recommended stiffness values. Field tests include second plate load test, followed by co-relation of resilient modulus by cyclic Triaxial tests to soil strength parameters.

For the case on IR Semi-speed scenario, against the background of German(DB AG) requirements forBlanket and Subgrade layer, and RDSO GE-14 Report with provisions for Higher Loads 25t axle load and above, Draft Specification for Track Subgrade have been suggested in terms of CBR and Ev2 values for subgrade as single or multi- 2 layer system. Thickness of ballast, Blanket layer, and Subgrade layer with adequate strength (CBR)/ stiffness (Ev2 values) is specified, basically to check and prevent i) Shear failure, and ii) limit cumulative plastic deformation.

Prepared Subgrade Layer with minimum CBR value of 6, and fines limited to 35% need to be uniformly adopted throughout the project with gradual vertical stiffness transition (systems) at approach of hard points like bridges.

Proposed multi-layer formation systems based on CBR value and min. Ev2 values is better option and will result in reduced blanket requirement and economic system as per site availability of soils.

Rail mounted, continuous subgrade modulus measurement systems getting developed, need to be adopted on IR for assessment of existing tracks and plan for subgrade strengthening, assurance for Semi-high speed implementation on Indian railways.

Acknowledgements:

(i) Author was Member of the Technical Group to set up Formation Draft Specs and Testing Regime for High Speed Track on Malaysian Project**.** Efforts of Dr.Siew Ann Tan, Assoc. Professor, and Dr. Ganeswara Rao Dasari, Asst Professor at NUS, Singapore is duly acknowledged, for Research Consultancy done for DRB- Hicom Bhd, Malaysia.

(ii) Specifications , as per GE Guideline 14 Subgrade for Heavy Axle Load, by RDSO were finalized & adopted by Railway Board in 2009, for Track Formation for DFCCIL Project.

[Relevant Units: 100 kPa = 10 t/m^2 = 1 kg/ cm^2 = (1/10) N/ mm^2; 1 Pa = 1 N/m^2]

The views expressed in this paper are based on Authors' personal opinion and does not necessarily imply any official decision of RDSO, or Railway Board, Indian Railways.

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E- Procurement on Indian Railways

By
C.M.Gupta*

E-procurement-
E-procurement (electronic procurement, sometimes also known as supplier exchange) is the business-to-business or business-to-consumer or business-to-government purchase and sale of supplies, work, and services through the Internet as well as other information and networking systems, such as electronic data interchange and enterprise resource planning.
The e-procurement value chain consists of indent management, e-Informing, e-Tendering, e-Auctioning, vendor management, catalogue management, Purchase Order Integration, Order Status, Ship Notice, e-invoicing, e-payment, and contract management. Indent management is the workflow involved in the preparation of tenders. This part of the value chain is optional, with individual procuring departments defining their indenting process. In works procurement, administrative approval and technical sanction are obtained in electronic format. In goods procurement, indent generation activity is done online. The end result of the stage is taken as inputs for issuing the NIT.
Elements of e-procurement include request for information, request for proposal, request for quotation, RFx (the previous three together), and eRFx (software for managing RFx projects).

1.0 History:

It was first used by IBM in the year 2000, when the company launched it's Replenishment Management System and Method, created by Mexican engineer Daniel Delfín, who was then the procurement director at IBM's largest production plant, and Alberto Wario, an IT programmer. The system was designed to solve IBM's complex procurement process for the plant in Guadalajara, Mexico, the largest IBM laptop producing plant in the World, with a production value of 1.6 billion dollars a year. Three years after the system was implemented, the production of the plant grew to 3.6 billion dollars, after which, the company used the system in Germany, and later sold using licenses to other companies around the World.

E-procurement in the public sector is emerging internationally. Hence, initiatives have been implemented in Ukraine, India, Singapore, Estonia, United Kingdom, United States, Malaysia, Indonesia, Australia, European Union and other countries.

Public sector organizations use e-procurement for contracts to achieve benefits such as increased efficiency and cost savings (faster and cheaper) in government procurement and improved transparency (to reduce corruption) in procurement services. E-procurement in the public sector has seen rapid growth in recent years.

E-procurement projects are often part of the country's larger e-Government efforts to serve better its citizens and businesses in the digital economy. For example, Singapore's GeBIZwas implemented as one of the programmes under its e-Governmentmasterplan.The "Procurement G6" (an informal group six national central purchasing bodies) leads the use of e-procurement instruments in Public procurement.

One more example of successful incredible reform is shown by Ukraine Prozorro. It is a result of collaboration between Ukrainian government, business sector, and civil society. This system was developed by reputable international anti-corruption organization Transparency International Ukraine with a help of volunteers, NGOs, business community and state bodies of Ukraine, the WNISEF fund, the EBRD and other partners.

This field is populated by two types of vendors: big enterprise resource planning (ERP) providers which offer e-procurement as one of their services, and the more affordable services focused specifically of e-procurement.

2.0 Scenario in Indian Railways-

Indian Railways took steps towards e-procurement. In 2008-09 downloadable tender form was made compulsory. In 2010 stores e tender were started.

In Railway budget of 2011-12, thrust was given on use of latest technology giving emphasis on e-procurement and e-auction to ensure transparency and economy and stated in para 47 (viii) of budget document.

Para 47 . Madam, the thrust of the Budget this year is also on modernisation. A number of measures will be taken to usher in latest technology. I would like to spell out some of these steps for improving the efficiency of the system that will ultimately benefit our customers:-

**Senior Professor/Br.3,*
IRICEN Pune

viii. E-procurement and e-auction to ensure transparency and economy.

In Railway budget of 2012-13 also emphasis was given on e-procurement and e-auction which has exclusive para on this as under:

Para 101. Indian Railways have a highly professional procurement protocol and a codified and transparent system of decision making to procure the required products at reasonable prices. Yet there is scope for further improvement. To provide further transparency and efficiency to the procurement process, the system of e-procurement has been implemented for purchase of stores in the Zonal Railways Headquarters and production units. These initiatives are being expanded further for including the field units within the ambit of this process. Feasibility of including works tenders also within the ambit of e-procurement is being explored. In addition to this, a pilot project for e-auction of sale of scrap has been successfully conducted on Northern Railway and this would be expanded and rolled out on other units during 2012-13, thereby considerably improving transparency, efficiency and wider reach for this important activity.

In Railway budget 2014-15 on this aspect it was stated that -

Para XXI. TRANSPARENCY IN RAILWAY FUNCTIONING

2. Strategic Procurement Policies will be adopted to make the procurement process transparent and most efficient. E-procurement will be made compulsory for procurements worth Rs. 25 lakhs and above.

In Railway budget of 2016-17 greatest emphasis was given on transparency. In this regard para 115 of budget document is reproduced below -

Para 115. In order to provide a thrust to transparency, e-procurement value chain is being expanded to cover all Divisions, Depots and Workshops.

3.0 E-procurement in works contracts-

Detailed instructions were issued vide Railway Boards letter no. 2014/CE-I/WP/5 dated 03.09.2015 for implementation of e-procurement system in works contract on Indian Railways. Web based system for e-tendering in works contracts on IR was inaugurated and launched by Hon'ble MR on 01.02.2016. E tendering for works contract has been started from 2016.

CRIS has developed software for e-procurement of stores and works and maintaining the site www.ireps.gov.in.

Now all tenders are to be done through IREPS. In year 2017-18 (upto 08.02.18), 174652 tenders (works + stores) were opened through IREPS website Upto 20.02.18, 29343 works tenders have been dealt on IREPSvaluing Rs. 72019.70 Crs.

Requirements for e tendering through IREPS are as under:-

Prerequisite for Vendors-

- Vendors need to have valid **Class III Digital Signature Certificate**in Firm's name issued by licensed Certifying Authorities for registration with IREPS.
- They also need to have a computer with Internet browser (IE 6 to IE 9) and internet connectivity. Without valid Digital Signature Certificate, User ID and Password, vendor cannot participate in E-tenders.
- Vendor must open "New Vendors" link from Home page and fill login registration form to obtain User ID and password for future use and direct participation in E-tenders.

Prerequisite for Railways-

- CRIS has created various departments under each Railway/Division as per Railways organisation structure.
- Every department shall have an admin who will do all admin function for IREPS.
- Admin shall have a DSC (Digital Signature Certificate) and a DEC (Digital Encryption Certificate) (in two copies).
- Admin shall get himself registered as admin with CRIS by sending an authorisation letter from head of the office (PCE/DRM/Director).
- Admin can create his organisation in IREPS on his own.
- Finance also need to register on IREPS with DSC.

Features of IREPS

- All types of tenders can be created in IREPS.
- SOR/USSOR can be uploaded.
- Eligibility criteria can be uploaded.
- General and Special conditions can be uploaded.
- Drawings and Documents (pdf only) can be uploaded.
- Date and time of opening can be set.
- System calculates EMD itself.
- Vendor can be tagged.
- Uploaded tender is encrypted to make it secure. It need to be decrypted to download.

- Vendor has to pay Cost of tender form and EMD through payment portal. No paper instrument is allowed.
- Vendor has to upload pdf documents wherever demanded by Railway.
- Vendor can also upload all other documents which he wants Railways to see.
- Vendor can fill their rate and upload. The rates can be changed till closing time. Last updated rates are valid.
- Tender can be opened online anytime after opening date and time by two officials.
- DSC and DEC will be required to open a tender.
- Once opened comparative statement is generated by system.
- Payment reports are generated.
- Briefing Note is also generated by the system.

4.0 Advantages of E- Procurement system

Implementing an e-procurement system benefits all levels of an organization. E-procurement systems offer improved spend visibility and control and help finance officers match purchases with purchase orders, receipts and job tickets. An e-procurement system also manages tenders through a web site. This can be accessed anywhere globally and has greatly improved the accessibility of tenders.

The manual system of tendering has problems regarding non receipt of tenders, clerical mistakes, inordinate delays in tender processing; Tampering/ Misplacement of tender files etc. Further there is lack of adequate transparency and discretionary treatment in tendering process. There may be proliferation of agents/ local offices for various tender related works like purchase of tender document, submission of the bid and attending the bid opening etc. Infructuous expenditure in preparing tender document in physical form, travel by bidders, communication, paperwork, postage/courier etc. is physical and financial barriers in the whole process. Bidders may be prevented from dropping tenders and participation in tender opening at some of the places resulting in complaints.

Benefits have been achieved by Indian Railways and vendors/ contractors due to implementation of e-procurement system, which are as under:-

Benefits to the buying organization

- Improved image and transparency of the buying organization.
- Savings in cost of purchase.
- Reduced paper work.
- Improved decision-making.
- Audit trail
- Reduction in procurement cycle time.
- 24*7 availability.
- Wider choice of suppliers.

Benefits to vendors/ contractors

- Centralized information of all the business requirements of goods/ labour.
- Information regarding corrigendum (tenders).
- Reduction in cost of travel in collection of tender documents, dropping of bids and attending tender opening event.
- Greater confidence due to transparency and fairness in purchase process.

IREPS developed by CRIS is a user friendly and menu driven web based software where with a basic knowledge of computer, NIT can be created, published, offers can be made by prospective bidders and tenders can be opened on line. Brief note can be prepared on line. Further work for tender committee and acceptance of tenders on line is under implementation. Various reports can be seen by the higher ups for better management of tender finalization. Software also supports online management of contract billing and payment tacking.

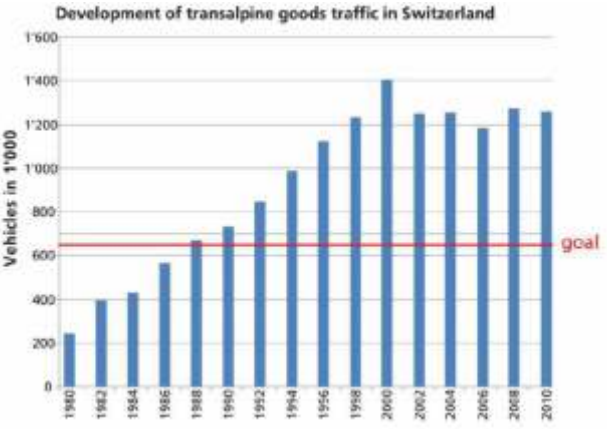
Gotthard Base Tunnel – The Longest Rail Tunnel in world

By
R. K. Shekhawat*



1. A Brief about Gotthard Base Tunnel

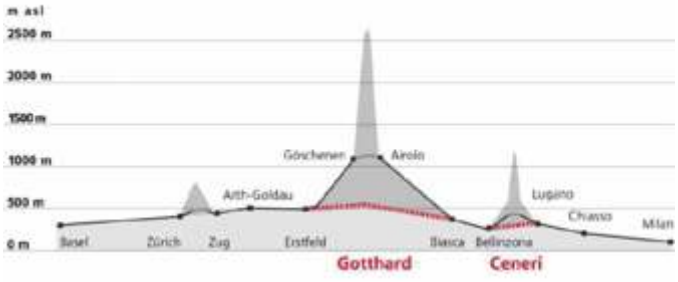
The old Gotthard railway line in Switzerland, constructed in year 1882, is an important trade route through the Alps from northern to southern Europe, transporting around 26 million tonnes of freight every year. Trains and volume of freight transported on this route was increasing.



Considering the importance of an efficient rail system on the Gotthard axis, for the rest of Europe, the 57 km long Gotthard Base Tunnel (GBT)is a major infrastructure project in Switzerland, planned to bringnorthern and southern Europe closer. It is part of a New Rail Link through the Alps (NRLA) including two other base tunnels – Lötschberg and Ceneri. Switzerland's neighbours, Germany and Italy, bore the majority of the costs of the original Gotthard rail tunnel so that they could reap the benefits of an improved north-south link. The Gotthard Base Tunnelhas been financed solely by Switzerland.



With very flat gradient (0.70%), the new twin-tube Gotthard tunnel can carry longer and heavier trains as compared to the existing line.

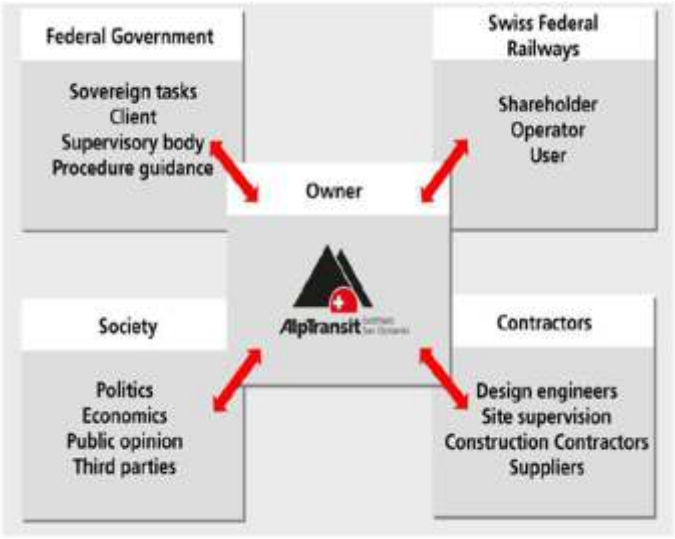


The new line will reduce the route between Altdorf and Bellinzona by 30 kms, allowing trains to travel more quickly through the Alps. The line will be fully completed with opening of the Ceneri base tunnel in year 2020, after which time the journey between Zurich and Milan will be shortened by nearly an hour.

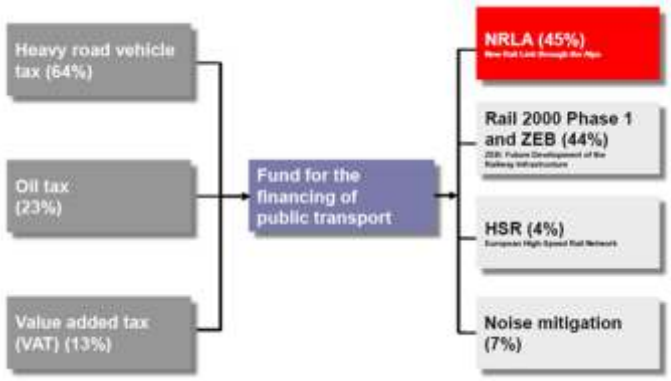
The Gotthard base tunnel surpasses the 53 km long Seikan tunnel in Japan to become the longest rail tunnel in the entire world. At 50 km, the Channel Tunnel between France and the UK comes at third. With 2300 m of rock above it, the Gotthard is also world's deepest rail tunnel.

The role and responsibility of various agencies involved, in construction/maintenance/ operation of the tunnel, is as under:

**Sr.Professor / Projects / IRICEN*



The funding pattern for construction of new Gotthard Base tunnel (GBT) was as under:



2. Features of the tunnel

The salient features of this tunnel are as under:

(i) The north portal is located at Erstfeld and south portal is at Bodio.

(ii) Consists of two 57 km long two single track tubes of diameter 9.0m to 9.5m each, with 178 Cross-passages providing connection between two tunnel tubes at every 325 m.

(iii) Two multifunction stations (MFS) at Faido and Sedrun, divide both tubes into three approximately equally long sections. The multifunction stations act as emergency-stop stations and have two track crossovers and water points for fire-fighting and rescue trains.

(iv) Including all cross-passages, access tunnels and shafts, the total length of the tunnel system and electrified track is 153 km.

(v) Numerous built structures, such as underpasses and bridges, were constructed for the tunnel approaches.

(vi) There isa 13 km long over-ground section which crosses inhabited areas, roads, rivers and agricultural land.

(vii) Ballasted track length 31 km, Ballastless track length (incl. MFS tunnel crossover) 115 km, Concrete 131000 m³, Rails (incl. MFS tunnel crossover) 290 km and 43 Points and Crossings in the tunnel.

(viii) Having 360 Axle counters, 500 Km of drainpipes, 900 ETCS beacons, 7200 Lights and 1900 Electrical cabinets.

(ix) Designed for useful life of 100 years.

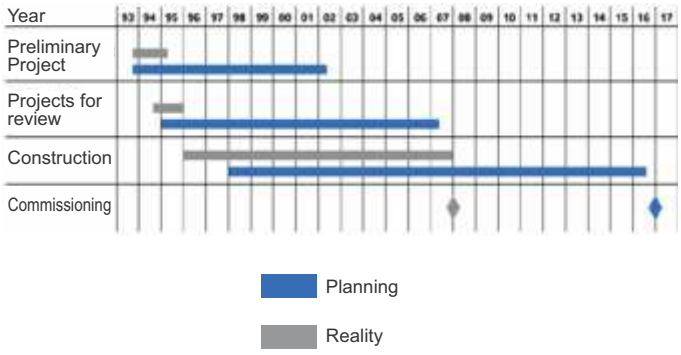
(x) Minimum radius of horizontal curves – 5000m.

(xi) Runs through alps at average of 500-550m above MSL (more than 1000m above MSL-30 km length, more than 1500m above MSL-20 km length and more than 2000m above MSL- 5km length).

3. Construction of the tunnel

Construction of this line was approved by the public of Switzerland in a referendum in year 1992.More than 90% of ground encountered was crystalline rock (strong Igneous and Metamorphic rock with high strength), broken by narrow Sedimentary Zones.Main danger during Tunnelling was rock burst, instability of rock wedges and water inflow. Short fault zones were also encountered for about 1100 m length.Building the tunnel through gneissic rock and granite, including through a large number of problem areas, represented a major technological achievement. Total volume of excavation was about 13.3 Million m3.Protective measures against noise, dust and floods, as well as for nature conservation, were as important challenges as the technical implementation of the new railway line.

After a construction period lasting 17 years, the work of the planners, tunnellers, civil engineers, electricians, electronics specialists and many other people came together to produce a modern high-performance rail system deep under the Alps.The opening of the Gotthard Base Tunnel took place on 01.06.2016 and scheduled commercial services began on 11.12.2016.



4. Operational aspects of the tunnel

The Gotthard Base Tunnel provides a quicker and more reliable link between north and south Europe for both people and goods. Faster, more frequent and more convenient services as well as new and modern rolling stock will considerably increase the transport quality on the north-south axis. Journey time between the German-speaking part of Switzerland and Ticino will be around 25–40 minutes shorter (depending on the route).Customers will also benefit from more seats. The improvements will take effect gradually from the end of year 2016 and provide their full benefit from the end of year 2020. At the same time, SBB (Swiss Federal Railway) will actively market the Gotthard region and the mountain route. In total, SBB expects demand for passenger services to almost double by year 2025, with passenger numbers increasing from the current figure of 9000 people to approximately 15000 people per day.

When it comes to freight traffic, the new Gotthard tunnel will bring increased capacity, faster services and greater reliability. SBB Cargo customers will receive efficient, congestion-free and environmentally friendly solutions for their logistics requirements.

The maximum speed permitted for passenger trains is 249 kmph but as a general rule, the passenger trains travel at a speed of 200 kmph because the increase in speed differentialbetween freight and passenger services on the same route decreases the line capacity of the route. With this, six freight train paths can be accommodated per hour in each direction (after opening of the Ceneri Base Tunnel), as required by law. For the time being, four freight trains and up to two passenger trains will run per hour in each direction every day. Journey through the tunnel,by passenger train, takes about 20 minutes.In the event of delays, the speed can be increased provided that the rolling stock and the operating situation allow for this.Freight trains must travel at a minimum speed of 100 kmph in order to achieve the required capacity of two passenger trains and six freight trains per hour in each direction. During passenger service operating hours, only 5 train paths will be offered every two hours rather than 6, because long-distance trains will be stopping every two hours at Altdorf, the capital of the canton of Uri, meaning that there is no capacity for the 6th train path for freight services. Overall, there is a freight transport capacity of 260 train paths per day.

The new Gotthard tunnel was planned as a freight tunnel from the outset, as is clear from the usage concept, i.e. up to 6 train paths for freight services and 2 train paths for passenger services per hour in each direction (following the opening of the Ceneri Base Tunnel).This allocation of capacity was fixed right at the start of the planning stage and will not change when the tunnel comes into operation. The allocation is a reflection of integrated passenger and freight service planning.Capacity planning for the new Gotthard Base Tunnel also provides the model for future plans regarding network usage, which will be a feature of the new legislation on freight traffic which is scheduled for discussion by the Federal Assembly.

5. Maintenance aspects of the tunnel

The large and highly complex tunnel system of the longest railway tunnel in the world, complete with its many technical installations needs to be maintained properly. Maintenance work is scheduled for the Saturday and Sunday nights (closed for eight hours) and Monday nights (closed for six hours).This will involve closing one of the tunnel tubes for commercial operations on each occasion.All maintenance work on the system components, which cannot be carried out from an external location via remote access or by means of diagnostic vehicles travelling through as a normal train journey, will be carried out in this period. Examples include maintenance and cleaning work on drainage systems, electro-mechanical installations (tunnel ventilation, cross-passage doors etc.) and railway infrastructure (track, contact lines, safety systems etc.).

Maintenance cost of the tunnel is just under CHF (Swiss Francs) 40 million per year. Maintenance of the structures and installations, which is funded by the SBB's NRLA guarantee credit (e.g. maintenance centres, new signal boxes in the north and south, substations) is aboutCHF 4 million per year.Operational cost is approximately CHF 24 million per year (including operation& intervention, operation of electrical and telecommunications systems and IT). Thus, total maintenance and operating costs of the tunnel is just under CHF 68 million per year.Maintenance and operating costs are funded through the 2017–2020 performance agreement with the federal government.

6. Safety aspects during operation in the tunnel

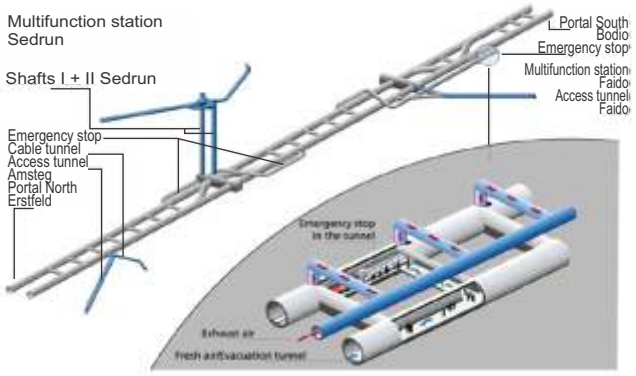
The Gotthard Base Tunnel features state-of-the-art safety systems to protect passengers, staff and the tunnel itself. With European Train Control System ETCS L2, trains can travel safely at high speed and at 3-minute intervals. Wayside train monitoring systems, which are installed close to the track and transmit a range of measurement data to an analysis system,

automatically detect irregularities in passing vehicles before the trains enter the tunnel. If any vehicle irregularities are detected, information is sent to rail service staff and to the wayside train monitoring system intervention centre in Erstfeld. They then decide on the measures which are required in order to ensure operational safety. The following measurement systems are used to monitor trains round the clock:

(i) Hot box and brake-locking detectors: detect overheating axle bearings and brakes which have got stuck.
(ii) Fire and chemical detectors: detect fire as soon as it starts and any leakage of hazardous goods.
(iii) Wheel load checkpoints: measure load displacement, overall gross tons and wheel roundness.
(iv) Profile clearance and aerial detection: monitor the permitted clearance profile and protruding aerials.
(v) Uplift measurement: detection of defects on pantographs in order to protect the contact line.

Collisions are prevented thanks to the tunnel design with its separate tunnel tubes for each direction of travel. There are two emergency stop stations to allow for evacuation procedures.

In the event of an incident, such as a fire in a train or a fault in the Tunnel, whenever possible the affected train travels out of the tunnel into the open air. If this is not possible, the train driver halts the train at one of the emergency-stop stations. Rolling stock is fitted with emergency features which enable it to reach these emergency stop stations. This means that trains are fitted or upgraded with technical equipment which allows them to continue traveling a certain distance even after a fire has broken out in the train. If the train stops outside the emergency stop station, positive pressure can be applied to the adjacent tunnel tube to protect people. There are cross-passages into the adjacent tube every 325 m, which allows for fast access into a safe area. Two ventilation units in Sedrun and Faido as well as 24 jet fans at the tunnel entrances supply and extract air in the event of an incident.



There is an open water conduit system in each tunnel tube, which is fed with 5 litres of water per second (continuous supply), so that contamination and hazardous substances can be transported to the retention basins in front of the tunnel entrance. Deflagration in the tunnel can therefore be prevented.

If the train has to stop, special infrastructure is in place to help passengers get themselves to safety. Emergency lighting, handrails, raised walkways (35 cm above the upper edge of the rails), signs, fresh air supply and extraction system for any combustion gases as well as cross-passages to side galleries have all been provided.

State-of-the-art fire-fighting and rescue trains are on stand-by at the Erstfeld and Biasca maintenance and intervention centres. The aim is to reach the site of an incident anywhere in the Gotthard Base Tunnel and to have started the rescue procedure within 45 minutes. People should be evacuated from the tunnel within 90 minutes.

7.Some photos of the completed tunnel



View of the Gotthard area in Alps

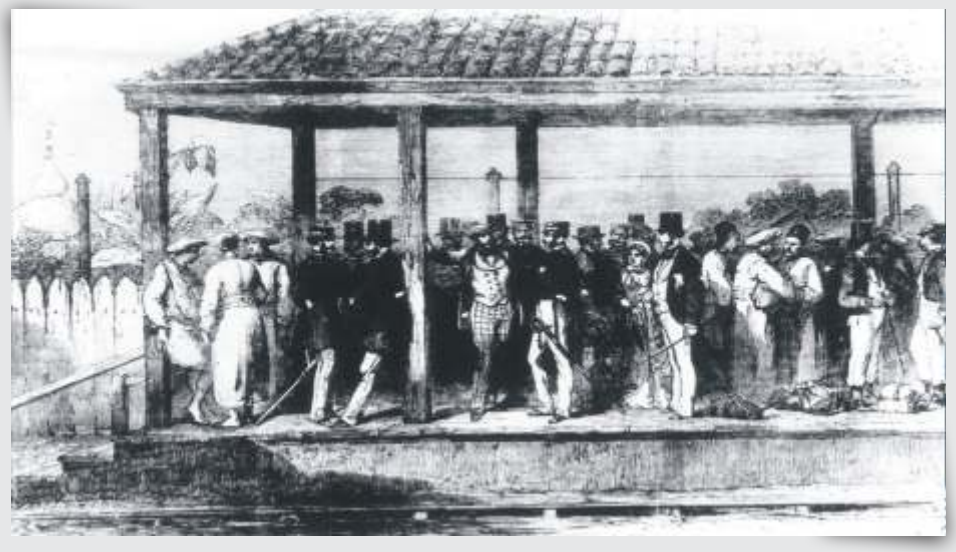


View ofsouth end portal at Bodio



Completed tunnel with Lighting

Ref.: Information from the website of AlpTransit Gotthard Ltd. (www.alptransit.ch) and other information available in public domain.



Byculla Station 1853

Concept of Concrete Mix design

By
Ramesh Pinjani*

Synopsis*: The paper deals with step by step method of concrete mix design including concrete with chemical & mineral admixtures. The concepts involved are included as explanatory note under the step itself. The relevant references from other codes i.e. concrete bridge code, IS-456 & IS-383 is also placed under the relevant step/ para for better understanding of subject.*

Step 1 Target Strength for mix
TMS = f_{ck} + 1.65 x S,

Where
TMS is target mean compressive strength at 28 days in N/mm^2
f_{ck} is characteristic compressive strength at 28 days in N/mm^2
S standard deviation in in N/mm^2 (Based on test results of minimum 30 samples)

Note - Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in the table below, may be assumed for the proportioning of mix in the first instance.

As soon as the results of samples are available actual calculated standard deviation shall be used and the mix proportioned properly.

Assumed Standard Deviation (Ref: – Table 1 – IS 10262:2009)

GRADE OF CONCRETE	M10 & M15	M20 & M25	M30 to M55
Assumed Std. Deviation	3.5	4	5.0

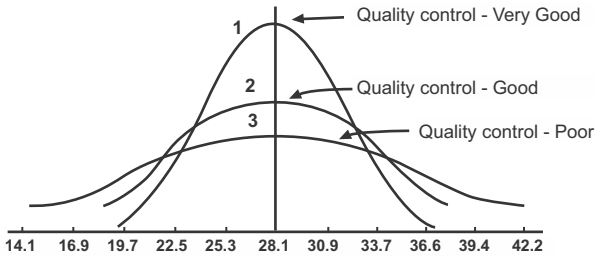
Explanatory Note:

i) Concept of Standard Deviation

$$S.D.\ (\sigma) = \sqrt{\frac{\sum (x-\mu)^2}{n-1}}$$

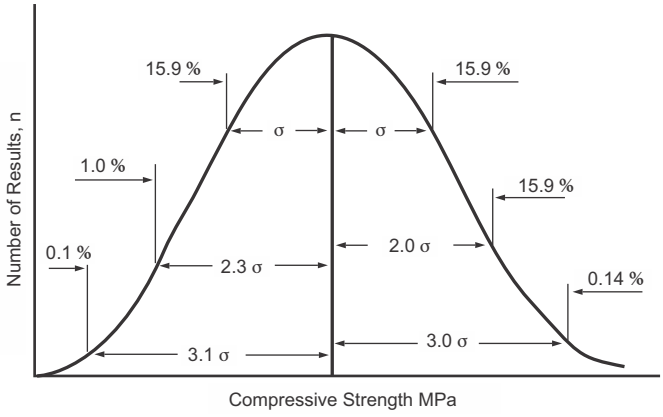
Where x = cube strength value of sample, n = total no. of samples, μ = Arithmetic mean of strength value of 'n' samples.

Standard Deviation represent spread of results from the mean. The less value means higher degree of reliability and lower probability of failure and higher value means higher probability of failure, poor quality control.



ii) Concept of normal distribution curve

A normal distribution curve is defined by two parameters viz. The mean strength and standard deviation. The mean strength is defined as arithmetic mean of set of actual test results. The standard deviation is a measure of spread of results. Standard deviation increases with increasing variability.



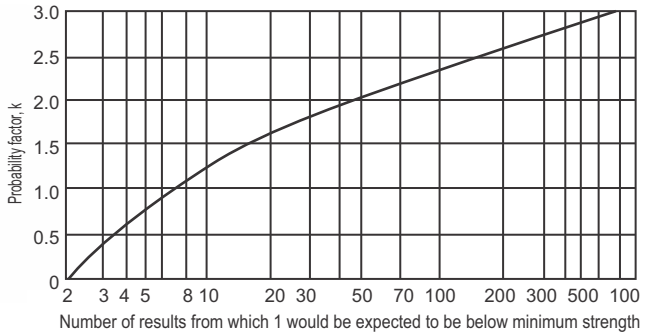
From the normal distribution curve above, it is seen that:
50% results are expected to be lower than mean strength.
15.9% results are expected to be lower than strength value = meanstrength - **1** x σ
2.3% results are expected to be lower than strength value = meanstrength - 2 x σ

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IRICEN PUNE

iii) Concept of probability factor K

The probability factor K depends upon percentage of results falling below the minimum required strength for e.g. out of 20 results if one sample result is falling below the minimum required strength i.e. 5% results falling below the minimum strength then the value of probability factor is 1.65.

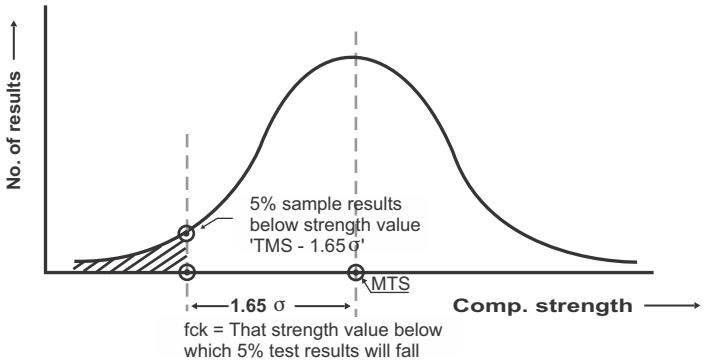
The probability factor for % of failures (lower than min. specified value) / tolerance in graphical & tabulated form is placed here under:



1 No out of n below fck n	2	5	1σ	10	20	40	2σ	100	3σ
% below fck	50	20	15.9	10	5	2.5	2.3	1	0.14
Probability factor k	0	0.84	1	1.28	1.65	1.96	2	2.33	3

Logic for target mean strength (T.M.S) = fck + 1.65σ

If we target trial mix for value = fck then 50% test results are expected to be below fck, but fck means we should have only 5% test results below the fck. Therefore, the target strength for the trial mix has to be much higher so that only 5% test results are less than fck.
Suppose the Target mean strength is TMS then 5% sample test results shall be lower than strength vale equal to 'TMS – 1.65 x 's (Ref fig below)



Because TMS – 1.65 x σ means that strength value below which only 5% test results will come. This should be made equal to fck because the definition of fck says that strength value below which 5% test results will fall.

Therefore, TMS – 1.65 x σ = fck
→ TMS = fck + 1.65 x σ Where σ = standard deviation, denoted by 'S' also so
→ **TMS = fck + 1.65 S**

iv) Grade of concrete specified

Grades of Concrete (Ref: – Table 2 – IS 456:2000)

GRADE	ORDINARY CONCRETE			STANDARD CONCRETE						
	M10	M15	M20	M25	M30	M35	M40	M45	M50	M55
fck	10	15	20	25	30	35	40	45	50	55

GRADE	HIGH STRENGTH CONCRETE				
	M60	M65	M70	M75	M80
fck	60	65	70	75	80

Grades of Concrete (Ref: – Table 2 – Concrete Bridge Code)

GRADE	M10	M15	M20	M25	M30	M35	M40	M45	M50	M55	M60
fck	10	15	20	25	30	35	40	45	50	55	60

Step 2 – Selection of water cement ratio

Different cements, supplementary cementitious materials (mineral admixtures) and aggregates of different maximum size, grading, surface texture, shape and other characteristics may produce concretes of different compressive strength for the same free water cement ratio.

In absence of such data, the preliminary free water cement ratio (by mass) corresponding to the target strength at 28 days may be selected from the established relationship, if available. (In this context following table can be used.)

General Relationship free w/c & Comp. strength of Conc. (in MPa).

Gen Strength Curve	51	43	37	32	27	23	19
OPC-43	-	42	35	29	25	21	17
OPC-53	-	51	44	37	31	26	22
W/C	0.3	.35	0.4	.45	0.50	0.55	0.60

Otherwise the water cement ratio given in Table 5 of IS 456/Table 4a of Concrete Bridge Code for respective environment exposure conditions (as reproduced here under) may be used as starting point.

Maximum Water Cement Ratio (Ref – Table 4a of Concrete Bridge Code)

Environment	Maximum Water Cement Ratio		
	(PCC)	(RCC)	(PSC)
Moderate	0.50	0.45	0.40
Severe	0.45	0.40	0.40
Extreme	0.40	0.35	0.35

Maximum Water Cement Ratio (Ref – Table 5 of IS 456: 2000)

Environment	Maximum Water Cement Ratio		
	(PCC)	(RCC)	(PSC)
Mild	0.60	0.55	Not Specified
Moderate	0.60	0.50	
Severe	0.50	0.45	
Very Severe	0.45	0.45	
Extreme	0.40	0.40	

Step 3 – Selection of water content

The water content of concrete is influenced by number of factors such as aggregate size, aggregate shape, aggregate texture, workability, water cement ratio, cement and other supplementary cementitious material type and content, chemical admixture and exposure condition.

The water demand will reduce with increase in aggregate size, use of rounded aggregate, increase in the proportion of coarse aggregate to fine aggregate, water reducing admixtures and reduction in slump requirement.

Maximum Water Content per cum of concrete for nominal max. Sizeaggregate (Ref – Table 2 of IS 10262:2009)

S.No	Nominal Max Size of CA	Maximum Water Content (Kg)	Applicable for angular coarse aggregate and 25-50 mm slump.
(i)	10 mm	208	
(ii)	20 mm	186	
(iii)	40 mm	165	

Effect of aggregate and slump on water content (Ref- Para 4.2 of IS 10262)

	Effect of aggregate/slump	Water content
I	a) Sub angular aggregate	Reduction by 10 kg
	b) Gravel with some crushed particle	Reduction by 20 kg
	c) Rounded gravel	Reduction by 25 kg
II	For every 25 mm increase in slump	+3% increase
III	a)Water reducing admixture	Reduction by (5-10)%
	b)Superplasticizers	Reduction by (20)%

Workability requirement (Ref – Concrete Bridge Code Para 5.3.1)

Placing conditions	Degree of Workability	Vee bee time	CF	Slump
Concreting of shallow section with vibration	V. Low	20 - 10 seconds	0.75-0.8	Not specified
Concreting Of light reinforced section with vibration	Low	10 - 5 seconds	0.8-0.85	Not specified
Concrete of light reinforced section without vibration or heavily reinforced section with vibration	Medium	5 – 2 seconds	0.85-0.92	25-75mm for 20mm aggregate
Concrete of heavily reinforced section without vibration	High	Not specified	Above 0.92	75-125 mm for 20mm aggregate

Explanatory Note:

i) Higher slump will require more water content

ii) The coarser particle size (40 mm) requires less water cement paste compared to smaller particle size (10 mm) because of the lesser surface area per unit volume of concrete

iii) The rounded aggregate has minimum voids i.e. 32-33% in comparison to angular aggregate having voids 38-40%. The lesser voids means minimum ratio of surface area to the volume thus requiring lesser cement paste. The rounded aggregate require lesser amount of water and cement paste for given workability.

Step 3a – Modification in water content due to use of chemical admixtures.

The water content calculated in step 3 above shall get modified, in case chemical admixtures are used. For e.g. a super plasticizer is proposed to be used having an expected reduction in the water content by say 30% then the water content required shall be 70% of calculated in step 3 above

Step 4 – Calculation of cementitious material

$$\text{Cementitious material} = \frac{\text{Water content (as fixed in step}-3/3a)}{(\frac{W}{C}\text{ratio}) \text{ (as fixed in step}-2)}$$

The cementitious material content so calculated shall be checked against the minimum cement content for the durability requirement and greater of the two values adopted.

In addition the cementitious material as worked out above shall not exceed the maximum value as defined in IS 456/Concrete Bridge Code.

Minimum cementitious material (kg/m3)

	Conc. Bridge Codetable 4(c)			IS 456 table 5		
	PCC	RCC	PSC	PCC	RCC	PSC
Moderate	240	300	400	240	300	Not specified
Severe	250	350	430	250	320	
Extreme	300	400	440	280	360	
	Maximum cementitious material = 500 kg/m^3– Para 5.4.5			Maximum cement content not including flyash and GGBS = 450 - IS 456 Para 8.2.4.2		

Step 4a – Modification in the cementitious content due to use of mineral admixtures

The quantity of cementitious material as calculated under step 4 above is the quantity of cement (if no mineral admixtures are used). In case mineral admixtures are used then Cementitious material calculated in Step 4 above shall normally increase by 10% due to use of mineral admixtures.

(Note: The amount of actual increase in cementitious material content is generally based on experience and field trials)

I.e. Cementitious material

$$1.1 \times \frac{\text{Water content (as fixed in step}-3/3a)}{(\frac{W}{C}\text{ratio) (as fixed in step}-2)} \text{ say £ .}$$

Suppose 25% of fly ash is to be used as cementitious material then quantity of fly ash shall be 0.25 x £. Quantity of cement = £-0.25 x £.

The various types of mineral admixture & % permitted for use in concrete is placed here under.

Maximum % Content permitted of mineral admixture

S.N	Mineral admixture	% Content Permitted	IS code reference
1	Fly Ash	It shall not be less than 10% & not more than 25% (10% – 25%)	Para-5 IS 1489 part-I -1991
2	GGBS	It shall not be less than 25% & not more than 65% (25% – 65%)	Para-4 IS 455 - 1989
3	Silica Fumes	It is usually used in the proportion of 5 -10% of the cement content of a mix.	IS 456 – para 5.2.1.2

Step 5 – Estimation of Coarse aggregate Proportion

For equal workability, the volume of coarse aggregate in a unit volume of concrete is dependent only on its nominal maximum size and grading zone of fine aggregate. The coarse aggregate used shall conform to IS 383. Coarse aggregate of different size may be combined in suitable proportions so as to result in an overall grading conforming to Table 2 of IS 383 for particular nominal maximum size of aggregate.

Volume of Coarse aggregate for unit volume of total aggregate (Ref: Table 3 – IS 10262)

S. N.	Nominal maximum size of aggregate	Volume of coarse aggregate per unit volume of total aggregate (p)				Remarks
		Zone IV	Zone III	Zone II	Zone I	
(i)	10 mm	0.5	0.48	0.46	0.44	Applicable for water cement ratio of 0.5, the proportion of coarse aggregate shall be increased by 0.01% for 0.05 reduction in w/c ratio
(ii)	20 mm	0.66	0.64	0.62	0.60	
(iii)	40 mm	0.75	0.73	0.71	0.69	
Note : The estimated coarse aggregate proportion shall be reduced by 10% for Pumpable concrete						

Explanatory Note:

Fine aggregate particle size become finer from Zone I to Zone IV i.e. zone IV has the finest particle size. Means more surface area of fine aggregate. It will require more cement paste for coating. Therefore for a given water cement ratio (as fixed in step 2) and quantity of cement overall (as fixed in step 4) surface area can be optimized by opting more coarse aggregate proportion i.e. for zone IV the coarse to total aggregate ratio will be maximum.

F.M/ Zone	ZONE I	ZONE II	ZONE III	ZONE IV
Fineness modulus	4-2.71	3.37-2.1	2.78-1.71	2.25-1.35

Table Grading of Coarse Aggregates (Ref IS 383 Table 2)

Sieve size	%age passing for single sized aggregate of nominal size			%age passing for graded aggregate of nominal size		
	40 mm	20 mm	10 mm	40 mm	20 mm	12.5 mm
80 mm	-	-	-	100	-	-
63 mm	100	-	-	-	-	-
40 mm	85 - 100	100	-	95 - 100	100	-
20 mm	0 - 20	85 - 100	-	30 - 70	55 - 100	100
16 mm	-	-	-	-	-	-
12.5 mm	-	-	100	-	-	90 - 100
10 mm	0 - 5	0 - 20	85 - 100	10 - 35	25 - 55	40 - 95
4.75 mm	-	0 - 5	0 - 20	0 - 5	0 - 10	0 - 10
2.36 mm	-	-	0 - 5	-	-	-

Physical properties	Concrete for wearing surface	Other concrete
Aggregate crushing value	30%	45%
Aggregate impact value	30%	45%
Aggregate abrasion value	30%	50%

Step 6 Estimation of Fine Aggregate Proportion:

The total absolute volume of coarse and fine aggregates (saturated surface dry condition) is computed by subtracting the sum of absolute volumes of cementitious material, water, chemical admixture and entrained air (if considered from unit volume of concrete). The total absolute volume of aggregates is given by

$$V_a = 1 - \left(\frac{1 \times \text{Mass of cement}}{1000 \times \text{Sp.gravity of cement}}\right) - \left(\frac{1 \times \text{Mass of mineral admix.}}{1000 \times \text{Sp.gravity of mineral admix.}}\right) - \left(\frac{1 \times \text{Mass of water}}{1000 \times \text{Sp.gravity of water}}\right) - \left(\frac{1 \times \text{Mass of chemical admixture}}{1000 \times \text{Sp.gravity of admixture}}\right)$$

$$\left(\text{Sp. Gravity of material} = \frac{\text{density of material}}{\text{density of water}} = \frac{mass}{volume \times density\ of\ water}\right)$$

$$\ldots \left(\text{Volume} = \frac{mass}{Sp.gravity \times 1000}\right)$$

Volume of fine aggregate content will be V_a x (1 – p).

Fine Aggregates Grading (Ref: IS 383 Table 4)

IS SIEVE	%AGE PASSING FOR			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90 - 100	90 - 100	90 - 100	95 - 100
2.36 mm	60 - 95	75 - 100	85 - 100	95 - 100
1.18 mm	30 - 70	55 - 90	75 - 100	90 - 100
600 micron	15 - 34	35 - 59	60 - 79	80 – 100
300 micron	5 - 20	8 - 30	12 - 40	15 - 50
150 micron	0 - 10	0 - 10	0 - 10	0 – 15

Note –

The fine aggregate grading becomes progressively finer from Grading Zone I to Grading Zone IV. Accordingly, the ratio of coarse aggregate to total aggregate should progressively increase from zone-I to Zone-IV.

The fine aggregate confirming to Grading Zone IV should not be used in RCC unless test has been made to ascertain the suitability of proposed mixed proportion.

For crushed stone sand the admissible limit on 150 micron is increased to 20%. This does not affect the 5% allowance permitted for other sieve sizes except 600 microns IS sieve.

All in Aggregate Grading (Ref IS 383 Table 5)

	IS SIEVE	80 MM	40 MM	20 MM	4.75 MM	600 microns	150 microns
%AGE PASSING OF ALL IN AGGREGATE OF	40 mm nominal size	100	95-100	45-75	25-45	8-30	0-6
	20 mm nominal size	-	100	95-100	30-50	10-35	0-6

Step 7 – Mix Calculations

a) Vol. of concrete = $1m^3$

b) Volume of cement = $\frac{1 \times \text{Mass of cement (calculated under step 4/4a)}}{1000 \times \text{Spcific gravity of cement}}$

c) Volume of water = $\frac{1 \times \text{Mass of water (calculated under step 3/3a)}}{1000 \times \text{Specific gravity of water}}$

d) Volume of chemical admixture = $\frac{1 \times \text{Mass of chemical admixture (as fixed in step 3a)}}{1000 \times Sp\ gravity\ of\ admixture}$

e) Volume of mineral admixture = $\frac{1 \times \text{Mass of mineral admix.(calculated under step 4a)}}{1000 \times \text{Specific gravity of mineral admix.}}$

f) Volume of all in aggregate (V_a) = a – (b + c + d + e)

g) Mass of coarse aggregate= V_a x p (as fixed in step 5) x sp. gravity of coarse aggregate x 1000

h) Mass of fine aggregate = V_a x (1-p) x specific gravity of fine aggregate x 1000

Step 8- Adjustment for Aggregate Moisture

Since the aggregates are batched on actual weight basis, the amount of mixing water to be added for concrete production is adjusted to take into account the water absorption and the current moisture content of coarse & fine aggregate to generate equivalent of saturated surface dry condition of the aggregates.

i) Corrected mass of coarse agg. = mass of coarse agg. (g) x $\left(1 + \frac{\%\ \text{moisture content in coarse agg.}}{100}\right)$

ii) Corrected mass of fine agg. = mass of fine agg. (h) x $\left(1 + \frac{\%\ \text{moisture content in fine agg.}}{100}\right)$

iii) Free water in aggregate = mass of coarse aggregate (g) x moisture content in coarse aggregate – water absorption value) + mass of fine aggregate (h) x (moisture content in fine aggregate – water absorption value)

iv) Corrected mass of water = mass of water calculated in step 3 / 3a – free water in aggregate(as calculated in sub para iii) above).

Step 9 – Mixed Proportions

	Cement	Water	Chemical admixture	Mineral admixture	Coarse aggregate	Fine aggregate
By weight						
For 1 bag of cement						

Step 10 Trial mixes

The calculated mix proportions shall be checked by means of trial mixes/ batches.

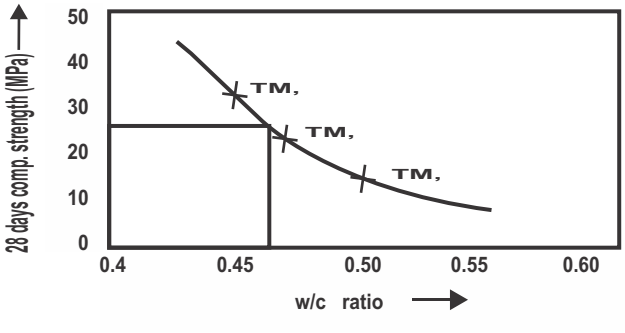
Workability of the Trial Mix No. 1 shall be measured. The mix shall be carefully observed for freedom from segregation and bleeding and its finishing properties. If the measured workability of Trial Mix. No. 1 is different from the stipulated value, the water and/or admixture content shall be adjusted suitably. With this adjustment, the mix proportion shall be calculated keeping the free water-cement ratio in the pre-selected value, which will comprise Trial Mix No. 2.

In addition two more trial mixes no. 3 and 4 shall be made with the water content same as trial mix no. 2 and varying the free water-cement ratio by ± 10% percent

of the pre-selected value.

Mix. No. 2 to 4 normally provides sufficient information including the relationship between compressive strength and water-cement ratio from which the mix proportions for field trials may be arrived at.

To achieve this, A graph between three w/c ratio (corresponding to trial mix 2,3,4) & their corresponding strength is plotted, to work out the w/c (including corresponding mix proportions) for the given target strength.



Example: An example illustrating the mix proportion for a concrete of M35 grade using chemical admixture & mineral admixture (fly ash) is given here under.

Input data

1. Grade of conc.	2.Cement type	3.Const. type	4.Environment	5. Max. size of C.A/type	6. F.A Zone	7. Slump
M35	OPC-53	RCC	Severe	20 mm, angular CA	Zone-II	100 mm
8. Mineral admixture	9. Chemical admixture/ % water red.	10. Sp. gravity cement	11. Sp. gravity fly ash	12. Sp. gravity admixture	13. Sp. gravity C.A	14. Sp. gravity FA
20%Fly ash	Super-plasticizers 25% water reduction	3.15	2.21	1.145	2.74	2.74
15. Moisture content CA	16. Moisture content FA	17. water absorption C.A	18. water absorption F.A	19. Remarks		
1%	2%	0.5%	1.0%	Pumpable concrete		

Solution:

Step 1:- Target mean strength for mix.	TMS = f_{ck} + 1.65 x S f_{ck} = 35, S = 5 for M35 grade of conc. TMS = 35 + 1.65 x 5 = 43.25 N/mm^2
Step 2:- Selection of water cement ratio	For OPC-53, for strength 44 N/mm2, w/c is 0.4, Check for max. w/c: For severe environ.& RCC, maximum w/c is 0.4 Hence adopt w/c = 0.4
Step 3:- Selection of water content	For 20 mm nominal coarse aggregate water content = 186 litres. Required slump is 100 mm, so add 6% water (@3% for each 25 mm slump over 50 mm slump Coarse aggregate is angular so no correction. Total water content = 186 x 1.06 = 197.16 litres
Step 3a:- Modification in water content due to use of chemical admixtures	Expected water reduction due to super plasticizer = 25%, hence modified water content = 0.75 x 197.16 = 147.87 say 148 litres.
Step 4:-Cementitious material = $\frac{\text{Water content (as fixed step-3/3a)}}{(\frac{W}{C}\text{ratio})\text{ (as fixed in step-2)}}$	Cementitious material= $\frac{148\text{ (as fixed in step 3a)}}{(0.4)\text{ (as fixed in step-2)}}$ = 370 kg

Step 4a:- Cementitious material calculated in Step 4 above shall increase by say 'A' % due to use of mineral admixtures i.e. 1.0A x $\frac{\text{Water content (as fixed step-3/3a)}}{(\frac{W}{C}\text{ratio) (as fixed in step-2)}}$	Total cementitious material = 1.1 x 370 = 407 kg (10% cementitious material increased due to use of fly ash) i. Fly ash = 0.2 x 407 = 81.4 say 80 kg. ii. Cement = 407 – 80 = 327 kg. iii Super plasticizer @ 2% by mass of cementitious material = 0.02 x 407 = 8.14 kg.
Step 5:-Estimation of C.A proportion (p).	For fine aggregate Zone II and 20 mm CA p = 0.62, but w/c = 0.4, add 0.02 (@ 0.01% for every 0.05 reduction in w/c over w/c = 0.5), so p = 0.64 Reduce p by 10% due to Pumpable concrete so p = 0.64 x 0.9 = 0.576 say 0.58
Step 6:- Estimation of F.A proportion = (1- p)	FA proportion (1-p) = (1 – 0.58) = 0.42
Step 7:- Mix Calculations $Va = 1 - (\frac{1 \text{ x Mass of cement}}{1000 \text{ x Specific gravity of cement}})$ $- (\frac{1 \text{ x Mass of mineral admix.}}{1000 \text{ x Specific gravity of mineral admix.}})$ $- (\frac{1 \text{ x Mass of water}}{1000 \text{ x Specific gravity of water}})$ $- (\frac{1 \text{ x Mass of chemical admixture}}{1000 \text{ x Sp gravity of admixture}})$	a) Vol. of concrete = **1m^3** b) Volume of cement = $(\frac{1 \text{ x } 327}{1000 \text{ x } 3.15})$ = **0.104** c) Volume of water = $(\frac{1 \text{ x } 148}{1000 \text{ x } 1})$ = **0.148** d) Vol. of chemical admix. = $(\frac{1 \text{ x } 8.14}{1000 \text{ x } 1.145})$ = **0.007** e) Vol. of mineral admix. = $(\frac{1 \text{ x } 80}{1000 \text{ x } 2.21})$ = **0.036** f) (V_a) = 1 – (0.104+0.148+0.007+0.036) = **0.705** Vol. of Coarse agg. = Va x p = 0.705 x 0.58 = **0.41** Vol. of fine agg. = Va x (1 – p) = 0.705 x 0.42 = **0.295** g) Mass of coarse agg. = 0.41 x 2.74 x 1000 = **1123 kg** h) Mass of fine agg.= 0.295 x 2.74 x 1000 = **808 kg**
Step 8:- Adjustment for aggregate moisture Free water in agg. = mass of coarse agg. (g) x moisture content in coarse agg. – water absorption value) + mass of fine agg. (h) x (moisture content in fine agg. – water absorption value) + Corrected mass of water = mass of water calculated in step 3 / 3a – free water in aggregate.	Corr. mass of coarse agg. = 1123 x (1 + $\frac{1}{100}$) = 1134 Corr. mass of fine agg. = 808 x (1 + $\frac{2}{100}$) = 824 Free water in aggregate = 1134 x (0.01 − 0.005) + 824 (0.02 − 0.01) = 13.91 Say 14 litres. Corrected mass of water =148 − 14 = 134 litres.

Step 9 – Mixed Proportions

	Cement	Water	Chemical admixture	Mineral admixture	Coarse aggregate	Fine aggregate
By weight	327	148	--	80	1134	824
In terms of 1 bag of cement	1	0.36 (w/c.m)	--	0.24	3.46	2.52

References:

1.Concrete Mix Proportioning guidelines (IS 10262-2009)
2.Concrete Bridge Code – September 2014
3.Code of Practice for Plain and Reinforced concrete IS 456-2000
4.Specifications for coarse and fine aggregate from natural sources for concrete IS 383-97.
5.Literature/ Information available on internet/ books on the subject.

Quality Control in Production of Concrete

By
Mahesh Dekate*

Synopsis:
Desired quality concrete can only be achieved with high quality control at various stages of making of concrete at site such as batching & mixing of ingredients, transportation, placing & compaction of green concrete, curing & removal time of formwork, besides selection & proportioning of ingredients. These various stages in production of quality concrete are discussed in this article with reference to CBC and relevant IS codes.

1.0 Batching (measurement of materials) of concrete ingredients

A proper and accurate measurement of all the materials used in the production of concrete is essential to ensure uniformity of proportions and aggregate grading in successive batches. For most of large and important jobs the batching of material is usually done by weighing. The batching equipment falls into 3 categories viz.manual batching, semi-automatic batching and automatic batching.

For most of small jobs, volume batching is adopted. In volume batching it is generally advisable to set the volumes in terms of whole bags of cement.

Important points:

1) To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixes on any site or in any one plant.
2) A competent person shall supervise all stages of production of concrete. Competent person is one who has been issued competency certificate by Divisional Engineer/Senior Engineer.
3) In proportioning concrete, the quantity of both cement and aggregate should be determined by mass. Water should be either measured by volume in calibrated tanks or weighed. Any solid admixture that may be added, may be measured by mass, liquid and paste admixtures by volume or mass.
4) The grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock piles.
5) In case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching for M20 grade concrete with the approval of the engineer, provided the materials and aggregates conform to the grading as per IS:383.
   Where weigh batching is not practicable, the quantities of fine and coarse aggregate (not cement) may be determined by volume batching for concrete of grade up to M25. If the fine aggregate is moist and volume batching is adopted, allowance shall be made for bulking in accordance with IS: 2386 (part III). (Ref: CBC 5.6.2.2)
6) It is important to maintain the water cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the engineer according to weather condition.

The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregates, IS: 2386 (Part-III) may be referred to. To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregate shall also be made

2.0 Mixing of concrete ingredients

The object of mixing is to coat the surface of all aggregate particles with cement paste, and to blend all the ingredients of concrete into a uniform mass. The mixing action of concrete thus involves two operations

(i) General blending of different particle sizes of the ingredients to be uniformly distributed throughout the concrete mass, and
(ii) Vigorous rubbing action of cement paste on to the surface of the inert aggregate particles.

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Classification of the mixers is based on the technique of discharging the mixed concrete as follows:

1. Tilting type mixer
2. Non-tilting type
3. Pan or stirring mixer

Important points:

1) The size of a mixer is designated by the total volume of mixed concrete in liters which can be obtained from the mixer per batch. The capacity of a mixer for a particular job should be such that the required volume of concrete per hour is obtained without speeding up the mixer or reducing the mixing time below the specified period and without overloading the mixer above its rated capacity, as given in IS : 1971-1985.

2) In the tilting-type mixer, the chamber (drum) which is generally bowl shaped or double conical frustum type, is tilted for discharging. The efficiency of the mixing operation depends upon the shape and design of the vanes fixed inside the drum. The tilting drum mixers are preferable for the mixes of low workability and for those containing large size aggregates.

3) The mixing time is reckoned from the time when all the solid materials have been put in the mixer, and it is usual to specify that all water has to be added not later than after one quarter of mixing time. The time varies with the type of mixer and depends on its size. Strictly speaking, it is not the mixing time but the number of revolutions of the mixer that are to be considered, because there is an optimum speed of rotation for the mixer.

4) The order of feeding the ingredients into the mixer depends on the properties of the mix and those of the mixer. Generally, a small amount of water should be fed first, followed by all the solid materials, preferably fed uniformly and simultaneously into the mixer. If possible, the greater part of the water should also be fed during the same time the remainder of water is added after the solids have been fed.

5) Concrete shall be mixed in a mechanical mixer. The mixer should comply with IS: 1791. The mixing shall be continued until there is a uniform distribution of the materials in the mass is uniform in colour and consistency. If, there is segregation after unloading from the mixer, the concrete should be remixed.

Note: For guidance, the mixing time may be taken as 1.5 to 2 minutes for normal mixer and 45 to 60 seconds for high rated batching plant. (Ref: CBC 5.6.3)

3.0 Transportation of concrete

The requirements to be fulfilled during transportation are:

1. No segregation or separation of materials in the concrete
2. Concrete delivered at the point of placing should be uniform and of proper consistency.

The principal methods of transporting concrete from the mixer are the following:

1. Barrows
   (a) Wheel barrows and handcarts
   (b)Power barrows or powered buggies or dumpers
2. Tippers and Lorries
3. Truck mixers and agitator Lorries
4. Dump buckets
5. The monorail system or trolley or rails.

The wheel barrows are suitable for small job and where the length of transport is small, and over muddy ground. The average quantity that can be carried in one wheel harrow is about 35 liters (80 kg). For transporting ready- mixed concrete truck mixers and agitator Lorries are used.

Important points: (Ref: CBC para 8.1)

1) Mixed concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which will prevent the segregation or loss of the ingredients. Concrete shall be deposited as near as practicable to its final position to avoid re-handling.

2) When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow in the chute. The slope of te chute shall be such as to allow the concrete to flow without the use of excessive quantity of water and without segregation of the ingredients. The delivery end of the chute shall be as close as possible to the point of deposit.

3) During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

4.0 Placing of concrete

The methods used in placing concrete in its final position have an important effect on its homogeneity, density and behavior in service.

The forms must be examined for correct alignment and adequate rigidity to withstand the weight of concrete, impact loads during construction without undue deformation. Before placing the concrete, the inside of the forms are cleaned and treated with a release agent to facilitate their removal when concrete is set.

The concrete should be placed in its final position rapidly so that it is not too stiff to work. Water should not be added after the concrete has left the mixer. The concrete must be placed as closely as possible to its final position. It should never be moved by vibrating it and allowing it to flow, as this may result in segregation

Important points:

1) While concreting in walls, footings and other thin sections of appreciable height, the concrete should be placed in horizontal layers not less than 150 mm in depth, unless some other thickness is specified.
2) The concreting should start at the ends or corners of forms and continue towards the center. In large openings, concrete should be placed first around the perimeter.
3) On slope, concreting should begin at the lower end of slope to avoid cracking due to settlement. The concrete in columns and walls should be allowed to stand at least for two hours before concrete is placed in slabs or beams which they are to support
4) While concreting a slab, the batches of concrete should be placed against or towards preceding ones, not away from them. Batches should not be dumped in separate individual piles
5) Under no circumstances concrete shall be dropped freely from a height of more than 1.5 meter. (Ref: CBC 8.2)

5.0 Compaction of concrete

The process of removal of entrapped air and uniform placement of concrete to form a homogeneous dense mass is termed compaction. The different methods of compaction are:

1. Hand rodding
2. Mechanical Vibrators.

IS 3558 – Codal Provision on immersion vibrators

(a) Applications of Immersion Vibrators

S.N.	Diameter of the Vibration Needle in mm	Applications
1	25 & 35	Plastic (workable) concrete in very thin members and very confined place and for fabrication of laboratory test specimens. Suitable as auxiliary to larger vibrators in prestressed work where cables and ducts cause congestion in the forms. Auxiliary vibrations adjacent to form of the pavement
2	40 & 50	Plastic (workable) concrete in thin walls, columns, beams, precast piles, light floors, light bridge decks and along construction joints. Auxiliary vibrations adjacent to forms of the pavements.
3	60	Plastic (workable) concrete in general constructions such as walls, columns, beams, precast piles, heavy floors, bridge deck and roof slabs. Auxiliary vibration adjacent to forms of mass concrete and pavements.
4	75	Mass and structural concrete deposited in increments up to $2m^2$ heavy construction in relatively open forms in power houses, heave bridge piles and foundations, and for auxiliary vibration in dam construction and forms and around embedded forms and reinforcing steel.
5	90	Mass concrete containing 150 mm aggregate deposited in increments up to $8m^2$ in gravity dams, large piers, massive walls etc. Two or more vibrators will be required to operate simultaneously to spread and consolidate increments of concrete of $4m^2$ or greater volume deposited at one time in the form .

1) **Height of concrete layer** – Usually concrete shall be placed in thickness not more than 600 mm and on initial placing in thickness not more than 150 mm. Very deep layers more than 600 mm should be avoided as far as possible because it may trap air rising up by vibration.

2) **Depth of immersion of vibrator –** The active part of vibrator shall be completely immersed in the concrete. The vibrator head shall be dipped to a further depth of 100 to 200 mm in the already consolidated lower layer for effective homogeneity and bond between layers.

3) **Spacing and number of insertion positions –** With concrete of workability of 0.75 to 0.85 compacting factor, the vibrator shall be operated at points 350 to 900 mm apart depending on the rated capacity of vibrator.

4) **Duration of vibration –** The duration of vibration in each position of insertion is dependent upon the height of layer, the size and characteristics of vibrator and the composition and work ability of concrete mix. It is better to insert the vibrating head at number of places than to leave it for a long time in one place.

   The vibrator head shall be kept in one position till the concrete is completely consolidated which will be indicated by formation at the surface of circular shaped laitance of cement mortar, stoppage of rise of entrapped air. The complete consolidation is readily judged by the experienced vibrator operator through the feel of vibrator due to resumption of frequency of vibration after the short period of dropping in the frequency when the vibrator is first inserted.

   For optimum compaction, a minimum time of vibration is 90 secs. For mixes with a compacting factor of 0.78 (stiff mixes). This time may be reduced if more workable mixes are

5) **Re-vibration -** Re-vibration is delayed vibration of concrete that has already been placed and consolidated. Except in case of exposed concrete and provided the concrete becomes again plastic under vibration, re-vibration is not harmful and may be beneficial. The repetition of vibration earliest after 1 hour from the time of initial vibration, the quality of concrete may improve because it re-arranges the aggregate particles and eliminates entrapped water from under the aggregate and reinforcing steel.

6) **Over vibration -** Generally, with properly designed mixes, extended vibration will be only waste of effort without any particular advantage to the concrete. However, where the work ability of concrete is high, for the conditions of placing or where the grading of aggregate is unsatisfactory, or where the quantity of mortar is in excess of the volume of voids in the coarse aggregate, over vibration will encourage segregation, bleeding or both causing the migration to the surface of the lighter and smaller constituents of the mix, thus producing a layer of mortar or laitance on the surface.

(b) External or shutter vibrators – These are clamped rigidly to the formwork at pre-determined points so that both the form and concrete are vibrated.

These vibrators can compact 450 mm from the face but have to be moved from one place to another as concreting progresses. These operate at a frequency of 3000-9000 rpm at an acceleration of 4g.

The shuttering must be stronger and more rigid and formwork should be absolutely water type.

In case parallel forms are used for casting of structural elements the distance between parallel shutters should not be more than 750 mm.

These are often used for pre-casting of thin in-situ sections which cannot be compacted by internal vibrators.

(c) Surface vibrators – These are placed directly on concrete mass, best suited for compaction of shallow elements. These should not be used when the depth of concrete is more than 250 mm.

Very dry mixes can be most effectively compacted with surface vibrator since vibration acts in the direction of gravity thereby minimising tendency for segregation.

Surface vibrators cause movement of finer material to the top and hence aid the finishing operation.

Most commonly used surface vibrators are pan or trowel vibrators (size 400mm x 600 mm on which an electric motor is mounted) and vibrating screeds.

Surface vibrator is carried out in straight continuous stroke with a 100-200 mm overlapping on previously compacted area. The vibration time at a position may be 30-60 seconds depending upon mobility of concrete.

(d) Vibrating table- It consists of rigidly built steel platform mounted on flexible springs and driven by en electric motor. Normal frequency of vibration is 4000 rpm at an acceleration of about 4g to 7g. The springs are so designed that they cause resonance, the mounts are rigidly clamped on the platform to enable the system to vibrate in unison. Vibration is considered adequate when the concrete develop a smooth level surface.

These are very efficient in compacting stiff and harsh concrete mixes required for manufacture of precast elements in factories.

Important points: (Ref: concrete bridge code para-8.3)

The vibrator can be internal or external type and depending on the shape and size of the member both the types may be used in combination.

When internal vibrators are used they shall be used vertically to the full depth of the layer being placed and shall penetrate into the layer below while it is still plastic to the extent of 100mm.

The vibrator shall be kept in place until air bubbles cease to escape from the surface and then withdrawn slowly to ensure that no hole is left in the concrete, care being taken to see that it remains in continued operation while being withdrawn. Vibrator should not be used to move the concrete as it can cause honey-combing.

The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about 1.5 times the radius of the area visibly affected by vibration.

6.0 Curing of concrete

This process of creation of an environment during a relatively short period immediately after the placing and composition of the concrete, favorable to the setting and the hardening of concrete is termed curing.

The rate of development of strength not only depends on the period of curing but also on the temperature during the period of curing. The optimum temperature during the curing period is 15°C to 38°C.

The increase in strength with increased curing temperature is due to speeding up of the chemical reactions of hydration. This increase affects only the early strengths without affecting ultimate strengths.

Important points:

1) IS: 456-2000 stipulates a minimum of seven day moist-curing while IS:7861 (PartI) -1975 stipulates a minimum of 10 days under hot weather conditions. High-early-strength cements can be cured for half the periods suggested for OPC. For Pozzolana or blast-furnace-slag cements, the curing periods should be increased.

2) **Moist Curing** – The concrete should be kept constantly wet for a minimum period of 14 (fourteen) days. (Ref: Concrete Bridge code para 8.4)

7.0 Stripping Time

Forms shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected at the time of removal of formwork.

Important points (Ref: Concrete Bridge code Para 6.4)

In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods:

	Walls, columns & vertical faces of all structural members.	24 to 48 hrs. As may be decided by the Engineer.
	Slabs (props left under)	3 days
	Beam soffits(props left under)	7 days
	Removal of props under slabs: i) Spanning up to 4.5m ii) Spanning over 4.5m	 7 days 14 days
	Removal of props under beams: i) Spanning upto 6 m. ii) Spanning over 6m	 14 days 21 days

For other cements, the stripping time recommended for ordinary Portland cement may be suitably modified.

Induction of Technology for Monitoring Railway Track to Optimize Track Maintenance in Indian Railways

By

T. V. Mahaganapathy*

Synopsis: *In our Railway Daily inspection by Key Man is a basic inspection in which, identification and rectification of defects are done simultaneously. Initially Key Man inspection was designed for a single line section with wooden/metal sleeper track. Subsequent to doubling of the section and upgrading to PSC sleeper work load on key man was reduced. Additional maintenance works like greasing of ERC and sealing of linear seat were included in the Key man work. There are stretches of track where adequate space for Key man or patrolman to take refuge on seeing train approaching is not available such locations become life threat to Key man and patrolman. There were instances of Key man, patrolman hit and run by train. Subsequent to introduction of multiple railway tracks threat to life of Key man and patrol man are increased. Technology based Monitoring is a solution available to take care of this problem. In this technical paper Machine vision method of monitoring is suggested for critical locations like multiple line, cuttings, Platform lines, track with inadequate cess. In these locations it is difficult for Key man, Patrolman to take refuge when train approaching. Ratification of defects if required on critical locations based on machine vision alarms will be done as work of short duration. In this method life threat to Key man, patrolman is eliminated and maintenance activity is optimized due to redeployment of human resources for other maintenance activities.*

1. Introduction: Human element in monitoring is existing in our railway .Human based monitoring is a threat at platform lines, multiple lines and track with inadequate cess. K. Man and Patrol man is at risk of hit and run over at these critical locations.



In this technical paper an attempt is made to analysis existing monitoring mechanism. Evaluation of technology based monitoring mechanism available worldwide is taken up to suggest a technology for monitoring on Indian Railway Track. The strength of the existing Key man monitoring of railway track is that inspection and correction of deficiency are simultaneously taken care. Driving of fallen ERC, tightening of loose bolts, renewal of broken fittings is completed along with inspection. In the proposed monitoring system list of missing, loose, broken fittings will be generated and alert sent for corrective action to the maintenance team and the correction in the critical stretch to be taken up as work of short duration. Threat to the existing Key man monitoring is that it is individual based and possibility for loss of life due to train hit and run over. Threat to the existing system is completely eliminated in Technology based monitoring. Some of the duties assigned to Key man like greasing of ERC, sealing of linear seat are already out sourced hence the proposed system will not affect existing aintenance activities.

2. Existing monitoring system by Key man

There are 5 different ways a Key man can perform his inspection.

1 Inspection by waking centre of the railway track.
2. Inspection by waking outside of LH rail of railway track
3. Inspection by waking in side of LH rail of railway track.
4. Inspection by waking in side of RH rail of railway track
5. Inspection by waking outside of RH rail of railway track

As per IRPWM Key man in case of single line has to walk on one rail and come back on another rail. On double line Key man will carry out one round of inspection on up line and then return along the DN line. By this provision in case of double line the inspection frequency is 50% of single line track. It is also to be noted that subsequent to up grading to PSC sleeper track additional works like ERC greasing is added. The concept of driving Key is gone with regard to ERC driving it is both sides of rails. The role of Key man inspection is grouped in to

1. Looking for dropped or loosened ERC and driving Dropped ERC/tightening loose ERC
2. Looking for Loose bolts/broken Bolts and tightening/renewal of broken bolts
3. Un manned LC clearing flange way
4. Observing USFD defect marked rails/welds and joggled fish plating.
5. Detecting broken rail/weld, track protection, and rectification

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6. Observing height gauge for its damages and looking out for shifting/damage to bridge girder and track protection

3. Drawbacks of existing monitoring system

Key man inspection was initially defined for wooden sleeper track single line section. In wooden sleepers keys were on inside of track hence Key man has to go inside of LH rail of railway track and come by inside of RH rail of Railway track so that dropped keys of the sleepers are visible can be driven immediately.

In the case of double line Key man walking on centre of one line can see ERC of inside only. If the Key man is walking on the centre of the track cannot see the outer fastenings.There were instances of Key man going to other end by road vehicles. There were also instances of Key mandoing greasing work in the morning and not doing inspection.

Considering this there is every possibility of overlooking dropped fastening.

When Key man walks on platform lines, multiple line sections, Lines with inadequate cess if train is approaching it will be difficult for a Key man to take safe refuge due to critical stretch of track. There is every possibility of hitting by a train. These factors make the critical stretch ineffective monitoring. Considering the threat and in-effectiveness it is proposed to monitor the track by any one of the following.

1. Way side monitoring at critical locations
2. Road cum rail vehicle for mounted monitoring system

The machine vision monitoring of the critical stretches can be taken up by eliminating manual inspections. Defects if any rectification can be taken up under the works of short duration based on alarms. Machine vision inspection is one way to set right Key Man hit and run issue.

The weakness of the existing Key man monitoring is that it is done only one time in a day. The frequency of monitoring is once in 24 hrs. Proposed monitoring system will be continuous for way side and need based for vehicle mounted.

Presently the recording car is available for standard gauge. To be inducted to our railway system with technological transfer so that we our self can produce the recording car for 1673 gauge. Initiallyone recording car is to be inducted in to the system. Subsequent to calibration and successful commissioning each railway may be provided with one recording car. Our ultimate aim will be to daily monitoring and Key man roll will be rectification of identified defects.

4. Correction to existing monitoring system

The role of Key Man inspection is grouped in to

1. Looking for dropped or loosened ERC and driving Dropped ERC/tightening loose ERC
2. Looking for Loose bolts/broken Bolts and tightening/renewal of broken bolts
3. Un manned LC clearing flange way
4. Observing USFD defect marked rails/welds and taking corrective action
5. Detecting broken rail/weld , track protection , and rectification
6. Observing height gauge for its damages and looking out for shifting/damage to bridge girder and track protection
7. Existing bolts we shall provide split pins so that nut dropping can be avoided.

Corrections required in the existing system are

1. Avoid dropping ERC by replacing worn out ERC with new
2. Provision of split pin for bolts to prevent nut working out
3. Need based cleaning of flange way
4. Phasing out unmanned LC.
5. Ballast covering the fittings to be cleared.

5. Inspection of Railway track has three aspects

1. Schedule of inspection
2. Quality of inspection
3 Rectification of defect detected

Presently we have technology with regard tomonitoring schedule of inspection. We do not have technology for monitoring quality of inspection. Our main aim is to find out technology that can be adopted so that quality of inspection can be fool proof and error due to human element is removed. Once inspection quality is improved that output can be used for rectification.

Presently the identification of defect is individual based. In the present system in some cases defects not getting recorded for analysis but getting attended.

On implementation of machine vision inspection Key man will be sent with specific task of making up deficiency at identified location. Hence he can go to that location and attend to the deficiency. On completion the compliance can be photographed.

1. Presently during night there is no monitoring of track other than monsoon patrolling.
2. Engineering deportment is depending on
3. Auto signal on
4. Driver reporting jerk

To detect rail/weld fracture happened during night. This method should change. Engineering deportment shall have their own mechanism to detect rail/weld fracture during night.

6. Already available mechanism for monitoring in Indian Railway

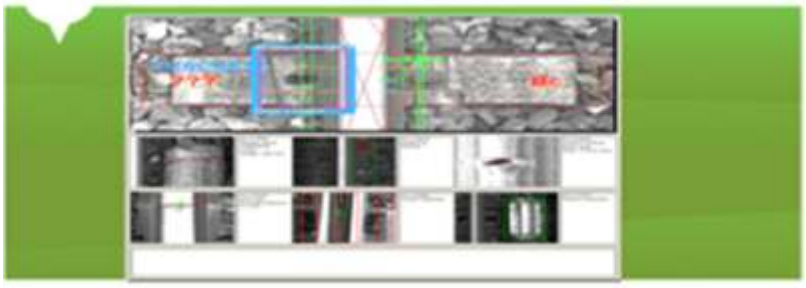
1. TMS

It replaces register and monitors the inspection schedule. Existing manual inspections are not modified. E-stick for patrolman tried to monitor patrol man but some of the problems listed during trial not sorted out. This method is not applicable for critical locations.

2. GPS Tracking system

It is one of the monitoring systems required and this can be included in the present system.

7. Technology available for monitoring

	Technology	Video Track Inspection System
	Used at	Italy Railway
	Features	1.Non-contact method of measurement 2.Laser optic principle 3.Video records 4.Accurate identification of the structural elements of railway track •Broken and missing fastenings are detected and report sent
	Photo	**VPR evaluation, examination report** 
	Technology	Automatic Inspection Of Railroad Track**:**
	Used at	European railway
	Features	1. Vision based and vibration based method 2. Continuous monitoring 3. Assessment of the condition of the rail tracks 4. Calibration to identify the fault location on the track 5. Inspections include detecting defects, missing bolt, and clips 6. The device capture videos of railway track component using vehicle-mounted Cameras, image enhancement using image processing and assisted automation. 7. In vibration based method the device will do calibration of the rail track by using vibration sensors
	Photo	 Fastenings LH & RH rails all four sides recorded

	Technology	Measurement of the track surroundings and track inspection
	Used at	US
	Features	The options available are 1.Ultrasonic car flaw detector 2.Contact less electronic track recording car 3.Video inspection of track 4.Evaluation of track geometry 5.Infrastructure surveillance of condition 6.HEAT insulated enclosure and evenly illuminated image at any time and any weather
	Technology	**Integral diagnostic systemRussian**
	Used at	**Railways**
	Features	1.It combines 7 diagnostic vehicles NDT,Track geometry, high speed track inspection, tunnel inspection, automation and telemetry vehicle, radio link inspection, georader for road bed inspection, visual defect detection system 2.Automatic transmission of data to external system 3.Storage of all the inspection results of diagnostic system in a single archive. 4.Provides maintenance and repair schedules. 5.All weather recording 6.Uses three testing methods ultrasonic, magnetic and optical 7.High resolution cameras for detection of visible defects 8.Multi channel NDT analyzer 9.Visual defect detection 10.P.Way component inspection system 11.Simultaneously analyze NDT data and track geometry. 12.Assessment of adjacent track 13.All season
	Photo	
	Technology	Beena Vision
	Used at	Unites States
	Features	1.machine vision system for rail and track inspection 2.The system can be attached to an inspection vehicle for field inspection of rai 3.One on-board computer for data acquisition and display up to six cameras composes the system, known as Surfview 4.The system also designed to detect missing, worn or broken track components. 5.GPS Based 6.Way side 7.Road cum rail Vehicle mounted
	Photo	

8. Selection of locations for monitoring :

Based on the details collected and the requirement following three locations are short listed for trial induction.

1. Critical stretches of track like
(1) multiple line stretches
(2) Yards
(3) Stretches with inadequate cess

Way side inspection system as well rail cum road vehicle mounted system will be inducted for the trial

9. Re deployment of Key man

Key man and patrol man of the stretches planned for monitoring will be retained in their same gang. They will have to be ready to attend the notes received as alert.

10. Answers to Frequently asked questions

a. Number of camera or sensors to be deployed in the way side monitoring depends on coverage area to be decided at the location.

c. Way side monitoring planned round the clock to

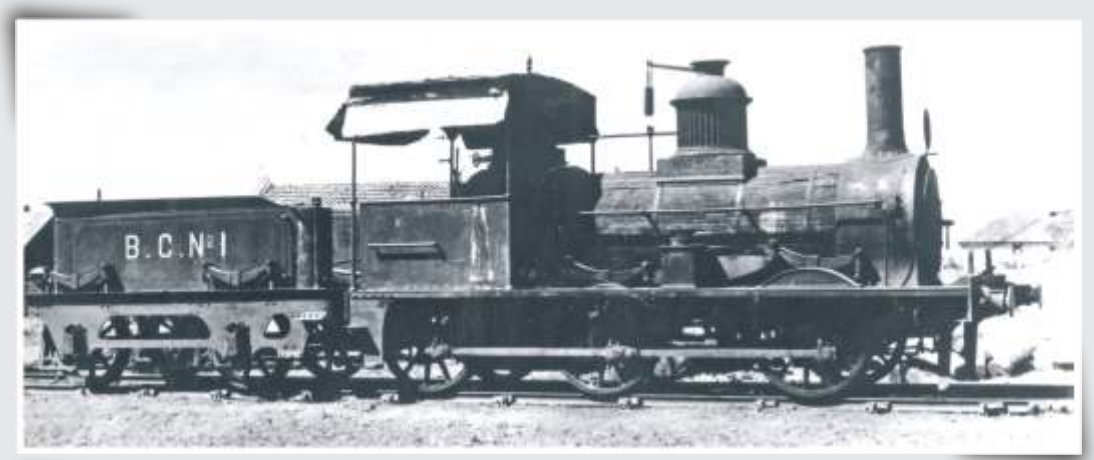
b. Transmission of captured data from way side location to adjacent station will be through OFC take care of K.Man patrolling, all other types of patrolling.

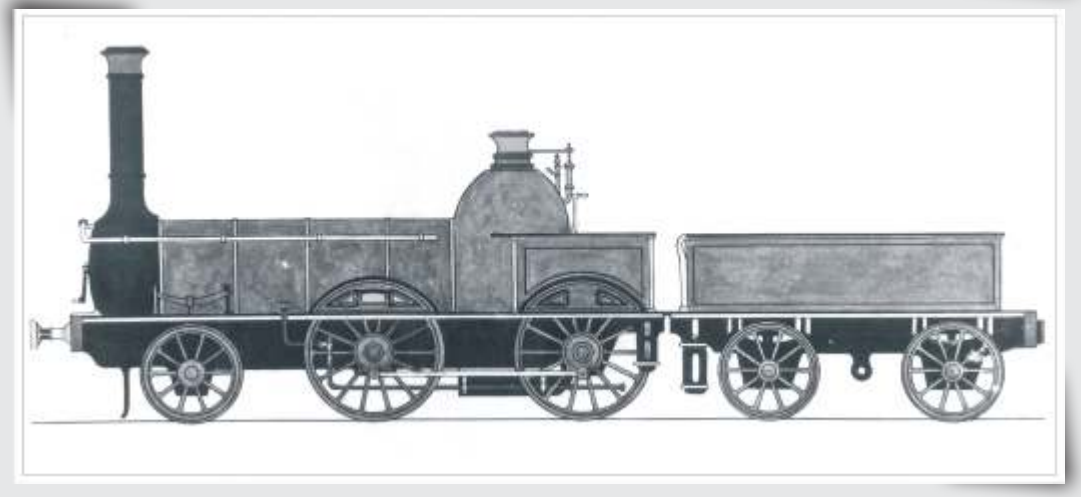
d. One rail cum road vehicle mounted with monitoring mechanism for a P.W section. USFD monitoring also to be included.

e. Initially this system will be under the control of JE/ USFD/PW

11. Conclusion

Machine vision inspection system is necessary at critical location like multiple lines, yards, lines with inadequate cess. Induction of this system will be beneficial from the point of view of protecting key man, patrolman from hit and run. Systems to be selected are way side for critical locations and wheel mounted for SSE/PW/Section. The proposed system to be calibrated to our requirement with facility for upgrading.





Optimising Ultrasonic Flaw Detection of Rail/Welds Through Improved Methodology & Equipments

By

A K Mandal *

V G Kulkarni**

Synopsis

Ultrasonic Flaw Detection has been employed over Indian Railways for over six decades for in-service flaw detection of rails and welds and their failure prevention. It has emerged as one of the most powerful tools to ensure safety and reliability of rail, rail welds and the track structure. This paper describes various technological advancements in recent past in Ultrasonic Equipments, Ultrasonic Testing Methodology, Test Data acquisition, their Analysis and interpretation. Simultaneously it explains various typical defects in Rail and welds observed on Indian Railways and paradigm changes taking place in their characteristics and their incidence level due to improved rail metallurgy and enhanced traffic scenario. It highlights the significance of implementation of these improved test methodology, protocol and testing equipment over Indian Railways to derive maximum benefits and optimize Ultrasonic Flaw Detection with adequate sensitivity and transduction for enhanced safety and reliability. The paper concludes with key areas of attention during ultrasonic examination, special features to be incorporated in the Ultrasonic testing equipments and Data acquisition facility.

Key words – USFD, Single Rail Tester (SRT), Double Rail Tester (DRT), A-Scan, B-Scan, Hydrogen Degassing, Vacuum Degassing, RH Degasser,

1.0 Introduction

Ultrasonic Examination is one of the most versatile and efficient NDT methods for ensuring safety and preventive fracture management because of its high sensitivity, accuracy & in-situ adaptability. Its unique capabilities of superior penetration, single surface accessibility, versatility of flaw detection, instantaneous flaw indication and freedom from hazards make it an obvious choice for safety management in almost all the strategic industries and Railways are no exception and have rightly employed in their safety management protocol.

Ultrasonic Flaw Detection (USFD) of Rails and welds was introduced over Indian Railways during late 1950s and since then it has evolved as a significant tool for internal flaw detection in rails and welds. Large number of defects in Rails and Welds are detected by USFD testing every year and their timely corrective intervention has resulted in avoiding many catastrophes and traffic disruptions. During the past six decades, significant technological developments have taken place in USFD examination methodology, USFD equipments, Flaw Data acquisition and Data processing which are in turn on account of tremendous advancements in Electronics and Computer Technology as well as the sensors. The nature of defects and their incidence level have also undergone paradigm changes during the past 60 years due to significant developments taken place in steel making, steel refining, rail rolling operations and traffic scenario on Indian Railways. These significant developments both in the USFD technology and the flaw characteristics call for a thorough review of the existing protocol and suitable intervention to upgrade the existing USFD system to derive maximum benefits from the technological advancements taken place and experience gained from USFD testing in the past six decades. A quick glance through the history and recent developments taken place in USFD equipment and Rail/Weld Defects scenario shall be appropriate and these are briefly brought out in the succeeding discussions.

2.0 Test Methodology

Rail USFD examination is carried out employing the Pulse-echo method in which the Ultrasonic Wave propagation and its reflection from a discontinuity forms the basis of flaw detection. Both Normal and Angle probe are used to detect various defects based on the flaw location and orientation. The display of the signals in the SRTs/DRTs and AT weld Testing Ultrasonic Equipment is A Scan representation (Displacement Vs Amplitude) on the CRT or LED Screen.

3.0 Rail USFD equipment Status

The first USFD equipment employed over Indian Railways for Rail examination during late 1950s was Double Rail Tester (DRT) & Single Rail Tester (SRT) of Krautkramer (Germany) make. These DRTs/SRTs were Valve operated equipment with 5 probes viz. Normal (0° Degree), 37° Forward, 37° Backward, 70° Forward & 70° Backward for each rail for detection of Horizontal, Transverse and Bolt Hole cracks. During late 60s and early 70s these SRTs were indigenized and later the valve operated equipments gave way to

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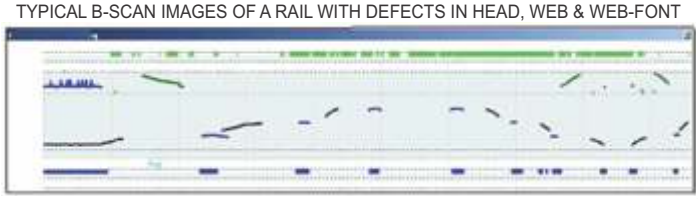
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transistorized (Micro-processor based) ones because of advancements taken place in the electronics. During early 1990s, the need for enhanced testing productivity led to indigenous development of Double Rail Testers (DRTs) which were capable of testing both rails at a time and hence resulted in higher testing output (4 KM). Subsequent developments in Digital Technology paved the way for Digital SRTs and DRTs replacing the erstwhile Analog System. In the meantime, due to incidence of Gauge Corner Defects, these SRTs & DRTs were equipped with additional probes to detect Gauge and Non-gauge corner fatigue cracks. To record the test results and analyze them, Data Logger was also indigenously developed simultaneously but with little success.

Thus, as on date Indian Railways are employing indigenous A-Scan (Displacement Vs Amplitude) Based SRTs & DRTs with Normal, 70° Angle Forward, Backward & Gauge/Non-gauge Corner Probes & 37° Forward and backward probes. An SRT typically employs 7 probes currently and the DRT 14 probes.

A-Scan display method provides flaw indication signals whenever the equipment encounters a flaw and is further supported by LED Display and an Audio Alarm to caution the operator. However, in the event of a defect remaining unnoticed by the operator at the point of its occurrence (due to lack of coiling, ambient noise, attention diverted etc), there is no method to recall the same. At the same time, vital data acquisition facility about section under test, flaw location, date and time of testing, operator's identity, nature of flaw, flaw position in rail, flaw signal amplitude is not recorded for future reference, verification and analysis. These are extremely important parameters which must be incorporated in the USFD equipment to make the examination comprehensive. In view of this it is imperative to introduce B-Scan facility along with data acquisition capability to make the USFD equipment more efficient. B-Scan image (shown below) is formed by a combination of number A-Scan signals, which are synchronized to the movement of the Rail Testing equipment, and hence presents a comprehensive view of a Rail under inspection. B-Scan image makes the interpretation much easier and reliable compared to reading many A-scan information over the same length of rail

TYPICAL B-SCAN IMAGES OF A RAIL WITH DEFECTS IN HEAD, WEB & WEB-FONT



Some salient features of the B-Scan system are enumerated below.

- Relative dimension of Defect is presented on screen for easy defect/artifacts identification.
- The Depth and Location of Defect displayed along its Two Axis.
- Interpretation of Defects is made easier.
- Display of Larger Rail lengths on the screen (13 m to above 100 m)

The envisaged equipment while meeting RDSO standards of DRT/SRT in respect of sensitivity, accuracy and reliability must (a) be equipped with continuous display and recording of B-scan Data over longer lengths for all the sensors employed in real time (b) provide enhanced test productivity i.e. 20-25 KM per day (c) possess Built-in alarm and display for Loss of Coupling (d) be Light weight for easy off-tracking (e) be equipped with enhanced electronics for data processing and GPS (f) have encoded distance measurement facility (g) consume Least water and shall be able to run without interfering with the existing track fittings and signaling system.

4.0 Test periodicity & Test Sensitivity

The basic principle of any preventive maintenance exercise is to examine the component/asset at such a periodicity so that no failure takes place till the time next inspection falls due. This brings into focus the acceptable flaw size and the flaw detection interval which in turn calls for an-depth study into the characteristics of the defects, their crack propagation rate and critical flaw size. These are obviously dependent upon the stresses, the stress intensity factor and are a subject of Fracture Mechanics. Thus, Periodic preventive examination is an attempt to optimize strategy of inspection and is a trade-off between costs of inspection vis-a-vis cost of replacement. Thus, it has both economic and technical considerations. On Indian Railways, the test periodicity has been decided to be 8 GMT for rails and 40 GMT for AT Welds and the acceptable flaw size is 12 mm SDH for rail head kidney defects, 5 mm FBH for Gauge corner defects and 3 mm dia hole for AT welds. These criteria have been evolved over a long period of timeemploying both experimental as well as experiential data and have served the system extremely well.

5.0 Rail/Weld Defects Scenario

Defects in Rails and Welds are mostly of manufacturing origin however some defects also generate during service. Most commonly observed

rail defects are Vertical Transverse Rail Head Defects (also called Tache Ovale, Kidney), Vertical Longitudinal Defects (Piping, Segregation), Horizontal Defects (in Head, at the Head/Web & Web/Foot Junction) and Bolt Hole Cracks (also called Star cracks).

Vertical Transverse Defects occur because Hydrogen Embrittlement (leading to shatter cracks) and Non-Metallic Inclusions which form sites for nucleation and growth of cracks. Incidence of these defects have reduced considerably due to introduction of advanced Secondary Steel making (Vacuum Degassing, Ladle Refining) which have brought down the Hydrogen level from erstwhile 5-6 PPM to 1.6 PPM and led to very low content of Non-Metallic Inclusions. Piping and Segregation which were major reasons for Vertical Longitudinal defects have almost been eliminated due to switching over to Continuous Casting (CC) Route from the Ingot Route. Introduction of Electro-Magnetic Stirring have overcome the problem of segregation altogether. Horizontal defects in the rail head/web/foot were associated with Non-Metallic Inclusions and rolling defects. These have been effectively addressed by suitable intervention of Vacuum Degassing, Ladle Metallurgy and modern Universal Rail Rolling Mill & their efficient operation. Bolt Hole cracks have become less evident since introduction of LWR, CWR and Rails of Longer Lengths. Thus, incidence levels of majority of the Rail Defects, observed in rails of vintages till the year 2009, are either on significant decline or have drastically reduced as a result of several advanced metallurgical interventions and modern rolling mill operation. This is demonstrable and verifiable from the available data.

However, in the meantime, incidence of Rolling Contact Fatigue Defects (like Gauge Corner, Non-Gauge Corner Defects, and Shelling) has arisen sharply in the past 10 years changing the landscape of the rail defects. These newer defects are a consequence of excessive contact shear stresses generated from changed traffic scenario (both in terms of GMT/Throughput and Speed) and are likely to show a growing trend for heavy haul and higher speed operations.

In the AT weld and Flash Butt welded joints, the defect scenario has remained almost constant with no newer ones cropping up and the nature and incidence level of the common defects e.g. Lack of Fusion, Shrinkage, Blow Holes, Porosity have not varied much.

Thus, due to paradigm change in Rail Defects, reduced level of erstwhile Rail Defects & near constant incidence level of Weld Defects, the total Rail/Weld Defect Scenario has undergone a significant shift calling for significant strategic interventions in the USFD examination equipment and related protocol.

6.0 Ultrasonic Flaw Detection in AT Welds

Due to its typical metallurgical characteristics and the complex profile, USFD testing of AT welds have always been a challenge for the operators. Large number of controversies has arisen in the past on signal interpretation and series of instructions have been issued from RDSO to clarify the same. However, these have not eliminated the ambiguities and the problem of fool-proof examination remains elusive. A novel solution to this is the C-Scan USFD examination of the AT welds which provides a pictorial view of the defects vis-a-vis the AT Weld profile. Such systems are in vogue in Railway Systems abroad and can be gainfully utilized on Indian Railways as well for an effective and lasting solution. Advantages of this system are as follows.

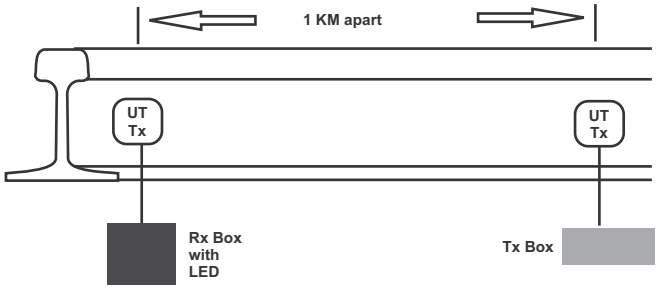
►Visualisation of Defects in C-Scan provides unambiguous 3-D information regarding Area of defect, boundaries of the defect, its location in the AT weld (including the reinforcement).
►Interpretation of Defects and artifacts and defect classification is easier and accurate
►Defect information can be stored as images and reconstructed for further analysis/studies.

7.0 Brittle Fracture of Rails/Welds

During early morning hours, especially during winter months, sudden rail /weld fractures are a very common and most disturbing sight destroying the trains operation schedule and punctuality and sometimes leading to serious consequences. These fractures have no apparent origin and hence remain undetected by the USFD system in vogue. No effective mechanism exists at present to combat the menace over Indian Railways. A novel method recently developed is the Rail Fracture Detector which works on the principle of transmission of Low Frequency Ultrasound Waves. The system developed utilizes ultrasonic transducers to generate acoustic vibrations in the rail that are detected by similar transducers kept about **1KM** or more away. Figure below shows an overview of the proposed system.

Failure to receive the ultrasonic signal will indicate a break. The information describing which rail has broken will be sent back to the train control center via a wireless communication. This is a fool-proof and real-time fracture detection system which continuously (24X7) monitors the track integrity and provides instantaneous communication to the Trains Control

Centre for suitable intervention. Some limited trials have been carried out on Indian Railways and its vigorous pursuance is imperative. The equipment employed must function independent of the existing track fittings and signaling system and shall be equipped with Data Logging and data monitoring facilities.



8.0 Key Ares of Attention

Based on the above discussions, the key areas of attention emerged are as under.

(a) Improvement in the existing USFD equipment of Rails & AT Welds (incorporating B-Scan and C-Scan, Data Acquisition facility, advanced electronics, advanced sensors)

(b) Enhancing the test productivity with suitable modifications in the existing equipment.

(c) Enhancing the accuracy, test sensitivity, test reliability and detection probability through proper design and quality of sensors.

(d) Flaw detection to be specifically oriented towards Rolling Contact Fatigue Defects & AT Weld Defects in view of their higher propensity of development and incidence

(e) Systematic periodic review of the test data, nature of defects, their incidence level to upgrade and modify the test protocol appropriately

(f) Brittle Fracture Detector to be extensively employed over Indian Railways especially in the vulnerable sections to guard against the ill-effects of sudden Rail/Weld Fractures.

9.0 Conclusion

Ultrasonic has emerged as one of the most powerful tools for enhancing Indian Railway's safety performance and to achieve the objectives of reliable and economic operation and has strong potentialities for a much wider and comprehensive role. Efficient Ultrasonic equipment, methods and techniques are essential for implementation and need to be developed and introduced on Indian Railways. In addition, continuous review and up-gradation of Ultrasonic methodology (Procedure, Periodicity, Sensitivity) and Test Equipment (employing the most modern methods e.g. B-Scan. C-Scan, Phase Array, EMAT Guided waves, Air coupled laser etc.) is essential to address all the nature of defects arising and their incidence level efficiently through timely detection.



Matheran

Reducing Noise and Vibration from High Speed Railway.

In this article the author described noise & vibration for Railway in two types. One is air borne N&V and other is ground borne N&V. Air born noise diminishes with distance from the source. The main noise sources are traction and equipment at low speed. Again aerodynamic noise becoming significant at high speed and it is mainly from bogies, underwear and from pantograph. The first source is managed by means of line side noise barriers or berms. But it is less effective for high rise buildings. Ground born N&V transmitted through the ground and the natural frequency of the track system affix the ground borne N&V. Source vibration transmit ion into the ground may be kept lowered by keeping the natural frequency sufficiently lowered. As speed increases risk of the excitation frequency coinciding with the system's natural frequency, it should be avoided the train velocity becoming too close to the critical velocity of the track.

By:-Dr.Julie Dakin and Brian Stewart Mott Macdonald.

Ref :-The Journal of P-Way Institution, Volume:- Jan/2017 Vol-135 Part-1

Ballastless Track on Earthworks

In this article the author discussed the desired features of ballast less track. This system of track structure is PORR system consists of prefabricated RCC slabs of 5.0m long and 2.4m wide. Each slab has 8 pairs of rail fastenings and there are two square “windows” in the four foot area of each slab. The slabs are installed on base slab, normally of mass concrete, which may be laid by machine. The slabs are temporally supported on adjustable support for proper self levelling and compacting concrete. The concrete is brought up to the top of slab through “windows”, which act as key to prevent the movement of slab longitudinally and laterally. Track quality after installation is high. The rail fastenings provide 90% of elasticity in PORR system. The maintenance and repairs may be done easily and quickly. This system of track structure have a life of at least 80 years under heavy tonnages. This system may be used for noise & vibration control. First installation done in 1989 in Austria.

By: Dr.Dieter Pichler

Ref: The Journal of P-Way Institution, Volume:- Jan/2017 Vol-135 Part-1

Engineering Approach to Rail Noise and Night Tube.

[3]

The author explained the rail noise of two types. One is ground borne and other is air borne. The ground borne noise arise due to rail corrugation, stiff track form, rail joint and other track irregularities. Air borne noise is due to wheel squirrels, flanging and rail joint. Train running remains continue but N&V become objectionable and irritating to the people when they have not been used the trains. For this reasons night tube is being introduced on Friday and Saturday night.

Physical works are to improved problem areas of N&V may be overcome by grinding corrugated rail, but it may affects lasting of rail so another alternative measures may be adopted like uses of fastening like the pendoral vanguard and Delkur system. Friction modification and “silent track” are also being employed incorporating such anti N&V measures during five months 60 N&V complaints have been resolved successfully out of 340 sites.

By: Dominic Trueman

Ref: The Journal of P-Way Institution, Volume:- Jan/2017 Vol-135 Part-1

Developments in Rail Welding

This article expressed about more effective and efficient rail welding installation of Al.Th welds. This process has been improved recently and now mostly used in LU. Porosity in rail weld is the vital problem and it has been removed in process. This is a sealed disposable crucible containing the weld portion, which eliminate the risk of moisture contamination. This adaption of new Al-Th system also very effective for repairing of rail.

By:- Marc Clarke

Ref: :-The Journal of P-Way Institution, Volume:- Jan/2017 Vol-135 Part-1

Sugarcane Bagasse Ash Brick as A Novel Insulator for Dwellings

In this article, the author describes the potential of sugarcane bagasse ash as a novel insulator for dwellings. In India, the production of some building materials can consume vast amount of energy and the disposal of solid waste from agriculture and industrial process significant disposal problem.

Auther assess the feasibility of using sugarcane bagasse ash in brick manufacture. The simulation modeling techniques used by the authors .The SBA brick showed lower thermal conductivity and

higher physical stability with respect to commercial bricks. Therefore, the development of new technologies to recycle and convert waste materials into reusable materials is critically important for protection of the environment and the sustainable development of society.

By :M.Madurwar and R.Ralegaonkar
Ref: Construction Materials, Volume 170 Issue CM5, October 2017

Modified Asphalt-Based Crack and Joint Repair System.

In this topic author focussing on joint repair system for pavements. Pavement cracking is a common form of distress seen on the majority of Indian roads. Cracks develop due to various reasons. In this study a new method was used to seal cracks and joints in rigid and flexible pavements. The crack-sealing and anti-skid materials normally used currently include polymer-modified and asphalt rubber sealants. These prevent water from entering deep into the pavements and thus eventually help them last longer. Therefore, effective sealing of cracks and joints in pavements is important. Auther describe laboratory experiments and field studies of modified asphalt-based crack and joint repair systems in both flexible and rigid pavements.

By: S.S.Kar, R.Solanki, G.Kumar, P.K.Jain
Ref: Construction Materials, Volume 170, Issue CM5, October 2017

Performance of bitumen protective coatings for buried concrete

In this article author investigate the performance of bitumen protective coatings for buried concrete. Controlling concrete deterioration in situations where concrete is exposed to chemically aggressive conditions, with the result that the long term performance and safety of a structure is at risk, is of great importance. The damage caused by thaumasitesuiphateattack (TSA) has been well documented.

There is wide range of surface coatings on the market, including chlorinated rubber, epoxy and bitumen, and this makes choosing the appropriate type of coating difficult. Almusallam reported that some of the coatings they tested failed to meet appropriate engineering requirements, so they either fail to fulfil their intended functions or lacked reasonable durability. The performance of different coatings under various conditions has been extensively investigated. Such treatments have shown adequate improvement in concrete durability in aggressive conditions. However, the researchers note that there is a need to develop guidance for the selection of appropriate coatings in different conditions.

By: F.Abubaker, John c. Cripps, cyril J. Lynsdale, and H.S.Pouya
Ref: Construction Materials, Volume 170 Issue CM5, October 2017

YUKRID, a System That Reduces Railway Damage Caused by Wild Deer

Authors describe In Japan, many accident occures during collision between a train and deer every year.Those incidents lead to train delays and breakdown of vehicle movements and have become a serious problem that threatens the safety of passenger and freight transportation. Nippon Steel and Sumikin Metal Products co. Ltd. (NSMP) identified why deer enter the railway land and based on the results of biological research developed a new countermeasure system" YUKRID" is capable to reducing the number of collision incidents. This article introduces adeer anti beast damage measures system.

By: N.Kajimura, Akira KENJO
Ref: Japanese Railway Engineering, July 2017, Vol. 57 No. 3

High-Volume, Density Fly Ash Foamed Ultra-Low- Concrete

This report the development a low embodied carbon dioxide backfill material based on an ultra-low-density foamed concrete using a high volume of fly ash to replace Portland cement. This material builds on nearly 28 previously reported research on the underlying causes of instability in low-density foamed concrete mixes and demonstrates that with the addition of a small amount of calcium sulfoaluminate cement, stable ultra-low-density foamed concretes with density as low as 150kg/m^3 can be produced. A high volume of fly ash up to70% of cement phase has been used, which reduced the average bubble size of the foamed concrete and increased the thickness of the bubble walls. The observed micro structure of fly ash foamed concretes was improved over the long term. The use of fly ash significantly reduced the embodied carbon dioxide of these mixes, which potentially has significant benefits for large-scale backfill and similar applications.

By:- M. Roderick Jones, Kezban Ozlutas & Li Zheng Ref: Magazine of Concrete Research, Volume:- 69, Nov 2017

Cracking in Walls with Combined Base and End Restraint

This paper describes an experimental programme to study early-age thermal and long-term cracking in reinforced concrete walls with combined edge and restrain. Cracking was monitored in four specimens over a minimum period of 6 weeks early-age cracks only formed at the vertical construction joints, which were a plane of weakness. Subsequently, internal cracks formed between the vertical constructions joints due to restrained shrinkage. The main variables in the test programme were concrete cover and reinforcement ratio. Early-age cracking is simulated with non-linear finite-element analysis, which is shown to capture the observed behavior adequately. Eurocode 2 gives reasonable estimates of long-term crack widths in the tested walls if edge restraint is assumed, but significantly over estimates crack widths if the worst case of end restraint is assumed.

By:- Marianna Micallef, Bassam A. Izzuddin and Robert L. Vollum

Ref: Magazine of Concrete Research, Volume:- 69, Nov 2017

Effects of the Hydration Reactivity of Ultrafine Magnesium Oxide on Cement-Based Materials

The effects of the chemical reactivity of ultrafine magnesium oxide(UFM) on mechanical and volume compensating properties at early and later ages were investigated, Combined with an assessment of the effect of UFM on cement hydration and pore structure, it is hoped this study will contribute to better understanding of the role of Ultrafine magnesium(UFM) in the hydration of cement. The results showed that the hydration of UFM followed the first order reaction mode in the first 3d and then slowed down due to the alteration of the reaction to the diffusion-controlled mode. Ultrafine Magnesium contributed to an increase in compressive strength and a decrease in shrinkage of cement-based materials (CBM) at the very early age, but hindered the hydration of cement at later ages, coarsened the microstructure and decreased the later-age shrinkage to a much smaller extent than normal light-burnt magnesium oxide. The relatively high hydration reactivity of UFM may contribute to the formation of a more compact gel structure around cement particles at the very early age, which may hinder the reaction of cement at later ages, thus leading to the slowed property gain of cement-based materials (CBM) at later ages. The findings from this study may help in the selection of magnesium oxide types for achieving a desired cement-based material (CBM) with certain properties.

By:-PengkunHou, YamelCai, Xin Cheng, Xiuzhi Zhang, Zonghui Zhou, Zhengmao Ye, Lina Zhang, Wengui Li and Surendra P. Shah

Ref: Magazine of Concrete Research, Volume:- 69, Nov 2017

Improvement of Response and Efficiency of Railway Air Brake System by Modifying Softwarefor Control

This paper proposes a method for reducing air brake response time using Wheel slide protection (WSP) dump valves and another for reducing air consumption in wheel slide protection (WSP) control, in order to improve air brake performance by taking full advantage of the existing vehicle facilities and improving related software. A new method for reducing response time of the system for supplying the compressed air, by controlling wheel slide protection(WSP) dump valves installed in recent railway vehicle. Attempts were also made to reduce air consumption in the air braking system, focusing on cases where a wheel slide protection (WSP) system is applied. The benefits of the new approach were verified through actual railway vehicle tests and hybrid simulation method etc. Results demonstrated that the proposed method reduced the response time and air consumption, and improved braking performance.

By:- Shin-ichi NAKAZAWA, Daisuke HIJIKATA

Ref: Quarterly Report of RTRI, Volume:- 58 No.1, Feb 2017

Simple Evaluation of Water Permeability of Cover-Concrete Using a Water Spray Method

This paper proposes a simple testing method has been developed, called the Water Intentional Spraying Test (WIST), with especial emphasis on the applicability to the inspection of Railway reinforced concrete structure. By using the latest method –A for the evaluation of cover-concrete quality, which is based on the visual inspection of a small amount of water sprayed on the surface to be evaluated. Technological investigations were also carried out with a view to adapting the test method for practical use. This test quantitatively clarify the relationship between the frequency sprayings in the Method-A and the different type of physical properties of concrete, further work will be continued on the basis of collected measurement

data and further experimental studies as well.

By:-Sohei NISHID

Ref: Quarterly Report of RTRI, Volume:- 58 No.1, Feb 2017

Planning, Progress and Monitoring of Rural Roads under PMGSY in India

The article talks about, Pradhan Mantri Gram SadakYojana(PMGSY) which launched in 2000 aiming at constructing and repairing about 6,00,000 all-weather roads in rural India. The roads are identified at the block level and district level by District Rural Roads plan (DRRP) and is then verified by State technical committee (STA) who then recommends to National Rural Roads Development Agency (NRRDA), which provides technical and managerial support to the program. A project is completed within 12 months and Technical specifications from IRC is used like Rural roads manual, Operations manual etc. A three tier quality assurance is implemented from in-house, state level as well as NRRDA level. C-DAC has developed Online Management, Monitoring and Accounting System (OMMAS) for the program and the Tendering process has switched to E-Tendering mode from 2009. Even though lakhs of Rural areas are connected, PMGSY-1 failed to reach its goals mainly due to non-availability of materials and technical and man power. On seeing the slow movement of PMGSY-1, in 2015 Govt launched PMGSY-2, revising the plans and projects from DRRP and STA. Even though the goals have not been achieved completely, according to the study conducted, the quality of life of people in inaccessible rural areas have been improved due to the connectivity with major centres.

By: Dr. I.K Pateria

Ref: Civil Engineering and Construction Review, Vol: 3 No. 3, November 2017

Road Construction in Cold Climatic Areas.

The author explains in detail, the challenges and solutions to the problems of road construction in cold climatic areas. Road construction in colder regions experienced from Perma frost needs special attention. The layer below the ground is usually frozen all the seasons. While building roads in such areas, preserving the perma frost layer beneath and drainage of water is to be considered primarily. Author suggests construction of high embankment, insulation from heat, and construction of drainage ditches on both sides of roads to prevent heating and thawing of frost layer.

In cases where hard rocky strata is present, sub-base is not required, and a triangular shaped wedge can be constructed wherever there is a change in subgrade from rocks to soil.

Journal also suggests the desired specifications of parameters such as embankment, base and sub base courses as well as topping layer. Use of white toppings will help, as black toppings will absorb heat and may melt the frost layers. The author also puts the ways like rubber mats as an alternative temporary arrangement.

By: U.K Guruvittal

Ref: Civil Engineering and Construction Review, Vol: 3 No. 3, November 2017

Fast Track Bridge Construction in India.

The Journal tries to explain why the bridge construction in India is generally taking so much time when compared to developed countries and what can we do about that. The author rememebers the measures taken by Maharastragovt 20 years back, which helped reducing the building time of flyovers in Mumbai city drastically. Mumbai-Pune highway was done on time with half the cost due to handling by a smaller team and dividing of works into smaller stretches. Simialr examples are also seen in case of Konkan railway as well as Assam railway link.

The article also suggests delegation of powers, Updation of codalprovions, contacts, and delay in settling of contractor bills and approval of drawings as the main reason in slow going of construction activities. The behaviour of young engineers is also mentioned. Author suggests mainly planning as the reason, while nothing about fieldwork is mentioned in the journal. The ideas mentioned in the journal are relevant and need to be considered by every bridge engineer.

By: M.C Bhide

Ref: Civil Engineering and Construction Review, Vol: 3 No. 3, November 2017

500m Long Continuous Precast Segmental Balanced Cantilever Superstructure Construction of Allahabad Bridge.

The structural design and construction of major bridge across Ganges in Allahabad. 4 Nos of countinous precast cantilever beams of 506.8 m long are used. Casted in the nearby yard, match casting method is used and is cured with sprinkers. Temporary prestressing has to be done at the site using high tensile steel

threaded bars. The prestressed beams were erected using launching girders and moves forward as each beam is fixed in position. The foundation is well foundation of circle shape and is sunk by jack down method. The bearings used for load transmission are POT bearings and special Shock transmission units were installed for absorbing seismic shocks.

The jounal explains how good planning in the early stages helped build high quality bridge which results in faster construction and reduction in cost.

By: Er. Vinay Gupta

Ref: Civil Engineering and Construction Review, Vol: 3 No. 3, November 2017

The Bhupen Hazarika bridge – The Longest Bridge in India

The journal explains the feats achieved by the Bhupenhazarika bridge, newly constructed across River Brahmaputra connecting Assam and Arunachal Pradesh. The bridge is currently the longest one in India with 9.15 kilometers and the Feasibility study was finished in 2003 and the construction began in 2011. The bridge serves the region of Sadiya in Assam which has flood troubles from Brahmaputra after the earthquake of 1950 Arunachal Pradesh being a border state with China, has lot of strategic importance. The bridge was constructed keeping in mind of the army bases so that even 60Tonne tanks can travel through them. North east India is seismic prone area and hence innovative earthquake resistant technology is used.

The author is empathetic towards the boatmen who lost their jobs due to the bridge and proposed the govt to consider their troubles.

By: Dr. R. Kuberan

Ref: Civil Engineering and Construction Review, Vol: 3 No. 3, November 2017

Self Compacting Concrete – History and Current Trends

Self Compacting Concrete (SCC) is a major innovation in concrete technology and author has been successful to establish its essence for using in construction of reinforced concrete through its implementation since around 30 years back starting from Japan ,European project group and subsequently by American Concrete Institute although it has faced considerable lack of trust by more experienced engineers, particularly in the early years of its development for a range of different reasons but mainly due to high slump ,absence of relevant testing standards and production cost implications. SCC ensures effective fresh concrete compaction through extraction of entrapped air, full encasement of reinforcement bars even in complex formwork and through congested reinforcement purely under its own weight and without need of mechanical vibration due to its enhanced rheological behavior. SCC reduces dependency on worker's skills and ensures proper quality control, durable concrete with consistent performance and excellent surface finish.

By :IoannisSfikas

Ref: Concrete, Vol : 51, June,17

Concrete Renovation

The project involved the major refurbishment of a 17000 sqm mixed-use university building, originally constructed during the 1960s.Renamed in honor of Sir David Attenborough after the completed works, the building is a focal point for conservation research. With energy intensive building in mind, the design was focused on upgrading thermal performance of the building fabric and introducing new and more efficient building services system and strategies. The result is an outstanding environmental benchmark for refurbished developments. Passive and low energy design strategies focused on the use of natural ventilation in areas where feasible, along with the use of the exposed concrete's thermal mass. This enables the building to absorb and release heat in order to aid internal conditions, especially during the summer.

Ref: Concrete, Vol : 51, June,17

Concrete Properties "Smart Thermal Mass"

Concrete can play with its ability to store and release heat i.e. its thermal mass, which can be used as basis of a Demand Side Response (DSR) electric heating system in buildings. This essentially involves using the floors and walls in heavy weight concrete/ masonry buildings as a form of storage heater, managed by an intelligent control system that takes advantage of cheap electricity to preheat or precool the structure when power from renewable sources is not being fully used. At other times, when the demand price is high, the heating or cooling is switched off as much as possible and comfort is maintained by slow release of stored heat from the building fabric. Since DSR- controlled heating will not only respond within predetermined operating parameters i.e. temperature bands, there is no risk of occupants getting too hot or cold. This will prove

game changer in real- time energy pricing and link wirelessly to a new generation of heating controls.

By : Tom de saulles
Ref: Concrete, Vol : 51, June,17

BS - 8548: 2017 – The New Guidance Standard for Welding of Reinforcing Steels

There has been significant growth in the amount of welded prefabrication conducted by reinforcement fabricators in the UK in recent years. This is an opportunity for the fabricating engineers to add value to their product for their clients by supplying a rapid-fix cage to site, dispensing with the requirement for costly, time-consuming traditional fixing methods. Welded prefabrication has common for pile cages, beam cages, diaphragm walls and roll mat reinforcement, with very significant productivity gains being achieved on time-critical construction projects. However, the practice also poses some risks, since although reinforcing steels are weldable, the properties can be adversely affected by inappropriate welding procedures or poor welding technique. Without suitable system for control of the welding processes, the structural integrity of the reinforcement is compromised. With BS-8548:2017 in place, the market for welded fabrication is expected to continue to grow and clients can gain the benefits of productivity with confidence.

By: Tony Franks, Lee Brankley and Kevin Lloyd
Ref: Concrete, Vol : 51, June,17

Training and Education "Creating Solid Foundations for New Apprenticeships in England"

In September 2014, the UK Government began the process of reforming apprenticeships in England. Mineral Products Qualifications Council's (MPQC) standard-setting organization, MP Futures moved quickly along with a number of industry employers and have battled hard since January 2015 to develop a number of apprenticeships, such as;

(1) Mobile and static plant operations
(2) Weighbridge operations
(3) Mineral and construction product sampling and testing operations
(4) Plant and equipment maintenance

Employers are utilizing their 0.5 % apprenticeship levy monies to provide a funded training route for their employees who are progressing in their career and need upskilling. Over the past few years, MP Futures has worked hard to keep employees up to date not only on the progress of the new apprenticeships but also on apprenticeship policy changes and levy updates.

By: Stacey Jackman
Ref: Concrete, Vol : 51, June,17

Elongation Tolerance for Short Tendons in Post- Tensioned Building Structure.

Codal provision in variation of tendon elongation value is showing some deviation between measured elongation and calculated elongation, specified tolerance are stringent , unrealistic for short tendons. In this article authors have tried to resolve this issue on the basis of statistically analysing of actual projects of post tensioned building structures and also given emphasis on updating the Codal value.

By: Carol Hayek and Thomas H.-K.
Ref: ACI Structural Journal,
Volume: July- Aug.-2017.

Reinforced Concrete One –Way Slabs with Large Steps.

In recent times Architects and Engineers required to provide space and different height of floor elevation for aesthetic appearance and functional purpose of mechanical equipment and duct work. In this article Authors have tried to provide a design guideline of reinforcement details of large stepped one way slab on the basis of crack pattern and analysis of different types of structural performances.

By: Thomas H.-K Kang, Sanghee Kim, Seongwon Hong, Geo-Ho Hong and Hong-Gun Park.
Ref: ACI Structural Journal,
Volume: July- Aug.-2017.

Geosynthetic Application in Pavement Construction

It deals with the topic of use of geosynthesis as reinforcement within flexible pavement. Geosynthesis is often provided at the interface between the bituminous layer and granular layer where poor CRB is the only concern.

Geosynthesis often considered for pavement are geocell and bioaxialgeogrids.The mechanistic-elastic method best suits designing a pavement section with geocellwheras The AASTO method best suits a pavement with geogrid.

By: S P Bagli
Ref: NBM & CW,
Volume -22 ,Issue -9, March 2017

Durable and Cost Effective Concrete Overlay on City Bituminous Road: White Topping

It deal with the topic regarding use of concrete (white topping) as durable material for construction of road and highway. White topping is defined as Portland cement concrete overlay constructed on the top of existing bituminous pavement. All type of white topping viz. conventional type, TWT(thin white topping),UTWT(ultra-thin white topping) are effective particularly Indian road where ruffing and potholing of bituminous road is recurring problem.

UTWT involves placing 50-100 mm thick concrete overlay with joint spacing 1.0 m to 1.5 m.TWT involves placing 100-200 mm thick concrete overlay with joint spacing 1.0 m to 1.5 and conventional type concreting is more than 2.00 m with joint spacing and slab size 3.4 by 4.5m. Many project in India has completed with white topping in cities like Pune, Bangalore etc.

By: Binod Kumar
Ref: NBM & CW,
Volume -22 ,Issue -9, March 2017

Cold Asphalt Mixes for Indian Highways Environment Friendly Technology

It deals with cold asphalt mix. Cold asphalt mix is produced by mixing unheated mineral aggregates with either emulsified bitumen or foamed bitumen. Cold asphalts mixes can be used both for initial construction (100% virgin mixes) and recycling of asphalt pavement. Virgin cold asphalts mixes are of two types.

(a) Dense graded:- Dense graded mixes are continuously graded from the maximum aggregate size down to material passing 0.075 mm sieve size
(b) Open graded :- Open graded mixes usually lack material passing 2.67 mm sieve and have high air voids

It can be produced either by mixed –in-place method or by central and travel plant.

In Cold mix asphalt recycling, reclaimed asphalt pavement are combined with new bitumen binder to produce the mixes.

By – Prithvisingh Kandhal
Ref: NBM & CW, Volume -22, March 2017

Resilient Infrastructure TrackHigh Speed in a Cold Climate

It deals with development of base plate which suits to the temperature of -35^{0}c. Getzner has developed a base plate for slab track using novel polyurethane composition .It provides high elasticity and long term durability at lower temperature. When modulus of elasticity of low temperature base plate is compared with standard base plate, it is found that stiffness rises notably at -20^{0}c for standard base plate whereas stiffness phenomenon evident from -30^{0}c in case of low temperature base plate.

Both the change of the static load deflection and the value calculated from the ratio of critical dynamic to static stiffness, which represent long term dynamic performance of pad is well below the standard value.This material has also got approval of China Railway Corp.

By – Stefan Kopeinig ,Ferdinandpospischil and Michael Kessler
Ref: Railway Gazette International,
Volume -22 ,Issue -9, September 2017

Apps Support Welding as Digital Worksite Emerges

Here it is discussed about Apps support welding. It is for electronic documentation of work flow in real time to improve the consistency and reliability of welding work. Goldschmidf digital app is one such app which is connected to number of tools and small plant for reliable welding. The App can identify which welding process is to be used with which rail profile and grade. The detailed work flow is storied in the App to help the welder through rail joining process step by step. All data are recorded in CSV or PDF format which can be analyzed and evaluated.

By: Dr. Ing Matthias Weweland
Dr. Claudia Stein
Ref: Railway Gazette International,
Volume -22, Issue -9, September 2017

Fast-Tracking Special Track work

This article presents a research on special track work innovations. The aim of these innovations is to reduce the dynamic forces from trains which results in longer life of track components and lesser maintenance cost. This research includes innovations of turnout geometry improvements, pad materials and flange bearing components. In turnout geometry improvement, the large lateral forces are reduced by allowing entry at lower angle at the point of switch with speed limitations in curve closure, the idea behind this is to use coning of wheels to steer the axle slightly before the point of switch. In pad material innovation, the use of elastomeric pad materials in turnouts and in diamond crossings as it provides more uniform

stiffness throughout its length, reduces peak impact forces and remains constant over time and maintain integrity after more than 600 MGT. A flange bearing component is required for optimization of shapes and materials of track components.

By: Duane Otter, Scientist and Joseph Lopresti,
Ref: Railway Age, September 2017

Effect of Substrate Surface Roughness on the Flexural Performance of Concrete Slabs Strengthened with a Steel-Fiber-Reinforced Concrete Layer

This article represents a new strengthening technique that includes the addition of a thin layer made of steel-fiber-reinforced concrete (SFRC) over precast concrete slab. The desired structural performance for this method can only be achieved if the SFRC overlay and the precast concrete slab behave compositely. In this research, the effects of using different substrate treatments on the composite behavior of precast concrete slabs strengthened by an SFRC overlay are evaluated through experimental tests. Also, the advantages and disadvantages of a SFRC topping over the conventionally reinforced concrete topping are investigated. The obtained results showed that presence of steel fibers in the concrete of toppings enhanced the deflection at the ultimate load, energy absorption capacity and failure mode of the strengthened slabs. However, specimens strengthened by SFRC toppings exhibited slightly lower ultimate-load-carrying capacity compared with the conventionally reinforced topping. It was also found that a composite behavior for the strengthened specimens was achievable if the surfaces of substrates were roughened either transversally or longitudinally.

By:FarnoudRahimi Mansour, Suhaimi Abu Bakar, MohammadrezaVafaei and Sophia C. Alih
Ref: PCI Journal, January-February 2017, Volume 62, Number 1

Geographic Information System Aimed at Understanding the Actual Situation ofFreight Transport

This Article represents the Geographic Information System (GIS) development. GIS provides the uniform environment in which the data for numerous planning purposes can be integrated. GIS technology provides the core framework for freight transport using freight transport database.

The developed database can be further supplemented with new information as when it is available. This enables and helps users, customers and operators for real time freight tracking and understands transport conditions, hence, this result in better transparency of system and improves freight transport efficiency. The database keeps on evolving, which is otherwise not possible to compile at one time. The information available in GIS database opens the new ways for analyzing the transportation related data for different purpose and can be used to facilitate the transport planning and management at various levels.

By: Guoquan LI,
Ref: Quarterly Report of RTRI, May 2017, Volume 58, Number 2

Title: Evaluation of Acoustic and Vibratory Characteristics of Impact Noise Due to Rail Joints

This article represents a research on impacts occurs when a railway wheel encounters discontinuities such as rail joints. Impact noise by rail joints is one of the major sources of noise on railways. A field study was conducted on rail joints, for this a model is presented in which the wheel impacts due to rail joints are simulated. The impact forces are transformed into the frequency domain and converted into the form of an equivalent roughness input. Using impulse hammer, Dytran models 5800B4, accelerometers and the equivalent roughness input, the frequency response was estimated and the impact noise radiation is predicted for different rail joints and at various impacts. It is found that the impact noise radiation due to rail joints is related to the train speed, the joint geometry and the static wheel load. The overall impact noise level from single joint increases with the speed. Study showed that noise generated by sleepers is the dominant source of impact noise below 500Hz, and above 1 kHz it is from the rails. Ii is predicted that modification in track parameters could considerably reduce impact noise.

By: Takeshi Sueki, Toshiki Kitagawa and Tsugutoshi Kawaguchi,
Ref: Quarterly Report of RTRI, May 2017, Volume 58, Number 2

Method for Selecting Appropriate Sounds to Convey Alerts to Train Drivers

This paper presents a method for the design and evaluation of auditory warning signals modelled on an existing standardized method for evaluating public information systems. The procedure is essentially user-centered, capitalizing upon users associations between sounds and their meanings i.e. information conveyed through spoken messages (speech information). The procedure is presented in a step-by-step manner, from the initial identification of references for which warnings might be required, through the generation of ideas for warning sounds, an appropriateness ranking test, a learning and confusion test, a recognition test and an operational test carried out with on-board staff. Practical issues are discussed with respect to each of the stages, and suggestions are made as to courses of action that might be taken if problems are encountered. Theory behind the relationship between sound and meaning is discussed with reference to the practical issues addressed.

By: Ayano Saito, Yufuko Abe and Ayaku Suzuki, West Japan Railway Company

Ref: Quarterly Report of RTRI, May 2017, Volume 58, Number 2

Advances in Rail Weld Life Extension Procedures

Transportation Technology Centre, Inc ,Pueblo, colo. South America (TTCI) is currently evaluating methods to improve the performance of rail welds .In this technology a high hardness welding electrode is used to deposit a weld bead covering the softest portion of the heat treated zone (HAZ) of the weld. This treatment is applied soon after completing the primary weld so that a second preheat is not required. The technique, termed HAZO overlay treatment (HAZOT).A weld bead is applied manually to the regions of the soft HAZ. This is done while the primary weld is still hot; therefore the process add little to no extra time to the overall weld installation. The result of the treatment is a modified HAZ shape near the running surface of the rail that reduces the width of the softened HAZ. Process timing restrictions are to be followed precisely for a quality weld.

On the other hand ,the newest weld technology being evaluated on the HTL is full- section alloyed(FSA) thermite welds .In contrast to the head alloyed thermite welds where the alloying elements are held in the weld mold plug, FSA welds have the alloying elements added to the entire weld portion. FSA thermite have the same crucible, moulds, and installation procedures as standard thermite welds. Laboratory testing concluded that these welds have higher hardness throughout the weld and higher residual stress amplitudes. These technologies being exercised in future in American & Canadian National Railway.

By-Megan Archuleta

Ref: Railway Track and Structure, July 2017

Customer Partnership Push Advances in Fastening System

Reliable, resilient fastening systems play a key role in railroad safety and efficiency. Railway fastening systems suppliers are expanding their product line and working with their customers to find solutions to their needs in order to provide a track component with consistent performance, extended service life and reduced maintenance.

Regarding this connection, J. Lanfranco Fastening systems Inc. manufacturing metal locknuts for safety critical bolted joints, having ERM style of nut and integrated disc spring washer has been installed on splice joints to eliminate loss of bolt tension. L.B.Foster Transit Products developing and commercializing fastener technology. Lewis Bolt & Nut Company Introduced the new quick set hook bolt system to prevent both vertical and horizontal deck movement, good for a bridge fitting. Pandrol north America co. has tie plate & bearing plate combined type of special fastening product assembly has a big market. Progress Rail fastening is a best solution for wooden track system, having E-clip best for concrete sleeper also. vossloh fastening system developed a product in which loose fittings like clips, pads, insulators these all eliminates by a single assembly.

By – Mischa wanekLibman

Ref: Railway Track and Structures, July 2017

Striking the Right Compact

Maintaining proper track geometry and providing a uniform track structure bed begins with proper tamping .in another word tamping can help increase the durability of the track structure. Manufacturers are providing equipment that is versatile and able to perform more tasks, but remain easy to transport. Tamping equipment is also becoming ``smarter'' by accessing data sets that are designed to increase the efficiency and productivity of this key maintenance practice.

It will be more difficult for railroads to get track time

since maintenance requirements increase as traffic increases. it can be minimize with increased production using continuous action tamping technology, multi tie tampers and combining multiple functions, i.e. tamping and track stabilizing, into a single machine without adding additional operators. By using a tamping simulator and its carefully designed training programs, it is possible that trainee operators gain this specialist knowledge in two to six weeks, depending on their prior knowledge. All this without the risk of damage to the track or the machine. In recently developed technique Measurement data is collected and stored while the tamper is traveling and then recalled when the tamper is switched to work mode. This unique feature saves valuable time and reduces potential errors associated with manually typing in correction values. once the operator accepts the best fit curve; the tamper will begin to place the track accordingly.

By-Mischa Wanek, Libman
Ref: Railway AGE, June 2017

Tamping Technology: Key Parameters under Control

The higher the level of quality and, particularly sustainability of maintenance actions, the longer the Intervals between maintenance operations. In this connection consisting of rails, sleepers and ballast, form an elastic system .Traffic loads subjects this system to enormous dynamic forces causing the entire track to deflect and return to its original position. in the long run ,these high stresses lead to deviations from the ideal track position. if, the track quality falls below a certain level, the track must be maintained. To restore the ideal track position, a tamping machine is used to level, lift, line and tamp the track. This measure aims at ensuring safe operation and thus the customer's satisfaction. Delays in maintenance lead to speed restrictions hindering rail traffic. Therefore we should place a particular focus on leveling, lifting, lining and tamping.

The safe tamping process starts with reliable measuring equipment on the machine. The 3 point method is used to measure the track geometry at three points on the machine before, during, and after tamping. The precision method uses correction values calculated In advance, while the compensation method uses only the machine's chord length as reference base. The automatic guiding computer provides the machine with the information required for track geometry correction. Note that, squeeze frequency of 35 HZ at the tamping tines, tamping force (static) 10 to 12 KN, squeeze time 0.8 to 1.2 sec, amplitude of 4 to 5mm, should be maintained.

By-Gerhard Polterauer
Ref: Plasser & Theurer, Vol-131, July 2017

Is Growth in Rail an Oxymoron?

In this article author describes a brief idea about the American Railroad financial crisis in coming future. High drama of service disruptions, increasing freight traffic and what seems to be a stabilizing and so many other things tells its dark future. The railroad do not seem to be pursuing business growth. Calculating to measure the growth operating ratio is increasing day by day.

Railcars hauling coal remain excess to overall fleet needs. In connection to covered hoppers for grain, no good news. One of the only bright spots, sand covered hoppers remain in demand and are continuing to be built. The Rail car market remains week due to available cars in excess of demand. STB in railroad decreases from 9.61% (2015) to 8.8% (2016).Railroad manufactures increased in respect of requirement of commodity group demand for transportation. Therefore a deep survey in this industrial growth is required.

By-David Nahass
Ref: Railway AGE, Oct. 2017

Ladle FurnaceSlag as Binder for Cement-Based Composites

This study has been done from environment waste management point of view in which ladle furnace slag (LFS) a bye-product of secondary refining of steel is used as sustainable binder for OPC mortar in place of hydraulic lime. LFS composed of mainly calcium and magnesium silicates. For comparison hydraulic lime and processed LFS samples testing has been done. The LFS is processed for magnetic particle separation, milling and sieving through 75 micron sieve. Physical and chemical characteristics of both binder mortars for all type of properties have been evaluated have been evaluated. From the test results it is concluded that technically it is feasible to use LFS in place of hydrated lime as sustainable binder for cement based composites. LFS use improves compressive strength, tensile strength, adhesion, lesser porosity, better adhesion. The use of LFS also improves waste management in steel production and lime production.

By: Ana Luiza Borges Marino
Ref: Materials in Civil Engineering,
Volume: 29, Issue: 11, Nov.2017

Effects of Cracking and Improper Consolidation as Important Concrete Defects on Water Absorption and Electrical Conductivity

This research is to compare the effect of load-induced cracking, thermally induced cracking and faulty consolidation on concrete durability which can be used for condition assessment of structures. The study has been done by testing cylindrical test specimen of w/c ratio 0.40 of mix proportion sand 433kg, cement 433kg, stone 941kg, different w/c ratio and different consolidation levels for various test samples. Tests have been conducted by split tensile testing, microwave heating, ultrasonic pulse velocity, water absorption, electrical conductivity and resistivity. Test specimens have been tested after 56 days aging.

Result/conclusion:The permeability is not greatly affected below 0.8 fu loading as below this loading only localized cracks are developed. Thermal stressing has far more effect on durability than mechanical loading as the water dries out and pores are developed and cracking is induced which effect durability, more w/c ratio also result in higher thermal stress effect. Less consolidation results in maximum deterioration than loading and thermal induced damage. Electrical sensitivity results give misleading results. Therefore it is learnt that proper consolidation is most important factor for permeability

By: ShahzadEghtesadi and Michelle Nokken
Ref: Materials in Civil Engineering, Volume: 29, Issue: 11, Nov.2017

Methods for Calcium Carbonate Content Measurement of Biocemented Soils

Biocementation is improvement of soft soil properties by use of microbially induced calcium carbonate precipitation (MICP) resulting in improvement of shear strength of soil, and reduction in water flow into the soil. Calcium carbonate crystals precipitated in the soil act as a cementing agent for soil particles like cement. The common MICP process uses urease-producing bacteria (UPB) to decompose urea to increase pH. Therefore calcium carbonate content CCC is important parameter for such biocemented soils. There are various six methods to measure CCC. This study aims to compare CCC measurement results using these six different methods. UPB strains cultivated treated into samples of pure silica sand samples of specimen size 50 dia and 100 height at relative density of 40% have been tested by Titration, inductively coupled plasma ICP-AES, X-ray differaction, thermogravimetric analysis TGA, ASTM, and washing methods. Results of CCC % varies in each method, the titration method gives least CCC vaue then ICP, XRD, TGA, ASTM and Washing respectively. The washing gives maximum CCC value. On averaging TGA, XRD and ASTM methods give reasonable results, which may be used to determine CCC value in Biocemented soils.

By: Sun-Gye,Sung-sik,Shifanwu,and Jian Chu.
Ref: Materials in Civil Engineering,
Volume: 29, Issue: 11, Nov.2017

Evaluation of Shrinkage and Fracture Properties of Internal Cured 100-Mpa Ultrahigh-Strength Steel Fiber-Reinforced Concrete

High strength concrete of 100 MPa has high durability, improved resistance to freeze-thaw cycle and chemicals and extreme penetration resistance. Shrinking and cracking is a major problem in the high strength concrete. Environmental drying is called shrinkage drying and cement hydration is called autogenous shrinkage. Autogenous shrinkage is due to capillary stress produced during cement hydration. Capillary stress is is inversely proportional to to radius of capillary pores, which in turn proportional to water-to-binder ratio of concrete. Higher the water to binder ratio, lower the autogenous shrinkage. Therefore in high strength concrete it is necessary to slow down moisture loss from concrete which is done by using presoaked lightweight aggregate (PSLWA), it acts as internal water reservoir and delays drying and decreases cement hydration shrinkage. The study evaluates shrinkage and fracture properties of internally cured steel fibre reinforced 100 MPa concrete. Tests conducted on different samples of normal and PSLWA show that the by using PSLWA shrinkage is reduced from 706.6micro m/m to 373.4 micro m/m and noticeable decrease in cracking, tensile strength reduction by 20%, and bending strength even with less negative impact on compressive strength. Addition of 1% steel fiber improved the fracture performance. The ratio of fracture energy is 50 to 70 without /with 1% steel fiber. In this study the steel fiber did not increase tensile and cracking strength.

By: Jun Zhang, Jiajia Zhang and Xiaoping Ding
Ref: Materials in Civil Engineering,
Volume: 29, Issue: 11, Nov.2017

Calendar of courses

Course No.	From	To	Name of the Course	Duration	Eligible Group
IRSE Probationary Courses					
18002	04/06/2018	10/08/2018	IRSE Phase-II	10 Weeks	IRSE (P) 2016 Exam.
18003	30/07/2018	03/08/2018	IRSE Joining	1 Week	IRSE (P) 2017 Exam.
18004	19/11/2018	11/01/2019	IRSE Phase-I	8 Weeks	IRSE (P) 2017 Exam
18005	03/12/2018	07/12/2018	IRSE Posing Exam	1 Week	IRSE 2016 Exam.
Integrated Courses					
18101	12/03/2018	13/04/2018	Integrated /Part-1	5 Weeks	
	02/05/2018	31/05/2018	Integrated /Part-2	5 Weeks	Gr.B officers
18102	25/06/2018	27/07/2018	Integrated /Part-1	5 Weeks	
	13/08/2018	14/09/2018	Integrated /Part-2	5 Weeks	Gr.B officers
18103	10/12/2018	11/01/2018	Integrated /Part-1	5 Weeks	
	28/01/2018	28/02/2019	Integrated /Part-2	5 Weeks	Gr.B officers
Sr. Professionals Courses					
18202	16/04/2018	18/05/2018	Sr. Pro. (P Way)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
18203	13/08/2018	14/09/2018	Sr. Pro. (Br & Genl)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
18204	01/10/2018	02/11/2018	Sr. Pro. (P Way)	5 Weeks	JAG/SS officers with minimum 6 years of Service in Gr.'A'
18212	09/04/2018	11/05/2018	Advance Sr. Pro. course	5 Weeks	SAG& NFSAG officers
Seminars , Workshops					
18305	12/04/2018	13/04/2018	CE(W)/CPDEs Seminar	2 Days	CE(W)/CPDEs
18306	24/05/2018	25/05/2018	CE/TMs' Seminar	2 Days	CE/TMs
18307	17/05/2018	18/05/2018	State JVs	2 Days	SAG/SG officers of Civil Engg. & other Rly services
18308	07/06/2018	08/06/2018	CTEs' Seminar	2 Days	CTEs
18309	05/07/2018	06/07/2018	Workshop on PPP&EPC	2 Days	JAG/SG of Civil Engg & Accountsgg.
18310	26/07/2018	27/07/2018	CAOs' Seminar	2 Days	CAOs
18311	16/08/2018	17/08/2018	CE/TP Seminar	2 Days	CE/TPs
18312	06/09/2018	07/09/2018	CGEs' Seminar	2 Days	CGEs
18313	19/09/2018	20/09/2017	State JVs	2 Days	SAG/SG officers of Civil Engg.& other Rly services.
18314	03/05/2018	04/05/2018	CBEs' Seminar	2 Days	CBEs
18315	31/10/2018	01/11/2018	IRICEN Day Seminar	2 Days	IRSEs of 1992'batch

18316	22/11/2018	23/11/2018	PCEs' Seminar	2 Days	PCEs
18317	13/12/2018	14/12/2018	Addl slot for Seminar	2 Days	
18318	27/12/2018	28/12/2018	Addl slot for Seminar	2 Days	
Special Courses for Regular Serving Officers					
18409	04-06-2018	08/06/2018	USFD	1 Week	JS/SS/JAG/SG
18410	16/04/2018	20/04/2018	Land Management (W-1)	1 Week	SS/JAG
18411	16/04/2018	27/04/2018	PSC & Steel Structures including Crane Working (B-4)	2 Weeks	JS/SS/JAG
18412	23/04/2018	27/04/2018	Points, Xings, Curve and Yards (T-3)	1 Week	JS/SS/JAG
18414	11/06/2018	22/06/2018	Mechanised Track Maint Monitoring & Renewals, RG, USFD and Tr.	2 Weeks	JS/SS/JAG
18415	25/06/2018	30/06/2018	Rail Wheel Interaction & derailments	1 Week	JS/SS/JAG/SG of OL
18416	25/06/2018	29/06/2018	Layout Calculations	1 Week	JS/SS/JAG
18417	09/07/2018	20/07/2018	Construction Engineers (C-2)	2 Weeks	JS/SS/JAG of Const.Org.
18418	30/07/2018	03/08/2018	Layout Calculations	1 Week	JS/SS/JAG
18419	06/08/2018	24/08/2018	Course for Bridge Design Asstt	3 Weeks	AEN/XEN(Design) /Bridge Design Asstts of OL/Constr.
18420	20/08/2018	24/08/2018	Modern Surveying (C-1)	1 Week	JS/SS/JAG of Const.Org.
18421	10/09/2018	14/09/2018	USFD	1 Week	JS/SS/JAG/SG
18422	17/09/2018	22/09/2018	Rail Wheel Interaction & derailments	1 Week	JS/SS/JAG/SG of OL
18423	17/09/2018	20/09/2018	Rly. Formation & Geo. Tech. Invest	1 Week	JS/SS/JAG of Const.Org.
18424	24/09/2018	05/10/2018	Mechanised Track Maint & Renewals, RG, USFD and Tr. Monitoring	2 Weeks	JS/SS/JAG
18425	24/09/2018	05/10/2018	Contracts, Arbitration & Project Management	2 Weeks	SS/JAG
18426	24/09/2018	28/09/2018	Steel Structure (B-3)	1 Week	JS/SS/JAG
18427	15/10/2018	19/10/2018	Points & Xings and Yards (T-3)	1 Week	JS/SS/JAG
18428	22/10/2018	26/10/2018	Land Management (W-1)	1 Week	SS/JAG
18429	26/11/2018	01/12/2018	Rail Wheel Interaction & derailments	1 Week	JS/SS/JAG/SG of OL

18430	14/05/2018	15/05/2018	Workshop on TMS for Sr.	2 Days	Sr.DEN(Co)s of 34 Div.
			DEN(Co)s		
18431	02/07/2018	03/07/2018	Workshop on TMS for Sr. DEN(Co)s	2 Days	Sr.DEN(Co)s of 34 Div.
18432	17/12/2018	21/12/2018	USFD	1 Week	JS/SS/JAG/SG
Special Courses for PSU Sr. Level Officers					
18505	28/05/2018	01/06/2018	Special 1 Wk course for PSU	1 Week	PSU Sr. Level Officers
18506	22/10/2018	26/10/2018	Special 1 Wk course for PSU	1 Week	PSU Sr. Level Officers
Awareness/Appreciation Courses for Probationers of Other Deptt					
18707	30/04/2018	04/05/2018	Awareness course	1 Week	Prob. Of NAIR (IRAS & IRPS)
18708	07/05/2018	11/05/2018	Awareness course	1 Week	Prob. of IRIEEN.
18709	18/06/2018	22/06/2018	Awareness course	1 Week	Prob. of IRITM.
18710	27/08/2018	31/08/2018	Awareness course	1 Week	Prob. of IRIEEN.
18711	15/10/2018	19/10/2018	Awareness course	1 Week	Prob. of IRIMEE.
18712	26/11/2018	30/11/2018	Awareness course	1 Week	Prob. of JJ RPF Academy.
Special Courses for Regular Serving Supervisers (SSEs,JEs at SSTW)					
18819	02/04/2018	13/04/2018	Land, Stores & Contract Management(PWay)	2 Weeks	SSE/JEs of P.Way
18820	09/04/2018	20/04/2018	Mechanized track-Maint ,Renewals &TMo	2 Weeks	SSE/JEs of P.Way
18822	23/04/2018	04/05/2018	Fabrication of steel Bridge with Crane wkg	2 Weeks Bridge	SSE/JEs of Works &
18823	23/04/2018	04/05/2018	Points & crossing, Curves & Yards	2 Weeks	SSE/JEs of P.Way
18824	02/05/2018	12/05/2018	USFD, Welding, Rail Grinding	2 Weeks	SSE/JEs of P.Way
18825	14/05/2018	25/05/2018	Long Welded Rail	2 Weeks	SSE/JEs of P.Way
18827	21/05/2018	01/06/2018	Survey of Works, Estimate, Contract Planning and its Management	2 Weeks	SSE/JEs of Works
18828	21/05/2018	01/06/2018	Rail Wheel interaction and derailment	2 Weeks	SSE/JEs P.Way & Inst. Of DTI,ZRTI
18829	28/05/2018	08/06/2018	Formation	2 Weeks	SSE/JEs of Works
18830	04/06/2018	15/06/2018	Land Management including Water supply, sewerage & water audit	2 Weeks	SSE/JEs of Works
18831	04/06/2018	15/06/2018	Inspection and Maintenance of bridges	2 Weeks	SSE/JEs of Works & Bridge

18833	11/06/2018	22/06/2018	Building construction & Maintenance	2 Weeks	SSE/JEs of Works
18834	18/06/2018	29/06/2018	Mechanized track- Maint, Renewals &TMo	2 Weeks	SSE/JEs of P.Way
18835	18/06/2018	29/06/2018	USFD, Welding, Rail Grinding	2 Weeks	SSE/JEs of P.Way
18836	02/07/2018	13/07/2018	Points & crossing, Curves & Yards	2 Weeks	SSE/JEs of P.Way
18837	02/07/2018	13/07/2018	Concrete Technology	2 Weeks	SSE/JEs of Works & Bridge
18838	16/07/2018	27/07/2018	Long Welded Rail	2 Weeks	SSE/JEs of P.Way
18839	23/07/2018	03/08/2018	Land, Stores & Contract Management(Pway)	2 Weeks	SSE/JEs of P.Way
18841	30/07/2018	10/08/2018	Rail Wheel interaction and derailment	2 Weeks	SSE/Jes P.Way & Inst. Of DTI,ZRTI
18842	06/08/2018	17/08/2018	USFD, Welding, Rail Grinding	2 Weeks	SSE/JEs of P.Way
18843	13/08/2018	24/08/2018	Mechanized track- Maint, Renewals &TMo	2 Weeks	SSE/JEs of P.Way
18844	27/08/2018	07/09/2018	Points & crossing, Curves & Yards	2 Weeks	SSE/JEs of P.Way
18845	27/08/2018	07/09/2018	Survey of Works, Estimate, Contract Planning and its Management	2 Weeks	SSE/JEs of Works
18846	04/09/2018	14/09/2018	Safety at Track work sites & Crane working	2 Weeks & Bridge	SSE/JEs of Works
18847	10/09/2018	21/09/2018	Long Welded Rail	2 Weeks	SSE/JEs of P.Way
18848	10/09/2018	21/09/2018	Formation	2 Weeks	SSE/JEs of Works
18849	17/09/2018	28/09/2018	USFD, Welding, Rail Grinding	2 Weeks	SSE/JEs of P.Way
18850	17/09/2018	28/09/2018	PSC construction with crane wkg	2 Weeks & Bridge	SSE/JEs of Works
18851	24/09/2018	28/09/2018	Track Management System	1 Week	SSE/JEs of P.Way
18852	01/10/2018	12/10/2018	Land, Stores & Contract Management(Pway)	2 Weeks	SSE/JEs of P.Way
18853	01/10/2018	12/10/2018	Concrete Technology	2 Weeks	SSE/JEs of Works & Bridge
18854	08/10/2018	19/10/2018	Mechanized track- Maint, Renewals &TMo	2 Weeks	SSE/JEs of P.Way
18855	08/10/2018	19/10/2018	Rail Wheel interaction and derailment	2 Weeks	SSE/Jes P.Way & Inst. Of DTI,ZRTI

18856	22/10/2018	02/11/2018	Points & crossing, Curves & Yards	2 Weeks	SSE/JEs of P.Way
18857	22/10/2018	02/11/2018	USFD, Welding, Rail Grinding	2 Weeks	SSE/JEs of P.Way
18858	22/10/2018	02/11/2018	Fabrication of steel Bridges with crane wkg	2 Weeks	SSE/JEs of Works & Bridge
18859 18861	19/11/2018 19/11/2018	30/11/2018 30/11/2018	Long Welded Rail Building construction & Maintenance	2 Weeks 2 Weeks	SSE/JEs of P.Way SSE/JEs of Works
18862	26/11/2018	07/12/2018	Inspection and Maintenance of bridges	2 Weeks	SSE/JEs of Works & Bridge
18864	03/12/2018	14/12/2018	Land Management including Water supply, sewerage & water audit	2 Weeks	SSE/JEs of Works
18865	10/12/2018	21/12/2018	Concrete Technology	2 Weeks	SSE/JEs of Works & Bridge
18867	17/12/2018	28/12/2018	Rail Wheel interaction and derailment	2 Weeks	SSE/Jes P.Way & Inst. Of DTI,ZRTI
18868	24/12/2018	04/01/2019	Mechanized track- Maint, Renewals &TMo	2 Weeks	SSE/JEs of P.Way
Special Courses for PSU Jr. Level Officers & Contractors' Engineers					
18903	16/04/2018	20/04/2018	Sp.1 Wk course for Contractor Engineers	1 Week	Engrs of Rly Wkg Contractors
18904	02/07/2018	27/07/2018	Special 4 Wks course for PSU	4 Weeks	Jr. Level officers of PSUs
18905	20/08/2018	24/08/2018	Sp.1 Wk course for Contractor Engineers	1 Week	Engrs of Rly Wkg Contractors



Group Photo of IRSE Silver Jubilee (1991 batch) Officers with Member Engineering

CALENDAR OF COURSES 2018 (REV. 4 Dated 26/03/2018)

INDIAN RAILWAYS INSTITUTE OF CIVIL ENGINEERING/PUNE -

R — Months: DECEMBER'2017 | JAN.2018 | FEB.2018 | MAR.2018 | APRIL'2018 | MAY'2018 | JUNE'2018 | JULY'2018 | AUGUST'2018 | SEPT ' 2018 | OCTOBER'2018 | NOV.'2018 | DECEMBER'2018 | 'JAN.2019 | FEB.2019 | MAR.2019

Date (Monday): 4 11 18 25 | 1 8 15 22 29 | 5 12 19 26 | 5 12 19 26 | 2 9 16 23 30 | 7 14 21 28 | 4 11 18 25 | 2 9 16 23 30 | 6 13 20 27 | 3 10 17 24 | 1 8 15 22 29 | 5 12 19 26 | 3 10 17 24 31 | 7 14 21 28 | 4 11 18 25 | 4 11 18 25

Institute holidays: 26/1, 2/3, 30/3, 1/5, 15/8, 22/8, 13/9, 21/9, 2/10, 18/10, 8&9, 25/12

IRSE COURSES: ALL COURSE NUMBERS PRECEDE WITH DIGIT '17' FOR THE YEAR 2017, '18' FOR THE YEAR 2018

- 2015 Ex batch: 17011; 18001
- 2016 Ex batch: 18002; 18005
- 2017 ExBatch: 17012; 18003; 18004
- Integrated courses: 17103 INTEGRATED; 17103 Integrated; 18101 INTEGRATED; 18101 Integrated; 18102 INTEGRATED; 18102 Integrated; 18103 Integrated; 18103 INTEGRATED
- Sr.Prof. courses: Sr.Prof.Bridge 201; Adv.SrProfCourse18211; Adv.SrProfCourse18212; Sr.Prof.P.Way 18202; Sr.Prof.Bridge 18203; Sr.Prof.P.Way 18204

HAG/SAG SEMINARS: 313 PPP& EPC; 301 S J V; ~~302~~ ~~RHW~~; 303 E&P; ~~304~~ ~~E&P~~; 305 CE/W CPDEs; ~~306~~ ~~CE/TM~~; 314 CBE; 307 SJV; 306 CE/TM; 308 CTE; 309 E&P; 310 CAO (C); 311 CE/TP; 312 CGE; 313 S J V; 315 ID; 316 PCE; 317 A Slot; 318 A Slot

SPECIAL COURSES (Tr. / Wks / Br. / VS):
- 433 RWI; 401 PXC; ~~403~~ ~~LOC~~ Post pone; 404 LOC; 406 MTMR; 407 RWI; 413 TMS; 410 LM; 412 PXC; 430 WS TMS; 409 USFD; 414 MTMR; 415 RWI; 431 WS TMS; 418 LOC; 419 BDA; RDSO; 421 USFD; 422 RWI; 424 MTMR; 426 FSB; 427 PXC; 429 RWI; 432 USFD
- 402 RF&GTI; 405 C,A&PM; 408 TNLG; 411 PSC; 416 LOC; 417 CONST ENGINEERS; 420 MS; 423 RF&GTI; 425 C,A&PM; 428 LM

Sp.Courses forPSU: PSU; 434 NTPC (T&BM); 501 IRCON; ~~502~~ ~~PSU~~; ~~503~~ ~~PSU~~; IRPS& IRSS; IRSSE; 504 IRCON; IRAS &IRPS; IRSEE; 505 PSU; IRTS; Sp.Course IRSEE; IRSEE; IRSME; 506 PSU; RPF

AWARENESS COURSES: IRSEE 701; 703; 704; Post pone; Post pone; 702; 705; 706; IRSME; 707; 708; 709; 703; 710; 711; 712

SPECIAL COURSES FOR SSEs,JEs at IRICEN Sr. SUPERVISORS' TRAINING WING (SSTW)/PUNE

MONTH: DECEMBER'2017 | JAN.2018 | FEB.2018 | MAR.2018 | APRIL'2018 | MAY'2018 | JUNE'2018 | JULY'2018 | AUGUST'2018 | SEPTEMBER'2018 | OCTOBER'2018 | NOVEMBER'2018 | DECEMBER'2018 | 'JAN.2019 | FEB.2019 | MAR.2019

4 11 18 25 | 1 8 15 22 29 | 5 12 19 26 | 5 12 19 26 | 2 9 16 23 30 | 7 14 21 28 | 4 11 18 25 | 2 9 16 23 30 | 6 13 20 27 | 3 10 17 24 | 1 8 15 22 29 | 5 12 19 26 | 3 10 17 24 31 | 7 14 21 28 | 4 11 18 25 | 4 11 18 25

SP. COURSES for Track, Works & Bridge streams in SSTW (Tr. / Wks / Br.):
- LWR; USFD; 802 LWR; 804 TMS; 807 MTMR; 809 PXC&YM; 2/3; 812 BC&M; 814 LWR; 818 L,S&CM; 822 PXC&YM; 1/5; 825 LWR; 830 LM; 832 TMS; 834 MTMR; 836 PXC&YM; 839 L,S&CM; 15/8; 22/8; 843-MTMR; 844 PXC&YM; 13/9; 21/9; 849 USFD; 2/10; 854 MTMR; 18/10; 856 PXC&YM; 8&9; 859 LWR; 863 PXC&YM; 865; 25/12; 868 MTMR
- 887 BC; 890 PXC; 801 CT; 803 LM; 806 USFD; 808 FMN; 811 S,E & CM; 816 USFD; 817 TWS&CW; 820 MTMR; 821 TNLG; 824 USFD; 827 S,E & CM; 829 FMN; 833 BC&M; 837 CT; 838 LWR; ~~840~~ ~~CM~~; 842 USFD; 845 S,E & CM; 847 LWR; 852 L,S&CM; 857 USFD; 861 BC & M; 864 LM; CT; 866 USFD
- 885 CM; 888 RWI; 805 RWI; 810 CM; 813; 815 PSC; 819 RWI; 823 FSB; 828 RWI; 831 IMB; 835 USFD; 841 RWI; 846 TWS&CW; 850 PSC; 855 RWI; 858 FSB; 862 IMB; 867 RWI

SPECIAL COURSES for PSU & Cont.Engr: PSU; C-E; 901; IMB; 902; 903; 904 PSU; 905; 848 FMN; 851 TMS; 853 CT

MAIN COURSES	Integrated				Sr.Prof. courses				ADV.SPC	ADV.SPC
COURSE NOS.	104	101	102	103	204	201	202	203	211	212
WEEKS	12	12	12	12	5	5	5	5	5	5
ACTUAL ATTENDED										
ALLOTED SEATS	45	45	45	45	45	45	45	45	30	30

SPECIAL COURSES FOR OFFICERS IN GREEN BUILDING. REFER TABLES BELOW FOR DETAILS

COURSE NOS.	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416
WEEKS	1	1	1	1	2	2	1	1	1	1	2	1	3	1	2	1
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

COURSE NOS.	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432
WEEKS	1	2	1	1	1	1	1	2	2	1	1	1	1	2D	2D	1
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45	45	34	34	45

SLOTS FOR PSU SR&MIDDLE LEVEL OFFICERS

COURSE NOS.	501	502	503	504	505	506
WEEKS	2	1	1	2	1	1
ALLOTED SEATS	MIN.15 - MAX.35					

SSTW COURSES

COURSE NOS.	801	802	803	804	805	806	807	808	809	810	811	812
WEEKS	1	1	1	1	2	2	2	2	2	1	2	1
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45

MAIN COURSES: SSTW COURSES

COURSE NOS.	813	814	815	816	817	818	819	820	821	822	823	824	825	~~826~~	827	828	829	830	831
WEEKS / DAYS	2	1	2	2	2	2	2	2	1	2	1	2	2	~~1~~	2	2	2	2	2
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

COURSE NOS.	832	833	834	835	836	837	838	839	~~840~~	841	842	843	844	845	846	847	848	849	850
WEEKS / DAYS	1	2	2	2	2	2	2	2	~~1~~	2				2			2	2	2
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

COURSE NOS.	851	852	853	854	855	856	857	858	859	~~860~~	861	862	863	864	865	866	867	868	901
WEEKS / DAYS	1	2	2	2	2	2	2		2	2–	12		2	2	2	2	2	2	4
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	MIN.15 - MAX.35

SLOTS FOR PSU JLO: 901

No	Start date	End date	Details	Dur.	Eligibility	CD	ACD	
301	24/01/2018	25/01/2018	Seminar on State JV	2 D	SAG/SG officers of Rly	SPW	SPP	
302			Workshop onRLY Heritage	2 D	DRMs&HeritageZonal I/Cs	SPW	SPP	
303	08/03/2018	09/03/2018	Workshop on PPP&EPC	2 D	HAG/SAG of Engg & A/C	SPP	SPW	R.01
[redacted]								
305	12/04/2018	13/04/2018	CE(W)/CPDEs' Seminar	2D	CE(W)/CPDEs	SPW	SPP	
306	24/05/2018	25/05/2018	CE/TMs' Seminar	2 D	CE/TMs	PTM	SPT2	
307	17/05/2018	18/05/2018	Seminar on State JV	2 D	SAG/SG officers of Rly	SPW	SPP	
308	07/06/2018	08/06/2018	CTEs' Seminar	2 D	CTEs	SPT2	SPT1	
309	05/07/2018	06/07/2018	Workshop on PPP&EPC	2 D	HAG/SAG of Engg &A/C	CMG	SPP	
310	26/07/2018	27/07/2018	CAOs' Seminar	2 D	CAOs	SPP	DN	
311	16/08/2018	17/08/2018	CE/TPs' Seminar	2 D	CE/TPs	SPB2	SPT1	
312	06/09/2018	07/09/2018	Trg Mgr/CGE Seminar	2 D	CGEs	CMG	SPT2	
313	19/09/2018	20/09/2018	Seminar on State JV	2 D	SAG/SG officers of Rly	SPW	SPP	
314	03/05/2018	04/05/2018	CBEs' Seminar	2 D	CBEs	SPB1	SPB2	
315	31/10/2018	01/11/2018	IRICEN Day Seminar	2 D	IRSE 92' Batch	SPP	SPW	
316	22/11/2018	23/11/2018	PCEs' Seminar	2 D	PCEs	SPT1	DN	
317	13/12/2018	14/12/2018	Addl slot for Seminar	2 D				
318	27/12/2018	28/12/2018	Addl slot for Seminar	2 D				

C.Code	Course name	No	No	No	No	No	No	No.	NOC	Dur.	TWks
MTMR	Mechanised Track maint & Renewal	406	414	424					3	2	6
RWI	Rail Wheel Interaction & derailments	407	415	422	429				4	1	4
TMS	TMS (T-5)	413	430	431					1.4	1	3
PXC	Points, Xings & Curves	401	412	427					3	1	3
LM	Land Management	410	428						2	1	2
C,A&PM	Contract, Arbitration & Proj. Management	405	425						2	2	4
TNLG	Spl course on Tunnelling	408							1	1	1
RF&GTI	Rly Formation & Geo Tech Investigation	402	423						2	1	2
PSC,SS & Cr	PSC Construction	411							1	2	2
FSB	Fabrication of Steel Bridge	426							1	1	1
BDA	Bridge Design Assistant	419							1	3	3
CE	Construction Engineers	417							1	2	2
MS	Modern Surveying	420							1	1	1
LOC	Lay out Calculations		404	416	418				4	1	6
PSU1 PSU	Special 1 Wk courses for PSU Engineers	502	503	505	506				4	1	4
PSU2 PSU	Special 2Wk courses for PSU Engineers	501	504						2	2	2
USFD	USFD	409	421	432					2	1	2
									35.4		48
PSU	Sp. Courses for Middle & upper Mgmt officers of PSU										

C.Code	Course name	No	No	No	No	No	No	No	No	No	No	No	No	NOC	Dur	T Wks
RWI	Rail Wheel Interaction & Derailment Inv.	805	819	828	841	855	867							6	2	12
LWR	Long Welded Rail	802	814	825	838	847	859	Duration of courses in red of 2 wks						6	2	10
TMS	Track Management System	804	832	851										3	1	3
USFD	USFD,Welding & Rail Grinding	806	816	824	835	842	849	857	866					8	2	16
MTMR	Mech.Track Maint. & Renewals	807	820	834	843	854	868							6	2	12
LS&CM	Land, stores & Contract Management	818	839	852										3	2	6
PXC	Points, Xings, curves & Yard maint.	809	822	836	844	856	863							6	2	12
PSCC	PSC Construction	815	850											2	2	4
FSB	Fabrication of Steel Structure	823	858											2	2	4
IMB	Inspection&Maintenance of Bridges	813	831	862										3	2	6
CM	Contract Management	810	~~826~~	~~840~~	~~860~~									1	1	1
BC&M	Building Construction & Maintenance	812	833	861	Duration of courses in red of 2 wks									3	2	5
CT	Concrete Technology	801	837	853	865			Duration of courses in red of 2 wks						4	2	7
FMN	Formation	808	829	848										3	2	6
LM	Land Management incl. WSS&WA	803	830	864	Duration of courses in red of 2 wks									3	2	5
TNLG	Sp. Course on Tunnelling	821												1	1	1
S,E& CM	Survey of Works, Estimates & Contract mgmt	811	827	845										3	2	6
STW,CW&CM	Safety at Tr.work site,Crane wkg&Cont Mgmt	817	846											2	2	4
PSU	Special course for Diff. PSU Engineers	904												1	4	4
C-E	Sp. Courses for contractors' Engineers	901	902	903	905									4	1	4
														70		128

Pink cell Indicates holiday in the week | Dt in red: Indicates Monday being holiday | 1 Week at RDSO for BDA course | To IRTMTC / RDSO | BREAK FOR PROJECT

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