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ज्ञान ज्योति से मार्गदर्शन

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BOGIBEEL BRIDGE

Indian Railways Institute of Civil Engineering, Pune

ज्ञान ज्योति से मार्गदर्शन



Vision

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,

This edition of journal includes papers on diverse topics. While the paper on Relevance of Junction Strength, Junction Stability, and Junction Integrity gives collation of information for geogrid for base & subbase reinforcement, another paper deals with geometry required for laying of vertical curves.

An attempt is made in a paper on Smart Non-Interlocked Level X-ing Gate Indication System, in this paper to provide low cost fool proof solution to prevent accidents on manned level crossings.

I hope that the readers would find the papers and other articles contained in this edition relevant and useful. The suggestions and contributions of technical papers, news items, articles etc. must be sent by field engineers, for inclusion in the forthcoming issues of this journal, and sharing of knowledge and experience with engineering fraternity.

Pune
Aug 2018

(A. K. Mishra)
Director

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

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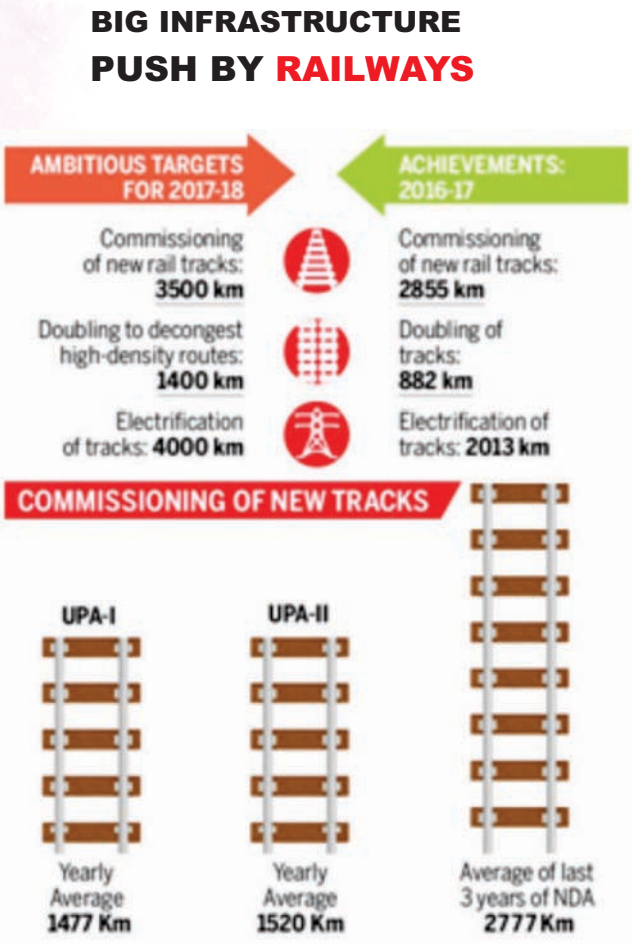
Articles on the Railway Civil Engineering are welcome from the authors. The authors who are willing to contribute articles in the IRICEN Journal of Civil Engineering are requested to please go through the following guidelines :

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

Moves of the Modi Government that Point to a Major Track Change at the Indian Railways

Prime Minister Narendra Modi's ambitious project to transform the railways is chugging on. From the engines, trains and stations to food and bookings, everything is getting a makeover. With next Lok Sabha elections less than a year away, the Modi government is trying to ensure it lives up to his promise of changing the way Indians travel on trains.

While big-ticket changes such as building a Delhi-Mumbai freight corridor and introducing dozens of high-speed new trains with contemporary features and amenities are transforming the basic constitution of the railways, introduction of new services and tweaking of the existing ones is changing the face of the railways.



Changing things, one tech at a time

Recently, the railways announced a new service that can go a long way in improving its image. Passengers may not get confirmed berths each time they book a train ticket, but now, thanks to a predictive service on the IRCTC website, they will get to know their chances of getting one. It will let the passengers know the probability of confirmation of wait-listed tickets, based on a new algorithm developed by the Centre for Railway Information Systems (CRIS). Such a technological novelty was unexpected just a few years ago since Indian railways has come to be perceived as an old, lumbering system impervious to change.

Hot on the menu

The railways knows that small tweaks can make a big difference. After the government auditor scolded it for serving food that didn't quite pass muster, the railways is planning to go for quality over quantity, starting with premium trains such as the Rajdhanis and the Shatabdis. Maintaining quality has become difficult because a large quantity of food is being provided at low cost. So the railways will now reduce the quantity so that it can ensure quality food in trains.

Watch the watch

Recently, Railway Minister Piyush Goyal has warned heads of Zonal Railways that delays in train services will defer their appraisal proportionately, giving them a month to improve punctuality. Trains are now likely to run on time as any deviation from the schedule will cost officials their promotions.

Airport-like feeling

Besides attention to detail that can matter a lot for passengers, the railways is also on track to introduce big-ticket reforms. Next year, India will get several airport-like railways stations, which will be a massive change as railways stations are hardly seen as attractive places. Habibganj railway station in Madhya Pradesh and Gandhinagar railway station in Gujarat will be model railway stations which could put to shame an ordinary airport. The Indian Railways will spend Rs 5,000 crore on modernising 68 more stations before the 2019 general elections.

Space jam

Modi has pulled up governments of Gujarat, Maharashtra and Uttar Pradesh over delay in land acquisition for the 1,504-km Western Dedicated Freight Corridor, while directing railways ministry to make some "selected sections" of the project

operational from Independence Day this year. A 190-km leg of the project between Ateli in Haryana and Phulera in Rajasthan will be made operational from August 15. The eastern corridor runs from Ludhiana to Dankuni (1856 Kms) and the Western Corridor from Dadri to Jawahar Lal Nehru Port, Mumbai (1504 Kms). When completed, the corridor would ease the burden of the existing railway network and strengthen the economic backbone of the country.

Due to its humongous size and widely spread-out operations, it is not easy to transform Indian railways without a persistent focus and innovation. The Modi government has been on the job by constantly introducing changes, big and small, in the way Indians travel on trains.

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

POC Trials of Satellite based Warning System at Unmanned Railway Crossings Satisfactory: ISRO

The trial of a satellite-based early warning system about approaching trains at unmanned level crossings has been completed by the railways, a top official of Indian Space Research Organisation (ISRO) said. Speaking to media, Ahmedabad-based Space Applications Centre (SAC) Director TapanMisra said, "The one-year phase-1 trial of the satellite-based early warning system is over. Its performance has been satisfactory."



Under a pilot project, the railways had last year installed ISRO-developed integrated circuit (IC) chips on some train engines. The Indian Regional Navigation Satellite System (or NaVIC) was used to caution road users at crossings about approaching trains through hooters installed at these crossings.

On its efficiency, Misra said, "The satellite-based technology was tested under different terrains and tough climatic conditions throughout the year. Its smooth functioning shows it is an all-weather system." The pilot project in November 2017 as how the railways had installed IC chips on five train engines on different routes.

The test has been going on since June 2017 to check if the system is reliable. Misra said, "After developing the system, we transferred the hardware technology to four companies for limited production for the pilot project." Research Designs & Standards Organisation (RDSO), R&D wing of the railways, submitted its report to the Railway Board after the trial concluded.

RDSO, in its report, said though the ISRO technology has worked satisfactorily, it wants certain modifications before its rollout. Moreover, the railways has to sort out issues of vandalism and theft of the system first. There are about 5,792 unmanned crossings till date, which account for 40% of railways accidents.

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

CSTM Heritage Building will now be Illuminated with Green Energy – Yet Another Green Energy Initiative by CR



Chhatrapathi Shivaji Maharaj Terminus Heritage Building, Mumbai will soon be illuminated with green energy. The full energy consumption of heritage building and other office buildings of various divisions of Central Railway will be from Green Energy. This is yet another green initiative by Central Railway after recently converting Neral – Matheran section, Asangaon and Mankhurd as fully green energy stations.

The supply of green energy to Chhatrapati Shivaji Maharaj Terminus will soon be possible as Central Railway entered into an Agreement with M/s Sri Pavan Energy Pvt. Ltd, a Government of India Undertaking, to provide Power at Rs. 5.18 per unit recently. Under this agreement the power of 6 Mega Watt green energy generated by Wind Turbine by M/s Sri Pavan Energy Pvt. Ltd, under commissioning at Sangli district of Maharashtra will be utilized at 6 different stations of Central Railway and South Eastern Railway i.e Chhatrapati Shivaji Maharaj Terminus, Manmad, Bhusawal and Nagpur. A Total of 12.93 million units green energy is expected to be generated that will be utilised for the full energy consumption of Heritage building of Chhatrapati Shivaji Maharaj Terminus and other office buildings of various divisions. The energy will be generated at Sangli district it will be received through the grid connection to various points of Central Railway. This power purchase will be utilized for meeting the requirement of Renewable Purchase Obligations (RPO) and the agreement will be valid for 25 years. An estimated amount of Rs. 1.5 Crores will be saved on electricity bill through this agreement. The illumination of Chhatrapati Shivaji Maharaj Terminus Building with green energy will add another feather to the cap of Energy Conservation initiatives as a high priority mission in Railways.

Ref: www.railnews.in

Railways brings TCS on Board to Work on Safety Operations

With a focus on safe and efficient operation of train services, the Railways is partnering with Tata Consultancy Services (TCS) under the Technology Mission for Indian Railways (TMIR) programme.

At a high-level meeting convened recently at the Research & Innovation Facility of TCS at the Indian Institute of Technology (IIT), Madras, top officials of the Mission Implementation and Coordination Committee of the TMIR explored the possibility of deploying advanced technology to monitor the stability of bridges and railway tracks.

Launching of drones for safe passage of trains, particularly at unmanned level crossings and fog-affected routes, was also mooted.

According to railway sources, N.S. Vyas, Chairman, IIT-Kanpur, identified asset management, health diagnostics and corrosion-resistant coating for rolling stock/tracks as priority areas where TCS could contribute.

With huge investments expected in the railways in the next five years, safety and reliability were paramount with increasing axle load and frequency of trains.

Prof. Vyas called for advanced communication technology in the train, off the train, train-to-platform etc.

A different way of thinking about technology was required and TCS could partner with the Railways for such innovations, he added.

It may be noted that multiple research centres were established at IITs/Universities to facilitate TMIR bring in new ideas to the Research Designs and Standards Organisation of the Indian Railways that approves new technologies for implementation, the sources said.

RailCloud Data

The meeting assumes significance in the backdrop of train accidents due to rail fractures in the recent past. The meeting underscored the need for rail cloud data and analytics for actionable intelligence across multiple applications.

Steel for high speed tracks using TATA Steel Corus Technology, corrosion resistance coating using nano technology, condition monitoring of rolling stock and introduction of technologies for modernising manufacturing/maintenance facilities were among the initial pilot projects finalised, the sources added.

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

जहाँ पवित्रता है, वहीं निर्भयता है ।

महात्मा गाँधी

Indian Railways First Dedicated Corridor for Freight Trains on August 15

After 165 years of its birth, Indian Railways is set to get its first publicly-owned dedicated corridor for freight trains on August 15, when the country will be celebrating its 72nd Independence Day.

State Covered

Western DFC (km)

Total	1,504	Haryana	177
Rajasthan	567	Maharashtra	177
Gujarat	565	Uttar Pradesh	18

Eastern DFC (km)

Total	1,856	Jharkhand	196
UP	1,058	Punjab	88
Bihar	239	Haryana	72
West Bengal	203	Both corridors to be commissioned by April 2020	

Prime Minister Narendra Modi is likely to dedicate the 190-km Freight Corridor between Dadri in Uttar Pradesh and Phulera in Rajasthan, which fall under the Western Dedicated Freight Corridor (WDFC), to the nation on August 15th Independence Day celebrations.

For the railways, that is facing stiff competition from roadways in freight traffic, this can come as a fresh lease of life as the project is finally taking shape even though partially after 12 years of its formation. It was in February 2006 that the Cabinet had given in-principle nod to the project.

"The feeder route at Tundla is already in place and the Ateli-Phulera route will be functional on August 15," said a government official. The Rs 814-billion-project of Eastern and Western DFCs will cover a total of 3,360 km track, of which around 1,500 km falls in the western region starting from Dadri to Jawaharlal Nehru Port Trust.

Sources said that the government is likely to highlight this as a major achievement for the elections as it was successful in completing land acquisition and awarding the contracts for the projects. After eight years of its conceptualisation, the Congress government was able to award only 18.45 per cent of the contracts as of March 2014.

While Japan International Cooperation Agency is providing loan of Rs 387.22 billion for the Western India project, the Eastern DFC (Mughalsarai-Allahabad-Kanpur-Khurja-Dadri- & Khurja-Ludhiana) is being funded by the World Bank through a loan of $2.360 billion.

The availability of this loan was also ensured in the last four years. Early this year, the railways had conducted a trial run on the Ateli-Phulera section of the Western DFC at a maximum speed of 100 km per hour. It took less than four hours to complete the journey.

According to its current road map, the railways is planning to commission both the lines by April 2020.
"There will be at least 10 feeder lines in the western corridor only connecting the main line to the supply freight. This is going to reduce the traffic by more than half in these busy routes," he said.

According to estimates, delay in the projects has led to a cost overrun of 189 per cent from the earlier lined up Rs 281.81 billion in 2008 to Rs 814.59 billion. This includes higher land costs.

This includes Rs 266.74 billion for EDFC and Rs 467.18 billion for WDFC along with a land cost of Rs 80.67 billion.

According to CAG estimates, there was a Rs 44.42 billion increase in land cost by 2014.

Ref: www.railnews.in

Train-18: Made-in-India 160 kmph Train to run from September



India's much-awaited indigenously manufactured semi high-speed train, code-named Train 18, is expected to be rolled out in September. The train, built by Integral Coach Factory (ICF) of Chennai to

promote Make in India, is capable of running at a speed of 160 km per hour. The luxury train was earlier scheduled for roll-out in July. When asked about the reason for the delay, ICF Chennai General Manager Sudhanshu Mani said there was no delay but only change in anticipated turnout time.

“There is no delay. The train has been built in record time of 16 months while it takes 2 to 3 years to manufacture such trains anywhere in the world. Earlier, the anticipated turnout time was July. We now expect to roll it out in September,” said Mani.

Train 18 doesn’t require an engine to run as it will be self-propelled on electric traction like the metro trains. It will replace existing intercity express trains including Shatabdis. ICF will make six such train sets, out of which two will have sleeper coaches.

The train has some striking features to enhance passenger comfort. The most prominent feature is that all coaches are inter-connected by fully sealed gangways to enable passenger movement from one coach to another. Here are some of the other key features of Train 18:



* Automatic doors with retractable footstep.
* Onboard Wi-Fi and infotainment.
* GPS-based passenger information system.
* Modular toilets with bio-vacuum system.
* Improved centre couplers to lessen jerk impact.
* Electro-pneumatic brake system with brake discs mounted directly on wheel discs to reduce the braking distance.
* All coaches are AC chair-car type (executive class as well as second class) including the driving cab.
* Continuous window glasses for contemporary look.
* The executive class will have rotating seats which can be aligned in the direction of travel.
* Modular luggage rack with glass bottom.
* New bogie design with fully suspended traction motors.
* Roller blinds and diffused LED lighting.
* Halogen-free rubber-on-rubber flooring.
* Space for wheelchair.
* Accessible toilet for persons with disability.

Ref: www.railnews.in



Calendar of courses

C.No	From	To	Name of the course	Duration	Eligible group
IRSE Probationary courses					
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	17/12/2018	21/12/2018	IRSE Posing Exam	1 Week	IRSE 2016 Exam.
18006	25/06/2018	29/06/2018	IRSE Posing Exam	1 Week	Rem IRSE(P) of 2013, 14 &15 Exam.
Integrated courses					
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	19/11/2018	04/01/2019	Integrated /Part-1	4 Week	
	07/01/2019	07/02/2019	Integrated /Part-2	1+5 Wk	Gr.B officers
Sr. Professionals courses					
18203	13/08/2018	14/09/2018	Sr. Professional course (Br & Genl)	5 Week	JAG/SS officers with minimum 6 years of Service in Gr.'A'
18204	01/10/2018	02/11/2018	Sr. Professional course (P Way)	5 Week	JAG/SS officers with minimum 6 years of Service in Gr.'A'
Seminars, Workshops					
18308	30/08/2018	31/08/2018	CTEs' Seminar	2 Days	CTEs
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.
18315	22/11/2018	23-11-2018	IRICEN Day Seminar	2 Days	IRSEs of 1992'batch
18316	27-12-2018	28-12-2018	PCEs' Seminar	2 Days	PCEs
Special courses for regular serving Officers					
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	08/10/2018	19-10-2018	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

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C.No	From	To	Name of the course	Duration	Eligible group
18426	10/09/2018	20/09/2018	PSC&Steel Structures	1/ 2Wks	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	21-12-2018	Rail Wheel Interaction & derailments	1/ 2Wks	JS/SS/JAG/SG of OL
18432	10/12/2018	14-12-2018	USFD	1 Week	JS/SS/JAG/SG
18433	11/06/2018	15/06/2018	Sp. Course on MIDAS software	1 Week	ABEs/Design Asstts of OL/Constr.
18434	24/09/2018	28/09/2018	Sp. Course on MIDAS software	2 Days	ABEs/Design Asstts of OL/Constr.
18435	19/11/2018	21/11/2018	Workshop on TMS for Sr.DEN (Co)s	3Days	Sr.DEN(Co)s of remaining Div.
Special courses for PSU Sr. Level Officers					
18504	17-09-2018	28-09-2018	Special 2 Wks course for PSU	2 Weeks	PSU Sr. Level Officers
18506	22/10/2018	26/10/2018	Special 1 Wk course for PSU	1 Week	PSU Sr. Level Officers
18507	27/08/2018	07/09/2018	Special Course for Metro Rail Engineers	2 Weeks	Engineers of Metro Rails
Awareness/Appreciation courses for Probationers of other Dept.					
18709	01-10-2018	05-10-2018	Awareness course	1 Week	Prob. of IRITM.
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 Supervisors (SSEs,JEs at SSTW)					
18839	23/07/2018	03-08-2018	Land, Stores & Contract Management(Pway)	12 Days	SSE/JEs of P.Way
18841	30/07/2018	10/08/2018	Rail Wheel interaction and derailment	12 Days	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	14/09/2018	Survey of Works, Estimate, Contract Planning and its Management	12 Days	SSE/JEs of Works
18846	04/09/2018	14/09/2018	Safety at Track work sites & Crane working	12 Days	SSE/JEs of Works & Bridge
18847	10/09/2018	21-09-2018	LWR	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 Week	SSE/JEs of P.Way
18850	08-10-2018	19-10-2018	PSC construction with crane wkg	12 Days	SSE/JEs of Works & Bridge

Revision 9 dated 26/03/2018

C.No	From	To	Name of the course	Duration	Eligible group
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)	12 Days	SSE/JEs of P.Way
18853	01/10/2018	12/10/2018	Concrete Technology	12 Days	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	17/09/2018	28/09/2018	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	12 Days	SSE/JEs of Works & Bridge
18859	19/11/2018	30/11/2018	LWR	12 Days	SSE/JEs of P.Way
18861	26/11/2018	30/11/2018	Building construction & Maintenance	12 Days	SSE/JEs of Works
18862	17/12/2018	28/12/2018	Inspection and Maintenance of bridges	12 Days	SSE/JEs of Works & Bridge
18864	03/12/2018	14/12/2018	Land Management including Water supply, sewerage & water audit	12 Days	SSE/JEs of Works
18865	10/12/2018	21/12/2018	Concrete Technology	12 Days	SSE/JEs of Works & Bridge
18867	26-11-2018	07/12/2018	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					
18902	19/11/2018	24/11/2018	Sp.1 Wk course for Contractor Engineers	1 Week	Engrs of Rly Wkg Contractors
18903	01/10/2018	06/10/2018	Sp.1 Wk course for Contractor Engineers	1 Week	Engrs of Rly Wkg Contractors
18905	20/08/2018	24/08/2018	Sp.1 Wk course for Contractor Engineers	1 Week	Engrs of Rly Wkg Contractors

For latest status please refer IRICEN Website.

अंग्रेजी आवश्यक है क्योंकि वर्तमान में विज्ञान के मूल काम अंग्रेजी में हैं । मेरा विश्वास है कि अगले दो दशक में विज्ञान के मूल काम हमारी भाषाओं में आने शुरू हो जायेंगे, तब हम जापानियों की तरह आगे बढ़ सकेंगे।

– डॉ. ए.पी.जे. अब्दुल कलाम

Relevance of Junction Strength, Junction Stability & Junction Integrity for Geogrid for Base & Subbase Reinforcement

By
Rajeev Bhargava

Performance specifications of geogrids, for base & sub-base reinforcement, mentioned in Tender enquiries many times lack transparency. These parameters are supposed to pertain to those which affect deformation & load distribution and durability, failing which parameters mentioned in tender enquiry may suffer from following infirmities:-

(i) Parameters may be irrelevant, or
(ii) Parameters may be such as leaving scope for manipulation, or
(iii) Parameters may disregard /may be in conflict with the contents of ASTM, extract of standard text books such as Koerner, TRI lab reports & findings of fundamental research on the subject.
(iv) Parameters may brand the product as 'manufacture oriented' and thereby tending to debar other legitimate manufacturers of geogrid from participation.

1. In the context of junction, there are misplaced notions in regard to:-

A. Junction Strength
B. Junction Stability
C. Junction Integrity

2. At the outset, it is stated that the deliberation herein in context of Junction of the geogrid have nothing to do with my impressions & belief.These deliberations are purely based on well accepted wisdom and accepted referenced literature [Koerner, Webster, ASTM].

3. Junction Strength.

Regardless of jargon, assessment of Junction Efficiency/Strength as per GRI-GG2 or ASTM D7737 gives the strength of the junction only. It does not give any indication about the load distribution capacity of the geogrid hence is not a performance parameter. It is thus a quality control parameter. The version of ASTM, Koerner and Webster in this regard are placed below.

3.1 A plain reading of Koerner at page 380 makes clear that some mechanical properties can be index tests while others may be clearly performance oriented. **[Annexure A]**

3.1.1 Regarding Junction Strength, Page 381 of Koerner, says:-

"It is important to note that these results have the junction in an unconfined status"

It further says "That said, both of the alternative clamping methods still **result in an index, rather than performance, test result" [Annexure A]**

3.1.2 The sedecisive sentences at page 381 of Koerner are generally kept out of purview **while floating tender enquiry which** erroneously in corporate Junction Strength as 'Geogrid Performance Property Requirement'.

3.2 It may be worth noting that ASTM D7737 for determination of Junction Strength also mentions very clearly this test is a quality control test & an index testand is no way a performance parameter. The extract of ASTM D7737 are as under :-

"5.1 **This index test** method is to be used to determine the strength of an individual junction in a geogrid product. **The test is performed in isolation, while in service the junction is typically confined. Thus the results from this test method are not anticipated to be related to design performance.**

5.2 The value of junction strength can be used for manufacturing quality control, development of new products, or a general understanding of the in-isolation behavior of a particular geogrid's junction (for example, in relation to handling during shipment and placement of the geogrid).

1. Scope

1.1 This test method is an index test which provides a procedure for determining the strength of an individual geogrid junction, also called a node. The test is configured such that a single rib is pulled from its junction with a rib(s) transverse to the test direction to obtain the maximum force, or strength of the junction. The procedure allows for the use of two different clamps with the appropriate clamp selected to minimize the influence of the clamping mechanism on the specific type of geogrid to be tested."

3.3 In view of above, there is therefore no denying that Junction Strength is a quality control test. Junction Strength therefore cannot be made part of Geogrid performance property requirement in Tender Enquiry. However, in the context of junction test, following are also important:-

(i) Junction Strength gives the strength of the junction but does not give any indication to about the load distribution

*Retd. General Manager (IR)

capacity of the geogrid.

(ii) All said and done, specifying 95 % junction efficiency in data sheet has no meaning as performance indicator. Geo grid is not meant for failure stage. It is designed for serviceability criteria. Reliance is always on 'a minimum level' of junction strength. Webster (1993) has stated that junction (node) strength tests were not conducted because none of the products were damaged during test section construction or traffic testing. Webster had used various geogrid products ranging, from the geogrids which brought no improvement to a 40% reduction in total pavement thickness.

(iii) The interesting part is that some of the manufacturers do specify this parameter Junction strength as manufacturing specific parameter.

4. Junction stability- Aperture Stability Test.
Prescribing Aperture Stability Test as per ASTM D7864 or GRI-GG9 is **normally inadvertently / advertently left out while floating tender of geogrid.** The version of ASTM, Koerner and Webster placed below, **go unnoticed.**

4.1 ASTM D7864 on stability Modulus of Geogrids [annexure B] enlightens as :-
"The aperture stability Modulus is a measure of the in-plane shear modulus, which is a function of other geogrid characteristics, **most notably junction stability,** flexural rib stiffness, and rib tensile modulus"

4.1.1 Similarly, Koerner at page 393 which says :-
"The focused application of this test method (Aperture Stability) is the use of geogrids in **paved or unpaved** roadway base courses in such a manner as to challenge the entire geogrid structure i.e., all sets of ribs and the junction as well" **[Annexure C]**

4.1.2 Where do we lead to?
Both the paras 4.1 & 4.1.1 stresses on the **efficacy** of Apperture Stability test. This is a single test which evaluates entire geogrid structure –junction, rib tensile, flexural rib stiffness.

4.2 What makes this test so important?

GGI-GG9 lays down the method of carrying out the test.
This test is by clamping the geogrid test specimen in a rigid frame & firmly gripping the junction and then applying torque.

4.2.1 Higher the torque required to cause unit degree of rotation, **higher is the geogrid capacity to resist deformation of its aperture in its plane. High torsional rigidity ensures the movements within angular particles are reduced** and thus deformations are minimized. This optimizes the interlocking hence the load distribution.

4.2.2 This test is thus a **fantastic test and cannot be undervalued.** The modulus of angular rotation – Aperture Stability (Rotational Stiffness), is therefore Torque applied / degree of rotation of which the unit is of mm-Kg/deg.
Aperture stability / Rotational Stiffness test is often quoted as a method to demonstrate in–plane Stiffness of junction

4.3 What do the experts say about the applications of this test:-

4.3.1 ASTM D7864 [Annexure B] says :-
"This test is not intended for routine acceptance testing of geogrid. This test method should be used to characterize geogrid intended for use in applications in which aperture stability is considered relevant."

4.3.2 Besides Koerner at page 393 [AnnexureC], Koerner at page 380 [annexure D] says :-
"The test has its greatest applicability for bidirectional geogrid reinforcement in pavement base courses and perhaps soft soil foundation as well"

4.3.3 It is now clear that Para 4.3.2 , Para 4.1.1 dictate the applicability of Aperture Stability / Torsional Rigidity / Rotational Stiffness test for geogrid reinforcement. Its inclusion as Geogrid Performance Parameter in technical parametersof tender enquiry, is very much warranted as it brings completeness to the performance parameters in view of para 4.2.1.

4.4 Clue to benchmarking of Aperture Stability.

4.4.1 Attention is invited to **Page 25 Of Webster report of May 1993 which says:-**

"The performance of the various geogrid products tested ranged from no improvement to a 40% reduction in total pavement thickness requirement. **The relatively rigid sheet type geogrid (SS-2) performed best of all products.** The lighter weight version of this product performed second best. However, one other sheet type product and one woven type product with good strength properties failed to provide any measurable performance improvement. "

In the context of SS-2 , annexed are :-

(i) Graph between Aperture Stability Modulus vs Traffic Improvement Factor at page A5 of Webster report (May 1993) for various geogrids used in Test **[Annexure E]**

(ii) Summary of Laboratory Measurement of Geogrid Properties of Geogrids **[Annexure F]**

As per **Annexure F**, the value of Aperture Stability 25 years back for Torque of 2 N-m **for SS-2** was 8.55 cm-kg/deg

4.4.2 Aperture Stability calculated at a torque (2 N-m), is lately preferred to be calculated on small torque 0.5 N-m which is known **as Initial Modulus.**
Initial modulus is the slope of the early portion of the curve - rotational angle vs applied torque. The 0.5 N-m value is in the initial modulus region and the 2 N-m value is in the offset modulus region. ASTM D7864. is similar to the GRI GG9 test

method.

4.4.3 Over a period of time, Aperture stability value which earlier used to be prescribed by manufacturers in their data sheets is now not seen in their data sheet. However, in view of aforesaid, it is desirable to prescribe suitable value at 0.5 N-m as Aperture Stability [Initial Modulus]. It is my understanding that manufacturers of geogrid 30x30 are able to ensure value of initial Modulus of 9 cm-kg/deg.

4.5 In view of the aforesaid, there is therefore no denying about the applicability of Aperture Stability, as one of Geogrid Property for base reinforcement to assess its capacity to resist deformation of its aperture in its plane. Both for road sector & railway sector, this needs to be prescribed while floating any tender enquiry in view of aforesaid deliberations based on literature.

5. Junction Integrity - Installation damage test

5.1.Junction integrity is necessary to be maintained while facing ruggedness during construction.

5.2 Installation damage test measures junction integrity of Geogrid when subjected to mechanical loads of construction equipment and compaction of fill materials.
Reduction factors are applied for Geogrid application in Reinforced soils, Drainage geo-composites, and filter geo-textiles. Reduction factors provide safety in design and assure the proper functioning of a product under service condition.
In case of Geogrids used for Base reinforcement, it is important to ascertain residual properties after installation so as to assure proper functioning as is desired by the designer.

5.3 Important consideration for establishing equivalence
Geogrid is installed on site specific soils/ gravel and covered & compacted as per and in excess of actual specifications. Geogrid is then exhumed out of the aggregate layers to assess site damage with simulated field trial (e.g. granular material placed over geo grid and compacted with compaction equipment). Loss of tensile strength is expressed as percentage. **It is the fill aggregates used to cover the geogrid is the most important factor which governs the amount of installation damage.**

5.4 It is important to prescribe this test as Geogrid Performance Property requirement while floating tender enquiry. It is important to mention that geogrid will be installed below the coarse granular material for checking the strength retained after installation.

6. Gist
It would be perceived that gist in paras 3.3 regarding Junction Strength, gist in para 4.3.3 & 4.5 regarding Junction Stability/ Apperture Stability/ Rotational Stiffness/ Torsional Rigidity & gist in para 5.4 regarding junction integrity are based on well accepted wisdom and literature. It is hoped that the above collation of information will avoid loss of transparency while floating tenders for geogrid for base & subbase reinforcement in the context of junction.

References :
1. Geogrid Reinforced Base Courses for Flexible Pavement for Light Aircraft: by Steve L. Webster for US Army Corps of Engineers
2. Designing with Geosynthetics By Robert M. Koerner
3. ASTM D7737 Standard Test Method for Individual Geogrid Junction Strength
4. ASTM D7864/D7864M-15 Standard Test Method for Determining the Aperture Stability Modulus of Geogrids

Annexure A

3.1.2 Mechanical Properties
The mechanical properties of geogrids covered in this section all relate directly to their use in tensile reinforcement applications. Some are index tests, while other are clearly performance oriented.

Single Rib and Junction (Node) Strength. The initial tendency toward assessing a geogrid's tensile strength is to pull a single rib in tension until failure adn note its behavior. A secondary tendency is to evaluate the in-isolation junction strength by pulling a longitudinal rib away from its transverse rib's junction. It is important to state in-isolation since there is no normal stress on the junction; thus the test will not represent performance conditions. A performance junction strength test must be done with the entire geogrid structure contained within soil embedment, This is a much more complicated test and will be covered in this section under anchorage strength from soil pullout.

A single rib tension strength test merely uses a constant rate-of-extension testing machine to pull a single rib to failure, as described in ASTM D6637. For unidirectional geogrids, this would most likely be a longitudinal rib. For bidirectional geogrids, both longitudinal and transverse ribe require evaluation. By knowing the repeat pattern of the ribs, an equivalent wide-width strength can be calculated. Alternatively, a number of ribs can be tested simultaneously to obtain a more statistically accurate value for the wide-width strength (see below).

An in-isolation junction or node strength test can also be performed. The test method uses a clamping fixture that grips the transverse ribs of the geogrid immediately adjacent to and on each side of the longitudinal rib (see figure 3.2). The lower portion of the longitudinal rib is gripped in a separate clamp, and each clamp is mounted in a tensile testing machine, where the test specimen is pulled apart. The strength of the junction, in force units, is obtained. The test is standardized as GRI-GG2. Also, note that the individual rib strength can also be evaluated as described previously. Having both sets of data, a junction strength efficiency can be calculated.

In General, the unitized geogrids give junction

efficiencies from 90 to 100; the bonded strap geogrids from 40 to 70; and the woven or knit geogrids from 10 to 25% It is important to note that these results have the junction in an unconfined status. The gri-gg2 test method has an alternative that constrains junction rotation and results in improved strength efficiencies for the woven or knit geogrids. That said, both of the alternative elamping methods still results in an index, rather than performance, test result.

Annexure B

EXTRACT FROM ASTM ORG WEBSITE

ASTM D7864/D7864M-15 Standard Test Method for Determining the Aperture Stability Modulus of Geogrids

The mechanical properties of geogrids covered in this section all relate directly to their use in tensile reinforcement applications. Some are index tests, while other are clearly performance oriented.

Organization:	ASTM International
Publication Date:	1 June 2015
Status:	Active
Page Count:	7
ICS Code (Geotextiles):	59.080.70

Abstracts

Significance And Use

5.1 The Aperture Stability Modulus is a measure of the in-plane shear modulus, which is a function of other geogrid characteristics, most notably junction stability, flexural rib stiffness, and rib tensile modulus.

5.2 The test data can be used in conjunction with interpretive methods to evaluate the geogrid aperture stability at various traffic loads and base/subgrade conditions.

Note 1: Aperture stability modulus is referenced in the FHWA Geosynthetics Design and Construction Guidelines (2008) as an input parameter for the design of geogrid- reinforced unpaved roads using punched and drawn biaxal geogrids. Geogrids of different manufacturing process and material composition may use this property in calibration and validation of their material within the associated design.

5.3 This test method is not intended for routine acceptance testing of geogrid. This test method should be used to characterize geogrid intended for use in applications in which aperture stability is considered relevant.

1.1 this test method covers the procedure for measuring the "Aperture Stability Modulus" of a geogrid. (the terms "Secant Aperture Stability Modulus," "Torsional Rigidity Modulus," "In-plane Shear Modulus," and "Torsional Stiffness Modulus" have been used in the literature to describe this same property.)

1.2 This test method is intended to determine the in-plane stability of a geogrid by clamping a center node and measuring the stiffness over an area of the geogrid. This test method is applicable for various types of geogrid.

1.3 This test method is intended to provide characteristic properties for design. The test method was developed for pavement and subgrade improvement calibrated design methods requiring input of aperture stability modulus.

Annexure C

The capability of the geogrid's connection to the wall facing should generally by evaluated. Based in part by research in teh literature (e.g., Bathurst adn Simac [7]) ASTM has developed the D6638 Test Method. It is primarily focused on modular concrete blocks with a geogrid in its proper location and orientation, at a predetermined normal stress on the blocks. The geogrid is tensioned until failure. Failure can come about in numerous ways-form geogrid tension and connection failure to geogrid slippage ro block wall failure. Teh test nicely exposes the mode of failure adn also the ultimate strength of the entire anchorage system. However, recognize that there are a large number of modular-block wall systems, many with a matching geogrid type and facing type. Thus, this test must use the specific materials that will be used in the actual wall construction. Furthermore, substitutions. cannot be allowed at the time of bidding or during construction vai value engineering or the like unless acceptable data is available.

Torsional Rigidity. The in-plane torsional rigidity (or rotational stability) of bidirectional or tridirectional geogrids can be evaluated using GRI-GG9. In this test method, an unsupported geogrid specimen is fixed on its four sides in horizontally oriented containment box. Its central node is then clamped by a torquing device that has the capability of applying moment to the geogrid structure and of simultaneously measuring the resulting rotation. The modulus of the angular rotation versus moment curve is the desired value of geogrid torsional rigidity in units of mm-kg/deg. The focused application of this test method is the use of geogrids in paved or unpaved roadway base courses in such a manner as to challenge the entire geogrid structure, i.e., all sets of ribs and the junctions as well.

3.1.3 Endurance Properties
As geogrids are used in critical reinforcement applications, some of which require long service lifetimes, it is generally necessary to evaluate selected endurance properties. Installation damage, creep and accelerated test methods will be addressed.

Installation Damage. As with all geosynthetics, the placement of geogrids in the field requires a considerable degree of planning and care. As happens all too often with careless field construction crews and

values will be greater than unity. Coated yarn geogrids are difficult to evaluate since the coating cannot be readily removed. In addition, the very fine filaments are troublesome to measure in their own right.

Out-of-Plane Bending Stiffness. Bending stiffness is a physical property of geogrids that is of direct interest insofar as constructability is concerned. This can be measured using ASTM D1388, A test for flexural rigidity. This test method slides a geogrid test specimen hanging over an inclined plane measuring an angle of 41.5o with the horizontal. When the geogrid bends and eventually touches the surface of the inclined plane, its distance is measured and then related to the mass per unit area. The test is described in section 2.3.2 The unitized and strap geogrids are quite stiff and are characterized by having flexural rigidity values significantly greater than 1000 g-cm in this test. The woven or knit yarn geogrids are quite flexible and are characterized by having flexural rigidity values less than 1000 g-cm in this test.

in-Plane Torsional stiffness. Kinney [1] has proposed clamping a square bidirectional geogrid test specimen in a rigid frame and firmly gripping the central node. A torque is applied and teh angular rotation versus the geogrid's resistance is measured. The test is formalized as GRI-GG9. For stiff geogrids, the resulting plot shows a near linear performance. For flexible geogrids, the response is initially low, but after a 5o to 100 rotation, the resisting force increases markedly. The test has its greatest applicability for bidirectional geogrid reinforcement in pavement base courses and perhaps soft soil foundation stabilization as well.

3.1.2 Mechanical Properties
the mechanical properties of geogrids covered in this section all relate directly to their use in tensile reinforcement applications. Some are index tests, while others are clearly performance oriented.

Single Rib and Junction (Node) Strength. The initial tendency toward assessing a geogrid's tensile strength is to pull a single rib in tension until failure and note its behavior. A secondary tendency is to evaluate the in-isolation junction strength by pulling a longitudinal



VT Station Mumbai 1894

Provision of Vertical Curves in Track Geometry

By
Ramesh Pinjani*

Synopsis *: Provision of vertical curves in track geometry is an important issue especially for tracks catering higher speeds. I.R is gradually moving towards speeds in the range of 140 kmph & above. Any abrupt change in track geometry in vertical plane at such speeds will create discomfort & bad riding. The paper mainly deals with geometry required for laying of vertical curves.*

1.0 General

In terms of IRPWM para 419, vertical curve shall beprovided at the junction of the grades, when the algebraic difference between the grades is equal to or more than 4 mm. per m. or 0.4 per cent.

Ex.: say 1 in 100 ascending gradient meets with 1 in 200 descending gradient, then at the junction of grades the algebraic difference of grade shall be as under:

1 in 100 grade means $\Rightarrow \frac{1}{100} = \frac{10}{1000} = \frac{10\ mm}{1m}$ =10 mm/m (ascending grade)

i in 200 grade means $\Rightarrow \frac{1}{200} = \frac{5}{1000} = \frac{5\ mm}{1m}$ = 5mm/m (descending grade)

Algebraic diff. in grade = 10 - (- 5) = 15 mm/m, It is ≥ 4mm / m
Hence, vertical curve is required, at the junction of grades.

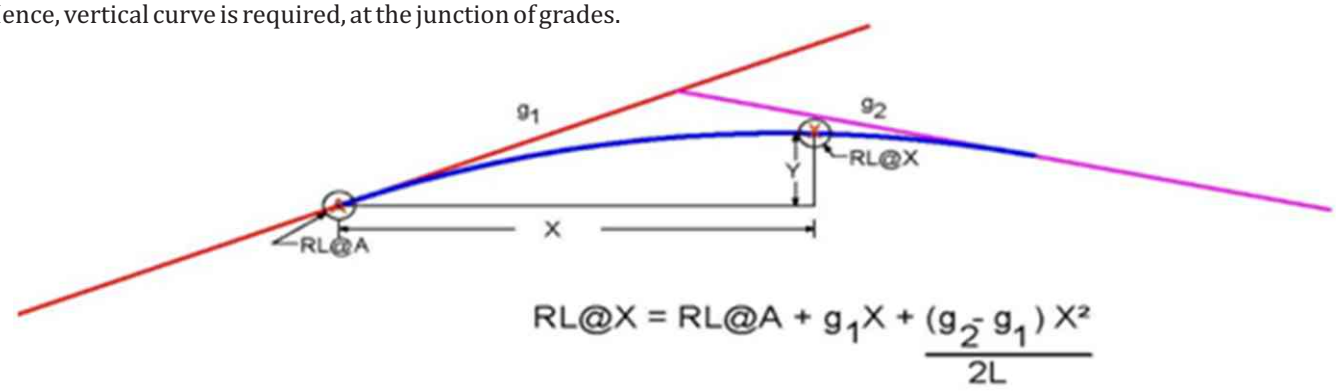


Fig -1 Geometry of vertical curve

Illustration -1:1 in 100 ascending grade meets with 1 in 100 descending grade, on A route. RL at start of curve = 100. Workout the geometry of vertical curve.

Solution: The vertical curve shall be worked out as under

1 in 100 grade means $\Rightarrow \frac{1}{100} = \frac{10}{1000} = \frac{10mm}{1m}$ = 10 mm/m

Algebraic diff. in grade = 10 - (- 10) = 20 mm/m, Therefore vertical curve is required.

g1 = $\frac{1}{100}$ = 0.01
g2 = $\frac{-1}{200}$ = -0.01
g2 - g1 = - 0.02

2.0 Minimum radius of vertical curve: Minimum radius of the vertical curve as stipulated under IRPWM para 419 shall be kept as under:

Route	B.G – A Route	B.G – B Route	B.G C,D,E Route & MG Routes
Min. Radius	**4000 metres**	**3000 metres**	**2500 metres**

3.0 Geometry fixation for laying of vertical curve: The geometry of vertical shall be fixed using following equation:-

Reduced Level (RL) at X = RL at A (start of curve) + g1 x + $\frac{(g2-g1)x2}{2L}$

Where, g1 and g2 are gradients involved, L is length of vertical curve

Radius of curve say 4000 m. (which is minimum, however it can be taken more if terrain is favourable)

Length of curve = 4000 x 0.02 = 80 meters

RL at X = RL at A + g1 x + $\frac{(g2-g1)x2}{2L}$
RL at any point X = 100 + 0.01 x + $\frac{(-0.02)x2}{2\ x\ 100}$

X	0	10	20	30
RL AT X	100.00	100.09	100.15	100.19

40	50	60	70	80
100.20	100.19	100.15	100.09	100.00

*Sr. Prof. Bridge-2 IRICEN

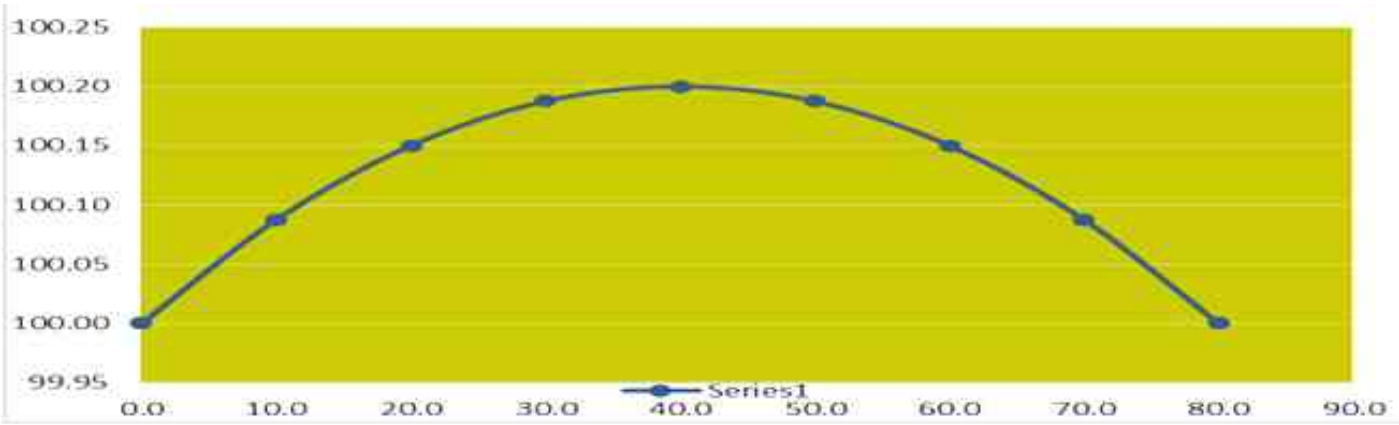


Illustration-2: 1 in 100 descending grade meets with 1 in 200 ascending grade, on A route. RL at start of curve = 100. Workout the geometry of vertical curve.

The vertical curve shall be worked out as under:-

Algebraic diff. in grade = -10 mm/m - (5 mm/m) = -15 mm/m, Therefore vertical curve is required.

$g1 = \frac{1}{100} = 0.01$

$g2 = \frac{1}{100} = -0.005$

g2 - g1 = - 0.015

Radius of curve say 4000 meters

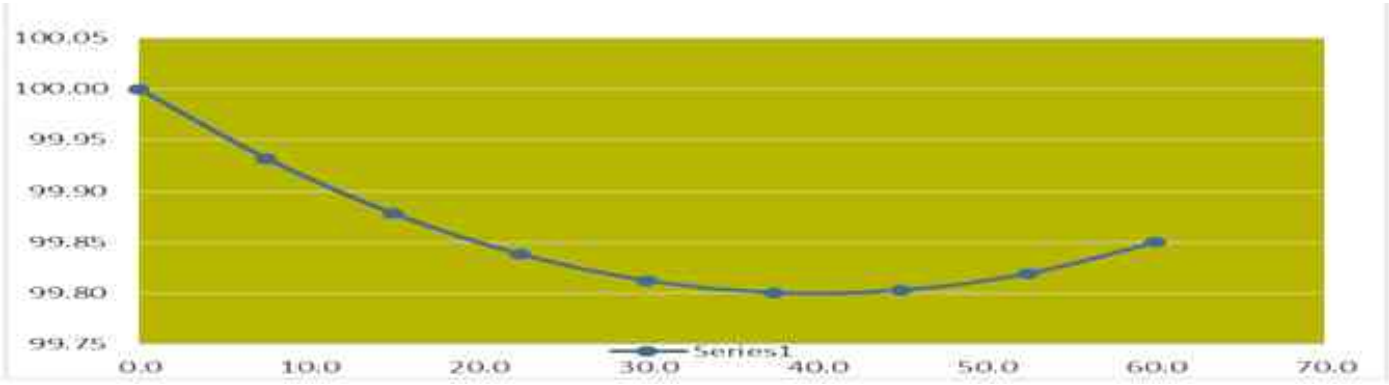
Length of curve = 4000 x 0.015 = 60 meters

Reduced level (RL) at X = RL at A + g1 x + $\frac{(g2-g1)x2}{2L}$

RL at any point X = 100 - 0.01 x + $\frac{(0.015)x2}{2\ x\ 60}$

X	0	7.5	15.0	22.5
RL AT X	100.00	99.93	99.88	99.84

30.0	37.5	45.0	52.5	60.0
99.81	99.80	99.80	99.82	99.85



4. Laying of vertical curves: The best way of introducing vertical curve in new lines is, by providing it in the formation itself. i.e. the formation top profile is finished with vertical curve. In other cases i.e inexisting running lines/ tracks & new lines where it could not be introduced in the formation, it is to be introduced by profiling top of track by tamping the track in design level ling mode. In case the max. lift involved is more than tamping machine capacity for lifting, the predetermined part lifting can be done manually ahead of machine prefarably in the same traffic block. It may be noted that introduction of vertical curve on new track/lines is easier, compare to on existing lines especially, when summit curve is involved.

5. Precautions involved in existing tracks: Following issues need proper study/ survey , planning & due consideration for introduction of vertical curve on existing tracks.

Existing formation width, adequacy & condition of existing ballast cushion, lifting of track in the near vicinity of obligatory points (such as Level crossings, girder bridges, approach of yards, ballasted bridges etc.),ensuring availablity of adequate ballast quantity before start of work, ensuring proper reference pegs for appropriate lifting of tracks.

Smart Non – Interlocked Level Crossing Gate Indication System

By
Nitish Kumar Ranjan*

Synopsis:
Over Indian Railway a large number of level crossing (LC) gates are available. Most of them are manned and many other are still unmanned gate. It is general perception that manned level crossing gates are safe from accident point of view. But still there are regular incidences of accident taking place or averted over Indian Railway due to passing of trains at gates kept in open condition. Complete process of operation of LC gate opening and closing is depended simply on Gateman's efficiency and out-dated method of exchange of private number between gateman and station master. Station master has to rely completely on the information given by gateman. He has no means to find out status of gate closing. Through this article an attempt is made to provide low cost fool proof solution to avoid such incidences and to save valuable life.

1.0 Introduction:

Manned level crossings are considered safer and railway has targeted to man all leftover unmanned level crossings within time frame which can't be eliminated by other way. This is huge task and lots of trained as well as skilled manpower will be required to man these gates. Even manned level crossings are further classified into two categories:

1) Interlocked manned LC gates
2) Non interlocked manned LC gates.

As we are aware that in interlocked manned LC gates, gates are protected by gate signal and because of this train will not get green signal unless these gates are interlocked. This makes the vulnerability of these gates zero, which is not the case with non interlocked manned LC gates.

2.0 Problems:

- Current system of communication between gate man and station master is exchange of private numbers (PN) to ensure the status of Level crossing(LC) gate, i.e. closed or open condition of the gate. This mode of communication is through human interface and is very much vulnerable.
- In past there are incidences of failure of such communication and gatemen have not closed the gates even after exchange of private number. Such vulnerabilities are eliminated by Interlocking of LC gates.
- Interlocking is very costly affair and considering the large number of non-interlocked LC gates available over Indian Railway; it is not possible to do interlocking of LC gates in near future.
- In case of failure of existing mode of communication (PN exchange), whole activity goes un-recorded & safety of road users as well as rail passengers are compromised.

3.0 Solutions:

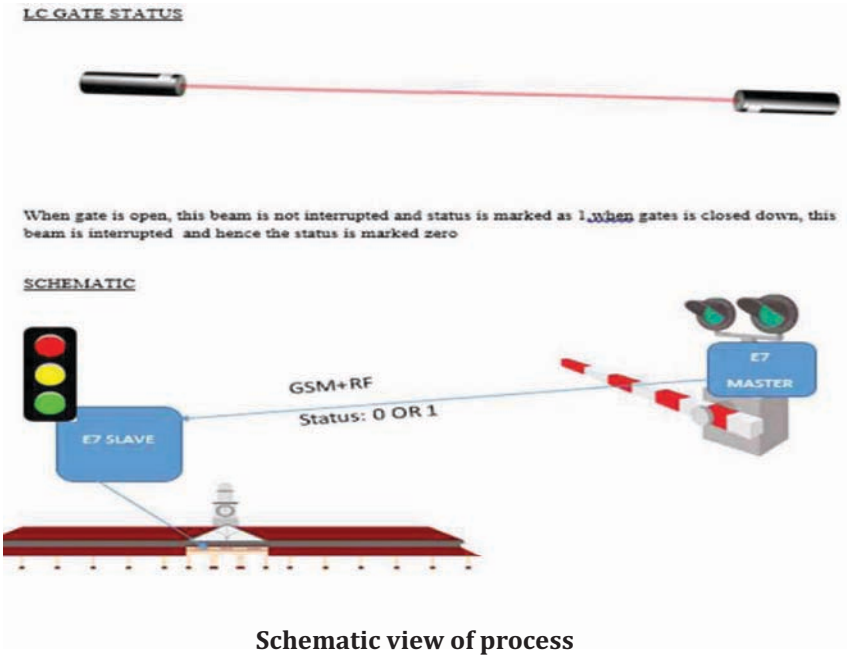
- IOT(INTERNET OF THINGS),the latest technology of the generation .IOT can be used to provide a wireless and automated means of indication directly to station master about the current status of gate.
- A non human interface, self maintained and automated system which gives 24*7 indications directly to station master about the current status of gate. A parallel system in addition to existing system for additional safety of road users as well as rail passengers.
- IOT solutions can be installed in a budget of approx. 1.5 lakhs per gate, at much cheaper cost compared to interlocking.
- Data logger can be an integral part of the IOT solution so that in addition to data transmission, data can be logged every minute. This way all time history can be cross checked and each operations.

4.0 Principal of Working:

In this automation, two devices will be installed. One would be called MASTER, which will be fixed at LC gate and other would be SLAVE which will be fixed at station master room. Master module detects the status of LC gate(closed or open) and communicates the same to slave module fixed at station master premises.

Master device is equipped with LASER TRANS-RECEIVER module, which works on principle of laser beam. Transmitter of this device continuously generates laser beam which in turn is intercepted by receiver. When gate is in open condition, there will not be any interruption in beam and status is read as 1,but as soon as gate is locked and boom of gate comes down, the beam is interrupted and status changes to zero. Once status zero is identified, same is communicated to slave device which in turn operated LED representing gate closed mark and vice –versa for open gate indication.

**Sr. DEN (E)/ Hubballi.*



Schematic view of process

6.0 Functionality & Implementation:

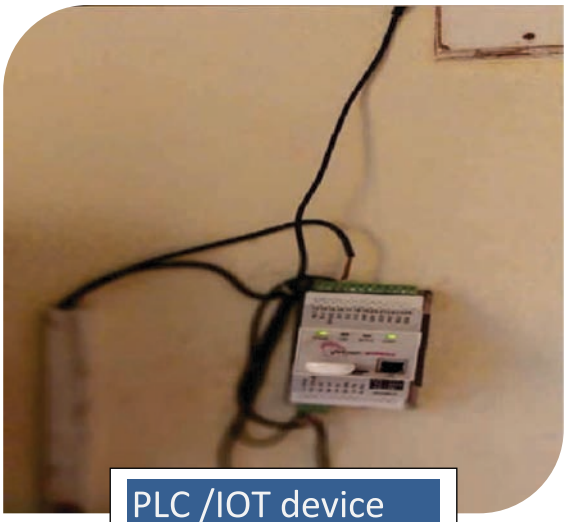
With the concepts discussed here, a smart non interlocked LC gate live indication system was fixed between LC gate no 61 and Koppal Station (on Gadag -Hospet section of Hubli division/South Western Railway) in consultation with ENERGY7.

1) Detection: Status of gate open or close can be achieved either via mechanical means say LEAF SWITCH or embedded means say LASER BEAM. Principle of working is like that whenever gate is closed LEAF SWITCH will be in pressed state hence using NO-NC concept, status can be determined .In similar way in case of LASER BEAM is used, when boom is down, there would be interruption of beam and which in turn can be recorded as output 0 and vice versa for boom upv



LEAF SWITCH was used to detect the status of LC gate 61

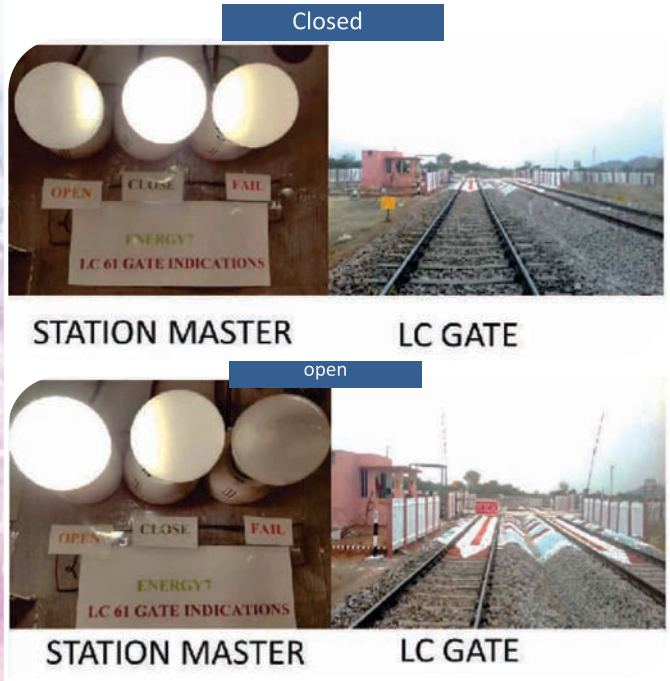
2) Transmission : Status once recorded can be processed on an IOT device and using **GSM network as well as** RF medium, it will be transmitted to other end i.e station **master room. Use of Dual** mode of communication is important for ensuring 100% **delivery as in case of heavy** wind, fog, rains RF network may not work properly. RF device can use frequency which is available in free bands permitted by government.



PLC /IOT device

3) Indication: A counter device to IOT device installed at gate, to be installed at Station master room to receive the data transmitted from device at gate. Apart of it, IOT device must be equipped with relay connected to 3 different color LED bulb in such a way that based on indication from gate

device, LED turns ON /OFF indication for **GATE OPEN, GATE CLOSE, SYSTEM FAILURE STATUS.**



4) Data Logging : All operations and various activities will go on record with a proper provision to access and analyze data in the time of need. Hence device at both end will log data of every minute about status of gate and send it to some cloud portal where end user can login and access data from PC, mobile etc.

PROOF OF CONCEPT

DATA LOGGING : Dashboard Snapshot.

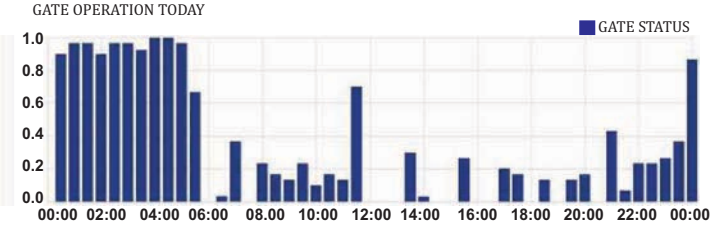


Data were logged at both ends and stored at cloud portal ENERGY7, credendtials to access the website are

- URL :energy7.in/railways
- Login id : hubeng
- Password : e7@railway

SMART NON-INTERLOCKED GATE INDICATION SYSTEM

Data Selection



Device data for period 11/02/2018 to 11/02/2018

Site ID	Time	G_GATE
HUBLI-LC61_G-SWR	2018-02-11 00:00:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:01:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:02:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:03:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:04:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:05:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:06:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:07:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:08:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:09:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:10:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:11:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:12:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:13:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:14:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:15:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:16:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:17:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:18:00	0.000
HUBLI-LC61_G-SWR	2018-02-11 00:19:00	0.000



Demonstration to GM and PCE SWR

5. Future scope/use/expansion:

• Wireless "Hand Shake" between station master & Gate man :

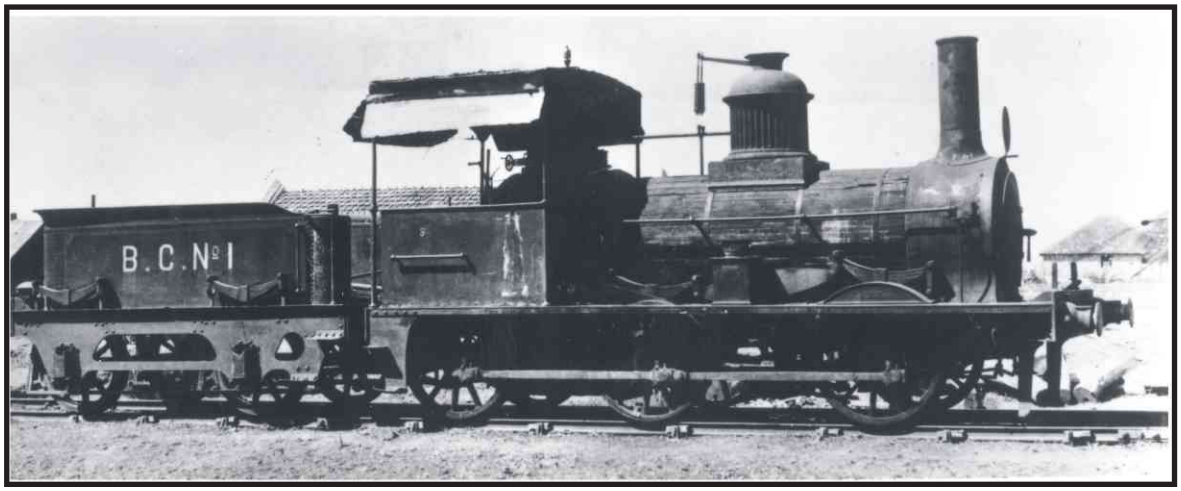
i. Provision for push button at both ends would be given such that station master use his push button to start a hooter at gate endas a Indication to close gate. In turn gate man will perform gate operation and press push button at his end to stop hooter and it would be recorded as acknowledgment to station master that requested operation has been done.

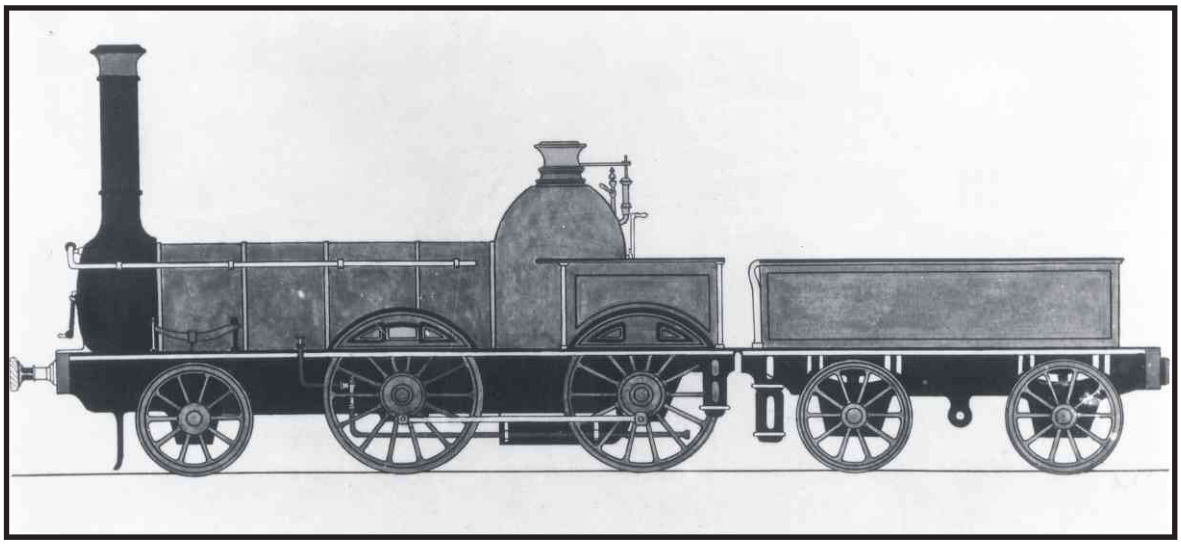
ii. In station master's room any indication will come only after gate is closed and also the same has been acknowledged by gateman.

iii. Every single event would lead to system in waiting state and no indication will be triggered. Hence safety will be ensured.

• Inter Locking of Non Inter Locked LC gates to Signal :

As inter locking of LC gates is a very costly affair, with the use of this system at a very low cost. Non inter locked gate can be made Interlocked with provisions discussed above.





GIP1 & EIR

Confided Masonry Construction - Earthquake Resistant for Low to Medium Rise Buildings

By
M. Rama Lekshami*

Common low-rise residential construction is made either of unreinforced masonry (URM) or reinforced concrete (RC) moment resisting frames with masonry in fill walls. Both the systems can be significantly affected by seismic forces. Unreinforced masonry buildings also cannot deal adequately with large horizontal forces though they have some strength against lateral forces. Confined masonry construction combines the elements of both unreinforced masonry (URM) or reinforced concrete (RC) framed construction. This article gives an introduction to readers about confined masonry construction having far better performance which can be adopted by Indian Railways for residential buildings and office buildings having maximum of six storey.

1.0 Introduction:

Unreinforced masonry works well in areas not prone to earthquakes. Unreinforced masonry walls do resist some lateral force during earthquake action but its resisting capacity is limited that it undergoes degradation once the force exceeds its capacity.

Commonly constructed RC framed buildings are made with masonry infill. RC frames are ductile and hence during earthquakes they can undergo large deformation but the infill walls are not designed to deform along with the walls and hence gets damaged.

Confined masonry is a structural system consisting of masonry wall panels surrounded by vertical and horizontal reinforced concrete 'confining elements' called tie beams and tie columns. The masonry wall panels consist of masonry units with mortar.

1.1 History and development:

Confined masonry is a construction system developed by practitioners all over the world during the last half century. This system has generally evolved empirically. Over the years, builders have tried to improve the seismic performance of Confined masonry buildings through trial and error. To encourage proper detailing and proportioning of members in confined masonry guidelines have been developed. In 2011 researchers developed global 'Seismic guideline for low rise confined masonry buildings' under the guidance of EERI, California. UNESCO developed its guidelines 'Guidelines for earth quake resistant non-engineered construction' in 2013. 'Design guidelines for confined masonry buildings' has been developed by CSIR-Central Building Research Institute, Roorkee in 2017.



Figure 1 - Six storey confined masonry building remain undamaged in Pisco (Peru) 2007 earthquake

2.0 Seismic action and response of any building:

Earthquakes induce stress into a building by accelerating and displacing its foundation. The walls, floors and roof due to inertia try to remain in their original positions as no lateral forces are applied on them. But the foundation while getting displaced drags the building along with it. The structural elements apply forces on the building above ground while moving with the foundation. The forces applied by the structural elements to overcome inertia are called inertial forces. Inertia of a component of a building is directly proportional to its mass.

For the purpose of analysis usually the base of the structure is considered to remain still and equivalent lateral loads are applied onto the building equal to inertial forces caused by ground motion. Deflected shape of the building due to ground motion is equal to that due to inertial forces.

The magnitude and direction of seismic loads continually change during the course of seismic action which shall be accounted for in the seismic design of the building.

3.0 Confined Masonry Buildings:

An earthquake resistant low or medium rise building with confined masonry properly designed and constructed is safe, satisfactory and sustainable. Horizontal bands are provided at the plinth level of the building, lintel level (i.e. at door and windows) and at the ceiling levels (roof band and gable band).

3.1 Structural Behaviour:

In confined masonry construction seismic loads are carried by masonry walls while RC ties confines them providing more resistance to earthquake forces. Masonry walls are the load carrying elements for gravity loads also.

The masonry walls perpendicular to ground motion that bends outwards are weaker and transfer the forces to much stiffer bordering elements. The roof and floors transfer inertial forces from their own mass and the forces transmitted by the walls undergoing out-of-plane bending (out-plane walls) to the walls (in-plane walls) parallel to the

**XEN/CN/CAN*

direction of shaking. For this effective load transfer roof and floors must act as diaphragm. Ineffective diaphragms lead to out-of-plane wall failure and walls or floors sliding off the building. In-plane walls transfer inertial forces from their own mass along with the forces from diaphragm and out-plane walls by deforming in-plane in shear and bending to the foundation where it is transmitted to the ground. A structure must be able to withstand inertial forces induced in both the directions. Therefore walls have to act well both as in-plane and out-plane walls.

3.2 Strength contributing factors:

Structural adequacy of confined masonry buildings depends on a number of factors such as quality of bricks, mortar, workmanship, methods of bonding, slenderness of walls, position and size of openings, eccentricity in loading and location of cross walls.

3.3 General aspects:

A regular building configuration with rectangular plan of length of the building not more than 4 times the width with good distribution of walls in both direction can be made an effective confined masonry building.

There should be vertical continuity of walls and wall openings in buildings with more than one floor. Gable wall ends are also to be confined. Masonry parapets can be avoided. If provided parapet walls need to be confined when the height is more than 0.5 m.

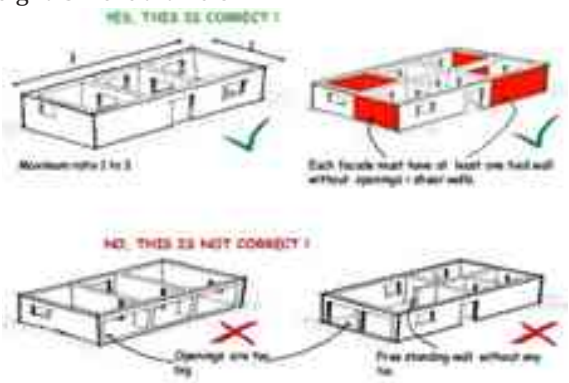


Figure 2- Building layout with shear walls

Minimum wall thickness for brick or full concrete block masonry is 11 cm. For hollow concrete block masonry the minimum wall thickness is 15 cm. Height of walls shall not exceed 3m normally and shall not exceed 3.5 m.

A sufficient number of confined masonry walls without openings must be placed in each direction and should be distributed as evenly as possible over the floor layout.

1. Each facade needs at least one solid wall panel
2. A confined wall panel can only be used as a shear wall if its length is more than two third of its height

Window and door reinforcements are tied to the plinth and ring beams through tie columns to create more confined shear walls.

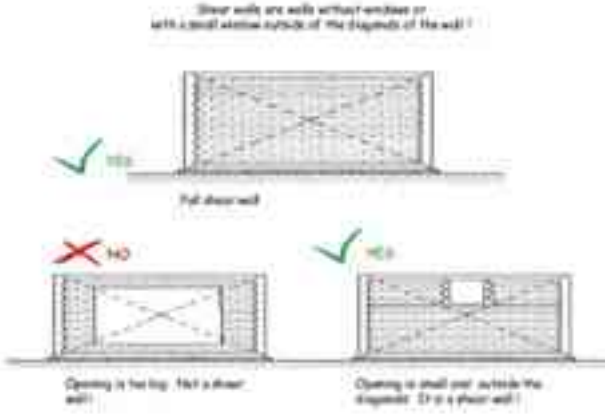


Figure 3-Shear walls

All openings larger than 600 mm x 600 mm must be confined and properly placed.

Wall ends should have toothing for good connection with the confining tie. Dowels are placed at various brick layers using 6mm rebars.

The rigid diaphragm action of floors should not get disturbed by discontinuity in the form of stairway.'

3.4 CSIR Design guidelines:

The layout of confined masonry building shall be checked for wall density, equivalent stiffness of wall panels, torsional stiffness of wall panels

The design lateral force is distributed along the height of the building. The storey shear is distributed into individual wall panels in the given direction.

Walls should be checked for compressive stress, tensile stress and shear stress for in-plane stability. The dynamic stability of walls against out-of-plane forces depends on its slenderness ratio and checked for overturning and tensile stresses developed.

Minimum width to depth ratio of bond beams shall be 0.3.Minimum depth of bond beams shall not be less than 200 mm. Width of bond beams shall be same as the wall thickness dimension. Minimum 4 numbers of 10 mm dia deformed bars shall be provided for bond beams.

Minimum size of tie columns should be same as the thickness of wall. Reinforcement detailing must conform to ductile detailing provisions of IS 13920-2003.

Foundation shall be laid on hard and well compacted strata. The foundation is normally a continuous strip footing but clayey soil requires under-reamed piles.

3.5 Materials:

Burnt clay building bricks conforming to IS 1077- 1992 or IS 2180- 1988 or IS 2222-1991, concrete blocks (solid and hollow) conforming to IS 2185 (part-I) 2005, burnt clay hollow bricks conforming to IS 3952-1988 and autoclaved

(aerated) cellular concrete blocks conforming to IS 2185 (part-III) 1984 shall be used for confined masonry construction. Mortar types M1, M2, H1 and H2 as per IS 1905 shall be used. Clay burnt bricks of strength 3.5 MPa shall be used for buildings upto 2 storey. Clay burnt bricks of strength 7.0 MPa shall be used for buildings with more than 2 storey.

Concrete of minimum grade M 15 as per IS 456 and slump 75-100 mm shall be used. Size of coarse aggregate shall be less than 12.5 mm. Steel reinforcement of Fe 415 grade steel (IS 1786-2008) must be used for RCC in tie beams and tie columns. Mild steel bars may be used for stirrups.

3.6 Construction Method:

A confined masonry building looks like an RC framed building with masonry infill. Though it uses the same materials the construction sequence and system are different.

Brick masonry shall be done only in Flemish bond. Walls should not be built in English bond. Cement mortar joint of 10 mm thickness is provided between brick courses.

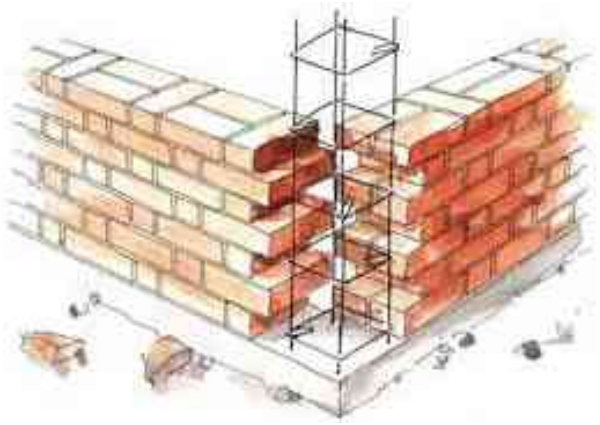


Figure 4-Confined Masonry in Flemish bond

After site clearance and the ground is leveled foundation trench is excavated. PCC leveling course 100 mm thick is laid. The reinforcement bars of the vertical ties are placed on a layer of lean concrete at the bottom of foundation. The foundation is madeon a PCC leveling course.

Prepare tie column reinforcement up to roof level. Construct brick masonry foundation wall up to plinth level. Prepare formwork for tie columns up to plinth level. Cast tie columns from the foundation level up to plinth level along with the plinth beams. Construct masonry walls above plinth level up to sill level. Prepare formwork for tie columns up to sill level. Cast tie columns from the plinth level up to sill level along with the beam at sill level if any. Construct masonry walls above sill level up to 1.2 m height. Prepare formwork for tie columns above sill level up to 1.2 m height. Cast tie columns from the level of previous casting up to 1.2 m height. Construct masonry walls up to lintel level from the previous level. Prepare formwork for tie columns up to lintel level. Cast tie columns from the level of previous casting up to lintel level along with the lintel beam. Cast confinement around the openings up to lintel level. Construct spandrel masonry walls up to the slab level. Prepare formwork for tie columns up to slab level. Cast tie columns from the level of previous casting up to roof level. Cast confinement around the opening up to slab level. Finally cast bond beam and roof slab together.

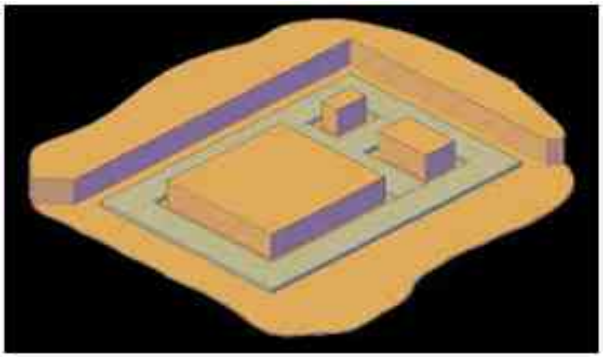


Figure 5- Foundation work (Image Source: CSIR-CBRI)

Walls should not be raised more than 1.2 m in one stretch so that the walls won't go out of plumb. The formwork for RC ties must be solid and well braced. Sewage pipes must pass through the foundation, not the plinth beams. Quality assurance checks should be made for all works.

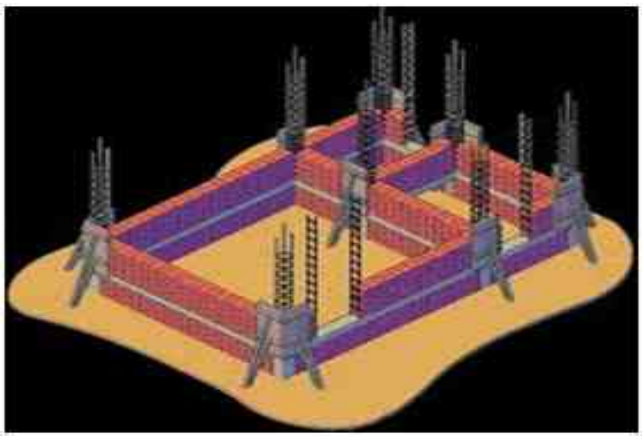


Figure 6-Formwork for tie columns
(Image Source: CSIR-CBRI)

4.0 Advantages:

This method of construction doesn't require advanced technology and equipments. Artisans practising masonry construction can be easily trained to adopt the techniques of confined masonry. Loss of lives can be avoided even in maximum considered earthquake. There is a significant cost reduction in confined masonry construction compared to RC framed construction with masonry infill.

5.0 Conclusion:

Well-constructed confined masonry buildings have been observed to incur little or no damage in moderate to even

severe earthquakes. Guidelines and handbooks are available for technicians and artisans for best construction practices of confined masonry construction. A policy guideline shall be issued by Railway Boardto adopt confined masonry construction technique for low rise to medium rise residential and office buildings.

6.0 References:

1. Build A Safe House With Confined Masonry by Gujarat State Disaster Management Authority, Government of Gujarat, September 2012.
2. Confined Masonry- A guidebook for technicians and artisans by National Information Centre of Earthquake Engineering, IIT Kanpur February 2009.
3. Design Guidelines for Confined Masonry Buildings CSIR-Central Building Research Institute, Roorkee, 2017.
4. Tom Schacher and Tim Hart, Construction Guide For Low-Rise Confined Masonry Buildings by Confined Masonry Network, Earthquake Engineering Research Institute, California October 2015.
5. Report on Evaluation of Confined Masonry Guidelines for Earthquake- Resistant Housing Earthquake Engineering Research Institute, California October 2014.
6. www.confinedmasonry.org



CST

Prestressing Force after Friction and Slip in Post-Tensioned Prestressed Concrete Girders – A Mathematical Solution

By
R.Sundaresan*

Abstract: Apart from the conventional method available from the standard texts on prestressed concrete, two other methods viz., 'linear-mirror image method' and 'non-linear mirror image method' are widely used in design office for calculating the prestressed force after the frictional and slip loss. In this paper, simple equations are derived for length of zero slip, value of slip, elongations of prestressing strands and prestressing force after frictional and slip loss by considering the exponentially decaying non-linear variation of prestressing force. The various issues related to the above are discussed in detail. It is now proved that the variation of prestressing force after slip is not the mirror image of the variation of prestressing force after friction. The derived formulae are more accurate in representing the true variation of the prestressing force and also simple for the day-to-day use in design office.

1.0 Introduction:

The loss of prestressing force can be grouped into two categories viz., Instantaneous loss and time dependant loss. The frictional loss due to curvature, wobbling effect of prestressing strands or wires and elastic shortening loss due to successive stressing of more than one cable are categorized under instantaneous loss as it results during stressing operation itself. The losses resulting from shrinkage of concrete, creep in concrete and relaxation of Prestressing strands are depending on the elapsed time after the initial stressing and hence called time dependant losses. In this paper, a closed form solution for calculating the prestressing force after friction and slip loss is presented for parabolic cable profile.

1.1 Need for the Study:

At present, the prestressing force after slip is calculated using computationally intensive numerical procedure using computer due to the lack of simple predictive equation. Hence an attempt is made to derive simple equations for determining the prestressing force by considering the effects of friction and slip for the desired sections of the girder. Thus, the cumbersome procedure for the calculation is eliminated.

2.0 Equation for cable profile:

The ordinate of the prestressing cable at a distance, 'x' from the jacking end can be expressed as

$$y = Ax^2 + Bx + C \qquad \text{Eq.(1)}$$

The coefficients A, B, and C in Eq.(1) can be obtained from symmetry of cable with respect to the midspan, the ordinates of cable at jacking end and midspan as shown in Fig.1. The distance between jacking ends is taken as 'L'.

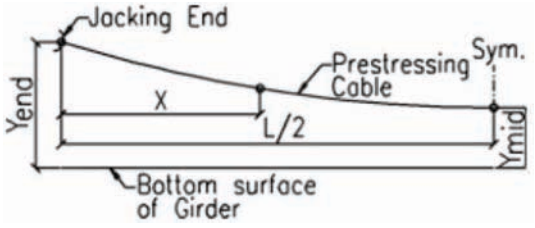


Fig. 1: Profile of cable

The values of coefficients arrived from the above boundary conditions are

$$A = \frac{4(Y_{end} - Y_{mid})}{L^2};\ B = -AL;\ C = Y_{end} \qquad \text{Eq.(2)}$$

2.1 Curved length of cable profile:

Neglecting the second order terms, the curved length of cable, sx can be obtained by taking the derivative of Eq.(1) and the integration shown below.

$$Sx = \int_o^x \sqrt{1+\left(\frac{dy}{dx}\right)^2}\,dx$$

$$= x\left\{1+\left(\frac{2A^2}{3}x^2 + ABx + \frac{B^2}{2}\right)\right\} \qquad \text{Eq.(3)}$$

2.2 Curvature of cable profile:

The curvature of the cable profile, 1/rps is arrived as

$$\frac{1}{r_{ps}} = \frac{d^2y}{dx^2} = 2A \qquad \text{Eq.(4)}$$

From the above, it is found that the curvature is constant along the length of the girder.

3.0 Frictional loss of Prestressing Force:

The prestressing force applied at the jacking end of the girder gradually decreases as the distance 'x' increases from the end due to the resistance offered by the curvature of the cable and the friction between the cable and the concrete surface surrounding it.

3.1 Prestressing Force after friction:

The variation of prestressing forceconsidering the effects of friction is expressed in the IRS Concrete Bridge code1 using an exponentially decaying function as

$$P_x = p_o e^{\left(\left(\frac{\mu}{r_{ps}}\right)+k\right)x} = P_o e^{-(2A\mu+k)x} \qquad \text{Eq.(5)}$$

In Eq.(5), P0, e, m, K, 1/rps are the prestressing force at the jacking end, base of Napierian logarithms, frictional coefficient, wobbling coefficient and curvature of the cable respectively.

In order to account for the curved profile of the cable, the wobbling parameter, 'K' in Eq.(5) is replaced by 'Kp' where 'p'

*Sr. Sect. Engineer (Drg.) S.Rly.

is a factor representing the ratio of arc length, sxto projected length, x of the cable resulting to a modified equation given by

$$P_{xs} = p_o e^{-(2A\mu+kp)x} \qquad \text{Eq.(6)}$$

4.0 Slip of anchorage:

In addition to the frictional loss, the loss of prestress is also caused by the elastic strain and slip in the anchorage device at the time of anchoring the strands after stressing. The slip of anchorage shall be calculated as the difference between the elongations of strands in forward and reverse direction as shown below.

4.1 Elongation of strands in forward direction before slip:

The elongation of prestressing strandsbetween the jacking end and the point of interest at a distance of 'x' can be calculated from the following equation.

$$\delta_x = \frac{P_0\left(1+e^{-(2A\mu+Kp)x}\right)(px)}{2E_pA_p} \qquad \text{Eq.(7)}$$

In the above equation, Ep, Ap are Young's modulus and area of prestressing strands respectively.

4.2 Elongation of strands in reverse direction after slip:

The prestressing force available at a distance of 'x' from the jacking end after friction is, Pxs. Now, the elongation of strands at the jacking end when the prestressing force, Pxs is applied at a distance of 'x' in reversed direction of stressing is calculated as

$$\delta_x' = \frac{P_{xs}\left(1+e^{-(2A\mu+Kp)x}\right)(px)}{2E_pA_p} = \frac{P_0e^{-(2A\mu+Kp)x}\left(1+e^{-(2A\mu+Kp)x}\right)(px)}{2E_pA_p} \qquad \text{...Eq.(8)}$$

4.3 Slip of prestressing strand:

The slip of prestressing strands after anchorage is the difference of elongations in forward and reverse directions and is calculated as

$$\delta_{slip} = \delta_x - \delta_x' = \frac{P_0\left(1-e^{-2(2A\mu+Kp)x}\right)(px)}{2E_pA_p} \qquad \text{Eq.(9)}$$

5.0 Length of zero Slip for stressing from both sides:

For any assumed value of 'x' between 0 and 'L/2', we can find a corresponding slip, δ_{slip} from Eq.(9). Taking δ_{slipA} as the assumed slip in the design, then the above assumed value of 'x' is the length of zero slip denoted by 'x_0' if $\delta_{slip} = \delta_{slipA.}$ Otherwise, another value of 'x' is to be assumed and the above is repeatedtill convergence is achieved. Numerical method like Bisection Method can be used for the solution of x0 by writing 'macros' in Excel.

However, the following procedure can be used for manual calculation.

Step 1. Assume x=L/2.

Step 2. Find δslip for the assumed value of 'x' from Eq.(9).

Step 3. Find Derror=$\delta_{slipA} - \delta_{slip}$

Step 4. If Derror is nearly equal to zero then x0 = x and stop iteration.

If $_{Derror}$< 0 then assume a new value x slightly lower value of x assumed earlier. If $_{Derror}$> 0 and x < L/2,assume a new value x slightly higher value of x assumed earlier. At the same time, the value of x cannot be greater than L/2. Repeat Steps 2 to 4 until $_{Derror}$ is nearly equal to 0.

If $_{Derror}$> 0 and x=L/2 then x0 = L/2 as the value of xcannot be more than L/2 for the case of stressing at both ends. Since the value of x is forced to take a constrained value of L/2, the prestressing force, Pxs at x= L/2 is required to be reduced by

$$\Delta P = \frac{\left(\delta_{slipA}-\delta_{slip}\right)E_pA_p}{\left(\frac{L}{2}\right)} \qquad \text{Eq.(10)}$$

6.0 Loss of prestress after Slip of anchorage:

During slipping of strands, some resistance to this slip is caused by the concrete in opposite direction of slip and this is called 'reverse friction'. The prestressing force after slip considering the above reverse friction is obtained in the following.

6.1 Prestressing force after friction and slip for stressing from both sides:

For the given value of x and calculated value of x0, the prestressing force, Pxs'can be calculated from the following procedure.

If x_0<L/2 and x>x_0, the prestressing force after friction at the zero slip point is calculated as

$$P_{x0} = P_0e^{-(2A\mu+Kp)x_0} \text{ where } p = \frac{s_{x0}}{x_0} \qquad \text{Eq.(11)}$$

And the prestressing force after friction and slip, Pxs' is calculated by

$$P_{xs}' = P_{x0}e^{-(2A\mu+Kp)(x_0-x)} \qquad \text{Eq.(12)}$$

$$\text{where } p = \frac{(s_{x0}-s_x)}{(x_0-x)}$$

If x0<L/2 and x>x0, the prestressing force after friction and

slip can be arrived as

$$P'_{xs} = P_{xs} = P_0 e^{-(2A\mu+Kp)x} \qquad \text{Eq.(13)}$$

$$\text{where } p = \frac{s_x}{x}$$

If x_0=L/2 and x x_0, the prestressing force after friction at the zero slip point is calculated as

$$P'_{x0} = P_0 e^{-(2A\mu+Kp)\frac{L}{2}} - \Delta P \qquad \text{Eq.(14)}$$

$$\text{where } p = \frac{s_{0.5L}}{0.5L} \text{ and } \Delta P \text{ is found from Eq.(10)}$$

And the prestressing force after friction and slip, Pxs' is calculated by

$$P'_{xs} = P'_{x0} e^{-(2A\mu+Kp)(L/2-x)} \qquad \text{Eq.(15)}$$

$$\text{where } p = \frac{(s_{0.5L} - s_x)}{(0.5L - x)}$$

If it is required to find the prestressing force after friction and slip for stressing from one side only, we can use the procedures given in previous sections 5 and 6 with a modification that in the place of L/2, the value of L is to be substituted.

7.0 Application of the equations and discussions:

The following values are taken from the RDSO drawing No. BA-10247/12 for the purpose of demonstration of the application and discussion of various related issues. In this drawing, the cables are stressed from both sides. The salient features of the prestressing cables are shown in tables 1 and 2 below.

Table 1-Common data for all cables

SNo (1)	Description (2)	Value (3)
1	Distance between jacking ends	18350mm
2	Friction coefficient, μ	0.25
3	Wobble coefficient, K	0.0046/m
4	Young's modulus, E_p	1.96(10^5)MPa

Table 2-Specific data for each cable

Cab .No. (1)	Y_{end} (mm) (2)	Y_{mid} (mm) (3)	A_p (mm^2) (4)	P_0 (kN) (5)
1	365.27	125	1875.3	2617.73
2	728.80	275	1875.3	2617.73
3	1252.52	425	1875.3	2617.73
4	1562.70	575	1579.2	2204.40

7.1 Calculation of slip up to theassumed section:

Assuming x=L/2, the constants for the Eq.(1) viz., A, B, & Care calculated for the data given in tables 1 and 2.The curved length of cable, s_x from the jacking end to section assumed, is calculated using Eq.(3).The ratio of curved length to projected length, p=s_x/x is found and the slip of strands up to the section considered is calculated finally using Eq.(9).The results are tabulated in table 3.

Table 3-Calculated slip

Cab .No. (1)	s_x (mm) (2)	p (3)	δ_{slip} (mm) (4)
1	9179.19	1.0005	3.42
2	9189.96	1.0016	4.10
3	9224.76	1.0054	5.28
4	9245.88	1.0077	5.77

7.2 Offset of prestressing force for the slipconsidered in design:

The zero slip length is calculated as per the procedure in section 5 above. The difference between the assumed slip and the calculated slip are tabulated in table 4. Since the difference of above slips is more than zero and x=L/2 for all the cables, the length of zero slip, x_0=L/2for the above cables. Since x cannot be more than L/2, the value of DP is found from Eq.(10) and entered in the same table.

Table 4-Offset of prestressing force

Cab .No. (1)	δ_{slipA} (mm) (2)	δ_{slip} (mm) (3)	Δ_{error} (mm) (4)	ΔP (kN) (5)
1	6	3.42	2.58	103.27
2	6	4.10	1.90	76.00
3	6	5.28	0.72	29.27
4	6	5.77	0.23	8.11

7.3 Prestressing forces before and after slip at zero slip point:

The prestressing force at zero slip point after friction, Px0 is calculated by Eq.(11) and also the prestressing force after slip, Px0' is calculated by Eq.(14). The values are shown in table 5

Table 5-Prestressing forces before and after slip at zero slip point

Cab .No. (1)	P_{x0} (kN) (2)	P_{x0}' (kN) (3)
1	2476.85	2373.58
2	2448.07	2372.08
3	2398.34	2369.07
4	2001.90	1993.80

7.4 Variation of prestressing force along the girder after friction:

The available prestressing force after frictional loss can be calculated using the Eq.(6) for any desired section along the girder. The cable No. 4 alone is considered for this study. The half of the length of cable between jacking ends are divided into eight segments and the rate of change of prestressing force with distance is obtained for each section and tabulated in table 6. It is interesting to note that the variation of prestressing force along the girder is non-linear as observed from the last two decimal places of the values in the forth column of the table.

Table 6-Prestressing force and rate of change of prestressing force with distance after friction

No. (1)	x (mm) (2)	P_{xs} (kN) (3)	$\Delta P_{xs}/\Delta x$ (kN/mm) (4)
1	0	2204.40	
2	1147	2177.86	-0.0231
3	2294	2151.70	-0.0228
4	3441	2125.90	-0.0225
5	4588	2100.46	-0.0222
6	5734	2075.34	-0.0219
7	6881	2050.56	-0.0216
8	8028	2026.08	-0.0213
9	9175	2001.90	-0.0211

As the distance, x increases, the force Pxs decreases and hence negative sign for the values in column 4 of the table 6

7.5 Variation of prestressing force along the girder after slip:

The prestressing force after friction and slip can be calculated by Eq.(15). The above prestressing force and the rate of change of the same force with distance for cable No. 4 for various sections along the girder are given the table 7.

Table 7- Prestressing force ad rate of change of prestressing force with distance after slip

No. (1)	x (mm) (2)	P'_{xs} (kN) (3)	$\Delta P'_{xs}/\Delta x$ (kN/mm) (4)
1	0	1810.65	
2	1147	1833.16	0.0196
3	2294	1855.79	0.0197
4	3441	1878.56	0.0199
5	4588	1901.48	0.0200
6	5734	1924.59	0.0202
7	6881	1947.91	0.0203
8	8028	1971.47	0.0205
9	9175	1993.80	0.0195

From the last column of the table, it is established that the prestressing force after slip is also nonlinear just like one before slip as per table 6. Since the absolute value of the corresponding rows in column 4 of tables 6 and 7 are not same or equal, the variation of prestressing force after slip is not the mirror image of the variation of prestressing force before slip.

7.6 Ordinates of prestressing force before and after slip with respect of average force at the point of zero slip:

The average force after at the point of zero slip is calculated as

$$P_{avg} = 0.5\left(P_{x0} + P'_{x0}\right) \qquad \text{Eq.(16)}$$

The ordinate of prestressing force before and after slip with respect of the average force at zero slip point is shown in table 8.

Table 8- Ordinate of prestressing force before and after slip with respect to average force at zero slip point

No. (1)	x (mm) (2)	P_{xs}-P_{avg} (kN) (3)	P_{xs} -P_{avg} (kN) (4)
1	0	206.55	-187.20
2	1147	180.01	-164.69
3	2294	153.85	-142.06
4	3441	128.05	-119.29
5	4588	102.61	-96.37
6	5734	77.49	-73.26
7	6881	52.71	-49.94
8	8028	28.23	-26.39
9	9175	4.05	-4.05

It can be concluded once again from the absolute values of last two columns of each row the variation of prestressing force after slip is not mirror image of the variation of prestressing force before slip. This conclusion is different from the majority of designer's view. Now it is mathematically proved to the contrary to their view of mirror image. If the ordinate of prestressing force is above the level of average force, it is considered as positive in table 8.

7.7 Prestressing force after slip using conventional practice:

The prestressing force after slip is calculated using the formula

$$P''_{xs} = P_{xs} - \frac{E_p A_p \delta_{slipA}}{s_{0.5L}} \qquad \text{Eq.(17)}$$

The values are given in table 9 below. The values of corresponding rowsin column 4 of table 6 and 9are equal. Hence it can be concluded that the conventional method of calculating prestressing force after slip does not take into account the 'reverse friction' that is the friction acting in the

opposite direction of stressing while the slipping of anchorage is taking place.

Table 9- prestressing force and rate of presltressing force with distance after friction and slip along the span of girder

No. (1)	x (mm) (2)	P_{xs}'' (kN) (3)	$\Delta P_{xs}''/\Delta x$ (kN/mm) (4)
1	0	2003.54	
2	1147	1977.00	-0.0231
3	2294	1950.84	-0.0228
4	3441	1925.04	-0.0225
5	4588	1899.60	-0.0222
6	5734	1874.48	-0.0219
7	6881	1849.70	-0.0216
8	8028	1825.22	-0.0213
9	9175	1801.04	-0.0211

The variation of prestressing force before and after slip as calculated by Eq.(6) and Eq.(15) respectively are shown in Fig. 2.The variation of prestressing force before slip is denoted by P_0P_{x0} and also the variation of prestressing force after slip is denoted by $P_{x0}'P_x'$ in Fig.2.

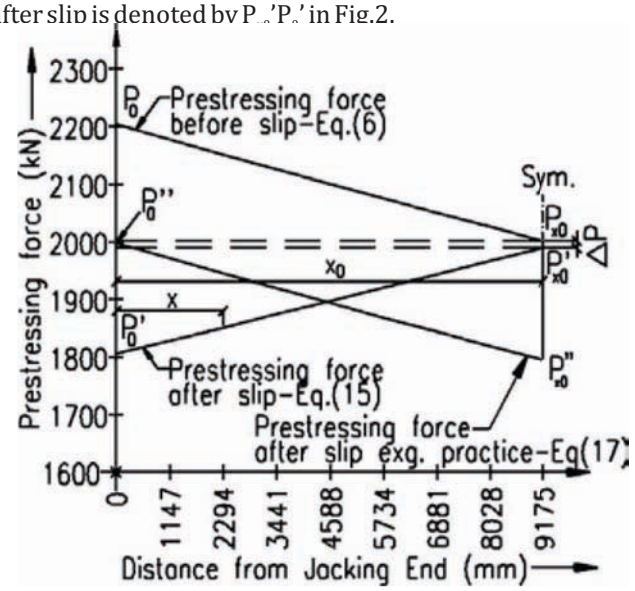


Fig. 2: Variation of prestressing force for both end stressing

The distance of zero slip point is shown by x_0. The variation of prestressing force after slip found from the conventional practice noted by $Px_0''P_0''$ is also superimposed in the same figure to show the non conservative estimates of prestressing force. Due to negligibly small variation of slopes along the length of the girder, the non linear variation cannot be distinctly represented.

Referring to Fig. 2, theconventional practice will not be conservative especially at initial stage of transfer of prestress near the mid section of girder. Due to over estimation of prestressing force near the end sections of girder, the results are less conservative at final stage of application of all loads to the girder considering all instantaneous and time dependent losses of prestress.

8.0 Curved profile versus projected profile of cable:

On close examination of the Eq.(6) and the values of the friction coefficient, mand Wobble coefficient, K from table 1, the loss of prestress caused be the curvature is more than that of Wobble. Hence, the difference between loss of prestress for the curved profile and projected profile is highly negligible as the effect of Wobble is small as compared to the effect of Curvature. The same can also be established by noting the ratio of length of arc to projected length, p in the table 3 is nearly equal to 1. Since, curved length, s_x is required to be evaluated for each section under consideration, the ratio, p is not constant for the entire length of girder. If we take p equal to 1, then all the equations are continuous functions and is applicable for the entire length of the girder without out the appreciable loss of accuracy as demonstrated in the following section.

9.0 Application of simplified equations to cables stressed at one end only:

The step by step calculations are shown below for customization of the application of the equations. For this study, the cable No. 4 is used for the demonstration of the method for calculation. The distance between jacking ends denoted by L is divided into eight equal segments and prestressing forces are calculated for nine sections as shown below.

9.1 Prestressing force after friction considering curved length of cable:

Here the curved length of cable, s_x for each section at a distance of x from jacking end is calculated by Eq.(3).The ratio of curved length to projected length is arrived fromp=s_x/x.The prestressing force after frictionis calculated using Eq.(6) for each section and tabulated in table 10.

Table 10- Prestressing force after friction for curved length of cable

No. (1)	x (mm) (2)	p (3)	P_{xs} (kN) (4)
1	0		2204.40
2	2294	1.0179	2151.70
3	4588	1.0135	2100.46
4	6881	1.0101	2050.56
5	9175	1.0077	2001.90
6	11469	1.0063	1954.41
7	13763	1.0058	1907.98
8	16056	1.0063	1862.53
9	18350	1.0077	1818.01

9.2 Prestressing force after friction considering projected length of cable:

The prestressing force after friction, P_{xp} is calculated using Eq.(5) considering only the projected length, x of cable for each section and tabulated in table 11. The error in percentage is calculated from $Abs(P_{xp}-P_{xs})*100/P_x$ by considering the corresponding rows in column 4 of table 10 and column 3 of table 11

Table 11-Prestressing force after friction for the projected length of cable

No. (1)	x (mm) (2)	P_{xp} (kN) (3)	Error in % (4)
1	0	2204.40	0.00
2	2294	2152.11	0.02
3	4588	2101.06	0.03
4	6881	2051.22	0.03
5	9175	2002.56	0.03
6	11469	1955.05	0.03
7	13763	1908.68	0.04
8	16056	1863.40	0.05
9	18350	1819.20	0.07

Since the error is less than 0.1%, the use of projected length of cable in the place of curved length may not affect the accuracy appreciably.

9.3 Calculation of length ofzero slip:

For considering the projected length in the place of curved length for calculating slip from Eq.(9), the length ratio factor, p is to be equated to 1. The modified equation is given below.

$$\delta_{slip} = \frac{P_0\left(1-e^{-2(2A\mu+K)x}\right)x}{2E_pA_p} \qquad \text{Eq.(18)}$$

The procedure for determining length of zero slip is given in section 5 for the stressing at both ends. For the present case of single end stressing system, the value of L/2 is to be replaced with L and the same procedure is for this case also. The assumed value of x, the calculated slip, δslip and the error between the assumed slip, δ_{slipA} and calculated slip are tabulated in table 12.

Table 12- Calculated slip for assumed distance, x and the error

Cab .No. (1)	Assume x (mm) (2)	δ_{slipA} (mm) (3)	δ_{slip} (mm) (4)	Δ_{error} (mm) (5)
1	18350	6	20.84	-14.84
2	9175	6	5.70	0.30
3	9500	6	6.10	-0.10
4	9400	6	5.98	0.02

For the assumed value of x=9400mm, the error is 0.04mm which is considered approximately equal to zero, the assumed value of x above is the zero slip length, $x_0$ie., x_0=9400mm. The prestressing force after friction at this point, P_{x0} calculated using Eq.(6) for the distance, x_0 is 1997.85kN.

9.4 Prestressing force after slip considering projected length of cable:

The prestressing force after slip, P_{xp}' is calculated using the procedure given in section 6.1 by replacing the value of L/2 with L and substituting p=1. The modified equations are also rewritten below for convenience.

If $x<x_0$ and $x<L$, the prestressing force after friction and slip, P_{xp} is calculated by

$$P'_{xp} = P_{x0}e^{-(2A\mu+K)(x_0-x)} \qquad \text{Eq.(19)}$$

And if $x>x_0$ and $x<L$, the prestressing force after friction and slip, $P_{xp}=P_x$ as calculated by Eq.(5). The results obtained are given in table 13.

Table 13- Prestressing force after slip for the projected length of cable No. 4

No. (1)	x (mm) (2)	P_{xp}' (kN) (3)
1	0	1810.65
2	2294	1854.64
3	4588	1899.71
4	6881	1945.87
5	9175	1993.15
6	9400	1997.85
7	11469	1955.05
8	13763	1908.68
9	16056	1863.40
10	18350	1819.20

9.5 Prestressing force after slip using conventional practice for the projected length of cable:

The prestressing force after slip is calculated using the formula

$$P''_{xp} = P_{xp} - \frac{E_pA_p\delta_{slipA}}{L} \qquad \text{Eq.(20)}$$

The results obtained from the Eq.(19) for various sections along the girder are shown in the table 14.

The results obtained from the Eq.(19) for various sections along the girder are shown in the table 14.

Table 14- Prestressing force calculated by conventional method

No. (1)	x (mm) (2)	P_{xp}'' (kN) (3)
1	0	2103.19
2	2294	2050.90
3	4588	1999.85
4	6881	1950.01
5	9175	1901.35
6	11469	1853.85
7	13763	1807.47
8	16056	1762.19
9	18350	1717.99

The variations of prestressing force before and after slip for single end stressing is shown in Fig. 3. The variation of prestressing force after slip calculated by existing practice denoted by P_0''P_L'' is superimposed in the same figure to study the effects on the girder in the light of safety.

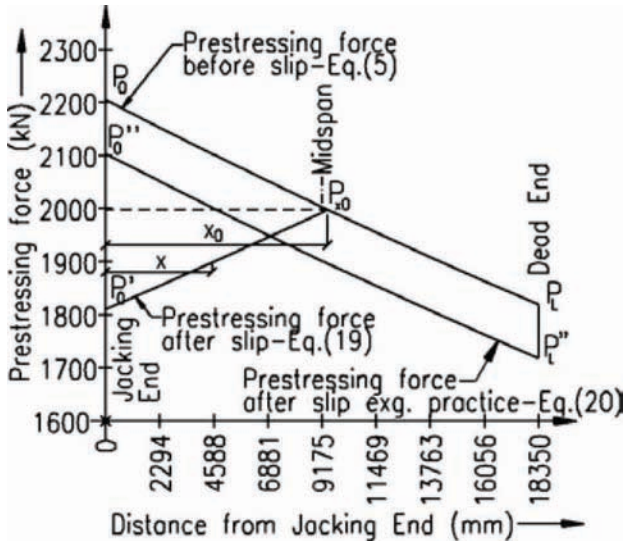


Fig. 3: Variation of prestressing force for single end stressing

For single end stressing system also, the conventional practice do not yield conservative results for the sections near midspan at transfer stage.

9.6 Single end stressing system versus both end stressing system:

The ratio between the strain energy stored for the entire length of the girder for single end stressing system and both end stressing system is proportional to the ratio of elongations given by

$$E_r = \frac{\left(\delta_L - \delta_{slipA}\right)}{2\left(\delta_{0.5L} - \delta_{slipA}\right)} \qquad \text{Eq.(21)}$$

If Er is nearly equal to 1 or greater than 1, then single end stressing system can be advantageously used. But the stressing end must be alternately changed from one end to another for successive stressing of cables. If Er is far less than 1, both end stressing system is to be used. In other words, if the length of zero slip for all the cables are greater than half of the distance between the stressing jacks, then single end stressing system can be used. This condition is almost satisfied for small to medium span girders for which single end stressing is advantageous.

10.0 Conclusion:

The following conclusions are drawn based on the extensive study of the variations of prestressing force due to friction and slip.

1). The variation of prestressing force before and after slip is non-linear. However, the difference between linear and non-linear variations cannot be distinctly represented due to negligible difference between them.

2). The variation of prestressing force after slip is not the mirror image of the variations of prestressing force before slip.

3). The projected length of cable can be used in the place of curved length of cable without any appreciable loss of accuracy.

4) The slip loss calculated by the existing conventional practice is not conservative.

5) Single end stressing system is advantageous for small to medium span girders ie., up to 18m.

11.0 Notations:

A, B, C = Constants for cable profile
A_p = Area of prestressing strands
e = base of Napierian logarithms
E_p = Young's modulus for prestressing strands
E_r = ratio of effective elongations for single end stressing to both end stressing for entire length of cable
K = Wobble coefficient
L = distance between jacking ends
p = ratio of curved length, sx to the projected length, x of cable profile
P_0 = prestressing force after at jacking end
P_x = prestressing force after friction at a section which is x distance from jacking end
P_{x0} = prestressing force after friction at zero slip point which is $_{x0}$ distance from jacking end
P_{x0}' = prestressing force at the end of slip at zero slip point which is x0 distance from jacking end

P_{xs} = prestressing force after friction at a distancex from jacking end by considering curved length of cable
P_{xp} = prestressing force after friction at a distancex from jacking end by considering projected length of cable
P_{xs}' = prestressing force after slip at a distancex from jacking end by considering curved length of cable
P_{xp}' = prestressing force after slip at a distancex from jacking end by considering projected length of cable
P_{xs}'' = prestressing force obtained from conventional practice after slip at a distancex from jacking end by considering curved length of cable
P_{xp}'' = prestressing force obtained from conventional practice after slip at a distancex from jacking end by considering projected length of cable
r_{ps} = radius of curvature of cable profile
s_x = curved length for a projected length, x
x = distance of section from jacking end
x_0 = length of zero slip from jacking end
y = Ordinate of cable profile

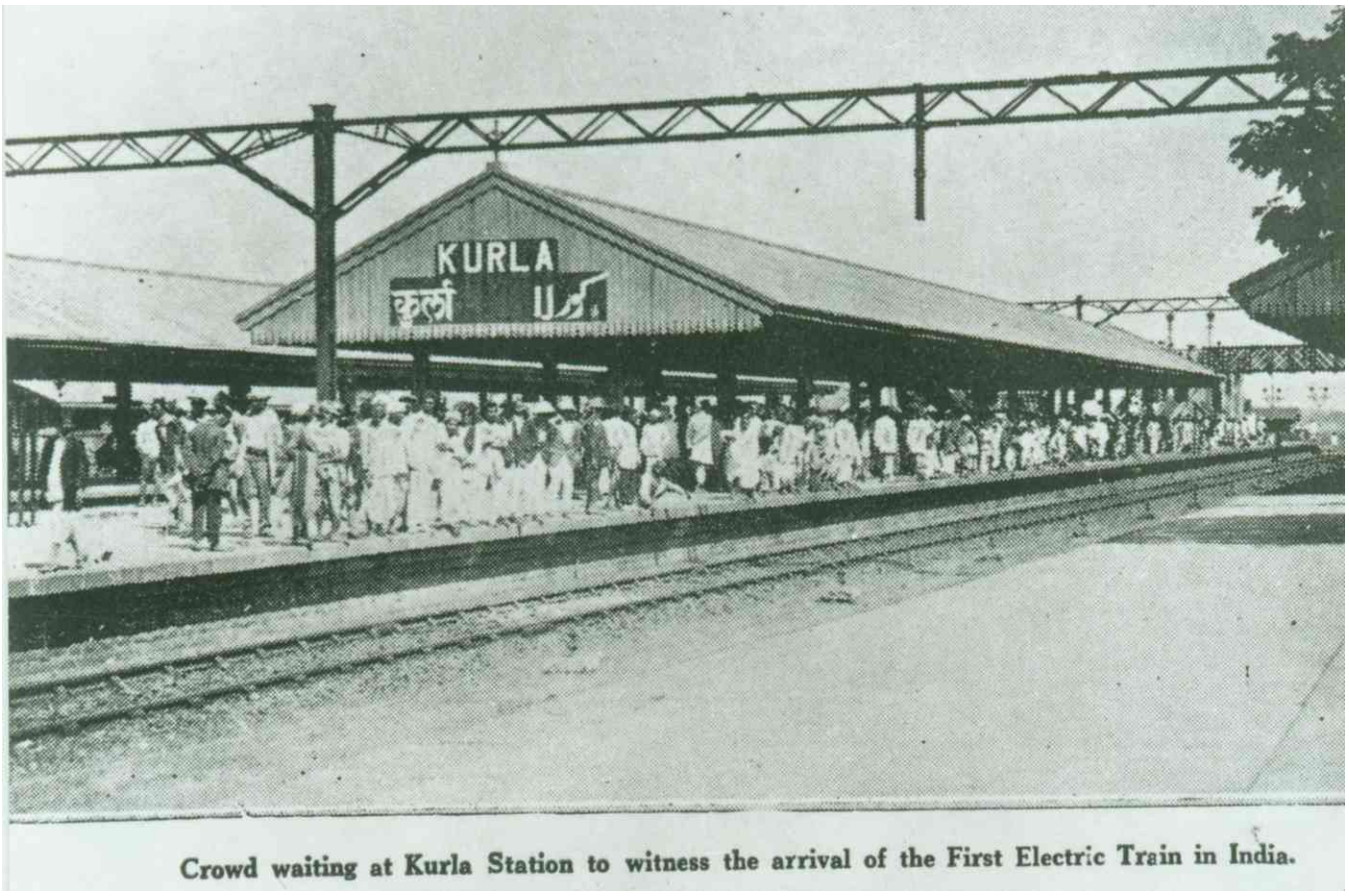
Y_{end} = Ordinate of cable at end
Y_{mid} = Ordinate of cable at midspan
y = Ordinate of cable profile

Y_{end} = Ordinate of cable at end
Y_{mid} = Ordinate of cable at midspan
δ_x = elongation of strands for a projected length of x in forward direction from the jack to section under consideration
δ_x' = elongation of strands for a projected length of x in reverse direction from the section to jack
δ_{slip} = calculated slip
δ_{slipA} = slip assumed in design
$_DP$ = offset of prestressing force at the end of slip at zero slip point
m = friction coefficient

12.0 References:

1. Indian Railways Standard code of Practice forPlain, Reinforced, and Prestressed Concrete forGeneral Bridge Construction, Second Revision, Research Design & Standards Organisation,
Lucknow, 1997

2. Drawing No. BA-10247/1 of Research Design & Standards Organisation, Lucknow



Crowd waiting at Kurla Station to witness the arrival of the First Electric Train in India.



IRICEN Auditorium

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CALENDAR OF COURSES 2018 (REV. 9 Dated 26/03/2018)

INDIAN RAILWAYS INSTITUTE OF CIVIL ENGINEERING/PUNE - CALENDAR OF COURSES (CoC) 2018-(Rev.09)(26-07-2018)

Months / Date (Monday): DECEMBER'2017: 4, 11, 18, 25 | JAN.2018: 1, 8, 15, 22, 29 | FEB.2018: 5, 12, 19, 26 | MAR.2018: 5, 12, 19, 26 | APRIL'2018: 2, 9, 16, 23, 30 | MAY'2018: 7, 14, 21, 28 | JUNE'2018: 4, 11, 18, 25 | JULY'2018: 2, 9, 16, 23, 30 | AUGUST'2018: 6, 13, 20, 27 | SEPT'2018: 3, 10, 17, 24 | OCTOBER'2018: 1, 8, 15, 22, 29 | NOV.'2018: 5, 12, 19, 26 | DECEMBER'2018: 3, 10, 17, 24, 31 | 'JAN.2019: 7, 14, 21, 28 | FEB.2019: 4, 11, 18, 25 | MAR.2019: 4, 11, 18, 25

Row	Entries (in calendar order)
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	17001, 001, 006
2016 Ex batch	18002, 005
2017 ExBatch	17012, 003, 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, Sr.Prof.P.Way 18202, Adv.SrProfCourse18212, Sr.Prof.Bridge 18203, Sr.Prof.P.Way 18204
HAG/SAG SEMINARS	313 PPP&EPC, 301 SJV, 302 RHW, 303 E&P, 304 E&P, 305 CE/WC PDEs, 306 CE/TM, 307 SJV, 314 CBE, 308 CTE, 309 E&P, 310 CAO (C), 311 CE/TP, 308 CTE, 312 CGE, 313 SJV, 435 TMS W/S, 315 ID, 316 PCE
SPECIAL COURSES – Tr.	433, 401, 403, 404, 406, 407, 413, 410, 412, 430, 409, 414, 415, 431, 418, 419, RDSO, 426, 424, 427, 429
SPECIAL COURSES – Wks	RWI, PXC, LOC, LOC, MTMR, RWI, TMS, LM, PXC, USFD, MTMR, RWI, LOC, BDA, P&SS, MTMR, PXC, RWI
SPECIAL COURSES – Br.	402, Post pone, 405, 408, 411, WS TMS, 433, 416, WS TMS, 417, 420, 421, 423, 425, 422, 428, 432
SPECIAL COURSES – VS	RF&GTI, C,A&PM, TNLG, PSC, MIDAS, LOC, CONST ENGINEERS, MS, USFD, RF&GTI, C,A&PM, RWI, LM, USFD
Sp.Courses forPSU	434 PSU NTPC (T&BM), 501 IRCON, 502 PSU, 503 PSU, IRPS& IRSS, IRSSE, 504 IRCON, Post poned, 505 IRCL, 507, 434/M IDAS, 504 IRCON, 506 PSU
AWARENESS COURSES	IRSEE 701, 703, 704, Post pone, Post pone, 702, 705, 706 IRSME, 707 IRAS &RPS, IRSEE 708, IRAS &RPS 713, IRSEE 704, Sr.Course IRSE 703, MRE, IRTS 709, IRSME 711, RPF 712

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

Row	Entries (in calendar order)
SP. COURSES for Track, Works & Bridge streams in SSTW – Tr.	802, 804, 807, 809, 2/3, 814, 818, 822, 1/5, 825, 832, 834, 836, 839, 15/8, 22/8, 844, 13/9, 21/9, 849, 2/10, 854, 18/10, 856, 8&9, 859, 863, 25/12, 868
Wks	LWR, USFD, LWR, TMS, MTMR, PXC&YM, 812 LWR, LS&CM, PXC&YM, LWR, TMS, MTMR, PXC&YM, LS&CM, 843-MTMR, PXC&YM, USFD, MTMR, PXC&YM, LWR, PXC&YM, 865, MTMR
Br.	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, 830/LM, 829/FMN, 833/BC&M, 837 CT, 838 LWR, 840 CM, 842 USFD, 845 S,E & CM, 847 LWR, 852 LS&CM, 857 USFD, 861 BC & M, 864 LM, CT, 866 USFD
SSTW	885 CM, 888 RWI, 805 RWI, 810 CM, 813, 815 PSC, 819 RWI, 823 FSB, 828/RWI, 827, 831 IMB, 835 USFD, 841 RWI, 846 TWS&CW, 855 RWI, 903 C-E, 850 PSC, 858 FSB, 867 RWI, 862 IMB
SPECIAL COURSES for PSU & Cont.Engr	PSU, C-E, 901 C-E, IMB, S,E & CM, 904 PSU, 905 C-E, 848 FMN, 851 TMS, 853 CT, 902 C-E

MAIN COURSES	Integrated				Sr.Prof. courses				ADV.S PC	ADV.S PC
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

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COURSE NOS.	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435
WEEKS	1	1	1	1	2	2	1	1	1	1	2	1	3	1	2	1	1	2	1	1	1	2	1	2	2	1	1	1	2	2D	2D	1	1	1	3D
ALLOTED SEATS	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	34	34	45	45	45	

SLOTS FOR PSU SR&MIDDLE LEVEL OFFICERS

COURSE NOS.	501	502	503	504	505	506	507
WEEKS	2	1	1	2	1	1	2
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	832	833	834	835	836	837	838	839	840
WEEKS / DAYS	2	1	2	2	2	2	2	2	1	2	1	2	2	4	2	2	2	2	2	1	2	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	45	45	45	45	45	45	45	45	45	45

COURSE NOS.	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868
WEEKS / DAYS	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	4	2	2	2	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	45	45	45	45	45	45	45	45	45

SLOTS FOR CE / PSU / SLOTS FOR CE

COURSE NOS.	901	902	903	904	905
WEEKS / DAYS	1	1	1	3	1
ALLOTED SEATS	MIN.15 - MAX.35				

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	30/08/2018	31/08/2018	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	22/11/2018	23/11/2018	IRICEN Day Seminar	2 D	IRSE 92' Batch	SPP	SPW	
316	27/12/2018	28/12/2018	PCEs' Seminar	2 D	PCEs	SPT1	SPB2	
~~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	1/2	6
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~~ P&SS	~~Fabrication of Steel Bridge~~ PSC & Steel Str.	426							1	2	2
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	507					3	2	6
USFD	USFD	409	421	432					2	1	2
MIDAS	Sp. Course on MIDAS software	433	434						2	1	2
PSU	...rses for Middle&upper Mgmt officers of I										

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	3	3
C-E	Sp. Courses for contractors' Engineers	901	902	903	905									4	1	4
														70		127

Legend: Pink cell Indicates holiday intheweek | Dt in red: Indicates Monday being holiday | 1 Week at RDSO for BDA course | To IRTMTC / RDSO | BREAK FOR PROJECT