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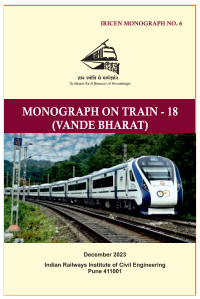
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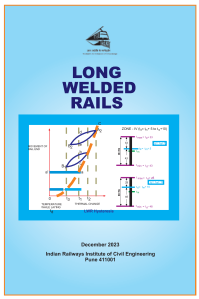
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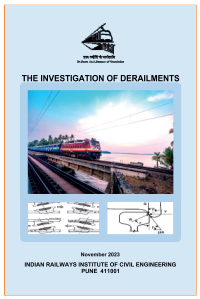


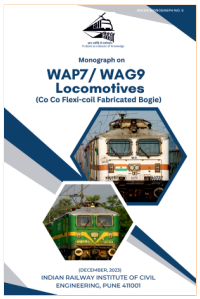
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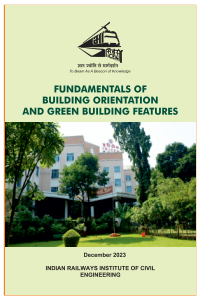
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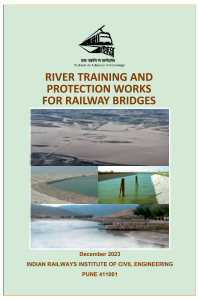


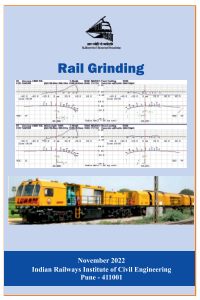




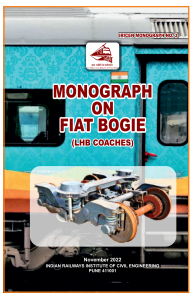




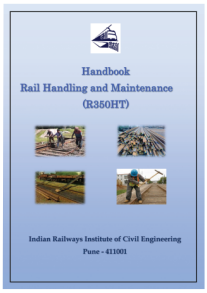


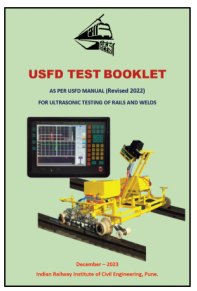






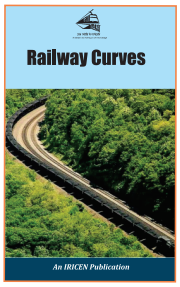


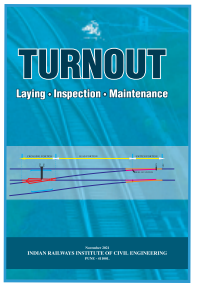


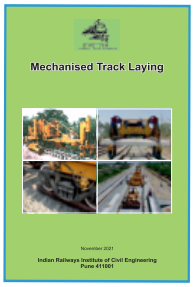


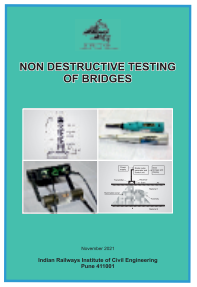


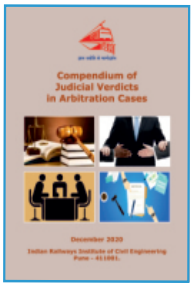




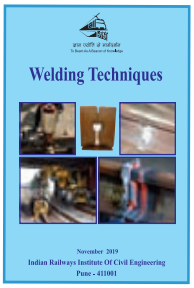


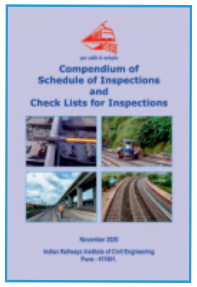


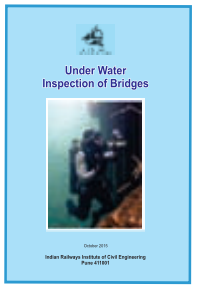


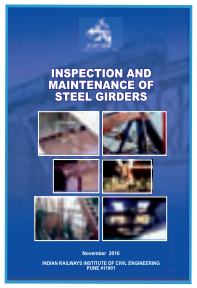






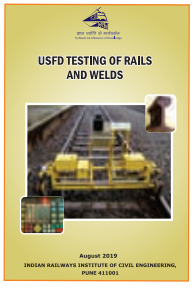


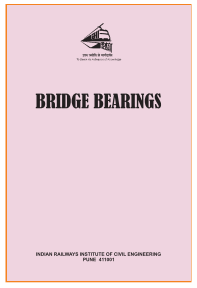


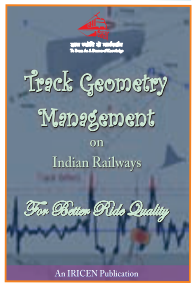


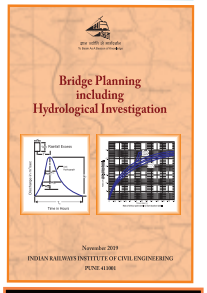


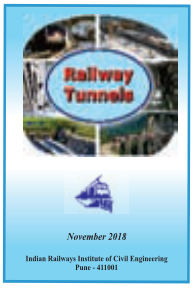


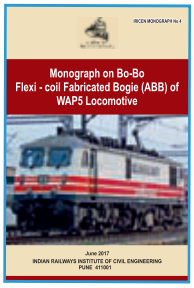


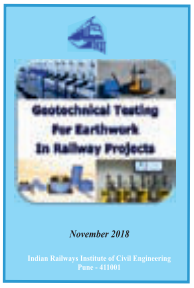


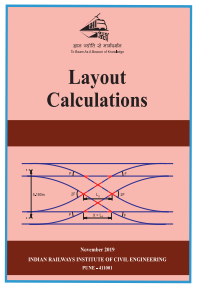


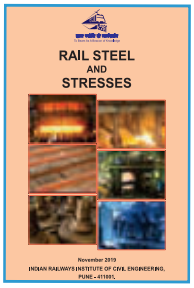


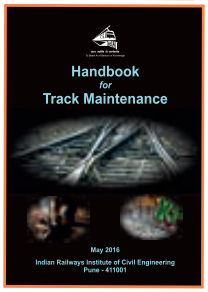














From Director General's Desk

Dear Readers,

In this edition of IRICEN journal, papers have been included on diverse topics. The first technical paper is on Use of the Jack-Down and Pulling Back Method for Tilt Correction in Well Foundation of the High-Speed Rail (HSR) Narmada Bridge. The second paper is on the study and review of the Installation of a Damper Stopper with special emphasis on the Internal Type Damper Stopper.

The third paper deals with a Case study on the use of TTHSB Bolts in the Mumbai Ahmedabad high-speed rail project.

The fourth paper is related to Analysing the strength of existing catch siding for higher axle loads. The fifth paper talks about the Coefficient of active earth pressure from First Principles.

I hope that the readers will find these papers and other articles contained in this edition relevant and useful. Any suggestions for making this journal more useful and contributing technical papers for inclusion in forthcoming editions would be greatly appreciated. This will help in sharing and spreading knowledge and experience among Railway Engineers.

Pune
June 2024

(Sunil Kumar Jha)
Director General

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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.

Relating the influence of track properties to axle load spectra through onboard measurements

This work aims at investigating how variations in measured stresses are affected by track conditions and, if possible, extract information on track conditions from onboard measurements. Axle bending strains measured in extensive field tests are employed to evaluate axle stress spectra. Correlation between stress spectra and parameters describing track design and condition for three sections of the Swedish mainline “Vastra stambanan” have been investigated. The study shows how switches and other discontinuities in the track running surface increase the scatter of the stress spectra and increase the number of overloads. Circular and transition curves mainly increase stress amplitudes with magnitudes close to quasistatic conditions load. A decrease in track quality leads to both a shift of stress spectra towards higher values and a higher number of overloads. The influence of bridges/tunnels and decreased track stiffness were found to be difficult to distinguish from effects of curves, switches and crossings and track quality. If effects exist, they are likely to be small. Results from the study aids future track condition monitoring, maintenance planning of track and running gear and the estimation of stress spectra for track stretches with known characteristics.

Ref. : Journal of Rail & Rapid January 2024

Study on the optimization of high-speed turnout crossing structures based on actual elastic deformation of point and splice rails

In this paper, to address the shortcomings of the crossing structure design based on the elastic bending center method and the lack of related research, an optimization method for high-speed turnout crossing structures was proposed based on the actual elastic deformations of point and splice rails. Based on the finite element theory, the actual loading characteristics and spatial variable section characteristics of point and splice rails were fully considered, and a refined simulation analysis model of the switching system of point and splice rails in crossing areas was established. Moreover, the elastic deformation lines of point and splice rails in the nonworking state were obtained for the first time, which were consistent with actual situations. On this basis, system optimization was performed for the connecting parts of the crossing with a movable point in a high-speed turnout. In the crossing structure simulation model, the length adjustment values of the first–sixth spacer blocks between the branch line–wing and point rails and between the mail line–wing splice rails were ≤1 mm. Moreover, the lengths of the seventh–ninth spacer blocks decreased by gradually increasing amounts, and the length of the ninth spacer block decreased the most (~6 mm). The length of the second spacer block between the point and splice rails slightly increased, but the length of the third spacer block significantly decreased by 6 mm. The length adjustment value of the distance block between the point and splice rails was smallest (0.7 mm). The calculated optimal lengths of the connecting parts of the crossing were found to be close to the empirical values used in actual manufacturing processes and the dimension optimization patterns were completely consistent with actual situation, which validates the proposed optimization method. Thus, the proposed method can effectively improve the coordination between rails and connecting parts in crossing areas, substantially reduce internal stresses in crossing systems, and improve their assembly performance and service life. Moreover, the proposed optimization parameters can provide valuable references for the research on next-generation high-speed turnouts (400 km/h) and for improving the designs of existing high-speed turnouts.

Ref. : Journal of Rail & Rapid February 2024

Studying the transfer mechanisms of water based top-of-rail products in a wheel/rail interaction

The railway industry uses top-of-rail products to control and manage the friction in the wheel/rail interface to help ensure efficient train operations and reduce wheel and rail damage. A product is typically applied from a wayside applicator that pumps a puddle onto the rail head where a passing wheel will pick it up and then transfer it down the track. The aim of this study was to study the transfer mechanisms of water-based top-of-rail friction modifiers (TOR-FMs) and how they are linked to the friction conditions in the wheel/rail interface. The transfer mechanisms were split into three parts: pick-up, carry-on and consumption. Pick-up looks at how the product transfers from the puddle on the rail to a wheel tread, whereas the carryon mechanism relates to the product transfer back to the wheel. Two products were tested of similar formulation. Results show that there are differences in the transfer and friction between the two products despite them being relatively similar. The test methods developed can clearly resolve differences between varying product types, which could be useful for product development studies or approvals work. The outcomes could also be used to develop a model of transfer/consumption.

Ref. : Journal of Rail & Rapid February 2024

Incentivized decarbonization through safer and more efficient heavy haul operations

The improvement in component service life and railway service reliability has been viewed from an environmental perspective. Delays and train accidents carry enormous costs and greenhouse gas (GHG) emissions potential due to the increased fuel burn and the need to replace heavy equipment prematurely. The use of higher-performance materials, more efficient vehicle design, and modern technology by Canadian railways to reduce service interruptions are presented. Their resulting cost savings not only can provide financial incentives for the continuous optimization of asset utilization but can also lead to significant contributions to the decarbonization of the railway industry. The authors have estimated a total reduction of 2.4 kt-CO2e per year in embodies carbon emissions due to life extensions of wheelsets compared to 2017 levels on a Class 1 railway. System-wide, the rail life extension has resulted in a saving of 8.1 kt-CO2e per year compared to 2017 for the same railway. Compared to 2004, the Canadian railway industry has achieved an annual

reduction in embodied carbon emission of 6.7 Mt-CO2e from the reduction in mainline derailments.

Ref. : Journal of Rail & Rapid March 2024

A twin-disc study of the role of the surface quality achieved by grinding on the wear resistance and rolling contact fatigue behavior of wheel/rail pairs

The tribological behavior of wheel and rail material twin-disc samples prepared under laboratory-controlled grinding operations was studied. A laboratory grinding device was designed and validated to produce similar results to those found in the field in terms of surface quality and presence of white etching layer (WEL). The test samples were evaluated in a twin-disc machine under dry and lubricated conditions. The results showed that the surface finishing parameters and the microstructure change greatly depending on the surface preparation procedure, and that such changes affect the tribological response of the samples. The wear rates of the tribological tests for the different rail surface qualities showed a reduction of 47.4% for the lubricated tests and 7.3% for the dry tests when the surfaces of the rail specimens were finished by grinding. This is only applied when the WEL thickness was less than 4 μm.

Ref. : Journal of Rail & Rapid April 2024

Modelling of rolling contact fatigue under various interface conditions

This study presents the results of modelling the rolling contact of the elastic sphere and the elastic half-space in the presence of a thin intermediate viscoelastic layer which properties are described by an elastic nonlinear Winkler body in the normal direction and a viscoelastic Maxwell body in the tangential direction. The analytical–numerical approach for the estimation of contact fatigue damage, accumulated in the elastic half-space under rolling friction conditions, is developed. The proposed model can be used, in particular, to study the effect of mechanical properties of the friction modifiers (elastic moduli and relaxation times) and its thickness as well as the relative slippage on the formation of the surface and under surface contact fatigue cracks in rails. The results of the analysis can also be applied for the estimation of efficiency of solid lubricants in rolling contacts under given operating conditions.

Ref. : Journal of Rail & Rapid April 2024

On-time and energy-saving train operation strategy based on improved AGA multi-objective optimization

On-time and energy-saving train operation is important for the sustainable development of rail transit. As for the problems of traction energy consumption and on-time arrival at stations faced by trains in rail transit, an optimization strategy of energysaving speed curves of trains based on an improved adaptive genetic algorithm (AGA) was proposed in this paper. First, weight coefficients of operation time and energy consumption were designed through an analytic hierarchy process, and an optimization model that targets train operation time and energy consumption was established according to a basic train operation model with constraints such as speed limits and precise train stopping. Then, on-time and energy-saving speed curves of trains were generated based on the improved AGA. Finally, a simulation was carried out with actual rail transit lines. The results show that the proposed method has strong efficiency for energy conservation and better optimization performance than the simple genetic algorithm in solving train trajectory optimization problem.

Ref. : Journal of Rail & Rapid May 2024

Train/track coupled dynamics model of long heavy haul train based on substructure and parallel computing

To consider the coupled effect on the running safety between elastic track and longitudinal impulse of Long Heavy Haul Train(LHHT), a train/track coupled dynamics model is established by using connection substructure theory. The ballasted track is divided into several segments called sub-tracks: a sub-track includes rail, sleepers and ballast. In the sub-track model, the sleepers and ballast are modelled as lumped mass. The rail is divided into the contact and connection rail. The contact rail is modelled as an Euler beam to reflect the wheel/rail interaction and the flexible vibration of the rail. The connection rail is modelled as a super element to reflect the interaction between adjacent contact rail. To increase the simulation speed, a new parallel computing method is proposed: a train/track coupled dynamics model is divided into different submodule, a submodule includes a sub-track and a vehicle on the sub-track. The simulation speed depends on the number of parallel computing cores instead of one core with a particularly large load. Finally, taking the 10,000-ton train as an example, the distribution of coupler force, the derailment coefficient and wheel unloading rate are given during the train braking on a curve, which shows the application and necessity of the train/track coupled dynamics model based on substructure and parallel computing.

Ref. : Journal of Rail & Rapid May 2024

The fatigue enhancement of Gade valley viaduct box girders due to distortional effects

In this paper, a case study is examined in which a bridge structure with fatigue critical details was successfully managed and remediated without extensive traffic closures. Severe theoretical fatigue life shortfalls have been identified at the transverse stiffener frames of the box girder due to distortional effects in the steel box. Gade valley viaduct was the final link in the M25 London orbital motorway, constructed in 1986 at Kings Langley, UK. It is a composite box girder viaduct 440 m long with typical spans of 42 m and carries 180 000 vehicles daily. A series of cracks and original sub-standard weld quality issues were discovered in the transverse stiffener frames of the box girder. The fatigue shortfall that was a significant contributor to the identified fatigue cracking was confirmed by assessment and strain-gauge monitoring. This case study illustrates how heavily used structures with theoretical fatigue life shortfalls can be successfully rehabilitated to ensure safety.

Ref. : ICE, Bridge Engineering, Vol. 177 no. 1

Use of the Jack-Down and Pulling back Method for Tilt Correction in Well Foundation of the High Speed Rail (HSR) Narmada Bridge

Akshaya Kumar[1]

[1] *IRSE/ Chief Project Manager, NHSRCL*

ABSTRACT

Well foundations are one of the oldest, yet most effective foundation types for large-scale Civil structures such as railways, highways, or bridges/viaducts over wide rivers. Though efficient & cost-effective, a usual issue associated with well foundation is the tilting and shifting of wells during the sinking process because of; natural forces such as high river flow and tides and unaccounted soil conditions at the sinking level. Over the past few decades, many methods have been innovated to rectify tilt and shift in well foundations: eccentric grabbing, eccentric loading, pulling, the Kentledge method, etc. This paper depicts an innovative technology of using the Jack-Down Method, apart from pulling back which is a process for tilt and shift correction, in conjunction with the kentledge and eccentric grabbing methods.

1. Introduction

The Narmada Bridge with Well Foundation case study, which is being built for the Mumbai – Ahmedabad High Speed Rail (MAHSR) Project, is the main focus of this report. India's Bullet Train Project, or MAHSR, is a major infrastructure project that aims to transform rail transportation in India. The project is to build a high-speed (320 km/h) double-track railway line spanning 508 kilometers that will connect Ahmedabad and Mumbai, two of India's largest cities. The longest river bridge (in Gujarat) in this project, the Narmada Bridge, is being constructed on well foundation.

The 1.26 kilometer long Narmada River Bridge has 22 well foundations.

The bridge's salient features are as follows:

Location: Near Bharuch (Gujarat)

Span : 21 X 60 m. (3X60 m Continuous span)

Diameter (outer dia) :	10 m
Diameter (Inner dia):	7m & 7.6 m
Steining Thickness:	1.2 m &1.5m
Depth:	51 to 77 m
Scour Level:	-19 m to -32 m
Founding Level:	-36.00 to -70.0 m

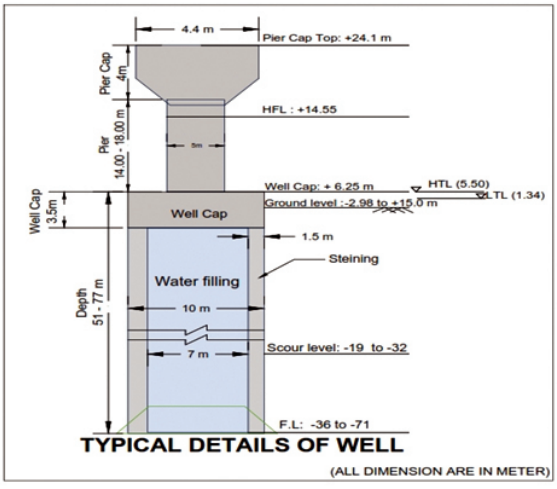


Figure-1

Tilt & Shift

Tilt of well foundation is deviation from its intended vertical position due to various factors such as uneven soil or rock conditions, obstacles encountered during sinking, or other unforeseen challenges.

Shift in a well foundation refers to the horizontal movement or lateral adjustment of the well structure during its sinking process.

Tilt is measured by checking the levels at fixed gauge mark on both opposite faces along axis of the well. The difference in level will establish the tilt along the axis. It is designated as ratio of difference in level to dia. of well.

The tilt of any well shall not exceed 1 (horizontal) in 100 (vertical), and the shift at the well base shall not be more than 150mm in any resultant direction.

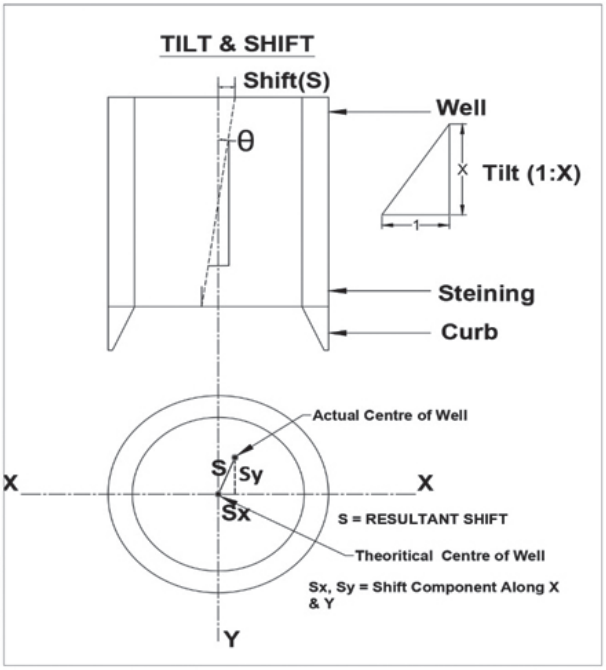


Figure 2 Tilt and Shift in Wells.



Figure 3 Tilted Well No P09

2. Methods for rectification of excess Tilt/Shift

- Widespread practices in construction industry for rectification of tilt/shift are enlisted, as below:
- Eccentric grabbing.
- Eccentric Static Loading (Kentledge)
- Water Jetting.
- Pulling of well.
- Strutting the well.
- Pushing the well by jacks.

In our present case study of MAHSR Narmada Well Foundation, because of site conditions, the use of the Kentledge method was not delivering acceptable results, as the sinking effort required was much higher than the practically feasible static load on the Kentledge method.

2.1 Calculation of Sinking Effort:

Sinking Effort is required to counter the resistance from:

- Skin friction on the outer surface of well.
- Buoyancy force

Skin Friction can be calculated as:

$$F = \frac{1}{2} Ka(Z\text{-}2C\ Ka) \tan\left\{\frac{2\phi}{3}\right\}$$

Where F = skin friction in t/m^2

Ka =Active earth pressure coefficient

ϕ = Angle of shearing resistance of soil (degrees)

C = Half of unconfined compressive strength.

Z = Depth of foundation below scour level (m)

γ = Density of soil in t/m3.

Skin Friction (F) can be ranged to below values, based upon soil type:

Stiff and soft Clay	= 0.73 to 2.93 t/m^2
Clay	=4.88 to 19.53 t/m^2
Very soft clay	= 1.23 to 3.42 t/m^2
Dense sand	=3.42 to 6.84 t/m^2
Dense gravel	= 4.88 to 9.76 t/m^2

In our case-study; Considering Sand and clay strata, Skin friction assumed in the calculation is 4.7 t/sqm.

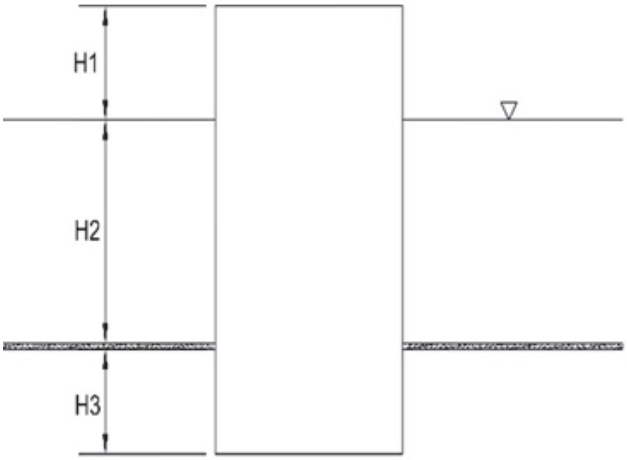
Generally, sinking effort is available from the self-weight of the well only. To reduce skin friction, methods such as air jetting and water jetting are used while sinking.

Sinking effort is available from:

- Self-weight of well
- Air/Water jetting (due to reduction of skin friction or buoyancy)
- External force such as kentledge / Jack down.

Hence, **Sinking Effort** can be calculated as:

F = (A x W)/P {H1/H3+(w-δ)/w*H2/H3+(w-δ)/w}



Wherein, f = Average Sinking Effort (t/m^2)

A = Cross sectional area of well steining (m^2)

W = Weight of steining per meter length of well (t/m)

w = Unit weight of plain concrete (t/m3)

δ = Unit weight of water (t/m^3)

P = Perimeter of well (m)

H1 = Height of Well above water (m)

H2 = Height of well below water level & upto bed level (m)

H3 = Depth of well below bed level, where skin friction applies.

In Limiting condition, H1=0, H2< of H3, hence H2/H3 is neglected,

f = (A x W)/P {(w-δ)/w}

Upon Simplifying above,

f =47x WP (approx.)

Wherein, f = Average Sinking Effort (t/m^2)

W= Weight of steining per meter of length of well (t/m)

P = Perimeter of Well (m)

Considering,

Buoyancy as: (1000/2500) of weight of well.

Skin Friction = 4.7 T/sqm x Surface area of well.

Air/Water jetting is reducing the requirement of external force by about 50%.

Calculation of Required External Sinking Effort

The sinking effort required for different depths is calculated and summarized as below: (These calculations are approximate, and no exact theoretical backing is there.)

Depth (m)	Weight of Steining per meter length of well (W) (MT)	Avg. Sinking Effort (T/m^2)	Total Sinking Effort (MT)	Total Skin Friction (MT)	External Force Req. (MT)	Air Jetting / Water Jetting (MT)	Jack Down Force requirement (MT)
A	b	C = (4/7)*(W/P)	d =c*Total surface area	e = 4.7*Total surface area	f = d-e	g = 0.5*f †	h = f-g
10	100	1.82	572	1477	905	452	452
20	100	1.82	1257	2954	1697	849	849
30	100	1.82	1886	4431	2546	1273	1273
40	100	1.82	2514	5909	3394	1697	1697
50	100	1.82	3143	7386	4243	2121	2121
60	100	1.82	3771	8863	5091	2546	2546
70	100	1.82	4400	10340	5940	2970	2970

† Due to Air Jetting & water jetting, 50% reduction in required external force is assumed.

As can be observed from the above table, the sinking effort required is more than 1000 MT for a depth of more than 30 meters, hence, the conventional Kentledge method seemed insufficient. Therefore, it was decided to use the 'Jack-Down Method using soil anchors with the Kentledge method' to achieve the desired sinking efforts.

3 Air Jetting and Water jetting arrangement in Wells

3.1 Provision of Air Jetting:-

PVC pipe of dia 25mm is being provided horizontally on cover zone to facilitate air jetting air jetting to reduce the skin friction of well surface. This is provided in alternate layer of well steining.

The vertical connection for each horizontal layer shall be kept at least 1m above the casted steining to facilitate compressed air.

The pipe shall be grouted with pressure grouting by cementitious grout after bottom plugging.

3.2 Provision of Water jetting:-

Water jetting can be used to facilitate sinking of wells through clay and hard strata.

For water jetting required number of steel pipes of 40mm -50 mm dia shall be embedded in the steining of well, spaced evenly around its periphery.

The steel pipe shall be kept about 1m above the top of each lift of steining cast.

The pipe may be passing through the center of well curb for facilitating water jetting arrangement.

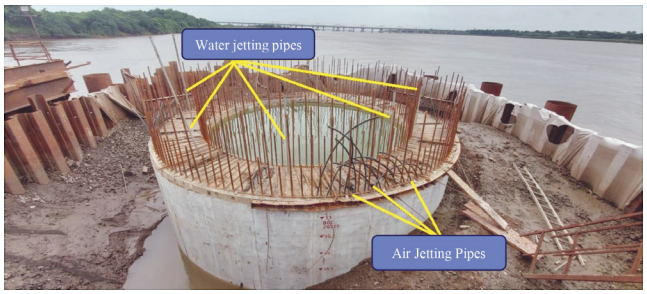


Figure 4 Provision of Air and water jetting arrangement in Wells.

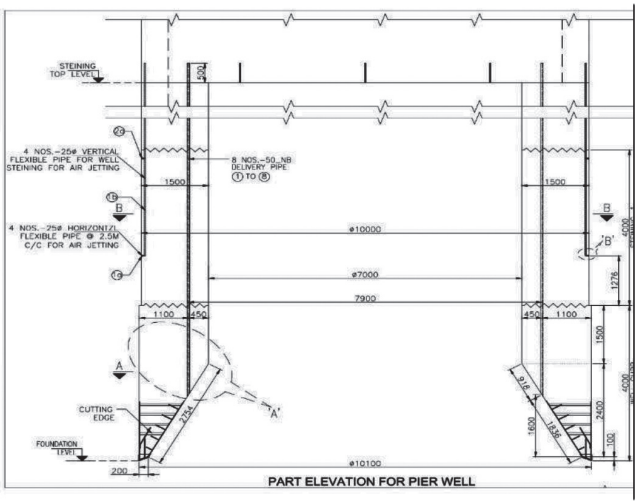


Figure 5 Air Jetting and Water jetting details (typical section)

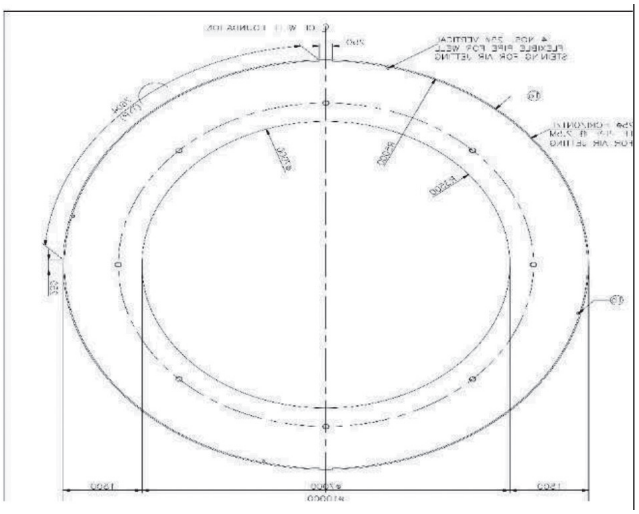


Figure 6 Air and Water jetting details (Typical Plan)

4. Jack-Down Method with Kentledge & Eccentric Grabbing for Tilt/Shift Correction.

The jacking down method with load up to 1200 MT (or more) on one side of the well (face opposite to tilt) creates a moment and rotates the Well at some point below the bed with support from stiff clay as a fulcrum. (Refer Figures 5, 7 & 8)

Construction Procedure:

The first step is to install ground anchors outside the periphery of the well (Figure 5). The number, location and depth of ground anchors outside the periphery of the surrounding soil shall be adequate to develop the necessary resisting force through skin friction.

The drill holes of the required diameter, along with casings shall be taken down to a depth below the founding level of the well. (Figure 7 & 8)

After drilling holes to the required depth, HT strands of adequate diameter and capacity are cut to the desired length and lowered into the holes.

The holes shall then be grouted with cement slurry with a non-shrink additive.

Heavy-duty pressurization girders fabricated of steel shall be placed over stools resting on the steining of the well against which the hydraulic jacks connected to the ground anchors can exert pressure to push the well down. (Figures 4 &6)

The hydraulic jacks shall be of the required capacity as per the required sinking efforts.

Pressure on different jacks is exerted in such a manner as to exert external force in the opposite direction of tilt.



Figure 7 (Jack down with kentledge arrangement)

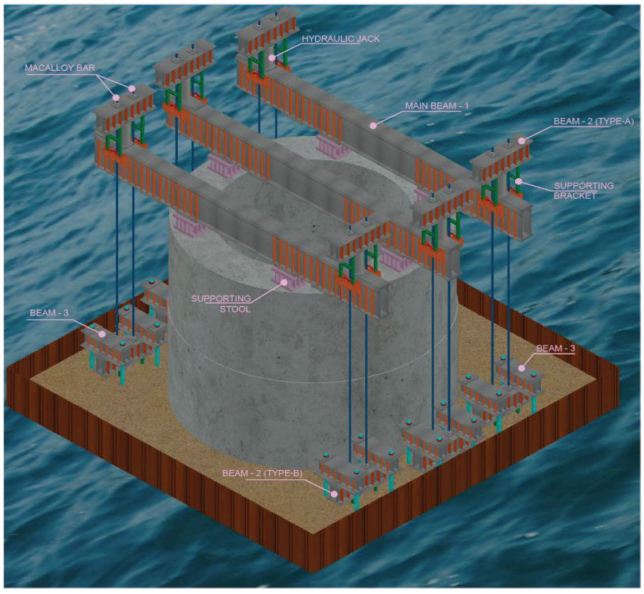


Figure 8 (Isometric view of Jack down arrangement)

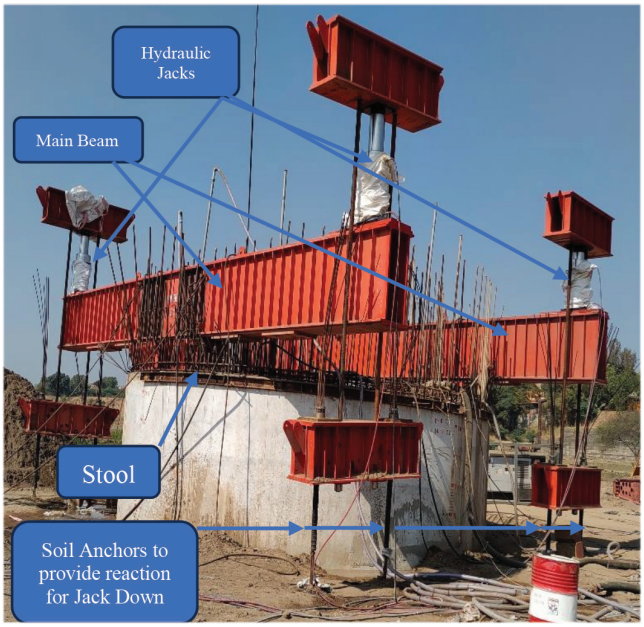


Figure 9 (Jack down arrangement)

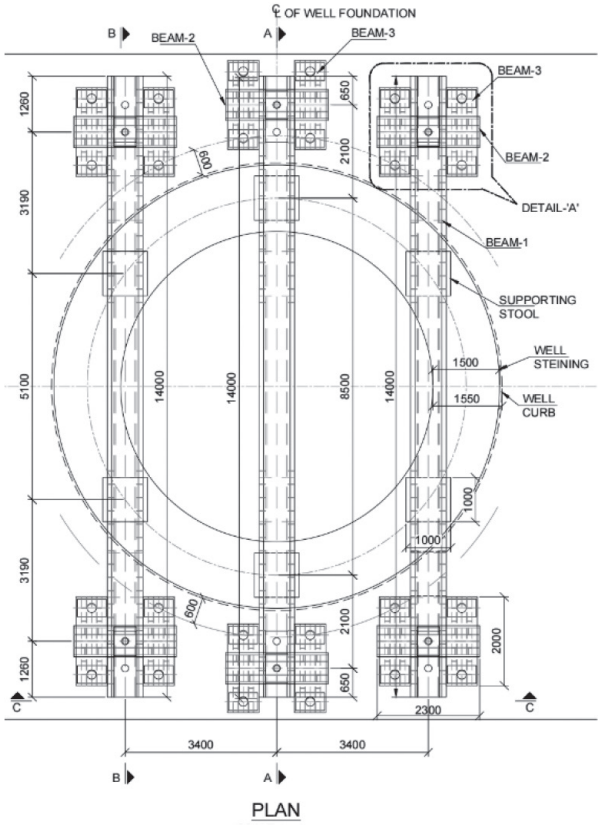


Figure 10 (Jack down schematic diagram)

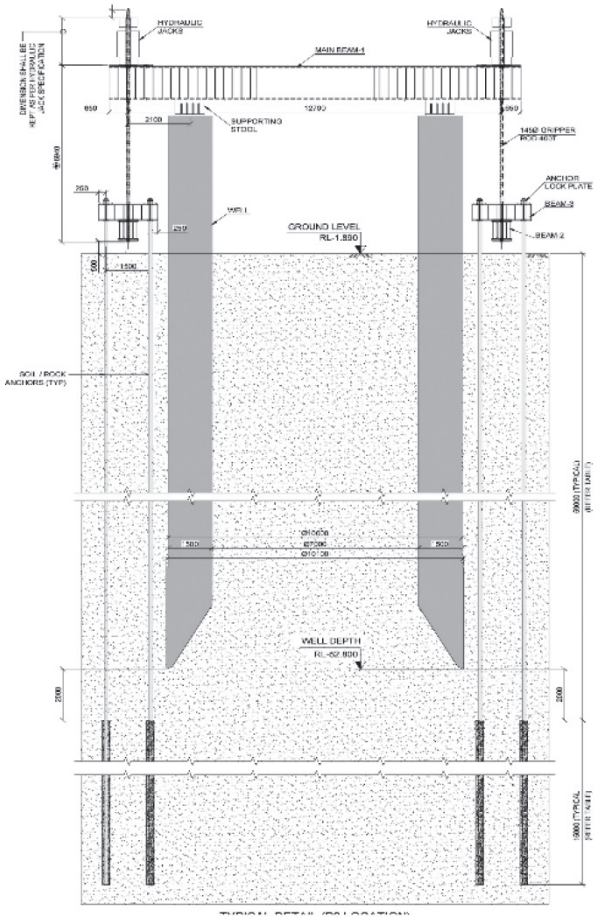


Figure 11 (Jack down Schematic diagram)

5. Pulling back of Well - Anchorage from adjoining well for Tilt correction.

Provision of kentledge for the correction of tilt in the opposite direction of tilt.

Providing 75mm sling wrap around well to be corrected and same is anchored in nearby well through the pulley. The tilted Well is pulled with a sheave pulley arrangement by taking reaction from the adjoining well.

The same sling after passing through pully is connected to rotating drum of mechanical crane which apply load by pulling the sling. (1/4th Load is taken from crane i.e 18T and 3/4th load through the well i.e 54T.) (Figure 9 & 10).

Simultaneously sump is made in the opposite direction of tilt so that well can sink and tilt is corrected.

After making sump grabbing in outer side will be carried out to reduce the grip length of the well which will help to sink.

Air jetting & water jetting are carried out simultaneously as required.

When all the above activity is carried out simultaneously tilt of the well got corrected to given tolerance.

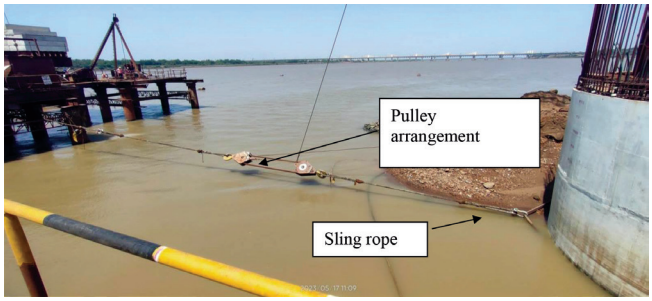


Figure 12 (Pully Arrangement for Tilt correction)

Well, No. 9 had a tilt of 1:25. Using the Kentledge method there was no improvement in tilt.

The pulling of the well by anchoring it with an adjoining well (Figure 9) was planned as explained above, and the results were very encouraging. Within two months, with about 5.0 m of sinking, the tilt got corrected to 1:140 (from 1:25). The date-wise tilt correction is given in the attached table. This method could be adopted as the adjoining well was not disturbed and sunk to an adequate depth so as to take up the reaction force as required.

Tilt Correction with Time for Well No.09

Date	Actual Sinking (m)	TILT		
		Tilt along Y – Axis	Tilt along x - Axis	Resultant Tilt
		1 in	1 in	1 in
03/07/2023	32.276	25	244	25
04/07/2023	32.426	24	263	24
19/07/2023	32.471	24	1250	24
20/07/2023	32.472	24	2000	24
20/07/2023	32.640	28	286	28
21/07/2023	32.640	28	286	28
22/07/2023	32.687	26	200	26
24/07/2023	32.735	26	200	26
25/07/2023	33.085	26	179	26
26/07/2023	33.189	27	179	27
27/07/2023	33.349	29	172	29
29/07/2023	33.507	29	172	29
31/07/2023	33.670	30	143	29
01/08/2023	33.685	30	147	29
02/08/2023	33.685	30	147	29
03/08/2023	33.685	30	147	29
05/08/2023	33.685	30	147	29
07/08/2023	33.678	32	145	31
08/08/2023	33.689	34	143	33
09/08/2023	33.778	116	256	106
10/08/2023	34.045	208	455	189
11/08/2023	34.038	204	417	183
25/08/2023	34.273	137	345	127
30/08/2023	34.422	169	370	184
31/08/2023	35.436	120	213	105
01/09/2023	35.559	172	278	146

02/09/2023	37.028	145	286	129
02/09/2023	37.597	149	417	140

In other wells, due to soil strata, the sinking of wells was not progressing adequately. The jack down method has been adopted to sink through the stiff clay strata. This paper mainly highlights the use of the above two (Jack down and pulling back) methods in the tilt correction of wells. Each method has to be adopted based on the site-specific requirements and feasibility. The method to be adopted must be followed very judiciously based on site specific requirements and suitability.

Tilt Correction in Well No. P09 of Narmada Well Foundation (HSR River Bridge)



Figure 13 (Well No. 09/Narmada River Bridge HSR)

6. Conclusion

There are many methods available for tilt correction in wells, like eccentric grabbing, Kentledge, etc. But in the construction of the HSR Narmada Bridge, some special measures have been taken, like the provision of air jetting, and water jetting to improve the sinking of the well. Also, pulling back (with Kentledge) with the help of reaction from adjoining wells has been used for tilt correction very effectively. The use of jack jack-down arrangements for well sinking where adequate sinking effort is not available is an innovative method adopted in the construction of this bridge. This paper discusses only the concepts used for different adopted schemes about well foundations, and the details given are site-specific only and should not be followed at any other site without proper technical analysis and study.

References

[1] Doc No. 2005/CE-I/BR-II/8 dated 8th June, 2005 from Sh. RR Jaruhar, Member Engineering Railway Board & Ex-Officio Secretary, Govt. of India, Ministry of Railways, New Delhi-110001.

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Simla-Kalka Mail

Damper Stoppers provision in Balance Cantilever bridges and Post Construction Lowering of Damper Stopper in balance cantilever Segment by Segment (SBS)

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ABSTRACT

NHSRCL is constructing MAHSR between Mumbai – Ahmedabad, measuring about 508 km with design speed of 350 kmph (Maximum operation speed of 320 kmph). Approx. 92% of MAHSR track will be Elevated Viaducts (460.3 km (~90.5%)) & Bridges (9.22 km (~1.8%)).

In order to cater space requirements, highways & railway crossings etc over which MAHSR will pass, special PSC bridges designed as balance cantilever segmental construction and are designed by Japanese Consultant based on JR standards & guidelines after gaining experience from Shinkansen High speed Railway network in Japan. One such area is Articulation of PSC box girder bridges i.e. selection & arrangement of bearings & stoppers (All to the degree of movement allowed) for use in bridges.

To resolve these concerns, a design method called "functional-separation" is used for the Japanese railway bridges, whereby Elastomeric bearings are provisioned only for vertical loads from the superstructure, whereas all the horizontal forces are catered through stoppers.

Damper Stopper has a mechanism that allows fix-moved design while in standard state, and distribution (all fixed) design during earthquakes. So it could be possible to avoid designing fixed single substructure from simple supported girder bridges to continuous bridges. It has been adopted in about 100m span bridges.

DAMPER STOPPER are used as SEISMIC RESTRAINER. Damper stopper used in bridges to distribute Seismic forces to adjacent Piers and are provided at the intermediate supports of continuous bridge

Two types of stoppers are adopted in MAHSR project- one is Steel stopper and other one is Damper stopper. This paper focuses mainly on the use of Damper Stopper in Continuous bridges of MAHSR and to provide information on installation of Damper stoppers.

1. Introduction

Bridges are subjected to a variety of influences that cause displacement of the superstructure and its supports. If these movements are restrained, forces will be generated within the superstructure. To control the development of restraint forces, it has become normal practice to place the superstructure on support bearings, allowing some freedom of relative movement between the deck and supports.

In addition to vertical loads (Dead Load, Super Imposed Dead Load, Live Load, etc.), Lateral forces act both in longitudinal direction (along the traffic) and transverse direction (perpendicular to traffic). Various types of lateral forces acting on railway viaducts/bridges are listed below:

- Braking/Traction Forces
- Long Welded Rail Forces
- Impact and Vibration Forces
- Racking Forces/Nosing Forces
- Temperature Forces
- Forces due to creep/shrinkage of PSC girder
- Wind Forces
- Seismic Forces
- Centrifugal Forces due to curvature in track

Provisioning of bearings alone to cater to the vertical as well as horizontal loads has some concerns like possibility of bearing dimensions becoming too large, possibility of structure becoming complicated, Need for replacement of bearings frequently etc.

To resolve these concerns, a design method called "functional-separation" is used for the Japanese railway bridges, whereby Elastomeric bearings are provisioned only for vertical loads from the superstructure, whereas all the horizontal forces are catered through stoppers.

Two types of stoppers are adopted in MAHSR project- one is Steel stopper and other one is Damper stopper. This paper focuses mainly on the use of Damper Stopper in Continuous bridges of MAHSR.

2.0 Use of Damper Stopper in Continuous Bridge:

At total five locations (tabulated below) where MAHSR alignment is crossing National Highway/Expressway, damper stopper is being used to take care horizontal forces in balance cantilever segmental construction.

S. No.	GAD No.	Location/ Chainage of MAHSR	Crossing over	Span (in meter)
1	9	Km 210.38	NH-48	40+65+65+40
2	10	Km 235.38	NH-48	40+65+65+40
3	11	Km 241.64	NH-48	50+80+80+50
4	1441	Km 297.03	Expressway Delhi-Mumbai	50+80+80+50
5	33	Km 459.464	NH-8	40+65+65+40

The main body of damper stopper uses square steel section. The portion placed in substructure consists of outer and inner box and the gap between these boxes is filled with a viscous fluid. The viscous fluid is velocity dependent; having small resistance force due to expansion etc., and designed to generate the maximum resistance in fast motion, such as during an earthquake. So, its mechanism that allows fix-moved design while in standard state, and distribution (all fixed) design during earthquakes is fulfilled. Viscous fluid is a state that is sealed by a sliding plate with a large stiffener which is placed on top of the box, the force of destruction by a large earthquake can be measured by leakage.

As per contract conditions, in MAHSR project, Damper Stoppers used either the "KP Stopper" (e.g. OILES DAMPER STOPPER) or, it's equivalent.

This materials used for Stopper is as per below Table 1:-

Table 1:

Item	Physical Properties	Standard Value	Name of Test and Referred Standard
Steel plate	Grade	See Table's Note 1	IS: 2062/JIS G 3101, JIS G 3106
Post filling concrete	Grade	M50 or more, as per the Drawing	IS: 516
Bolts and eye bolts	Grade	See Table's Note 2	IS: 2062/JIS G 3101, JIS G3459, JIS B 1180, JIS B 1181

Note:

1) Steel plate grade shall be: (i) E250 B0 or SM400A/SS400;
   (ii) E250 B0 or SM400B;
   (iii) E250 C or SM400C;
   (iv) E350 B0 or SS490A/SM490B;
   (v) E350 C or SM490C.
2) Threaded rod = CAC304; eyebolt = SS400 or E250 B0; set bolts = SUS30A and Hole-filling bolt = Ordinary bolts.

2.1 Use of damper stoppers along with elastomeric/sliding bearings allow flexibility to choose the same size of piers and foundation system compared to conventional systems used in India i.e. without using additional seismic retainers, and also provide good aesthetic appearance to the viaduct/bridge and the size of the pier cap is also optimized. (Fig. 1)

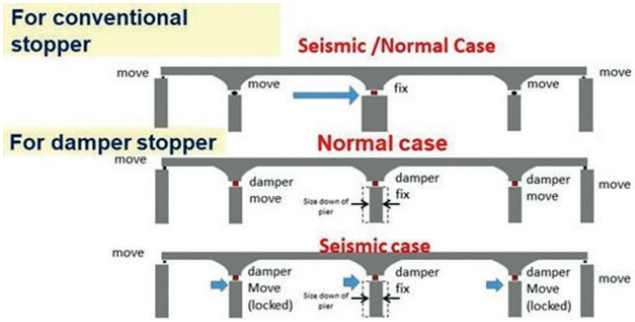


Fig. 1

2.2 Adoption of Damper Stopper for 4 span- Continuous Bridges in MAHSR

In design, separate stoppers are provided for PSC bridges alongside elastomeric bearings for small horizontal displacement restriction during service stage (due to shrinkage, creep, braking & tractive, LWR & thermal forces) and distribution of longitudinal forces among all the intermediate piers (all fixed) during earthquakes. This system aids in avoiding the design of single substructure/foundation as Fixed in Continuous bridges.

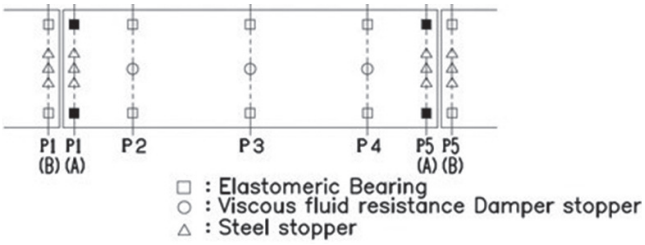


Fig. 2

For Intermediate piers of Balance Cantilever Bridges, "Viscous fluid resistance damper stopper" are adopted. Two types of Damper Stoppers have been used in MAHSR Project i.e., Fixed Damper Stopper and Movable Damper Stopper (Fig. 1). The main body of damper stopper uses square steel section, however the portion placed in substructure consists of outer and inner box and the gap between these boxes is filled with a viscous fluid. Over the outer and inner box, a sliding plate is placed. In addition to the above, fixed type damper stopper consists of spring leaves which acts under the service condition only (slow-moving loads). Under seismic conditions, the viscous fluid of fixed and movable damper stopper will act and take all the rapid loads (seismic forces). The general arrangement as per drawing is shown in Fig. 3 and the components of damper stoppers are shown in Fig. 4, 5, 6 & 7.

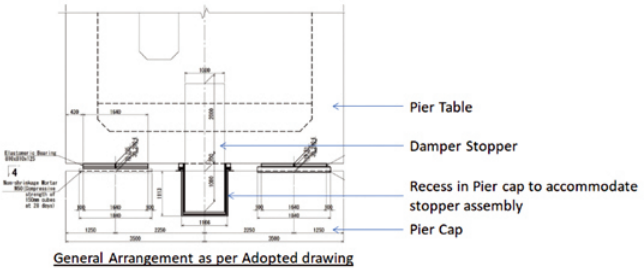


Fig. 3

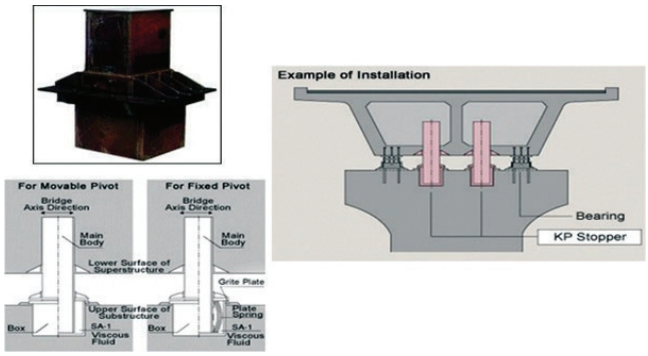


Fig. 4 Damper Stopper and its Components

3.0 Sailent Features of Damper Stopper Used in MAHSR

- Damper Stopper provide displacement restriction using the flow resistance of a viscous material.
- The damper stoppers also act as seismic restrainer in transverse direction.
- The viscous fluid of damper stopper (Asphalt Filler) is a high viscosity high polymer material with excellent performance of high flame resistance, high weather proof, and durability. It maintains stable resistance without deterioration of viscosity even after repetitive shearing.
- As a single structure, the damper stopper for movable type exerts not only an immovable support capability in direction perpendicular to the alignment but also a horizontal support capability in the rail direction. It does not bear any horizontal force (i.e. translation is allowed) in the case of expansion and contraction at a low deformation rate e.g. temperature or shrinkage by using the characteristics of special viscous fluid, but bears horizontal force in the case of earthquake (Shear thickening fluid).

3.1 Detailing of COMPONENTS OF DAMPER STOPPER

Main Components of Damper Stopper are:

a) Receiving Box-

i. Box A- It is fitted in the recess provided in Pier Cap.

ii. Box B- It is attached with main body.

Viscous fluid is filled in-between Box A and Box B.

b) Main body- It is embedded with Pier Table.

c) Viscous fluid/ Asphalt filler- It allows fix-move design.

d) Leaf Spring (in case of Fixed type Damper stopper only)- It caters horizontal forces other than Seismic forces.

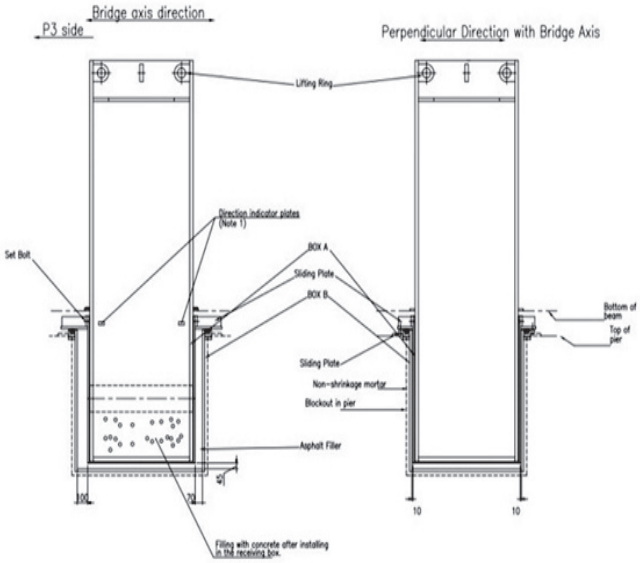


Fig. 5: Schematic drawing of Movable type Damper stopper

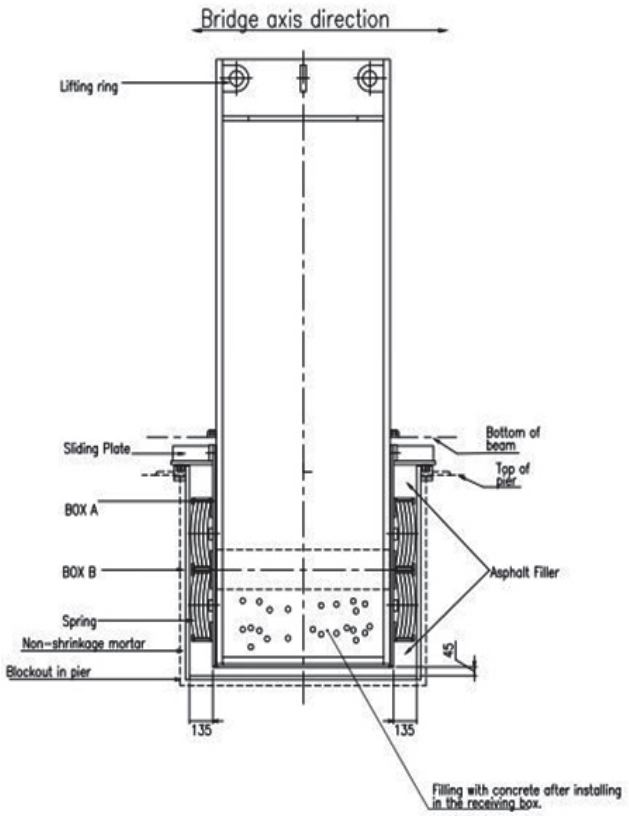


Fig. 6: Schematic drawing of Fixed type Damper stopper



Fig. 7 (From left to right): Main Body, Receiving Box, Viscous Fluid and leaf spring

4.0 Installation of Damper Stopper

Installation of Damper Stopper should ideally be done before construction of Pier Table and the same was planned as per original scheme in MAHSR project. But in unfavorable circumstances as happened in project, it was planned to install later on with the help of a cavity provisioned in pier table with the approval of Principal designer. Post Installation of damper stopper in MAHSR Package P-1(B) is done in assistance with JICA & JRE Experts.

4.1 Steps followed for installation of Damper Stopper:

STEP 1: Site Preparations & installation of top edge form work at pier head-

Taking proper measurements and levels of recess provided in pier cap and provide leveling course (if required) as per specifications. Place liner plates (packing plates) at corners.

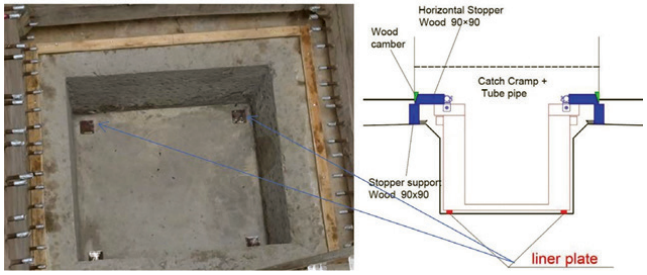


Fig. 8 Recess in Pier cap ready to lower Receiving box

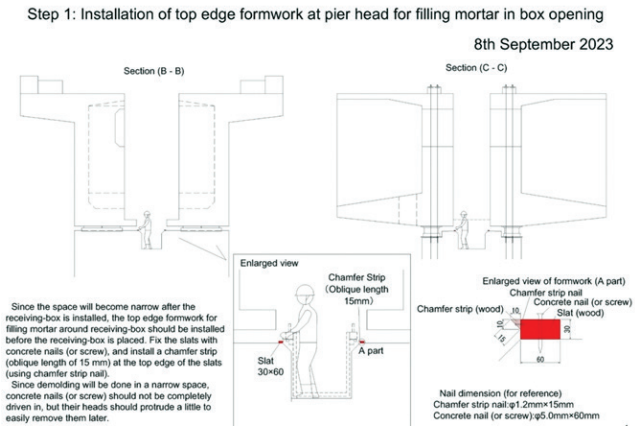


Fig. 9a Installation of top edge formwork at pier head for filling mortar in box opening

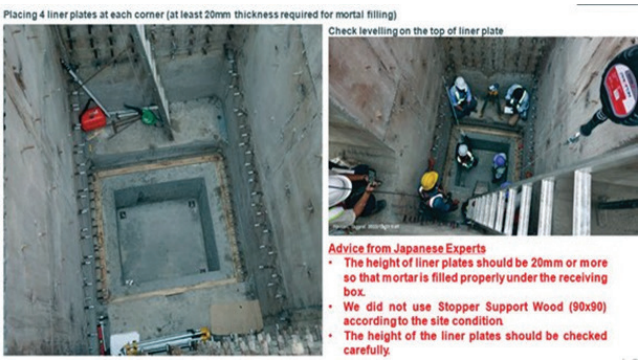


Fig. 9b: View after top edge formwork

STEP 2 : Installation of Receiving Box :- Before installing the receiving box, the height of the liner plate and levelness has to be verified and adjusted.

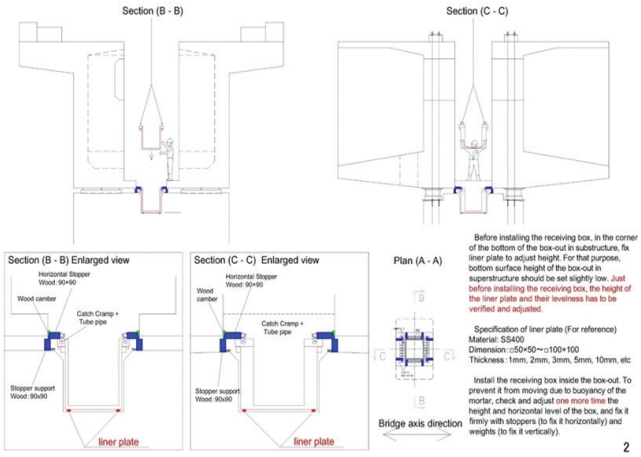


Fig. 10: Installation of Receiving Box



Fig. 11a Lifting of Receiving box after unpacking



Fig. 11 b: Various stages during installation of receiving box

After lowering of receiving box, it is required to be placed precisely and thereafter levelling & aligning the center with slightly lifting up as shown in Fig. 12. Before proceeding further, placement of catch clamp with tube pipe Fig. 13a and placement of wood stopper and wood wedge is done to avoid any possibility of floating or buoyancy due to non shrinkage mortar Fig. 13a & 13b.

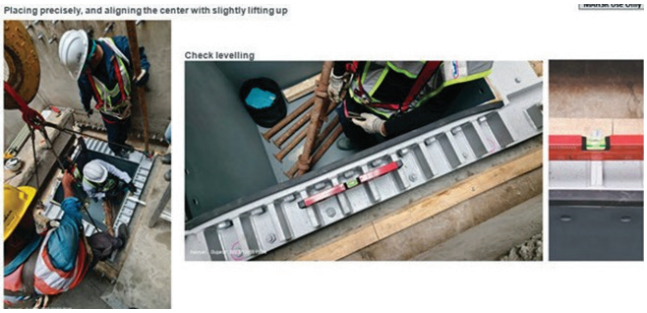


Fig. 12 Correcting alignment while placing receiving box.



Fig. 13a Placement of wood stopper and wood wedge



Fig. 13b Placement of wood stopper and wood wedge

STEP 3: Mortar filling in the gap around the receiving box 1/2 :- By inserting the grout hose into the gap, mortar may be filled until the bottom of the receiving box is covered. To avoid any buoyancy affect and as it is difficult to verify visually, approx. 1/3rd of the total requirement assessed should be filled in first go. Fig. 14.

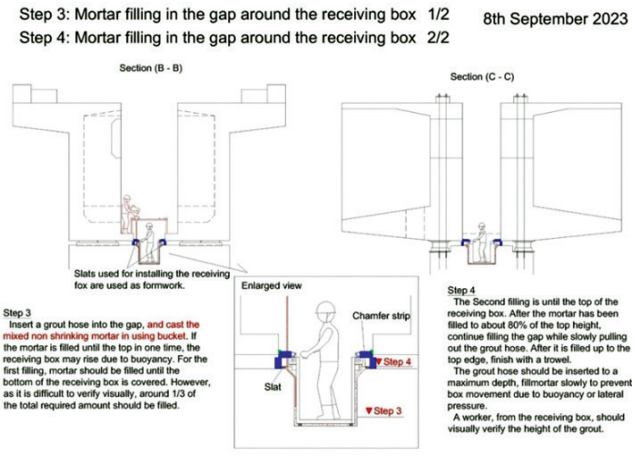


Fig. 14a

STEP 4: Mortar filling in the gap around the receiving box 2/2:- Filling should be continue in this step up to 80% of the top height. Filling may be continued further the grout hose should be pulled out slowly. Fig. 14.



Fig. 14b

To avoid buoyancy affect, it was planned to place the weight (about 300kg) in the receiving box before poring non-shrinkage mortar. First, the mix was with 4.3L of water for 1 bag, which is good for pouring. However, as there is the separation of mortar and water, segregated water should be removed for avoiding shrinkage. Don't leave water on surface before pouring the next mortar bucket. For the last, the mix was 4.0L of water for 1 bag.



Fig. 14c Mixing and pouring of non shrinkage mortar

STEP 5 : Removal of Temporary bolts: Temporary bolts are provided between Box A and Box B for assisting proper installation of receiving box (Fig. 15b). It is to be replaced with 'notch bolts' (Fig. 15c) which will break under the shrinkage stress after concreting.

STEP 6 : Demolding of the top edge formwork used for filling mortar- In view of space constraints after the lowering of the main body, the formwork and horizontal stopper is to be removed now (Fig. 15a).

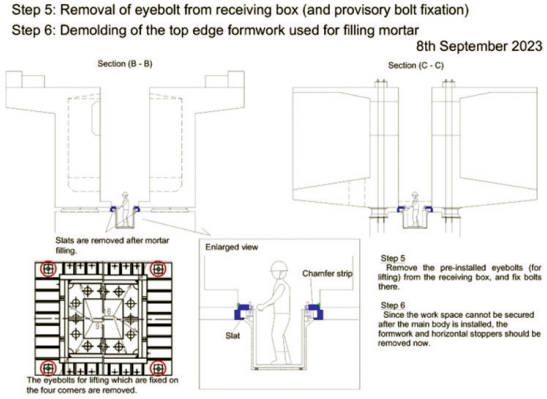


Fig. 15 a Demolding of the top edge formwork used for filling mortar

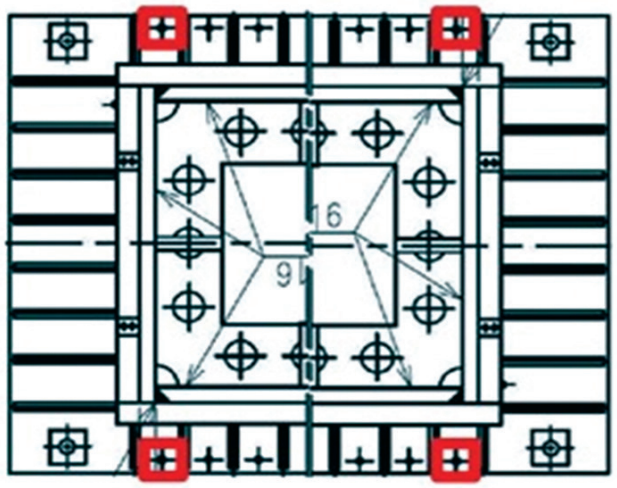


Fig. 15 b Temporary bolts shown with red colour



Fig. 15c Notch Bolt

STEP 7 : Bottom formwork assembly:- Bottom formwork is to be installed around the receiving box so that there is space for checking the resin filling around the main body and swap the temporary bolt. The plywood of bottom form work will be supported on the pier cap and the same will be sealed by suitable means to prevent leakage of the concrete from any gap at the bottom of the formwork (Fig. 16a & 16b).

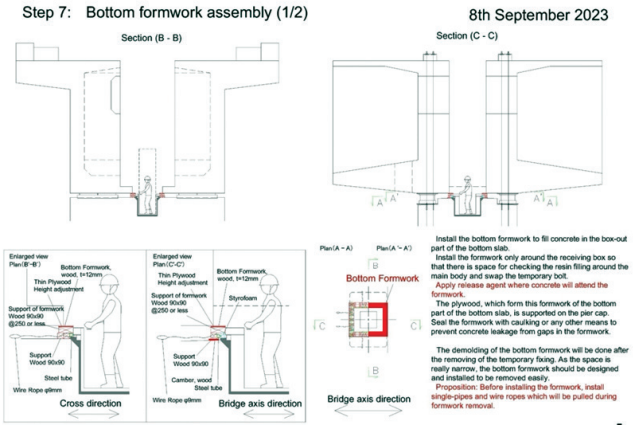


Fig. 16a Bottom Formwork before lowering of main body

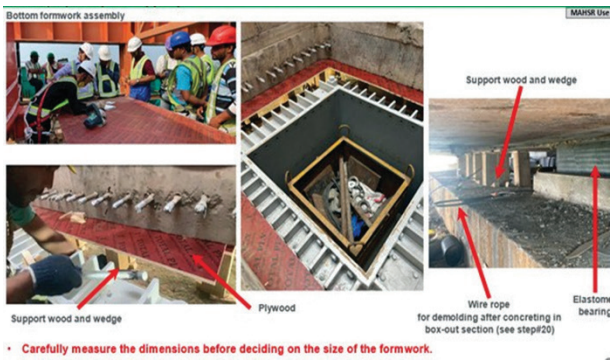


Fig. 16b Pics of bottom form work assembly

STEP 8: Installation of main body-

Align main body in proper direction, Lower the main body, check position and verticality, Install it in position and fix firmly (Fig. 17a & 17b). After lowering of main body and fixing it temporarily, its level will be checked with spirit level & verticality to be checked with plumb bob (Fig. 17c).

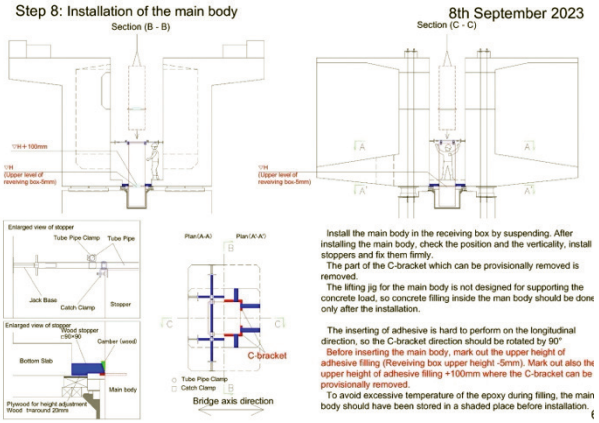


Fig. 17a Lowering of Damper body



Fig. 17b Pics of lowering of Damper body

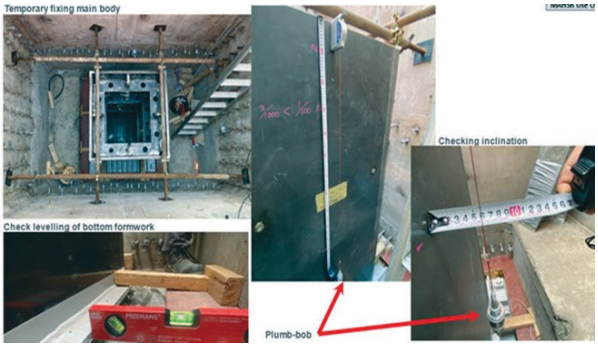


Fig. 17c Checking of level & verticality of main damper body

STEP 9 : Pouring of Adhesive (Epoxy Resin)-

- Specified adhesive to be poured up to specific height in the gap between main body and receiving box part B (~5mm) (Fig. 18).
- After filling Epoxy resin, shocks and vibration are to be avoided. i.e. no disturbance to be given for at least 2-4 days.
- While mixing of epoxy, the pot life of epoxy should be taken into account and quantity of each batch shouldn't be in excess to the quantity that can be poured within the pot life.
- 2 days curing time is given, keeping in view of ambient temperature about 30 degree Celsius.

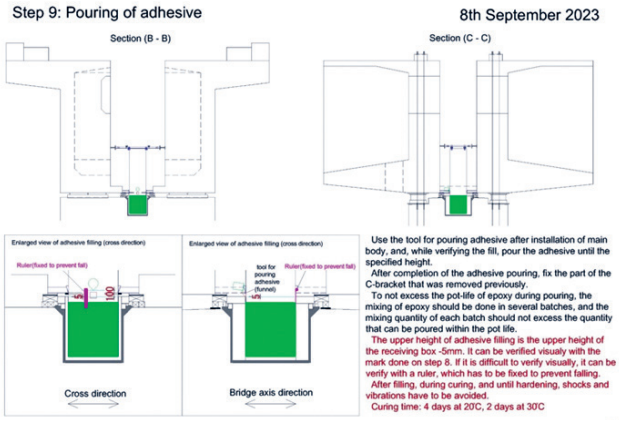


Fig. 18 Pouring of adhesive (Epoxy resin)

STEP 10 : Concrete filling inside Damper body-

Fill inside the main body with concrete of specified grade, M50 in MAHSR case (for adding stability) (Fig. 19).

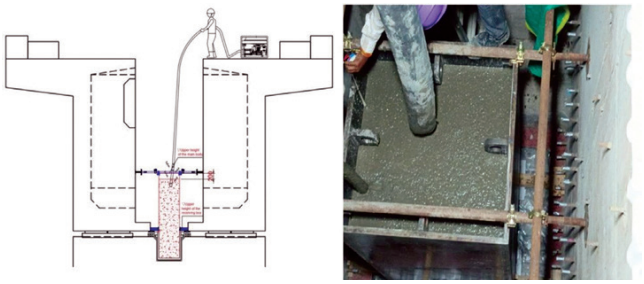


Fig. 19 Concrete filling inside Damper body

5.0 For post installation scheme, reinforcement is then installed around main body with the help of couplers and concreting to be done as per approved scheme. The view and elevation of one of the site (GAD 10 of MAHSR) (Fig. 20, 21) along with chronology of the activities (Fig. 23) are shown below through pics and figures for better understanding. The tools used for the whole process are also listed and shown in Fig. 22.

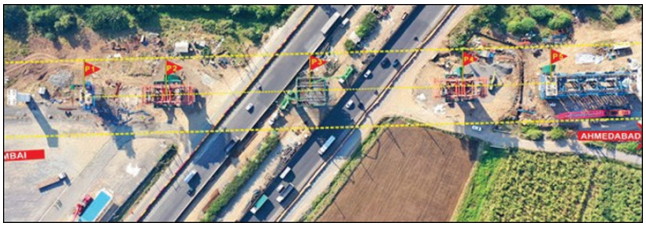


Fig. 20 View of balanced Cantilever site of GAD 10 (40+65+65+40)m crossing road over Delhi-Mumbai National Highway NH-48

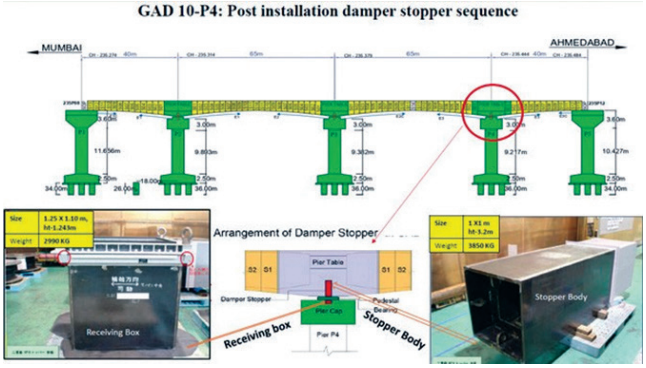


Fig. 21 Location of Damper Stopper in GAD, at P2 & P4 movable type and at P3 Fixed type of damper stoppers used

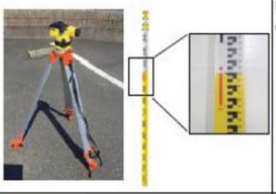
No.	Equipment name/photo	Overview/Applications
1	Levelling equipment set	[Measurement supplies]
		Equipment for measuring the height of concrete structures, stoppers, formwork, etc.
2	Measuring Tape	[Measurement supplies]
		For measuring dimensions of concrete structures, stoppers, formwork, etc.
3	Measuring Tape	[Measurement supplies]
		For measuring dimensions of concrete structures, stoppers, formwork, etc.
4	Plumb bob	[Measurement supplies]
		For measuring the verticality of stoppers
5	Level	[Measurement supplies]
		For measuring horizontality and verticality of stoppers, formwork, etc.
6	Perpendicular	[Measurement supplies]
		For checking right angle accuracy

Fig. 19

Sequence of activities at a glance during lowering of damper stopper at Pier P4 of GAD 10

Timeline for Damper Stopper Installation of lowering of one damper stopper at Pier P4 of GAD 10, based on the approved method statement is as follows (Table 2):-

Steps	Item/Days	1	2	3	4	5	6	7	8	9
1	Installation of top edge formwork at pier head for filling mortar in box opening									
2	Installation of receiving box									
3	Mortar filling in the gap around the receiving box 1/2 & Curing									
4	Mortar filling in the gap around the receiving box 2/2 & Curing									
5	Removal of eyebolt from receiving box (and provisory bolt fixation)									
6	Demoulding of the top edge formwork used for filling mortar									
7	Bottom formwork assembly (1/2)									
8	Installation of the main body									
9	Pouring of adhesive									

Materials & Equipment's used (Fig. 22)

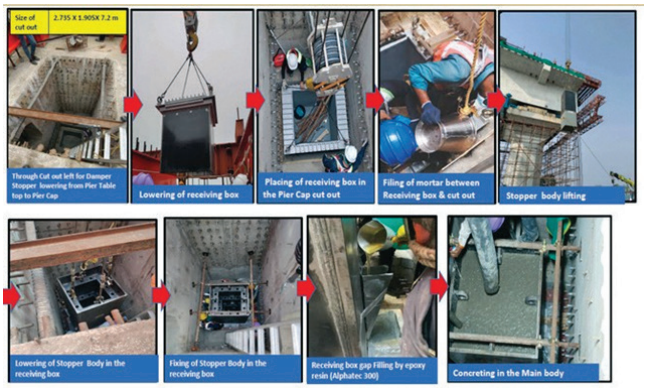


Fig. 23:

6.0 CONCLUSION

Bearing and stopper arrangement are judiciously chosen by design experts of MAHSR that will optimize the design requirement of substructure as well as provide long term durability to the system. Provision of Damper stopper allows a long multi-span continuous girders that can be constructed in seismic zones without using additional seismic retainers, and also provide good aesthetic appearance to the viaduct/bridge. Apart from steel structures (simply supported/continuous), the long multi-span continuous girders are convenient arrangement to cross National Highways for high-speed viaduct.

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Case Study on the Use of TTHSB Bolts in Mumbai-Ahmedabad High Speed Rail Project

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ABSTRACT

Mumbai Ahmedabad High-Speed Rail (MAHSR) project is one of the most ambitious rail project taken up by GOI. It is aimed to provide better connectivity between two major cities of western India with 12 stops in between. High speed rail is planned to cater the upcoming requirement of economic and population boom in the region. The project is being implemented with the technological help of Japan and is having approximately 92% elevated structure and remaining 8% as tunnel or on-grade. To withstand such tremendous loads of a train moving at staggering speed of 320 kmph, large steel girder spans were adopted at the crossings. The span of these steel girders are ranging between 60 m to 130 m for single span and average weight is 11-15 MT per meter length. Steel bridges were used in form of open web girders (OWG) and fabricated in different parts on India in RDSO approved workshops. The girders were transported to the site location in parts and assembled using TTHSB (Tor shear type high strength bolt) in connections. Case study is being conducted for the use of TTHSB bolts in 100m span Open Web Through Gider known as GAD 31.

1. Introduction

The whole project has been divided into various packages based on the type of structure and length of the stretch. The MAHSR alignment is crossing the existing railway lines and National highways at few locations. Such crossings have been designed as special bridges. A total 5 nos. of special bridges were located between Ahmedabad to Vadodara, and these were awarded as a separate package under the title P1C. The details of the bridges are as follow.

Table 1: List of Bridges in Package P1C

S. No	GAD No.	Type of Crossing	Span Configuration
			Girder Type
1	1967	Mumbai-Delhi Expressway NE-4	100 + 130 STEEL TRUSS
2	28	Railway	60 STEEL TRUSS
3	31	Railway	100 STEEL TRUSS
4	32	NH 48	100+100 STEEL TRUSS
5	33	NH 48	40+65+65+40 PSC

This case study covers the details i.e. materials used in manufacturing, mechanical properties, installation process, advantages etc. about TTHSB and the usage of same in MAHSR project.

2 TTHSB S10T Fasteners

TTHSB (Tor shear type high strength bolt), are a type of high-grade bolt that can be preloaded by a tightening process that is carried out entirely at the threaded end (i.e. at the nut or spline end) of the bolt. Consequently, TTHSB's are usually distinguished by their round heads (rather than hexagonal heads) and splines. TTHSB Grade S10T fasteners are high-strength (10.9), high-ductility (14%) friction grip bolts for use in structural steelwork connections. Their primary advantage (over other types of friction grip bolt) is the ease of preloading the bolts.

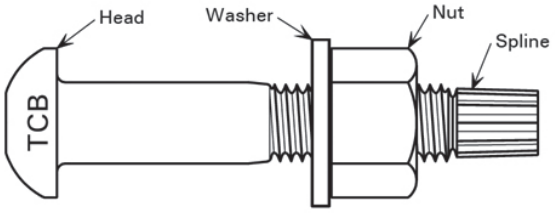


Fig. 1 TTHSB fastener assembly

The fastener assembly is illustrated in Figure (1), Preloading is carried out by an electrical shear wrench at the threaded end of the bolt i.e., the nut or spline end. At the other end, the head of a TTHSB, Grade S10T is round compared to a hexagonal head for normal bolts, making a TTHSB quite distinctive in appearance

3 Design Basis for Connecitons Using TTHSB

Most bolted connections transfer load 'in shear', i.e. the bolt axes are normal to the direction of the load to be transferred. A key choice facing the designer is whether the connection will allow or prevent slip between the joined components.

In a non-preloaded bolt configuration, the applied force is transferred through shear within the bolt shank and through bearing between the bolt shank and the connected layers. For this mechanism to function effectively, there must be relative slippage between the connected layers, as depicted in Figure (2). The benefits of non-preloaded bolting include the requirement for only minimal tightening of the bolts and the absence of a need to mask the faying surfaces (the interfaces) during painting. However, there are scenarios where such slippage is deemed unacceptable.

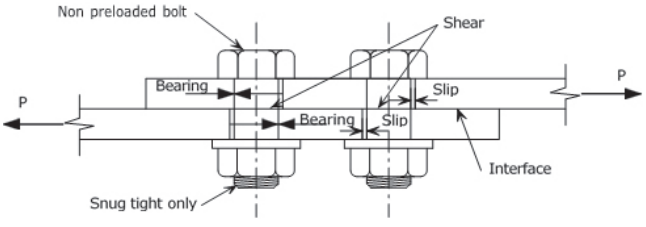


Fig. 2 Non Preloaded bolt arrangement

Preloaded bolted joints, commonly referred to as friction grip joints, transfer force in a distinct manner. The load is transmitted

through frictional resistance between the contact surfaces of the connected layers, as demonstrated in Figure (3) for a joint using TTHSBs. This contact surface is termed as an interface or faying surface. The frictional resistance is established by subjecting the bolt to significant tension during preloading, effectively clamping the layers together in compression.

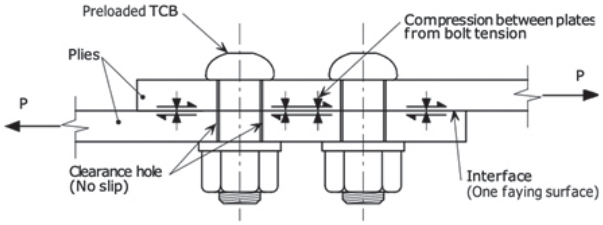


Fig. 3 Preloaded bolt connection

4 Quality Control for Bolts, Nuts and Washers

The TTHSB bolts were being used only second time (first being used in MTHL project) in the country and therefore quality control for the same was quite a challenge. Manufacturing of Tension control bolts is not being done regularly in country. Following criteria were followed in selecting the manufacturer, raw materials and finished products.

Sr. No.	Description	Characteristics	Frequency	Acceptance Criteria	Reference Document
1	Raw Material	Chemical Composition	Each size / lot	**Bolt :** C 0.25-0.55, S 0.025 Max., P 0.025 Max. **Nut :** C 0.58 Max, Mn 0.30 Min. P 0.048 Max, S 0.058 Max. **Washer :** C0.4-0.5, Mn 0.60-0.90, Si 0.05-0.35, S 0.040 Max, P 0.040 Max.	As per EN ISO:898-1
2	Mechanical Properties	**For Bolt** 1.Spectro Analysis 2. Tensile strength 3. Yield Strength 4. Elongation 5. Reduction of Area 6. Hardness 7. Decarburization Check 8. Surface Integrity **For Nut** 1. Spectro Analysis 2. Hardness 3. Proof Load **For Washer** 1. Spectro Analysis 2. Hardness	Each size / lot	TC Bolt As per BS EN 14399-10 & EN ISO:898-1 Chamfered Washer As per EN 14399-6	

Fig. 4 Inspection Test Plan for TTHSB

Grade of Bolt	Minimum Tensile (breaking) load (kN)							Hardness
	Nominal size of thread							
	M 12	M 16	M 20	M 22	M 24	M 27	M 30	
S10T	85	157	245	303	353	459	561	H_RC 27-38

Fig. 5 Minimum breaking loads for full size TCBs Grade S10T

5 Installation and Preloading

The preliminary test for axial tension forces was carried out for five bolt sets, sampled at random from each production lot to be used in a day. The average axial tension forces for tightening shall conform to Table Below-

Nominal diameter	Bolt Temp (10 C to 30 C)	Other Temp (0-10, 30-50 C)	Std Deviation of Axial force
M20	172-202	167-211	9.5 or less
M22	212-249	207-261	11.5 or less
M24	247-290	241-304	13.5 or less

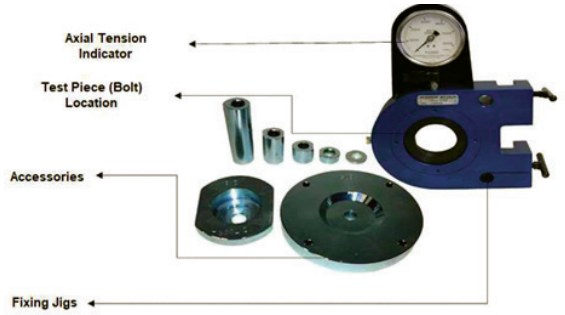


Fig. 6 TTHSB Axial tension testing device

This device is used at site to check the axial tension forces in the samples. The device can be mounted in any suitable beam at site and samples are taken from the lot and different sizes which are to be used on that day in field.



Fig. 7 Test setup at site to conduct preliminary test

It is ensured that the connection is properly fitted and assembled and in addition, all the bolts in the joint are snug tight prior to commencing of preloading.

1. Slide the inner socket over the bolt spline and the outer socket over the nut As shown in figure (8). Switch on the electric power supply to the wrench. The wrench applies a torque to the nut, via the outer socket, and reacts against the spline, via the inner socket. The nut rotates, while the bolt does not turn. When the torque reaches a sufficiently high level the spline shears off at the break neck (or grove).

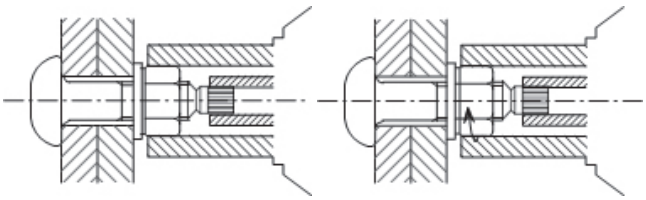


Fig. 8 Placing of Torque machine and Rotation of Torque wrench

2. When the spline has sheared off pull back on the wrench until the outer socket is no longer engaging the nut. The bolt spline is retained by the inner socket and can be discarded by engaging the small trigger on the wrench handle. To inspect the bolt – after tightening or in the future – merely check that the spline has been sheared off.

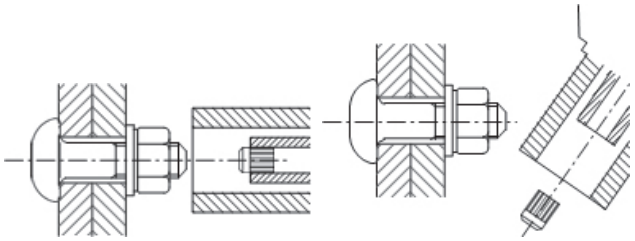
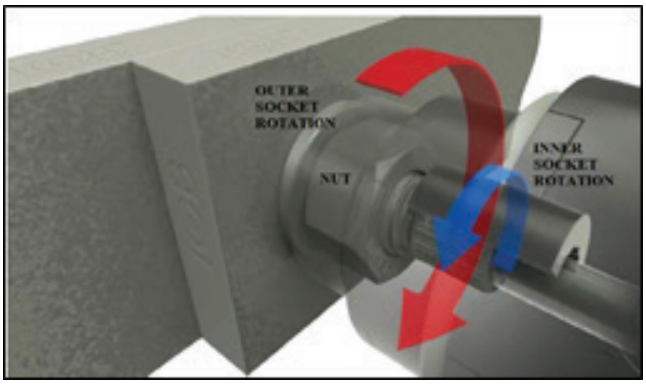


Fig. 9 Breaking of Spline and discarding of spline



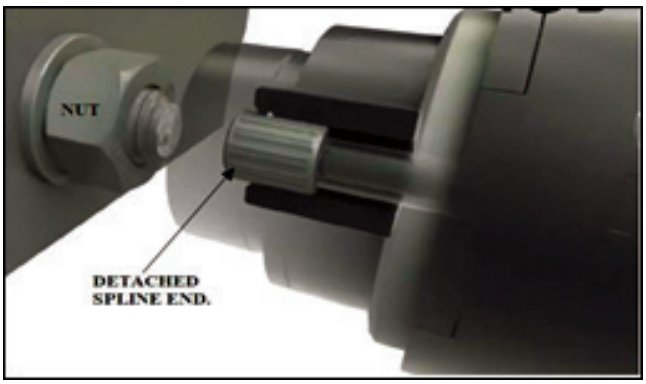


Fig. 10 Internal Mechanism of Wrench



Fig. 11 Actual Site photographs

6 Layout of Installation and Marking on Bolts

The bolts need to be tightened in a certain sequence on the girder to minimize secondary induced stresses on the assembly. Generally, the sequence followed is middle to outer, connections lying on the middle nodes are tightened first and the adjoining node connections on the both sides of middle node are tightened thereafter. The method is followed till the end node of girders is tightened. Same sequential method is followed while tightening in each splice plates, where middle bolts are tightened first. Figure (12) and (13) depict the sequential tightening.

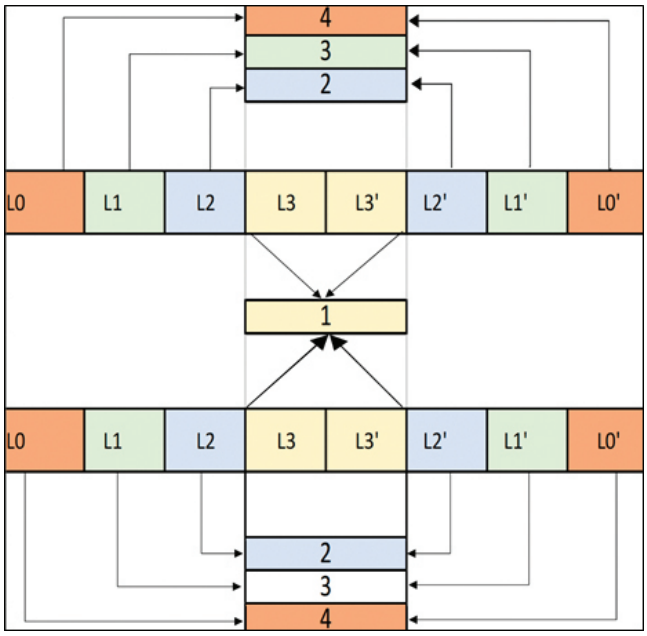


Fig. 12 Sequence of Tightening in Girder

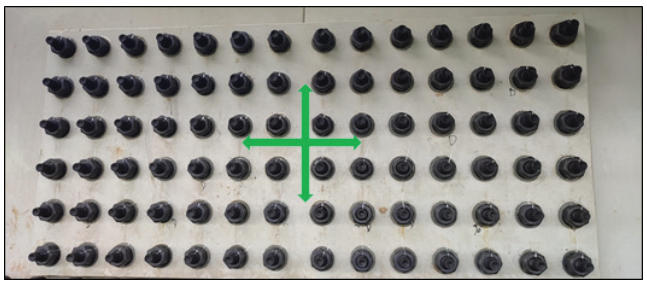


Fig. 13 Sequence of Tightening in Each Splice plate

After the 1st stage of tightening (Snug tight) the bolts are marked by a straight line passing through washer, nut and bolt using white marker. This line is used to determine the proper tightening of bolts after the 2nd stage of tightening.

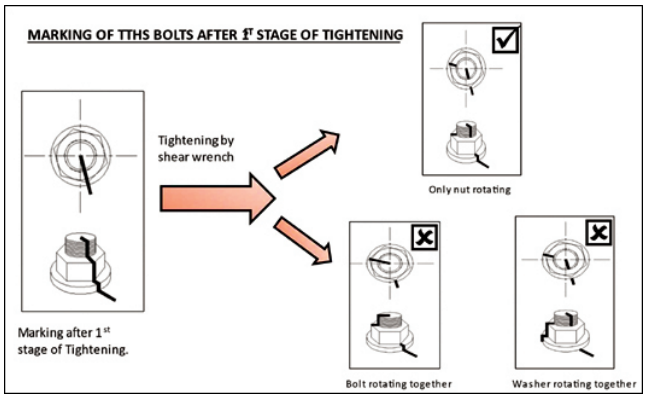


Fig. 14 Diagram showing the proper marking and rotation of bolts

As shown in above figure, the marked bolts are tightened using power-wrench. The ideal result after tightening is rotation of nuts only. Rotation of bolts or washer from its original position is not preferable as it depicts improper or inadequate tightening of TTHSB. Following measures shall be taken to ensure the TTHSB tightening in correct and appropriate manner.

- All the surfaces should be cleaned properly before commencement of final tightening.
- Washer must be installed correctly and proper contact area between washer and plate surface must be ensured.
- Sequence of tightening should be strictly followed in each splice plate.
- Tightening operation should be avoided in rainy weather and if at all necessary, proper shade must be installed to cover complete area of operation during rain.

Slipping of TTHSB should be avoided in all the cases as slipped TTHSB will not take full design load in its service period.

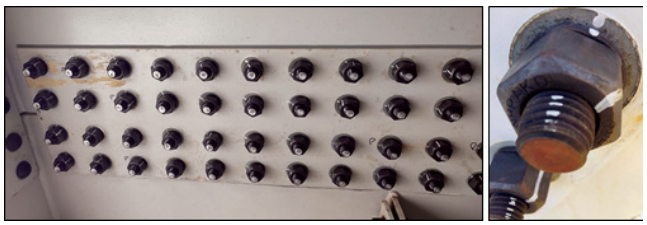


Fig. 15 Correct tightening of TTHSB

7 Conclusion

In nutshell, the TTHSB (Tor Shear type high-strength bolt) stands out as a superior fastening solution in various applications. Due to the heavy preload, the tension across the structure is evenly distributed, and there is no bolt relaxation because no torsional shear is induced during tightening. Its design offers unparalleled ease of use, simplifies installation process and reduces the likelihood of errors. TTHSB provides simple visual inspection for Quality Control as once the spline (pin tail) has sheared off, the correct tension has been achieved which can be checked through a quick visual inspection. It imparts consistent reliable friction grip strength in connections in compare to other preloaded bolts which provides prolonged durability and reliability in service period and makes it cost efficient choice as TTHSB only requires one person for installation with prebuilt functionalities to determine the tensioning required to hold the structure together which reduces installation cost. Further, these bolts are preloaded and involve light weight installation tools decreasing worker fatigue and ensuring no risk of HAVS (hand-arm vibration syndrome).

References:

1. JSS II 09-2015, sets of tor-shear type high strength bolt, hexagon nut and plain washer for structural joints.
2. DIN EN 14399-10, High-strength structural bolting assemblies in preloading.
3. INTERNATIONAL STANDARD ISO 898-01, Mechanical properties of fasteners made of carbon steel and alloy steel.
4. EN 14399-06, High-strength structural bolting assemblies for preloading - Part 6: Plain chamfered washers.

Disclaimer:

The following case study is provided for educational and informational purposes only. The views, opinions, and analyses presented in this case study are solely those of the author(s) and/or the organization(s) involved. Any resemblance to actual persons, organizations, situations, or events is purely coincidental. The information contained in this case study is based on the data available at the time of its creation and may not reflect the current status of the subject matter.

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COLABA STATION 1920

Analysing the Strength of Existing Catch Siding for Higher Axle Loads

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ABSTRACT

It is a siding taking off from main line with points normally set for it and of suitable length provided with devices such as rising variable grades and sand drags to fully absorb the velocity head attained by an inefficiently controlled train or part of train being pulled up therein without being wrecked. It is essentially a gravity catch siding. This paper describes about numerical method for checking adequacy of existing catch siding. and design of new catch siding. And also Input Data to design of catch siding for (WDM2 + BOXNM1) along with Loco and Wagon details are furnished. Calculation for work done by train against gravity are detailed. Variations in kinetic and static heads for different parameter are depicted. Variation of exit velocity and velocity head with entry grade are studied. Variation of velocity head (to be destroyed) with entry velocity is reviewed. Variation of static head resistance with Ratio for (length of sanded track (SL) to Entry velocity-(Vh) are examined. Design details for Kinetic energy due to Electrical and Disel locos (With 58 Wagons) are developed. Factor of safety of existing catch siding profile for Diesel and electrical locos-(with 58 BOXNM1 Wagons) are determined for the existing catch siding. The magnitude of Potential energy (work done on existing catch siding for passing diesel/electrical locos with 58 BOXNM1 Wagons arrive for assessing the strength of existing catch siding.

1. Introduction

Catch sidings are essential safety sidings which may be provided under the following circumstances. On long steep grades between stations where curves are designed for lower speed than may be conceivably be attained by the train or part of the train which for one cause for another cause may have got out of control, then it is necessary to protect a station from uncontrolled trains or part of trains liable to enter it. For arresting the train which is out of control when approaching station down under control, as per railway board order dated,09-05-68 circulated under letter no 62/WDO/SD/38, provision of catch siding shall be limited to grades steeper than 1 in 80 only.

The components of catch siding are dead end, sand hump, loop line from running track, entry point, exit point, entry gradient/level tracks ,sanded track and buffer ends, etc Various components of catch siding with wagons/locos are shown in the Fig.1, Fig.2, Fig.3 and Fig.5. The Fig.4 shows the various calculation parameters which are center of gravity of wagons / engines (h1&h2) at different entry points/exit points at varying level/gradients. These parameters are used for arriving static head generated by passing the locos/wagons on the existing catch siding profile.

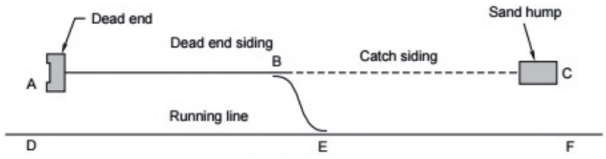


Fig.1.a. Typical Catch Siding Components



Fig.1.b. Typical Catch Siding



Fig. 2 a) Trap Points and Main Lines



Fig. 2 b) Trap Points and Main Lines

2. Input Data to design of catch siding for (WDM2 + BOXNM1).

Table 1 Locos and Wagons details

Sl. No	Description of items	WDM2	BOXNM1 (CC+6+2t)
1	No.of Wagons /Engines	3	58
2	Weight of Axle for Engine / Wagon	18.8 t	22.32 t
3	Length of Engine / Wagon	17.13 m	10.713m
4	Weight of loaded BOXNM1 /WDM2	6 x 18.8 =112.8 t	4 x 22.32 =89.28t
5	Total length of loaded BOXNM1 / WDM2	3 X17.13 =51.36 m	58x10.713 =621.354m
6	Total Weight of loaded BOXNM1/WDM2	3 x 112.8 =338.4 t	58x89.28 =5178.24 t

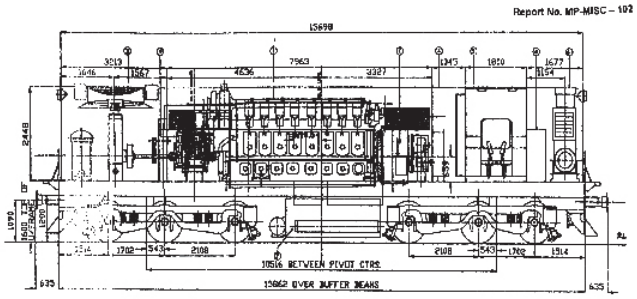


Fig. 3.a Engine Diagram of WDM2.



Fig. 3.b WDM2 Engine

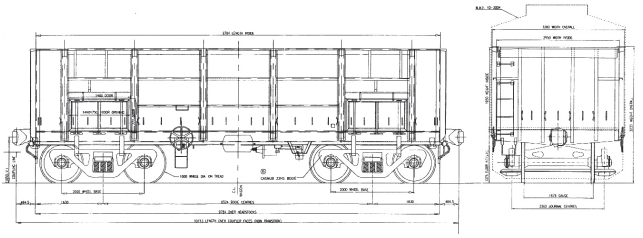


Fig. 3. c Model Wagon Diagram of -BOXNM1-(CC+6+2t).



3. d BOXNM1 Wagon (CC+6+2t)

The composition of engine and wagons are shown in the Fig. 6 of Annexure-A. The profile of catch siding for the composition of 3WDM2 + 58BOXNM1 wagon is indicated in the Fig. 7 of Annexure-A.

3.0 EXISTING CATCH SIDING (Energy Method)

Checking adequacy of existing catch siding each engine / wagon wise)

Existing grade = 1 in 260.
Approach grade 1 in 70
Entry grade = 1 in 70.
Total weight of train is ∑(P) = 5178.24 t
Speed of parted train (assumed) is = 50 Kmph
Speed at entry is = 13.88889 m/sec

3.1 Design of catch siding

The kinetic energy of train while entering the catch siding is to be balanced by the following

i.) Gravity head, ii.) Track resistance and iii.) Resistance due to sand drag

The kinetic energy	$1/2\times m\times v^2$ =54238.87
Track resistance for BG. Average track resistance for BG(track) =	1.5%.
G of train from A(front end of engine) Formation of parted train on entry of catch siding (3WDM2 + 58BOXNM1) is shown in the Fig.5.a- (Annexure-A). Formation of parted train on entry of catch siding and on catch siding with (3WDM2+58BOXNM1) is shown in the Fig. 5.b- (Annexure-A).	
Centroid distance of each engine / wagon from the trailing end of train formation =	Y
Centroid distance of each engine from the trailing end of train = Y_E, m= (51.396 X 0.5+621.354) =	647.052
Centroid distance of (58 BOXN wagons) engine from the trailing end of train = Y_{BOXN} = 621.354 X 0.5 m.	310.677
Total weight of Engines (P_E), t =	338.4
Total weight of Wagon (P_{BOXNM1}), t =	5178.24
$\sum (P\times Y) = [(P_E\times Y_E)+(P_{BOXN}\times Y_{BOXN})]=$	1683562
Total weight of train is ∑(P) =	5516.64 t
C.G ofloads $=\frac{\sum(P\times Y)}{(\sum(P)}=\frac{1827722}{5516.64}=$ 331.311 m	
Length of catch siding =	690 m
Distance traversed by C G along catch siding	358.689 m
Track resistance % =	1.5
Track resistance, a $=\frac{(358.689\times5516.64\times1.5)}{100}=$	29681.4
Sand track resistance =	4.05%
Length of sand hump =	50 m
Length of sand track, =	585 m
Existing length of sand track, =	595 m
Case 1 Net length of sand track (585-338.311) =	253.689 m
Case 2 Net length of sand track = (595-338.311)	263.689 m
Sand track resistance, b $=\frac{(253.689\times5516.64\times4.05)}{100}$	56680.23 tm

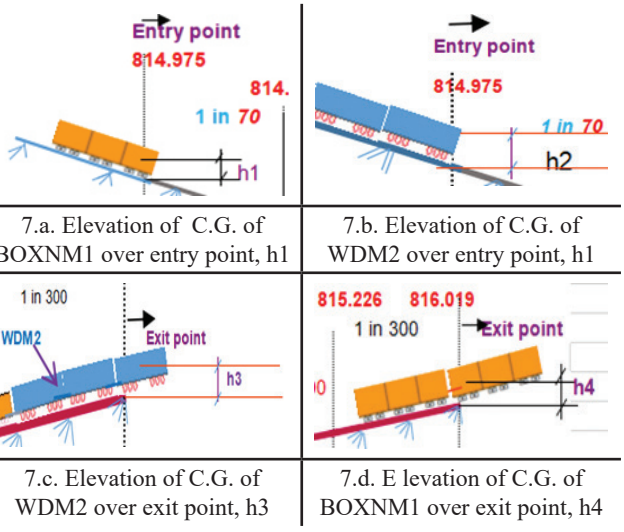
Gravity head for =	690 m
Rail level at the entry of catch siding (existing) =	814.975 m
Rail level at the end of catch siding (existing) =	816.020 m

3.2 Calculation of work done by train against gravity

The detailed calculations are explained below in various steps for the various values indicated in red under the particular column and row numbers. All the values are given below in the Table 2. The Fig. 4 shows the elevations of C.G of engine/ wagons at the entry/exit of catch siding for arriving the gravity head to be negotiated by the train compositions.

Table 2 Energy calculations data and details

Sl. no	Unit	Rail level at the centre of each unit while the first engine enters catch siding, m	Rail level at the centre of each unit while the engine exits catch siding, m	Difference in levels (dl), m D-C	Chainage of each unit from first engine front, m
A	B	C	D	E	F
1	E1	815.097	815.990	0.893	8.566
2	E2	815.342	815.933	0.592	25.698
3	E3	815.586	815.876	0.290	42.830
4	B1	815.785	815.830	0.045	56.753
5	B2	815.938	815.794	-0.144	67.466
6	B3	816.091	815.759	-0.333	78.179
7	B4	816.244	815.723	-0.521	88.892
8	B5	816.397	815.687	-0.710	99.605
9	B6	816.550	815.651	-0.899	110.318
10	B7	816.703	815.616	-1.088	121.031
11	B8	816.856	815.580	-1.276	131.744
12	B9	817.009	815.544	-1.465	142.457
13	B10	817.162	815.509	-1.654	153.170
14	B11	817.316	815.473	-1.843	163.883
15	B12	817.469	815.437	-2.031	174.596
16	B13	817.622	815.401	-2.220	185.309
17	B14	817.775	815.366	-2.409	196.022
18	B15	817.928	815.330	-2.598	206.735
19	B16	818.081	815.294	-2.786	217.448
20	B17	818.234	815.259	-2.975	228.161
21	B18	818.387	815.223	-3.164	238.874
22	B19	818.540	815.187	-3.353	249.587
23	B20	818.693	815.151	-3.541	260.300
24	B21	818.846	815.116	-3.730	271.013
25	B22	818.999	815.080	-3.919	281.726
26	B23	819.152	815.044	-4.108	292.439
27	B24	819.305	815.009	-4.296	303.162
28	B25	819.458	814.973	-4.485	313.865
29	B26	819.611	814.937	-4.674	324.578
30	B27	819.764	814.919	-4.845	335.291
31	B28	819.917	814.919	-4.998	346.004
32	B29	820.070	814.919	-5.151	356.717
33	B30	820.223	814.919	-5.304	367.430
34	B31	820.376	814.919	-5.457	378.143
35	B32	820.529	814.919	-5.610	388.856
36	B33	820.682	814.919	-5.763	399.569
37	B34	820.835	814.919	-5.916	410.282
38	B35	820.988	814.901	-6.087	420.995
39	B36	821.141	814.866	-6.275	431.708
40	B37	821.294	814.830	-6.464	442.421
41	B38	821.447	814.794	-6.653	453.134
42	B39	821.600	814.759	-6.842	463.847
43	B40	821.753	814.723	-7.030	474.560
44	B41	821.906	814.687	-7.219	485.273
45	B42	822.059	814.652	-7.408	495.986
46	B43	822.212	814.616	-7.597	506.699
47	B44	822.365	814.580	-7.785	517.412
48	B45	822.518	814.544	-7.974	528.125
49	B46	822.671	814.509	-8.163	538.838
50	B47	822.824	814.473	-8.352	549.551
51	B48	822.978	814.437	-8.540	560.264
52	B49	823.131	814.402	-8.729	570.977
53	B50	823.284	814.366	-8.918	581.690
54	B51	823.437	814.330	-9.106	592.403
55	B52	823.590	814.294	-9.295	603.116
56	B53	823.743	814.259	-9.484	613.829
57	B54	823.896	814.223	-9.673	624.542
58	B55	824.049	814.187	-9.861	635.255
59	B56	824.202	814.340	-9.861	645.968
60	B57	824.355	814.493	-9.861	656.681
61	B58	824.508	814.646	-9.861	667.394



7.a. Elevation of C.G. of BOXNM1 over entry point, h1

7.b. Elevation of C.G. of WDM2 over entry point, h1

7.c. Elevation of C.G. of WDM2 over exit point, h3

7.d. E levation of C.G. of BOXNM1 over exit point, h4

Fig. 4 The values of h1,h2,h3 and h4

5.2.a. At entry of catch siding
Height of C.G of BOXNM1 wagon when enters siding, h1 = 10.713*0.5/70.007
Height of C.G of WDM2 Engine when enters siding, h 2 = 17.132*0.5/70.000
At exit of catch siding
Height of C.G of WDM2 Engine when exits siding, h3 = 17.132*0.5/300
5.2.b. Under column "C" from Sl. No 1 to 5
814.975 + h2 = 815.097
814.975 + h2 X 3 = 815.342
814.975 + h2 X 5 = 815.586
814.975+h1+h2 x 2x3 = 815.785
5.2.c. Under Column "C" from Sl. No 6 to 61
815.785+2h1 = 815.938
5.2.d. Under Column "D" from Sl. No 1 to 5
816.099-h3 = 815.990
815.990-2xh3 = 815.933
815.933-2 x h3 = 815.876
814.975+h1-h3-h4 = 815.830
815.83-2xh4 = 815.794
5.2.e.Under Column "F" from Sl. No 1 to 6
17.13 x 0.5 = 8.560
8.56+17.13 = 25.680
25.69+17.13 = 42.800
42.8+17.13 x 0.5+10.713x 0.5 = 56.716
56.716+10.713 = 67.429
5.2.f. Under Column "D" from Sl. No 6 to 28
815.794-2h4 = 815.759
5.2.g. Under Column "D" from Sl. No 29 to 37
814.973-2h4 = 814.937
814.937-h4 = 814.919
814.919-0.00 = 814.919
5.2.h. Under Column "D" from Sl. No 38 to 58
814.919-h4 = 814.901
814.901-2 x h4 = 814.865
5.2.k. under column "D" from sl. no 59 to 61
814.187+2 x h1 = 814.340
814.340+2 xh1= 814.493
814.493+2 x h1 =814.646

3.3 Work done by train against gravity

Total difference in levels (dl) of three Engines $\sum H_1$, =	1.775 m
Total difference in levels (dl) of 58 BOXNM1 wagons $\sum H_2$ =,	-300.26 m
Total weight of 3 WDM2 engines (W1), =	338.40 tons
Total weight of 58 BOXNM1 wagons (W2) =	5178.24 tons
Work done due to gravity head (Engine + BOXNM1)	-27007.1931 ton- m
Sum of (W1 X H1 + Sum of W2 X H2), c, =	
Total work done = (a. Work done due to track resistance + b. Sand drag resistance + c. Gravity resistance) = (a+b+c)	
(29681.4 + 56680.2 + 27007.2)=	113368.813,t
Factor of safety, = 113368.8/54238.9=	2.0902>1,safe
Adopting the suitable length of sanded track decides the strength of catch siding.	

4. Catch Siding (RDSO METHOD) considering, (3WDM2 + 58BOXNM1 Wagons) **(Refer, Fig. 5, Fig.6 and Fig.7 of (Annexure-A.)**	
Datas:	
1. Continuous long approach grade =	1 in 260
2. Length of train, = 3×17.132+58×10.713=	672.750 m
3. Weight of train, = 58×89.28+3×112.8=	5516.64 t

4.1 Calculation of Centre of Gravity of train from Front end.	
Load intensity of engine WDM2 / m 112.8/17.132 =	6.584 t/m
Load intensity of BOXNM1 /m ((4×22.32))/10.713=	8.333 t/m
Length of loaded BOXNM1, =	10.713 m
Taking moments about A (front end of first engine)	
L×5516.64={58×89.28 × (58X10.713X0.5+3*17.132) + (3×112.8×(3X17.132X0.5))}	
L=1883597/5516.64=	341.439m
Hence Centre of Gravity of train From front end of first engine,	341.439 m
4.2 Velocity of runway train Clause 6.13 of Catch Siding calculations Page 22 (2nd Para of IRICEN – Booklet)	
(1/260×5734)=15.36+0.009×V^2,	
Where V is in Kilometers per hour,V=	27.27198 K mph
Velocity Head of train = V^2/235=	27.27198^2/235= 3.165 m
Assuming natural velocity =	50 Kmph
Velocity head of train =	50^2/235=10.6383m
Head of C.G of train 814.92-814.19=	0.73 m
Velocity head to be absorbed / destroyed = 10.63829+0.73=	11.3716 m

This velocity head is to be destroyed by i) Track resistance (to be taken as 1.5%) ii) Gravity head due to climbing of train as continuously upgraded catch siding iii) Resistance due to sand drag, IV). Curve resistance (neglected).

5.1 Absorption of Velocity head to be resisted by track resistance.	
Length of Catch siding from vortex =	635 m
Distance traveled by train lead system	
From Vortex = 635+55-341.439=	348.561 m
Work done in overcoming track resistance at 1.5% (1.5×348.561×5516.64)/100=	28843.26 tm
5.2 Loss of Velocity head due to track resistance	
Loss of Velocity head due to track resistance =	28843.268/5516.64=5.228 m
Intensity of Train, =	((6.584×3×17.132 +8.333×58×10.713))/ ((3×17.132+58×10.713))
=((338.391+5177.743))/672.750=	8.200 t⁄m
5.3 Design Calculations for varying Gradient (G). (Refer Fig. 5.a)	
Work done in ton-m for climbing 1.83 m elevation at the end of Catch Siding.	
((1.830+1.037)×238×8.20)/2 + ((1.037+0.733)×91×8.20)/2 + ((0.733+0.733)×86×8.20)/2 + ((0.733+0.490)×73×8.20)/2 + (0.49×147×8.20)/2 + ((0.0+(-1)X.786)×55×8.20)/2 =	
Total work done = (2797.339 + 660.398 + 517.155+ 366.150 + 295.328 - 177.181=)	4459.188tm
Absorption of Velocity head (Total work done) / (Weight of train) = 4459.188/((672.750X8.200))=	0.808m
5.4 Velocity Head to be destroyed by sand resistance	
Velocity Head to be destroyed by sand resistance = Total velocity head – Track resistance – Sand Resistance	
10.6383-5.2284-0.808-X=	4.602-X
Calculation of sand track resistance @ 4%	
Length of sand hump =	50 m
Length of sand drag	= 585 m
Distance traveled by C. G on sand drag) = 585-341.439-50 m	
= 243.5608-50 m	
Work done on the sand drag	
((243.5608-50)×4×5516.64)/ 100 = 42712.210ton-m	
Head of sand resistance -X	
42712.210/5516.64=7.7424 m	
Hence gravity resistance to be destroyed = 11.3716 m	
Velocity head absorption Capacity	

= 5.228+7.742+0.808=13.779 m
>11.3716 m Safe

6 Variations in kinetic and static heads for different parameters

The length of catch siding depends on length of graded track, length of sanded track and the magnitude of gradients. The variation of exit velocity vs. entry grade and velocity head vs. entry grade are shown in the **Fig. 8 a** and **Fig. 8 b** respectively.

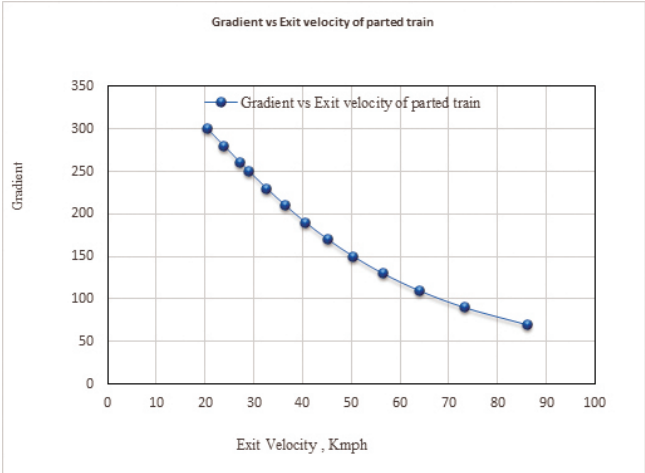


Fig. 8. a Variation of exit velocity vs. entry grade

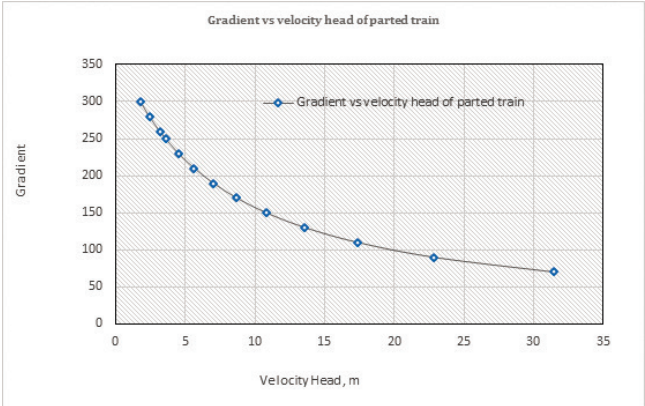


Fig. 8. b Velocity head vs. entry grade

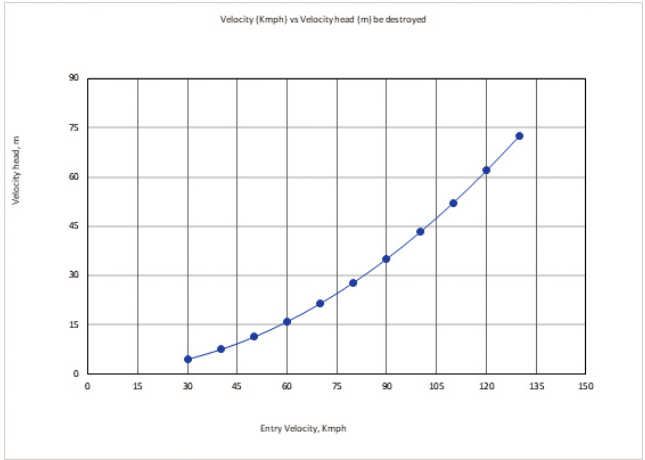


Fig. 8. c Variation of velocity head (to be destroyed) vs. entry velocity

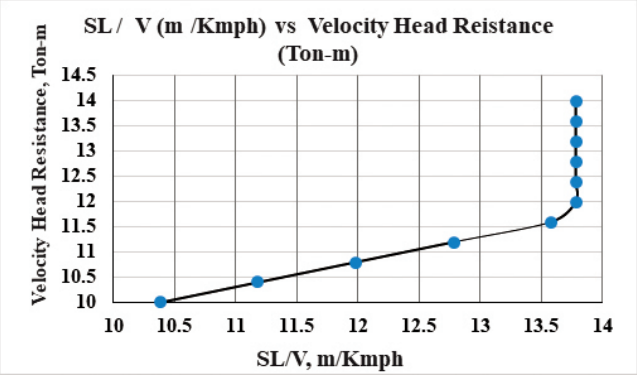


Fig. 8.d Variation of static head resistance vs. Ratio for (length of sanded track (SL) to Entry velocity)-Vh.

For the same profile of catch siding, variation of velocity head (to be destroyed) vs. entry velocity is shown in the **Fig.8 c.** The variation of static head vs. length of sanded track in catch siding for constant entry velocity is shown in the **Fig. 8 d.**

Table 4 furnishes the design data for verifying the strength of existing catch siding pertaining to Loco engines. Table 5 shows catch siding potential energy for passing loco coupled with 58 BOXNM1 wagons.

Table 4 Diesel and Electric locos data

Sl.no	Locos	Length of loco, mm	Speed, Kmph	Axle loads, t
1	WDG5	22262	105	22.3
2	WDG4D	23000	105	21.7
3	WDG4	21264	100	21.0
4	WDG3A	19150	100	20.5
5	WDP1	16110	120	20.0
6	WDG2	19974	90	22.0
7	WCAG1	20980	80	21.3
8	WAG5H	19974	80	21.0
9	WAG6	20600	100	20.5
10	WAG5	19974	120	19.8

Potential energy of catch siding as hown in Table 5. for passing Diesel / Electrical locos with 58 BOXNM1 Wagons are utilized for determining the factor of safety of existing catch siding profile.

Table 5. Potential energy of catch siding for passing locos with 58 BOXNM1 wagons

Sl no	Locos	work done, tm
1	WDM2	113368.813
2	WDG5	113116.914
3	WDG4D	113111.324
4	WDG4	113188.203
5	WDG3A	113267.735
6	WDP1	113371.852
7	WDG2	113201.546
8	WCAG1	113188.512
9	WAG5H	113228.797
10	WAG6ABC	113217.049
11	WAG5ABC	113261.498

Factor of safety shown in Table 6 for existing catch siding profile for Electrical locos (with 58 BOXNM1 Wagons) are used for arriving the catch siding profile of optimum length and less quantum of excavating/fill works to maintain safe functioning of existing catch siding.

Table 6. Factor of Safety for Existing Catch Siding for the passing the Electrical Locos

Speed Kmph	WCAG1	WAG5H	WAG6ABC	WAG5ABC
70.000	1.056	1.058	1.059	1.062
68.000	1.119	1.121	1.122	1.125
66.000	1.188	1.190	1.191	1.195
64.000	1.263	1.265	1.267	1.270
62.000	1.346	1.348	1.350	1.354
60.000	1.437	1.439	1.442	1.445
58.000	1.538	1.540	1.543	1.547
56.000	1.650	1.652	1.655	1.659
54.000	1.775	1.777	1.780	1.784
52.000	1.914	1.916	1.919	1.924
50.000	2.070	2.073	2.076	2.081
48.000	2.246	2.249	2.252	2.258
46.000	2.446	2.449	2.453	2.459

Factor of safety shown in Table 7 for existing catch siding profile for Diesel locos- (with 58 BOXNM1 Wagons) are generated for arriving the catch siding profile of optimum length and less quantum of excavating/fill works to maintain safe functioning of existing catch siding.

Table 7. Factor of Safety for Existing Catch Siding for the passing the Diesel Locos

Speed	WDM2	WDG5	WDG4D	WDG4	WDG3A	WDP1	WDG2
70.000	1.066	1.052	1.054	1.057	1.060	1.062	1.054
68.000	1.130	1.115	1.117	1.120	1.123	1.126	1.117
66.000	1.200	1.183	1.186	1.189	1.192	1.195	1.185
64.000	1.276	1.259	1.261	1.265	1.268	1.271	1.261
62.000	1.359	1.341	1.344	1.348	1.351	1.354	1.343
60.000	1.452	1.432	1.435	1.439	1.442	1.446	1.434
58.000	1.553	1.532	1.535	1.540	1.543	1.547	1.535
56.000	1.666	1.644	1.647	1.652	1.656	1.660	1.647
54.000	1.792	1.768	1.771	1.776	1.781	1.785	1.771
52.000	1.932	1.906	1.910	1.916	1.920	1.925	1.910
50.000	2.090	2.062	2.066	2.072	2.077	2.082	2.066
48.000	2.268	2.237	2.242	2.248	2.253	2.259	2.241
46.000	2.469	2.436	2.441	2.448	2.454	2.460	2.440

Kinetic energy shown in Table 8. due to Electrical locos (with 58 BOXNM1 Wagons) on entry grade is arrived for future assessment as ready reckoner for designer.

Table 8. Kinetic Energy due to Electrical Locos

Speed kmph	WCAG1 tm	WAG5H tm	WAG6ABC tm	WAG5ABC tm
70	107175	107071	106898	106655
68	101139	101040	100877	100648
66	95277	95184	95030	94814
64	89590	89503	89358	89155
62	84078	83996	83860	83670
60	78741	78665	78537	78359
58	73579	73508	73389	73222
56	68592	68526	68415	68259
54	63780	63718	63615	63471
52	59143	59086	58990	58856
50	54681	54628	54540	54416
48	50394	50345	50264	50150
46	46282	46237	46162	46058

Kinetic energy shown in Table 9. due to Diesel locos (With 58 Wagons) on entry grade is arrived for future assessment as ready reckoner for designer.

Table 9. Kinetic Energy due to Diesel Locos

Speed Kmph	WDM2 tm	WDG5 tm	WDG4D tm	WDG4 tm
70	106308	107522	107314	107071
68	100320	101466	101269	101040
66	94506	95585	95400	95184
64	88865	89880	89706	89503
62	83398	84350	84187	83996
60	78104	78996	78843	78665
58	72984	73817	73674	73508
56	68037	68814	68681	68526
54	63264	63987	63863	63718
52	58665	59335	59220	59086
50	54239	54858	54752	54628
48	49987	50557	50460	50345
46	45908	46432	46342	46237

7 Conclusions

1 Purpose of catch siding is to arrest the movement of the vehicles if they start roll down the grade which may eventually foul up the existing running lines.

2 Catch sidings are provided in the case of hilly terrains where the gradients are very steep towards the railway stations.

3 The numerical model described above are useful for designer to develop new catch siding profile and to certify the adequacy of existing catch siding for different composition of train engines and wagons.

4 Kinetic energy due to Diesel locos (With 58 Wagons) on entry grade is arrived for future assessment as ready reckoner for designer.

5 Kinetic energy due to Electrical locos (with 58 BOXNM1 Wagons) on entry grade is arrived for future assessment as ready reckoner for designer.

6 Factor of safety of existing catch siding profile for Diesel locos-(with 58 BOXNM1 Wagons) are developed for arriving the catch siding profile of optimum length and less quantum of excavating/fill works to maintain safe functioning of existing catch siding.

7 Factor of safety of existing catch siding profile for Electrical locos (with 58 BOXNM1 Wagons) are developed for arriving the catch siding profile of optimum length and less quantum of excavating/fill works to maintain safe functioning of existing catch siding.

8 Potential energy of catch siding for passing Diesel / Electrical locos with 58 BOXNM1 Wagons are arrived for determining the factor of safety of existing catch siding profile.

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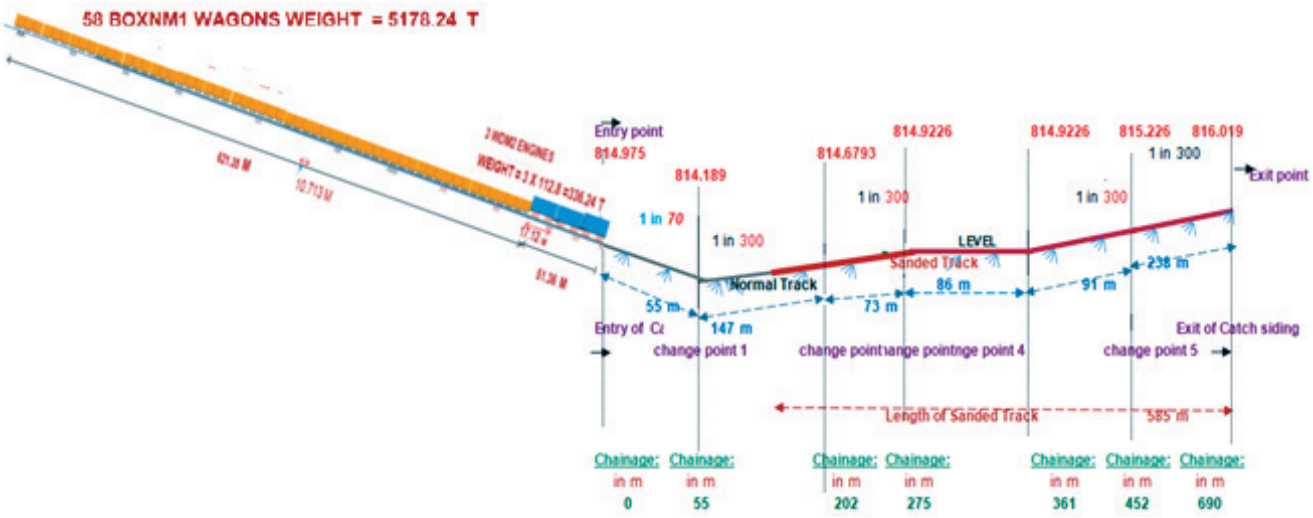
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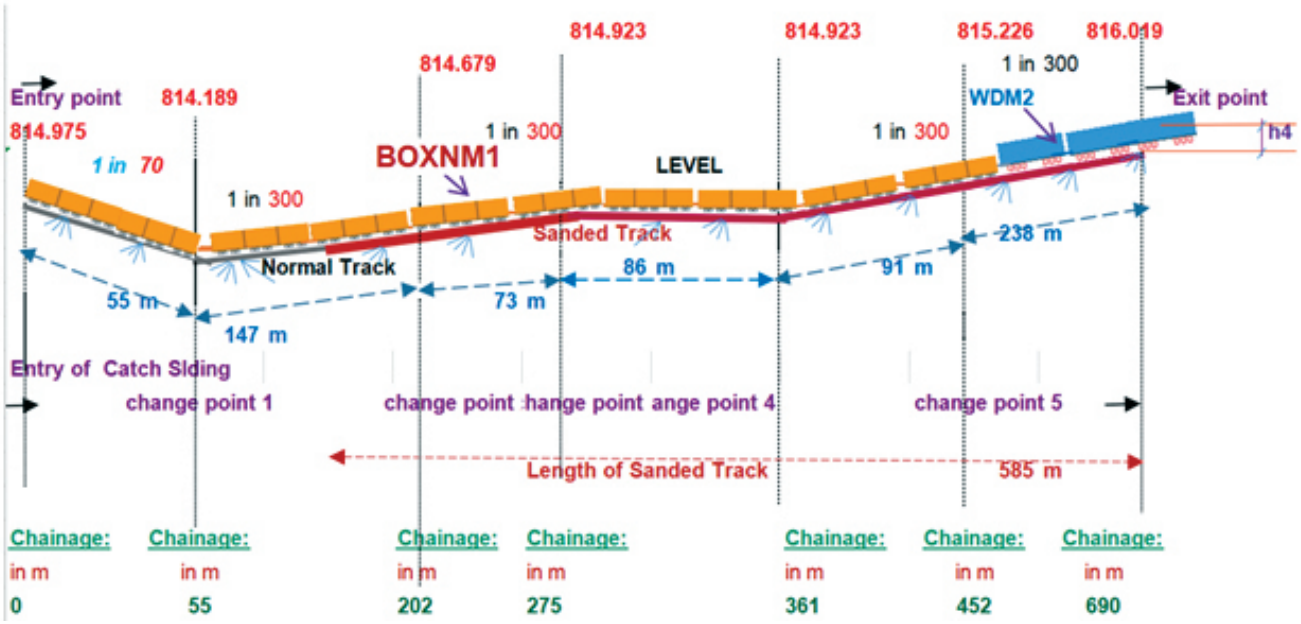
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5 Indian Railways: “Schedule of Dimensions 2004 (with latest ACS up to 29), RDSO, Lucknow.





5.a Formation of parted train on entry of existing catch siding (3WDM2+58BOXNM1)



5. b Formation of parted train on existing catch siding (3WDM2+58BOXNM1)

Fig.5. Formation of parted train on entry and on catch siding with (3WDM2+58BOXNM1)

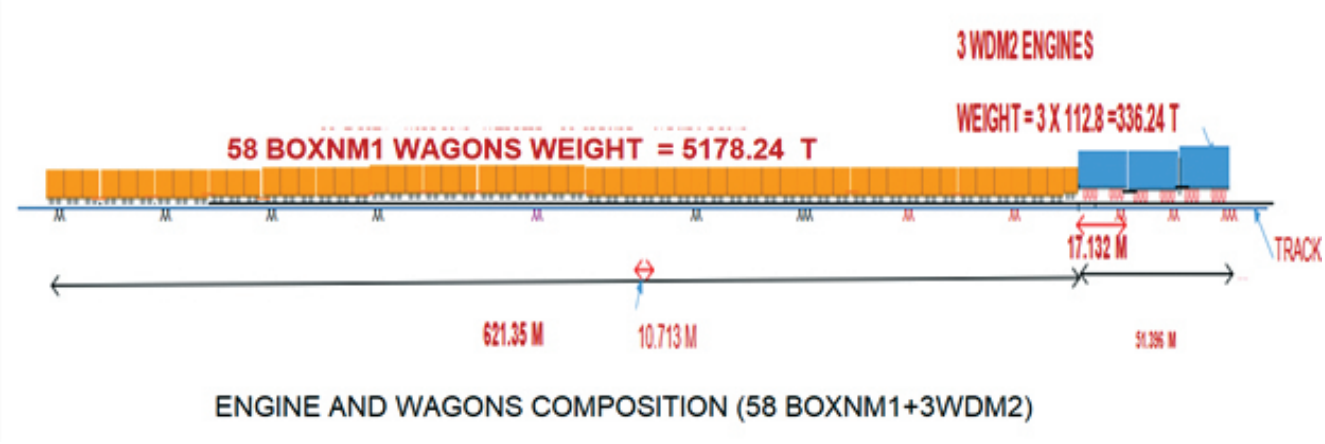
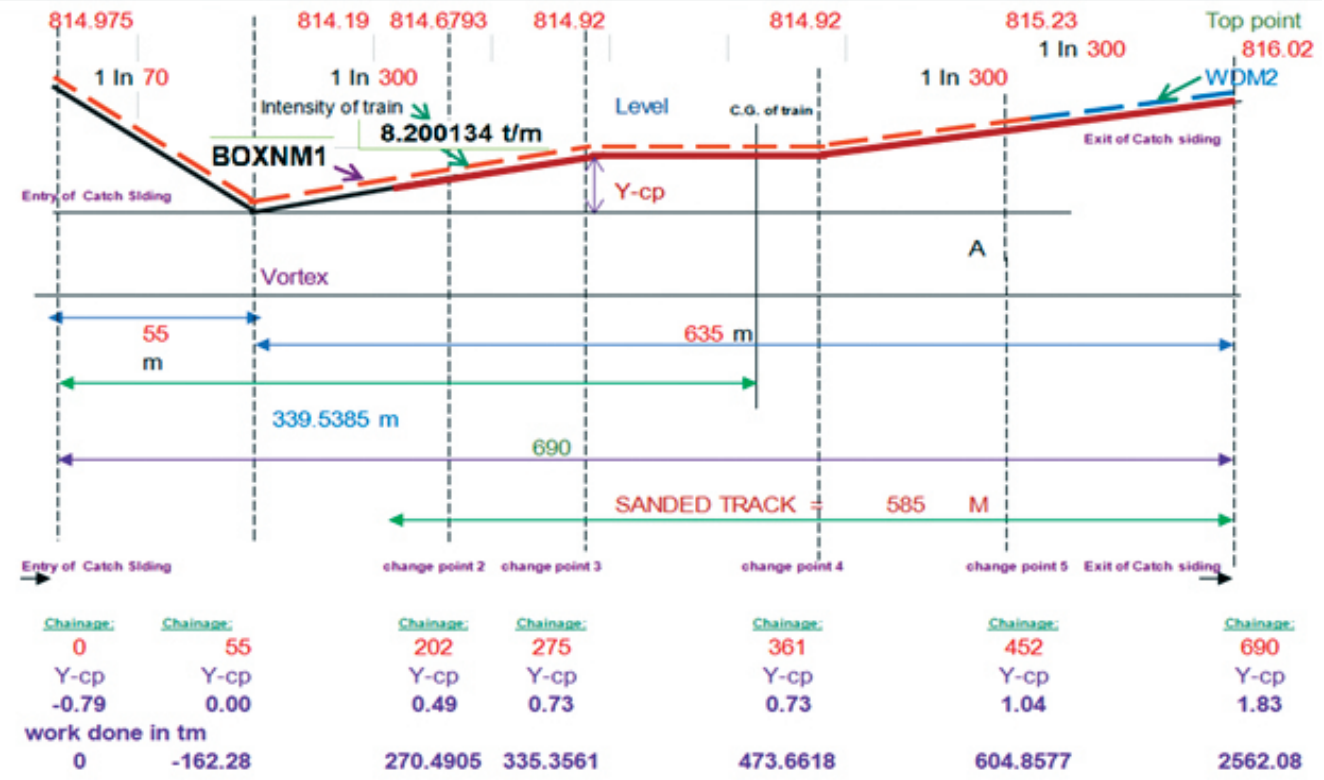


Fig. 6. Composition of Engine and Wagons



7. Profile of catch siding for the composition of (3WDM2+58BOXNM1)

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Coefficient of Active Earth Pressure from First Principles

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ABSTRACT

In this article, coefficient of earth pressure is estimated by considering the critical most sliding wedge with least shear strength. These coefficients are compared with those obtained through Rankine's formulae for Smooth wall with level backfill. A comparative study is made to bring out the variation in magnitude of these coefficients. It is found that, critical most slip surface follow a non linear equation pattern, depending on angle of internal friction of backfill material.

Introduction

In general, design of earth retaining wall is carried out based on earth pressure coefficients. Earth pressure coefficients are estimated based on formulae available in IRC/IRS codes depending upon the nature of work. In this analytical research work, earth pressure coefficients are estimated based on critical failure wedges and values are compared with those obtained through different formulae. Based on this comparative study, economy and safety aspects of the earth retaining structure can be well understood at all level of engineers. For new designs earth pressure is estimated based on active mode of failure. In most of the cases only the destabilizing active force is taken into consideration while ensuring the equilibrium of the structure. Hence in this article, active earth pressure coefficients based on critical wedges are determines and summarized in the form of graphs.

2 Literature Review

2.1 IRS Substructure Code method

For the design of Railway substructures, formula given in Para no. 5.7 of IRS Substructure is used.

$$K_a = \frac{COS^2(\emptyset - \alpha)}{COS^2(\alpha) * cos(\alpha + \delta) * \left[1 + \sqrt{\frac{sin(\emptyset + \delta)\, sin(\emptyset - i)}{cos(\alpha + \delta)\, cos(\alpha - i)}}\right]^2}$$

"Ø" is angle of internal friction of backfill,

"i" is Angle which the earth surface makes with horizontal behind the earth retaining structure.

"α" is Angle which earth face of the wall makes with the vertical

"δ" is angle of friction between wall and earth fill (Ø/3 for MCC/RCC & 2Ø/3 for Masonry Walls)

"Ka" is Coefficient of Active Earth Pressure.

2.2 IRC Method

For the design of roadway substructures, formula given in Para No.214.1.1 of IRC 6 is used, which is summarized as follows.

$$K_a = \frac{cos^2(\emptyset - \alpha)}{cos^2\alpha * cos(\delta + \alpha)} * \left[\frac{1}{1 + \left[\frac{sin(\emptyset + \delta) * sin(\emptyset - \beta)}{cos(\alpha - \beta) * cos(\delta + \alpha)}\right]^{1/2}}\right]^2$$

"Ø" is angle of internal friction of backfill.

"α" is angle which earth face of the wall makes with the Vertical

"β" is slope of the earth fill

"δ" is angle of friction between the wall and earth fill. Minimum among (22.5 or 2ø/3) degrees

"Ka" is coefficient of active earth pressure

2.3 Simplified formula for smooth vertical wall with level fill.

For a smooth vertical wall with horizontal level backfill, the Formulae mentioned in 2.1 & 2.2 can be simplified as

$$K_a = \frac{(1 - sin\,\emptyset)}{(1 + sin\,\emptyset)}$$

2.4 Coulomb's shear strength theory

In a soil mass, the most critical slip surface is the one which possesses minimum value of shear strength calculated using the following expression.

S = C + N * tan ø

Where S = shear strength along the sliding surface

N = Normal force acting on the slip surface.

ø = Angle of internal friction of the soil.

Hence, in case of cohesion less soil, shear strength along the failure surface is merely dependent on normal force acting on the failure plane and angle of internal friction of the soil.

3 Methodology

In this method, critical slip surfaces are determined among all possible slip failures ranging from 0 to 90 degree inclination with the level. Refer Fig 1.

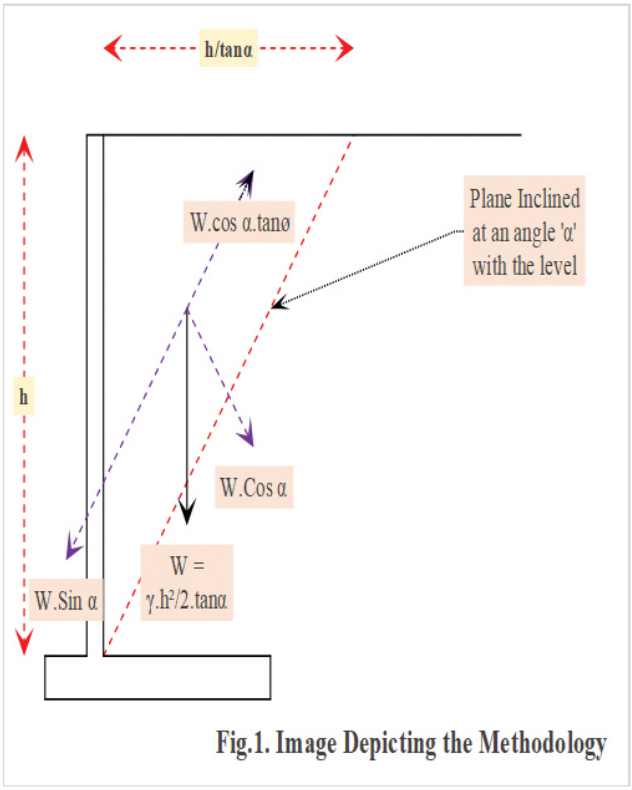


Fig.1. Image Depicting the Methodology

Weight of the wedge for the critical failure plane is calculated using the equation (M1).

$W = 0.5 * \gamma * h^2 / (\tan \alpha)$ .....eq. (M1)

Weight of the triangular wedge (W) is resolved into two components. i.e. along the slip surface (sliding component W * sin α) and normal to the slip surface (Stabilizing component W * cos α * tan ø).

The maximum sliding force corresponding to assumed inclined failure surface determined as follows.

In case of cohesion less soil, maximum net sliding force due to self weight of wedge can be considered as active force, which can be written as follows.

$P_a = W^*[\sin\alpha - \cos\alpha * \tan ø]$ .....eq.(M2)

It can be seen that sliding resistance is critical for minimum value of W * (Sin α - Cos α * tan ø) among all assumed surfaces.

For a wall of height 'h' containing backfill material having unit weight 'γ' maximum active pressure force 'Pa' can be derived as follows.

$P_a = (K_a * \gamma * H^2)/2$ .....eq.(M3)

From Equation (M1), (M2) & (M3), it can be concluded that critical value of coefficient of active earth pressure can be expressed as follows.

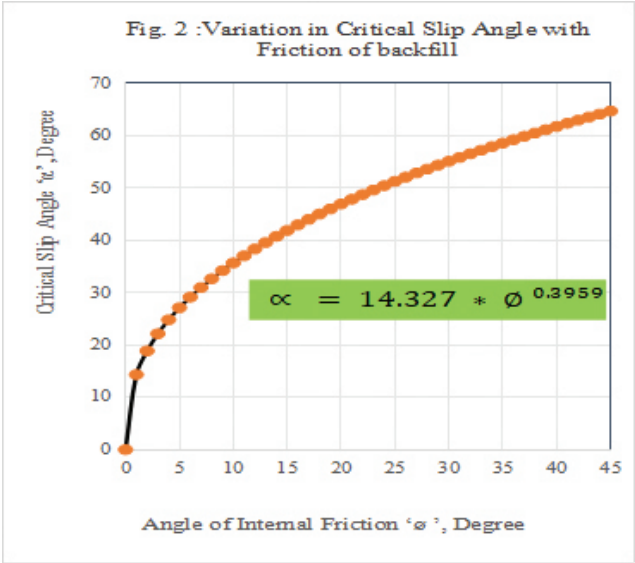
$$K_a = \frac{[\sin\alpha - \cos\alpha * \tan ø]}{\tan\alpha}$$ .....eq.(M4)

Where ,

$\alpha = 14.327 * ø^{0.3959}$

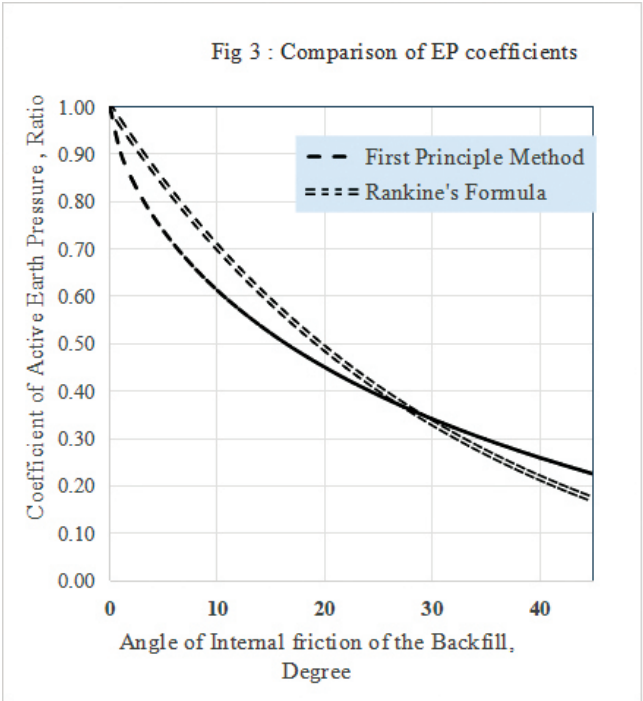
'α' is angle of inclination of the critical failure plane with the level. See fig.2.

'Ø' is angle of internal friction of the backfill.



Values obtained from eq. (M4) are compared with values obtained from following Rankine's equation (M5). Refer fig. 3

$$K_a = \frac{(1-\sin ø)}{(1+\sin ø)}$$ ……..eq .(M5)



4 Results and Discussions.

It is found that, for angle of internal friction values up to 28 degrees, coefficients derived from first principle is more economic than those derived using Rankine's

formula. Whereas more conservative values can be obtained in this method for angle of internal friction exceeding 28 degrees. (See Fig 3)

From detailed analysis, it is found that the critical slip surface is a non linear function of angle of internal friction which follows equation (R1).

$\alpha = 14.327 * \phi^{0.3959}$.....eq.(R1)

In general, as per Rankine's failure theory, the critical failure angle is located at an inclination of 'α' with the level, given by the equation (R2).

$\alpha = 45 + \phi/2$ .....eq. (R2)

However, outcomes of this study revealed that the critical slip surface angle is a non linear function of angle of internal friction of fill.

5 Conclusion :

Active earth pressure coefficients derived from first principles can be used in routine design works to obtain optimum results.

In case of a smooth vertical wall supporting homogeneous level backfill, the critical slip failure angle will be a non linear function of angle of internal friction of the fill.

6 References :

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AN INDIAN RAILWAY STATION.—(SEE PRECEDING PAGE.)

BYCULLA STATION 1853

Modi opens further sections of Dedicated Freight Corridors

INDIA's prime minister, Mr. Narendra Modi, opened orformally marked the start ofwork on rail projects worth acombined Rs 850bn ($US10.6bn) on March 12. This included opening two new sections of the Dedicated Freight Corridor (DFC) network: the 401km NewKhurja - Sahnewal section ofthe Eastern DFC (EDFC) andthe 244km New Makarpura -New Gholvad stretch of the Western DFC (WDFC).The Eastern and Western DFCs have cost an estimated Rs 1.24 trillion to build. While the 1337km EDFC is complete,around 14% of work remainson the 1506km WDFC, wherethe 109km Vaitarna– Mumbai section is now due forcompletion by 2025. Indian Railways (IR) carries 52% of its freight traffic on the Golden Quadri lateral routes connecting Delhi with Mumbai and Howrah. IR is committed to transferring 70% of freight traffic to the DFCs, which run parallel to these main lines. Around 250 freight trains aday are now operating on the DFCs, accounting for 304 million gross tonne-km. The Dedicated Freight Corridor Corporation of India (DFCCI) expects traffic to at least double within five years. DFC trains operate at an average speed of 55km/h, compared with 22km/h on the IR mainline network. The maximum speed on the DFCsis due to rise to 100km/h oncework on safety systems is completed. The EDFC is mainlyintended to move coal, whilethe WDFC is predominantly carrying intermodal traffic. Both new lines are designed for 25-tonne axle loads,supporting operation of trains weighing up to 13,000 tonnes.

Ref. : IRJ - APR -2024

Russia begins construction of first high-speed line and trains

RUSSIA has started construction of its firsthigh-speed line between Moscow and St Petersburg. The cost of the long-discussed VSM-1 project, which is due to open in 2028, hasnot been disclosed, nor has the total length ofthe new line.

The new line will serve 16 stations, four ofthese in Moscow. Within Moscow, workincludes providing extra tracks betweenLeningradsky and Alabushevo stations and rebuilding four stations that will be used by high-speed trains and provide interchange with the Moscow metro and commuter services. They are: Leningradsky, Rizhskaya, Petrovsko-Razumovskaya and Zelenograd-Kryukovo.

Russia is understood to be developing a newhigh-speed train with a maximum speed of 400km/h. Previous attempts to develop adomestic design were unsuccessful, leading Russia to partner with Siemens, which deliveredand maintained a fleet of Sapsan trains based on its Velaro platform. The partnership wasdissolved following Russia's invasion of Ukraine.

The new trains are expected to nearly halvethe current journey time between Moscow and St Petersburg to around 2h 15min. Services areexpected to run initially at intervals of 15-20 minutes at peak times, increasing to 10-15minutes from 2030.

Ref. : IRJ - APR -2024

Indian PM opens several metro and light rail lines

INDIAN prime minister, Mr. Narendra Modi, opened several metro and light raillines on March 6, either virtually or in person, ahead of the country's general election in April/May. Modi opened the first 6km section of the 27-station Agra metro, from Taj East Gate to Mankameshwar. The line will eventually connect Unesco World Heritage sites including the Taj Mahal, Agra Fort and Sikandra Fort.

The total cost of the 30km two-line Agra metro, operated with a fleet of Alstom Moviatrains, is estimated at Rs 83.8bn ($US 1.02bn). The project hasbeen backed by a $US 491mloan from the EuropeanInvestment Bank (EIB).

The other new metro linesopened by Modi on March 6 were:

- The Rs 49.7bn East-West linein Kolkata, which includes India's first undersea metro tunnel between Howrah Maidan and Mahakaran, 520m long and 13m below the surface of the River Hooghly
- A section of the Pune metro from Ruby Hall Clinic to Ramwadi, and
- The Phase 1B extension of the Kochi metro from SN Junctionto Tripunithura.

The prime minister also in augurated a further 17km section of the Delhi -Ghaziabad - Meerut Rapid RailTransit System (RRTS), designed for a maximum speed of 160km/h with station sat Murad Nagar, Modi Nagar North and Modi Nagar South.

On March 5, Modi celebrated the completion of track doubling and electrification of the 22km Sanathnagar–Moula Ali line in Telengana state.The line has been upgraded and resign alled as part of aproject to enable passenger trains to use it for the first time.

Ref. : IRJ - APR -2024

Indian railindustry concernover court ruling

INDIA's rail industry iscurrently debating the need for a review of dispute resolution in the infrastructure sector. This follows the decision by the Supreme Court on April 10 to overturn its own earlier arbitration award of Rs 29bn ($US 351m), or Rs. 80bn including interest, to Delhi Metro Express Private Ltd (DAMEPL), a joint venture between Reliance Infrastructure and CAF of Spain. Private investment in India's rail sector is sporadic, largely due to the absence of an effective dispute resolution process that can be trusted by all parties. The latest Supreme Court ruling was followed by a 20% drop in Reliance's shareprice, causing disquiet amongst the private sector.

In 2008 DAMEPL signed a concession agreement with Delhi Metro Rail Corporation (DMRC), a 50:50 joint venture between the Indian government and the government of the National Capital Territory of Delhi, for the construction, operation and maintenance of the 22.5km Delhi Metro Airport Line, connecting New Delhi

railway station with Indira Gandhi International Airport. DMRC was responsible for land acquisition, site clearance, civil works and all associated costs. Under the agreement DAMEPL was also responsiblefor the design, supply, installation, testing and commissioning of railway systems, as well as operations and maintenance. DAMEPL sought deferment of

the concession fee paid to DMRC in 2012 owing to delays in providing access to stations by DMRC. Operations were stopped by DAMEPL in July 2012 and arbitration proceedings began in October of that year. In May 2017 DAMEPL won the arbitration award, but the High Court in Delhi subsequently ruled that this order suffered from “patentillegality.” DAMEPL then went to the Supreme Court which restored the order, but DMRC subsequently lodgedan appeal against this ruling.

US manufacturer Wabtec officially opened its new manufacturing campus at Rohtak in Haryana state on May 20. Built at a cost of Rs 1.5bn ($US 18m), the new plant will manufacture components and subsystems for trains for Indian Railways.

Ref. : IRJ – June 2024

India increases funding in interim rail budget for 2024

THE Indian government revealed plans to establish three major economic railway corridors in its interim budget announcement on February 1.The precise routes, funding details and project timelines have yet to be announced.India’s finance minister, Ms. Nirmala Sitharaman, announced the plan in the interim budget, which includes the highest-ever allocation of Rs 2.55 trillion ($US 30.93bn) to Indian Railways (IR) for the coming financial year. The budget also includes proposals to expand the development of metro networks in more Indian cities, along with commuter railways similar to the Regional Rapid Transit System, the first 17km section of which opened in the National Capital Region centred on Delhi in October. Sitharaman also proposed that 40,000 Mail and Express coaches currently running onthe mainline network would be upgraded to match the standards of 160km/h Vande Bharat EMUs. The interim budget was presented ahead of India’s general election this month. The new government willannounce the full budget in May or June.

Ref. : IRJ March – 2024

Western Dedicated Freight Corridor

Following the completion of the 1337km Eastern Dedicated Freight Corridor (DFC) in October 2023, Dedicated Freight Corporation of India expects to complete the final three sections of the 1176km Western DFC this year. The 938km northern section of the Western DFC from Dadri to Sanand and the 238km section from Makarpur to New Gholvad have already been completed. The missing 138km section from Sanand to Makarpura is expected to open in March together with the 83km extension from New Gholvad to Vaitarna. The final 109km southern extension from Valtarna to Mumbai JNPT will open in December. The Western DFC is funded entirely by a Yen 645bn loan from the Japan International Cooperation Agency (Jica). The DFCs will bring about a step change in rail freight operation in India. The new lines will have a maximum speed of 100km/h compared with

75km/h on the conventional network and a 32.5-tonne axle load compared with 22.5 tonnes. Double-stack container trains will be operated for the first time in India.

Ref. : IRJ January 2024

Financial performance a concern for Indian Railways

Along with the incremental introduction of the indigenously-developed 160km/h Vande Bharat EMU on the mainline network, Indian Railways (IR) has two major achievements to show for 2023. First is the completion of the longawaited 1337km Eastern Dedicated Freight Corridor (EDFC) that connects Ludhiana in Punjab with Sonnagar in Bihar. The second is the buoyant growth in freight traffic seen last year, when IR carried 634.66 million tonnes between April and August, an increase of 1378 tonnes in the same period in 2022. IR also achieved its highest-ever capital expenditure over these five months, investing Rs 1150bn ($US 13.95bn) in building new lines, track doubling, gauge conversion, the enhancement of passenger amenities and safety projects. Several key projects are now starting to come to life. Trial runs on a 50km section of the Mumbai - Ahmedabad high-speed line are scheduled to start this year and other work on this project is being fast tracked, with tenders likely to be called during 2024 to supply the first batch of 18 Japanese series E5 Shinkansen trains at an estimated cost of Rs 70bn. Elsewhere, the 17km priority section of the Regional Rapid Transit System (RRTS) in the National Capital Region was inaugurated on October 20 2023. The remainder of the 82.15km Delhi - Meerut RRTS costing Rs 302.7bn has been making rapid progress and is likely to be completed in June 2025.

Following the collision at Balasore on June 1 2023 that killed 294 passengers, IR has also moved to introduce new electronic signalling systems, with railways minister, Mr Ashwani Vaishnaw, announcing plans to deploy solid-state interlockings across IR’s 68,103 route-km network within the next three years. The programme to roll out the Kavach anticollision system, a homegrown version of ETCS Level 2, has been accelerated, with contracts awarded for the Delhi - Mumbai and Delhi - Kolkata corridors totalling 3000 route-km. While IR has justifiably focused on meeting its asset modernisation needs, the company’s declining financial health remains a worry. As pointed out in a report presented by the Comptroller and Auditor General (C&AG) in March 2023, the operating ratio - or proportion of revenue consumed by operating costs - was 107.39% in 2021-22 compared with 97.45% in 2020-21. For the first time in several decades, IR has started to spend more than it earns. During 2021-22, its revenue expenditure increased by 49.3% and the proportion of capital expenditure met from extra-budgetary resources increased by 37.35% due to inadequate generation of internal resources. In the report, the C&AG advised IR to regularly monitor expenditure and budget allocation in order to ensure that funds are properly directed towards their intended purpose.

In the nine years since the current BJP administration came to power, IR’s capital expenditure budget has grown from Rs 539bn in 2013-14 to Rs 2.602 trillion in 2023-24. Gross budgetary support for IR capital expenditure has increased by a factor of eight since 2013-14. Despite this huge infusion of funding, IR’s performance and efficiency does not appear to have been radically transformed for the better. The average speeds of both freight and passenger trains have remained much at the same levels over the last 10 years, while major accidents have continued to happen. At the same time, ambitious plans to redevelop stations have been announced

to great fanfare, but have made little progress. Initiatives to divest IR public sector undertakings such as Railtel or the Container Corporation of India (Concor) have not come to fruition. Asset monetisation schemes, including plans to sell or lease surplus railway land, have not progressed, and policy reforms to set up an independent rail regulator or introduce a commercial accounting system have not moved forward.

Management reform stalls

The BJP administration has made several bold decisions since coming into office, such as the move to disband IR's eight existing services and merge them into a single cadre known as the Indian Railways Management Service (IRMS). With this measure, the government intended to do away with the prevailing culture of working in silos, but this change has also had the negative effect of gradually eliminating specialised personnel from the engineering function. The higher echelons of IR management have also been in turmoil following the introduction of new procedures whereby candidates for promotion to the rank of Railway Board member are handpicked and interviewed in person by a panel of ex-IR officials. However, the majority of these panel members did not themselves reach the rank of general manager while at IR. "As a result of this policy of pick and choose, complete chaos has come to prevail in the higher bureaucracy and decision-making has become slow," an IR official says.

Indeed, senior managers do appear to have been labouring under a climate of indecision during 2023. Examples include the 2500 diesel locomotives in operating condition worth Rs500bn that are now sitting idle, as IR pursues its 100% electrification drive without having worked out a viable programme to phase out or sell its surplus diesel traction. At the same time, more and more Vande Bharat EMUs are flooding onto the network without adequate attention being paid to setting up the many specialised depots needed to maintain and service these new trains. Apart from his responsibilities as railways minister, Vaishnaw holds two other cabinet portfolios and also shoulders other heavy political responsibilities as a member of the prime minister's core team. "At a time when big changes are happening, such a situation at the leadership level is not ideal," an official comments

Ref. : IRJ January 2024

Updates Of Codes & Manuals

S.NO.	ACS NO.	DT OF ISSUE	REMARKS
			TRACK
1. Indian Railways P-Way Manual			
01.	01	July 2021	Para No 915 replaced
02.	02	Aug. 2021	Para 636(2)(e), 702(1)(d), 702(2), 717(1)(b), 718 replaced. Para 702 (1)(2) renamed as Para 702(1)(b)
03.	03	21.10.2021	Heading of Para 228 replaced New para 228(4) added
04.	04	03.11.2021	Para 408(2)(e) replaced
05.	05	11.02.2022	Table 1A of para 103 replaced
06.	06	16.03.2022	Para 201 replaced
07.	07	03.04.2022	Para 1202 replaced
08.	08	20.06.2022	Para 404(1)(d), 405(3), 425 replaced
09.	09	12.08.2022	Para 1202 replaced
10.	10	07.11.2022	Para 404(1)(D), 404(2), 405(1)(3(5)(8)(9-a) replaced
11.	11	04.01.2023	Para 326(5)(g) added, Para 330 modified
12.	12	18.04.2023	Para 604(A) added
13.	13	14.06.2023	Para 335, 410, 635(2)(c) & 910(1) replaced
14.	14	11.10.2023	Para 331(2)(a), 613(3)(b) replaced, Fig 3.25 deleted
15.	15	23.10.2023	Table 1A Para 103, Table 1B Para 106, 106(4)(1), 109, Para 429, 328(2) replaced
16.	16	11.12.2023	Para 603 replaced
17.	17	01.03.2024	Para 326(2), (3), 331(7) replaced
18.	18	15.03.2024	Para 637(2), 708 replaced
19.	19	29.05.2024	Para 506 replaced

2. Track Machine Manual			
01.	01	19.08.2021	Para No 608(2) replaced
02.	02	17.05.2023	Annexure 7.7 replaced
3. Manual For Ultrasonic Testing of Rails & Welds			
01.	01	04.05.2023	Para 8.10.1 & Footnote below para 8.14 replaced
BRIDGES			
1. Indian Railways Bridge Manual			
01.	01	01.09.1999	Para No 1007 replaced, New para 1007(A) added.
02.	02	21.07.2000	New para 16 added
03.	03	21.07.2000	Deleted para 513(b)
04.	04	21.07.2000	Deleted para 515
05.	05	21.07.2000	Deleted para 603
06.	06	21.07.2000	Deleted para 222(1b), 222(2f)
07.	07	21.07.2000	Deleted para 618
08.	08	21.07.2000	Para No 504(4) replaced, Add new para 521, sub para 5 under para 616 and sub para 5 under para 210
09.	09	27.07.2000	Add new sub para 317 of Chapter III
10.	10	31.08.2000	Para No 604 replaced
11.	11	14.01.2003	Add para before chapter 1
12.	12	18.12.2007	Para No 217.2(a)(i) and para 217.2.(b)(i) replaced
13.	13	22.01.2008	Para No 317 replaced
14.	14	20.03.2008	Delete para 310, 312(4), 313(2) and 313(3) of chapter III,
15.	15	05.08.2008	Para No 410(2)(b), 418(5), 430 replaced, Para 3(ii) of 606 is proposed for deletion and Para 3(i) renumbered as 3
16.	16	13.08.2008	Para No 317(iii) replaced
17.	17	15.09.2008	Para 318 added
18.	18	17.12.2008	Para 224 added
19.	19	11.01.2010	Para 318 modified
20.	20	07.06.2010	Para No 1104(5) replaced
21.	21	02.07.2010	Para No 1107 (d) modified. Add para 1107(15)(i)
22.	22	28.03.2011	Para No 1107(15)(i) replaced & renumber as 1107(15)(b)(i), para 1107(15)(b) is renumbered as 1107(15)(b)(ii)
23.	23	23.08.2011	Replace existing Chapter-VIII by revised Chapter-VIII
24.	24	14.09.2011	Para 714(2), 1005(1), 1005(3), 1104, 1104(2), 1104(5), 1106(2), Page No xi (Index) 1104 modified
25.	25	17.12.2012	New sub para 3 may be added to existing para 311
26.	26	23.08.2013	Para No 217.2(a)(ii), 217.2(c), 217.4(c), 217.4(d), 217.4(e), 217.4(l), 615 to be replaced
27.	27	03.01.2014	New para 1107 5 i), 215 A added
28.	28	20.03.2014	Chapter-X, Part B – Title of Deep Cuttings replaced and para 1010 to 1015 & Annexure 10/2 replaced by Para 1010 to 1017 and Annexure 10/2 attached.
29.	29	15.04.2014	Para No 312(2), 312(4) replaced. Add new para 313(4)
30.	30	25.11.2014	Para 102(b), 504, 505, 506, 507, 508, 509 & Annexure 5/1 deleted
31.	31	09.02.2015	Para No 617 replaced.
32.	32	12.03.2015	Para No 222 2(f) replaced.
33.	33	21.03.2016	Para No 107(1) (a) is amended and 107 (1)(f) added. Para 222 (3) is amended by adding sub para (c), (d) and (e)

34.	34	04.10.2016	Added para 224
35.	35	31.07.2017	Para No 313(2) & 313(3) replaced.
36.	36	27.03.2018	Para No 317 & 318 replaced.
37.	37	09.10.2019	Para 1102.2(iv) replaced, Insert 11/2a proforma, Para 1107(15)(b)(i) & 1107(15)(b)(ii) modified
38.	38	14.01.2020	Para 317 replaced
39.	39	31.05.2023	Para 1107(7)(h) modified
40.	40	07.11.2023	Para 604 modified
2. Indian Railways Bridge Rule			
01.	47	22.06.2017	Add new para 2.8.1.2
02.	48	22.06.2017	Add new clauses
03.	49	26.12.2017	Para 2.12 deleted. New para 2.12 inserted
04.	50	06.12.2022	Add new clauses
05.	51	03.02.2023	Sub clauses (b), (d), (g) of clause 2.8.2.4.3 modified
3. Indian Railways Bridge Substructure & Foundation Code			
01.	01	17.04.2014	Para 4.8.1, 4.9.3 replaced
02.	02	20.10.2016	Modify description & heading of contents at S.No. 7.5, Delete para 7.5.3
03.	03	22.06.2017	Modified para 4.5.9
04.	04	11.08.2017	Modified para 4.9.2 & 4.9.3
06.	06	04.11.2019	Modified paras 1.2, 1.5 I (f), 5.12.1, 5.12.2 (a), (b), (c), 5.12.3, 5.12.5, 5.12.6, 5.12.7, 5.12.8, 5.16.2.7 (b).
07.	07	11.11.2019	Para 5.10
08.	08	11.11.2019	Para 3.1 of Appendix V (Clause 6.9.3) modified
09.	09	06.07.2020	Para No. 1.5 (I) - (c) & (g) modified
10.	10	30.08.2021	Para 6.9.2 replaced
4. Indian Railways Concrete Bridge Code			
01.	01	16.12.2014	Replace table 10 of para 10.2.1
02.	02	14.01.2015	Insert para 5.4.7 & 5.4.7.2
03.	03	20.01.2015	Insert note under para 4.5.1, delete para 14.9 & replace, delete para 15.9.4.1 & replace, delete para 15.9.4.2 & replace, delete para 15.9.9 & replace
04.	04	15.11.2016	Para 14.9, 14.9.1 & 15.9.9 deleted
05.	05	13.06.2017	Para 16.4.4.4.5 modified
06.	06	27.07.2017	Para 7.1.5 modified
07.	07	26.06.2018	New para 4.5.1 added, existing para 7.1.5 modified
08.	08	23.05.2019	Replace the clause 7.2.6.4.2.4.1, Replace clause 7.2.6.4.2.4.2 and 12.3.2, Replace clause 15.4.2.2.1, Appendix B (Table B1), Appendix B (Table B2), Appendix B (Clause B-7.1), Appendix B1 (Fig B1-2),
09.	09	08.07.2021	Para 5.4.7.1 replaced
10.	10	02.02.2024	Para 13.4 replaced, Para H-2(C) modified, Para 11.2.1.6 added
5. Indian Railways Arch Bridge Code			
01.	07	25.09.2000	Replace para 1.1
02.	08	28.01.2015	Replace para 5.3.3
03.	09	19.11.2019	Replace paras 2.1.2, 5.3.2, 5.3.4, 5.3.5, 5.3.5.1, 12.1.1, 12.1.2, 12.2, 12.3
6. Indian Railways Welded Bridge Code			
01.	01	16.02.2015	Para 27.1 replaced
02.	02	11.07.2018	Para 27.1 replaced

Works			
1. Indian Railways Works Manual			
01.	11	30.09.2022	Para 417 amended
2. Indian Railways Code For The Engineering Department			
01.	50	21.09.2017	Introduction of measurement & recording of 'executed works' by the contractor' in Rly Construction Works.
02.	51	27.09.2017	Para Nos 701, 1102, 1209 should be amended
03.	52	23.10.2017	Existing para 1238 replaced
04.	53	06.11.2017	Para No 701 should be amended
05.	54	22.01.2018	Para No 1264 (e) & 1264 (f) should be amended
06.	56	05.03.2019	Para No 1264 should be amended
07.	57	08.01.2020	Para No 1829 should be amended
08.	58	27.04.2022	Para No 1264 should be amended
09.	59	26.09.2022	Para No. 1109, 1110, 1111, 1112 should be amnded
10.	60	20.10.2022	Para No 1111 should be amended
11.	61	31.05.2023	Para No 1816 should be amended

Statement of Courses IRICEN CoC-2024

COURSE NO	COURSE NAME	FROM	TO	DURATION	TIMINGS	ELIGIBILITY
JULY						
24406	Project Management Tools & Software	01.07.24	05.07.24	1 W	Campus	All officers
24417	LWR & Yard Layout	01.07.24	05.07.24	1 W	Campus	All officers
24224	Webinar: Thick web switches and Points & Crossings on curves.	05.07.24	05.07.24	1 Day	Online	All officers & Supervisors
24418	USFD & Rail Grinding	08.07.27	12.07.24	1 W	Campus	All officers
24419	Bridge inspection and maintenance	08.07.27	12.07.24	1 W	Campus	All officers
24509	Special course for Supervisory Managers (Bridges) for Sri Lanka Railway through IRCON.	15.07.24	26.07.24	2 W	Campus	Sri Lanka Railway Personnel (Bridge Inspectors)
24510	Special course for MP Metro on "Dispute Resolution and Arbitration"	15.07.24	19.07.24	1 W	Campus	All officials of MPMRCL
24225	Webinar: Construction of embankment on soft soils	19.07.24	19.07.24	1 Day	Online	All officers & Supervisors
24420	Concrete technology and PSC construction	29.07.24	02.08.24	1 W	Campus	All officers
24421	Mechanised maintenance & Track tolerances and Track Monitoring	29.07.24	02.08.24	1 W	Campus	All officers

AUGUST						
24226	Webinar: Design with Curves for high speed 160 Kmph/180 Kmph	02.08.24	02.08.24	1 Day	Online	All officers & Supervisors
24422	Derailment Investigation	05.08.24	09.08.24	1 W	Campus	All officers
24103	Integrated	05.08.24	25.10.24	12 W	Campus	Gr. B officers
24423	Tunneling	05.08.24	16.08.24	2 W	Campus	All officers
24227	Webinar: Raising of speed on curves to 160/200 Kmph	16.08.24	16.08.24	1 Day	Online	All officers & Supervisors
24453	MIDAS	20.08.24	24.08.24	1 W	Campus	Officers and Design Assistants
24308	Workshop on Station development	20.08.24	21.08.24	2 Days	Campus	Dy.CE/CE/Station development
24309	CAO(C) Seminar	22.08.24	23.08.24	2 Days	Campus	All CAO(C) of Railways
24425	Project Management Tools & Software	26.08.24	30.08.24	1 W	Campus	All officers
24426	USFD & Rail Grinding	26.08.24	30.08.24	1 W	Campus	All officers
24228	Webinar: B- Scan USFD	29.08.24	29.08.24	1 Day	Online	All officers & Supervisors
SEPTEMBER						
24511	Special course for MP Metro on "Dispute Resolution and Arbitration"	02.09.24	06.09.24	1 W	Campus	All officials of MPMRCL
24516	Special course on 'LWR including mechanised maintenance' for CFM Mozambique through RITES	02.09.24	13.09.24	2 W	Campus	All officials of CFM Mozambique
24202	Sr.Professional course(Bridge)	09.09.24	04.10.24	4 W	Campus	JAG, Selection Grade, SAG Officers
24427	Fabrication and inspection of steel girders	09.09.24	13.09.24	1 W	Campus	All officers
24428	Special course for Gati Shakti Unit	09.09.24	13.09.24	1 W	Campus	XEN/Dy.CPM/ CPM/GSU
24229	Webinar: Controlling rail weld failures in LWR & precautions during repairs.	12.09.24	12.09.24	1 Day	Online	All officers & Supervisors
24424	LWR & Yard Layout	16.09.24	20.09.24	1 W	Campus	All officers
24429	Bridge Planning and construction	16.09.24	20.09.24	1 W	Campus	All officers
24430	Concrete technology and durability	23.09.24	27.09.24	1 W	Campus	All officers
24517	Special course on LWR and Mechanized Maintenance for Sri Lanka Railway Officials.	23.09.24	05.10.24	2 W	Campus	Sri Lanka Railway Personnel (P.Way Inspectors & Engineers)
24230	Webinar: Track Tolerances, Track Monitoring and maintenances	27.09.24	27.09.24	1 Day	Online	All officers & Supervisors
24431	Bridge inspection and maintenance	30.09.24	04.10.24	1 W	Campus	All officers
OCTOBER						
24432	Contract & Arbitration, IRWCMS	07.10.24	18.10.24	2 W	Campus	All officers
24454	STAADPRO	07.10.24	11.10.24	1 W	Campus	Officers & Design Assistants

24231	Webinar: Use of HSFG Bolts in Railways	11.10.24	11.10.24	1 Day	Online	All officers & Supervisors
24012	Course for MES Eng.	14.10.24	18.10.24	1 W	Campus	MES Engineers
24512	PSU Course Slot	14.10.24	25.10.24	2 W	Campus	
24433	USFD & Rail Grinding	21.10.24	25.10.24	1 W	Campus	All officers
24232	Webinar: Policy & Guidelines on QAP for steel/steel composite Bridge girders	25.10.24	25.10.24	1 Day	Online	All officers & Supervisors
NOVEMBER						
24002	IRMS (Civil)(Phase-II)	11.11.24	03.01.25	8 W	Campus	IRMS (Civil) 2022 (Exam Batch)(P)
24104	Integrated	11.11.24	31.01.25	12 W	Campus	Gr. B officers
24310	IRICEN Day	13.11.24	15.11.24	3 Days	Campus	IRSE 98 batch
24434	Formation construction	18.11.24	22.11.24	1 W	Campus	All officers
24233	Webinar: Calculation of design discharge for bridge using GIS techniques	22.11.24	22.11.24	1 Day	Online	All officers & Supervisors
24435	LWR & Yard Layout	25.11.24	29.11.24	1 W	Campus	All officers
24311	Workshop on Station development	25.11.24	26.11.24	2 Days	Campus	Dy.CE/CE/Station development
24312	CE/TMC Seminar	28.11.24	29.11.24	2 Days	Campus	All CE/TMC of Railways
DECEMBER						
24436	Concrete technology and PSC construction	02.12.24	06.12.24	1 W	Campus	All officers
24234	Webinar: LWR on sharp curves and steep gradients	06.12.24	06.12.24	1 Day	Online	All officers & Supervisors
24437	Mechanised maintenance & Track tolerances and Track Monitoring	09.12.24	13.12.24	1 W	Campus	All officers
24438	Derailment Investigation	16.12.24	20.12.24	1 W	Campus	All officers
24439	Fabrication and inspection of steel girders	16.12.24	20.12.24	1 W	Campus	All officers
24235	Webinar: Controlling rail weld failures in LWR & precautions during repairs.	19.12.24	19.12.24	1 Day	Online	All officers & Supervisors
24236	Webinar: Track tolerances & TRC	27.12.24	27.12.24	1 Day	Online	All officers & Supervisors
24455	AutoCAD/EDAS	30.12.24	03.01.25	1 W	Campus	All officers

SSTW Calendar of Courses -2024

COURSE NO	COURSE NAME	FROM	TO	DURATION	TIMINGS	ELIGIBILITY
JULY						
24612	Refresher Course (P.Way)	01.07.24	19.07.24	3 W	Campus	JE/SSE (P.Way)
24825	CAD	01.07.24	05.07.24	1 W	Campus	All JEs/SSEs
24826	Special course for JE/ SSE(Drawing)	08.07.24	19.07.24	2 W	Campus	JE/SSE (Drawing)
24613	Refresher Course (Bridges)	15.07.27	02.08.24	3 W	Campus	JE/SSE (Bridge)
24614	Refresher Course (USFD)	29.07.24	03.08.24	1 W	Campus	JE/SSE (USFD)
24827	P&C, Yard layout improvement and maintenance	22.07.24	26.07.24	1 W	Campus	JE/SSE (P.Way)
24902	Special Course for executives of DFCCIL GR. I Ph-II	29.07.24	25.10.24	13 W	Campus	Executive of DFCCIL
AUGUST						
24904	Special Course for Sr. Project Engineers/ Project Engineers of MRVC Gr. I	05.08.24	17.08.24	2 W	Campus	Sr. Project Engineers/ Project Engineers of MRVC
24615	Refresher Course (P.Way)	05.08.24	23.08.24	3 W	Campus	JE/SSE (P.Way)
24905	Special Course for Sr. Project Engineers/ Project Engineers of MRVC Gr. II	20.08.24	31.08.24	2 W	Campus	Sr. Project Engineers/ Project Engineers of MRVC
24828	Certificate course in Basics of Railway construction Project Supervision (Civil)	26.08.24	30.08.24	1 W	Campus	Engineers of PMS/ PSSA/ Contractors working on IR Projects/Works having completed Graduation/ Diploma in Civil Engineering
SEPTEMBER						
24616	Refresher Course (P.Way)	02.09.24	20.09.24	3 W	Campus	JE/SSE (P.Way)
24829	Tunneling	09.09.24	13.09.24	1 W	Campus	JE/SSE (Works & Bridge)
24830	Modern Surveying and Land Management	23.09.24	27.09.24	1 W	Campus	JE/SSE (Works)
24617	Refresher Course (USFD)	30.09.24	05.10.24	1 W	Campus	JE/SSE (USFD)
OCTOBER						
24618	Refresher Course (P.Way)	07.10.24	25.10.24	3 W	Campus	JE/SSE (P.Way)
NOVEMBER						
24619	Refresher Course (P.Way)	11.11.24	29.11.24	3 W	Campus	JE/SSE (P.Way)
24831	Fabrication & Launching of steel Girder	18.11.24	22.11.24	1 W	Campus	JE/SSE (Bridge)

24903	Special Course for executives of DFCCIL GR. II Ph-I	18.11.24	07.02.25	12 W	Campus	Executive of DFCCIL
24832	Certificate course in Basics of Railway construction Project Supervision (Civil)	25.11.24	29.11.24	1 W	Campus	Engineers of PMS/ PSSA/ Contractors working on IR Projects/Works having completed Graduation/ Diploma in Civil Engineering
DECEMBER						
24620	Refresher Course (USFD)	02.12.24	07.12.24	1 W	Campus	JE/SSE (USFD)
24833	Derailment Investigation	02.12.24	06.12.24	1 W	Campus	JE/SSE (P.Way)
24834	P&C, Yard layout imrpovement and maintenance	09.12.24	13.12.24	1 W	Campus	JE/SSE (P.Way)
24835	Inspection and Maintenance of Bridge	09.12.24	13.12.24	1 W	Campus	JE/SSE (Bridge)
24621	Refresher Course (P.Way)	16.12.24	03.01.25	3 W	Campus	JE/SSE (P.Way)
24622	Refresher Course (Works)	16.12.24	27.12.24	2 W	Campus	JE/SSE (Works)
24836	Mechanised maintenance,Track tolerances & Track Monitoring and Rail Grinding	30.12.24	03.01.25	1 W	Campus	JE/SSE (P.Way)



66th IRICEN DAY 2023

Calendar Of Courses IRICEN 2024(Revision-4 Date:- 13.06.2024)

Month & Year	Dec.2023				Jan.2024					Feb.2024				Mar.2024				Apr.2024					May 2024				June 2024			
Hostel Capacity	55	75	55	68	48	53	48	48	33	71	71	66	76	44	94	94	35	55	49	49	64	64	64	56	81	71	66	66	71	35
Date (Monday)	4	11	18	25	1	8	15	22	29	5	12	19	26	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24
Institute holidays				25				26				19					25 & 29		9 & 11			1			23				17	
IRMS (Civil)															24001 Appreciation course															
Trainees															40	40														
Integrated courses	23105 Integrated											24101 Integrated												24102 Integrated						
Trainees	25	25	25	25	0	25	25	25	25	25	25	19	19	19	19	19	0	19	19	19	19	19	19	31	31	31	31	31	31	0
Sr.Prof. courses																			24201 Sr.Professional course(P.Way)											
Trainees																			15	15	15	15								
Track courses	23458		23459	23417	24401														24407	24408	24409	24410	24411							
Trainees	15		15	20	20														15	15	15	15	15							
Bridge Courses	23442		23443 Bridge - Constructi		24402											24405 Bridge Design												24414		24416
Trainees	15		15	15	20											20	20	20										20		20
Work courses						24403								24404 Contract & Arbitration				24701								24412	24413		24415	
Trainees						20								10	10			16								20	20		20	
Software courses													24451 MIDAS													24452			24456	
Trainees													20													20			20	
Courses for PSU							24501 Special			24502 Special			24503 Special			24504 Special					24505 Special		24514	24506 Special			24507 Special			24508 Special
Trainees							15	15		16	16		15	15		15	15				15	15	20	15	15		15	15		15
Courses for PSU				23504 Special course for Junior Managers of DFCCIL Gr. II Phase II																			24515 Special course for Dhaka Metro							
Trainees				8	8	8	8	8	8	8	8												10	10	10					
Courses for PSU										24513 Special course for Civil Engineers of RITES.																				
Trainees										22	22	22	22																	
Webinars					24211	24212		24213	24237	24214	24239 Webi	24215 Webin	24240 Webina	24241	24242 &	24216,24	24238	24218		24219				24221 &	24304		24222		24223	
HAG/SAG Seminars		23307										24303 CTE			24302										24305					
Trainees		50										25			25										25					
Misc.																														
Spare Capacity available	13	-7	13	0	20	15	20	20	35	-3	-3	2	-8	24	-26	-26	33	13	19	19	4	4	4	12	-13	-3	2	2	-3	33

Month & Year	July 2024					Aug.2024				Sep.2024					Oct.2024				Nov.2024				Dec.2024					Jan.2025				Feb.2025			
Hostel Capacity	81	66	67	47	66	65	45	70	65	65	70	70	70	70	65	65	65	0	0	60	55	75	50	55	50	35	55	25	25	25	25	0	0	0	0
Date (Monday)	1	8	15	22	29	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	**3**	**10**	**17**	**24**
Institute holidays							15	19						2				31 & 1		15						25									
IRMS (Civil)																24012 MES		Diwali Holiday, No teaching activity		24002 IRMS (Civil)(Phase-II)															
Trainees																				10	10	10	10	10	10	10	10								
Integrated courses						24103 Integrated														24104 Integrated															
Trainees	31	31	31	31	31	25	25	25	25	25	0	25	25	25	25	25	25			25	25	25	25	25	0	25	25	25	25	25	25				
Sr.Prof. courses											24202 Sr.Professional course(Bridge)																								
Trainees											15	15	15	15																					
Track courses	24417	24418			24421	24422			24426			24424					24433					24435		24437	24438										
Trainees	15	20			20	20			20			15					20					15		20	20										
Bridge Courses		24419			24420						24427	24429	24430	24431									24436		24439										
Trainees		15			15						15	15	15	15									15		20										
Work courses	24406					24423 Tunneling			24425		24428				24432 Contract & Arbitration						24434														
Trainees	20					20	20		20		20				20	20					20														
Software courses								24453							24454												24455								
Trainees								20							20												20								
Courses for PSU			24509 Special							24516 Special			24517 Special																						
Trainees	15		16	16						20	20		15	15																					
Courses for PSU			24510							24511						24512 PSU Slot																			
Trainees			20							20						20	20																		
Courses for PSU																																			
Trainees																																			
Webinars	24224		24225		24226		24227	24308	24228		24229		24230		24231		24232				24233	24311	24234		24235	24236									
HAG/SAG Seminars								24309												24310		24312													
Trainees								25												25		25													
Misc.																																			
Spare Capacity available	-13	2	1	21	2	3	23	-2	3	3	-2	-2	-2	-2	3	3	3	68	68	8	13	-7	18	13	18	33	13	43	43	43	43	68			

Calendar Of Courses SSTW 2024(Revision-4 Date:- 13.06.2024)

Month & Year	Dec.2023				Jan.2024					Feb.2024				Mar.2024				Apr.2024					May 2024				June 2024			
Hostel Capacity	67	67	67	67	67	75	75	50	25	50	50	25	50	50	50	50	25	75	50	75	83	83	83	83	83	83	83	83	83	83
Date (Monday)	4	11	18	25	1	8	15	22	29	5	12	19	26	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24
Institute holidays				25				26				19					25 & 29		9 & 11			1			23				17	
Track courses	23624 Refresher Course		23626 Refresher Course (P.Way)			24601 Refresher Course (P.Way)			24603	24604 Refresher Course (P.Way)				24605 Refresher Course (P.Way)				24607 Refresher Course (P.Way)					24609 Refresher Course (P.Way)			24610	24611 Refresher Course (P.Way)			
Trainees	25	25	25	25	25	25	25	25	25	25	25	25		25	25	25		25	25	25			25	25	25	25	25	25	25	
Track courses						24802							24807	24809				24606				24815						24821		24823
Trainees						25							25	25				25				25						25		25
Bridge courses						24602 Refresher Course				24804								24812 Fabrication and inspection of								24819			24822	
Trainees						25	25	25		25								25	25	25						25			25	
Work courses	23625	23832	23830	23831	24801		24803				24805		24808		24810	24811 Special course for				24813	24608 Refresher Course		24816	24817	24818		24820			24824
Trainees	25	25	25	25	25		25				25		25		25	25	25			25	25	25	25	25	25		25			25
Courses for PSU	23907 Special Course for executives of DFCCIL GR. III Ph-II																				24901 Special Course for executives of DFCCIL GR. I Ph-I									
Trainees	17	17	17	17	17																33	33	33	33	33	33	33	33	33	33
Misc.																					24814									
Trainees																					25									
Spare Capacity available	-17	-17	-17	-17	-17	-25	-25	0	25	0	0	25	0	0	0	0	25	-25	0	-25	-33	-33	-33	-33	-33	-33	-33	-33	-33	-33

Month & Year	July 2024					Aug.2024				Sep.2024					Oct.2024				Nov.2024				Dec.2024					Jan.2025				Feb.2025			
Hostel Capacity	83	83	83	75	50	83	78	78	78	78	58	83	58	58	58	58	58	0	0	25	75	75	75	75	75	75	75	25	25	25	25	25	0	0	0
Date (Monday)	1	8	15	22	29	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24
Institute holidays							15	19						2				31 & 1		15						25									
Track courses	24612 Refresher Course (P.Way)				24614	24615 Refresher Course (P.Way)				24616 Refresher Course (P.Way)				24617	24618 Refresher Course (P.Way)			Diwali Holiday, No teaching activity		24619 Refresher Course (P.Way)			24620		24621 Refresher Course (P.Way)										
Trainees	25	25	25		25	25	25	25		25	25	25		25	25	25	25			25	25	25	25		25	25	25								
Track courses				24827																			24833	24834			24836								
Trainees				25																			25	25			25								
Bridge courses			24613 Refresher Course (Bridges)																		24831			24835											
Trainees			25	25	25																25			25											
Work courses	24825	24826 Special course for							24828		24829		24830									24832			24622 Refresher Course										
Trainees	25	25	25						25		25		25									25			25	25									
Courses for PSU					24902 Special Course for executives of DFCCIL GR. I Ph-II																24903 Special Course for executives of DFCCIL GR. II Ph-I														
Trainees	33	33			33	33	33	33	33	33	33	33	33	33	33	33	33				25	25	25	25	25	25	25	25	25	25	25	25			
Misc.						24904 Special Course for		24905 Special Course for																											
Trainees						20	20	20	20																										
Spare Capacity available	-33	-33	-25	0	-33	-28	-28	-28	-28	-8	-33	-8	-8	-8	-8	-8	-8			25	-25	-25	-25	-25	-25	-25	-25	25	25	25	25	25	50		