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STRENGTH PROBLEMS ASSOCIATED WITH TRACK BRIDGE INTERACTION IN PRESENCE OF CONTINUOUSLY WELDED RAIL

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Abstract
Continuous welded rail (CWR) most widely used. Today increasing the continuous welded rail day to day. Continuous welded rail having less maintenance cost and more life span. This chapter discusses about track bridge interaction which effects on stress and support reaction on rail and deck. Due to temperature variation rail stresses are developed.The present study done by SAP2000,by finite element method (FEM).This report include track-bridge interaction phenomenon, numerical modeling, numerical studies. In numerical study effect of stiffness variation, effect of bridge deck span length variation and effect of temperature variation are computed.

Introduction
Railways are important for travelling and goods carrying. Which are cheap and helped for long traveling. Also increasing the population of the country we need more and more rail network in India. As per the modernization of the railways occurred introduction of high-speed trains, technological improvements in track structure, maintenance works etc as the summer seasons the gap between the rail thermal expansion occurred. The joints will be weaken and more track maintenance cost required. To overcome this we use continuous welded rail (CWR). Continuous welded rail (CWR) having more than 1 km long, which having more length than short welded rail (SWR), long welded rail (LWR).Continuous welded rail reduces track maintenance cost, also increases life cycle. Not only several kilometer long but also expansion when temperature change occurred.
Bridges are the important part of rail network. Bridges helps to passage over the river. According to different topographical condition bridges are different structural shape such as girder and deck, box girder, truss etc.
The rigid guided way in which train run is known as track. The track which are placed over the deck carrying load on bridge. CWR and long welded rail poses positive impact on durability of the track, quality and maintenance. The bond between train and supporting structures are is important. A detailed study helps the Effects on them.

Rail joint
The UIC 60 rail standard length is 13m.The track structures are formed by joining of short length of rails. Rail joint requires 30 percentage than plain track. Some of the problems of rail joint: more manpower, poorer riding quality, lesser life span of the track, noise pollution etc.

Types of welded rails

Short welded rails (SWR)

3, 5 or 10 rail lengths are joined together form the rail. Expansion and contraction are the specification of short welded rail.

Long welded rails (LWR)

Temperature variations are affected only at the end portion not in the central part. LWR having minimum length of 200 m, maximum length having 1 km.

Continuous welded rails(CWR)

CWR having more than 1 km length. Which is greater than short welded rail and long welded rail.

Thermal stresses in cwr

Due to temperature variation rail which are expanded and contracted. The rail expansion due to linear expansion of rail material, the length of the rail, and variation in rail temperature. The layer of ballast which resist the movement of sleepers. The giving rise to locked up internal stresses in the rail formed due to restriction of free movement of the rail under thermal and traffic loads. The resulting forces are

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$F = E x A x \alpha x \Delta TR$

Where, F= force in the rail

E=modulus of elasticity of the rail material

A= cross-sectional area of the rail

A= coefficient of thermal expansion

ΔTR = change in rail temperature relative to the laying temperature

Thermal force variation in cwr

Due to thermal effects the variation of the longitudinal forces in a CWR track is shown in fig 1. If no restraint at the ends of the rail, they are assumed to be frictionless. At the center of the rail forces are constant. At the central zone of a CWR, all longitudinal movement is completely prevented. The expansion devices in the breather portion at the ends of CWR. The breather zones varies from 100 to 150 m.

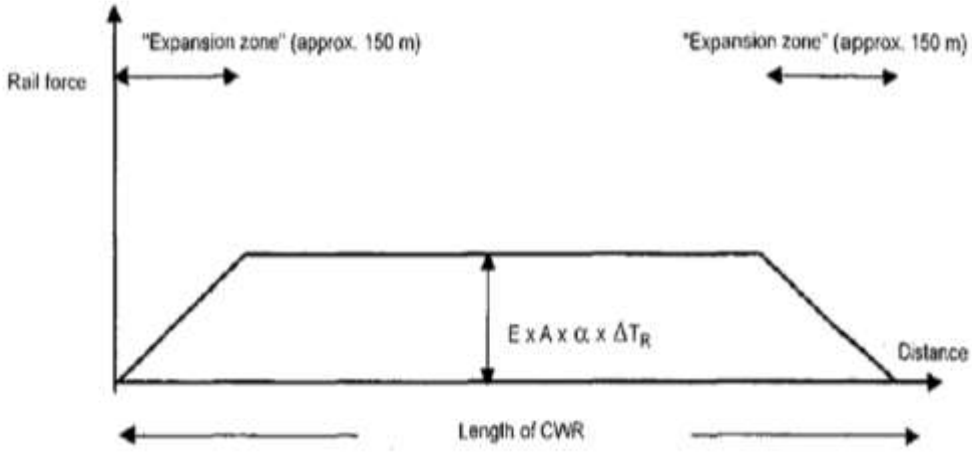

Fig 1 Variation of force due to thermal variation in CWR

Importance in Indian environment

Due to its advantages continuous welded rail has been are popular today. CWR and LWR tracks having low maintenance cost, simple to handle and suitable for high speed rail track. Problems associated with CWR tracks (Track-bridge interaction phenomenon) are major worry and implement this project. UIC codes are used for calculating stresses and displacement in continuous welded rail. But unfortunately no such codes are available for the feasibility of CWR track in indian context.

Objective for the study

The present work consists of continuous welded rail on the deck of bridge. The structure with suitable assumptions and interpret the results considering various types of forces/stresses attributed to continuity of track can be model with SAP2000.

The present study deals with:

- To develop a numerical modeling of track-bridge interaction phenomenon and parametric strength problems associated with it.
- Effect of temperature variation of track bride interaction phenomenon.
- Variation stresses and deck support reaction due to stiffness variation.
- Variation stresses and deck support reaction due to span length variation.

Guidelines of UIC leaflet 774-3(R)

UIC leaflet 774-3(R) track bridge interaction the primary work on the issues related to track-bridge interaction explored, explained and quantified. Track/ Bridge interaction calculation based on ERRI specialist committee which methods gives displacement and force linked to the interaction phenomenon. Different chart available for varieties of span,loads and support stiffness. Salient features and main assumptions of UIC recommendations are as follows:

- CWR over bridges having the effects is examined independently the Vertical bending of the track and bridge.
- Track and bridge are assumed to be bilinear. Resistance increases with displacement for track relative to bridge for small initial displacement. For increasing displacement the resistance remains constant.

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Methodology

Numerical studies has been conducted on a model for track-bridge interaction. For purpose of analysis work stiffness / finite element approach used.SAP2000 sofware have been used for creating the model and analysis. Validation of the model developed for rail stresses and bridge support reaction for UIC 774-3(R), and compared span length variations and then find percentage error less than 5 percentage Rail stress at fixed end, moveable end. Then due to the interaction phenomenon calculation of added stresses in rails, parametric study on track-bridge interaction for span length variations, temperaturevariations, stiffness variation. Then get the results. The flow diagram of methodology shown in fig 2.

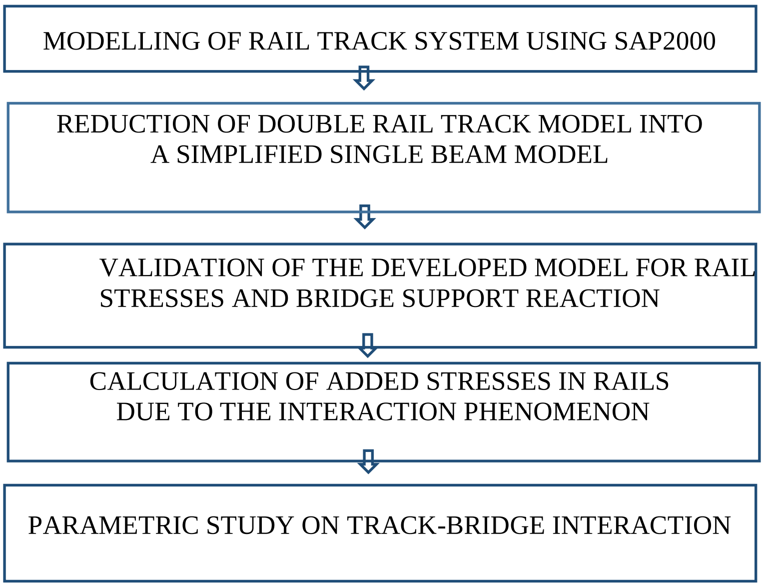

Fig 2 The flow diagram of methodology

Modeling of simply supported single track girder steps for modeling

First of find the Input data from rail sections. Then Create the rail model in sap2000.Then In put the ballast properties by using SAP2000.Then find out boundary length. Then create bridge deck. Then vary the span length and validated the structure.

Track bridge model

Different models for support stiffness, varying deck span and temperature are carry out or parametric study of the track bridge interaction. The deck stiffness variation from 0 to 1000 KN/mm for deck. A span length variation from 20m to 100m. The deck temperature $\pm 35°C$considered . Fig 3 shows Simplified track bridge model with sufficient boundary length on both the ends. Fig 4 shows Track and bridge model.

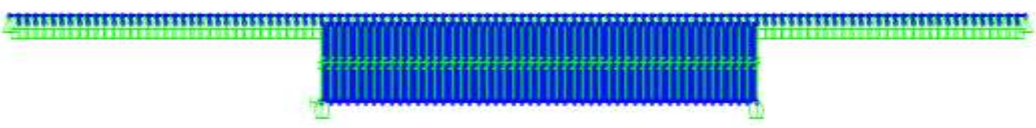

Fig 3 Simplified track bridge model with sufficient boundary length on both the ends (SAP2000)

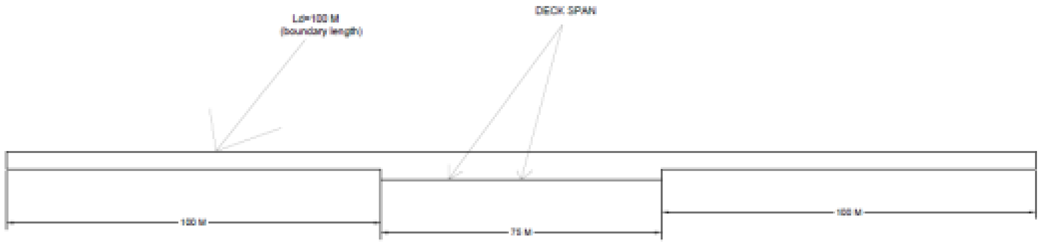

Fig 4 Track and bridge model

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The boundary length of the modal

The boundary length can be find out from the compares the temperature increment of 10 ^{O}C for the stress developed in the rail. Table 1 shows Stress developed in various lengths of the rail for boundary conditions.

Table 1 Stress developed in various lengths of the rail for boundary conditions

L	Stress (N/mm^2)	Percentage error
10	6.622	85.090
20	18.65	58.009
30	28.66	35.4755
40	35.189	20.772
50	39.08	12.011
60	41.35	6.90
70	42.65	3.97
80	43.408	2.26
90	43.8	1.38
100	44.08	0.75
Both ends fixed	44.415	0

Validation of the model

For the validation the values are taken from UIC 774-3R.

Verification of rail stress

Table 2 shows the validation for the rail stress at the fixed elastic end of the bridge. Table 3 shows validation for the rail stress at the movable end of the bridge.Table 4 validation for the support reaction at the fixed end of the bridge

Table 2 validation for the rail stress at the fixed elastic end of the bridge

Span	Rail Stress at the fixed elastic end		Percentage error
	SAP2000 value	UIC 774-3R value	
35 m	5.91	6.05	2.31
60 m	8.43	8.60	1.97
75 m	9.028	9.40	3.95
90 m	10.15	10.50	3.33

Table 3 validation for the rail stress at the movable end of the bridge

Span	Rail Stress at the movable end		Percentage error
	SAP2000 value	UIC 774-3R value	
35 m	15.17	14.60	3.75
60 m	26.14	27.00	3.15
75 m	33.14	34.00	2.52
90 m	41.14	42.00	2.03

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Table 4 validation for the support reaction at the fixed end of the bridge

Span	fixed elastic support reactions		Percentage error
	SAP2000 value	UIC 774-3R value	
35 m	305	295	3.27
60 m	551	530	3.81
75 m	668	660	1.19
90 m	776	800	3.00

Numerical study and observations

From the numerical analysis of the models the results are obtained from SAP2000 are described in this chapter. From the results we get rail stress and support reaction from this. Important points of structural behavior are discussed. For better understanding of the phenomenon are are given below

- Model having span varied from 20m to 100m.
- Horizontal ballast resistance = 20 KN at 2mm
- Lateral ballast stiffness = 5000 KN/m

For numerical study and observation we consider effect of stiffness variation, effect of bridge deck span length variation and effect of thermal variation

Effect of stiffness variation

A stiffness variation from 0 to 1000 KN/mm is considered. Then find out support reaction at the fixed end (KN), rail stress at fixed end (N/mm^2), rail stress at moveable end (N/mm^2). Here table 5 shows stiffness variation. Fig 5 shows stiffness variation stress. Fig 6 shows stiffness variation support reaction.

Table 5 Stiffness variation

K(x10^3 KN/mm)	support reactions at the Fixed end(KN)	rail stress at fixed end(N/mm^2)	rail stress at the moveable end (N/mm^2)
0	362.6	-14.994	14.994
50	520.72	-2.172	25.746
100	669.65	4.169	29.683
200	742.31	10.569	32.965
300	785.67	13.831	34.426
400	814.51	15.825	35.252
500	835.27	17.165	35.786
600	850.75	18.139	36.162
700	862.9	18.872	36.436
800	872.59	19.448	36.649
900	880.59	19.909	36.818
1000	981.89	20.289	36.958

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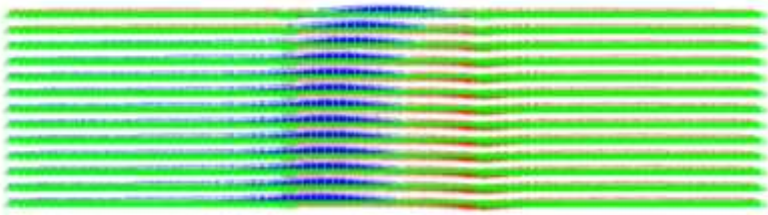

Fig 5 stiffness variation stress

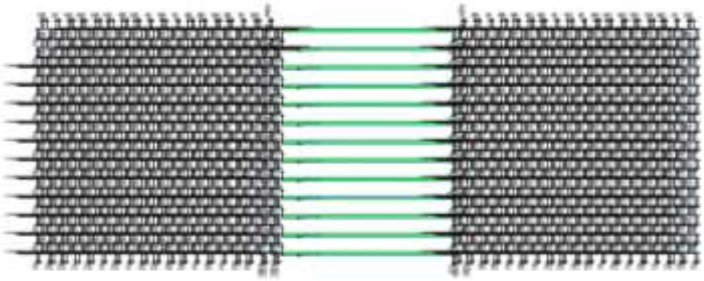

Fig 6 stiffness variation support reaction

Effect of bridge deck span length variation

Deck of span length variation from 20 m to 100 m. Then find out support reaction at the fixed end (KN), rail stress at fixed end (N/mm^2), rail stress at moveable end (N/mm^2). Table 6 shows bridge deck span length variation.

Table 6 Bridge deck span length variation

Span(m)	support reactions at the Fixed end(KN)	rail stress at fixed end(N/mm^2)	rail stress at the moveable end (N/mm^2)
20	195.14	4.677	8.008
25	242.99	5.705	10.363
30	289.4	6.067	12.746
35	335.28	6.623	15.173
40	380.38	7.106	17.622
45	424.59	7.517	20.085
50	478.74	7.763	23.359
55	531.43	7.982	27.465
60	551.88	8.43	29.147
65	591.95	8.665	29.817
70	630.89	8.865	32.149
75	668.69	9.027	33.144
80	705.71	9.164	36.714
85	741.38	9.254	38.944
90	776.04	9.306	41.145
95	810.06	9.327	43.336
100	842.62	9.302	45.478

Effect of temperature variation

The deck temperature variation from 0 to 50 ^{0}C. Table 7 shows deck increasing temperature variation. Table 8 deck decreasing temperature variation

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Table 7 deck increasing temperature variation

Deck temperature ^{0}C	support reactions at the Fixed end(KN)	rail stress at fixed end(N/mm^2)	rail stress at the moveable end (N/mm^2)
5	154.89	-0.081	10.15
10	292.17	0.306	18.686
15	393.78	1.579	24.02
20	477.87	3.607	27.459
25	550.56	5.959	29.832
30	613.98	8.322	31.592
35	669.65	10.569	32.965
40	718.74	12.647	34.078
45	762.38	14.558	35.004
50	800.9	16.287	35.779

Table 8deck decreasing temperature variation

Deck temperature ^{0}C	support reactions at the Fixed end (KN)	rail stress at fixed end (N/mm^2)	rail stress at the moveable end (N/mm^2)
-5	-154.89	0.086	10.15
-10	-292.17	-0.297	18.696
-15	-393.78	-1.566	24.031
-20	-477.87	-3.594	27.47
-25	-550.56	-5.946	29.843
-30	-613.98	-8.308	31.603
-35	-669.65	-10.555	32.976
-40	-718.74	-12.634	34.078

Conclusion & future scope

Summary

UIC codes are used for European countries for track bridge interaction. UIC code used for European condition not for Indian condition. For solving these problems using stiffness/finite element approach is considered for modeling this phenomenon in SAP2000.

Conclusions

- A simplified model using beam elements to model rails and bridge and spring elements to model various connections of the bridge-track system is developed and validated.
- From stiffness variationsincreases support reaction, stress at fixed and moveable end also increases. Due to bridge deck span length variation increases support reaction, stress at fixed and moveable end also increases. From bridge deck temperature variation increases support reaction, stress at fixed and moveable end also increases.
- The free end or also called the moving end of expansion span is observed to be critical location as large compressive forces are accumulated near to the free end.
- Study on the track strength would help track engineer to adopt measures to prevent track failure where an engineering structure will meet the CWR track. The interaction phenomenon need to be

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incorporated into the railway bridge design in India to eliminateexpansion joints and rail free fastenings and also to come out with optimum span length suitable for various temperature zones in India.

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