Analysis on Strengthening of Rail Joints

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Abstract: ***The rails laid down over the sleepers are made continuous by using welded connections, commonly the thermite welding technique. The damage of rails frequently occurs on the longitudinal and horizontal connection joints due to severe corrosion and fatigue. This paper investigates the performance of the strengthened rail joints. Three-dimensional finite element models were built to make a comparison between the strengthened and original rail joints. FRP sheets are used as a preventive maintenance on the joints to enhance the loading capacity as well as the durability of the existing connections. From the analysis obtained rail sections with FRP in two webs and in one flange was considered the best.***

Keywords: ***RAIL JOINTS, FRP, THERMITE WELD***

I. INTRODUCTION

Railway is the one of the most important mode of transportation for freight and passengers and playing a vital role in transportation of people across country for business, sight-seeing, education etc. Indian railway system is operated by the Ministry of Railways which helps in developing industry and agriculture and also binds the economic life of country. Indian railways are multi-gauge system operating on three gauges

- The broad gauge (1676mm)
- The meter gauge (1000mm)
- The narrow gauge (762mm and 610mm)

The track on a railway or railroad, also known as the permanent way, is the structure consisting of rails, fasteners, ballast and underlying sub grade. It enables trains to move by providing a dependable surface for their wheels to roll upon. It's often referred to as railway track or railroad track. Railway transport is capable of high levels of passenger and cargo utilization and energy efficiency, but is often less flexible and more capital- intensive than road transport, when lower traffic levels are considered. In 20th century, rail track used softwood timber sleepers and jointed rails and a considerable extent of this track type remains on secondary and tertiary routes. The main disadvantage of traditional track structures is the heavy demand for maintenance, particularly surfacing and lining to restore the desired track geometry and smoothness of vehicle running. Weakness of the sub grade and drainage deficiencies also leads to heavy maintenance costs.

1.1Components of Railway Track

The main component of railway track is

a) Rails
b) Ballast
c) Sleeper

The rolled steel sections which are laid end to end in two parallel lines over sleepers to form a railway track is called rails. Rail is graded by weight over a standard length. Heavier rail can support greater axle loads and higher train speeds without sustaining damage than lighter rails but at a very high cost. Rails provide hard, smooth and unchanging surface for passage of heavy moving loads with minimum friction between steel rail and steel wheel. Rails are mainly classified into three types;

I. Double headed rails
II. Flat footed rails
III. Bull headed rails

Rails having their head and foot of same dimensions which are known as double headed rails. The rail section having their foot rolled to a flat is known as flat footed rails. The rail section having their head of more dimension than that of their foot are called bull headed rails.

Fiber-reinforced polymer possesses outstanding advantages as a structural material, including high strength, anticorrosion properties, high durability and is able to restore the lose capacity of damaged structures. FRP sheets/strips are also effective in the strengthening of steel structural elements to extend their fatigue lifetime and reduce crack propagation if corrosion is prevented or sufficient bond is provided. CFRP material is commonly used for rehabilitation and strengthening of steel structures than any other FRP materials due to its high strength. CFRP is very tolerant to fatigue damage. Basalt- fiber reinforced polymers have increasingly considered in civil infrastructures because of low cost and their excellent chemical and mechanical properties. The successful implementation of FRP composites of the strengthening system is dependent upon the quality and integrity of the steel- composite joint and the effectiveness of epoxy adhesive used.FRP strengthening composites delay initial cracking, reduce the crack growth rate, extend the fatigue life and decrease the stiffness decay with residual deflection.

II.LITERATURE REVIEW

- Microstructure and mechanical response of thermite welded rail was analyzed by **Dr. Rajanna. S (2013).** In this paper, thermite welding is the method used in welding of rails. Heat treatment technique was used to improve the mechanical properties and weldment structures. In thermite welded rail, shows non symmetric hardness traverses along longitudinal direction of weldment. In the heat treated thermite welded rail, there is a significance differences in hardness between the base metal and heat affected zone. Hardness at weldment is lower than as compared thermite welded rail. Microstructure analysis was carried out with the help of SEM. Materials used was 52kg/m rail steel widely used as a rail road track. Thermite welded SEM shows that ferritic-pearlitic structure and consists of aluminium oxides. It exhibits low ductility and toughness due to the presence of carbon precipitate along the ferrite boundary. Results show that all the mechanical properties of thermite welded rails are lower due to reaction between welded metal and magnetite treatment. Heat treated thermite welded rail condition shows improvement in all mechanical properties as compared to as thermite welded rails due to minimize the residual stress in weldment.
- The fracture characteristics of cracked wide flange steel girder strengthened with CFRP was developed by **AmerHmidan and Yail J Kim (2014)**. A broad range of characteristics are considered to study their effects on the crack tip stress intensity of girders. A three-dimensional finite element approach is proposed and validated. Stochastic simulation is conducted to understand the vulnerability of the cracked girders and evaluate the efficiency of CFRP strengthening. Stress intensity factor of CFRP is not influenced by width and length but is influenced by the CFRP modulus and layers.
- A 3D model in FEM of double sided CFRP strengthened specimen was developed by **HeshamM.El-Emam and Hani A. Salem (2016)**, to study the fracture behaviour of inclined cracks under different loading conditions. Prestressing the CFRP produced a reduction in stress intensity factor by 70% and thus increased the fatigue life. The optimum benefit is obtained when the patch axial stiffness is about 50% of or below the plate stiffness. The effectiveness of CFRP is governed by the loading direction and crack inclination angle.
- The fatigue behaviour of FRP- to- steel interface and to develop a model to calculate the local deboned size with fatigue crack propagation was developed by **Hay- Tao and Gang Wu (2005).** The stress intensity factor and crack growth life of FRP repaired specimens were compared and parameter influencing the repair were analyzed. Stress intensity factor were quantified at crack tip. The fatigue crack growth lives were calculated and compared with fatigue test results. The estimated S-N curves were between the mean curve and mean 2s curve obtained from fatigue test results. Both single sided and double-sided repairs were investigated in order to investigate the effectiveness of composites on preventing fatigue crack and fatigue life of steel plates. Double sided bond and high modulus CFRP materials led to a better strengthening efficiency. During the fatigue test result, a beach marking was adopted to record the crack propagation developed with fatigue cycles.

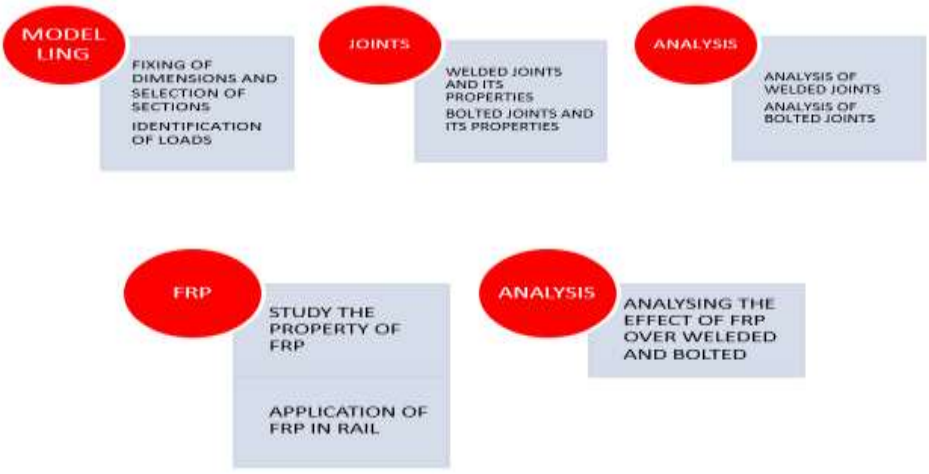
II. SCOPE AND OVERVIEW

The objective of this study includes

- Effect of welded connection in rail joints
- Effect of FRP on welded connections in rail joints
- Effect of bolted connections in rail joints
- Effect of FRP on bolted connections in rail joints

The scope of the study includes

- Effect of FRP in both welded and bolted connections in rail joints.
- Effect of welded connections and bolted connections in life of rail joints.



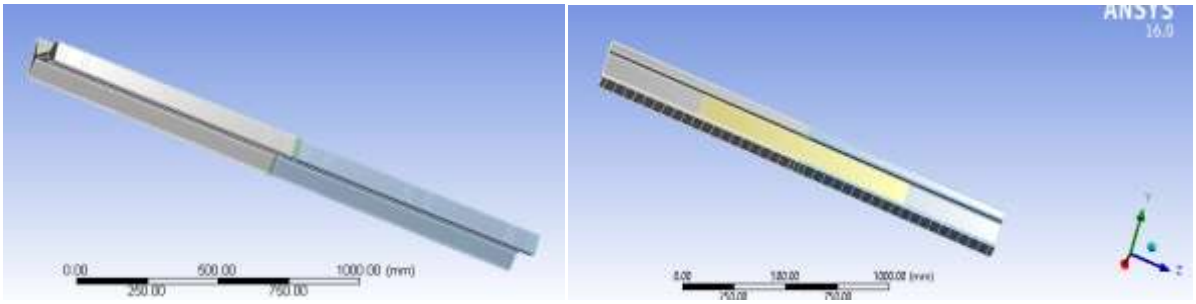
III.MODELLING AND ANALYSIS

Rails are joints are mainly classified into two types welded connections and bolted connections. Of the two connections existing three modifications were suggested, they are

1. FRP on two sides of web
2. FRP on two sides of web and on bottom flange and
3. FRP on two sides of web grooved.

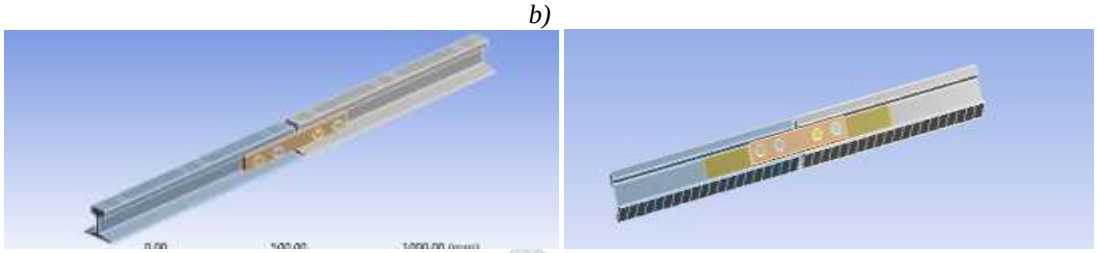
Along with these three cases the existing cases were also analysed resulting in a total number of eight models.

The specifications of the rail adopted are 60kg/m standard rail section adopted in the modern rail networks. The length of the rail on both sides of joint is 3.8 m, the minimum joint length and has a partially hinged support at every 30 cm length. The study is also done on rail sections with 1m length.



a) Normally Welded Rail Section b) Welded Rail Section with FRP On Two Sides of Web

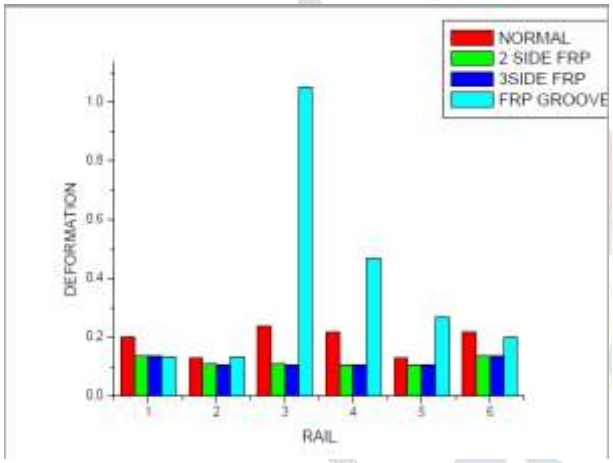
b)



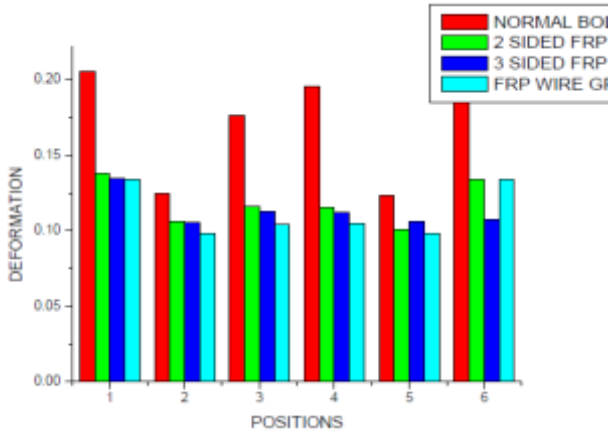
c) Normally Bolted Rail Section d) Bolted Rail Section with FRP on Two Sides of Web

IV.RESULTS AND DISCUSSIONS

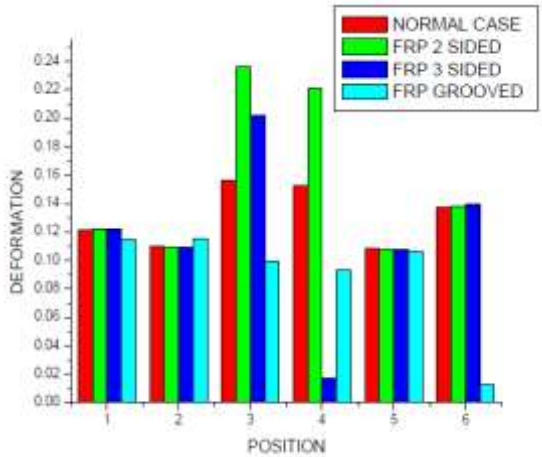
The rail models with a partially hinged condition were analyzed for their deformation, equivalent stress and maximum principal stresses for a load of 70 tons which is the maximum load that occurs in the rail. The vibration analysis along with the minimum life cycle is also carried out.



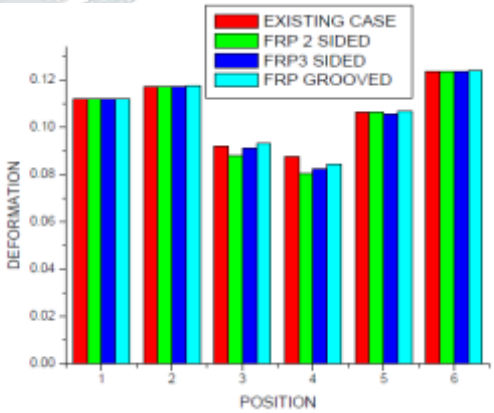
a) Welded joint- 1m



c) Bolted joint-1m



b) Welded joint -4m



d) Bolted joint – 4m

CONCLUSION

In the two cases investigated i.e. (i) FRP is applied to both sides of the web and (ii) on two sides of the web and bottom side of the flange, it is observed that the deformation was considerably reduced (approximately 20%), compared with the existing case of weld or bolted rail joint without FRP. But the third case of investigation i.e. FRP grooved to the surface is not found to be giving good results.

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