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COMPARISON OF LATERAL RESISTANCE BETWEEN I-SHAPED AND X-SHAPED SLEEPER USING DYNAMIC METHOD

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The side resistance of ballasted track is a crucial factor to maintain the stability of continuously welded rails. In this study, a new type of X-shaped sleepers was developed to increase the side resistance compared to conventional I- shaped sleepers. The performance of the X-shaped slumbered was examined using track panel drive- eschewal tests simulations. The results showed that the X-shaped slumbered could give 26 lesser side resistance compared to double I- shaped sleepers. This is due to the V- chopstick arms which distribute the central and side crib ballasts more effectively, enhancing the stability of the slumbered. Crib ballasts play a pivotal part in the side resistance of X-shaped sleepers, furnishing nearly double the side resistance compared to double I- shaped sleepers. Overall, the proposed X-shaped sleepers has stronger side resistance and stability, making it a promising option for future operations.

INTRODUCTION

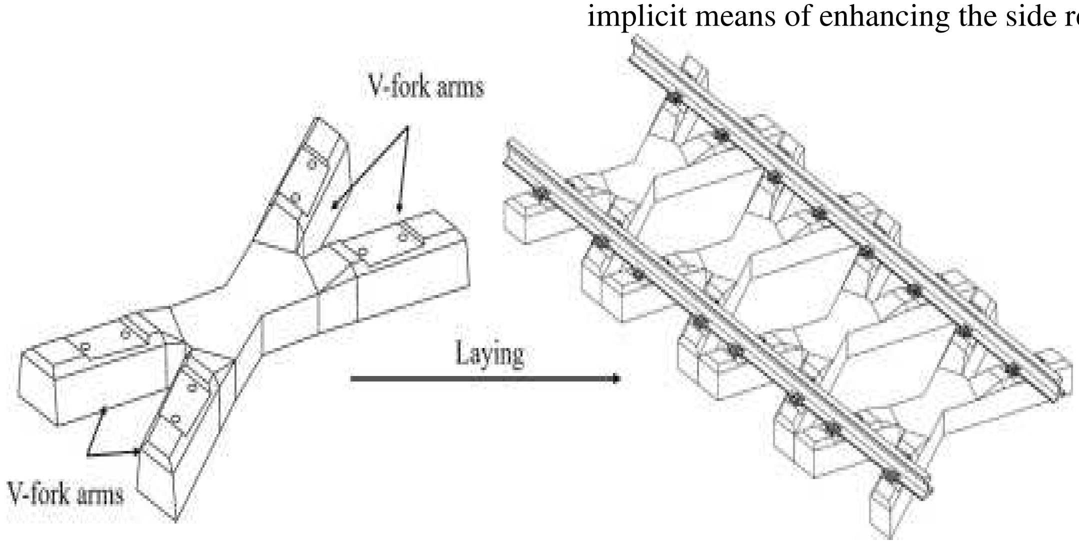
Railway sleepers play a crucial role in supporting railway tracks and distributing loads from trains to the underlying ballast. In this study, the analytical design of an I-shaped steel sleeper is investigated using the finite element method (FEM). The goal is to optimize the design to ensure adequate strength, stiffness, and durability while minimizing material usage and cost. Railway sleepers, also known as railroad ties, are essential components of railway tracks, providing support to the rails and distributing loads from passing trains to the underlying ballast. Traditional sleepers have been made of wood, but in recent years, there has been a shift towards using steel sleepers due to their superior strength, durability, and longevity. The design of steel sleepers is a critical aspect of railway track infrastructure, as it directly impacts the safety, stability, and performance of the tracks. The I-shaped steel sleeper, characterized by its distinctive profile resembling the letter "I," is commonly used in railway track construction due to its high bending strength and stiffness. The finite element method (FEM) is a powerful numerical technique used for analysing the structural behavior of complex systems, including railway sleepers. By dividing the sleeper into small elements and applying the principles of continuum mechanics, FEM can accurately predict the response of the sleeper under various loading conditions. This study aims to utilize the finite element method to analyses and optimize the design of I-shaped steel sleepers for railway applications. The objective is to develop a comprehensive analytical framework that considers the structural performance, material properties, and geometric characteristics of the sleeper to achieve an optimal design that meets all safety, performance, and cost criteria.

The research will involve modelling the sleeper using FEM, considering factors such as material properties, sleeper geometry, loading conditions, and boundary conditions. The results of the analysis will be used to optimize the sleeper design by adjusting key parameters to achieve a balance between strength, stiffness, durability, and cost-effectiveness.

Overall, this study will contribute to the advancement of analytical methods for designing steel sleepers and provide valuable insights into improving the performance and efficiency of railway track systems. the finite element system (FEM) system is used to anatomize the behavior of continuous paraphernalia and structures, an alogous as dozer and rail (Varandas et al., 2016, Nishiuraeta., 2018), while the separate element system (DEM) system is used to anatomize the behavior of weight (Indraratnaetal., 2015, Chenetal., 2015, Khatibietal., 2017, Gametal., 2020b). The FEM- DEM coupling system has been used to pretend the commerce between the continuous and separate corridor of the system, furnishing a more accurate and comprehensive analysis (Xiaoetal., 2022, Sos getal., 2019).

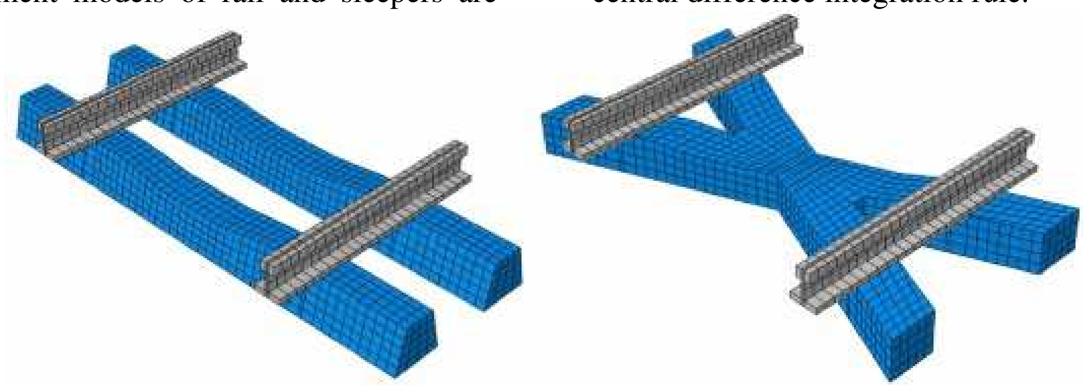
DESIGN OF NEW X-SHAPED SLEEPER

In the case of conventional I- shaped sleepers, also known as mono- block sleepers, the side resistance is primarily deduced from the disunion resistance performing from contact with the base cargo, crib cargo, and the end resistance caused by contact with the shoulder cargo. The experimental single sleeper drive-eschewal tests (SSPT) conducted by different experimenters may have variations in test spots, cargo specifications, sleepers' types, shoulder sizes, and the testing system employed (e.g., track panel tests versus single sleepers' tests). As epitomized in Table 1, the different factors of the total side resistance (base, crib, and shoulder) have different characteristics under loaded and disburdened conditions, and the resistance to side movement of a disburdened sleepers can vary extensively. The resistance handed by the base contact depends on the normal cargo, while that from the shoulder and crib cargo is mainly independent of the normal cargo. therefore, the crib and shoulder cargo resistance are always available, and play a pivotal part in guarding the track from buckling due to temperature- convinced compressive loads in the rails, whether or not a train is present (Le Pen and Powrie, 2011). thus, adding the contact with the crib cargo could be an implicit means of enhancing the side resistance.



FEM Methods

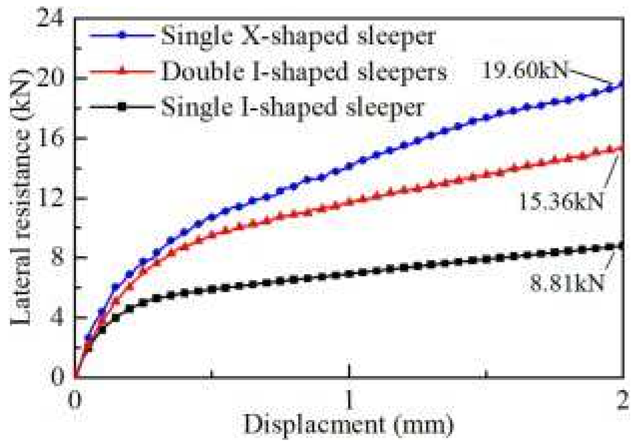
In this study, the FEM system was employed to pretend the sets of grainy accoutrements within ballasted track systems. The FEM system utilizes the important FEM element library and corresponding algorithms in ABAQUS to dissect the static or dynamic response of continua. It allows for the consideration of the commerce between separate cargo patches, and nonstop concrete sleepers model to achieve FEM system illustrates the way involved in enforcing the FEM system in ABAQUS, which includes both the model generation and computation processes. originally, separate element models of cargo and finite element models of rail and sleepers are created using different software. Next, their separate data is combined into a single input train for the ABAQUS solver. Within the solver, clicked multiple single- knot separate globular rudiments are used to rebuild the desultorily shaped ballasts. By exercising clicked separate rudiments as ballasts and finite rudiments as superstructure in the simulation, the coupling system is achieved in ABAQUS. The erected- in unequivocal dynamic solver of ABAQUS is used for the following computation, which involves enforcing an unequivocal integration rule in confluence with slant or "lumped" element mass matrices. The stir equations of the corridor are integrated using the unequivocal central difference integration rule.



(a) (b)

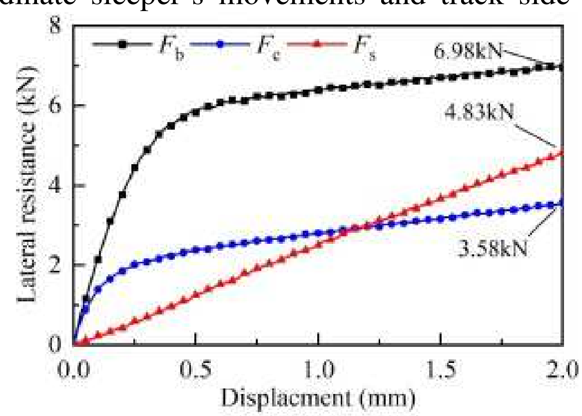
Resistance Comparison of Total Lateral

shows the side resistance of the X-shaped sleepers, double I- shaped sleepers, and single I- shaped sleepers during the simulation. It can be observed that the X-shaped sleepers exhibit the loftiest side resistance growth rate compared to the single and double I- shaped sleepers. At a relegation of 2 mm, the outside side resistance of the X-shaped sleepers is19.6 kN, while that of the single and double I- shaped sleepers is8.81 kN and15.36 kN, independently. Compared to double I- shaped sleepers, the side resistance of the X-shaped sleepers is 27 advanced, and the growth gap tends to increase after 2 mm. also, when comparing the side resistance between single and double I- shaped sleepers, it can be noted that there's no direct relationship between the side resistance and the number of sleepers. This observation is harmonious with Zakeri et al. (2020), where adding the number of sleepers didn't proportionally increase the side resistance. This miracle indicates that the resistance offered by a single sleeper in double I- shaped sleepers is reduced.

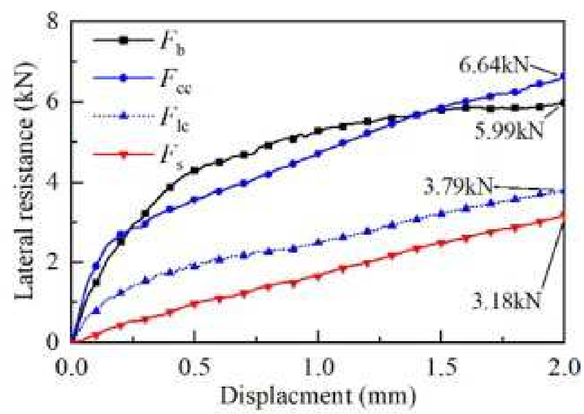


LATERAL RESISTANCE DISTRIBUTION OF SLEEPER

As one of the main structural forms, ballasted tracks are extensively used in heavy haul and high- speed railroads. They correspond of a cargo subcaste, sleepers, and rails. The cargo subcaste supports the sleepers and bears the perpendicular, transverse, and longitudinal forces from train and thermal loads. To help inordinate sleeper's movements and track side buckling due to these loads, the cargo subcaste must give sufficient resistance in each direction (Kish and Samaveda, 2013). For twisted tracks with small diameters or high train pets, the side resistance of the track is critical for maintaining stability. With the increased demand for faster and heavier train loads, perfecting the side resistance of the cargo subcaste has come necessary.



(a) Double I-shaped sleepers



(b) X-shaped sleeper

CONCLUSION

The study introduces X-shaped sleepers as a solution to enhance side resistance in ballasted tracks compared to traditional I-shaped sleepers. Through track panel drive- eschewal tests simulations, the X-shaped sleepers demonstrated 26% lower side resistance than double I-shaped sleepers, attributed to their V-chopstick arms that improve ballast distribution. Additionally, crib ballasts significantly contribute to the side resistance of X-shaped sleepers, providing nearly double the resistance of double I-shaped sleepers. These findings suggest that X-shaped sleepers offer improved stability and side resistance, making them a viable choice for future railway operations.

SUMMARY

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