ENGINEER

international scientific journal

ISSUE 1, 2025 Vol. 3
E-ISSN
3030-3893
ISSN
3060-5172

SLIB.UZ
Scientific library of Uzbekistan

A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

A bridge between science and innovation

E-ISSN: 3030-3893

ISSN: 3060-5172

VOLUME 3, ISSUE 1

MARCH, 2025

engineer.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

ENGINEER

INTERNATIONAL SCIENTIFIC JOURNAL
VOLUME 3, ISSUE 1 MARCH, 2025

Founder of the international scientific journal "Engineer" – Tashkent State Transport University, 100167, Republic of Uzbekistan, Tashkent, Temiryo'lchilar str., 1, office: 465, e-mail: publication@tstu.uz.

The "Engineer" publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

- Engineering;
- General Engineering;
- Aerospace Engineering;
- Automotive Engineering;
- Civil and Structural Engineering;
- Computational Mechanics;
- Control and Systems Engineering;
- Electrical and Electronic Engineering;
- Industrial and Manufacturing Engineering;
- Mechanical Engineering;
- Mechanics of Materials;
- Safety, Risk, Reliability and Quality;
- Media Technology;
- Building and Construction;
- Architecture.

Tashkent State Transport University had the opportunity to publish the international scientific journal "Engineer" based on the **Certificate No. 1183** of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. **E-ISSN: 3030-3893, ISSN: 3060-5172.** Articles in the journal are published in English language.

Analysis of the condition of track superstructure elements using the finite element method in the ABAQUS software package

S.T. Djabbarov[1][a], N.B. Kodirov[1][b]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: The aim of this work was a comprehensive study of the process of modeling the elements of the track superstructure using modern three-dimensional finite element methods. Given the high degree of complexity and versatility of the problem, a detailed model of the railway track was developed and implemented during the study, which allowed for a deeper understanding of the behavior of its elements under the influence of various operational loads. The modeling included both static and dynamic analyses, which made it possible to assess the influence of various factors on the strength and durability of the structure.
Keywords: Model, stress, von Mises, wheel, rail, modeling, finite element track superstructure, ABAQUS

1. Introduction

The use of finite element modeling (FE) allows to significantly reduce both financial and time costs, while effectively achieving the set goals. This method allows to quickly identify the maximum values of strength, stresses and displacements in the railway track structure, which, in turn, helps to focus attention on the most vulnerable sections of the infrastructure.

Table 1

Technical characteristics of the track superstructure

Elements of the railway superstructure	Density (kg/m2)	Young's modulus (E)	Poisson's ratio (υ)
Rail (steel)	7850	210 GPa	0.3
Sleeper (reinforced concrete)	1200	80 GPa	0.3

2. Research methodology

Statement of the problem

The calculations modeled the contact interaction between the wheel and the rail. The parameters of the contact interaction depend on the adopted configuration of the wheel and rail profile, as well as their nominal dimensions. During movement, the wheel and the rail can occupy various mutual positions, which are shown in Fig. 1.

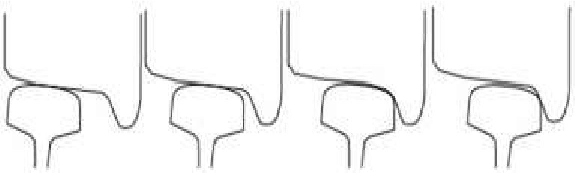

Fig. 1. Location of wheel and rail contact zones

The model of interaction between the wheel and the rail in the wheel-track system, adopted for modeling the process of the impact of dynamic load [1-2] on this system, is presented in Fig. 2.

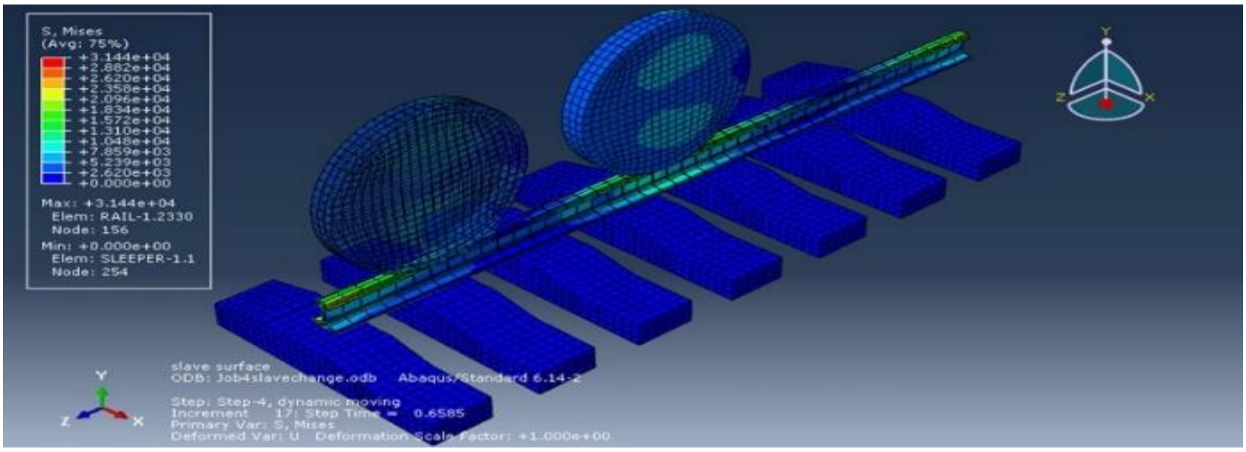

Fig. 2. Stresses at wheel-rail interaction points

[a] https://orcid.org/0000-0002-3798-407X
[b] https://orcid.org/0000-0002-8814-3123

https://doi.org/10.56143/3030-3893-2025-1-94-97

The loading process includes two steps:

– general static analysis
– dynamic implicit analysis

Stress elements in the wheel-rail contact zones, as well as the stress distribution according to the von Mises criterion, are shown in Figures 3 and 4. The von Mises stress is widely used to assess the deformation of isotropic and plastic metals under complex loads. Using ABAQUS software allows you to calculate the von Mises stress values at specified points at each stage of the calculation.

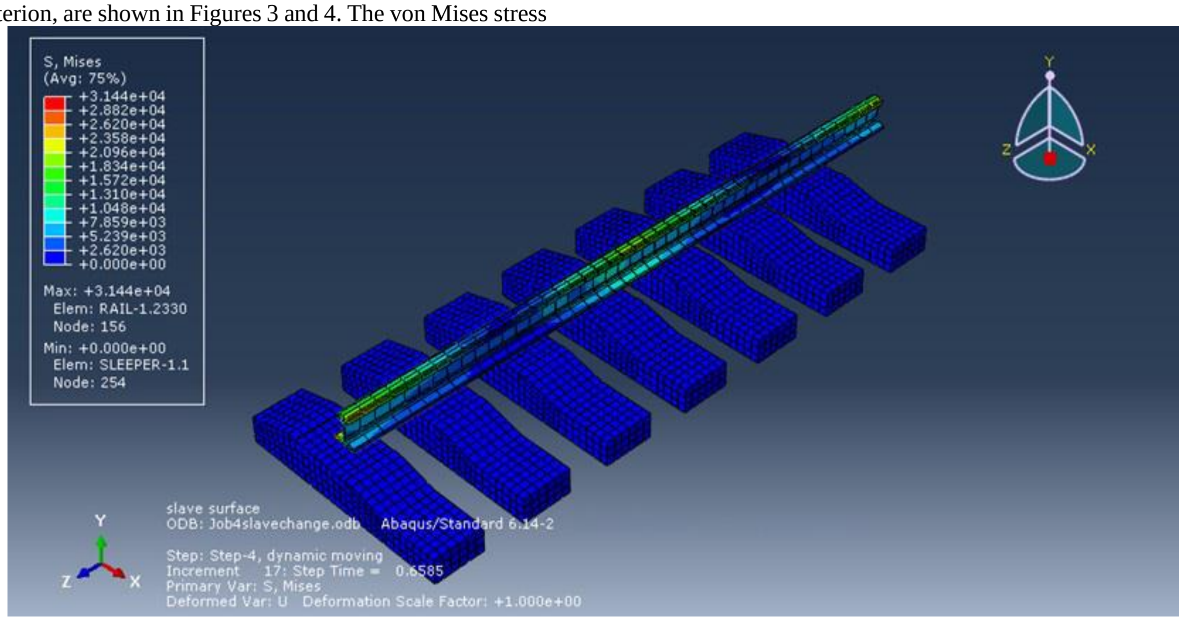

Fig. 3. Distribution of von Mises stresses (without wheel)

Distribution of maximum principal stress

The von Mises stress is a theoretical measure of stress used to evaluate limit state criteria in ductile materials and is also popular in fatigue calculations (where it can be positive or negative depending on the dominant principal stress). While the principal stress is a more "real" and directly measurable stress.

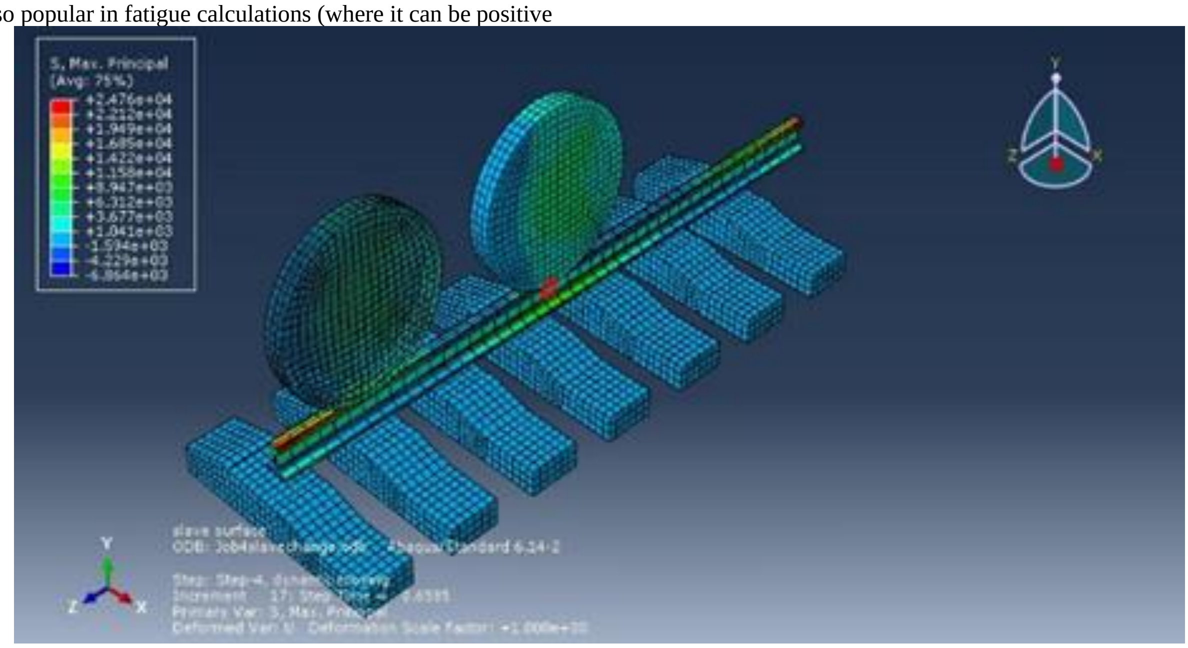

Fig. 4. Distribution of maximum principal stress

https://doi.org/10.56143/3030-3893-2025-1-94-97 A bridge between science and innovation

ENGINEER

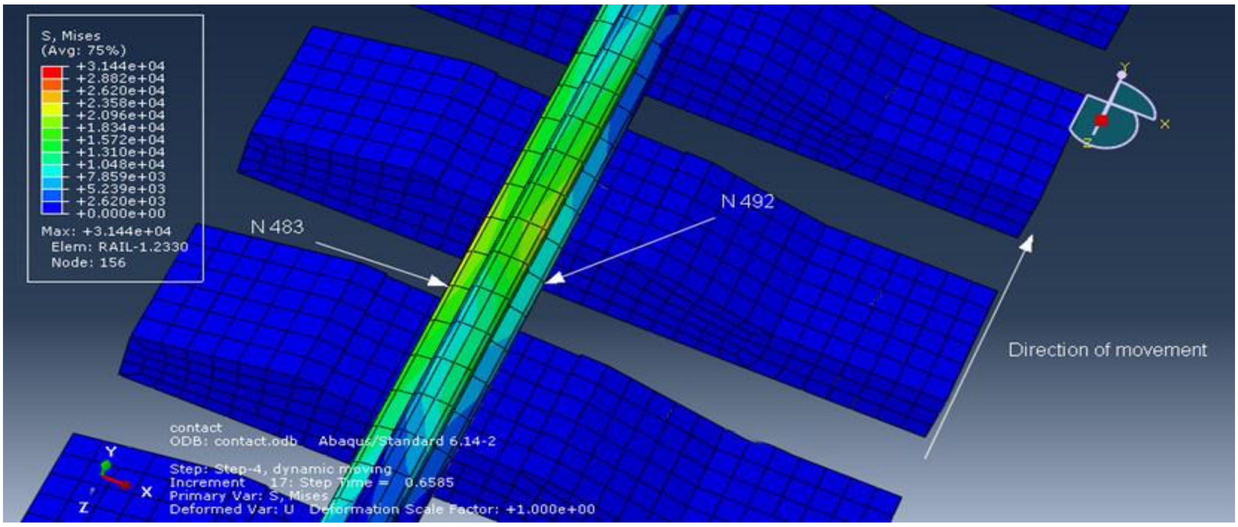

Fig. 5. Location of nodes with maximum and minimum von Mises stress

Analysis of the obtained results

Calculations show that the maximum von Mises stress for step #17 corresponds to node N483, while the minimum von Mises stress for the same increment corresponds to node N492. The change in the von Mises stress distribution can be seen in Figure 6. The stresses are σ=21.3 × 10³ N/cm² for node N483 and σ=4.40 × 10³ N/cm² for node N492. However, node N483 reaches the maximum stress value at time t=0.7585 s, equal to σ=22.9 × 10³ N/cm² [3-4] .

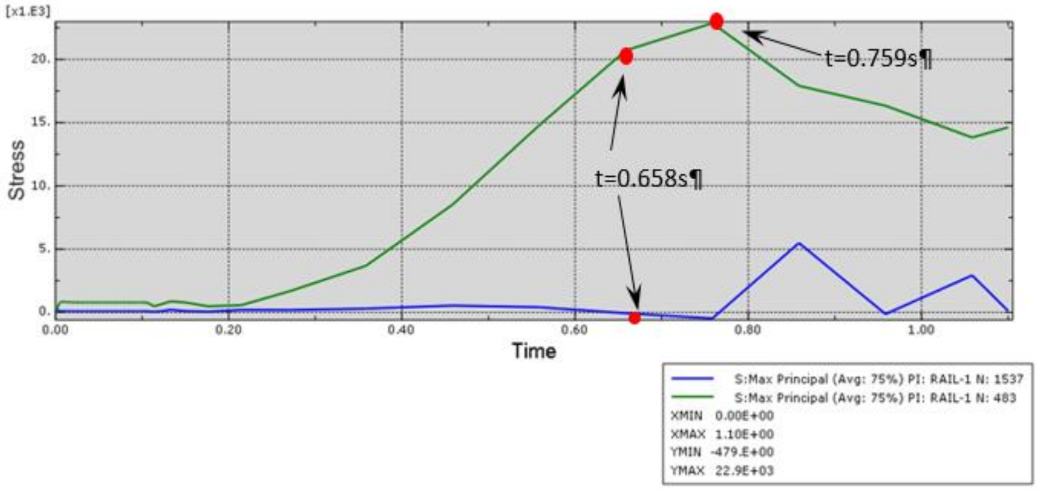

Fig. 6. Maximum and minimum voltage of the Von Mises for increment No. 17 at t=0.658s

The values of the principal stress for node N483 are σ = 21.27 × 10³ N/cm², and for node N1537 σ = -0.175 × 10³ N/cm². Comparing the von Mises stresses and the maximum principal stress in node N483, it can be seen that these values differ [3].

3. Conclusion

During the study, an analysis of stresses was carried out according to the von Mises criterion , maximum principal stresses, spatial displacements of rail and sleeper assemblies, as well as contact interactions between the wheel and the rail, including normal contact forces and reaction forces in the sleepers [5-10].

Modeling in ABAQUS allowed us to obtain the following results:

— deformations, contact forces, stresses and reaction forces were calculated;

— a difference was established between the von Mises stresses and the maximum principal stresses for one node (21.30×10³ for von von Mises and 21.27×10³ for maximum principal stress);

The developed finite element model of the railway track reproduces the geometry of the real structure. The analysis of the stress distribution according to von Mises showed that in the wheel-rail contact zone the maximum values reach 22.9 MPa. The ultimate stresses were recorded in node N483 (σ = 22.9 MPa), and the minimum ones were recorded in node N492 (σ = 4.4 MPa). The analysis of the main stresses also revealed significant fluctuations that affect the wear of the rails and wheels. The maximum values of the main stress are 21.27 MPa.

References

[1] Finite element analysis of railway track under vehicle dynamic impact and longitudinal loads. Zijian Zhang.

[2] Theory of elasticity and plasticity. Jane Helena.

[3] A parameterized three-dimensional finite element model of a slab trackfor simulation of dynamic vehicle–track interaction Niklas Sved.

[4] Djabbarov S., Mirakhmedov M., Sładkowski A. Potential and Problems of the Development of Speed Traffic on the Railways of Uzbekistan //Transport Systems and Delivery of Cargo on East–West Routes. – Springer, Cham, 2018. – С. 369-421.

[5] Djabbarov S., Khakimova Y. Formation of rail defects on the high-speed railways of Uzbekistan //AIP Conference Proceedings. – AIP Publishing LLC, 2022. – Т. 2432. – №. 1. – С. 030013.

[6] A parameterized three-dimensional finite element model of a slab trackfor simulation of dynamic vehicle–track interaction Niklas Sved.

[7] Kaynia A. M., P. Zackrisson. 2000. "Ground vibration from high speed trains: prediction and countermeasure." Journal of geotechnical and geoenvironmental engineering, vol. 126,no. 6, pp. 531-537.

[8] Z. Cai, g.p. raymond. 1994. "modelling the dynamic response of railway track to wheel/rail impact loading" . 1) dep. Of civil engineering, royal military college, Kingston, Ontario, Canada.

[9] Djabbarov S., Mirakhmedov M., Sładkowski A. Potential and Problems of the Development of Speed Traffic on the Railways of Uzbekistan //Transport Systems and Delivery of Cargo on East–West Routes. – Springer, Cham, 2018. – С. 369-421.

[10] Djabarov S., Kodirov N. The impact of dynamic load from the wheel on the rail for high-speed trains in Uzbekistan //E3S Web of Conferences. – EDP Sciences, 2023. – Т. 402. – С. 06009.

Information about the author

Djabbarov Saidburxan Tulaganovich	Toshkent davlat transport universiteti "Temir yol muhandisligi" kafedrasi professori. t,f,n, E-mail: _saidhon_@inbox.ru Tel.: +99890185 2934 https://orcid.org/0000-0002-3798-407X
Kodirov Nodirbek Baxtiyarovich	Toshkent davlat transport universiteti "Temir yol muhandisligi" kafedrasi tayanch doktoranti E-mail: nodir_kodirov_95@mail.ru Tel.: +998971002908 https://orcid.org/0000-0002-8814-3123

CONTEXT / MUNDARIJA