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.

Assessment of the condition of a railway track based on finite element modeling

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

Abstract: This article discusses the use of finite element (FE) modeling to analyze the characteristics of a railway track. Graphs of spatial displacements of rail and sleeper nodes are provided, and an analysis of maximum displacements at different points in time is performed. In conclusion, the importance of the obtained results for further study of the dependence of stresses on deformations of track elements is noted, which contributes to optimization of design and improvement of the reliability of railway infrastructure.
Keywords: stress, von Mises, track superstructure, rail, sleeper, modeling, model

1. Introduction

This study used commercial finite element software ABAQUS, which allows predicting the degree of fracture of rails, sleepers and other track elements, promptly assessing the technical condition of the railway track infrastructure taking into account loads, traffic intensity of high-speed and other categories of trains and climatic conditions.

As it is known, each material has its own specific characteristics, and taking these factors into account in the modeling process is of great importance and gives us acceptable results for subsequent calculations. The ABAQUS software used gives us such an opportunity, taking into account the above factors [1,2] . The following elements of the track superstructure were used in the modeling.

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

In this study, conducted to assess the fatigue limit, wear resistance and operational strength of both elements of the system, the calculation of stresses arising from the interaction of the wheel with the rail was carried out using the finite element method. In this case, the wheel was considered under conditions of movement on a straight section of the track with an axial load on the wheel of 125 kN and a speed of 80 km/h.

The displacements in rail nodes N488 and N1556 for a given pitch of 17 at t = 0.658 s are 0.8094 mm and 0.8266 mm, respectively. The maximum displacement is observed at t = 0.7585 s and reaches 0.8864 mm. The study considered two sleepers under the wheel, as well as nodes of sleepers N3 and N3' with the largest displacement values. The location of nodes N3 and N3 is shown in Figure 1, and the changes in the sleeper displacement are shown in Figure 2.

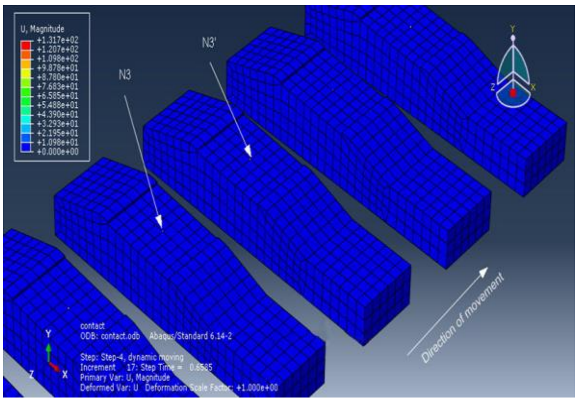

Fig. 1. Location of nodes N 3 and N 3'

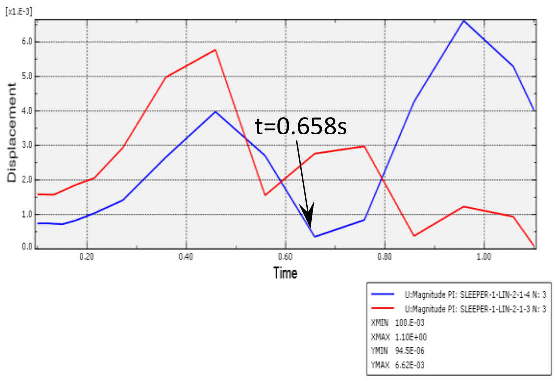

Fig. 2. Spatial displacement of sleepers

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

The maximum displacements recorded at t = 0.658 s for step 17 are observed in the middle of the sleepers. The displacement of node N3 is 2.7627×10^{-3}, and that of node N3' is 0.354×10^{-3}

Axial displacements in rail nodes. The displacements of nodes U1 for rails N483 and N1556 are recorded as maximum at step 17 at t = 0.658 s, amounting to -0.585 mm and -0.615 mm, respectively. The graph includes both nodes, since it is at these points that the largest displacements are recorded. The data are presented in Figures 3 and 4.

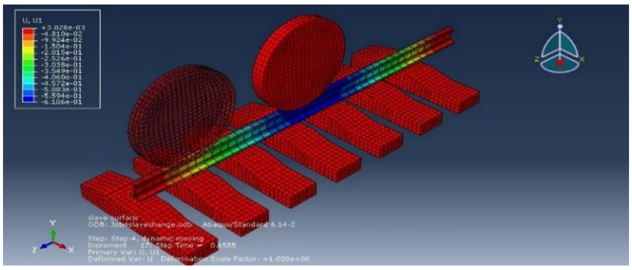

Fig. 3. Displacement - U 1 of the rail at step 17 t = 0.658 s

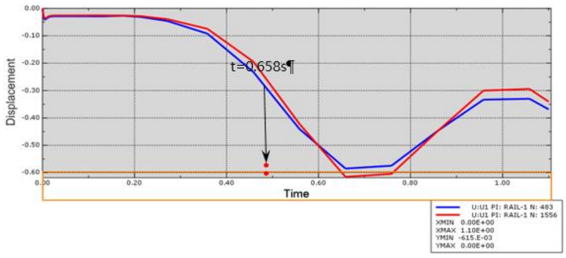

Fig. 4. Displacement of U 1 at step 17, t = 0.6585 s at nodes 483 and 1556

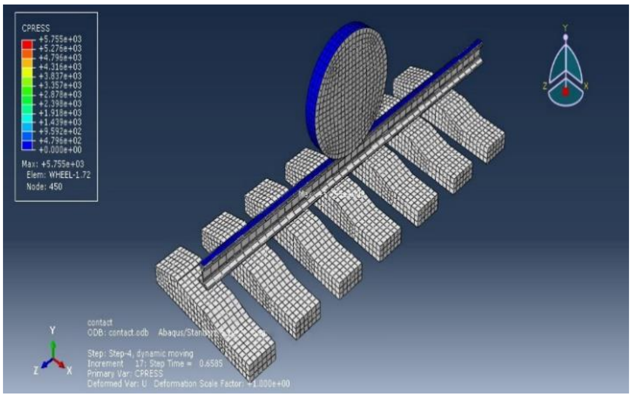

Fig. 5. Contact stress on the surface at step 17

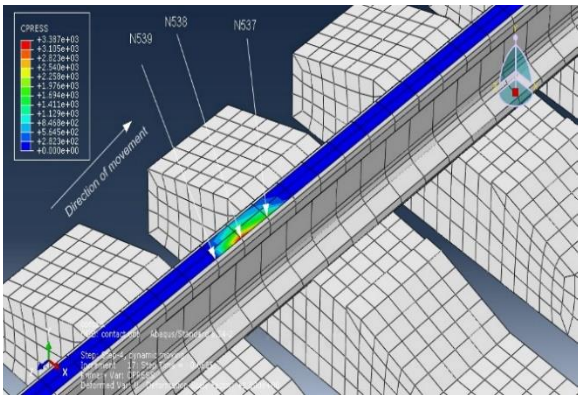

Fig. 6. Distribution of contact stress (KN) on the surface during displacement

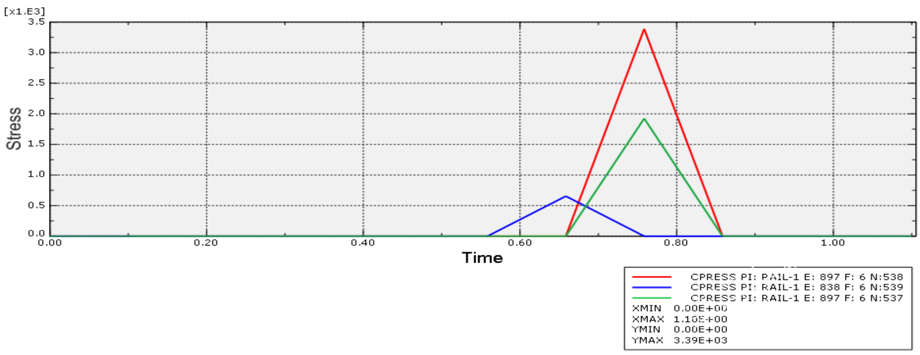

Fig. 7. Distribution of CN at nodes 537, 538 and 539

Thus, with an axle load of 125 kN, the maximum stress value for a given step 17 at time t = 0.658 s reaches 0.654×10^3 N/cm², and in node N538 the maximum value of Cpress is recorded, amounting to 3.3871×10^3 N/cm², which is shown in Fig. 7.

https://doi.org/10.56143/3030-3893-2025-1-98-101 A bridge between science and innovation

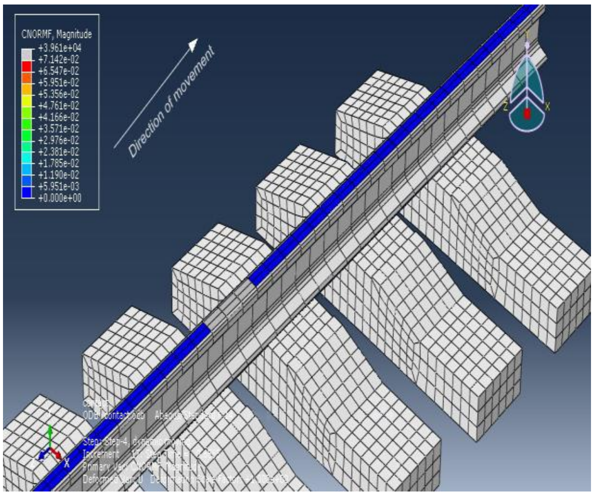

Fig. 8. Distribution of contact stress on the surface with increment

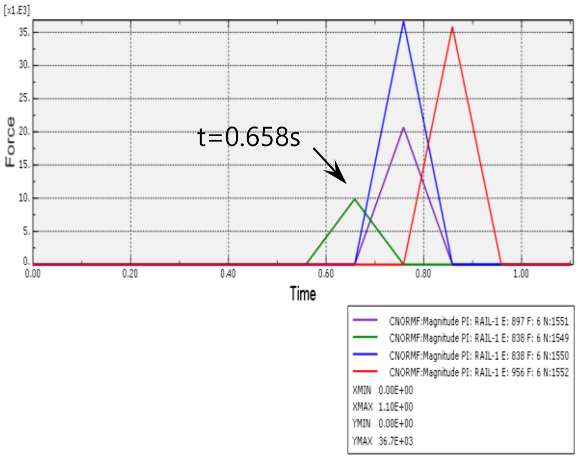

Fig. 9. Distribution in nodes 1549-1551

From Figure 9 it can be determined that for node N 1549 the force is equal to 9.866× 10^3N, for node N1550 36.673×10 ^{3} N, for unit N1551 20.690× 10 ^{3} and for N1552 35.859×10 ^{3} N [5,6,7].

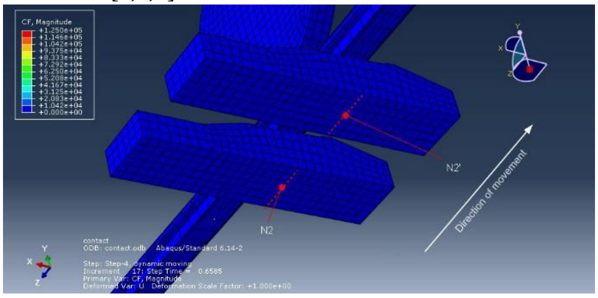

Fig. 10. Research of nodes from PC

For the analysis, two sleepers located under the wheel were considered. 14 nodes were analyzed, which are located parallel to the bottom of the rail (dotted line in Fig. 10).

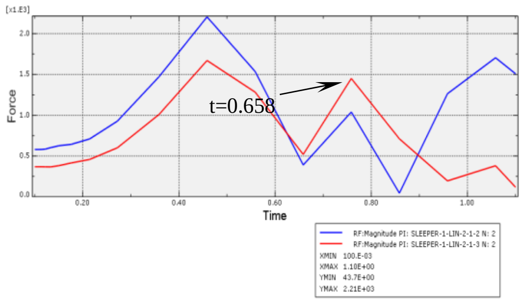

Fig. 11. Values of RS at nodes N 2 and N 2'

The analyses show that the maximum reaction force occurs in the middle of the sleepers at nodes N2 and N2'. The displacements with a step of 17 of the reaction force are equal to F=0.519 for N2 ×10^3Hand F=0.389 N for N2' ×10^3, which is shown in Fig. 11 [12].

3. Conclusion

Based on the calculated stress values, it can be concluded that for further research it is advisable to use a model based on elastic-plastic materials [6]. Verification of the limiting conditions adopted for finite element modeling requires experimental testing, which requires a special test bench.

When investigating the reaction forces on sleepers, the maximum values were recorded at nodes N2 and N2', where the forces amount to 0.519 kN. These forces can have a significant impact on the operational characteristics of the railway track.

The simulation showed that the static and dynamic analyses of the track under a load of 125 kN allow us to evaluate the changes in stresses and displacements depending on different time stages. The static analysis uses automatic increments with a step of 0.0001, while the dynamic analysis is carried out with a step of 0.001, which ensures high accuracy and stability of the results.

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. – C. 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. – T. 2432. – №. 1. – C. 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

[11] Кодиров Н. Б., Мирзахидова О.М. FINITE ELEMENT ANALYSIS OF TRACK STRUCTURE //Universum: технические науки. – 2022. – №. 9-5 (102). – С. 46-49.

[12] Джаббаров С. Т., Кодиров Н. Б. Моделирования элементов верхнего строение пути в програмном комплексе «ABAQUS» // Научно-практический электронный журнал “Пожаро-взрывобезопасность” Ташкент -2024- С. 381-р

Information about the author

Djabbarov Saidburkhan 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 Bakhtiyarovich	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

K. Turdibekov, D. Rustamov, M. Mamadalieva
Increasing the selective operation of microprocessor terminals.......**56**

M. Shukurova, E. Abdurakhmanova, F. Usarkulova, M. Botirov
Mathematical modeling of transient groundwater filtration in multilayered media with a low-permeability barrier…………………..**59**

T. Amirov, K. Muminov, M. Dauletov, S. Rakhmatov
Evaluating the impact of elevations between concrete pavement slabs on road surface smoothness………………………………………………**64**

I. Bedritsky, M. Mirasadov, L. Bazarov
Single-phase to six-phase voltage converter……………………………**70**

B. Kodirov, S. Shaumarov, S. Kandakhorov
Production of aerated concrete blocks using energy-efficient technology……………………………………………………………………**73**

B. Kodirov, S. Shaumarov, S. Kandakhorov
Development of building structures with individual characteristics taking into account the conditions of Uzbekistan…………………………**78**

E. Salayev
Assessing the risk of public transport in southern cities of Azerbaijan using the "bow tie" method……………………………………………**83**

T. Verdiev
Evaluation effectiveness of solutions to improve mobility in cities....**90**

S. Djabbarov, N. Kodirov
Analysis of the condition of track superstructure elements using the finite element method in the ABAQUS software package……………**94**

S. Djabbarov, N. Kodirov
Assessment of the condition of a railway track based on finite element modeling……………………………………………………………………**98**

CONTEXT / MUNDARIJA