УНИВЕРЗИТЕТ У БЕОГРАДУ
ГРАЂЕВИНСКИ ФАКУЛТЕТ
Булевар краља Александра 73
11120 Београд, Р. Србија
П. фах 35-42
Телефон: (011) 321-86-06, 337-01-02
Телефакс: (011) 337-02-23
ПИБ: 100251144 , Мат. бр. 07006454
Управа за трезор подрачун сопствних прихода: 840-1437666-41
Е пошта: dekanat@grf.bg.ac.rs
www.grf.bg.ac.rs

UNIVERSITY OF BELGRADE
FACULTY OF CIVIL ENGINEERING
Bulevar kralja Aleksandra 73
11120 Belgrade, Republic of Serbia
P.O.B. 35-42
Phone+381 11 321 8606, +381 11 3370102
Fax +381 11 3370223
Tax Id. No: 100251144, Reg. No 07006454
Serbian National Treasury Account No: 840-1437666-41
Email: dekanat@grf.bg.ac.rs
www.grf.bg.ac.rs

REVIEW REPORT
on the DISSERTATION entitled

"METHODOLOGY OF THERMAL STRESS DETERMINATION IN CONTINUOUS WELDED RAIL ",

submitted by Ing. Petr Vnenk, (supervisor: doc. Ing. Bohumil Culek, Ph.D.)
on the University of Pardubice, Faculty of transport engineering, Czech Republic

Study Programme: **Technique and Technology in Transport and Communications.**
Study Field: **Transport Means and Infrastructure.**
Supervisor: **Assoc. Prof. Bohumil Culek, Ph.D.**
Supervising Department: **Department of Transport Structures.**

Belgrade, October 27, 2022 Reviewer:

Prof. Ing. Zdenka Popović, Ph.D.
University of Belgrade, Faculty of Civil Engineering
Bul. kralja Aleksandra 73, 11120 Belgrade, Republic of Serbia
zdenka@grf.bg.ac.rs
+381 60 0515859

INTRODUCTION

Based on the proposal from the Subject Advisory Board of the Doctoral study program "Transport Means and Infrastructure", I am appointed as a reviewer of the dissertation thesis called "Methodology of Thermal Stress Determination in Continuous Welded Rail", submitted by Ing. Petr Vnenk.

The CV of the candidate Petr Vnenk and the complete versions of the Dissertation in English were officially delivered and available to me.

After reviewing the Dissertation, I give my opinion of the presented results of scientific research.

This Dissertation deals with the methodology of thermal stress determination in continuous welded rail (CWR). Considering that the CWR is a part of the modern track structure, the Dissertation topic is significant for scientific research in the field of railway infrastructure worldwide. The performed research covers the rail temperature determination, especially the investigation of the air temperature and cloudiness impacts, as well as geography on the rail temperature. Furthermore, the research covers the neutral temperature development in CWR and the monitoring of rail strains.

STRUCTURE OF THE THESIS

The Dissertation is organized in a common monographic form, in which the student presents the results of his research grouped into six chapters, as follows:

1. Introduction,
2. Current Knowledge,
3. Rail Temperature,
4. Strain of Continuous Welded Rail,
5. Neutral Temperature Development of Continuous Welded Rail (CWR), and
6. Conclusions.

In Chapter 1, the research motivation, objectives and methodology, as well as the specifications of the dissertation concept are presented.

Chapter 2 presents the state-of-the-art in the research area and the knowledge of the most important and current literature. In this regard, the considered Dissertation contains 65 references to relevant literature. This chapter covers a concise description of the historical development of CWR. The theoretical aspect of CWR is briefly presented. The state-of-the-art of stress determination in the rails was particularly considered. The chapter concludes with the overview on the stress structure in rail using the Smith diagram for new and corroded rail 60E1/900 and fatigue stress diagrams.

Chapter 3 considers the influence of air temperature and cloudiness on the temperature in CWR. In this chapter, the results of the rail temperature monitoring in selected locations (five monitoring locations on the Czech Railway Network) are presented and discussed.

Chapter 4 describes an investigation into strain detection in CWR. The analysis of an experimental setup under laboratory conditions and the description of an experimentally developed measuring set are presented in detail. Further, an extensive CWR Strain

Monitoring (which has been realised within the scope of investigation of TAČR Zéta Project TJ04000301 Non-Destructive Determination of Mechanical Stress in Continuous Welded Rail) is presented.

Chapter 5 describes the methodology of non-destructive determination of mechanical stress in CWR and analyses the CWR strain data presented and discussed in the previous chapter. A proposition of the thermal stress determination and the rail neutral temperature change in CWR is given in this chapter.

The final chapter of the Dissertation contains recommendations for further research and suggests the application of the presented approach for determining thermal stresses and changes of neutral temperature in CWR over time.

The reviewed Dissertation contains 106 Figures and 29 Tables. Furthermore, the Dissertation contains seven appendices, as follows:

A. Appendix A - Rail Temperature Recordings,
B. Appendix B - Measurement Uncertainty Determination,
C. Appendix C - CWR Strain Recordings,
D. Appendix D - Relation of Strain and Temperature,
E. Appendix E - Development of Measured and Extrapolated Temperature Difference,
F. Appendix F - Comparison of Temperature Differences per Cross-Sectional Profiles, and
G. Appendix G - Comparison of Standard and New Approach to the Thermal Stress Determination in CWR.

Moreover, the following documents are annexed to the Dissertation:

- Methodology of Non-Destructive Determination of Mechanical Stress in Continuous Welded Rail as an outcome No. TJ04000301-V1 of research project No. TJ04000301 Non-Destructive Determination of Mechanical Stress in Continuous Welded Rail,
- Scheme of Strain Gauge Installation in Bezpráví Locality as an annex to the methodology,
- Documentation of the Measuring Set for Diagnostics of Time-Based Development of Stress States in Continuous Welded Rail as an outcome No. TJ04000301-V2 of the research project No. TJ04000301 Non-Destructive Determination of Mechanical Stress in Continuous Welded Rail and as an annexe to the methodology, and
- Certificate of Approval of the Methodology by the Ministry of Transport of the Czech Republic (in Czech only).

The candidate attached a list of eight publications related to the submitted Dissertation.

THESIS' REVIEW

The methodology of thermal stress determination in CWR belongs to contemporary topics deserving research at the level of a doctoral dissertation.

The Dissertation covers a description of the historical development, importance and theoretical aspect of CWR on the state-of-the-art level.

The applied procedure for measuring temperature, deformation and stress in rails is clearly described. The measurement results are followed by appropriate analyses of the obtained measurement data. The methodology is presented in a scientific form and described in a

manner that allows the reproduction of the conducted experiments. Furthermore, the investigation into the impact of air temperature, cloudiness and geography on the rail temperature is presented in the Dissertation.

This Dissertation shows the methodology to determine the current value of normal mechanical stress using strain gauges and a measuring set, as well as the procedure to determine the deformation and neutral temperature in CWR (using non-destructive testing). The theoretical considerations and research results of the experimental work are presented clearly and at a sufficient level of detail in this Dissertation.

The science and railway industry could use the results achieved in the thesis for future contributions and developments.

CONCLUSION AND PROPOSAL

The scientific research within the Dissertation "Methodology of Thermal Stress Determination in Continuous Welded Rail", submitted by Ing. Petr Vnenk, is a valuable and original contribution to the field of stress determination and the methodology to determine the neutral temperature in continuously welded rail (CWR). The Dissertation considers problems of the rail temperature determination (including the impact of air temperature, cloudiness and geography on the rail temperature) and problems of neutral temperature development, particularly the strain monitoring and the determination of the neutral temperature development in CWR. The research generates significant new knowledge in the scientific field. The results of the research can have a wider range of applications for stress-deformation analyses of the CWR in tracks in service.

The considered doctoral Dissertation is an original scientific work. The candidate Ing. Petr Vnenk demonstrated the ability for independent scientific and research work in all stages of the preparation of this Dissertation.

Accordingly, I suggest acceptance of the doctoral Dissertation entitled "Methodology of Thermal Stress Determination in Continuous Welded Rail", submitted by Ing. Petr Vnenk, and give my consent for the public defence.

Belgrade, October 27, 2022 Reviewer:

Prof. Ing. Zdenka Popović, Ph.D.
The University of Belgrade, Faculty of Civil Engineering
Bul. kralja Aleksandra 73, 11000 Belgrade, Republic of Serbia
zdenka@grf.bg.ac.rs
+381 60 0515859