Continuously Welded Rail Longitudinal Resistance Modeling

Exhibit D

Recipient/Grant (Contract) Number: University of Texas Rio Grande Valley (UTRGV)/Grant No. 69A3552348340

Center Name: University Transportation Center for Railway Safety (UTCRS)

Research Priority: Promoting Safety

Principal Investigator(s): Siang Zhou (PI, UTRGV) and Constantine Tarawneh (co-PI, UTRGV)

Project Partners: David Allen (Collaborator, Texas A&M University (TAMU)) and Stephen Wilk (Collaborator, MxV Rail)

Research Project Funding: $54,278 (Federal), $22,603 (Non-Federal Cost Share)

Project Start and End Date: 06/01/2024 to 05/31/2025

Project Description: Continuously welded rail (CWR) is standard in North American freight railroads despite the common concerns for rail buckling and rail breaks. Rail longitudinal resistance is an important parameter for proper re-establishment of rail neutral temperature (RNT) after rail breaks and reducing longitudinal rail movement under external vertical and longitudinal loads. Existing rail longitudinal resistance values are based on limited rail cut field testing and are not applicable when it comes to special track conditions, such as near fixed assets, and have not been used to evaluate rail movement without a break. In collaboration with MxV Rail engineers who are consulting on this work, the proposed research aims to develop efficient 2D and 3D finite element (FE) rail longitudinal resistance models based on experimental studies and historical data, which can be implemented considering the effect of frozen ballast, frozen structures, vehicle forces, and maintenance disturbance. The FE models will be carried out in ABAQUS, and will consider various rail sizes, multiple material and geometric tie properties, and three critical forms of interactions: rail-to-tie friction, anchor slipping force, and tie-to-ballast restraint. These force-displacement interactions are nonlinear and are represented using springs, with stiffnesses determined based on experimental studies (for anchor slipping force) and historical data (for rail-sleeper friction and sleeper-ballast restraint). The development of FE rail longitudinal resistance models that consider efficient representation of rail-to-tie and tie-to-ballast interactions can have multiple practical applications, including: 1) provide improved RNT re-establishment guidance under special track conditions and 2) evaluate changes in RNT from vehicle and maintenance-induced longitudinal rail movement.

US DOT Priorities: The proposed work in this project is aligned with four of the six USDOT strategic goals: **(a) Safety:** The project directly investigates a potential safety concern and lack of standard practice that has been identified by MxV Rail engineers. **(b) Economic Strength:** Unscheduled stoppages and field repairs cause serious economic losses for rail companies and their customers, and other users of the track. **(c) Equity:** UTRGV is a minority serving institution with an established record of training students from underrepresented groups and placing them in professional positions in the transportation industry. This project will directly employ one graduate student who will perform model development and data analysis as part of the student's thesis research. The proposed project also needs laboratory testing, which will be led by the graduate student and assisted by one undergraduate student. These students will also undergo professional training at MxV Rail facilities as part of them receiving relevant workforce development opportunities. **(d) Sustainability:** By proposing approaches to evaluate CWR longitudinal resistance, improved strategies to re-establish RNT after rail break (considering special rail conditions) and enhanced methods to evaluate change in RNT under external longitudinal and vertical loads will be available to practitioners, which will facilitate CWR maintenance and retrofit, extend the useful lifetime of CWR, and mitigate the number of environmentally-significant derailments caused by rail buckling and rail pull apart failures.

Outputs: The expected products include:

1. Rail longitudinal resistance evaluation charts considering various rail designs, special rail conditions, and external longitudinal and vertical loading conditions.
2. User-friendly 3D FE models that can be quickly deployed by railway engineers.
3. Dissemination of the proposed project will take form in the following ways: (a) final report documenting research procedures and results, (b) journal publications with peer-reviews to strengthen credibility of the work, (c) conference presentations (e.g. ASME Joint Rail Conference 2025 and Transportation Research Board Annual Meeting 2025) to help the research reach a larger audience, and (d) a Master's thesis documenting details of the proposed project.

Outcomes/Impacts: The research objective of this proposed project is to develop efficient rail longitudinal resistance FE models that include efficient representation of rail-to-tie friction, anchor slipping force, and tie-to-ballast restraint, to propose rail longitudinal resistance charts considering various rail sizes, multiple material and geometric tie properties, and a wide range of track conditions, such frozen ballast, frozen structures, turnouts, crossings, vehicle forces, and maintenance disturbance. The theoretical research of developing FE rail longitudinal resistance models that include efficient representation of rail-to-tie and tie-to-ballast interactions can have multiple practical applications, including 1) providing improved RNT re-establishment guidance under special track conditions and 2) evaluating changes in RNT from vehicle and maintenance-induced longitudinal rail movement. However, the research will have impacts beyond this specific engineering problem. **Industry Impact:** The results could lead to recommendations for industry best practices; for example, a recommendation for proper rail longitudinal resistance for various CWR segments considering multiple special conditions, to assist determination of RNT pre-failure or after-break. **Educational Impact:** The project will be carried out by undergraduate and graduate students working under the supervision of the PIs. As a minority serving institution in a rapidly growing metropolitan area, we anticipate that most of the students will be from underrepresented groups, and that these students will have the chance to work with MxV Rail engineers and spend some time during the summer at MxV Rail facilities. The students will gain invaluable experience in designing and fabricating the laboratory test setup and in conducting tests according to AAR standards. We anticipate that at least one graduate student and one undergraduate student will participate in the various aspects of the project.

Final Research Report: Upon completion of the project, a URL link to the final report will be provided.