Background

Railways are the backbone of our nation’s economic system, allowing for swift, economical and fuel efficient movement of agricultural products, coal, and finished goods. Keeping freight moving requires efficient train networking and reliable track systems. Kansas State University has multi-disciplinary expertise in railway track systems, and is investigating methods of improving the safety and durability of concrete railroad ties under current contracts with the Federal Railroad Administration totaling over $3.2 Million. The KSU departments involved in this research include Civil Engineering (CE), Mechanical and Nuclear Engineering (MNE), and Industrial and Manufacturing Systems Engineering (IMSE).

Description

The overarching theme of this work has been enhancing our understanding of how different materials and fabrication processes interact to affect the railway durability. Kansas State University has pioneered the development of a laser-speckle imaging (LSI) device that can be used in rugged environments. This patented device has led to the development of a system for imaging concrete railroad ties to determine if they are properly stressed at the manufacturing plant to prevent cracking and failure in track.

Researchers are also currently working on methods to determine how the raw materials and manufacturing processes affects durability in cold, wet climates found in Kansas and northern climates. As such, KSU has recently installed a large environmental chamber dedicated to the investigation of full-sized concrete railroad ties under freezing and thawing thermal cycles, and is the only existing facility of its kind in the United States.

The use of LSI techniques and full-scale freeze-thaw testing of concrete railroad ties has positioned Kansas State University at the forefront of railroad track systems durability research. Under the proposed center, these existing technologies will be leveraged and deployed to improve the durability and sustainability of the US rail infrastructure.

Funding for the Rail Infrastructure Durability and Sustainability Center will have the following objectives:

New Railway Infrastructure Environmental Test chamber. Long-term durability of railroad ties under repeated loads from heavy coal and other freight loads should be tested under extreme weather conditions, including hot and cold temperatures, wet and dry conditions, and varying sub-grade materials and temperatures. Existing test infrastructure that has been developed under current concrete railroad tie research funding will be enhanced to create the the nations first climate-controlled full-scale test chamber for railroad track systems.

Durability of Railroad Ties Under Different Loadings. Concrete railroad ties made with different reinforcing materials have the potential to provide longer life, increasing the sustainability of the railroad infrastructure. Concrete ties with material-related durability problems stemming from chemical reactions between the aggregate and cement may also decrease the service life of ties. Testing to determine the reduction in service life in these ties will help determine the interplay between material problems and loading.

Deployment of Existing Laser-Speckle Technology. KSU researchers will demonstrate the application of the newly-developed LSI technology at concrete railroad tie plants in the United States and assist with the implementation of the technology in concrete tie manufacturing plants for improved quality assurance. This technology will allow for the optimal components (concrete mixtures and prestressing reinforcement) to be selected for maximum durability.

Relevance National/Regional

Railways play an increasing role in our nation’s economy, with sharp increases in rail traffic in recent years. Heavy-haul and high-speed rail lines use concrete railroad ties because in spite of their higher initial cost, their increased durability. Improved materials and test methods for railroad tie systems, and development of reliable test procedures for new ties and components, will help prevent derailments and increase the lifespan of current railways.

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Summary: Railways are the backbone of our nation's economic system, allowing for swift, economical and fuel efficient movement of agricultural products, coal, and finished goods. However, defective ties can cause derailments and threaten the security of this critical infrastructure.

Opportunity: KSU has multi-disciplinary research expertise in railway track systems, and has partnered with over 15 companies to improve the safety and durability of the railroad infrastructure through basic and applied research. Additional funds are needed to leverage existing research contracts by enhancing and deploying the technologies that have been developed at KSU and which can prevent failure of track components.

Solution: The multidisciplinary research team has developed a patented Laser-Speckle Imaging (LSI) system for imaging concrete railroad ties to determine if they are properly stressed at the manufacturing plants to prevent cracking and failure in track. This work had led to over 30 refereed publications since 2011.

Impact: The LSI technology developed at KSU was successfully used at a concrete tie plant in July 2014 to identify defective ties before they were potentially put in track. Thus, the further development of this technology can be used to prevent potential derailments and maintain the security of the rail infrastructure.

Equipment & Expertise: Laser-Speckle Imaging (LSI) – this optical measurement technique has been successfully developed for use on concrete railroad ties by multi-disciplinary researchers at Kansas State University. Dr. Peterman has expertise in prestressed concrete and bond; Dr. Riding has expertise in concrete materials and durability, Dr. Beck has expertise in optics and analytical modeling; Dr. Wu has expertise in automation and computer optimization algorithms.