Background
Railways are the backbone of the United States economic system because they allow swift, economical, fuel-efficient movement of agricultural products, coal, and finished goods. However, maintaining freight movement requires efficient train networking and reliable track systems. Kansas State University (KSU) currently utilizes multi-disciplinary expertise in railway track systems for $4.1 million research contracts with the Federal Railroad Administration to investigate methods of improving the safety and durability of concrete railroad ties. Additionally, KSU researchers are assisting KDOT to evaluate track infrastructure for heavier car loads and to evaluate track ballast non-destructively. KSU departments involved in this research include Civil Engineering, Mechanical and Nuclear Engineering, and Industrial and Manufacturing Systems Engineering.

Description
The overarching objective of this multi-disciplinary research is to enhance current understanding of how various materials and fabrication processes interact and consequently affect railway durability and sustainability. KSU has pioneered development of a laser-speckle imaging (LSI) device that can be used in rugged environments such as railroad tie production facilities. This patented device has led to development of a system that images concrete railroad ties in order to determine if they are properly assembled at the manufacturing plant to prevent cracking and failure in track.

KSU researchers are also developing methods to determine how raw materials and manufacturing processes affect durability of the railroad ties in states such as Kansas where many freezing and thawing cycles occur each year. Therefore, KSU recently installed a specially-designed 120-cubic-foot environmental chamber dedicated to testing full-size railroad ties under water-saturated freezing and thawing cycles. This chamber is the only test apparatus of its kind in the United States capable of testing full-scale railroad ties.

The use of LSI techniques and full-scale freeze-thaw testing of concrete railroad ties has positioned KSU at the forefront of railroad track systems durability research. Therefore, KSU proposes to establish a Center for Rail Infrastructure Durability and Sustainability (CRIDS). The proposed center will be used to further develop and deploy the existing KSU-developed technologies in order to improve durability and sustainability of the U.S. rail infrastructure.

New Railway Infrastructure Environmental Test Chamber. Long-term durability of railroad ties under repeated loading from heavy-freight and high-speed railway lines should be tested under extreme weather conditions, including hot and cold temperatures, wet and dry conditions, and varying subgrade materials and temperatures. Funds will be used to design and build the first high-tech varying-climate full-scale test chamber for railroad track systems in the United States.

Durability of Railroad Ties Under Various Load and Support Conditions. Railroad ties made with newly-developed materials could provide longer life, thereby increasing sustainability of the railroad infrastructure. The existing full-scale testing capabilities at KSU will be enhanced to include the ability to evaluate the performance of railroad ties under varying load and support conditions such as found on heavy-freight and high-speed railways with different supporting ballast conditions.

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

Relevance
Sharp increases in rail traffic in the last ten years has caused railways to become increasingly critical to the U.S. economy. 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.