Assessment of Failure Mechanisms of Joints in Ultra-Large Section Jacking Prestressed Concrete Cylinder Pipe (JPCCP): Insights from Zhengzhou, China

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ABSTRACT:

Jacking prestressed concrete cylindrical pipe (JPCCP) is an innovative pipe that combines the benefits of prestressed concrete cylinder pipe (PCCP) and the pipe jacking method, playing a crucial role in water conservancy projects across China. Due to its structural characteristics and manufacturing process, the JPCCP joints are prone to circumferential cracks during jacking, and the harmful cracks can damage the inner concrete core over time, posing significant safety risks to the pipeline's structural integrity. To investigate the influence of jacking factors on cracking behavior at the JPCCP joints, this study examines the failure modes of concrete at the bell-spigot ends of the pipes. The analysis combines field experiments and numerical simulations, using data from China's largest-diameter JPCCP project. The study finds that local tensile stress at the spigot end is the primary cause of cracking and potential fracture, and micro-cracks initially form on the inner surface of the damaged region, progressing circumferentially. Both jacking force and deflection angle significantly affect the distribution and magnitude of the maximum principal stress in the concrete. The ultimate jacking forces for deflection angles of 0.1° and 0.5° are 3842 T and 1134 T, respectively. Controlling concrete cracking can be achieved in the construction process by reducing the relative deflection between adjacent pipes. This study introduces novel approaches for improving JPCCP construction techniques and optimizing joint design, providing valuable insights for future projects.

Brief Bio:

Dr. Ariaratnam is a Professor and Sunstate Chair of Construction Management & Engineering at Arizona State University with 30 years of experience in trenchless pipeline engineering research and education. He graduated from the University of Waterloo with a B.A.Sc. in Civil Engineering in 1989 and received a Master's degree in 1991 and Ph.D. in 1994 from the University of Illinois at Urbana-Champaign. He has published over 350 technical papers and reports and is a co-holder of five patents. Dr. Ariaratnam was elected to the Canadian Academy of Engineering in 2018, the U.S. National Academy of Construction in 2019, and the European Academy of Sciences & Arts in 2023.

Dr. Ariaratnam has received numerous awards including the 2012 North American Trenchless Technology Person of the Year. Additionally, he has received recognition from the American Society of Civil Engineers (ASCE), where he received the John O. Bickel Award, Arthur M. Wellington Prize, Pipeline Division Award of Excellent, and the Stephen D. Bechtel Pipeline Engineering Award. In 2022, Dr. Ariaratnam was elected Distinguished Member, the highest honor that ASCE can bestow. He is currently the ASCE Utility Engineering and Survey Institute (UESI) President and leads an 11-member Board of Directors. Dr. Ariaratnam was appointed by the U.S. Secretary of Transportation to serve on the Gas Pipeline Advisory Committee of the U.S. Pipeline and Hazardous Materials Safety Administration (PHMSA) in March 2022.

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