Brittle Fracture Tests on Steel Bridge Bearings: Application of the Potential Drop Method

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Abstract : Usually, steel structures are designed for the upper region of the steel toughness-temperature curve. To address the reduced toughness properties in the temperature transition range, additional safety assessments based on fracture mechanics are necessary. These assessments enable the appropriate selection of steel materials to prevent brittle fracture. In this context, recommendations were established in 2011 to regulate the appropriate selection of steel grades for bridge bearing components. However, these recommendations are no longer fully aligned with more recent insights: Designing bridge bearings and their components in accordance with DIN EN 1337 and the relevant sections of DIN EN 1993 has led to an increasing trend of using large plate thicknesses, especially for long-span bridges. However, these plate thicknesses surpass the application limits specified in the national appendix of DIN EN 1993-2. Furthermore, compliance with the regulations outlined in DIN EN 1993-1-10 regarding material toughness and through-thickness properties requires some further modifications. Therefore, these standards cannot be directly applied to the material selection for bearings without additional information. In addition, recent findings indicate that certain bridge bearing components are subjected to high fatigue loads, necessitating consideration in structural design, material selection, and calculations. To address this issue, the German Center for Rail Traffic Research initiated a research project aimed at developing a proposal to enhance the existing standards. This proposal seeks to establish guidelines for the selection of steel materials for bridge bearings to prevent brittle fracture, particularly for thick plates and components exposed to specific fatigue loads. The results derived from theoretical analyses, including finite element simulations and analytical calculations, are verified through component testing on a large-scale. During these large-scale tests, where a brittle failure is deliberately induced in a bearing component, an artificially generated defect is introduced into the specimen at the predetermined hotspot. Subsequently, a dynamic load is imposed until the crack initiation process transpires, replicating realistic conditions akin to a sharp notch resembling a fatigue crack. To stop the action of the dynamic load in time, it is important to precisely determine the point at which the crack size transitions from stable crack growth to unstable crack growth. To achieve this, the potential drop measurement method is employed. The proposed paper informs about the choice of measurement method (alternating current potential drop (ACPD) or direct current potential drop (DCPD)), presents results from correlations with created FE models, and may proposes a new approach to introduce beach marks into the fracture surface within the framework of potential drop measurement.

Keywords : beach marking, bridge bearing design, brittle fracture, design for fatigue, potential drop
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