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Avoidance of Brittle Fracture in Bridge Bearings: Brittle Fracture Tests and Initial Crack Size

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Abstract : Bridges in both roadway and railway systems depend on bearings to ensure extended service life and functionality. These bearings enable proper load distribution from the superstructure to the substructure while permitting controlled movement of the superstructure. The design of bridge bearings, according to Eurocode DIN EN 1337 and the relevant sections of DIN EN 1993, increasingly requires the use of thick plates, especially for long-span bridges. However, these plate thicknesses exceed the limits specified in the national appendix of DIN EN 1993-2. Furthermore, compliance with DIN EN 1993-1-10 regulations regarding material toughness and through-thickness properties necessitates further modifications. Consequently, these standards cannot be directly applied to the selection of bearing materials without supplementary guidance and design rules. In this context, a recommendation was developed in 2011 to regulate the selection of appropriate steel grades for bearing components. Prior to the initiation of the research project underlying this contribution, this recommendation had only been available as a technical bulletin. Since July 2023, it has been integrated into guideline 804 of the German railway. However, recent findings indicate that certain bridge-bearing components are exposed to high fatigue loads, which necessitate consideration in structural design, material selection, and calculations. Therefore, the German Centre for Rail Traffic Research called a research project with the objective of defining a proposal to expand the current standards in order to implement a sufficient choice of steel material for bridge bearings to avoid brittle fracture, even for thick plates and components subjected to specific fatigue loads. The results obtained from theoretical considerations, such as finite element simulations and analytical calculations, are validated through large-scale component tests. Additionally, experimental observations are used to calibrate the calculation models and modify the input parameters of the design concept. Within the large-scale component tests, a brittle failure is artificially induced in a bearing component. For this purpose, an artificially generated initial defect is introduced at the previously defined hotspot into the specimen using spark erosion. Then, a dynamic load is applied until the crack initiation process occurs to achieve realistic conditions in the form of a sharp notch similar to a fatigue crack. This initiation process continues until the crack length reaches a predetermined size. Afterward, the actual test begins, which requires cooling the specimen with liquid nitrogen until a temperature is reached where brittle fracture failure is expected. In the next step, the component is subjected to a quasi-static tensile test until failure occurs in the form of a brittle failure. The proposed paper will present the latest research findings, including the results of the conducted component tests and the derived definition of the initial crack size in bridge bearings.

Keywords : bridge bearings, brittle fracture, fatigue, initial crack size, large-scale tests
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