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New Concept for a Non-Welding Connection in Steel Structures and Steel-Concrete Composite Structures to Accommodate Large Building Tolerances Using Grout

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Abstract

Accommodation of tolerance in huge buildings is one of the challenges confronting the site engineer. Dimensional variation and the accuracy of positioning structural elements are more critical concerns in huge buildings than in other types of structures. The accumulation of the dimensional variations in such structures is significant due to the large dimensions and the dependency of each element on the previous erected element in a long series of successive steps throughout the construction process. Therefore, in this research, with an eye toward tolerance accommodation in huge multi-storey buildings, an adaptable grouted connection is suggested.

The research deals primarily with the strength characteristics of a grouted connection proposed to be employed between steel-to-steel elements or steel-to-concrete elements. The connection has been designed and tested at TU Berlin in the department of Composite structures (Verbunstrukturen). It consists of two toothed steel plates and grout in between; three types of grout have been used. The commercial names of the grout are BETEC180, COMPONO, and Sikadur-42; BETEC180 belongs to the family of high-performance cementitious grout, whereas COMPONO and Sikadur-42 relate to polymer concrete. Though the compressive strengths of all grout are close, there are substantial differences in the tensile and shear capacity between the cementitious grout and the polymer concrete grout.

Firstly, to investigate the performance of the connection under vertical shear, three tests for each material are conducted. The connection of cementitious grout showed brittle performance, and cracks started to propagate under relatively small loads. On the other hand, the polymer concrete connections displayed more ductile behavior in contrast to the BETEC connection; the displacements of the COMPONO and Sikadur-42 connections are 4.5 and 1.7 times, respectively, the displacements of the BETEC connection. Also, the ultimate strength of the COMPONO and Sikadur-42 connections is 81% and 74% greater than the parallel strength of the BETEC connection, respectively. Sikadur-42 connection presents the best behavior in terms of ductility and load capacity. However, the failure mode is comparable in all connections.

In order to demonstrate the connection's behavior and to trace the development of stresses and strains inside the connection, three-dimensional nonlinear Finite Element Models (FEM's), for the three different materials, have been carried out using ANSYS software. The FEMs exhibits reasonable good behavior and compatibility with the observations in the experiments. The models are useful in interpreting the stress development within the grout and the failure mode of the connection. Furthermore, the load capacities of the models tie in well with the test outcomes.

In order to calculate the strength of the connection, analytical approaches have been developed. The calculation procedure relies on a strut and tie model and the FEMs. The calculations distinguish between two phases; before and after cracking of the grout. The Utilization of the outcomes from the FEMs improves the results of the analytical approaches. The proposed theoretical approaches are sufficiently accurate to estimate the strength at the level of first cracks and to determine the ultimate strength of the connection.