Slip-resistant Connections with Imperfections in Steel Construction

Maik Dörre a, Mathias Schwarz a, Lukas Makevičius b, Ralf Glienke c, Knuth-Michael Henkel d, Natalie Stranghöner b

a) Fraunhofer-Institute for Large Structures in Production Engineering IGP, Rostock, Germany
b) University of Duisburg-Essen, Institute for Metal and Lightweight Structures, Essen (UDE/IML), Germany
c) University of Applied Sciences Technology, Business and Design, Wismar, Germany
d) Universität Rostock, Fakultät für Maschinenbau- und Schiffstechnik, Lehrstuhl für Fügetechnik, Rostock, Germany

ABSTRACT

Slip-resistant connections are traditionally used in steel and plant construction whenever slip and deformation in the bolted connections must be minimized. The current test procedure according to EN 1090-2, Annex G is limited to the basic load-bearing behavior under laboratory conditions. On the part of the industry, recurring questions arise as to the extent to which production-, assembly- and operation-related influences must be considered in the design of slip-resistant connections, as these affect the economic efficiency of this type of connection. This article publishes results of systematic investigations into slip-resistant connections under consideration of imperfections in form of structural, weather related and logistical influences.

KEY WORDS: slip-resistant connections, imperfections, edge misalignment, lining plates, damage friction surface, aging of the coating

INTRODUCTION

Bolted slip-resistant connections are traditionally used in steel and plant construction whenever slip and deformation in the bolted connections have to be minimized. Typical applications include single- and multi-section connections in (temporary) bridges, radio masts, flying structures and wind turbine towers. One of the most important parameters for the design of slip-resistant connections is the slip factor μ, which mainly depends on the surface properties of the mating friction surfaces and on the preload in the bolts. (Stranghöner et al, 2015; Stranghöner et al, 2018; Ebert, 2019a; Ebert, 2019b; Ebert, 2020; Afzali, 2021; Friedrich 2016). For a few surface conditions slip factors are already specified in EN 1090-2 (Deutsches Institut für Normung, 2018). Depending on the surface finish, a slip factor between μ = 0.2 (surfaces in the as-rolled condition) and μ = 0.5 (surfaces blasted) can be assumed without further ado. For other surface conditions, Annex G of EN 1090-2 provides a test procedure for determining the slip factor, which is, however, limited to the basic load-bearing behavior under laboratory conditions as part of a three-stage test procedure with the standard test specimens. These tests do not take into account any possible practical effects (Fig. 1) in the design.

In this context, it should be mentioned that EN 1090-2 permits a difference in thickness D of separate components of the same layer in the case of preloaded bolted connections in the amount of D = 1 mm without reduction. Furthermore, a maximum of three lining plates are permissible, which must be compatible with the adjacent connecting components in terms of their corrosion properties and mechanical strength. The systematic investigations carried out at the Institute for Metal and Lightweight Structures of the University Duisburg-Essen (UDE/IML) and at the Fraunhofer IGP Rostock as part of the IGF research project No. 19749 BG (Stranghöner et al, 2021) serve to record the influence of manufacturing and operational influences on the load-bearing behavior of slip-resistant connections in steel structures. Based on the contribution by (Stranghöner et al., 2022), an evaluation of the current regulations in