Determining splitting failure in secondary beam – Main beam connections by calculation

Part 1: Development of a calculation model
Part 2: Verification and extension of the calculation model

A great variety of connectors for secondary beam - main beam connections are applicable in timber constructions. For the most part the design rules of these connectors are regulated by technical approvals. The required calculation models are usually based on extensive full-scale tests regarding secondary beam - main beam connections. By introducing a numerical model for determining the load carrying capacity of the connectors the considerable effort involved in these tests could be reduced. For most failure modes the determination of the load carrying capacity of secondary beam - main beam connections by calculation is already possible. However, this is not true for splitting failure that may occur if the spacings and distances of fasteners are too small, which is common practice for connections of this type. To fix secondary beam - main beam connectors self-tapping screws are often used as they can be arranged maintaining only small spacings and distances without risking a consequential splitting failure of the member. The determination of the required spacings, edge and end distances for this type of screws necessitates numerous and comprehensive insertion tests. Yet the results of such tests cannot be transferred to other types of screws because of their different geometries and shapes or to screws of different diameter.

In the first part of this research project a calculation model on the basis of the Finite Element method was developed which can be used to estimate the splitting behaviour of timber during the insertion process. This model was extended to include different arrangements of several screws. Now it is possible to calculate the resulting split areas for several screws in a row in different end distances, spacings as well as for different cross sections of timber. Furthermore the model can be used for connections with screws arranged in several rows.

The test method which is used to measure forces affecting the member perpendicular to the grain during the insertion process was improved and verified by numerous experimental and numerical studies. Further influences on the splitting behaviour as e.g. the insertion speed or the angle between screw axis and tangent to the annual rings were determined with the help of this test method. By this it is possible to consider these influences in the numerical calculation of split areas. For the calibration and verification of the model simulated and experimentally determined crack areas were compared. Therefore the experimental method to determine the resulting split areas was used for connections with several rows of screws. Parameters to evaluate the splitting behaviour and the limits of the parameters (e.g. limits for the dimension of split areas) were derived.

In the continuation of the research project the calculation model will be verified by studies with further types of screws. Besides, it is necessary to verify the calculated distances, spacings and timber thickness for laterally and axially loaded screws. To this purpose load carrying capacity tests with connections are supposed to be carried out.

The extended model developed here allows a calculation of required timber thickness and required distances for connections with several rows of screws. This offers a basis for a realistic calculation of the load carrying capacity of joints in the case of failure by splitting.