# Macroscopic Modeling of Flow-Drill Screw Connections

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Flow-drill screws (FDS) are used in the automotive industry to join parts in the load-bearing structure of cars. The process is a simple one-step procedure, which requires access only from one side of the assembly, and a variety of dissimilar materials may be joined. As it is easy to automate, the FDS technology is well suited for the production lines in the automotive industry.

In large-scale finite element simulations (for instance crash simulations) point connections such as FDS connections cannot be modeled with accurate geometry with a reasonable simulation run-time due to limitations in computer power. Hence, simplified models are required to include the connections in such simulations.

The focus of this study was modeling of FDS connections in large-scale shell analyses in LS-DYNA. Five commercial macroscopic connections models available in LS-DYNA were investigated; two element-based models (***MAT_SPOTWELD** and ***MAT_240**) and three constraint-based models (***CONSTRAINED_SPR2** and the two versions of ***CONSTRAINED_INTERPOLATION_SPOTWELD**). Cf. [1-3] for detailed discussions of the theory of the models.

All models were calibrated using cross tests in tension, shear and a mixed tension/shear mode. In order to assess the flexibility of the models two sets of experimental data was used. First, a short screw was used to join two sheets of the same rolled alloy. In the second set, a long screw was used to join a rolled alloy to an extrusion. The models were validated using a two-steps approach including benchmark tests (single lap-joint and peeling) and component tests (crash box crushing and T-component tests). Cf. [4] for detailed descriptions of the test set-up.

None of the two element-based models were flexible enough to reproduce the cross test results. The tensile and shear modes were well captured, but the force and initial stiffness in the mixed mode were severely over-estimated for both sets of experimental data. For this reason simulations of the benchmark and component tests were not carried out for the element-based models.

The three investigated constraint-based models gave better results compared to the two element-based models. The tensile and shear modes were well captured, and in the mixed mode the level of the maximum force as well as the ductility were to some extent reproduced. However, the shape of the force-displacement curves was not matched in the mixed mode. In particular the initial stiffness was too high in the simulations of the mixed mode. Best results were obtained using ***CONSTRAINED_SPR2,** and in the following some brief results are shown for this model.

The calibration results (cross tests) for both sets of experimental data are shown in Fig. 1. As seen, the tensile and shear modes were relatively well captured, but the model lacks the required flexibility to capture the mixed mode for both data sets. The over-predicted initial stiffness in mixed mode is clearly seen in the left figure. Fig. 2 shows the results from simulations of T-component tests. For both data sets the maximum force was relatively well predicted. The ductility was over-estimated for the short screws, while it was better predicted for the long screws.

This study has shown that of the five models investigated ***CONSTRAINED_SPR2** is best suited to represent FDS connections in large-scale shell simulations in LS-DYNA. However, none of the models are flexible enough to capture the physics in the mixed mode. Constraint-based models gave in this study more accurate results than element-based models.

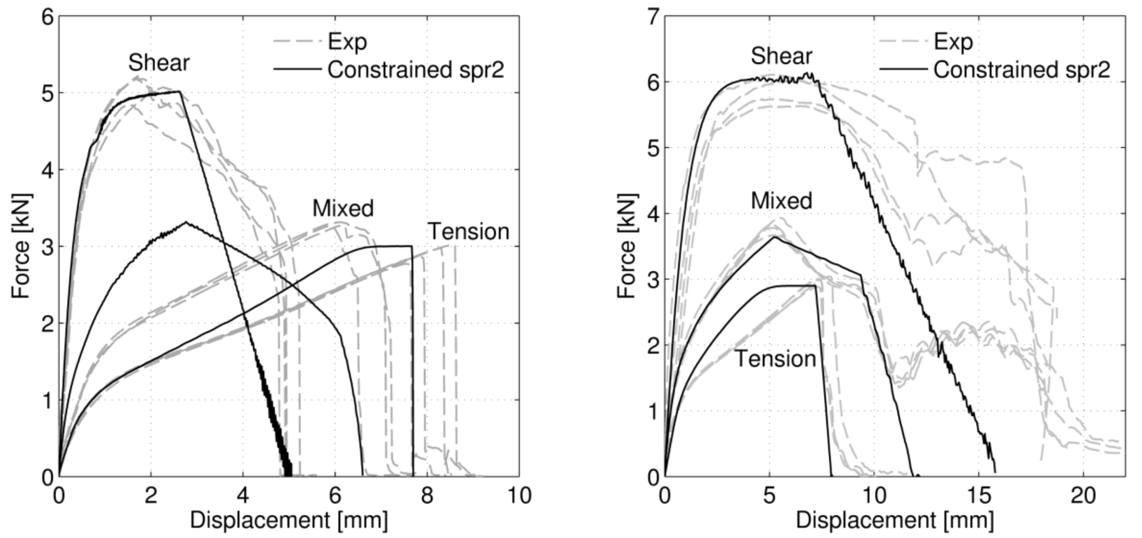


*Fig.1: Calibration of* ****CONSTRAINED_SPR2*** *to cross test results for short (left) and long (right) screws.*

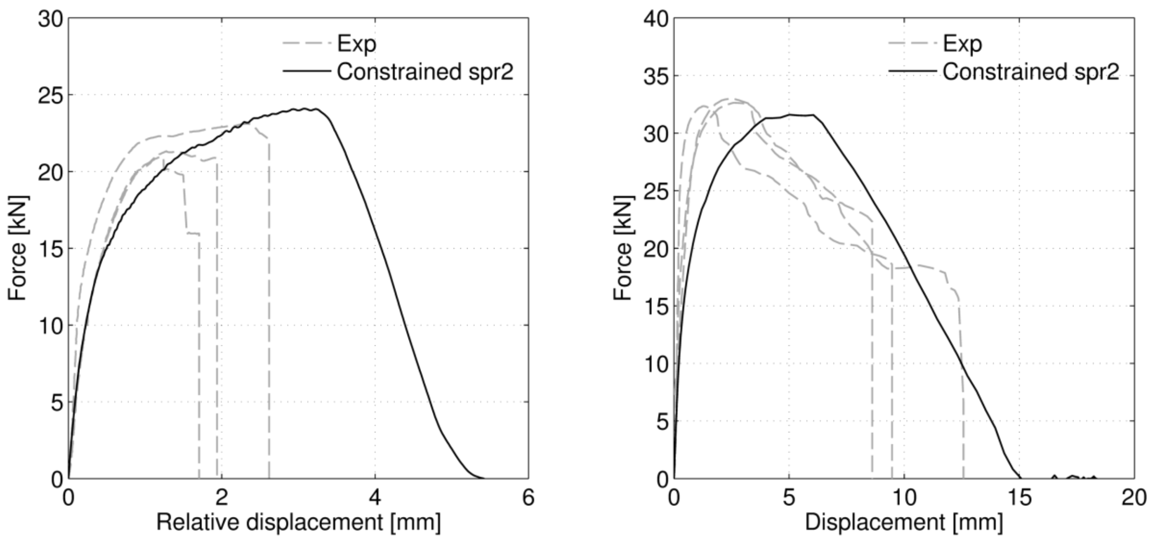


*Fig.2: Simulations of T-component tests with* ****CONSTRAINED_SPR2*** *for short (left) and long (right) screws.*

## Literature


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