Modelling of Adhesively Bonded Joints with *MAT252 and *MAT_ADD_COHESIVE for Practical Applications

F. Burbulla[1], A. Matzenmiller[2], U. Kroll[2]

[1]Dr. Ing. h.c. F. Porsche AG, Germany
[2]Institute of Mechanics (IfM), Department of Mechanical Engineering, University of Kassel, Germany

1 MAT_TOUGHENED_ADHESIVE_POLYMER (TAPO-Model)

The new material model **`*MAT_TOUGHENED_ADHESIVE_POLYMER`** (**`*MAT_252`**) has been developed at the Institute of Mechanics of the University of Kassel [1], [2] and become available for the use with solid elements since LS-DYNA R7.1.1. The theoretical framework of the model equations is based on continuum and damage mechanics in order to predict the complex mechanical behaviour of crash optimized high-strength adhesives under combined shear and tensile loading. Therefore, the non-associated I1-J2-plasticity model is extended to consider material softening due to damage, rate-dependency and the constitutive behaviour under compression. Consequently, the mechanical behaviour of structural adhesives is predicted sufficiently well, which is demonstrated by means of various simulations of specimens and components with adhesive joints under quasi-static and crash loading conditions [2].

2 MAT_ADD_COHESIVE

The cohesive elements ELFORM 19 and 20 in **`*SECTION_SOLID`** have a major advantage compared to standard solids: They have no influence on the critical time step in explicit analyses, if they are used to model thin adhesive layers [3]. So the modelling of adhesive layers with cohesive elements makes a significant contribution to the increase of the efficiency and the corresponding reduction of computational costs in numerical applications. So far, only approaches based on fracture mechanics **`(*MAT_41-50, 138, 184, 185, 186, 240)`** have been available in LS-DYNA for cohesive elements. The new interface **`*MAT_ADD_COHESIVE`** is available since LS-DYNA R7.1.1 and overcomes this difficulty. The interface allows the application of all classical material models originally developed for solids **`(*MAT_1, 3, 4, 6, 15, 24, 41-50, 81, 82, 89, 96, 98, 103, 104, 105, 106, 107, 115, 120, 123, 124, 141, 168, 173, 187, 188, 193, 224, 225, 252, 255`**) together with the cohesive elements 19 and 20 without any modification of the previously established set of material parameters [1], [2]. Thus, the numerical efficiency according to the modelling of thin structures with the cohesive elements is accessible to every solid material model.

3 Parameter identification and optimization, model verification and validation

The influences of particular model parameters on the model response are elaborated leading to a simple and robust identification procedure. The model parameters for the elastic-plastic behaviour, damage and material failure are directly identified and computationally optimized with the optimization software LS-OPT [1], [2]. Six quasi-static tests of the bluntly-glued steel tube specimen provide the target data for the identification, verification and optimization. The parameters for the rate dependency are determined by means of dynamic tests of the butt jointed steel tube specimen [1], [2]. The responses of the TAPO- and ARUP-model are compared to each other. Comparisons of the simulations with the data of the KS2-, Peel-Shear- and T-Joint test prove the validity of the TAPO-model and the interface **`*MAT_ADD_COHESIVE`** in order to predict the mechanical behaviour of the toughness modified structural adhesive investigated [2], [4], [5].

4 Literature

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[3] Matzenmiller, A., Gerlach, S., Fiolka, M.: A critical analysis of interface constitutive models for the simulation of delamination in composites and failure of adhesive bonds. Journal of Mechanics of Materials and Structures, Vol. 5, Nr. 2, S. 185-211, 2010.

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