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TOPOLOGY OPTIMIZATION OF A STEEL JOINT FOR TEMPORARY SPACE FRAMES

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Abstract: This contribution focuses on a recently developed modular building system for temporary space frames [1]. The building system is based on standard scaffolding bars, which are connected to a custom-designed steel joint by means of a pin-lock system. The system has already been used to build various types of pavilions for festivals and other temporary events. While the boltless connection system allows for fast erection and dismantling, the custom-designed joint is relatively heavy and, as a consequence, difficult to handle. In order to reduce the weight of the joint, a new design is proposed based on topology optimization, which is presented in this contribution. The joint consists of 3 intersecting square plates that are mutually perpendicular. A maximum of 12 bars can be connected to the joint – one bar at each corner of each plate. The design load of the joint is equal to the axial load resistance of the bars, which is 30 kN. The weight of the joint is reduced by removing obsolete material from the plates by means of water jet cutting. The perforation pattern is determined by topology optimization. The optimization problem is formulated for a single plate as a 2D minimum compliance problem with a volume constraint and with multiple load cases. The load cases reflect all possible combinations of maximum tension (30 kN), zero force, and maximum compression (-30 kN) at each of the 4 corners of the plate. After the optimization, a 3D joint is assembled as the intersection of three identical perforated plates, and the Von Mises stresses for all possible load combinations are computed. Next, the volume constraint is adjusted to ensure that the Von Mises stress does not exceed the yield stress, and the 2D optimization problem is solved again. This procedure is repeated until convergence is reached in terms of the volume constraint. The geometry of the optimized joint is significanlty different from the original geometry, and the weight is about 50 % of the original weight. In the coming weeks, a prototype of the optimized joint will be produced by means of water jet cutting. The strength and stiffness of the prototype will be determined by means of tension and compression tests, and compared with the values predicted by the numerical model used for the optimization. [1] M. Van de Winkel. VakWerk. www.vakwerk.net, April 2018.