Design of Friction-Joint Patterns for Segmented Concrete Shells

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Abstract

This contribution proposes a method to determine patterns of joints that enable to transfer loads by means of friction in segmented concrete shells.

By constructing concrete shells from precast segments, the efficient load-bearing behaviour of curved structures can be combined with the advantages associated with prefabrication, such as high precision of geometry and quality of the concrete produced in controlled environment. Especially when combined with new methods to reduce the weight of structural components by optimizing their interior volume [1], [2], this presents a promising approach to increase the material efficiency of shell structures. When segmenting a shell, however, close attention needs to be paid to a possible change in load-bearing behavior imposed by the chosen type, place and orientation of the connection. In case of concrete shells, usually designed to exhibit compression dominated membrane-action, forces can be transferred continuously in between segments by means of hard contact. In [3] for example, it is shown that transfer of compression loads by hard contact can be achieved by aligning joint-lines in perpendicular to principal compressive stresses.

Hard contact joints subjected to compression forces may also transfer shear stresses due to friction. Thus, they do not necessarily need to be oriented in perpendicular to a compressive stress. The authors have developed a method that indicates all possible hard contact joints for a segmented shell for which loads can be transferred by friction. By evaluating the stress state (or a set of stress states) at every point inside of a shell with respect to COULOMBs law of friction, the orientation of all friction joints at this point can be determined. Aligning joints alongside the indicated orientations will therefore results in continuous load transfer due to friction throughout a segmented shell.

This contribution discusses the method for the design of friction-joint patterns. The theoretical background will be described alongside with an implementation of the method for 3D-CAD environments using Rhinoceros and Python. Furthermore, two case studies will be shown to indicate possible applications of the method.

References

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