Yield surface of a zero-tension masonry quadrilateral section subjected to an eccentric compressive force

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Abstract

In a previously paper [1], for the masonry subject to limited compressive stress and assuming that the material cannot sustain any tensile force, the authors have defined in complete way the yield domain of a rectangular section subjected to eccentric compressive normal force. Besides, a consistent linear approximation of this domain for applications in limit analysis was proposed. In the present work, for the same masonry type, such analysis is extended to a generic quadrilateral section.

As in the case of the rectangular section, the three-dimensional (3D) domain is composed of convex surface portions; each of those - corresponding to a field in which the application point of the compressive force can fall - is described by a different nonlinear function expressed in terms of normal force and bending moments. Unlike the case of the rectangular section, the complexity of this 3D domain does not allow a generalizable representation of the actual domain (which in any case has a spindle-shape with two vertices at the ends); this has led us to abandon the idea of obtaining the non-linear expressions of the portions of limit surface, of little practical utility, and to focus our attention on the identification of a useful linearized domain for applications of limit analysis.

This linearized domain is defined by 24 tangent planes that envelop the actual one. To construct it, we have to define the cross section of the actual yield domain in the 3D reference (G, N, M_1, M_2) at $N_0/2$ abscissa point, being N_0 the limit normal force applied in the centroid which leads to the complete plasticization of the entire section. For this purpose, we preliminarily construct the closed line of the centroids of all the half sections totally plasticized, that is homothetic (with respect to principal axes of inertia) to the cross section of the yield domain. Unlike the rectangular section, the aforesaid closed line for the quadrilateral section is not always constituted by four parabolic curves, but by a number of curves ranging from four to eight, depending on the quadrilateral shape. After defining the actual domain cross section, by tracing eight tangents to this curve, the cross section of the linearized circumscribed domain is obtained. By translation along the N axis of the reference (G, N, M_1, M_2), it generates 8 tangent planes that envelop the 3D yield domain; other two groups of 8 planes, forming two octagonal pyramids, complete the envelope of the actual spindle-shape domain.

Of course, a less restrictive approximate yield surface of only twelve planes could be also used, with the consequent computational advantages; however, the use of the proposed more restrictive failure surface (24 planes) allows a more realistic assessment of the collapse load multiplier.

Keywords: Masonry, zero-tension material, yield surface, quadrilateral section, eccentric compressive normal force, limit analysis.

References

[1] Anselmi, C. and Saetta, E. (2012) Yield surface of a zero-tension rectangular masonry section subjected to an eccentric compressive force, *Masonry International* **25**, 55-62.