Oryginalny artykuł naukowy

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Determination of mortar and brick failure surface based on research in a complex state of stress

Wyznaczenie powierzchni zniszczenia zaprawy i cegły na podstawie badań w złożonym stanie naprężenia

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Abstract. The paper shows a investigation of masonry components in a complex state of streses. In the mortar and brick material model the Willam-Warnke failure criteria are used. All parameters of failure criteria are obtained from mortar and brick samples investigations. To estimate the position of the meradians of the failure surface, the triaxial and uniaxial tests of mortar and brick were made.

Keywords: masonry unit, mortar, Willam-Warnke failure criteria, triaxial and uniaxial investigations of load state.

Streszczenie. W artykule opisano wyniki badań komponentów muru w złożonych stanach naprężenia. Jako kryterium zniszczenia zaprawy i cegły przyjęto model Willama-Warnkego. Wszystkie parametry powierzchni zniszczenia zostały określone na podstawie badań zaprawy i cegły. W celu wyznaczenia południków powierzchni granicznej wykonano badania zaprawy i cegły w trójosiowym aparacie ściskania.

Słowa kluczowe: elementy murowe, zaprawa, kryterium zniszczenia Willama-Warnkego, badania w osiowym i trójosiowym stanie obciążenia.

In the numerical analysis of the masonry structures two methods can be used: micro and macro-modeling [2, 3, 4, 5, 6]. Micro-modeling depends on different description of mortar and brick properties. It involves separate division on finite-elements in each material. To make an appropriate description of the mortar and brick interaction on the plane of their contact, the additional contact elements must be used. Macro-modeling depends on estimating substitute material description presenting connections between average strengths and strains. The masonry model is showed here as a homogeneous material. The basic advantage of the homogeneous models is the unlimited size and shape of the finite-elements. However, the main disadvantage of the said models is the lack of the possibility to make an appropriate mapping of the masonry destruction. There can be showed the crack effect on the contact of mortar and brick only by using micro-modeling. In the paper results of triaxial and uniaxial tests for mortar and brick samples were submited. Parabolic meridians of Willam-Warnke failure surface established and presented.

Failure surface

Willam-Warnke failure surface has non-circular cross sections consist of three tangent ellipses (fig. 1a). The surface has a pyramid similar shape (fig. 1b) with straight or second-order parabolic generating line, called meridians [8]. In the paper the five-parameter Willam-Warnke criteria was used. In the said criteria the failure surface has parabolic meridians.

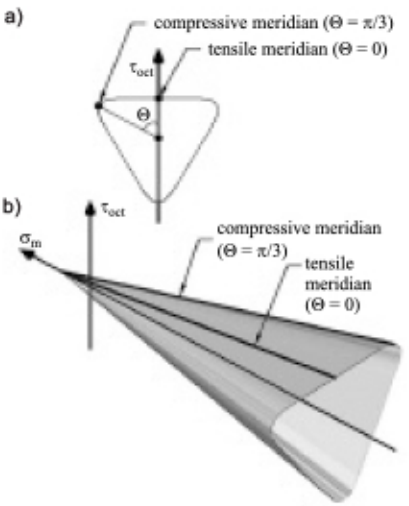

Fig. 1. Willam-Warnke failure surface: a) deviatoric section; b) general view
Rys. 1. Powierzchnia zniszczenia Willama-Warnkego: a) przekrój dewiatorowy; b) widok

Failure surface defines the area of safe material's operating process. If the stress paths puncture the failure surface, it will damage the material. The meridian, where the point responsible for the uniaxial compressive strength is located, is called compressive meridian (fig. 2a). Whereas the meridian, where the point responsible for the uniaxial tensile strength and biaxial compressive strength is located, is called tensile meridian (fig. 2a). The shape of the deviatoric section's surface is periodical – the compressive and tensile meridians are situated interchangeably with an angle between them equals Θ = 60°. All meridians converge in mean normal stress axis on the triaxial tensile strength point f_{tt}.

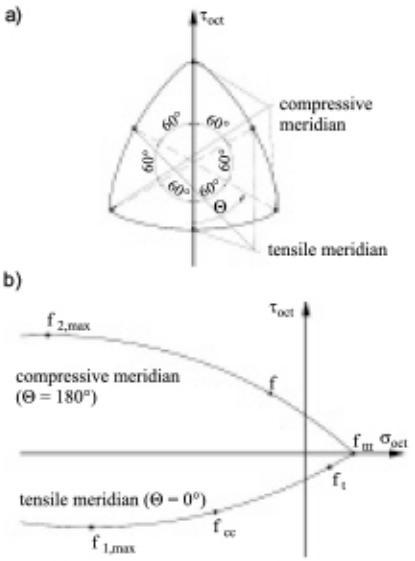

Fig. 2. Parameters of Willam-Warnke failure surface: a) hydrostatic section; b) deviatoric section
Rys. 2. Parametry opisujące powierzchnię zniszczenia Willama-Warnkego: a) przekrój aksjatorowy; b) przekrój dewiatorowy

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