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THE PERFORMANCE DEPENDENT FAILURE CRITERION FOR NORMAL AND HIGH STRENGTH CONCRETES

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ABSTRACT

A new failure criterion to predict maximum strength of plain concrete is presented. The proposal is based on the definition of a parameter that objectively quantifies the quality of a concrete, so-called the "Performance Parameter" (β_P), and on the elliptic interpolation between the compressive and the tensile meridians by Willam and Warnke (1974). A unified mathematical formulation is obtained that predicts different maximum strength surfaces for concretes of different performances, from normal (NSC) to high (HSC) strength concretes, depending on the three stress invariants, and only on two material parameters: the performance parameter β_P and the uniaxial compressive strength f'_c. (See Fig. 1 and Fig. 2)

To define the performance parameter, a large set of experimental data available in the literature is evaluated, regarding their differences in the considered mix proportions and related uniaxial compressive strength. It is concluded that the most effective set of parameters to objectively quantify the quality of concrete is the one composed by f'_c and the water/binder ratio (W/B). Therefore, the performance parameter is defined in terms of these last two parameters.

In the mathematical approach of the proposed criterion, the compressive and the tensile meridians are defined as quadratic polynomials with two constraints: a common vertex, and the same coefficient defining the quadratic dependence of the maximum strength surface on the normalized Haig Westergaard shear stress coordinate $\bar{\rho}$. Therefore, four coefficients need to be determined to fully define the compressive and tensile meridians of the proposed maximum strength surface. Then, auxiliary conditions are considered, by enforcing the failure surface to pass through the uniaxial compression, the uniaxial tensile, and the biaxial

compression test points, and, by setting the tangent to the compressive meridian on the stress point corresponding to the uniaxial compression test, equal to a known material parameter *m* empirically calibrated and analogous to a friction parameter.

The coefficients are then determined, resulting scalar functions in terms of the following material parameters: the uniaxial compressive strength f'_c; the tangent to the compressive meridian on the stress point corresponding to the uniaxial compression test, so-called *m*; the uniaxial tensile strength ratio $\alpha_{t,}$; and, the biaxial compressive strength ratio α_b.

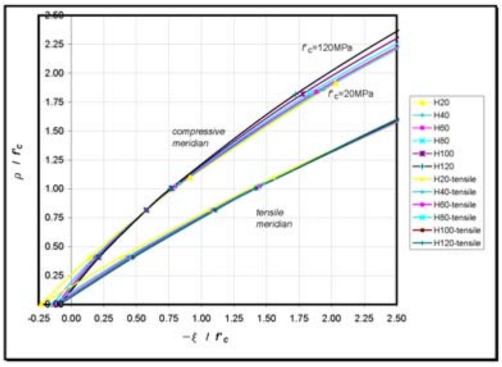

Fig. 1 – Performance dependent model predictions of the normalized compressive and tensile meridians for different concrete performances

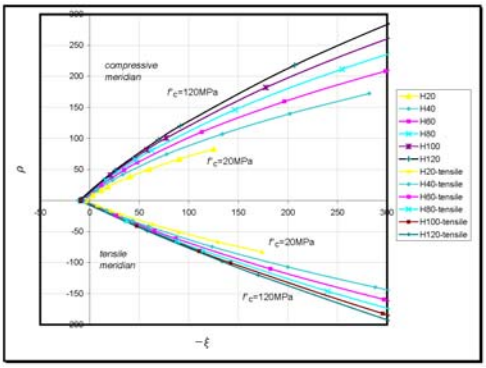

Fig. 2 – Performance dependent model predictions of the compressive and tensile meridians for different concrete performances

The performance parameter is incorporated to the proposed criterion by calibrating the last three material parameters as empirical functions in terms of β_P.

Regarding the dependence of β_P on the water/binder (W/B) ratio, which is not always easy to be obtained, different numerical methods are presented to assure the feasibility of the solution procedure for any possible set of known data. For the case of existing concretes, an empirical method is presented. For the case of concretes to be designed, a system based on ANFIS is proposed. A genetic algorithm (GA) system is being developed to solve the inverse problem: to obtain different concrete mixes that correspond to a given or desired concrete strength.

The capability of the proposed performance dependent failure criterion is verified with experimental data available in the literature corresponding to uniaxial, biaxial and triaxial compression tests, observing a good agreement of the peak stresses predicted with the new criterion for both, NSC and HSC.

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