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(Revised)

Summary

The present work is based on tests of tubular concrete specimens subjected to combined torsion and compression. It has two main purposes. The first is to determine the stress/strain properties under biaxial tensile and compressive stress. A boundary curve in principal stress plane is found within which the stress/strain relations are substantially elastic, if allowance is made for creep. The curve is called discontinuity. Discontinuity occurs at about the same percentage of maximum stress as previous writers report the onset of serious microcracking. The effect on discontinuity of altering certain mix proportions or ingredients is suggested. Several well-known theories of yield and fracture are used together with empirical terms appropriate to the specific mix to try to fit the data at discontinuity. The theory of plasticity is applied to see if the curve has the properties of a yield curve.

Biaxial-stress/strain relations are found experimentally and are described by empirical formulas. The principal directions of stress and strain are found to coincide within about 3 degrees. This finding applies both to tests in which the principal directions of stress are held fixed in the specimen, and to tests where the principal directions vary. The result implies that the specimens are virtually isotropic. However, a small amount of elastic shortening and circumferential expansion due to torsion was found which

indicates a small degree of anisotropy.

The second purpose of the present thesis is to study the fracture process, which is considered to begin with spreading of microcracks. The extent of cracking is measured by the permanent tensile strain and the amount of irrecoverable work done up to maximum stress. It is found that in some cases such properties of the specimen as strength, stiffness and the stability of cracks depend on the extent of microcracking it contains. The transition in mode of fracture from that typical of uniaxial tension to that typical of uniaxial compression is studied. The two modes, called cleavage and crushing respectively, are distinguished by the ratio of principal stresses, the amount of microcracking up to maximum stress and the energy absorbed during large-scale fracture. The effect of changing mix proportions and ingredients on the stress ratio at transition is considered. Possible engineering theories of strength are compared with the experimental results.

Some specimens containing extensive microcracking are unloaded and tested a second time. This treatment has an important effect on the cleavage type of fracture and a lesser effect on the crushing type. The effect of moisture on strength is also studied experimentally.

X-radiography is used to study cracking. Factors which govern the development of microcracks into larger cracks such as effective blunting of the crack tip are noted. The maximum length of microcrack which the specimens can tolerate without suffering large-scale cleavage is estimated, and compared with predictions of Griffith's theory.