Nonlinear Analysis of Reinforced Concrete Structural Elements

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Abstract

Nonlinear analysis of reinforced concrete elements is the focus of the present study. A concrete damage plasticity model available in Abaqus commercial software has been modified using user defined modules to include the concrete stiffness degradation and growth in the Poisson's ratio in plain concrete with increase in compressive strain. In reinforced concrete the degradation of cracked concrete in compression, tension stiffening effects and bond slip have been considered to enhance the prediction of responses observed in reinforced concrete elements under various loadings. The model predicts the salient features of multiaxial response observed in experiments on plain and reinforced concrete elements subjected to various loads.

Keywords: Strain softening, Tension stiffening, concrete plasticity, reinforced concrete beams.

1 Introduction

The development of rationale analytical procedures for the analyses of reinforced concrete (RC) structural elements has been the focus of many investigations over the years. Experimental studies on reinforced concrete membrane elements [1-3] have identified the influence of several parameters on the post cracking response of RC elements. These include the strain softening response of cracked plain concrete, contribution concrete between cracks in carrying tensile loads (tension-stiffening), compression softening response of cracked concrete, aggregate interlock action at crack interfaces and dowel action of rebars in cracked concrete, yielding of the reinforcement, post yield hardening of the reinforcement, steel concrete interface bond slip, etc.

Kupfer et al. (1969) [4] conducted tests on plain concrete under biaxial stress states and reported that the strength of concrete under biaxial compression is larger than that of concrete under uniaxial compression. The experimental results show that the normalized biaxial strength for different strength of concrete is almost the same. In the range of compression-tension and biaxial tension, the relative strength decreases as the uniaxial strength increases. The strength of concrete under biaxial tension is almost independent of the stress ratio σ_1/σ_2 and equal to the uniaxial tensile strength. It has been reported that damage in the concrete due to microcracking is a result of volumetric expansion of material [5]. Restraint against expansion, which is imposed by boundary conditions, influences the stress state of material [6]. Pantazopoulou (1995) [6] proposed that the strength and residual stiffness of concrete subjected to any stress combination can be completely evaluated from the state of damage