Failure modeling of brittle materials in dynamic loading via the Gurson plastic – damage model

A.R. Khoei[1], M. Hajibabaee[2]

[1]Professor, Department of Civil Engineering, Sharif University of Technology, Tehran, Iran
[2]MSc student, Department of Civil Engineering, Sharif University of Technology, Tehran, Iran
arkhoei@sharif.edu
hajibabaee@mehr.sharif.ir

Abstract

In this paper a method is developed to model the RC concrete behavior with an emphasis on tension and compression damage, micro crack closure effect in cyclic loading and irreversible strains in plastic state. The tension of concrete produces the micro and macro crack exhibition and growth (degradation). The compaction of concrete is physically a collapse of the material voids and movement of micro cracks (softening), which produces plastic strains. The model is based on the damage and plasticity in porous materials, which is implemented in dynamic problems. Finally, numerical examples are presented to verify the accuracy of model in static, cyclic and dynamic loadings.

Keywords: Gurson, plasticity, brittle, damage, dynamic

1. INTRODUCTION

There are two mechanisms that induce a variation (decrease) of the elastic modules of the material, the micro cracking in tension and the crushing of the cement or mortar matrix in compression. For the first phenomenon, we use a classical rate dependent damage model (Dubé et al. 1996), which uses two damage variables in order to provide a realistic response of the material in uniaxial compression while preserving a good description of what occurs in tension. Rate effects are necessary in order to represent dynamic experiments (mostly dynamic tensile tests). In addition, rate dependency preserves well posedness of the equations of motion when strain softening occurs (Sluys 1993). The second phenomenon is captured by using the modified Gurson yield function (Gurson 1977, Needleman and Tvergaard 1984) in which the porosity of the material F^* is governed by the plastic flow. These two mechanical effects are combined in the final relationships that relate the stresses to the elastic strains as:

$$\sigma_{ij} = (1-D)(K\,\varepsilon^{e}{}_{kk}\delta_{ij} + 2G(\varepsilon^{e}{}_{ij} - \frac{1}{3}\varepsilon^{e}{}_{kk}\delta_{ij})) \tag{1}$$

$$\dot{\varepsilon}_{ij} = \dot{\varepsilon}^{e}_{ij} + \dot{\varepsilon}^{p}_{ij} \tag{2}$$

where K and G are the bulk and shear modulus of material and $\dot{\varepsilon}^{p}_{ij}$ is the plastic strain rate. D is the damage parameter that reduces the stiffness of damaged material.

2. Plasticity Model

The Gurson plasticity model was first proposed by Gurson (1977) and then modified by Tvergaard and Needleman (1984). This model used widely used for ductile behavior modeling of steel materials, the model is then used in plasticity modeling of brittle materials especially in dynamic loading, The experiment