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Effect of Tensile Damage Parameter Reducing in Non-linear Analysis of Reinforced Concrete Structures using Concrete Damage Plasticity Method

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ABSTRACT: Introducing the behavior of reinforced concrete materials is generally considered as one of the complex parts of modeling in finite element software. Thus, entering accurate material information has an effective role in software output results. There are several methods in ABAQUS software for nonlinear analysis of reinforced concrete, one of which is the use of a Concrete Damage Plasticity (CDP) model. In this method, entering the mechanical properties of concrete is of special importance, so that in case of insufficient data entry, many errors are created in the results and sometimes cause no convergence despite spending a lot of time analyzing in the software. In numerical modeling in ABAQUS using the CDP method, two conditions must be observed. Firstly, the sing of the plastic strains of the concrete are positive and secondly, with increasing the concrete strain, the plastic strains of concrete are also upward. These conditions cause the elimination and reduction of some points in the input information of concrete materials in the CDP method. In this study, the analysis procedure is performed by varying the number of stress points and tensile strain and tensile damage parameter (dt), this analysis is repeated. The results obtained by nonlinear analysis of reinforced concrete structure due to the reduction of the number of points of the mentioned parameters are specified as force-displacement curves and the results show that by reducing the number of these points, with a minor error, the time of structural analysis is significantly reduced.

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1. INTRODUCTION

The behavior of reinforced concrete structures in the face of extreme forces such as the force of ground motion is very complex, and this complexity is mainly due to the joint confrontation of concrete and steel with those forces. In addition, increasing seismic awareness and concern around the world has led to new advances in reinforced concrete engineering. However, simple numerical models are widely used and relied on in many issues due to their average cost. Researchers have begun extensive research into modeling concrete using advanced numerical models. Chen *et al.* in a study entitled constitutive relations of concrete showed that the nonlinear response of concrete can be expressed using the theory of plasticity or the theory of damage, but none of these methods alone can describe this phenomenon [1]. Lin *et al.* also confirmed this subject in another study [2]. Many models of isotropic plastic damage from 1996 to 2008 have been proposed by many researchers [3-8]. Several different models have been simulated reinforced concrete structures with the concrete plastic damage method, with different strengths and different temperatures, using ABAQUS software and the results with experimental models have been compared [9]. In the present study, to analyze the reinforced concrete structure using ABAQUS in the section of concrete compressive damage, first, the number of points of the parameters of concrete compressive stress, concrete compressive strain, and compressive damage (d_c) are completely entered as input of the software. In the section of tensile damage of concrete, the number of points of the parameter of tensile damage of concrete (d_t) are completely entered. Then, the number of tensile stress points of concrete and the cracking strain of concrete are reduced to determine the effect of reducing these points on the capacity of reinforced concrete structures.

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2. MODELING IN SOFTWARE

The precise definition of materials for finite element modeling with elastic and plastic behavior in compressive and tensile parts has a great impact on output responses. The compressive behavior of concrete should include both elastic and full plastic properties of the concrete in softening and stiffening. Regarding the tensile behavior of concrete, the properties of concrete in both elastic and plastic states for tensile softening, tensile hardening, and local bonding effect must be considered. Relationships between compressive stress in terms of fracture strain and tensile stress in terms of crack strain and relations between damage parameters are obtained [10]. To ensure the accuracy of the simulated

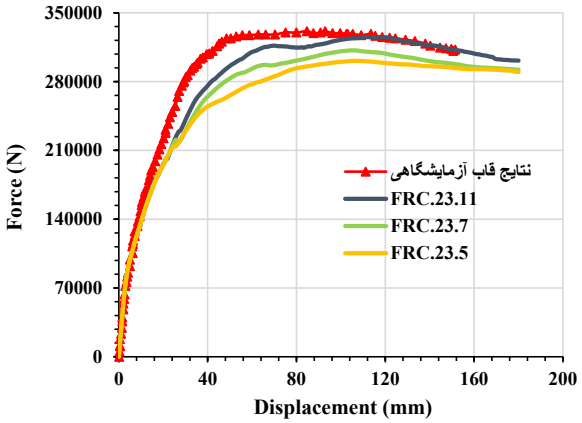

Fig. 1. Comparison of capacity (force-displacement) curves of frames modeled in ABAQUS with the experimental model.

models in ABAQUS, the results of a laboratory model are compared with the results of the simulated model analysis. The values of tensile damage of concrete and tensile stresses and cracking strains of concrete can be obtained using the relationships. These values are entered in the tensile behavior of concrete as input of the software. In this research, three models of reinforced concrete frames have been simulated by the concrete plastic damage method with different tensile behavior characteristics. These models are named FRC. XX.YY. In this designation, XX shows the number of tensile stress points in terms of concrete cracking strain and YY shows the number of cracking strain points in terms of the concrete tensile damage parameter. In the first model, the tensile behavior of concrete is completely considered using the CDP nonlinear analysis. So, the points related to tensile stress in terms of the tensile cracking strain of concrete are completely entered with 23 points, and the points related to the strain of concrete cracking in terms of tensile damage are completely entered with 11 points. Similarly, in the second and third models, the number of points related to the cracking stress of concrete is reduced in terms of tensile damage. Thus, YY values decrease from 11 points to 7 and 5 points, respectively. The output results of force values and lateral displacement of the structure and the number of analysis steps of these three models are obtained.

3. RESULTS AND DISCUSSION

One of the suitable methods for nonlinear analysis of reinforced concrete structures in the concrete plastic damage method is the use of a stepwise nonlinear static analysis. In this type of analysis, due to a large number of problem-solving steps and the short distance between them, it is possible to accurately assess the location of cracks, crack growth and investigate tensile and compressive damage in reinforced concrete structures. It is easy to compare simulated models with laboratory models. Fig. 1 compares the numerical results of the laboratory reinforced concrete frame capacity with those results of the nonlinear analysis of the three models FRC.23.11, FRC.23.7, and FRC.23.5. In FRC.23.11 model, the number of tensile and compressive behavior points of concrete is equal to the number of tensile and compressive behavior points of the laboratory model. As can be seen in Figure 1, a comparison of the laboratory frame results curves with the FRC.23.11 model results shows that the modeling validation has been done well and the specifications of concrete and steel materials have been entered correctly into the software.

4. CONCLUSIONS

In the present study, it was found the analysis time is also reduced by reducing the number of points of tensile behavior, which is an effective application for the nonlinear analysis of the large reinforced concrete structures using the CDP method. On the other hand, by reducing the number of values of tensile behavior, a maximum of 10% error occurs in calculating the capacity of the structure, which in many analyzes, this error can be ignored. It should be noted that reducing the number of values of tensile behavior is not appropriate for the analysis of structures to compare the amount of damage in each element. Therefore, it is recommended to use the maximum number of tensile values for this type of analysis.

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