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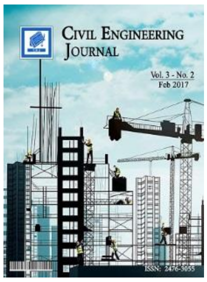

Effect of Cyclic Loadings on the Shear Strength and Reinforcement Slip of RC Beams

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Abstract

Numerous studies of the response of reinforced concrete members under cyclic loadings, many of which have been summarized and have indicated that, in general, the flexural strength of under-reinforced beams remains unimpaired under cyclic loadings consisting of a reasonable number of cycles. However, there is a body of evidence indicating that their shear strength may suffer under such loadings. The first objective of the current study is to construct an accurate 2D shell finite element model of reinforced concrete beams under cyclic loadings. The second objective is carrying out a parametric study on reinforced concrete beams, using the suggested 2D shell model. The objective of this study was to observe the effect of the stirrup spacing, steel-to-concrete bond properties on the performance of reinforced concrete beams under cyclic loadings. For this purpose, an efficient and accurate finite element model was established taking into account the compression and tensile softening introducing damage in the concrete material, the Baushinger effect using nonlinear isotropic/kinematic hardening in the steel and an adequate bond-slip law for the concrete–steel interface. The simulated results of numerical models were verified by experimental results available in literature in order to validate the proposed model, including hysteretic curves, failure modes, crack pattern and debonding failure mode. The model provided a strong tool for investigating the performances of reinforced concrete beam. The results showed that: Cyclic loadings may change the failure mode of the beam to bond failure even though it has sufficient bond length to resist static loadings. So that under cyclic loadings additional anchorage length must be taken, cyclic loadings also influence the ductility and peak load for beams fail in shear. All these topics are of the utmost importance to RC behaviour to be considered by construction codes.

Keywords: Finite Element Models; Reinforced Concrete Beams; Damage; Plasticity; Cohesive Model; Cyclic Behavior.

1. Introduction

Reinforced concrete (RC) beams in general fail in two types, flexural failure and shear failure. As it known well, the shear failure of RC beam is sudden and brittle in nature. It is less predictable and so it gives no advance warning prior to failure. As a result shear failure is more dangerous than the flexural failure. It is why the RC beam must be designed to develop its full flexural capacity to assure a ductile flexural failure mode under extreme loading. However, many of RC structures are encountered shear problems due to various reasons, such as mistake in design calculations and improper detailing of shear reinforcement, construction faults or poor construction practices, changing the function of a structure from a lower service load to a higher service load, and reduction in or total loss of shear reinforcement steel area causing corrosion in service environments. Cyclic loadings in the beams of high level of shear reduce the ductility and cause brittle failure.

In service state, many engineering structures are subjected to cyclic actions. The traffic of vehicles in bridges, the wind loads on slender buildings and the wave actions in offshore structures are examples of loading with a large number of cycles acting during the life time of those structures. It is recognized and well known in the specialized literature that cyclic loads cause, in a general way, a progressive damage of the mechanical properties of structural

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