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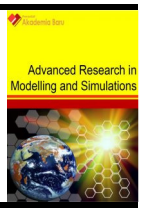

Strength Enhancement of Restrained Concrete Beam using Nonlinear Finite Element Analysis

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ABSTRACT

The behaviour of concrete beams subjected to the action of static concentrated load is usually nonlinear in nature. The capacity of the beams varies according to the type of their support restraint. These variations make the understanding of beam responses more complex. This paper is aimed at investigating the flexural behaviour of concrete beams with different degree of restraint. The beams were firstly tested in the laboratory using three point load test to failure. Ultimate loads, stresses and strains were obtained. The beams were then modelled using nonlinear finite element and a good agreement with the experimental results was achieved. Additional models with full support restraints were further developed in which an enhanced ultimate capacity was obtained. The results highlighted a significant increased capacity of the beams with higher degree of restraint.

1. Introduction

Beams and slab when restrained against horizontal movements are expected to have an enhanced carrying capacity due to the presence of a phenomenon reffered to as compressive membrane forces or arching action.

Arching action mechanism had been realised many years back, Ockleston [1], reported a test carried out on a very lightly reinforced two-way slabs that resulted on obtaining a much higher ultimate loads which are far greater than anticipated, thereby exceeding the collapse load by a greater margin [2]. These tests results were re-examined and more experimental investigation was carried out to give a more rational understanding of the slabs behaviour with the enhanced capacity. After that, [3] determined an ultimate strength capacity on thirty-five concrete slabs with restrained in at least three edges against lateral movement by developing the yield-line theory. The developed theory shows a much higher ultimate strength of the slabs with induced membrane stresses due to its boundary conditions.

In another development, Bazan [4] demonstrates the development of a compressive axial forces and a resulting contribution of increased flexural capacity for a fixed-end reinforced concrete beam.

FarhangVesali *et al*., [5] carried out a study on six reinforced concrete beams with longitudinal end restraint tested and analysed numerically. The findings shows a significant influence of concrete

compressive strength and strain penetration on arching action produced as a result of monotonically induced deflection.

2. Experimental Works

A three point load flexural test was carried out using a compression test machine in structures and materials laboratory, Faculty of Civil engineering, Universiti Teknologi Malaysia. 600 mm beam supported at 100 mm from two ends was subjected to the action of static concentrated load as shown in Figure 1. Stress and loads at failure were recorded and shown in Table 1.

Fig. 1. Laboratory test specimen

3. Numerical Analysis

The beam was modelled using nonlinear finite element software Abaqus using the same configuration as the experimental tests (figure 2). Concrete damaged plasticity model with nonlinear material properties was used and the results are presented in Figures 3 and 4.

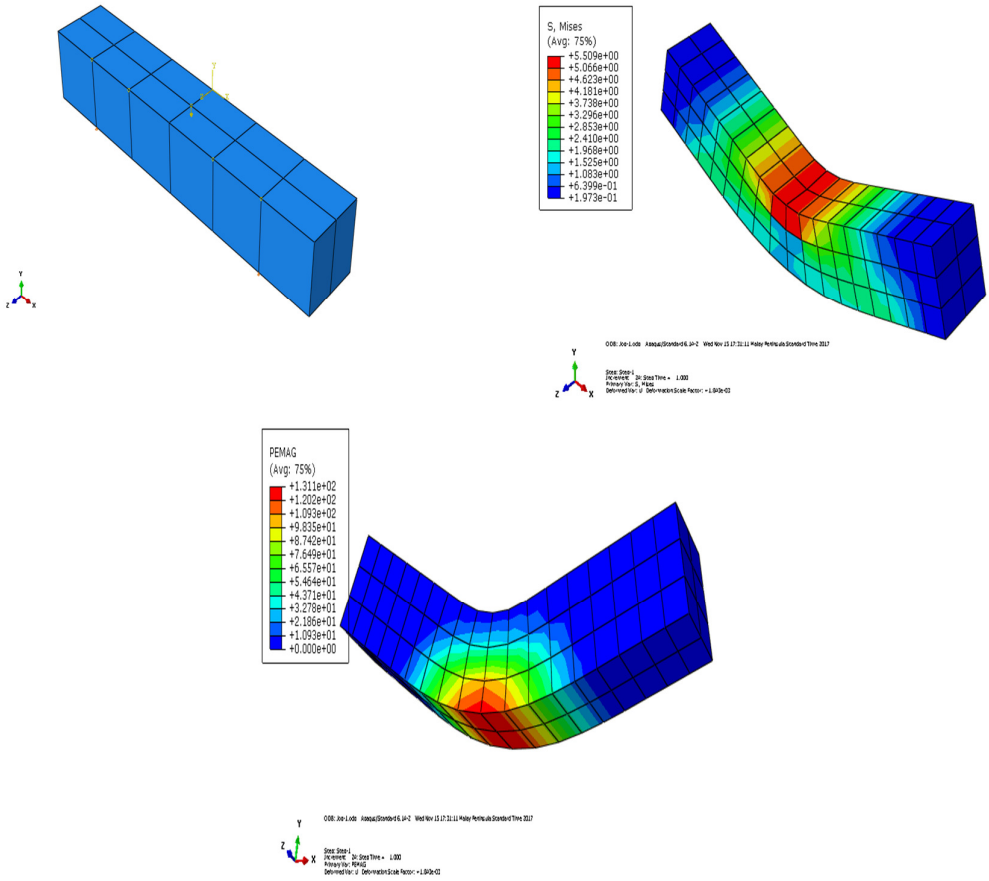

Fig. 2. Modelling with finite element software Abaqus

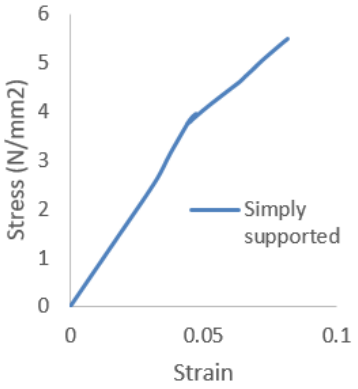

Fig. 3. Stress-strain curve for pinned supported beam

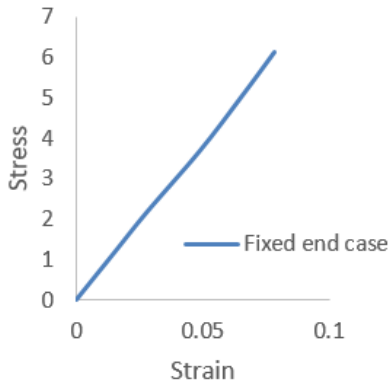

Fig. 4. Stress-strain curve for fixed supported beam

4. Conclusion

From the experimental and numerical study of the concrete beams carried out, following conclusions are drawn. Higher stresses are obtained with high degree of support restraint in beams subjected to flexural test. The ultimate capacity of a restrained beam is much greater than that with pinned supports.

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