EFFECTS OF LARGE OPENINGS IN THE SHEAR ZONE OF REINFORCED CONCRETE BEAMS

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Abstract
Openings are often provided in reinforced concrete (RC) beams to facilitate the passage of utility pipes and ducts to accommodate essential services in buildings either commercial or residential. They are usually provided by structural engineers in the bending zone (safe zone) to avoid the beams from losing their original beam capacities. However, there are situations when Mechanical and Electrical (M&E) engineers requested to provide openings at critical locations of RC beams to simplify the arrangements of pipes and ducts. This paper provides an investigation to study the effects of large openings (circular and square) in the shear zones of RC beams. Seven beams were tested to failure under four-points loading. The beam specimens had a cross-section of 120 mm x 300 mm and a total length of 2000 mm. The openings were provided at both ends; at distances 0, 0.5d, and d from the beam supports. The experimental results were validated using a finite element (FE) program, ATENA. Results show that these openings at the studied locations have significantly reduced the beam capacity to approximately 70 - 80%. Comparison of experimental and FE results in terms of crack patterns and load-deflection behaviour were presented and discussed. Agreeable results in terms of crack patterns and load-deflection curves were obtained between the experimental and FE results; about 50 – 60% and 15 – 20%, respectively.

Keywords: *Circular, Effects, Large Openings, RC Beams, Shear, Square*

INTRODUCTION

Commercial and residential buildings either in high rise or low rise structures need to be installed with building services such as conduits, electrical cables, air-conditioning, ventilation system and network system access. To accommodate such services, services can be provided through pipes and ducts which run horizontally or vertically. The routes of the pipes and ducts are usually under the ceiling which will penetrate through the beams or suspended under the soffit of the beams. When suspending under the soffit of the beams, the storey-height may be higher to meet the headroom requirement. On the other hand, in order to reduce the storey-height and to maintain the headroom requirement, the pipes and ducts are usually penetrated through the beam structures. However, the provision of openings in the web of RC beams leads to many problems in the beam behaviour including reduction in beam stiffness, excessive cracking and deflection and reduction in beam capacity. In addition, the presence of openings leads to high stress concentration around the openings especially at the opening corners. The reduction of area in the total cross-sectional dimension of a beam changes the simple beam behaviour to a more complex one (Mansur et al. 1992; Mansur, 2006).

Providing openings in RC beams to accommodate the passage of utility pipes and ducts have been a challenging issue. Therefore, many research interests in this area have been dedicated since 1960s. Numerous literatures addressed the problems including the behaviour of beams containing large (Mansur et al. 1985; Mansur, 1988; Tan and Mansur, 1996) and small openings (Mansur and Hasnat, 1979; Mansur et al. 1983; Mansur and Paramasivam,