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Failure modes and serviceability of high strength self compacting concrete deep beams

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ABSTRACT

The behaviour of deep beams is significantly different from shallow beams. In deep beams, the plane section does not remain plane after deformation. The main purpose of this study is to facilitate the prediction of deep beam failure related to tensile bar and web reinforcement percentage variations. Six high strength self compacting concrete (HSSCC) deep beams were tested until failure. Strains were measured on concrete surface along mid span, tensile bar and compression strut trajectory. The load was incrementally applied and at each load increment new cracks, their widths and propagation were monitored. The results clearly show that, at ultimate limit condition, the strain distribution on concrete surface along mid-span is no longer parabolic. In deep beams several neutral axes were obtained before ultimate failure is reached. As the load increases, the number of neutral axis decreases and at failure load it reduces to one. The failure of deep beams with longitudinal tensile steel reinforcement less than that suggested by ACI codes is flexural and is accompanied by large deflections without any inclined cracks. As the longitudinal tensile steel reinforcement increases, the failure due to crushing of concrete at nodal zones was clearly observed. The first flexural crack at mid-span region was always vertical. It appeared at 25–42% of peak load. The crack length was in the range of 0.24–0.6 times the height of section. As the tensile bar percentage increases number of cracks increases with reduced crack length and crack width. The appearance of first inclined crack in compression strut trajectory is independent of tensile and web bar percentage variations.

1. Introduction

Deep beams are widely used as transfer girders in offshore structures and foundations. With the strong growth of construction work in many developing countries, deep beam design and its behaviour prediction are a subject of considerable relevance. Traditional design assumptions, especially regarding plane section remaining plane after bending for shallow beams, do not apply to deep beams. Even the definition of transition from shallow to deep beam is imprecise in most codes of practice. The ACI 318-99 [1] and CIRIA Guide 2 [2] use span/depth ratio to define RC deep beams while the Canadian code CSA 1994 [3] and CEB-FIP model code [4] employs the concept of shear span/depth ratio. The ACI code defines beams with clear span to effective depth ratios less than 5 as deep beams, whereas CEB-FIP 1993 [4] code treats simply supported and continuous beams having span/depth ratios less than 2 and 2.5 respectively, as deep beams. However, it should be noted that the design of these structural elements are not adequately covered by existing codes of practices. For example, the British code BS8110 [5], explicitly states that, for design of deep beams, reference should be made to special literature. The ACI code,

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