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Experimental investigation on continuous reinforced SCC deep beams and Comparisons with Code provisions and models

M.A.T. Khatab *, A.F. Ashour, T. Sheehan, D. Lam

The University of Bradford, United Kingdom

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ABSTRACT

The test results on eight two-span deep beams made of self-compacting concrete (SCC) are presented and discussed in this paper. The main parameters investigated were the shear span-to-depth ratio, and the amount and configuration of steel reinforcement. All beams failed due to a major diagonal crack formed between the applied mid-span load and the intermediate support separating the beam into two blocks: the first one rotated around the end support leaving the other block resting on the other two supports. Both concrete compressive strength and web reinforcement had a major effect in controlling the shear capacity of the beams tested. For the shear span-to-depth ratio considered, the vertical web reinforcement had more influence on the shear capacity of the specimens than the horizontal web reinforcement. The shear provisions of the ACI 318M-11 are unconservative for most of the beams tested. Comparisons of test results with the strut-and-tie model (STM) suggested by ACI 318M-11, EC2 and CSA23.4-04 showed that the predictions are reasonable for continuous deep beams made with low and medium compressive strength. Although the equation suggested by ACI 318M-11 is very simple, its prediction is more accurate than the STM suggested by different design codes.

1. Introduction

Reinforced concrete deep beams are a commonly-used structural member, especially when free space among the columns is required. They are used in different civil engineering applications such as stores, hotels, offshore structures, theatres, tanks, pile caps and others. In practice, continuously-supported deep beams are often used in constructions as an alternative to simply-supported beams. However, all previous investigations have been conducted on simply supported SCC beams [1–6]. In contrast, there are no research investigations on continuous reinforced self-compacting concrete (SCC) deep beams. This area of research is of special interest due to the high depth of deep beams and congested steel reinforcement, making it difficult for normal concrete (NC) to properly be placed and vibrated. SCC provides higher quality, improves productivity and achieves engineering properties similar to those of NC but more durable structures. Moreover, the lower amount and smaller size of coarse aggregate used in SCC lead to different behaviour compared with NC. The lower amount of coarse aggregate in SCC leads to more brittle behaviour as cracks can propagate further through the paste or mortar phase before stopped or diverted by a coarse aggregate particle. Furthermore, inadequate vibration causes high surface permeability, unfilled voids and micro-pores within NC which, in turn, results in negative effects on mechanical properties and durability of NC. SCC requires no vibration as it can easily flow and be placed under its self-weight with excellent surface finishes and homogenous distribution of concrete within the formwork, to the advantage of durability, thanks to concrete lower permeability.

The loads applied at the extrados (top side) in deep beams are transferred to the reaction points through compression struts formed between the loads and the supports. The load carrying capacity of deep beams is controlled by their shear resistance. The failure mode of continuous deep beams is significantly different from that of simply supported deep beams or that of shallow beams. The failure in continuous deep beams generally occurs in regions where high shear simultaneously occurs with high bending moment, whereas in simply supported deep beams the high shear

Abbreviations: *SCC*, self-compacting concrete; *NC*, normal concrete; *STM*, strut-and-tie model; *l*, beam span; *b*, width of beam section; *a/d*, shear span-to-depth ratio; *d*, effective depth of beam; *h*, overall depth of beam section; f'_c, cylinder compressive strength of concrete; f_y, yield strength of steel reinforcement; E_s, elastic modulus of steel reinforcement; P_t, failure load; *V*, shear capacity; v_n, normalised shear strength; *v*, effectiveness factor of concrete.

* Corresponding author.
E-mail address: mahmudkhttab@yahoo.co.uk (M.A.T. Khatab).

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Table 1
Geometrical dimensions and reinforcement details of test specimens.

Beam no.	f_c', MPa	h, mm	d, mm	L, mm	Longitudinal reinforcement ratio		Web reinforcement ratio	
					Bottom	Top	Vertical	Horizontal
B1	31.1	600	560	2750	0.0067	0.0067	–	0.003
B2	42.5				0.0067	0.0067	0.003	–
B3	36.0				0.0067	0.0067	0.003	0.003
B4	46.0				0.0067	0.0067	0.003	0.006
B5	47.8				0.0067	0.0067	0.006	0.003
B6	50.4				0.011	0.011	0.003	0.003
B7	32.0	300	260		0.0142	0.0142	0.003	–
B8	38.6				0.0237	0.0237	0.003	–

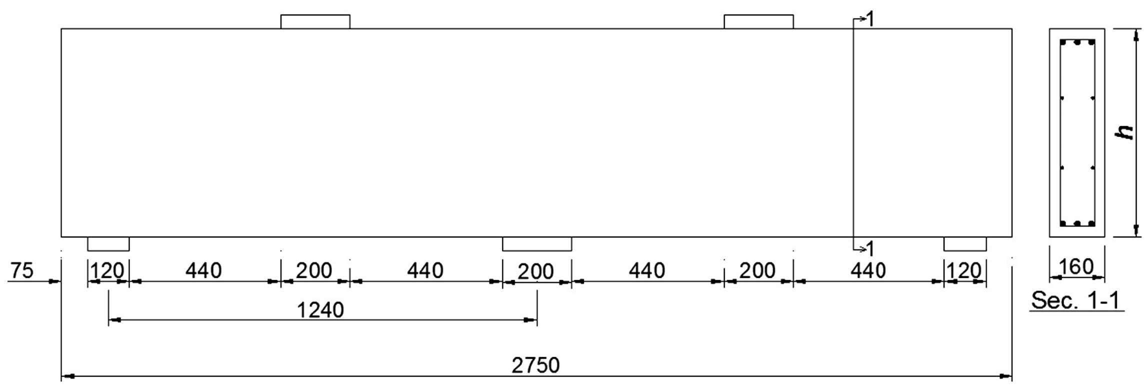

Fig. 1. Geometrical dimensions of test specimens (dimensions in mm).

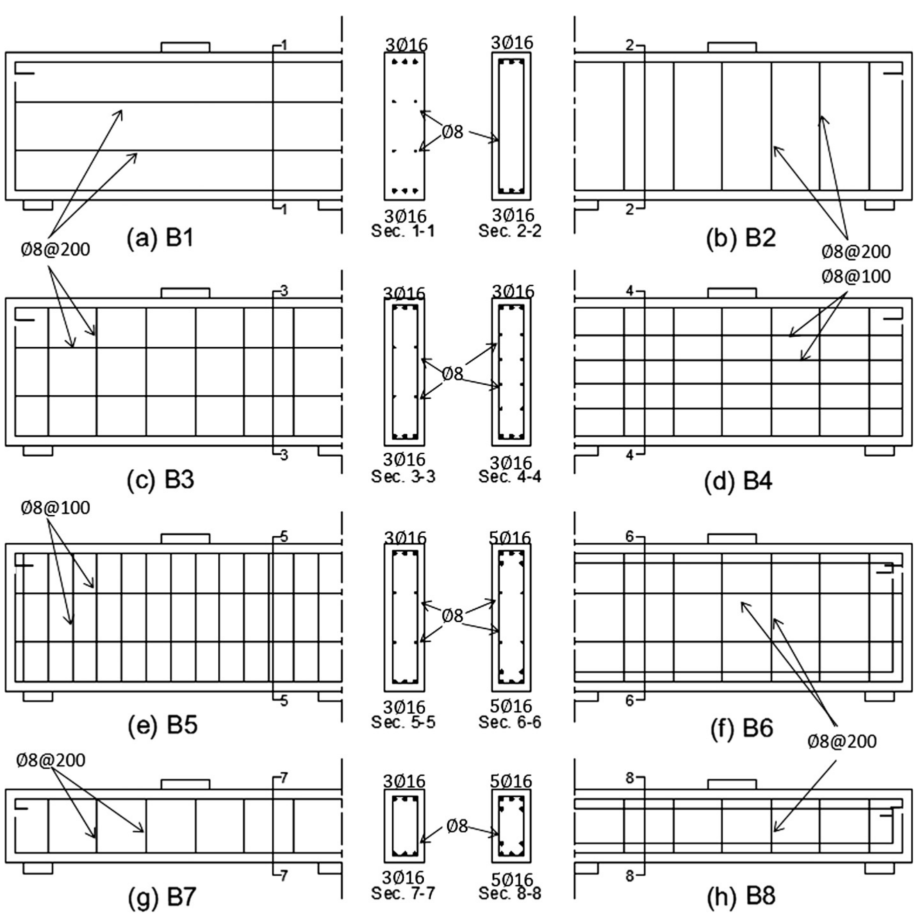

Fig. 2. Details of test specimen reinforcement.

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