Construction and Building Materials 189 (2018) 640–648

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Shear capacity investigation of self compacting concrete beams with rectangular spiral reinforcement

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HIGHLIGHTS

- Shear behavior of twenty self compacting concrete beams was investigated.
- The beams included rectangular spiral stirrups.
- Results showed improvement in shear capacity compared to traditional stirrups.
- The best angle of inclination for spiral stirrups was 85°.

ARTICLE INFO

Article history:
Received 28 May 2018
Received in revised form 7 August 2018
Accepted 9 September 2018

Keywords:
Self compacting concrete
Reinforced concrete beams
Shear
Spiral reinforcement
Stirrups inclinations

ABSTRACT

Replacing traditional closed stirrups by rectangular spiral reinforcements in concrete beams constructed using self compacting concrete (SCC) is experimentally investigated in this paper by testing twenty beams under static loading. The shear performance of SCC beams is evaluated by measuring the maximum shear load values, load-deflection curves, and crack propagation for all tested beams. Two different spirals spacing of 200 and 150 mm and five different angles of inclination for the spiral reinforcement (85°, 80°, 77.2°, 75°, and 72.5°) are adopted. The experimental shear capacity results are compared with theoretical shear strength determined by the (ACI 318) code. The results indicated that using of continuous spiral reinforcement improves the shear capacity of SCC beams up to 16.67% increase in comparison to traditional closed stirrups. Moreover, the results showed that optimum performance depends on the angles of inclination, where 85° was the optimum angle of inclination regardless of pitch spacing. It is recommended to use the continuous spiral reinforcements in SCC beams because it enhances the shear capacity, and reduces time and labor cost needed in construction.

1. Introduction

The strength of any structural member must be high enough to resist all the loads that act upon during its life time without failure. Reinforced concrete beams must be provided with stirrups in regions of high shear force in form of individual vertical closed stirrups or continuous spiral, as determined and required by the codes. Typically, stirrups is required in case of the shear forces exceed the design shear resistance of the concrete only [1–3].

In the last few years, the use of spiral reinforcement in rectangular cross-section beams became an innovative encouraging technique. The shear and torsion capacities of these beams were improved in comparison with individual vertical single stirrups [4]. From the construction point of view, using of rectangular spiral reinforcement in beams is more effective because the spiral cage can be quickly installed and this will decrease labor costs and time needed. Also, the traditional closed stirrup requires two end hooks for anchorage where that will increase the steel weight and leads to extra unneeded cost and extra time in construction. On the other side, the only disadvantage of using this proposed technique could be from the construction point of view in bending the steel to obtain the angle and shape required depending on the diameter of the steel bars used.

A very limited number of researchers studied the advantages of using the spiral reinforcement in rectangular cross-section beams. Corte and Boel [5] studied using of continuous spiral reinforcement instead of traditional shear reinforcement in reinforced concrete beams through testing of 24 beams that constructed using conventional vibrated concrete and self compacting concrete. The test results proved that the continuous spiral reinforcement were similarly effective as the traditional closed stirrups. The results

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https://doi.org/10.1016/j.conbuildmat.2018.09.046
0950-0618/

Fig. 1. Conventional single stirrups and continuous rectangular spirals.

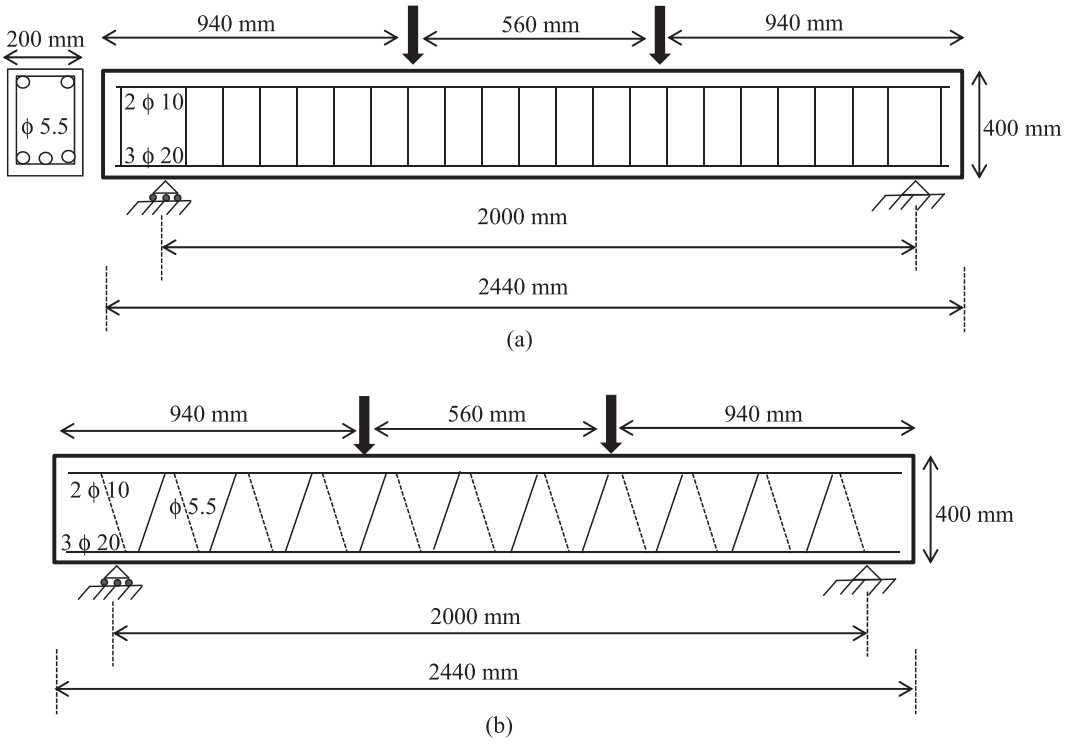

Fig. 2. (a) Beam details using single stirrups; (b) Beam details using rectangular spiral reinforcement.

showed that self compacting concrete has a positive effect on the ultimate load, which was 20% higher comparing to conventional vibrated concrete. The authors recommended that more experiments are required since the results were based on two angles of inclination only. Karayannis and Chalioris [6] studied the influence of using spiral reinforcement on the behavior of rectangular cross-section beams through testing of eight beams subjected to shear loads. The test results revealed that the shear capacity increased by 17.2% and 21.7% for pitch spacing of 120 and 80 mm respectively, compared with beams with closed stirrups. Shatarat et al. [7] studied the effectiveness of using rectangular spiral reinforcement as shear reinforcement through testing 28 beams at different inclination angles: 62°, 70°, 75°, 80° and 85° representing three different spacing: 125 mm, 150 mm, and 200 mm. The test results showed an increase in the shear strength and the most optimum angle of inclination was 80°. The authors concluded that the shear performance and ductility of tested beams were improved by using spiral reinforcement. Shahrooz et al. [8] studied the performance of continuous transverse reinforcement (CTR) by testing 30 different beams and columns with five loading conditions: (1) flexure and shear; (2) pure torsion; (3) combination of flexure, shear and torsion; (4) axial loading; and (5) lateral cyclic loading. The test results showed that members reinforced with CTR had more strength and stiffness in terms of post peak behavior compared with traditional transverse reinforcement.

Conventional concrete has no longer remained the only material used in the construction industry. Recently, a new form of concrete with several new constituents called high performance concrete, self compacting concrete, and self levelling concrete is introduced in the concrete technology due to its many advantages