Behavior of Self– Compacted Concrete Deep Beams with Reinforced Compressive Struts

By

Sarah Farhan Jebur

Supervised by

Assist. Prof. Dr. Khattab S. Abdul-Razzaq

ABSTRACT

The main aim of this research was to study the behavior of self compacted concrete deep beams when reinforcing their struts based on the STM of ACI 318M-14. The experimental program contained casting and testing nine specimens divided into three groups. The difference between the three groups was the type of loading; 2-concentrated forces, 1-concentrated force and uniformly distributed load. Every group contained three specimens. The first specimens of each group were the conventional reference deep beams. The second specimens of each group were the specimens in which only the struts and ties paths were reinforced in addition to removing concrete shoulders (in order to save cost, reduce weight and provide a front side area for services). The third specimens of each group were the RC frames that their shapes were defined by the STM of ACI 318M-14. The struts and ties of these frames were reinforced as compression members and as tension members, respectively.

The effect of reinforcing struts and ties, response of load-deflection, cracking load, deflection at first crack, cracks characteristics (spreading, width, number and type of cracks), strain in steel bars, strain in the surface of concrete, the contribution of reinforcement to the strength of the struts and ties in addition to failure conditions were studied.

The experimental results exhibited that the first specimens (references) of each group showed superiority in terms of ultimate capacity about 20% in comparison with the theoretical design loads of STM, ACI 318M-14. The second specimens of each group (where only the paths of struts and ties were reinforced) in addition to

the third specimens of each group (RC struts and ties frames) exhibited acceptable differences with the theoretical design loads of STM, ACI 318M-14. Accordingly, these frames were good alternatives for the reference beams because of cost saving, reducing weight and providing a front side area which amounted to 4-27%, 41-51% and 46-56%, respectively.

Measuring strain assisted in investigating the contribution of reinforcement to the strength of the struts. For example, in the case of the frames, the contribution in inclined struts was 29%, 53% and 30% in cases of 2-concentrated forces, 1-concentrated force and uniformly distributed load, respectively. These experimental contribution ratios were close to equations of (ACI 318M-14). Measuring strain also assisted in more clarifying the failure type that took place in the specimens.

For all specimens, measuring the width of the first cracks assisted in observing that the first flexural cracks did not exceed limits of crack width, so they were not critical. While the first shear cracks exceeded the limits and they were critical.

In addition to the experimental work, a numerical analysis of these nine specimens using the finite element program ANSYS 13 has been conducted. The numerical results of this analysis showed good agreement with the experimental ones. Besides, the numerical effects of concrete compressive strength (f'_c) and reinforcement yield stress (f_y) on the ultimate capacity and the midspan deflection of the proposed reinforced SCC specimens were investigated. It was found that the increase in concrete compressive strength (f'_c) about 33.3% led to increase both the ultimate capacity and the midspan deflection about 7-13% and 20-70%, respectively for the specimens in which only the struts and ties were reinforced. While for the RC frames, the increase in both the ultimate capacity and the midspan deflection was about 5-11% and 15-41%, respectively. It was also found that the increase in reinforcement yield stress (f_y) about 40% led to increase the ultimate capacity and decrease the midspan deflection about 22-38% and 8-15%,

respectively for the specimens in which only the struts and ties were reinforced. While for the RC frames, the increase in the ultimate capacity and the decrease in midspan deflection were about 26-40% and 19-28%, respectively.