Punching Shear Capacity of Reinforced Lightweight Foamed Concrete Two-Way Slabs Using Varies Shear Reinforcing Systems

By

Dunya Khalil Ismail

Supervised by

Assist. Prof. Dr. Suhad Mohammed Abd

Abstract

This study optimizes the properties of lightweight foamed concrete (LWFC) and investigates the punching shear capacities of two-way slabs using different punching shear reinforcement systems.

In the part of optimizing and improving LWFC properties comprise on utilizing different types of lightweight coarse aggregate (LECA) and Porcelinate as coarse aggregates and fly ash (FA) as fine aggregate (replacement for sand), were utilized and silica fume was added to optimize LWFC properties. Moreover, steel fibers with different aspect ratio were used. The investigated properties were fresh-state properties (i.e. fresh density and workability) and hardened properties (i.e. compressive strength, splitting tensile strength, flexural strength, modulus of elasticity and dry density). For comparison, four different mixes were used to complete the second part of the study, three mixes of LWFC with optimum properties and NWC as reference mix.

In the second part of the study, the effects of different systems for punching shear reinforcement, namely, band, stud and lattice, on the punching shear capacity of two-way slabs were evaluated. Fourteen two-way slabs, which were simply supported along the four edges and had dimensions of 1000 mm × 1000 mm × 90 mm, were tested under a concentrated load on a central stub column. The specimens were divided into four groups according to concrete type: Group 1 comprised lightweight foamed concrete LWFC , Group 2 consisted of lightweight foamed concrete with lightweight aggregate (LWFC+LWA), Group 3 included high strength foamed lightweight concrete with fly ash (LWFC+FA), and Group 4 was composed of reference concrete, i.e. normal concrete (NC). Each group included four slabs, depending on the shear reinforcement system (without reinforcement, with stud, with band and with lattice). The main characteristics studied were deflection at the center slab, crack pattern, ultimate load capacity, stiffness, ductility, failure angle, punching stress and punching strain in the tension and the compression zone. Results were compared with reference codes (ACI318M-14, BS8110 and EC2).

The results of the trial mixes for LWFC when materials (e.g. steel fiber, aggregate and FA) were added exhibited improved properties of LWFC in terms of compressive and tensile strengths. These results meet structural requirements and reduce weight by approximately 25%. The ultimate load of NC is higher than that of foamed concrete by 5%. However, the ultimate loads of foamed concrete slabs with shear reinforcement are greater than those of slabs without shear reinforcement. The increase in ultimate load for (LWFC) is approximately 16% to 43%, that for (LWFC+LWA) is approximately 13% to 40%, that for (LWFC+FA) is approximately 19% to 31% and that for (NC) is approximately 55% . The deflection in LWFC is higher 25.6% than that in NC. Nevertheless, the deflections in slabs with shear reinforcements are lower than that in the slab without shear reinforcement. The slabs with punching shear reinforcements are stiffer than the slab without shear reinforcement approximately (9%-67%). The results achieve optimum resistance for punching shear failure by using lattice and stud reinforcement systems. The band system has lower stiffness and resistance than the other systems by 18%. The addition of aggregates to foamed concrete improves the structural behavior of foamed concrete slabs. The ACI318-14 code gives higher estimates of punching strength than the experimental results. The EC2 code provides estimates that are close to the test results. The prediction results of the BS8110 code underestimate the experimental results.