Structural Behaviour of Waffle, Ribbed and Composite Joists Slabs: A Review Study

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***Abstract*— Due to the importance of the joists slab system as an excellent solution for increasing span demands in different building types, investigating its properties becomes essential for different researchers. The effects of numerous parameters on the structural behaviour of the joists slab system, whether it was a waffle, ripped, or composite sections were reviewed in this paper from past studies. The main conclusions were that the slab thickness and joists height were the critical parameters for increasing load capacity and stiffness of the slab, perimeter beams stiffness governs the bending moment distribution in rips, small opening in the slab was more efficient in reducing punching shear effect than larger openings and providing stiffening rips around the opening was more effective in rose load bearing and reducing deflection than strengthening by carbon fibre sheets.**

Keywords—waffle slab, ribbed slab, composite section

I. INTRODUCTION

Two-Way Ribbed (Waffle) slab system might be characterised as slabs having a flat flange plate or deck and two orthogonally spaced parallel beams [1]. The key objective of using two-way ribbed (waffle) slabs is to decrease the quantity of concrete and reinforcement and, therefore, the structure's weight [2].

A waffle slab is a common structural configuration used in the building of hotel porticos, airports, large banquets, conference centres, and parking garages, see Fig. 1 [3]. Architectural lighting utilises the void space created on the underside of waffle slabs. This slab system is structurally stable without requiring much more material. That makes waffle slabs ideal for large, flat areas such as foundations and floors [4].

Fig. 1. Waffle slab with opening

Two-way slab systems are primarily used to resist high loads or when there are large spans to minimise slab thickness, reduce internal forces in the slab, and limit slab deflection [5].

Waffle slab systems are now an ideal structural option for designers. It is an evolution of solid slabs from eliminating a substantial amount below the neutral axis concrete that contributes little to final strength. Due to the more efficient and economical use of resources, forming these voids results in more structural integrity and cost improvements [6].

II. GEOMETRY AND BOUNDARY CONDITIONS

In order to optimise waffle slabs' dimensions, many studies were conducted experimentally. That is of the main benefits for structural and architectural designers for having various space options for such a system. A summary of the different properties of control specimens from many previous studies is listed in TABLE I. While Fig. 2 shows a graphical relationship of size factor (total slab thickness (mm)/ slab area(m2)) from different studies.

The effects of waffle slab thickness to ribs height ratio and layout of ribs on the flexural behaviour were investigated by [7]. The data showed that compared with the reduction of ribs, lowering the thickness of the upper panel could more significantly weaken the integrity of the waffle slab. The opening size may increase to 40% of the column strip width without significantly changing the moment capacity values [8]. An inverse relationship was obtained between waffle slab joists spacing and total load-carrying capacity [9].

Providing additional depth and thickness to the ribs for the waffle slabs subjected to eccentric loading improved the stiffness and the punching shear strength [10]. A comprehensive analysis to establish optimal joist spacing, and the results showed variety in optimum spacing depending on panel dimensions [11].

The behaviour of waffle contained openings close to rectangular columns was investigated by [12]. The results established that openings adjacent to columns with small dimensions were more effective in reducing the punching shear strength of the slabs than large openings and even the number of openings.

Compared to a topping thickness of 50 mm, the ultimate load of a slab with a topping thickness of 75 mm is equivalent to 100 mm thickness specimens [13]. A wide beam ribbed slab