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Investigation of Punching Behaviour of Steel and Polypropylene Fibre Reinforced Concrete Slabs Under Normal Load

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Abstract

Punching is among the most important risks leading to abrupt and brittle fracture in reinforced concrete structures. Punching effect at the end-parts of columns takes place during the transmission of loads from the slab to the columns and this effect is as important as the resistance of slab against bending. In this paper, punching performances of plain, steel fibre and polypropylene fibre incorporating reinforced concrete slabs were compared experimentally. Research program involved testing of three specimens. One specimen was cast as reference specimen and normal load were applied. One steel fibre and one polypropylene fibre-reinforced concrete specimens were produced as flat slab and normal load were applied. For comparison with other studies, the dimensions of test specimens were 1000 x 1000 mm and slab thickness was selected as 100 mm. Reinforcing bars were placed in only bottom parts of the slabs in all specimens. Ø10 S-335 steel reinforcement were used in the study. It was decided to locate the column in the middle part of the slab for providing formation of punching. The column shape was selected to be circular with a diameter of 150 mm.
In the first phase of the experimental study, results of load-displacement curves were interpreted. In the second phase, the punching performances of specimens under normal loads were compared and some suggestions were made.

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Keywords: punching; fibre reinforced concrete slabs; normal loading;

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1. Introduction

Concrete has a complex structure that consists of different ingredients. This heterogeneous structure, causes different stresses in the internal structure of concrete. Stress gradients particularly at the weakest zone of concrete known as transition zone at aggregate-cement paste contact surfaces are formed. Cracks in this zone tend to propagate under the effect of external loads. If the propagation of cracks can be stopped after their first formation, the potential deleterious consequences can be prevented.

Conventional concrete is normally weak in tension, bending, impact, fatigue, abrasion, deformation capacity, post crack load carrying capacity and toughness; however, these properties can be significantly improved through the use of synthetic fibres. The main mechanism by which glass, synthetic, carbon, steel, etc. fibres make improvement in concrete performance is preventing the growth of cracks. The reduced propagation and coalescence of micro-cracks results from the stress transfer provided by fibres. Fibres carry some part of stress by themselves depending on their geometry and volumetric amount and also transfer the remaining stress to the solid portion of concrete mass.

The maximum cracking deformation in fibre reinforced concrete is much higher compared to traditional concrete. In fibre reinforced concrete, the declining portion of the G-ε curve after the peak stress is much steadier. Thus, the energy required to fracture fibre reinforced concrete is much higher than plain concrete due to the elongation and separation of the fibres from concrete. In fibre reinforced concrete the most important characteristics of fibres that play role on concrete performance can be listed as aspect ratio and volumetric fraction of fibre [7]. Aspect ratio influences the workability of concrete during mixing and placing operations. Generally, the optimum amount of fibres in concrete varies between % 0.5 and % 2.5 by total volume of concrete [10]. Regardless of the kind of fibre participating in concrete, the homogenous distribution of fibres throughout the mixture should not be impaired after the concrete has been mixed.

As a result of several research studies, the use of fibres as a concrete ingredient has become widespread in concrete technology. These include glass wool fibred, steel fibred, polymer, mica plate and plastic fibred concrete [12]. The effectiveness of the reinforcement in fibre reinforced concrete depend on the fact that the modulus of the elasticity of the fibre is much higher than that of the hardened concrete. Stress-strain curves of traditional and fibre reinforced concrete under compression are shown in Fig. 1.

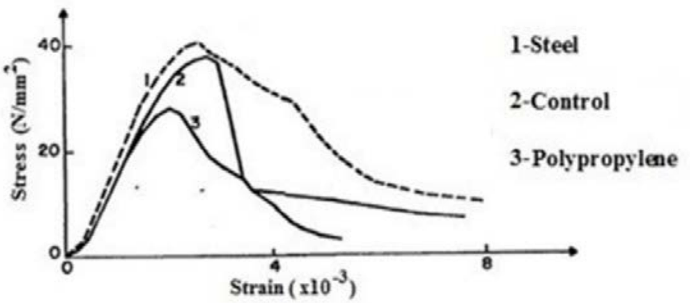

Fig. 1. Stress-strain curves of traditional and fibre reinforced concrete under compression (Sancak, E., 1998).

Punching failures are particularly encountered at the stage of construction in structures. This is due to the fact that the slab has not reached its potential strength yet and thus, it is too weak to carry its self-load. In flat slabs, the time of demoulding and the time of the vertical supports placed under the slabs have vital importance in terms of punching safety.

Punching one of the most important risks in flat slabs can lead to great damage. For instance, principal tensile stresses resulting from shear stresses formed around column at the contact zone with slab may exceed tensile strength of concrete. This extremely abrupt and brittle punching fracture causes the structure to be demolished within a few seconds (Özden, 1998).