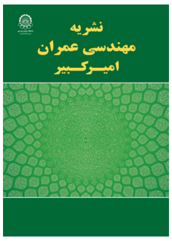


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# Study of Mechanical Properties of Structural Lightweight Concrete Reinforced with Hybrid Fibers

M. Hejazi*, F. Fathi, H.R. Sadrarhami

Department of Civil Engineering, Najafabad Branch, Islamic Azad University, Najafabad, Iran

**ABSTRACT:** In this research the mechanical properties of structural lightweight concrete including compressive, tensile and flexural strengths and energy absorption using five types of fibres (industrial and scrap steel, glass, polypropylene and straw) in the form of single type of fibre or combination of two or three types of fibres have been studied. At the first stage, two reference samples of lightweight concrete and normal concrete without fibres are produced. At the second stage, samples of lightweight concrete with single type of fibres with volume percentages of 0.1, 0.25, 0.4, and 0.5 are made. At the third stage, samples of lightweight concrete containing twin combination forms of fibres with volume percentages of (0.1, 0.4), (0.4, 0.1) and (0.25, 0.25) are produced. At last stage, samples of lightweight concrete with triad combination forms of fibres with volume percentages of (0.1,0.1,0.3), (0.1,0.3,0.1) and (0.3,0.1,0.1) are produced. Obtained results indicated that samples with combination of two types of fibres had the best behaviour compared to other samples. The highest compressive strength have been resulted from the combination of industrial steel and polypropylene fibres and the highest tensile and flexural strengths have been obtained from the combination of glass and polypropylene fibres. The highest energy absorption is related to the combination of industrial steel and glass fibres.

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## 1- Introduction

Concrete is one of the most widely used construction materials. It is a non-homogeneous, non-isotropic and brittle material with different strengths in tension and compression; in which the tensile strength is much less than the compressive strength. To compensate for this defect using a material that can increase the tensile strength of the concrete is essential. A common method is the use of fibres [1]. One way to reduce the structural weight of the concrete to produce lightweight concrete is using Leca [2]. Sorelli [3] studied the effect of steel fibres on concrete slabs by experimental tests. He concluded that the use of 0.38% of fibres improves the behaviour of the slab. Poulsen [4] conducted a series of tensile and bending experiments on concrete beams. He showed that physical and mechanical behaviour of concrete beams improves by using 0.5% steel and polymer fibres.

## 2- Methodology

In this study, five types of fibres including industrial and scrap steel, glass, polypropylene and straw fibres in the form of single type of fibre or combination of two or three types of fibres have been used to evaluate the increase of the mechanical properties of concrete. At the first stage, two reference samples of lightweight concrete and normal concrete without fibres are produced. At the second stage, samples of lightweight concrete with single type of fibres of volume percentages of 0.1, 0.25, 0.4 and 0.5 are made. At the third stage, samples of lightweight concrete containing twin combination forms of fibres with volume percentages of (0.1, 0.4), (0.4, 0.1) and (0.25, 0.25) are produced. At last stage, samples of lightweight concrete with triad combination forms of fibres with volume percentages of (0.1,0.1,0.3), (0.1,0.3,0.1) and (0.3,0.1,0.1) are produced. The mechanical properties including compressive strength, tensile strength, flexural strength and energy absorption of all the mixes were compared.

## 3- Main Contributions

**1-** The energy of conventional concrete (control) of concrete is substantially similar.

**2-** Industrial steel fibers alone increase energy absorbtion.

**3-** Glass fiber alone at 0.25% by volume, with the greatest increase has been absorbed energy.

**4-** Polypropylene fibers alone 0.4% by volume, with the greatest increase has been absorbed energy.

**5-** Waste steel fibers alone with the percentage of fiber enhances energy.

6- Straw fibers alone 0.4% by volume, with the greatest increase has been absorbed energy.

In the double-sided composition of the fibers, the maxi- **7-** mum energy absorption combined industrial steel, glass, and .0.4, 0.1% is obtained

*Corresponding author, E-mail: m.hejazi@pci.iaun.ac.ir

**8-** In the triple combination of fibers, combining maximum energy absorption of industrial steel, glass and polypropylene with 0.3, 0.1 and 0.1% respectively.

The load-deflection diagrams of a number of samples are shown in Figures 1-5.

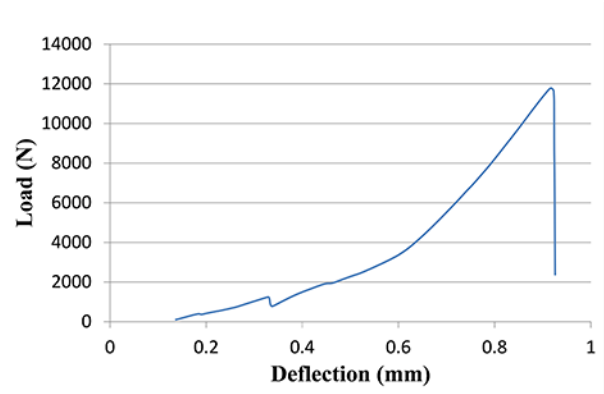


**Figure 1: Load-deflection diagram for conventional (control) concrete**

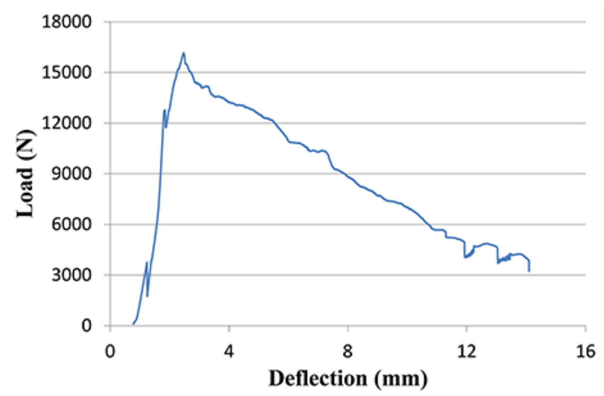


**Figure 2: Load-deflection diagram for lightweight concrete with 0.5% of industrial steel fibres**

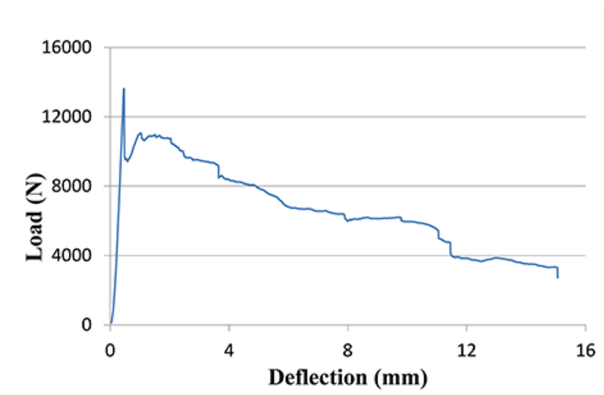


**Figure 3: Load-deflection diagram for lightweight concrete with 0.4% of industrial steel fibres and 0.1% of glass fibres**

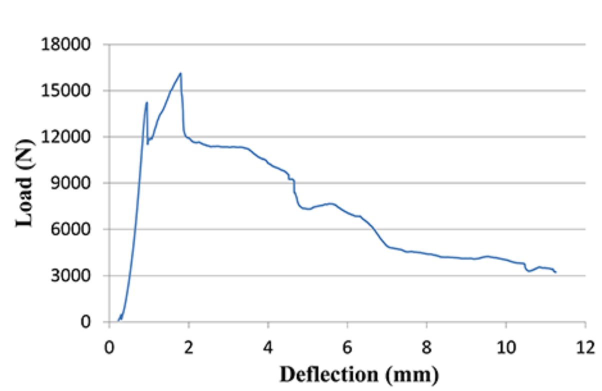


**Figure 4: Load-deflection diagram for lightweight concrete with 0.4% of industrial steel fibres and 0.1% of polypropylene fibres**

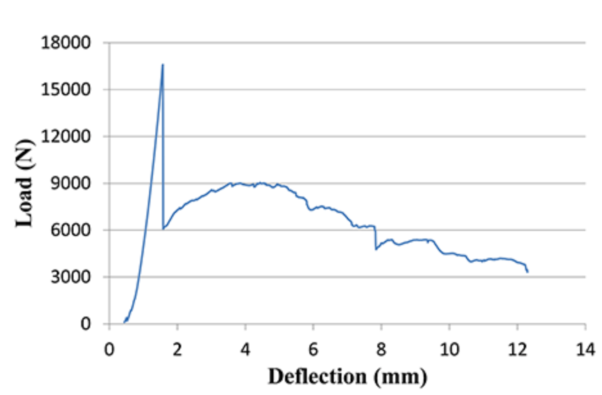


**Figure 5: Load-deflection diagram for lightweight concrete with 0.3% of industrial steel fibres, 0.1% of glass fibres and 0.1% of polypropylene fibres**

## 4- Conclusions

**1-** The mechanical strengths of conventional concrete is significantly more than those of lightweight concrete.

**2-** Fibres increase the ductility significantly. Using 0.5% of industrial steel fibres increases the absorbed energy by 40 times.

**3-** The effect of glass fibres in compression and tension has been better than other types of fibres. 0.25% of glass fibres has produced maximum strengths.

**4-** In general, the use of fibres does not increase the compressive and tensile strengths significantly. The average increase for individual fibres and combined fibres has been 6.8% and 9%, respectively. The reason is the small compressive and tensile strengths of the fibres.

**5-** Comparison of acquired resistance shows that the effect of scrap steel and straw fibres is similar to industrial steel and polypropylene fibres; hence, those fibres can also be used in concrete.

**6-** Twin combined forms of fibres can: a) increase the strength compared to concrete with single type of fibres, b) prevent condensation of fibres in high percentages, and c) provide a more favourite behaviour for concrete due to use of different properties of two types of fibres.

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