Effect of Fibre Reinforced Concrete and Behaviour in Rigid Pavement

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***Abstract*— Concrete such widely material is present in different constructions. Nowadays the behaviour the rigid pavement is on the expansion and need more analysis in improvement the properties of concrete. The lack of tensile strength and durability under the severe conditions is one of the orientation or target in this paper. The improvement of the concrete in rigid pavement will be focused on using the fibres, in this case the steel and polypropylene fibres. Fibre reinforcement (depend of type of fibres) is expected to improve the mechanical performance, deformability, fatigue and cracks under the loading. The percent of fibres is oriented to change the brittle failure, and in this paper, we can analyses the different percentage of fibres and difference effect from steel and polypropylene fibres. The comparison of the results will lead us to propose the type and percentage depend of structural characteristics.**

***Index Terms*—Concrete, FRP, Strengthening, Flexure, Deformations**

I. Introduction

Concrete in pavement structures is the layered structure on which vehicles travel. It serves two purposes: to provide a comfortable and durable surface for vehicles and to reduce stresses on underlying soils. In scope of developing and increasing the loadings in pavement structures, our intention is oriented in improvement the behaviour the rigid pavements using the reinforcement with different reinforcement materials: steel and Polymers. Improvement will be focused on the Mechanical Properties, such are: Ductility; Fracture Toughness; Flexural Strength; Shrinkage and Cracking Properties, etc.

Concrete can be characterized as a brittle material with a low tensile strength and strain capacity. Fibre reinforced concrete is a concrete containing dispersed fibres. This means that, unlike ordinary reinforced concrete with an appropriate minimum percentage of reinforcement bars, a softening response is observed for fibre concrete after cracking. In contrast to plain concrete, the ductility is significantly increased as a result of fibres bridging cracks and its intrinsic brittleness is overcome. This is very beneficial for the durability of concrete structures. Indeed, for a durable structure, small crack widths are necessary in the serviceability limit state. Fibres of various shapes and sizes produced from steel, synthetics, glass and natural materials can be used. However, for most structural and non-structural purposes, steel fibres are the most used of all fibre materials. Synthetic fibres on the contrary are mainly used to control the early cracking in the slabs and the effect will be oriented in improvement of flexural strength and in same time will not be effected in compressive strength. Polymeric fibers are gaining popularity because of its properties like zero risk of corrosion and cost effectiveness

Compare the concrete sample behavior with different types of fibres and different percent of fibres , including the comparison with common plain concrete is the main aim of this paper. [1][2][3].

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II. Experimental Work

Objectives of Work:

- To find out effect of variation of different types of fibres; steel and Polypropylene depend of percentage and effect in properties of FRC. The focused properties in this work are: Workability, Flexural strength, displacements; presence of cracks, Compressive Strength, for rigid pavement constructions. [5][6][7]
- To find out optimum dosage of steel and polypropylene fibres for improvement the behaviour through the properties with compare to normal concrete pavement.
- To find out the comparing the results using the reinforcement with steel and Polypropylene fibres.
- To find out the effect of percent of air voids in concrete in relations with other properties.

A. *Mix Design of Concrete*

1) Materials

The using constituent materials in the research works:

- Cement CEM I grade 52.5
- Aggregate – lime stone aggregate, Course and fine aggregate with grain size:

Fr I (0/4) mm; Fr II (4/8) mm; Fr III (8/16) mm and Fr IV (16/32) mm.

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- Hooked Steel Fibers with properties presented in Table I.
- Polypropylene fibers with properties presented in table II
- Drinking Water
- Chemical Admixture: Super plasticizer: Dynamon SX Aerating agents: Mapeplast PT1

2.1.2 The preliminary requested parameters In research works for Mix Design are requested following parameters:

- Class of Concrete C35/45
- Class of Consistency of concrete S1 (30-40) mm
- Flexural Strength > 4.5 N/mm2
- Percent of air voids: p= (4-6) %

2) Types of fibers

During the Mix Design in this research work we used the two types of fibres were the characteristics are presented in following tables: [8][4][9]

TABLE I. PROPERTIES OF STEEL FIBERS

Property	value
Type	Hooked
Average fiber length,	6 0 mm
Average fiber width,	0.8 mm
Aspect Ratio (L/d)	75
Young's Modulus	200 GPa
Tensile Strength	1100 MPa

Figure 1. Steel fibers

TABLE II. PROPERTIES OF POLYPROPYLENE FIBERS

Property	value
Type	Sika Fiber
Average fiber length,	12 mm
Melting point	160 0C
Tensile Strength	165 MPa
Specific Gravity	0.91 r/cm^3

Figure 2. Polypropylene fibers

3) Mix proportion

Five types of concrete mixes are prepared in scope of research works, were for etalon is prepared one mix and for using the steel and polypropylene fibers are prepared two mixes for each set. The composition design of concrete is prepared for 1 m^3 with details, presented in Table III. The preparation works during the Mix Design are presented in following fig.3 [8][9][10]12]

The preparation laboratory works during the Mix Design are presented in following fig. 3, including the all steps of preparation specimens.

TABLE III. CONCRETE COMPOSITION DESIGN

Type/ Name/Mix Design	Cement [kg]	Water [L]	Fine Aggregate - FI – (0/4) mm [kg]	Coarse Aggregate - FII – (4/8) mm [kg]	Coarse Aggregate - FIII – (8/16) mm [kg]	Coarse Aggregate - FIV – (16/32) mm [kg]	Super plasticizer Dynamon SX [kg]	Aerating agent Mapeplast PT1 [kg]	Steel Fibre s %	PP Fibres %
"1"-etalon	380	152	740	330	370	405	3.5	0.4	0	0
"2"-SF1	380	152	740	330	370	405	3.5	0.4	0.5	/
"3"-SF2	380	152	740	330	370	405	3.5	0.4	1.0	/
"4"-PPF1	380	152	740	330	370	405	3.5	0.4	/	0.025
"5"-PPF2	380	152	740	330	370	405	3.5	0.4	/	0.05

SF-steel fibres ; PPF-polypropylene fibres

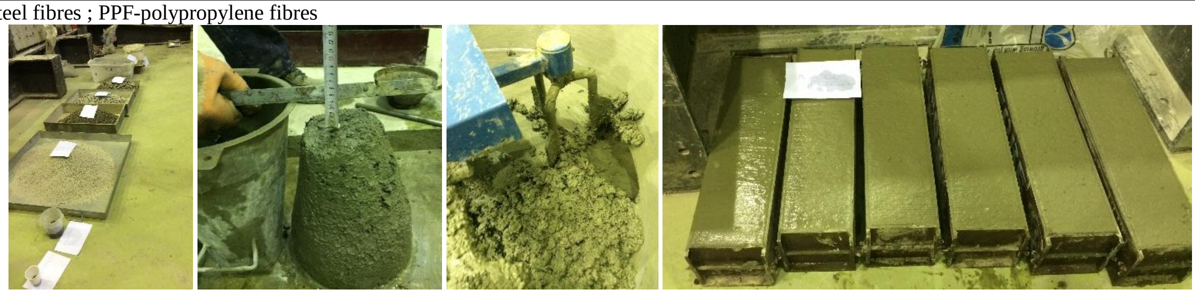

Figure 3. The all necessary steps during the laboratory works

4) Test methodology and results

Intention of the research papers was to analyze the requested value and final data, to make the comparing of properties of fresh and hardening concrete.

The slump test for all 5 types of concrete mixes was performed with a targeted slump flow of 40 mm±10mm. Following mechanical properties were determined for the 5 types of concrete mixes at the ages of 7 and 28 days of curing in laboratory conditions:

- Compressive strength test by casting 150x150x150mm cubes,
- Flexural strength test by casting 150x150x600mm beam for all the five sets
- Cracks in concrete beams

All the comparable values presented in Table IV, are based on the test results for all types of sets and are represented through the fig.4; fig.5; and fig 6; were are presented some of typically results. [8][9][12]

TABLE IV. CONCRETE COMPOSITION DESIGN

Type/Name/Mix Design	Age of samples [days]	Compressive Strength [MPa]	Flexural Strength [MPa]	Positions and number of cracks[p;nr]	Behavior the sample [comment]
“1”-etalon	7	33.5	4.85	/	/
	28	62	9.53	Middle/1	brittle
“2”-SF1	7	32.5	5.15	/	/
	28	60.5	9.38	Middle/1+2	brittle
“3”-SF2	7	33.5	5.55	/	/
	28	64.5	10.35	Middle/1+2	brittle
“4”-PPF1	7	31.8	5.00	/	/
	28	57.5	9.58	Middle/1+2	brittle
“5”-PPF2	7	31.5	4.85	/	/
	28	54.5	9.74	Middle/1+2	brittle

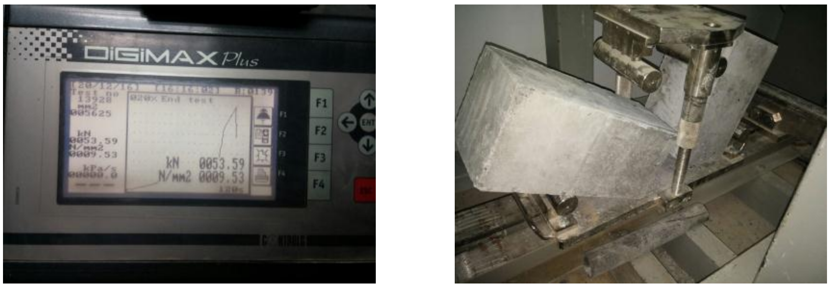

Figure 4. Examinations the type “1” Mix Design - behavior of sample-plain concrete

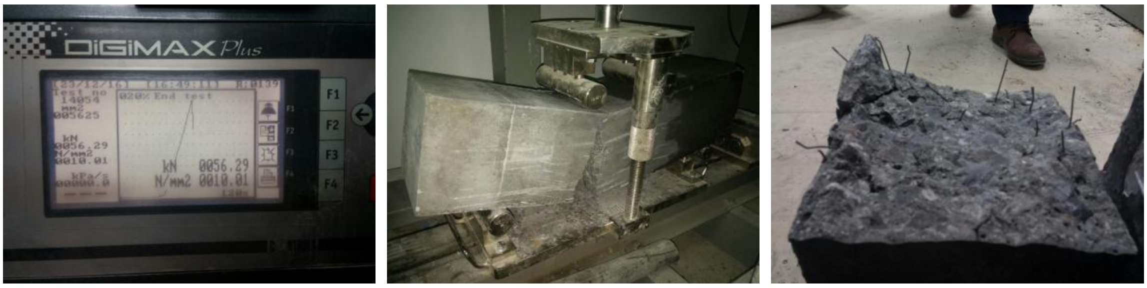

Figure 5. Examinations the type “3” Mix Design -behavior of sample-1% SF

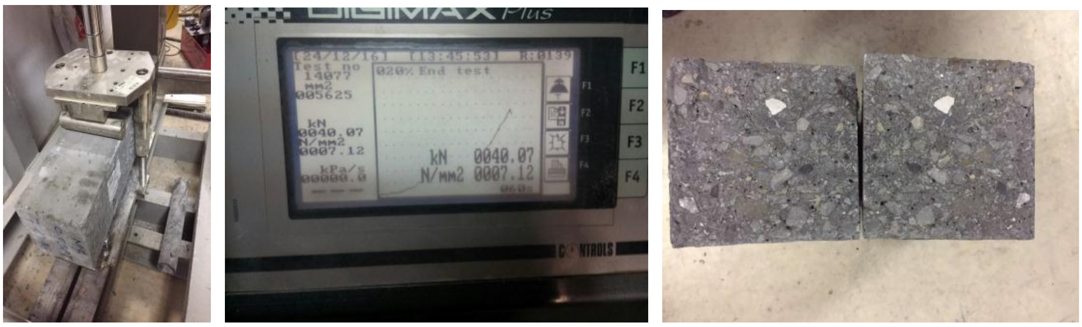

Figure 6. Examinations the type “5” Mix Design -behavior of sample-0.05% PPF

B. Results and Discussion

1) Fresh Concrete

a) Workability

The comparability between the all mix Design, represent the difference of workability, were the using the Steel Fibres haven't indicate in workability, but the using the Polypropylene Fibres have the effect in Mixing process and also in other parameters, such are: casing in place; vibration, etc. The workability is described also with slump of concrete.

b) Porosity

In this paper the effect of air voids it's requested and in all Mix Designs was in low limit: 4 %, except the Mix Design with Polypropylene Fibres were was the tendency to not achieve the requested parameter.

c) Mixing time

Using the Fibres, especially the Polypropylene Fibres need to increase the mixing time, towards the homogenization of concrete, because in some of places results with concerted amount of fibres. One of the important thinks is to determine the best method in distributing the fibers into concrete. The mixing method was crucial in determining a uniform fiber distribution and in preventing the formation of fiber clumps and balls. [10, 11]

C. Hardening Concrete

2) Compressive strength

From Table 4, at 7and 28days of curing, the compressive strength of concrete mixture, comparing the Plain Concrete; Concrete with steel fibres and concrete with Polypropylene fibres no represent the increasing values, and also the our topic was not oriented in this directions to compare the compressive strength.

3) Flexural strength

From Table 4, at 7 and 28days of curing, the flexural strength concrete mixture increases by 9.6 % & 2.15% for SF2 and PPF2, in age of 28 days.

4) Cracks positions

From Table 4, focused on age of 28 days, the cracks are concentrated in mid span with very few developed cracks from this point, just one or two cracks near the main crack.

5) Behavior under testing

In general, in all cases was the presence of the brittle failure, in main crack, with very small indicated in other cracks. The presence of neighbor cracks was limited in visible, just when we used the microscopes.

III. Conclusions

Based on the laboratory test conducted the following conclusions are made:

It is evident from the present research that the effect of fibres is used to improve the mechanical properties of concrete, towards the improvement the ductility or flexural strength. In our case the used the steel fibres and Polypropylene fibres, comparing the Plain Concrete and based in laboratory tests we can conclude:

• At percentage of steel fibre=(0.5 - 1.0) % results by increasing the flexural strength about 9.6 %, but the improvement of brittle failure it was very few improvements.

• At percentage of polypropylene fibre=(0.025 – 0.050) % results by increasing the flexural strength about 2.15 %, but without effects in brittle failure, because the length of fibres was to small, and we recommend the using the more length fibres in improvement the beahviour parameters.

• The using the fibres haven't the effect in compressive strength, in all cases

• The results of the compressive strength are higher than requested, and this one of reason of effect of fibres was limited, especially the Polypropylene Fibres.

• The optimize percent of fibres using in the rigid pavement, based on the laboratory results will be:

• Steel Fibres: from 1.0 % - 1. 5 %

• Polypropylene Fibres: 0.025%-0.075 %, but the length will be more than 40 mm

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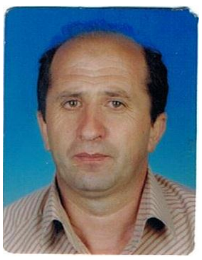

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