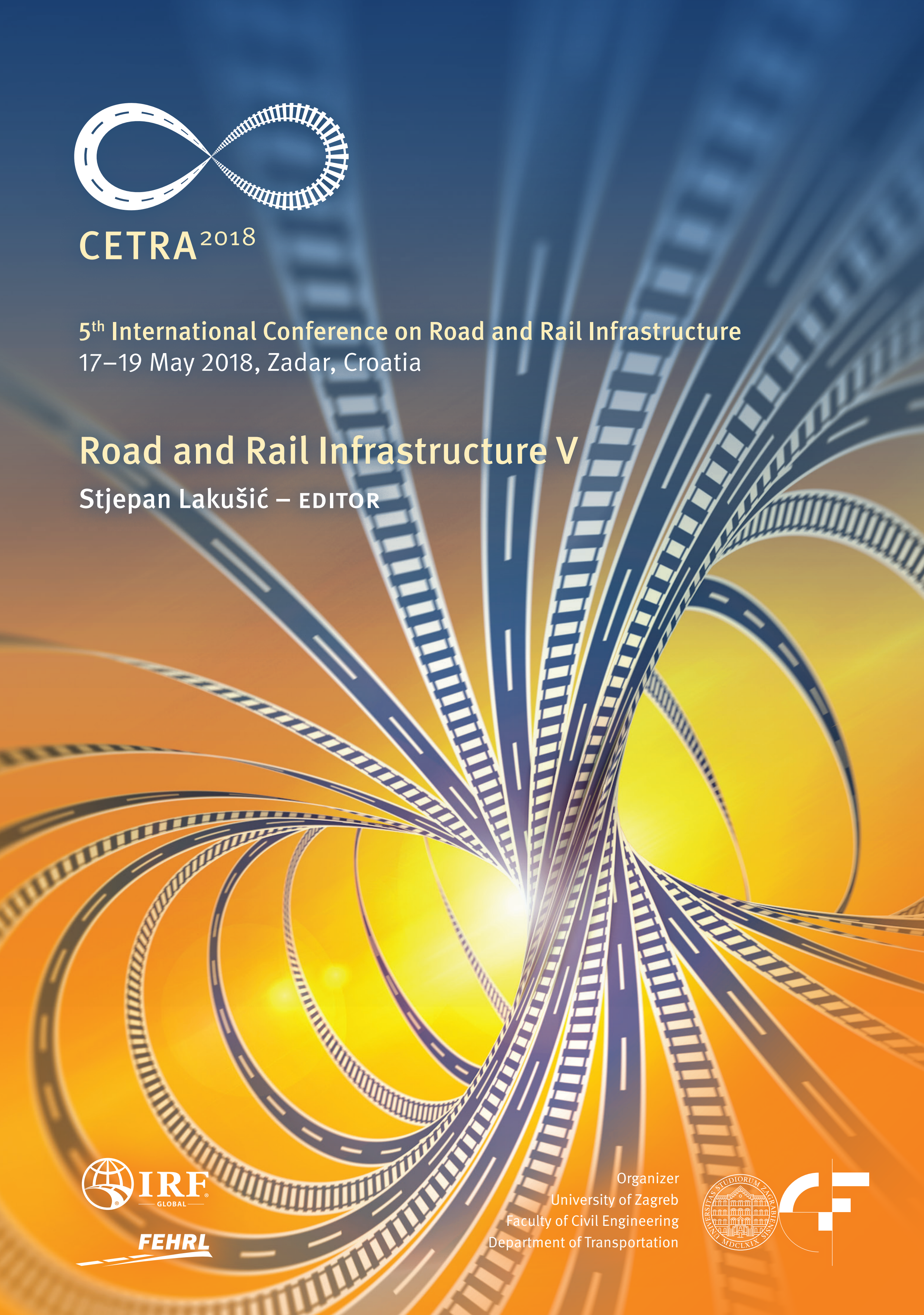

CETRA^{2018}

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – **EDITOR**

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THE INVESTIGATION OF POLYAMIDE FIBER AS AN ADDITIVE IN HMA

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Abstract

The number of heavy vehicles on traffic and traffic volume are extremely increasing nowadays. Consequently, maintenance costs are increasing too. So, durability becomes necessary in asphalt pavement design and construction. For this purpose, asphalt industry partners are investigating innovative technologies and additives for Hot Mix Asphalt (HMA) Pavements. In this study, the utility of Polyamide 6.6, which is a synthetically produced flexible and highly thermoplastic material that have good mechanical and physical properties in terms within the nylon species, was investigated in HMA as a fiber. For examining the test results, specimens were prepared in four different proportions including reference specimens. Volumetric mix design was used to determine the optimum bitumen content. Then Indirect Tensile Strength (ITS) Test was applied to HMA specimens. The aim of this research was to identify the usability of Polyamide 6.6 in HMA mixtures as a fiber, and the engineering properties of the specimens with Polyamide 6.6 fiber.

Keywords: Polyamide 6.6, fiber, Hot Mix Asphalt pavement, volumetric mix design, Indirect Tensile Strength Test

1 Introduction

Hot Mix Asphalt (HMA) is a widely used material in asphalt pavements because of its service performance quality in providing driving comfort, durability, stability and water resistance. The enhanced cost of materials, energy and lack of resources have motivated highway engineers to investigate alternative materials in new road constructions [1].
For this reason, additives like fibres have been generally viewed for HMA [2]. Polymers and natural or synthetic fibers are often used as additive in HMA mixture for improving the pavement performance in the field [3]. They can be added either to the bitumen (modified bitumen) or directly to the final HMA. As a stabilizer, fibres enriching the adhesion between binder and aggregates during construction. And some researches have shown that fibres can also improve rutting and fatigue resistances [2]. Also some reports have shown that fibres can increase the optimum asphalt content in the HMA design and prevent asphalt leakage by absorbing asphalt in the mixture. Previous researches shown that, fibres change the viscoelasticity, enhance moisture susceptibility, rutting resistance, creep compliance and reduce the reflective cracking of HMA pavements [4, 5]. Fibres can also enhance the fatigue life, low-temperature anti-cracking properties and durability of HMA. Additionally, fibres can enhance tensile strength, material toughness, elasticity and dynamic modulus [4]. Also a report showed that the use of acrylic fibers or crumb rubber can improve the mechanical behaviour of conventional high modulus asphalt mixes[6].

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There is a report that polyester fiber was effective to reduce reflective cracking based on a field application at Pennsylvania Department of Transportation. Additionally, a research also stated that Fiber reinforced asphalt concrete (FRAC) with polypropylene fibres decreased reflective cracking at Indiana. Those field experiences consistently reported that, compared to regular HMA, FRACs have enhanced ravelling, fatigue, moisture damage and thermal cracking resistances [7].

Accordingly, in this study the primary objective is to examine the volumetric properties and design method of FRAC mixtures with Polyamide 6.6 fiber. For this aim four different fiber ratio (0 %, 0,1 %, 0,2 %, 0,3 %) including control sample were used to measure the moisture susceptibility and ITS.

2 Materials and method

2.1 Aggregate selection

Standard aggregate tests are conducted for mineral aggregate characteristics. Limestone mineral aggregate characteristics are given in Table 1 and aggregate gradation is given in Fig.1.

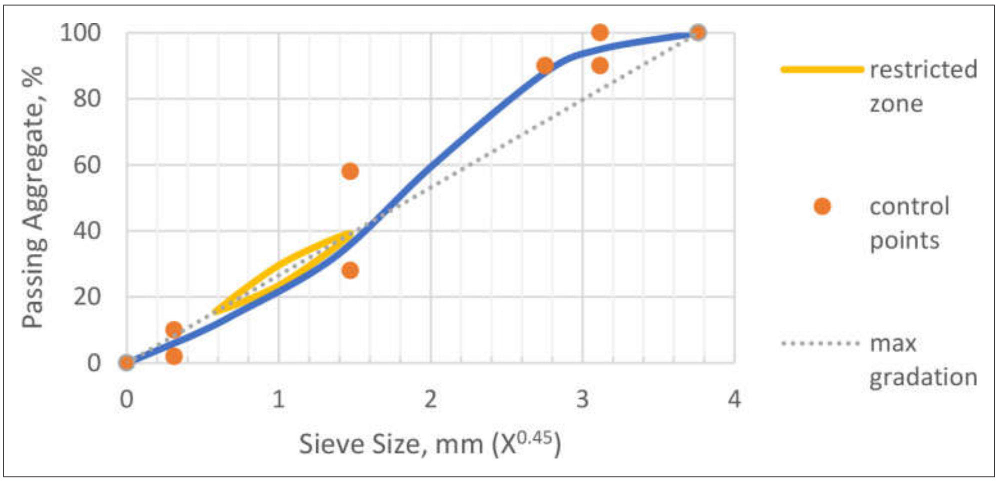

Figure 1 Aggregate gradation

Table 1 Aggregate properties

Sieve diameters	Properties	Standard	Value
25–4.75 [mm]	Specific gravity [g/cm³]	ASTM C 128-15 [8]	2.710
	Saturated specific grav. [g/cm³]		2.660
	Water absorption [%]		0.602
	Abrasion loss [%] (Los Angeles)	ASTM C 131 / C131M – 14 [9]	20.38
4.75–0.075 [mm]	Specific gravity [g/cm³]	ASTM C 127-88(2001) [10]	2.760
	Saturated specific grav. [g/cm³]		2.490
	Water absorption [%]		4.400
<0.075 [mm]	Specific gravity [g/cm³]	ASTM D854-14 [11]	2.840

2.2 Binder selection

Standard tests are conducted to define the asphalt binder properties and the test results are given in Table 2.

Table 2 Aggregate properties

Test name	Average values	Standard
Penetration [25 °C]	65	ASTM D5 / D5M – 13 [12]
Flash point	180 °C	ASTM D92-16b [13]
Fire point	230 °C	
Softening point	45.5 °C	ASTM D36 / D36M – 14e1 [14]
Ductility [5 cm/min]	>100 cm	ASTM D113-17 [15]
Specific gravity [g/cm^3]	1.030	ASTM D70-18 [16]

2.3 Fiber selection

In this study, Polyamide 6.6 fiber is used because of its good mechanical properties and widely usage [17]. The mechanical properties of Polyamide 6.6 fiber is shown in Table 3 and the fiber is shown in Fig.2. The specific gravity of the fiber is determined as 1.13 g/cm^3.

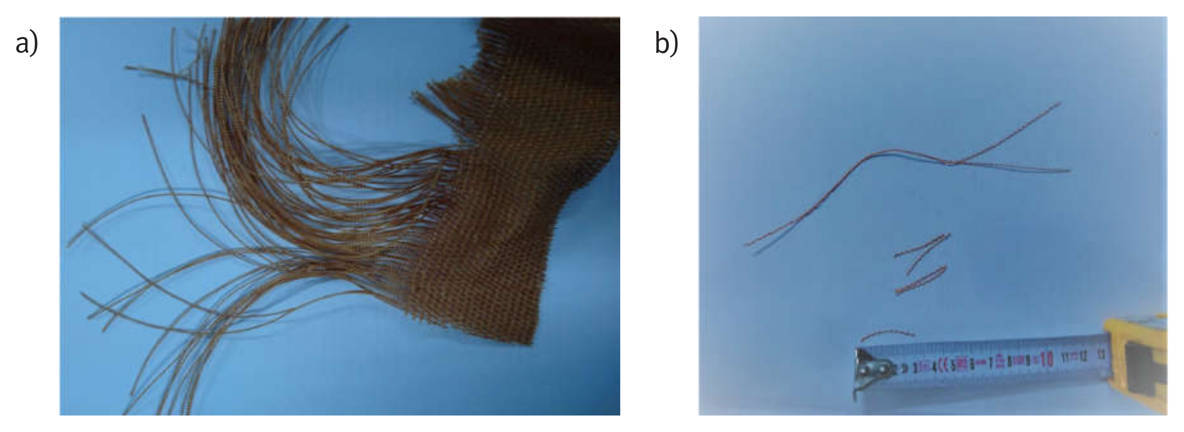

Figure 2 a) Polyamide 6.6 fiber sample; b) 3 cm cutted fibers

Table 3 Polyamide 6.6 fiber properties [17]

Shape of fibre		Round
Hygroscopicity	in normal conditions	4.2 – 4.5 %
	in saturated air	10 %
Density		1.13 – 1.14 g/cm^3
Dried strength		37 – 52 cN/tex
Wet tenacity		33 – 47 cN/tex
Dried extension		20 – 40 %
Wet extension		28 – 43 %
Abrasion resistance		Very high
Elasticity		Very high
Sensitivity towards exposure to sunlight		Very high
Softening point		175 °C
Melting point		218 °C
Shrinkage in boiled water		8 – 12 %
Solvents		Phenol, formic acid, hydrochloric acid
Susceptibility to electrification		Very high
Susceptibility to pilling		Very high

2.4 Indirect tensile strength test

In this study, Indirect Tensile Strength(ITS) test was performed on 8 samples prepared with 1 ‰, 2 ‰, 3 ‰ and 0 ‰ fiber ratios according to AASHTO T 283 [18] test, to determine the moisture susceptibility and the strength values. All specimens were compacted with Superpave Gyratory Compactor till 5 % air voids due to the specification limit of Turkey [19]. Half of the samples were conditioned and named as ITSwet and the other half is left unconditioned and named as ITSdry during the tests according to AASHTO T 283. All conditioned and unconditioned ITS values (kPa) were compared with eachother. Tensile Strength Ratio (TSR) values were obtained and checked for minimum TSR value of 80 % which is the recommended minimum value of moisture susceptibility by Turkey General Directorate of Highways [20].

3 Results and discussion

As a result of the test results, optimum binder content of each polyamide 6.6 fiber added mixture is given in Fig. 3. As shown in the figure, the optimum binder content is increasing by increasing with the additive rate.

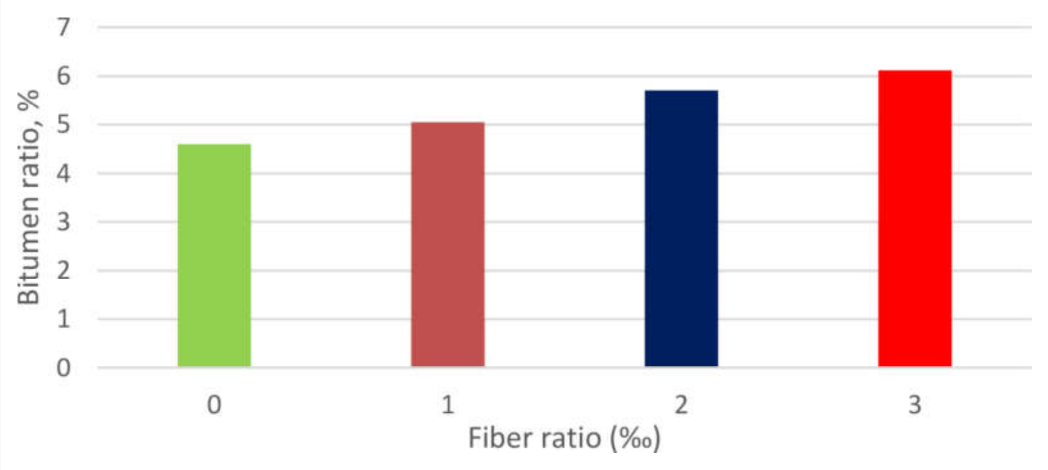

Figure 3 Optimum bitumen ratio results

As seen in Fig. 4, unconditioned test results have shown that, ITS was increased in 1 ‰ fiber additive. Than the ITS values were decreased according to the increased fiber amount in the mixture. In conditioned tests the ITS results were increased till 2 ‰ fiber additive ratio and than decreased with the increased fiber amount in the mixture.

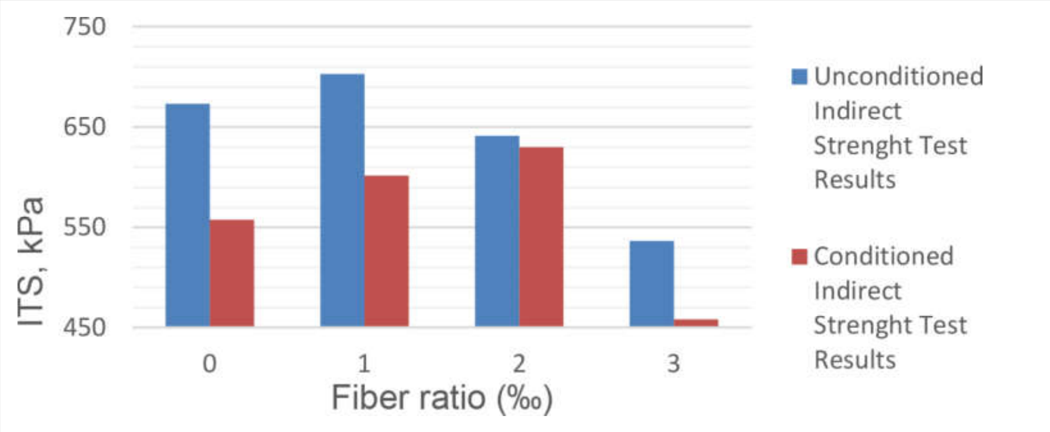

Figure 4 Comparison of Polyamide 6.6 Indirect Strength Test Results

The conditioned and unconditioned indirect strength values were compared in Fig. 5. The closest specimen to line of equality was determined as 2 ‰ fiber added mixture. As shown in Fig. 6 the tensile strength ratios (TSR) are given. In according to the Fig. 6, the obtained TSR values of all fiber ratios have satisfied the TSR limit value. But the 2 ‰ fiber additive has shown the best TSR value which is very close to line of equality.

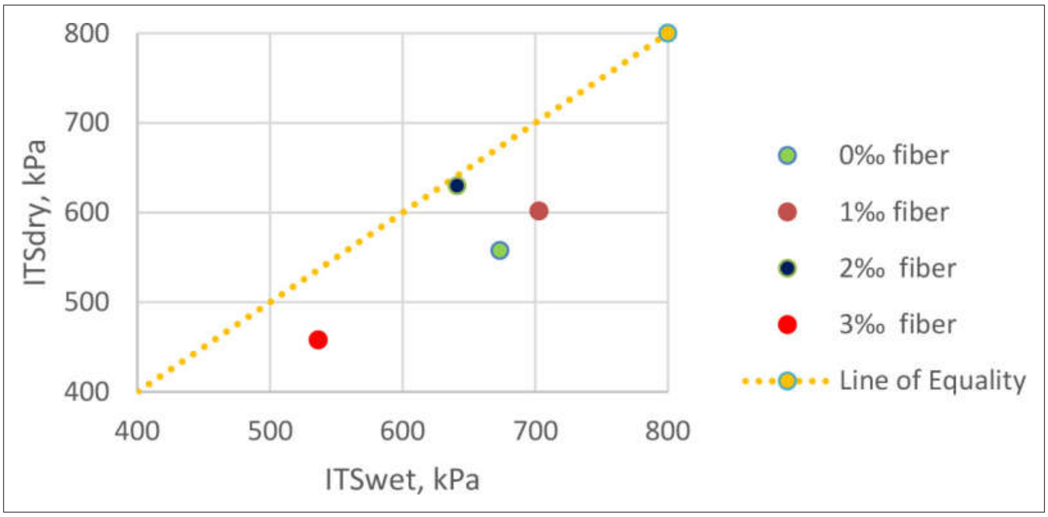

Figure 5 ITS comparision

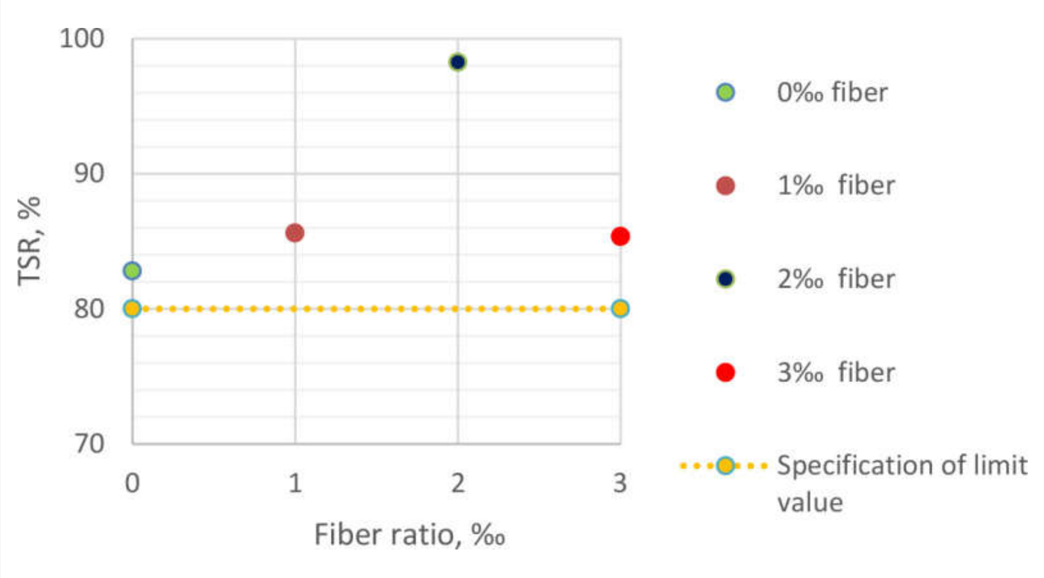

Figure 6 Polyamid 6.6 TSR Results

4 Conclusion

TSR is used for determining the moisture susceptibility. The wet and dry strength values were compared. Max ITSdry value was obtained with 2 ‰ fiber added specimen and tended to decrease with increased fiber additive ratio. All fiber added specimens shown adequate TSR values which are above the specification limit value. The wet and dry specimens ITS strengths were compared with eachother and the 2 ‰ fiber added specimen was the closest specimen to Line of Equality.

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