Control of fissures generated by the retraction in rigid pavements, applying synthetic fibers of recycled polypropylene.

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Control of fissures generated by the retraction in rigid pavements, applying synthetic fibers of recycled polypropylene.

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Abstract. The retraction affects the setting process and the useful life of the concrete with the appearance of fissures; in last year's studies and methods have been generated to mitigate and control it with the use of different products and applications. The development of road infrastructure with the use of concrete as a rolling folder, requires methods to guarantee the durability and reduce the effects of the efforts incorporated by the use, climatic conditions, support base and restrictions of movement of the structure. To evaluate the effects of recycled synthetic polypropylene fibers in plastic retraction tests (ASTM C 1579), 3 mix designs were prepared with different ratios 58 gr., 116 gr., and 176 gr. of recycled and virgin synthetic fibers; the most significant and positive result to reduce fissures without affecting the resistance of concrete by bending and compression, was 0.50 mm without addition fibers, 0.10 mm and 0.15 mm with 176 gr. of virgin and recycled synthetic fibers. Finally, it can be concluded that adding a ratio of 4 kg per m3 allows good workability, in addition, the costs of the fibers are not representative compared to the high costs for future repairs.

1. Introduction.

One of the main problems of the world population in constant growth, is that every year more waste is generated due to the increase in consumption rates (Hoornweg et al., 2013). These rates directly affect the depletion of raw materials and environmental pollution due to the lack of correct recirculation flows (Koppelaar and Wiekard, 2013). [1] (Gilardino, Rojas, Mattos, Larrea and V ásquez, 2017).

To improve the durability of airport pavement concrete, four types of reinforced synthetic fibers in concrete were investigated in this document. Modified polyester synthetic fiber concrete, Polypropylene monofilament reinforced with synthetic concrete fiber, reticular synthetic polypropylene concrete reinforced with fiber and concrete reinforced with synthetic polyacrylonitrile fiber, the resistance, impermeability and resistance to the frost of these were investigated. The results show that synthetic fiber improves the flexural strength of concrete, but has little effect on compressive strength. [2] (Chen, Cen and Cui, 2018).

Macro recycled plastic fiber offers significant environmental benefits over virgin plastic fiber and steel reinforcement. However, as there is limited research on the performance of recycled plastic fiber in concrete, it has not yet been widely adopted by the construction industries. In this investigation, *post-cracking* studied the performance of different types of recycled polypropylene fibers from industrial wastes. Compared with virgin polypropylene fiber in concrete. The recycled fibers during the performance of the test demonstrated a good balance between tensile strength, elastic modulus and concrete bonding, thus producing brilliant post cracking performance. This research demonstrated the feasibility of using recycled fibers as reinforcement in concrete pavement [3] (Yin, et al., 2015).

The basic guidelines for the design of a concrete reinforced with polypropylene-based fiber on road pavement, as it is applied in a real test section that rests inside a tunnel of the Marche-Umbria Quadrilatero, road empowerment project, Italy. The results of a six-month follow-up with the presence of real traffic loads, such as feedback to the design stage. The supervision covers the direct measurement of the level of tension inside the mold, as well as the acoustic measurement, it was a design solution for roads, especially within tunnels [4] (Nobili, Lanzoni and Tarantino, 2013).

2. Materials and Design.

The materials used in the design of the concrete and preparation of the mixture are sand, crushed stone, cement, recycled synthetic fibers of polypropylene "figure 1" and virgin synthetic fibers of polypropylene "figure 2", plasticizing and accelerating additives, necessary to prepare the slab in accordance with the mold proposed in the Norma ASTM C 1579, "figure 3", cylinders and rectangular beams for compression and flexural tests.

Figure 1. Recycled polypropylene fibers

Figure 2. Virgin polypropylene fibers

Figure 3. Norma ASTM C 1579 Metal Mold

The mixture design was prepared by the method of combining aggregates for an amount of 0.044 m3, enough amount to prepare the mold and the test tubes for resistance tests, also proportions of 58 gr, 116 gr. and 176 gr. were added of recycled and virgin fibers respectively, plasticizer additive for ease of handling and accelerating additive and achieve settings and contraction of concrete in less time, allowing visualize the fissures generated.

In the process of setting and contraction of concrete, fissures of 0.50mm, “figure 4”, were evident in the standard mold without fibers; Then an amount of 58 gr. was added to the same proportion of concrete of recycled fiber registering a fissure of 0.40 mm, “figure 5”.

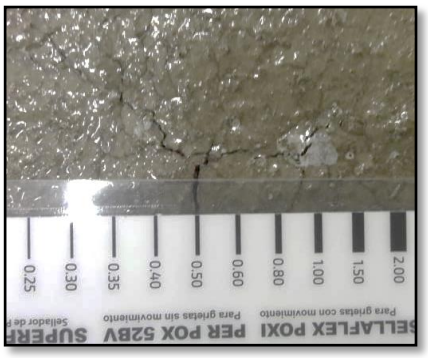

Figure 4. 0.50mm fissure.

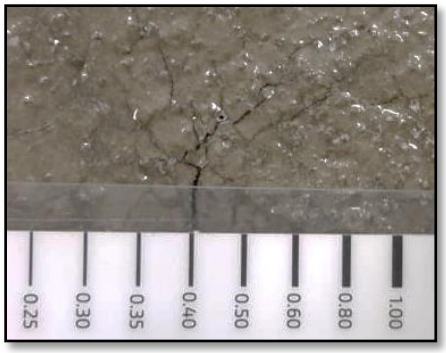

Figure 5. 0.40 mm fissure.

Then using the same proportion of concrete 116 gr. was added of recycled fibers, and 0.35 mm. fissures were observed, "figure 6"; The procedure is repeated and changed for 116 gr. of virgin fibers, obtaining fissures of 0.25 mm; "Figure 7".

Figure 6. 0.35 mm fissure.

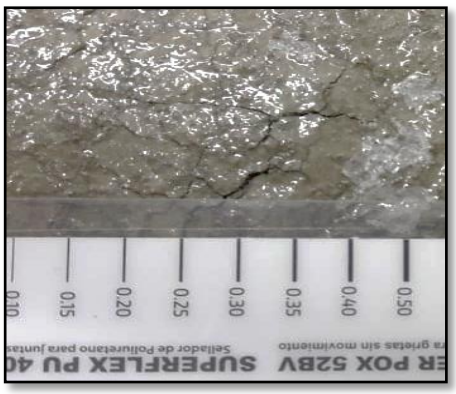

Figure 7. 0.25 mm fissure.

Finally, the amount of fibers is modified by 176 gr. from recycled fibers, 0.15 mm fissures were obtained, "figure 8"; and finally, with 176 gr. of virgin fibers, fissures of 0.10 mm were obtained, "figure 9".

Figure 8. 0.15 mm fissure.

Figure 9. 0.10 mm fissure.

3. Analysis of results

After compiling the data of the different tests carried out, the results obtained from the different dosages were compared with and without the addition of recycled and virgin synthetic fibers; in addition, the samples were subjected to tensile tests, bending and fissures monitoring to verify the impact on resistance, “figure 10” and “figure 11”; The results were positive as there were no effects on the physical characteristics of the concrete. This allows us to affirm that the use of recycled synthetic polypropylene fibers is a reliable alternative for the control of fissures and their use can occur without any restrictions.

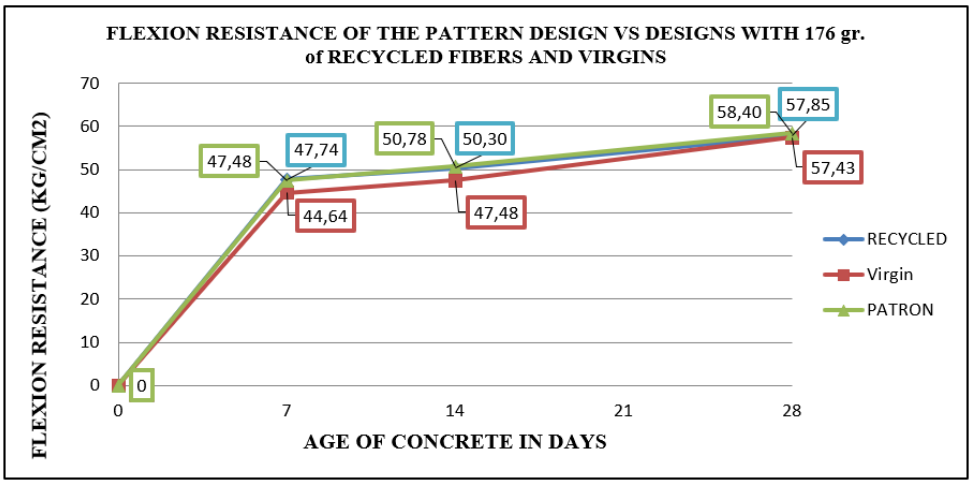

Figure 10. Flexural strength pattern design, with 176 gr. of recycled and virgin fibers

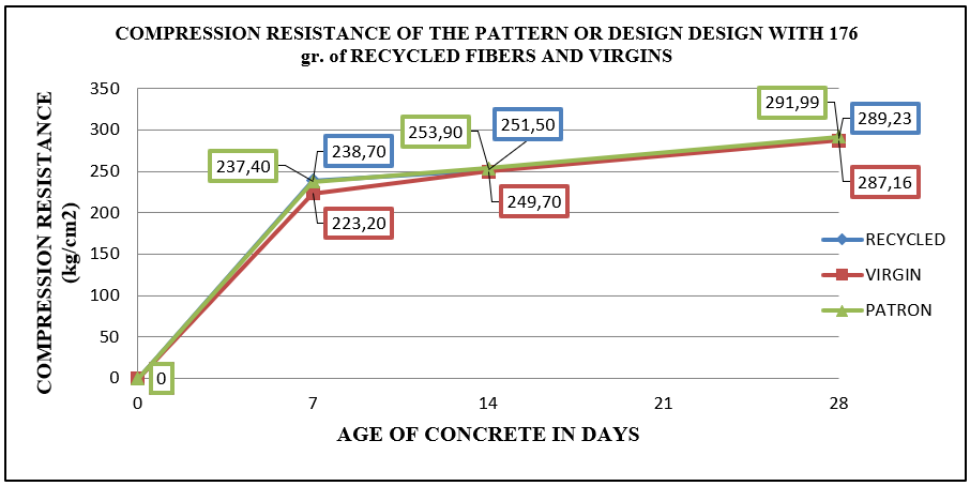

Figure 11. Compressive strength pattern design, with 176 gr. of recycled and virgin fibers

4. Conclusions

1. It was observed in the experimental analysis of concrete with the addition of recycled polypropylene fibers, which, by increasing the amount of fibers in the concrete, decreases the size of the fissures due to the effect of retraction; in the standard mold, fissures of 0.50 mm thick were found, with the recycled fibers fissures of 0.35 and 0.15 mm were found with

respect to 0.25 and 0.10 mm of virgin fibers in amounts of 116 and 176 gr respectively, observing a better control of fissures.

2. The variation of 210 Kg / cm2 concrete mechanical properties (compression and flexion at 28 days) was verified with the addition of recycled and virgin polypropylene synthetic fibers for a volume of (V = 0.044m3). With the addition of 116 and 176 grams of fibers, it was evident:

- For a proportion of 116 gr, of recycled fibers there is a higher compressive strength of 285.32 kg / cm2 compared to a concrete with virgin fiber of 279.45 kg / cm2; on the other hand, the flexural strength of 57.06 kg / cm2 was verified in comparison to a concrete with virgin fiber of 55.89 kg / cm2.
- For a proportion of 176 gr, the recycled fibers obtain a greater compressive strength of 289.23 kg / cm2 compared to a concrete with virgin fiber of 287.16 kg / cm2; on the other hand, the flexural strength is 57.85 kg / cm2 compared to a concrete with virgin fiber of 57.43 kg / cm2.

3. The economic analysis to use synthetic fibers of recycled polypropylene ($ 88.90 m3), demonstrates that they are a technically and economically viable alternative with respect to virgin fibers ($ 91.70 m3), because it allows a decrease in costs; In addition, it helps in reducing environmental pollution caused by polypropylene.
4. Finally, with the results and analysis obtained it was determined that the proportion of 176 gr. of recycled polypropylene synthetic fibers in the volume of concrete tested, represents an addition of 4 kg / m3; concrete maintains its characteristics and provides advantages in reducing and controlling the size of fissures in concrete pavements. The quantities of materials for 1 m3 are; 414.15 kg of cement, 193 liters of water, 821.51 kg coarse aggregate and 869.97 kg fine aggregate.

5. REFERENCES

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