International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 7, November-December 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Effects of Waste Polypropylene Fibers on the Mechanical Behavior of Fiber Reinforced Concrete: An Experimental Study

Pankaj Tiwari, R. S. Parihar, Abhay Kumar Jha

Department of Civil Engineering, Lakshmi Narain College of Technology, Bhopal, Madhya Pradesh, India

ABSTRACT

Concerning, the amount of industrial waste is increasing, which has led to issues with environmental sustainability and earth surface ecology. The production of fibres contributes to global warming by releasing carbon dioxide and other harmful substances into the atmosphere. It also manages waste produced during production and field use. Consequently, incorporating industrial waste in the concrete's formulation can help to mitigate ecological and environmental problems. In this present study, cement concrete was given an extra material of fibre (waste polypropylene fibre). To boost the concrete's compressive and split tensile strengths, polypropylene fibre (PPF), a synthetic hydrocarbon polymer, has been used. As part of this experiment, we produced a range of specimens utilising various polypropylene waste concentrations, including (0%, 0.25%, 0.5%, 0.75%, and 1.00%).

KEYWORDS: *industrial waste, atmosphere, tensile strengths, Compressive strength, polypropylene fibre*

How to cite this paper: Pankaj Tiwari | R. S. Parihar | Abhay Kumar Jha "Effects of Waste Polypropylene Fibers on the Mechanical Behavior of Fiber Reinforced Concrete: An Experimental Study" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-7, December 2022, pp.1187-1190, URL: www.ijtsrd.com/papers/ijtsrd52570.pdf

IJTSRD52570

I. INTRODUCTION

The most popular building material utilised worldwide is cement concrete. It is important to understand it better and enhance its qualities. It is becoming more and more crucial to manage and treat both the solid waste created by municipal garbage and industry by using waste and recycled materials in cement concrete mixtures. One of the most significant inventions of the 20th century was plastic. Plastic consumption has been steadily increasing and is now a significant environmental issue. The use of plastic in the concrete industry is regarded as a feasible application for resolving the disposal of a significant volume of recovered plastic material. According to certain researchers, the physical, chemical, and mechanical properties of plastic material particles utilised as aggregate in cement concrete mix were assessed. The outcome demonstrated that the mechanical properties of cement concrete are not significantly changed when polymeric components are added to a cement matrix in fractions of 10% by volume. In composite materials for building purposes, several researchers calculated the use of trash from consumed plastic bottles as a partial replacement of the fine aggregate. The study shows that plastic bottles that have been crushed into tiny PET particles can be used to partially replace the fine aggregate in cementitious concrete composites. This appears to present an appealing low-cost material with consistent or reliable properties and would help to resolve some of the solid waste issues caused by the production of plastics. Therefore, the potential for using waste plastic in cement concrete mixes has been examined in this study and contrasted with control samples. Only instances of plastic being utilised as a fibrous material in concrete are discussed in this section. The numerous varieties of fibrous waste material's diverse characteristics are depicted. Finally, this paper evaluates potential future investigations on the use of industrial waste polymer as fibrous material in cement mortar and cement concrete mix.

II. Literature review

According to (Manaswini and Vasu Deva, 2015), as industrial waste production rises, waste use can help us save money and is seen when being quite beneficial when added to concrete in the form of fibres. As reinforcement for regular concrete, we can utilise waste PP, PET, and HDPE fibres as well as metallic fibres. We can access the impacts of the integration of polypropylene fibres and on the fresh and waste metallic fibres (WMF) hardened concrete qualities; we are aware that these items are readily available in large quantities and at a lower cost. Numerous studies have been conducted to examine the performance of FRC in extreme settings, including compression, tension, shear, and flexure. According to the thorough analysis in this work, using waste metal fibres results in a nearly 41.25% increase in compressive strength. We may also state that the incorporation of fibres reduces the issue of disposing of plastic and offers sustainable, long-lasting, and affordable construction.

Branston et al. (2016) Due to its eco-friendly manufacturing technique and superior mechanical qualities, chopped basalt fibre has recently grown in prominence in concrete reinforcing applications. The purpose of this study is to compare the relative merits of bundle dispersion fibres and minibars, two different forms of basalt fibre, in improving the mechanical behaviour of concrete. Three different amounts of each fibre were used to make concrete examples, which were afterwards tested for flexural and drop-weight impact. Scanning electron microscopy was also used to study interfacial characteristics. The findings showed that while both types of fibre boosted pre-cracking strength, only minibars improved post-cracking behaviour, perhaps as a result of polymer protection.

Alberti et al. (2017) The mechanical behaviour of fiber-reinforced concrete is greatly influenced by the orientation and distribution of the fibres. The example of rigid steel fibres has seen extensive use of a number of classical models. New considerations in this matter were necessary due to the growing need for flexible synthetic structural fibres. In order to exploit flexible fibres, a probabilistic model that takes into account prior research and stereographical assumptions has been developed. This research also offers important design engineering tools to forecast and confirm the amount of fibres crossing a vertical surface utilising steel and polyolefin fibre reinforced concrete. The suggested model also accurately depicts the existence of boundaries and agrees with the widely accepted values.

Ali Amin et al. (2017) In this study, the post-cracking behaviour of concrete reinforced with macro synthetic polypropylene fibres is examined using a set of matched experiments that assess tension indirectly through prism bending and determined round panel tests and directly through uniaxial tension tests. The authors have previously created an analytical model for determining the residual tensile strength produced by steel fibres in prism bending tests. This model has been modified for the round panel testing, and it has been demonstrated to correspond well with the experimental results gathered.

Simões et al. (2017) Utilizing a total of 312 specimens, an experimental analysis focusing on the mechanical behaviour of fibre reinforced concrete matrixes (FRCM) is presented. After defining a reference plain combination, three different types of fibres were selected to reinforce it (polypropylene, glass and steel fibres). Four volumetric proportions were used for each type of reinforcement, ranging from 0.5% to 2% in 0.5% steps. It was examined how each fibre type and dosage affected the FRCM's compressive strength, bending behaviour, cracking and maximum loads, and ductility. In conclusion, it was found that the tensile strength of the fibre, specifically, has a significant impact on the compressive strength growth, which generally increases with the reinforcing dose. The type of reinforcement has a significant impact on the load-displacement curves as well. The composite material has a superior potential to tolerate significant deformations thanks to the steel and polypropylene fibres. Due of their brittle nature, glass fibres have less of an impact in this area. As the percentage of each type of fibre increases, the load capacity correspondingly rises, reaching a maximum of 160% for the addition of 2.0% steel fibres. Despite the positive effect related to the mechanical characteristics of the fibres, the cracking loads are continuously lower than those of the reference mixture due to the loss of homogeneity and increased porosity caused by the inclusion of fibres. The cracking stresses for polypropylene FRCM were almost 35% lower than those for the reference mixture. The toughness indices (I5, I10, and I20) for steel and polypropylene fibres were defined, and it was found that for a 1.5% volume fraction of steel fibres, the I5 and I20 are, respectively, 6.80 and 35.08, whereas for a similar fraction of polypropylene fibres, those indices are, respectively, 3.61 and 15.75.

Abbass et al. (2018) Low tensile strength and tensile strain capacity are combined with significant brittleness in concrete. The insertion of steel fibres to concrete can improve such subpar performance. Due to its better performance, steel fibre reinforced concrete (SFRC) has become more and more popular in recent years. Its key benefits include preventing macro crack propagation, stopping micro cracks from growing to macroscopic size, increasing ductility and residual strength after the initial crack forms, and having high toughness. In this study, the impact of introducing steel fibres of various lengths and diameters on the mechanical characteristics of concrete is examined for three concrete strength values. In this investigation, three different water-to-cement ratios were used with hooked terminated fibres of different lengths (40, 50, and 60 mm) and diameters (0.62 and 0.75 mm) (0.25, 0.35, and 0.45). Three volume fractions of steel fibres, 0.5%, 1.0%, and 1.5%, were added. The investigation and preparation of thirty concrete mixes. According to the results, adding steel fibres with varying contents and lengths and increasing water-to-cement ratios significantly changed the mechanical properties of concrete, increasing compressive strength by about 10–25% and direct tensile strength by about 31–47%. For fibres with a lesser aspect ratio of 65, the increase in fibre content from 0.5% to 1.5% raised the flexural strength from 3% to 124%, while for fibres with a larger aspect ratio of 80, a 140% increase in the flexural strength was seen when compared to the concrete without any fibres. A proposed mathematical model for the stress-strain relationship of fibre reinforced concrete under compression takes into account steel fibres of various lengths and diameters. The proposed model and the outcomes of the experiments agree fairly well.

III. Material used

Industrial Waste Polypropylene Fibre

Thermoplastic polymer polypropylene (PP), commonly referred to as polypropene, is employed in a wide range of applications. They are the fourth most mass produced material after polyesters, polyamides, and acrylics. About 4 million tonnes of polypropylene fibres are produced worldwide each year. These fibres are created in the mill using conventional melt spinning. Polypropylene fibres were formerly known as "Stealth" fibres. These monofilament fibres are classified as microreinforcement fibres made of 100% virgin homopolymer polypropylene. Polypropylene is derived from the monomeric molecule C3H6, which is the only hydrocarbon. These fibres' main purpose is to lessen the development of shrinkage cracks in freshly filled concrete. These fibres have a density of just 0.9 g/cc. They are extremely stiff, have a high degree of crystallinity, and are well-resistant to bacterial and chemical attack. The molecular weights of these fibres, which range from 90,000 to 300,000 g/mole, are around 70% crystallin. It is often not widely available due to the wide variety of polymers available on the market, including acrylic, polystyrene, and others. Oftentimes, it is opaque or coloured with colouring pigments. It has a high tolerance to fatigue loading. Commercially available isotactic polypropylene melts at temperatures between 160 and 166 °C, whereas perfectly isotactic polypropylene melts at about 171 °C. Polypropylene fibres are non-magnetic, safe, rust-free, alkali resistant, and easy to work with. These are chemically inert and have a hydrophobic nature. The presence of fibres enhances the performance of various parameters such as post-peak ductility, fracture strength, toughness, impact resistance, pre-crack tensile strength, flexural strength resistance, fatigue resistance performance, and others. Despite their strength, polypropylene fibres have a low elastic modulus and tensile strength. With hand packed manufacturing procedures, polypropylene fibre up to 12% by volume is believed to have been used effectively; nevertheless, 0.1% of 50 mm fibre in concrete has apparently been found to cause a 75 mm slump loss. Polypropylene fibres have been demonstrated to minimise uncontrolled plastic and drying shrinkage of concrete at fibre values of 0.1 to 0.3% by volume.

IV. CONCLUSION

Based on the above study following conclusions can be made:

- The addition of discarded polypropylene fibre does not significantly alter the density of the concrete mix.
- At 7 days and 28 days of curing with 0.25% and 0.50% addition of fibre, the compressive strength of Fiber Reinforced Concrete (FRC) gradually increased, but after that point, it started to decrease as the amount of fibre added increased.
- With fibre additions of 0.25% and 0.50%, the split tensile strength of Fiber Reinforced Concrete (FRC) gradually grew at 7 days and 28 days of curing, but as the amount of fibre added increased, it then began to drop.
- Using discarded polypropylene fibre raises the strength of concrete for all curing ages up to a point. After that, the fiber-reinforced concrete's strength suddenly starts to decline (FRC). because higher dosages of concrete cause it to lose its ability to establish a good connection.

REFERENCES

[1] AliAminaStephen J. Fostera R. Ian Gilberta Walter Kaufmannb (2017) Material characterisation of macro synthetic fibre reinforced concrete, Cement and Concrete Composites Volume 84, November 2017, Pages 124-133, ELSEVIER, https://doi.org/10.1016/j.cemconcomp.2017.08.018 `

[2] Amit Rai et al Int. Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 4, Issue 5(Version 1), May 2014, pp.123-131. http://www.academia.edu/7676360/Applications_and_Properties_of_Fibre_Reinforced_Concrete.

[3] Anon., 2003. Avoidance of waste: beneficial use of industrial by-products as constituents of concrete (The third information sheet prepared by the environmental working party of the concrete society's material group). Concrete 37 (5), 43–45. http://www.nanoient.org/JENT/Volume2/Issue2/Concrete-Made-With-Waste- Materials---A-Review/45#.WjPNSjRx3Mw.

[4] Assunc¸ a˜o, R.M.N., Royer, B., Oliveira, J.S., Filho, G.R., Castro Motta, L.A., 2004. Synthesis, characterization and application of the sodium poly (styrenesulfonate) reduced from waste polystyrene cups as an admixture in concrete. Journal of Applied Polymer Science 96, 1534–1538. http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-6f3da1f4-a1e2- 4ca5-ad8d-79b83d054050.

[5] Balaguru P.N. and Shah S.P., 1992, Fibre-Reinforced Cement Composites, McGraw- Hill Inc., New York, United State of America.

[6] Banthia, N., Trottier, J., 1995. Test methods for flexural toughness characterization of fibre reinforced concrete: some concrete and a proposition. ACI Materials Journal 92 (1), 48–57.

[7] Bentur A. and Mindess S., 1990, Fibre Reinforced Cementitious Composites, Elsevier Science Publishing Ltd., New York, United State of America.

[8] BIS: 10262-2009: Recommended guidelines for concrete mix design, Bureau of Indian Standard, New Delhi-2004.

[9] BIS: 1199-1959 (Reaffirmed 2004): Methods of Sampling and Analysis of Concrete, Bureau of Indian Standard, New Delhi-1999.

[10] BIS: 2386 (Part I)-1963 (Reaffirmed 2002): Methods of Test for Aggregates for Concrete, Bureau of Indian Standard, New Delhi-1963.

[11] BIS: 383-1970 (Reaffirmed 2002): Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standard, New Delhi-1997.

[12] BIS: 456-2000 (Reaffirmed 2005): Code of practice- plain and reinforced concrete, Bureau of Indian Standard, New Delhi-2000.

[13] BIS: 516-1959 (Reaffirmed 2004): Methods of tests for strength of concrete, Bureau of Indian Standard, New Delhi-2004.

[14] BIS: 5816-1999(Reaffirmed 2004): Splitting tensile strength of concrete-Method of test, Bureau of Indian Standard, Delhi-2004.