A TECHNICAL REVIEW ON RECENT USAGE OF USED TYRE WASTE IN CONCRETE

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ABSTRACT: *This review paper provides an overview of the effectiveness of using waste tires in concrete. With the increasing amount of waste tires generated globally, their disposal has become a major environmental concern. Incorporating waste tires in concrete can provide a sustainable solution to this issue, while also improving the performance and properties of concrete. The paper discusses the various methods of incorporating waste tires in concrete, such as using shredded tires as aggregates, adding rubber powder as a partial replacement for cement, and using crumb rubber as a filler material. It reviews the mechanical properties, durability, and environmental impact of the resulting concrete, including compressive strength, flexural strength, abrasion resistance, water absorption, and chloride ion penetration. The review highlights the potential benefits of using waste tires in concrete, including reduced energy consumption and greenhouse gas emissions, improved durability, and reduced material costs. However, it also acknowledges some challenges associated with this approach, such as the need for proper tire shredding and processing, and potential negative effects on workability and fresh concrete properties. Overall, the review concludes that using waste tires in concrete can provide a sustainable and effective solution for both waste tire disposal and concrete performance improvement. However, further research is needed to fully understand the long-term effects of using waste tires in concrete and to optimize the incorporation methods and ratios for different applications*

Keywords: *Waste Tyre Rubber, Crumb rubber concrete, light weight concrete, Flexible Concrete*

1. INTRODUCTION

The disposal of waste tyre rubber has been a major environmental concern worldwide due to its non-biodegradable nature and potential health hazards. One way to address this issue is by incorporating waste tyre rubber in construction materials, such as concrete. The usage of waste tyre rubber in concrete has attracted significant attention in recent years due to its potential benefits, including improved mechanical properties, durability, and sustainability. The utilization of waste tyre rubber in concrete has been reported in various forms, such as shredded rubber particles, crumb rubber, and rubber powder. The incorporation of waste tyre rubber in concrete has shown promising results in enhancing the properties of concrete, such as tensile strength, ductility, and impact resistance. The addition of waste tyre rubber in concrete can also improve the workability and reduce the density of the concrete, leading to reduced construction costs. Apart from the mechanical properties, the usage of waste tyre rubber in concrete can also contribute to sustainable development. The incorporation of waste tyre rubber in concrete can reduce the environmental impact of waste disposal, conserve natural resources, and reduce the carbon footprint of concrete production. Moreover, the utilization of waste tyre rubber in concrete can create new economic opportunities and promote circular economy principles. Despite the potential benefits of using waste tyre rubber in concrete, there are still some challenges that need to be addressed. The compatibility of waste tyre rubber with cementitious materials, the effect of rubber content on concrete properties, and the long-term durability of rubberized concrete are some of the key issues that need further investigation.

This review paper aims to provide an overview of the current state-of-the-art in the usage of waste tyre rubber in concrete. The paper will cover the various forms of waste tyre rubber used in concrete, the mechanical and durability properties of rubberized concrete, the environmental impact of waste tyre rubber in concrete, and the challenges and opportunities associated with its usage. The review will also highlight the potential areas for future research and development to further enhance the utilization of waste tyre rubber in concrete

2. REVIEW ON USAGE OF WASTE TYRE RUBBER IN CONCRETE

K. Dhivya et al., (2022) [15] The use of rubber tyre waste as a partial replacement for coarse aggregate in concrete production. The study aims to evaluate the effect of different percentages of rubber tyre waste (0%, 5%, 10%, 15%, and 20%) on the strength properties of concrete. The experiment was conducted by preparing concrete specimens with varying proportions of rubber tyre waste and measuring their compressive strength, splitting tensile strength, and flexural strength. The results were then compared with the control group (0% rubber tyre waste) to determine the effect of the waste material on the concrete properties. The findings of the study indicate that the incorporation of rubber tyre waste as a partial replacement for coarse aggregate in concrete production can result in a reduction in compressive strength, splitting tensile strength, and flexural strength. However, the reduction in strength is less significant for lower replacement percentages (5% and 10%) and increases with higher percentages (15% and 20%). The study suggests that the use of rubber tyre waste as a partial replacement for coarse aggregate in concrete production is feasible, but caution must be taken in selecting the appropriate percentage of replacement to ensure that the desired strength properties are maintained. The findings of this study can be used to inform the development of more sustainable and environmentally-friendly construction materials.

Oguzhan et al., (2021) [18] The effects of cement dosage and waste tire rubber (WTR) on the mechanical, transport, and abrasion characteristics of foam concretes exposed to H2SO4 and freeze-thaw cycles. The study uses foam concretes with cement dosages ranging from 350 to 600 kg/m3 and varying amounts of WTR replacement (0%, 10%, 20%, and 30%). The concretes are then subjected to H2SO4 and freeze-thaw cycles, and their mechanical properties (compressive strength, flexural strength, and modulus of elasticity), transport properties (water absorption and chloride ion penetration), and abrasion resistance are evaluated. The results show that increasing the cement dosage leads to an increase in the compressive strength, flexural strength, and modulus of elasticity of the foam concretes, while adding WTR as a partial replacement for cement reduces these properties. However, the addition of WTR also improves the transport properties of the foam concretes by reducing water absorption and chloride ion penetration. In addition, the foam concretes with WTR replacement exhibit improved abrasion resistance compared to the control concrete without WTR. The study concludes that adding WTR to foam concrete can improve its durability and abrasion resistance, while also reducing its environmental impact by using waste materials as a partial replacement for cement. However, the reduction in mechanical properties with WTR addition should be carefully considered in practical applications.

Asad Zia et al., (2023) [1] The use of waste tire-derived raw steel fibers as a sustainable alternative to traditional steel fibers in concrete. The researchers conducted a series of experiments to evaluate the effects of replacing traditional steel fibers with waste tire-derived steel fibers on the compressive strength, flexural strength, and toughness of concrete. The waste tire-derived steel fibers were obtained by processing waste tires through a pyrolysis process. The experimental results showed that the replacement of traditional steel fibers with waste tire-derived steel fibers had no significant negative effect on the compressive strength of the concrete. However, there was a slight decrease in flexural strength and toughness as the percentage of waste tire-derived steel fibers in the concrete increased. The researchers found that a 2% replacement of traditional steel fibers with waste tire-derived steel fibers resulted in the best overall performance of the concrete in terms of both mechanical properties and sustainability. Additionally, the use of waste tire-derived steel fibers in concrete has the potential to significantly reduce waste and carbon emissions. Overall, the experimental results indicate that waste tire-derived raw steel fibers can be a viable and sustainable alternative to traditional steel fibers in concrete.

Mohammed Momeen ul Islam et al., (2022) [13] A study for the complete replacement of conventional coarse aggregates explores the use of discarded vehicle tire rubbers as a complete replacement for conventional coarse aggregates in structural lightweight concrete. The study conducted several experiments to investigate the durability properties of the concrete, including compressive strength, splitting tensile strength, flexural strength, and water absorption. The experiments were conducted using varying percentages of waste tire rubber, ranging from 0% (control group) to 100% replacement of conventional coarse aggregates. The experimental results showed that as the percentage of waste tire rubber increased, the compressive, splitting tensile, and flexural strengths of the concrete decreased. However, the study found that the 100% replacement of conventional coarse aggregates with waste tire rubber did not result in a significant decrease in the durability properties of the concrete. The study also found that the water absorption rate of the concrete decreased as the percentage of waste tire rubber increased, indicating improved durability properties of the concrete. Additionally, the study found that the use of waste tire rubber in the concrete resulted in a reduction in the density of the concrete, making it a viable option for lightweight structural applications. Overall, the study suggests that waste tire rubber can be used as a complete replacement for conventional coarse aggregates in structural lightweight concrete, without significantly compromising the durability properties of the concrete

S.Amaan et al., (2022) [9] A discussion the effects of waste tire fiber and steel fiber reinforcement on the properties of concrete. The study was conducted through experimental tests to evaluate the fresh and hardened state properties of concrete with different percentages of waste tire and steel fibers. The study found that the addition of waste tire fibers up to 1% by volume improved the fresh state properties of the concrete, such as workability, slump, and flowability. However, at higher percentages, the workability decreased. In terms of hardened state properties, the waste tire fibers improved the compressive strength of the concrete up to

6%, but the flexural strength decreased. Similarly, the addition of steel fibers improved the flexural strength of the concrete, but the compressive strength was not significantly affected. The study also showed that combining waste tire and steel fibers resulted in a synergistic effect, where the combination of fibers improved both the compressive and flexural strength of the concrete. finally, the study suggests that waste tire and steel fibers can be effectively used as a reinforcement material in concrete, and the optimum percentage of waste tire and steel fibers for improved properties are 1% and 1.5%, respectively. The findings of this study could have significant implications for sustainable and cost-effective construction practices.

Xiancheng Mei et al., (2023) [10] The article describes an experimental study on the use of recycled waste tires as a replacement for sand in concrete for aseismic isolation layer applications. The study aims to investigate the mechanical and damping properties of rubber-sand-concrete with varying percentages of waste tire replacement. The study conducted a series of tests on rubber-sand-concrete samples with waste tire replacement percentages ranging from 0% to 50%. The test results showed that the rubber-sand-concrete with waste tire replacement had improved damping properties compared to traditional concrete. The maximum damping ratio was observed at a 20% waste tire replacement percentage. In addition, the study found that the compressive strength of the rubber-sand-concrete decreased with increasing waste tire replacement percentages. However, the reduction in compressive strength was within an acceptable range for aseismic isolation layer applications. Overall, the study concludes that the use of recycled waste tires as a replacement for sand in concrete can improve the damping properties of the material without significantly compromising its mechanical strength. The optimum waste tire replacement percentage was found to be 20%.

Hasan Sardar et al., (2022) [6] The investigation on the use of waste tire-derived carbon black as a partial replacement for cement in high-strength concrete, and its effect on the residual performance of the concrete under elevated temperatures. The study involved conducting compressive strength tests and exposing the concrete specimens to elevated temperatures ranging from 200°C to 800°C for 2 hours. The percentage replacement of waste tire-derived carbon black varied from 0% to 10% in the concrete mix. The experimental results showed that the addition of waste tire-derived carbon black up to a certain percentage can enhance the mechanical properties of high-strength concrete. The study also found that the residual mechanical properties of high-strength concrete after exposure to elevated temperatures were improved with the addition of waste tire-derived carbon black up to 8% replacement. The study concludes that waste tire-derived carbon black can be used as a partial replacement for cement in high-strength concrete, and it can improve the residual mechanical properties of concrete after exposure to elevated temperatures. The results of this study could provide a new sustainable solution for the recycling of waste tires and reducing the environmental impact of waste tire disposal.

Muhammed Halil Akın et al., (2022) [20] The use of waste tires as a replacement material in polyester-based polymer concrete. The study aims to explore the potential benefits of using waste tires as a sustainable and eco-friendly alternative to traditional construction materials. The experiment involved preparing various polymer concrete samples with different percentages of waste tire rubber as a replacement for traditional aggregate materials. The samples were then tested for mechanical, hardness, and stress-strain properties to evaluate the effects of waste tire rubber on the performance of the polymer concrete. The results of the experiment showed that the addition of waste tire rubber up to 15% as a replacement material had a positive effect on the mechanical properties of the polymer concrete, improving its compressive strength, flexural strength, and toughness. However, higher replacement percentages of waste tire rubber led to a decrease in mechanical properties. Additionally, the study found that the hardness of the polymer concrete decreased with an increasing percentage of waste tire rubber, while the stress-strain properties remained relatively unchanged. Finally, the study suggests that the use of waste tire rubber as a replacement material in polyester-based polymer concrete can have a positive effect on its mechanical properties, up to a certain percentage. However, further research is needed to investigate the long-term durability and performance of polymer concrete with waste tire rubber as a replacement material.

Gianni Blasi et al., (2022) [17] The article presents an experimental study on the use of waste tyres as a replacement for conventional fibres in fibre-reinforced concrete (FRC). The study aimed to evaluate the tensile behaviour of FRC with waste tyre fibres (WTF) by developing an inverse analysis-based model. The study used three different types of fibres: conventional steel fibres (CSF), manufactured tyre fibres (MTF), and WTF. The percentage replacement of conventional fibres with waste tyre fibres ranged from 0 to 100%, with increments of 25%. The study found that the addition of WTF to FRC resulted in an increase in the tensile strength and toughness of the concrete. The maximum improvement was observed when the WTF replaced 50% of the conventional fibres. The inverse analysis-based model developed in the study was able to accurately predict the tensile behaviour of the FRC with WTF. The model considered the influence of the fibre aspect ratio, orientation, and volume fraction on the tensile strength and toughness of the FRC. Overall, the study concluded that waste tyres can be used as a sustainable alternative to conventional fibres in FRC. The optimum replacement percentage of conventional fibres with WTF was found to be 50%, which resulted in a significant improvement in the tensile behaviour of the concrete. The developed inverse analysis-based model can be used to predict the tensile behaviour of FRC with WTF accurately.

Saeed M. Al-Tarbi et al., (2022) [19] The article presents a study on the utilization of waste materials, specifically high-density polyethylene (HDPE), low-density polyethylene (LDPE), and crumb tire rubber (CTR), in the production of eco-friendly hollow concrete blocks. The study involved replacing a percentage of the sand in the concrete mix with these waste materials, with the percentage of replacement varying from 5% to 25%. The compressive strength, water absorption, and density of the resulting hollow concrete blocks were then measured and compared to those of conventional hollow concrete blocks. The experimental results showed that the addition of waste materials improved the compressive strength and reduced the water absorption of the hollow concrete blocks. The highest compressive strength was achieved with a 25% replacement of CTR, while the lowest water absorption was achieved with a 20% replacement of HDPE. However, the density of the blocks increased as the percentage of waste material replacement increased. The study showed that the use of waste materials in the production of hollow concrete blocks can lead to eco-friendly and cost-effective building materials, with potential benefits for both the construction industry and the environment.

R. Gajendra Rajan et al., (2021) [8] The feasibility of using waste tire rubber as a partial replacement for fine aggregate in concrete. The study investigates the effects of replacing fine aggregate with waste tire rubber on the compressive strength and workability of concrete. The researchers conducted experiments using concrete mixtures with varying amounts of treated waste tire rubber as a partial replacement for fine aggregate. The treated waste tire rubber was obtained by treating the rubber with acid to improve its bonding with the concrete. The results of the experiments showed that the compressive strength of the concrete decreased as the percentage of waste tire rubber increased. However, the researchers also found that the workability of the concrete improved as the percentage of waste tire rubber increased, indicating that it may be possible to use waste tire rubber in certain types of concrete mixes. The study concludes that treated waste tire rubber can be used as a partial replacement for fine aggregate in concrete, but the percentage of replacement must be carefully considered to ensure that the desired strength and workability are achieved. The researchers suggest that further research is needed to investigate the long-term durability of concrete containing waste tire rubber and to develop guidelines for the use of waste tire rubber in concrete mixes. At the end, the article highlights the potential benefits of using waste tire rubber in concrete as a sustainable alternative to traditional building materials, while also emphasizing the importance of careful experimentation and testing to ensure the safety and reliability of these new materials.

Demarcus Werdine et al., (2021) [3] The article explores the potential of using tire rubber waste as a partial replacement for fine aggregates in self-compacting concrete (SCC). The study used a design of experiments approach to analyze the properties of the resulting SCC mixtures, including slump flow, compressive strength, water absorption, and permeability. The study found that the addition of tire rubber waste to SCC resulted in improved workability, with an increase in slump flow and a decrease in the required amount of superplasticizer. The compressive strength of the SCC also increased with the addition of tire rubber waste up to a certain percentage, after which it began to decrease. This optimum percentage was found to be 10% by weight of fine aggregates. In terms of durability properties, the SCC with tire rubber waste showed reduced water absorption and permeability compared to the control SCC mixture. This suggests that the addition of tire rubber waste could improve the durability and reduce the environmental impact of SCC. Overall, the study provides valuable insights into the potential use of tire rubber waste in SCC and highlights the importance of design of experiments approaches in optimizing SCC mixtures. The findings could have significant implications for the construction industry, particularly in terms of reducing waste and improving the sustainability of concrete production.

Zhiheng Liuet al., (2022) [11] The research opens the discussion on the dynamic compressive behaviour of self-compacting concrete (SCC) modified with waste tire rubber (WTR) under multiple impact loading conditions. The study aimed to investigate the effect of adding WTR on the dynamic compressive behaviour of SCC and to assess its potential for use in blast-resistant structures. The experimental investigation involved fabricating concrete specimens with varying proportions of WTR and subjecting them to multiple impact loading using a drop hammer testing machine. The results showed that the addition of WTR improved the dynamic compressive strength of SCC and its energy absorption capacity. The WTR-modified SCC specimens exhibited better deformation resistance and damage tolerance under multiple impact loading. Furthermore, the study explored the microstructure and fracture behaviour of the WTR-modified SCC specimens using scanning electron microscopy (SEM). The SEM analysis revealed that the WTR particles were well dispersed in the SCC matrix, and the interfacial transition zone (ITZ) between the WTR particles and the cement matrix was improved. Overall, the study concluded that the addition of WTR can effectively enhance the dynamic compressive behaviour of SCC under multiple impact loading, and the WTR-modified SCC has potential applications in blast-resistant structures. The research findings provide valuable insights into the development of sustainable and resilient concrete materials for use in high-performance structures.

Md. Shahjalal et al., (2021) [5] The article explores the potential of using waste tires rubber and recycled aggregate as a partial replacement for conventional concrete in fiber-reinforced concrete beams. The study involved testing six different types of beams, varying in the amount and type of recycled materials used. The beams were tested for their flexural strength, toughness, and energy absorption capacity. The results showed that the use of waste tires rubber and recycled aggregate as partial replacements for conventional concrete can significantly enhance the flexural performance of fiber-reinforced concrete beams. The addition of fibers also had a positive effect on the beam's toughness and energy absorption capacity. Furthermore, the study found that the optimal percentage of waste tires rubber and recycled aggregate for enhancing the flexural performance of fiber-reinforced concrete beams is around 10-20%. The study concludes that using waste tires rubber and recycled aggregate in fiber-reinforced concrete beams is a promising approach for sustainable construction practices. The use of these materials can reduce the environmental impact of construction and increase the economic feasibility of using concrete in building projects.

Sumit Choudhary et al .,(2020) [16] The potential of using waste rubber tire fiber in the production of functionally graded concrete was explored. Functionally graded concrete is a type of concrete that has varying properties and characteristics through its thickness, allowing it to be used in a wide range of applications. The article discusses the challenges associated with the disposal of waste rubber tires and the environmental impact they have. The author proposes a sustainable solution by incorporating waste rubber tire fiber into concrete. This approach not only reduces waste but also improves the mechanical properties of concrete. The article describes the experimental work done to investigate the effects of incorporating waste rubber tire fiber on the mechanical properties of functionally graded concrete. The study showed that the addition of waste rubber tire fiber increased the flexural strength of concrete and improved its impact resistance. The study also found that the compressive strength of concrete decreased slightly with the addition of waste rubber tire fiber. The author concludes that the incorporation of waste rubber tire fiber in functionally graded concrete is a promising approach to reduce waste and improve the mechanical properties of concrete. However, further research is needed to investigate the long-term durability and environmental impact of this type of concrete, this article highlights the potential of using waste rubber tire fiber in the production of functionally graded concrete. This approach could lead to a more sustainable and environmentally friendly construction industry.

Mohammad Saberian et al., (2020) [7] The article discusses the use of recycled concrete aggregate (RCA) and recycled tyre waste (RTW) in concrete production. The author aims to investigate the shear behaviour of RCA-RTW concrete in comparison to conventional concrete. The study includes the use of RCA, RTW, and conventional concrete in different proportions. The concrete mixtures were tested for their shear behaviour using the direct shear test method. The results showed that the incorporation of RTW in RCA concrete had a positive effect on its shear strength. The RCA-RTW concrete had higher shear strength than conventional concrete, especially at higher RCA replacement ratios. Furthermore, the study examined the effect of different parameters on the shear behaviour of RCA-RTW concrete. The parameters include the RCA replacement ratio, the RTW replacement ratio, the water-cement ratio, and the curing period. The results showed that the shear strength of RCA-RTW concrete increases with an increase in the RCA replacement ratio and the RTW replacement ratio. Moreover, the curing period has a significant effect on the shear strength of RCA-RTW concrete, the study demonstrated that the use of RCA and RTW in concrete production can have a positive effect on its shear behaviour. The RCA-RTW concrete had higher shear strength than conventional concrete, especially at higher RCA replacement ratios. Therefore, the use of RCA and RTW in concrete production can contribute to sustainable construction practices and the reduction of waste materials.

Masoud Bakhtiari Ghaleh et al., (2022) [14] The article investigates the potential of waste tire concrete as a sustainable alternative to traditional concrete. Waste tire concrete is a type of concrete that incorporates crumb rubber obtained from recycled tires as a partial replacement for conventional aggregates. The study investigates the effects of surface double pre-coating by resin and micro-silica on the mechanical performance of waste tire concrete. The researchers hypothesize that this technique can enhance the interfacial bonding between the rubber particles and the cement matrix, thereby improving the overall strength and durability of the concrete. The experiments conducted in the study involved preparing four different mixes of waste tire concrete, each with a different combination of resin and micro-silica coating. The mechanical properties of each mix were then tested, including compressive strength, tensile strength, flexural strength, and impact resistance. The results showed that the waste tire concrete with surface double pre-coating by resin and micro-silica exhibited significantly improved mechanical performance compared to the control mix. Specifically, the compressive strength and flexural strength were increased by up to 41% and 56%, respectively, while the impact resistance was increased by up to 92%. The findings suggest that surface double pre-coating by resin and micro-silica can be an effective technique for enhancing the mechanical properties of waste tire concrete. This can have important implications for the development of sustainable construction materials, as waste tire concrete offers a way to reduce the environmental impact of the construction industry by utilizing recycled materials.

Syed Minhaj Saleem Kazmi et al., (2021) [12] In the article a new approach to utilizing waste tire rubber and recycled aggregates in concrete products. The traditional method of using waste tire rubber in concrete involves shredding the rubber into small pieces and then mixing it with concrete. However, this approach has limitations due to the poor bonding between the rubber and the cement matrix, which can lead to reduced strength and durability of the resulting concrete product. To address this issue, the author proposes a new compression casting approach, which involves compressing the rubber and aggregates together into a mould and then pouring the cement slurry into the mould. This results in a higher bonding between the rubber and the cement matrix, which improves the strength and durability of the concrete product. The author conducted several experiments to test the effectiveness of this approach and found that the resulting concrete products had improved mechanical properties compared to traditional methods. Additionally, this approach is more sustainable since it utilizes waste materials and reduces the need for virgin aggregates. Overall, the author's new compression casting approach shows promising results for utilizing waste tire rubber and recycled aggregates in concrete products, and has the potential to improve the sustainability and durability of concrete infrastructure.

Wang Her Yung et al., (2013) [2] The article investigates the potential use of waste tire rubber in self-compacting concrete (SCC) as a means of sustainable waste management. The study aims to determine the effect of waste tire rubber on the durability properties of SCC, including compressive strength, water absorption, chloride ion penetration, and carbonation resistance. The research involves replacing a portion of the fine aggregate in SCC with waste tire rubber at various percentages ranging from 0% to 20%. The results show that the compressive strength of SCC decreases as the percentage of waste tire rubber increases. However, the water absorption, chloride ion penetration, and carbonation resistance all improve with the addition of waste tire rubber, especially at higher percentages. The study suggests that SCC with up to 10% waste tire rubber can meet the requirements for compressive strength and durability properties in practical applications. The use of waste tire rubber in SCC can contribute to sustainable waste management and reduce the environmental impact of traditional SCC production methods, The study demonstrates the potential of waste tire rubber as a partial replacement for fine aggregate in SCC, offering a viable solution to the environmental challenges posed by waste tire disposal while maintaining the necessary mechanical and durability properties of SCC.

Blessen Skariah et al., (2016) [4] The investigation on the possibility of using waste tire rubber as a replacement for natural aggregates in concrete. The study evaluates the performance of concrete containing waste tire rubber as an aggregate replacement in terms of durability-related properties such as compressive strength, water absorption, and chloride ion penetration. The experimental results showed that the addition of waste tire rubber in concrete as a replacement for natural aggregates led to a significant reduction in compressive strength. However, this reduction in compressive strength was within acceptable limits, and the overall strength of the concrete was still considered suitable for structural applications. Furthermore, the study showed that the addition of waste tire rubber in concrete led to a significant reduction in water absorption and chloride ion penetration. This suggests that the use of waste tire rubber in concrete can improve the durability of the resulting concrete structures, The article highlights the potential of using waste tire rubber as a replacement for natural aggregates in concrete. The use of waste tire rubber in concrete can not only reduce the environmental impact of waste tire disposal but also improve the durability of concrete structures. However, further research is required to investigate the long-term performance and economic feasibility of this approach.

3. CONCLUSION

1. The use of rubber tyre waste as a partial replacement for coarse aggregate in concrete production is feasible, but caution must be taken in selecting the appropriate percentage of replacement to ensure that the desired strength properties are maintained.

2. Adding waste tire rubber to foam concrete can improve its durability and abrasion resistance, while also reducing its environmental impact by using waste materials as a partial replacement for cement. However, the reduction in mechanical properties with waste tyre rubber addition should be carefully considered in practical applications.

3. Waste tyre-derived raw steel fibres can be a viable and sustainable alternative to traditional steel fibres in concrete.

4. Waste tire rubber can be used as a complete replacement for conventional coarse aggregates in structural lightweight concrete, without significantly compromising the durability properties of the concrete.

5. The use of recycled waste tires as a replacement for sand in concrete can improve the damping properties of the material without significantly compromising its mechanical strength. The optimum waste tire replacement percentage was found to be 20%.

6. Waste tire-derived carbon black can be used as a partial replacement for cement in high-strength concrete, and it can improve the residual mechanical properties of concrete after exposure to elevated temperatures.

7. The use of waste tire rubber as a replacement material in polyester-based polymer concrete can have a positive effect on its mechanical properties, up to a certain percentage. However, further research is needed to investigate the long-term durability and performance of polymer concrete with waste tire rubber as a replacement material.

8. The waste tires can be used as a sustainable alternative to conventional fibres in fibre-reinforced concrete. The optimum replacement percentage of conventional fibres with waste tyre fibres was found to be 50%.

9. The utilization of waste materials, specifically high-density polyethylene, low-density

polyethylene, and crumb tire rubber, in the development of eco-friendly hollow concrete blocks. The results showed that the use of these waste materials can enhance the mechanical and thermal properties of the concrete blocks while reducing their environmental impact.

10. The addition of waste tire rubber can improve workability, durability, and dynamic compressive behaviour, as well as reduce water absorption and permeability in concrete mixes.

11. Further research is needed to investigate the long-term durability and safety of concrete containing waste tire rubber and to develop guidelines for the use of waste tire rubber in concrete mixes.

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