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A Review on the Inclusion of Marble Powder and Bamboo Fiber on the Mechanical Properties of Concrete

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ABSTRACT:

Nowadays construction industry is focussing on various wastes from other industries to use them as substitutes for construction materials. Concrete is a construction material consisting of cementitious material, fine aggregate, coarse aggregate, and water. Nowadays the cost of these materials is increased so, we need to look for a way to reduce the cost of building materials, especially cement. The replacement of materials offers cost reduction, energy savings, and protection of the environment. To achieve the above objective the possibility of the partially replacing the cement with waste marble powder and addition of bamboo fiber to increase the mechanical properties of concrete.

Keywords: Marble powder (MP), Bamboo fibres (BF), Mechanical properties (MP), Rigid pavements

1. Introduction

In India the road networks are very large so we need to look after the cost of construction of roads. The replacement of materials offers cost reduction, energy savings, and protection of the environment. Pavement is usually defined as a structure consisting of layers and their key purpose is to share out the applied load to the sub grade. Rigid pavements have usually three layers namely sub grade, base layer and top most layers known as concrete slab. This concrete slab should be of above M30 grade of concrete as per IS recommendations. Rigid pavements also known as concrete pavements are used mostly for constructing major highways and airports. The volume of traffic on these pavements remains high and also required a long span of structure so that try to designed for better outcome with partially replacing the cement with waste marble powder and natural bamboo fiber. The addition of bamboo fibers to the concrete mixture because they are renewable and environmentally beneficial. It is crucial to evaluate how the performance of the concrete is affected by the reduced cement content because this can have favorable effects on the environment and cost analysis. in improvement will be there of tensile strength while the addition marble powder can be used as a partial replacement for traditional cement in concrete mixes. This not only reduces the demand for cement production, which is a significant source of carbon emissions, but also makes use of a waste product (marble dust). Marble powder will fill the voids present in concrete and will give sufficient compressive strength when compared with ordinary concrete. There is a rising interest in investigating alternative materials that can lessen the environmental impact of concrete while retaining or even improving its performance features in the pursuit of more environmentally friendly construction techniques. The use of marble powder as a partial replacement for cement in concrete pavement is one such creative strategy. A byproduct of the stone industry called marble powder shows promise as a long-term and environmentally responsible replacement. Environmentally, when industrial wastes are recycled not only the CO2 emissions are reduced but residual products from other industries are reused and therefore less material is dumped as landfill and more natural resources are saved. Among these, marble waste powder which using marble waste powder in cement and concrete production is a by-product of marble processing factory was studied by many researchers for its use in concrete and mortar production as sand replacing or cement replacing material. Marble is a metamorphic rock resulting from the transformation of a pure limestone Marble powder can be used as filler in concrete and paving materials and helps to reduce total void content in concrete. Marble powder can be used as an admixture in concrete, so that strength of the concrete can be increased. Marble dust is mixed with concrete, cement or synthetic resins to make counters, building stones, sculptures, floors and many other objects.

2. Literature Review

Yasin Onuralp Ozkılıc et al. (2023) [16] This study aimed to investigate the use of waste marble powder (WMP) as a replacement for cement in concrete. The WMP was replaced at different percentages (10%, 20%, 30%, and 40%) of the cement weight, and a reference concrete sample without WMP (REF) was created for comparison purposes. The study analysed the compressive strength, splitting tensile strength, and flexural strength of the concrete samples. The results indicated that the replacement of WMP at 10%, 20%, 30%, and 40% of the cement weight led to decreasing compressive strength by 5.7%, 21.7%, 38.1%, and 43.6%, respectively, when compared to REF. The splitting tensile strength showed a similar trend to the compressive strength. Additionally, the flexural strength dropped by 5.3%, 8.6%, 19.4%, and 26.7% for WMP at 10%, 20%, 30%, and 40% respectively, in comparison to REF. The study proposed three different methods for calculating the mechanical resistance of concrete with WMP, which varied in complexity. The simple calculation was based on the strength of the REF and WMP percentages, while the complex calculation involved the design of the concrete mixture, the age of the samples, and the WMP percentages. The ANN approach was used for the complex calculation, and the coefficient of determination (R2) for the K-fold cross-validation method was employed to validate the proposed methods. The research found that all the proposed methods provided highly accurate estimations to predict the properties of concrete with WMP. Based on the results, it is recommended to utilize 10% WMP as a replacement for cement to achieve the best results in terms of both mechanical and environmental aspects. Moreover, scanning electron microscopy (SEM) was used to examine the microstructures of the concrete samples.

Er. Brahamjeet Singh et al. (2021) [17] Pavement is a structure made up of layers, with the primary purpose of distributing the load to the subgrade. Rigid pavements are composed of three layers - the subgrade, base layer, and topmost layer, which is a concrete slab. According to IS recommendations, the concrete slab should be of M35 grade or higher. In rigid pavements, the most commonly used size of coarse aggregates is 20 mm, and fine aggregates should be of zone II. Compared to flexible pavements, concrete pavements are more durable, require less maintenance, and have a longer lifespan. This report discusses the use of bamboo pieces in the construction of rigid pavements to reduce settlement. The study examines the feasibility of using bamboo pieces in pavement-quality concrete with a water/binder ratio of 0.38. The report provides detailed information on the amount of bamboo pieces used, ranging from 0 to 1.5% with a variation of 0.5% on a trial basis. It was found that adding bamboo pieces up to 0.5% increases the compressive strength, but beyond this percentage, the strength starts decreasing. As the percentage of bamboo pieces increases up to 1.5%, the flexural strength also rises.

Hemant S et al. (2020) [18] The construction industry's excessive use of cement has led to undesirable consequences. To promote sustainability in construction practices, cement can be replaced with industrial by-products like fly ash (FA), ground granulated blast furnace slag (GGBFS), silica fume (SF), metakaolin, rice husk ash, etc., as mineral admixtures. This paper presents experimental investigations on the strength properties of concrete made using pozzolanic waste materials, i.e. supplementary cementitious materials (SCMs) such as FA, GGBFS, and SF, as cement replacing materials. Eight trial mixes were prepared using these materials with varying amounts of ordinary Portland cement. The SCMs were kept in equal proportions in all eight trial mixes. Additionally, a superplasticizer was used to improve workability. The compressive strengths corresponding to the curing period of 7, 28, 40, and 90 days, and the flexural and indirect tensile strengths corresponding to 7, 28, and 40 days of curing were evaluated. The study concludes that industrial waste materials can be used as a partial replacement for cement, resulting in sustainable concrete for use in rigid pavement construction.

Manpreet Singh et al. (2018) [1] The study concluded that the use of marble powder can be extended up to 10-15% replacement of cement in the concrete mix. However, if the use of marble powder exceeds 15%, it can reduce strength and durability and spoil the life of the concrete structure.

Yasin Onuralp Ozkılıc et al. (2023) [2] The study showed that adding waste marble powder to concrete production had a negative impact on its flexural strength. Specifically, adding 10%, 20%, 30%, and 40% of waste marble powder reduced flexural strength by 5.3%, 8.6%, 19.4%, and 26.7%, respectively. The researchers concluded that waste marble powder can be used as a substitute for cement in concrete production, but should be limited to a maximum of 10% replacement to avoid negatively impacting the flexural strength of the concrete sample.

G. Latha et al. (2015) [3] The study found that when waste marble powder was used to replace cement partially by 10% to 15%, the concrete's compressive, split tensile, and flexural strengths increased. The findings of this study could encourage wider use of alternative materials in the construction industry, leading to benefits like energy savings and environmental protection.

Vineet Bamanalli et al. (2022) [4] They carried out tests on cubes, cylinders, and beams to determine the material's compressive strength. The test results revealed that a partial replacement of bamboo chips at 15% achieved the desirable strength and low weight when compared to conventional concrete.

Esat Alyamaç and Alp Bu ra Kürat Aydin. (2015) [5] Compressive strength values are determined after 7, 28, and 90 days, splitting tensile strength values on the 28th day, and water absorption and abrasion resistance values. A feasibility evaluation is performed using parameters like fresh concrete, compressive strength, sportively, abrasion resistance, and estimated cost. Based on the feasibility evaluation, it is demonstrated that using up to 40% marble powder in concrete is suitable according to the requirements.

Syed Farzan Amin and Er. Renu. (2023) [6] The results showed that a 13% replacement of cement with MDP resulted in an 11.9% improvement in compressive strength after 28 days, compared to the blend with 0% replacement. Similarly, split tensile and flexural strength improved by 12% and 12.75%, respectively. When 13% replacement of MDP was combined with 1.1% polypropylene fibre, the compressive strength improved by 15% after 28 days. Split tensile strength and flexural strength also improved by 15% and 13.5%, respectively, after 28 days.

Oumaima Bourzi et al. (2022) [7] The study showed that the mechanical properties of concrete with WMP were superior to conventional mixtures. This finding indicates that WMP can replace sand in concrete, and mixtures containing a percentage of WMP lower than 15% can improve the mechanical properties of the concrete. Overall, the use of WMP is a viable source of raw materials for the construction industry and an eco-friendly solution for the disposal of WMP. In conclusion, the study suggests that the use of WMP in concrete can help preserve natural aggregate reservoirs while reducing the environmental impact of concrete production.

Er. Brahamjeet Singh. (2021) [8] This report examines the settlement of rigid pavements using bamboo pieces, to determine the feasibility of using bamboo pieces in pavement-quality concrete with a water/binder ratio of 0.38. The study used varying amounts of bamboo pieces ranging from 0 to 1.5%, in increments of 0.5% for trial purposes. The results showed that adding bamboo pieces up to 0.5% increased the compressive strength while adding more than 0.5% resulted in a decrease in strength. However, increasing the percentage of bamboo pieces up to 1.5% increased the flexural strength.

P. O. Awoyera et al. (2015) [9] The findings revealed that 1.0% bamboo fibre in concrete had the greatest impact on flexural strength, leading to an 81% increase in strength and splitting tensile strength, resulting in a 101% increase. However, it was discovered that bamboo fibre had little or no effect on the compressive strength of high-strength concrete. On the other hand, steel fibre-reinforced concrete showed a significant increase in compressive, flexural, and splitting tensile strengths compared to bamboo fibre-reinforced concrete.

atima alice tracy. (2022) [10] However, the flexural strength decreased with an increase in the age of the bamboo. Workability decreased with an increase in fibre proportions in concrete. Compressive strength decreased with increasing bamboo proportions by 1% and 38.5%. There was an increase in the tensile strength of bamboo fibre-reinforced concrete with an increase in fibre proportions from 1.9 to 2.7 N/mm² at 28 days. The optimal proportion of bamboo fibre for concrete strength improvement was at 1%, which gave 19.4 and 2.7 N/mm² for compressive and tensile strengths at 28 days, respectively. Bamboo fibre enhances the strength properties of fibre-reinforced concrete in tension and reduces the compressive strength of the concrete within acceptable ranges up to 1%.

Hemant S et al. (2020) [11] Eight trial mixes were prepared using different amounts of ordinary Portland cement and various supplementary cementitious materials (SCMs). The proportions of SCMs were kept equal in all eight mixes, and a superplasticizer was added to improve workability. The compressive strengths were measured after 7, 28, 40, and 90 days of curing, and the flexural and indirect tensile strengths were measured after 7, 28, and 40 days of curing. The study found that industrial waste materials can be used to partially replace cement, resulting in sustainable concrete that can be used in the construction of rigid pavements.

Abeer Hassan et al. (2022) [12] After conducting experiments, it was found that the ideal amount of carbon nanotubes (CNTs) to add to concrete is 0.05%. This proportion provides the highest levels of compressive, tensile, and flexural strength when compared to other combinations of concrete with varying amounts of CNTs. Furthermore, it was discovered that adding synthetic fibres (SFs) to the mix can enhance the mechanical properties and improve post-cracking and fatigue behaviour. Combining CNTs and SFs increased compressive, tensile, and flexural strength by 22.7%, 29.3%, and 70.8%, respectively, compared to traditional pavement.

Mohsen Shamsaei et al. (2017) [13] The study found that incorporating XLPE waste into concrete affected the material's fresh and hardened properties. Specifically, the use of XLPE waste caused a decrease in the unit weight and VeBe time of the concrete. However, replacing 5% of coarse aggregate with XLPE waste resulted in an 11% increase in the 28-day splitting tensile strength of RCCP. Additionally, the 28-day compressive and flexural strengths of the concrete mix met the minimum standards set by the RCCP guide. Based on these findings, the use of XLPE waste is recommended for low-traffic pavements, rural roads, and sidewalks, but not for high-traffic areas. Furthermore, the use of XLPE waste improved the ductility and resistance of RCCP to cracking, which contributes to preventing environmental waste and reducing landfill costs while saving energy.

Saeid Hesami et al. (2016) [14] The study found that using either CWP or CWA increased the water/cementitious materials ratios. Interestingly, RCCP mixtures containing 5% CWP or CWA performed just as well as the control RCCP mixture. However, when cement substitution exceeded 20% with these supplementary cementitious materials, the mixtures' strength values and elastic modulus decreased at all ages. The combination of LS and CWA resulted in higher mechanical properties, especially at the ages of 28 and 90 days. The study found that using either CWP or CWA increased the water/cementitious materials ratios. Interestingly, RCCP mixtures containing 5% CWP or CWA performed just as well as the control RCCP mixture. However, when cement substitution exceeded 20% with these supplementary cementitious materials, the strength mixtures' strength values and elastic modulus send at all ages. The combination of LS and CWA resulted in higher mechanical properties, especially for 90 days.

Tehmina Ayuba et al. (2013) [15] Experimental results showed that the addition of Basalt fibres up to 2% fibre volume together with mineral admixtures improved the compressive strength. The improvement in the strains corresponding to maximum compressive strength and splitting tensile strength results was observed at all fibre volumes, whereas there is a negligible influence of the fibre addition on the elastic modulus.

4. Conclusion

1.Based on the literature, it was found that the ideal replacement of cement with waste marble powder and the addition of bamboo fiber in the grade design mix resulted in achieving maximum values for compressive, flexural, and tensile strengths.

2. Increasing the percentage of fiber the flexural strength keeps on increasing and the chances of resisting bending also increases. This is due to the reason that the dimensions of slabs are larger which helps the bamboo pieces in spreading uniformly and the bamboo pieces gets a chance of forming a proper

bond in between the aggregates as a result it increases the bending ability of specimens.

3. Further, the cost of construction can be minimized with usage of marble powder which is freely or cheaply available and the environmental pollution can be reduced by using waste marble powder as partially replacement of cement in concrete.

4. The percentage increase in the waste marble powder the compressive strength values for M30 grade concrete tends to increase at each curing age. This increase in the strength of concrete can be due to the presence of calcium carbonate content in Marble Powder.

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