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A review paper on partial replacement of fine aggregate by different allied materials.

Un artículo de revisión sobre el reemplazo parcial de agregado fino por diferentes materiales afines.

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ABSTRACT

As results of the fast increase in construction activity, ancient construction materials reminiscent of cement, fine aggregate and coarse aggregate are in short supply. Concrete is the most significant part in building and is employed in massive quantities. It conjointly necessitates an enormous quantity of sand as a fine aggregate. Natural resources are being depleted by digging up sand from rivers, which poses a major threat to the ecosystem. Experts are therefore now focusing on developing a substitute to concrete and sand. In the manufacturing of concrete, however, a number of wastes and by-products from various industries are employed as substitutes or alternative materials. This paper reviews some significant attempts in the partial replacement of fine aggregate made by researchers in the last ten years.

Keywords: concrete, construction, fine aggregate, partial replacement, sand.

RESUMEN

Como resultado del rápido aumento en la actividad de la construcción, los materiales de construcción antiguos como el cemento, el agregado fino y el agregado grueso son escasos. El hormigón es la parte más importante en la construcción y se emplea en cantidades masivas. Requiere conjuntamente una enorme cantidad de arena como agregado fino. Los recursos naturales se están agotando al extraer arena de los ríos, lo que representa una gran amenaza para el ecosistema. Por lo tanto, los expertos ahora se están enfocando en desarrollar un

sustituto del concreto y la arena. En la fabricación de hormigón, sin embargo, se emplean como sustitutos o materiales alternativos una serie de desechos y subproductos de diversas industrias. Este artículo revisa algunos intentos significativos en el reemplazo parcial de agregado fino realizados por investigadores en los últimos diez años.
Palabras clave: hormigón, construcción, árido fino, sustitución parcial, arena

INTRODUCTION

Concrete is a mixture of cement, sand, coarse aggregates and water, the most commonly used substance on earth. Cement is a binding element in concrete that gives the compressive strength to concrete. The fine aggregate consists of small angular or spherical grains of silica. It minimizes shrinkage cracks in concrete by filling holes in coarse aggregate. Rapid economic growth, urbanization and prosperity have increased the need for construction activities, as well as the demand for construction raw materials such as cement, sand and aggregate. Building materials such as sand and cement are becoming increasingly expensive. Several industries are considering how to collect waste and by-products as substitutes or alternative sources for concrete preparation. The present study is to collect experimental information on various wastes used as partial sand replacements in concrete, and to assess the viability of concrete production while addressing environmental issues.

LITERATURE REVIEW

In this study glass powder and coconut shell the effects on concrete properties were examined [1]. M25 grade concrete mix was used. 0%, 5%, 10%, and 20% of glass powder and coconut shell are used to replace the fine aggregate. To test the compressive strength of the sample, 15x15x15 cm cubes were used. The effect of adding glass powder and coconut to concrete was tested according to the specification of the Indian standard, and the effect on the workability and strength properties was noted. Before making concrete, the materials used for its preparation were tested. Adding coconut shell to concrete also improves its workability, according to the authors. When the coconut shell was used as aggregate in concrete making, the amount of cement present may be higher than if standard aggregate concrete was used. It has been discovered that glass powder and coconut shell can be used to make building blocks at a lower cost than regular concrete blocks because higher strength is achieved with less mixing.

The paper [2] is about experimental research into the qualities of green concrete made with plastic waste as aggregate. The study done in primarily concerned with the recycling of metal parts in waste and the production of green concrete in order to improve the mechanical properties of green concrete. Green concrete was created by replacing 10%, 20%, and 30% of the waste with 10%, 20%, and 30% coarse aggregate, respectively, with a water-cement ratio of 0.45. The samples of concrete were compared to standard concrete. According to the findings, concrete waste can increase the strength of concrete by up to 20%. As a consequence, it has been determined that the trash may be utilized as a building material alternative. To fulfill the workability grade, all trail mixes must have a water-cement ratio of 0.45, according to IS: 10262:2009. The compressive strength of waste concrete is raised to 18 % when 20 % of the coarse particles are replaced. The reason is that plastic waste has a low adhesive strength.

The use of bagasse ash as a partial substitute for fine aggregates in concrete was investigated in the study [3]. Untreated bagasse ash is primarily substituted in concrete by a volume of fine aggregates in the following proportions: 0%, 10%, 20%, 30%, and 40%. On new concrete, compaction factor and slump cone tests were conducted, as well as compressive, tensile, and sorptivity testing on hardened concrete. In this experiment, Plain Portland cement (grade 53) was utilized. Coarse aggregate was manufactured from crushed stone up to 16mm in size while fine aggregate was made from locally available natural sand up to 4.75mm in size. Fine and coarse aggregates are approved to Indian Standard IS: 3831970 criteria. The following results were found: 1) Compressive strength was higher with 10% replacement of sugarcane bagasse than with 0% sugarcane bagasse replacement. 2) As the percentage of sugar cane babasse ash (SCBA) increases, the compressive strength decreases and the properties of fresh concrete change. 3) Due to the pozzolanic properties of SCBA, the rate at which the strength of the SCBA mixtures increases is faster in the following days. 4) When the tensile strength of concrete was examined, it was found that as the SCBA replacement increased, the tensile strength of mixtures decreased. 5) The sorptivity coefficient increases as the percentage of SCBA increases and decreases as the compressive strength of concrete increases. 6) The fine aggregate percentage, i.e. 10- 20%, may be successfully substituted by untreated bagasse ash without sacrificing processability or strength is studied in. 7) Compared to 7 days, the compressive strength of blends containing 10% and 20% gas ash rises later (28 days), which might be due to the Pozzolanic properties of bagasse. The authors concluded that bagasse ash can be utilised as a concrete element since it is a good alternative for cement and fine aggregates based on these findings.

Experimental study with the use of bottom ash to partially substitute fine particles in cement concrete is discussed in the article [4]. Ash is a by-product of pulverised coal combustion and one of the most common solid wastes created by power plants. The goal of this research was to investigate if clinker might be utilised to replace certain fine aggregate. The efficacy of bottom ash as a partial alternative for fine aggregates to address the disposal problem has been tested. When fine aggregate replaced up to 50% of the bottom ash, the samples were evaluated for compressive strength, tensile strength, and flexural strength. After 7 days and 28 days of curing, the fractional tensile strength of 10% clinker + 90% fine aggregate was increased by 9.4% and 10.5%, respectively, compared with the nominal concrete mix. The use of clinker instead of fine aggregate in concrete gives good flexural strength. The flexural strength of 10% bottom ash concrete improved by 6.92 % and 8.2 % after 7 and 28 days of curing, respectively, as compared to the nominal concrete mix. It has been proven that 10% clinker can be utilised as a fine aggregate alternative in concrete to achieve significant design blending.

The article [5] is a detailed study of the partial substitution of fine aggregates by stone rubble. The main aim of this research is to see whether stone rubble can be used instead of fine aggregates in concrete. Five replacement levels, 5%, 10%, 15% and 20%, were compared to the control mixture. Plain grade 53 Portland cement was used throughout the project. The stones were ground into a coarse powder and used as a fine aggregate in concrete. The concrete mix design was proposed based on the Indian Standard for control concrete (IS 10262: 1982). M20 was the grade used. In concrete, the percentages of sand replaced by stone powder were 5%, 10%, 15% and 20%. The compressive strength of rubble concrete with 5%, 10%, 15% and 20% substitution of fine aggregate was compared to conventional/natural concrete after 7, 14 and 28 days of curing. Compared to the corresponding conventional strength of concrete, the optimal replacement of fine aggregate by crushed stone rubble was achieved with 10% replacement of fine aggregate with crushed stone. The manufactured product was determined as an environmentally friendly concrete because it prevents the stagnation of the rubble of demolished bricks by devouring them. In addition, as the complexity of the mixture design increases, the percentage of cost savings increases.

By using crushed claystone aggregates (CCB) from broken brick pieces, the study also creates lightweight aggregate concrete with acceptable strength [6]. The aggregates have been replaced by CCB in percentages of 10%, 20% and 30%. CCB aggregate was used in all mixtures in the dry state (without prewet). Workability, density, water absorption and compressive strength have all been examined. Here are some of the observations made: 1) It was found that replacing fine or coarse additives with CCB resulted in a decrease in the depreciation. Compared to yellow brick aggregate mixes, red brick aggregate mixes show a greater reduction in sagging. Red brick aggregate consumes more SP due to its high porosity and water absorption. 2) The addition of CCB aggregates to all concrete mixes resulted in a reduction in density. When the fine brick aggregate was used to replace 100 percent of the coarse aggregate in the mixes, a combined effect was found. Compared to substitution of coarse aggregates, substitution of fine aggregates at low to moderate ratios has minimal effects. 3) Due to the dry state of the stone granulates, the water absorption capacity increased. Compared with the yellow brick aggregate, the red brick aggregate has greater water absorption capacity. 4) The inclusion of CCB lowers the concrete's strength. After 28 days, the compressive strength of aggregate concrete was compared to that of ordinary concrete. The compressive strength of concrete was further decreased when red brick material was utilised as fine aggregate. 5) Production of a serviceable, lightweight, compression-resistant CCB aggregate mixture suitable for structural projects may require complete substitution of coarse aggregates.

The use of slag in concrete as a partial replacement for fine aggregates has been the subject of further research [7]. The mechanical characteristics of steel slag concrete as a partial substitute for fine particles in M20 concrete are investigated in the study. After 28 days of curing, the compressive, tensile, and flexural strengths of the concrete were investigated with steel slag replacing 10%, 20%, 30%, 40%, and 50% of the fine particles. The slag testing is carried out in line with Indian regulations. Steel slag, both in the form of fine aggregates, has a minor influence on the process ability. There wasn't much difference between the numbers in terms of density. Conventional concrete had a specific gravity of 2.26. It ranges from 2.25 to 2.28 in the other compositions. Another essential characteristic of fresh concrete is the air content which causes small variations in all mixtures. Another important characteristic of fresh concrete is the air content which causes small variations in all mixtures compared to a standard concrete mixture. The heat released during the hydration process gives a temperature of 24.5 °C for conventional concrete, ranging from 24.0 °C to 24.9 °C for different mixtures. In general, the incorporation of steel slag in either form had no significant effect on the properties of fresh concrete. The compressive strength of fine aggregate was determined to be optimal at 30% slag replacement; however, when the slag replacement is more than 30%, the compressive strength decreases. Partial replacement of natural aggregates by steel slag aggregates leads to an increase in the compressive, tensile and bending strength, as well as the modulus of elasticity, to the optimum replacement value. In addition, the author also discovered the following advantages: 1) Cost reduction 2) Social benefits and 3) The amount of waste in construction can be utilized by using steel slag as an alternative material of fine aggregate in the concrete.

The experimental investigation of high-performance concrete with partial substitution of fine aggregates by demolition debris is discussed in paper [8]. Construction, remodelling, repair, and destruction of houses, big structures, and other structures create demolition debris. According to the study's findings, substituting fine aggregate with discarded trash enhanced compressive strength by 5.5 %, flexural strength by 6.25 %, and flexural strength by 9 %. All samples were cast with ordinary Portland cement (grade 53) and single density cement. Sand passed through a 4.75 mm IS sieve and recommended by IS: 3831970 were used as fine aggregate for all samples. All samples were taken and used according to IS: 3831970, coarse aggregates passing through a 20 mm sieve and remaining on a 12.5 mm sieve. In accordance with IS 456:2000, drinking water was used for casting and curing the samples. The authors observed the fineness and high water absorption properties of construction and demolition waste (C&D). Concrete's workability deteriorates as the percentage of C&D waste used to replace it rises. After some time, the strength properties of concrete mixes containing up to 20% C and D waste were relatively close to the strength value of crushed concrete (CC). Compared to CC, concrete mixes from construction and demolition waste and recovery of construction and demolition waste of 20% and 30% showed a decrease in compressive strength of only 2.03% and 5.7%, respectively, at 28 days of age. Also, the addition of C&D waste reduced water absorption, voids and porosity compared to CC.

The article [9] examined an experimental study of jute fiber with an optimal replacement of natural sand by artificial sand. The construction industry consumes a large amount of concrete all over the world. In India, traditional concrete is made with natural sand, cement, coarse aggregates and water. Concrete would be effective if it provides the required strength, and fibers such as jute are used to increase strength. Therefore, jute fiber was used in concrete in the study due to its high performance, environmental friendliness, high availability and low cost. It was replaced by 3%, 4% and 5% of the total cement volume, respectively. M30 concrete was prepared. The additional cementing materials were replaced by jute fiber at a ratio of about 3%, 4% and 5% by cement. Initial set time, final set time, strength and tightness tests were all performed on the cement. The study was conducted with natural black sand that was readily available in the area. Compression, split and flexural strength tests were performed. It has been found that as the percentage of fibers in concrete increases, so does the strength of concrete. The strength of concrete cubes with 5% replacement initially showed no long-term durability, but after 28 days it steadily increased and reached the acceptable limit.

A study on concrete with waste marble powder as a partial sand replacement was done in paper [10]. A typical byproduct of marble processing is marble waste (marble saw powder, marble slurry, or marble slurry). The major goal of the study was to explore if left over marble powder could be utilised in concrete as a partial substitute for fine aggregates. Since this concrete was prepared with marble powder as a partial substitute for fine aggregates (sand) in four different proportions, namely 10%, 20%, 30%, and 40%, it was evaluated for 7 days, 28 days, and 90 days of curing. The compressive strength of conventional concrete Portland cement pozzolan (ACC) with a specific gravity of 3.10 was compared in this study. To partially replace the fine particles in the concrete, marble powder with a density of 2.58 was utilised. The coarse aggregate had a density of 3.0 and was retained on a 10 mm screen after passing through a 20 mm filter. Excellent grade river sand with a fineness modulus of 2.72 and a density of 2.64 was used as fine aggregate, according to IS: 383-1970 Zone II. The strength characteristics of concrete with and without waste marble powder as fine aggregate, which was used in varying percentages to substitute sand, were determined through a series of concrete experiments. The authors arrived to the following conclusions: the compressive strength of concrete improved when the percentage of waste marble powder was increased to 20%; but, when the percentage of waste marble powder was increased further, the compressive strength of concrete dropped.

The paper [11] discusses the use of copper slag in concrete as a partial substitute for fine particles. Because it keeps its original characteristics, copper slag is a good by-product or waste. Because of its chemical makeup, which contains significant levels of iron, silica, and alumina, it may be used as a partial sand substitute. The concrete mix design was made by weight, using different percentages of copper slag (10%, 15%, 20%, 25%, 30% and 35%) instead of sand, and concrete mixes were prepared as a result. Then the cube, beam and cylinder samples were fabricated, demolded and well cured after 24 hours. At 7, 14 and 28 days after curing, the samples were subjected to compression, cleavage tensile and bending tests. With a density of 3.15, OPC 53 grade cement was used. A density of 2.65 was used with coarse aggregates of crushed granite over 12.5 mm and 20 mm. The sand from Zone III, with a density of 2.57, was used as a fine aggregate. The compressive strength of the samples was found to be greater than that of the control sample when 10-30% copper slag was added, but when the amount of copper slag was increased, the compressive strength decreased. For example, a 10% increase brought more power than the 30th edition. There was a delay in the curing of the concrete specimens. The specimens' dead weight increased by roughly 15 metres. The copper slag has been replaced. The authors made the following comments: 1) Copper slag is an excellent additive that can be used to replace up to 30% fine aggregate. However, more research was needed in the field of sustainability. 2) Adding copper slag to the concrete sample improved its own weight by up to 18%. 3) Although the resistance of the control sample is higher than that of the test sample, the replacement cost of copper slag is lower. 4) A delay in the curing step was noted in the test sample. Based on all these considerations, the author proposes to use copper slag as a mineral adjuvant. Based on these considerations, the author proposes to use copper slag as a mineral adjuvant in combination with an appropriate chemical adjuvant to control the movement of water.

The paper [12] discusses the effect of rock dust as a substitute for fine aggregates in concrete on the compressive strength. Due to the inaccessibility of the river all year round, good quality natural sand is becoming increasingly scarce and expensive. Stone dust is a sand-free alternative that can be used in construction as a partial replacement of sand. Therefore, research is currently underway to determine the acceptability and potential use of rock dust as a fine aggregate in concrete mixes. The results demonstrate that natural sand can be successfully replaced with rock dust based on compressive strength, with a maximum resistance of 60% to replace natural sand with rock dust. They utilised IS 1489 (part 1) 199 Portland Pozzolana cement (fly ash based), IS 3831997 river sand, and zone II sand. Coarse aggregates with diameters of 10 mm and 20 mm were utilised in proportions of 40% and 60% for the 10 mm and 20 mm, respectively. Rock dust with a gray tint is obtained from nearby rock crushing plants. M25 concrete was used as a reference point, which was designed according to IS guidelines. The proportions of the material were 1:1.54:3, with a water-cement ratio of 0.42 and a dose of super plasticizer 0.65% by weight of cement. 84 units of 150x150x150 mm were casted for the study.

Each percentage of replacement was represented by six cubes, three for seven days and three for 28 days. The concrete's compressive strength was evaluated for 7 and 28 days using pressure test equipment. The sample with replacement had a compressive strength that was higher than predicted for regular concrete. This illustrates the use of rock dust in concrete as a partial or total substitute for fine particles in terms of compressive strength. Environmental considerations, a shortage of excellent quality fine aggregate, and resistance criteria all benefit from using dust as fine aggregate in concrete. 2) The compressive strength of cubes using rock dust as a fine aggregate substitute achieves its highest value when 60 % of natural sand is replaced with rock dust. 3) It should only be used in circumstances where the curing time is not important, since too much superplasticizer would lengthen the cure period.

The use of construction and demolition waste as a replacement for fine aggregates in concrete is investigated in [13]. Concrete is one of the most widely used building materials on earth. The authors examined the use of construction and demolition waste to replace fine aggregates in M20 concrete. As a control, 100:0% of the sand was replaced with recycled fine aggregate, followed by 80:20%, 50:50%, 20:80% and 0:100%. Plain grade 53 Portland cement was used in the study. The aggregates were collected from a nearby crusher. The maximum aggregate size ranged from 26 to 12.5 mm recycled fine aggregate. The results of studies on compressive strength, tensile strength, water absorption and evaporation of different types of recycled fine aggregate concrete were compared with the results of the control concrete. The authors investigated other strength and transport properties for mixtures of substituted additives with construction waste and came to the following conclusions. 1) The percentage of fine particles in recycled fine aggregate (RFA) was higher than that in natural sand. 2) As the particles got bigger, the water absorption also increased. RFA was absorbed at a rate of 4%. 3) The compressive strength is increased to some extent, up to a certain percentage of the replacement value. 4) The recycled fine aggregate had properties quite similar to natural aggregates. 5) The tensile strength of concrete increased slightly when the thin material was replaced. 6) Recycling offers many benefits to both the environment and humanity. As a result, construction and demolition waste can be used to replace fine aggregates in concrete.

As conclusion, the construction activity is growing every day and as a result the market for concrete materials is also growing. The only source of fine aggregate is natural river sand, which poses a serious environmental risk. Excessive disposal of industrial and other waste, on the other hand, causes disposal problems and affects the ecosystem. River sand (natural resource) should be used as little as possible to avoid negative impact on the environment, and reuse of other materials or production waste in concrete will contribute to a pollution-free environment. After studying many research paper, it is clear that more research is needed on the use of locally available waste or the production of by-products in concrete, as well as a review of its final mechanical, physical and reliability characteristics. The main objective of this study is to develop a cost-effective concrete that respects the environment while keeping in mind the desired qualities.

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