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A Review on the Application of Recycled Aggregates in Concrete Technology

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Abstract

In the construction industry concrete is the most widely used material. It consumes natural resources like aggregate and water. The cost of cement production is high. The present paper discusses development of better concrete using different types of raw materials, e.g. stone slurry, fly ash, marble dust, silica, sugarcane ash, rice husk ash, bottom ash, silica fume etc., which are regarded as waste material. This paper reviews the use of above supplementary cementatious materials and recycled aggregate by various research scholars. Because of use of supplementary materials, waste generated from different industries such as slag can be efficiently used in concrete.

Keywords: Stone Slurry; Recycled Aggregate; Cement; Compressive Strength; Flexural

1. Introduction

In the construction industry concrete is the most broadly used material, which consumes natural recourses like aggregate and water. Production cost of cement is high and causes high secretion of CO2 [Ramachandran V. S.]. Excess quantity of CO2 damage the natural climatic condition. In order to make concrete more eco-friendly, cement has been replaced by some raw materials like stone slurry, fly ash, marble dust, silica sugarcane ash, rice husk ash, bottom ash, silica fume, granite dust, etc.

Recycled aggregate formed from harden concrete is one of the unused material that can replace the coarse aggregate. Recycled aggregate can be formed by crushing demolished concrete. Its cost is very less and is available without much difficulty. Recycled aggregate can be produced by crushing concrete, and asphalt, to reclaim the aggregate.

2. Literature Review

Aliabdo et al. (2014) experimentally investigated the effect of stone slurry on properties of concrete by replacing sand with stone slurry from 0.0% to 15% at an interval of .25% by weight and result showed that compressive strength varying from 3.8% to 10.5% at 7 days of age, and from 6.8% to 8.8% at 28 days of age, when compared with control mix. No effect was reported on setting time, soundness. Maximum compressive strength was observed at 10% replacement of cement by stone slurry (SS). It was also reported by the author that 5% replacement of SS in place of cement showed better strength properties. All the sample showed the lesser water absorption ratio ranged from 3.77% to 6.46 % than the specific range of 8% to 10%, because of the fineness of stone slurry.

Celik et al. (2014) experimentally investigated the effect of natural waste, like high volume natural volcanic pozzolana ash and lime stone powder. 50% sand was replaced by finely ground natural volcanic pozzolana ash with or without lime stone powder. The mechanical properties of concrete increased up to 50% replacement. 5% replacement of high volume natural volcanic pozzolana ash decreased 6.5% w/c ratio compared to the control mix. For 10% & 20% replacement of sand with volcanic pozzolana ash & lime stone powder decreased w/c ratio up to 9.5%, and 10% respectively.

Lakhani et al. (2014) experimentally studied the effect of stone waste as a mixture in pozzolana or non pozzolana material on self-compacting concrete (SCC). It was observed by the author that 20 % replacement of cement by marble powder (MP) without fly ash improved mechanical behaviour of cement. It was also reported that an aggregate of lime stone, marble and granite stone waste showed less compressive strength of mixture as compared to natural aggregate. Use of filler material reported 21% higher compressive strength than ordinary concrete. SCC mixes with 20% MP as a replacement of cement content give higher values of concrete compressive strength than those with 30% MP by about 12% and 10% for 550 kg/m3 and 450 kg/m3 cement content respectively.

Torkaman et al. (2014) experimentally studied the effect of replacement of cement by wood waste, rice husk ash and lime stone powder on light weight concrete. Replacement of cement by wood fibre decrease the compressive strength. W/C ratio also increased with increase in wood fibre and decreased with rice husk ash and lime stone powder. Replacement of cement by 25% wood fibre & lime stone powder resulted in 30% lighter concrete block comparison to normal concrete block. It was reported by the authors that replacement of cement with lime stone powder higher compressive strength was obtained in comparison to replacement with wood fibre and rice husk ash.

Bacarji et al. (2013) experimentally studied the effect of marble dust and granite powder as filler of concrete. It was reported that replacement of cement by granite powder and marble dust, the flexural strength and compressive strength was reduced. It was also reported that the workability and strength properties of different concrete mix proportion improved by 5% replacement of cement with marble dust and granite powder. Using 5 % replacement of sand with granite powder produced 10% to 11% compressive strength growth in all ages. The highest increment in compressive strength was reported 13% at 7 days curing. The increment in compressive strength slightly decreased by 9% at 28 days & 7% at 90 days of curing.

Balamurugan and Perumal (2013) experimentally studied the behaviour of concrete with stone dust as sand substitution. It was reported that use of stone dust up to 50% as sand replacement showed the higher mechanical properties of concrete. The compressive and flexural strength were increased by 19.18% and 17.8% respectively by 50% replacement of sand with stone dust. Maximum increase in tensile strength was 21.43% up to 50% replacement of sand by stone dust. The slump value was recorded lesser with sand replacement as compared to reference concrete. The workability (values of slump) for all mixes were fluctuating from
60-100mm.

Charkha (2013) experimentally studied the effect of quarry dust and fly ash for the production of conventional concrete. The workability reduced by replacement of sand due to having rough surface area and angular shape of quarry dust. It was reported that hardened properties of concrete improved at 30% replacement of sand and 10%replacement of cement by quarry dust &

fly ash respectively. The compressive strength and flexural strength were increased up to 10% with replacement of cement by fly ash and decreased up to 10 % replacement of sand by quarry dust. It was also investigated that 50% addition of quarry dust without fly ash as sand replacement improves the mechanical properties of concrete.

Devi (2013) experimentally investigated the effect of blended quarry dust on properties of concrete. Replacement of cement with 3% polypropylene by weight of cement increased flexural strength up to 42%. Use of polypropylene fibres prevented the cracks. Water absorption also reduced by use of blended quarry dust. When substituting all the sand with blended quarry dust, compressive strength showed 12% higher at 7 days & 14 % higher at 28 days in compare of ordinary concrete. The split tensile strength was increased by using blended quarry dust and it was reported 21% greater than the control mix at 28 days.

Krishnamoorthi and Kumar (2013) experimentally studied the workability and harden properties of concrete with quarry dust as sand replacement and fly ash as cement replacement. The sand was replaced by 10% to 20% quarry dust in an interval of 5% and cement was also replaced by same amount by weight. Silica fume was also used with quarry dust and fly ash in the range of 5 to 15% as an additive. 12% replacement of cement by fly ash with silica fume improved 14.56 % compressive strength in 7 days of curing. Workability decreased 19% by replacement of fine aggregate with quarry dust in comparison of reference concrete. The compressive strength reduced in comparison to ordinary concrete. It was reported that no effect was observed on flexural strength & split tensile strength of concrete in comparison to reference concrete. Max compressive strength obtained at 15% replacement of sand by quarry dust 40.5 MPa compared to control mix at 28 days of curing.

Suaiam and Makul (2013) experimentally investigated the effect of rice husk ash on self-compacting concrete with lime-stone powder. In SCC rice husk ash and fly ash reduced the w/c ratio up to 28 %. Workability of the concrete also increased due to high volume of rice husk ash replaced as fine aggregate. The mechanical properties of concrete showed better performance in early days due to reaction of pozzolana material. 5% replacement of cement by limestone powder caused minor decrease in the compressive strength about 6% to 10%. Exceeding 5% of cement replacement by lime-stone powder caused higher decrement in the compressive strength compared with the ordinary concrete. 15% replacement of cement by lime-stone powder reported 32% decrement in compressive strength as compared to control mix.

Vijaylakshmi et al. (2013) experimentally studied the mechanical properties and durability of concrete using waste product released from granite industry. Fine aggregate was replaced by granite waste in the ratio of 5%, 10%, 15% and 20% by weight of sand. The compressive strength indicated higher result up to 15% replacement of fine aggregate. The split tensile strength and flexural strength reported 18% & 21% lesser value as compared to control mix. Replacement of sand by granite waste reported the lesser corrosion effect and lesser water permeability on concrete. The compressive strength increased by 11% at age 28 days when replacing 17.5% of sand with granite waste. The authors also investigated that using waste product released from granite industry above 15 %, the compressive strength was decreased.

Dehwah (2012) experimentally investigated the effect of quarry dust, silica fume and fly ash on properties of concrete, these cementation material improved the flow ability of fresh concrete and increased the hardened properties. 8% to 10% replacement of cement by quarry dust showed the higher compressive strength (71 MPa). The w/c ratio was fixed as 0.38. It was reported that quarry dust showed better result with silica fume as compared to fly ash individually because the quarry dust replaced all the micro pores more as compared to fly ash or silica. The compressive strength is increased by 1.64%, & 3.92% with replacement of cement by 8% silica fume & 8% quarry dust at 7 and 28 days respectively.

Gesoglu et al. (2012) experimentally studied the effect of marble dust on the mechanical and soft properties of self-compacting concrete. The quantity of super plasticizer was reduced 20% by using fly ash. Fly ash indicated the viscous phenomena. It was reported that the maximum compressive strength (36MPa) at 28 days was achieved with 6% replacement of cement by lime - stone powder. The split tensile strength reduced by 35% as compared to ordinary concrete. Maximum compressive strength (71 MPa) was obtained by adding of both fly ash and lime-stone powder. The compressive strength with 10% substitution of cement by marble dust for 7 days cement mortar was showed 17%, lower than the strength of control cement. The replacement of marble dust in the cement increases the specific gravity & decrease specific surface.

Al-Akhras et al. (2010) experimentally studied the effect of brunt stone slurry (BSS) on strength and durability properties of concrete. It was reported that 28 days compressive strength of mortar with 10% replacement of cement by BSS was higher than control mix. Fine aggregate was replaced by brunt stone slurry in the ratio of 5%, 10%, & 15% by weight cement. It was reported that compressive strength was increased with increases in BSS content. BSS Mortar showed 21% higher compressive strength than conventional mortar. The tensile strength increased by 17% with replacement of sand by 15% lime waste and marble powder by weight at 28 days of curing.

Almeida et al. (2007) experimentally studied the effect of recycled stone slurry on properties of concrete. Maximum compressive strength was obtained at 5 % replacement of cement by stone slurry. It was also reported that the durability of concrete showed better result at 5 % replacement. The fresh properties of concrete showed better result up to 16 % substitution of cement by stone slurry. Fully replacement of SS showed 72% higher water absorption and 59% higher vol. of voids as compared to control mix. 5% replacement of cement by SS showed 6.2% higher performance of modulus of elasticity than reference concrete. All mix containing less than 20% of stone slurry showed minor improvement in modulus of elasticity (2.2%). In the exciting case of 100 % replacement the average of test results for the modulus of elasticity was 26.7 GPa and it was 28.1% less than the ordinary concrete.

Zhu and Gibbs (2005) experimentally investigated the behaviour of self-compacting concrete (SCC) with partial replacement of cement with chalk powder and lime stone powder. Super plasticizer was also used to improve the workability. Lime stone powder showed higher workability as compared to chalk powder at same quantity of super plasticizer. Maximum compressive strength obtained at 7 days and at 28 days was 60 % to 80 % higher and 30% to 40% higher respectively than the conventional concrete. The maximum 28 days split tensile strength was achieved by17 to 20% higher with 25% replacement of sand by chalk powder and lime stone powder.

3. Conclusions

In the present paper, work done by various research scholars has been reported. It has been observed from the above review that cement can be replaced up to 20% by SS for satisfactory performance. Rice husk ash reduces the w/c ratio and sand replacement by SS improve the workability of concrete. 21 % replacement of cement by BSS content increases the mortar strength. Use of lime stone powder increases the compressive strength up to 30% to 40%.

Replacement of sand by granite dust improves compressive strength up to 14%.

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