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Partial Replacement of Cement by Brick Dust: A Review

Sashank Bikram Rana[1], Shamshad Alam[2]
[1,2]*Department of Civil Engineering, Sharda University*

Abstract – ***Due to the increase in construction activity, the demand of cementing material is increased. In 2010 based on survey of world coal association, over 3.3 billion tons of cement was used. However, the increase in production of the cement causes the environment problem due to emission CO_2. In order to control the environmental impact, it is necessary to partially replace the cement material by other cementing material. Several researchers are working on the partial replacement of cement by other cementing materials in cement mortar. This review is presenting the previous research on the partial replacement of cement by different cementing materials. On the other, huge amount of broken bricks are wasted during construction activities. Several investigations are made regarding partial replacement of cement and/or sand by these bricks in concrete and mortar. The objective of this study is to analyse the effect of brick powder in cement in concrete and mortar. This paper presents a review and the comparison of the results presented by the earlier researchers. It was observed that the replacement of cement by up to 10% of the brick dust gives better result as compared to higher percentage. However, further study to justify the strength gain is required as the brick duct was found to have lower percentage of CaO. But the percentage of SiO_2 and Al_2O_3 was found higher in brick dust as compared to cement.***

Keywords— Brick powder, partial replacement of cement, compressive strength

I. INTRODUCTION

A partial replacement of cement by waste materials; fly ash, silica fume, and blast furnace slag in concrete/mortar would help in overcoming the environmental problem due to the production of cement. On the other hand, several by-products contain pozzolanic material which can be used as cementing materials. Also, the construction waste can be used in place of aggregate as it contains the coarse aggregates. This would also lead additional benefits in terms of reduction on cost, energy savings, promoting ecological balance and conservation of natural resources. The continuing search for partial replacement of cement has led the researchers to investigate the utilization of waste fired brick as a pozzolan for mortar and concrete. The environmental aspects of cement are a growing concern, as cement manufacturing is responsible for about 7% of total worldwide emissions from industrial sources. One of the effective ways to reduce the environmental impact is to use mineral additions, as a partial cement replacement. This strategy will have the potential to reduce costs, conserve energy, and waste minimization. Mineral admixtures such as granulated blast furnace slag, fly ash, silica fume and natural and artificial pozzolans are silica based pozzolanic materials so they can partially replace clinker. The use of mineral admixtures improves the compressive strength and permeability of the mortars and concretes with time, because the total porosity decreases with increasing hydration time. An increasing interest in the pozzolanic admixture of clays with calcium hydrate has been shown recently by researchers dealing with the production of new hydraulic materials for the masonry industry.

II. LITERATURE REVIEW

Raj et al. (2018) studied the strength characteristic of concreate prepared by partial replacement (5%, 10%, 15%, and 20%) of cement by brick powder [1]. The test was conducted on the M40 grade of concrete and the result was presented in term f compressive strength and split tensile strength. An increase in the compressive strength was observed up to the replacement level of 10%, however, further increase in brick dust causes in the decrease in strength irrespective of the curing period. However, the tensile strength was observed to increase till 15% replacement.

Khan et al. (2018) studied the strength and workability characteristic of concrete prepared using the brick duct [2]. The cement was replaced by 5%, 10%, 15%, and 20%brick dust and the result is presented in term of strength and workability. Addition of the brick dust was found to increase the workability of the concrete till 15%, however, further increase in brick duct causes the decrease in workability. The split tensile strength was found to achieve maximum value at 15% replacement.

Rani et al. (2016) studied the possible use of crushed brick in the cement concreter. In this study, the sand was partially replaced by 15%, 20% and 25% of crushed bricks [3]. The results is presented in term compressive, flexural and splitting tensile strengths and compared with the controlled sample. The concrete was prepared in the ratio of 1:1.16:3.15 with water-cement ratio of 0.5. The 28 days compressive strength was observed to increase up to replacement of 20%, however, higher percentage caused decrease in strength. Similar pattern was also observed in the tensile and flexural strength. It was concluded that the 20% replacement of the cement by crushed brick is the optimum; however, further study is required in this regard to gain confidence in replacement.

Abbas et al. (2017) studied the effect of brick, glass and, tile waste as partial replacement of cement [4]. The cement was replaced by the waste up to 30%. Result showed that the 10% replacement of cement by either brick or glass increases the strength up to 2% after 90 days of curing. However the increase in 28 days strength was observed higher (4.7%) as compared to 90 days. Replacement of cement by tiles powder showed a reduction in strength irrespective of the replacement percentage and the curing periods. The chemical studies show that the SiO_2 is the major constituent in brick (70.6%), glass (72.8%), and tiles powder (40.5%) which is higher than that of cement (20.2%). However, the CaO content in cement (62%) is much higher that of brick (6.57%), glass (10%), and tiles powder (21.64%).

Divakar et al. (2012) studied the effect of partial replacement of fine aggregate with granite in concrete [5]. The fines was replaced with 5%, 15%, 25%, 35% and 50% and the results was presented in term of compressive strength, flexural strength, and split tensile strength. The compressive strength was observed to increase by 22% with an optimum dose of granite powder (35%). However, further increase in granite powder causes a decrease in compressive strength. The tensile strength was observed to be unaffected at higher percentage (25%, 35%, and 50%) of granite powder, however, at lower percentage, tensile strength decreased by 2.45 and 8% at the granite powder percentage of 5 and 15 respectively. The flexural strength was observed to increase by about 5% for any percentage of granite powder up to 50%, however, further increase may result in different result.

Demir et al. (2011) studied the sulphate resistance of the mortar prepared by partial replacement of cement by ground waste brick [6]. The cement was partially replaced by 2.5%, 5%, 7.5%, 10%, 12.5%, and 15% crushed brick. The mortar samples were cured for 7, 28, 90, and 180 days in different curing condition such as; continuous curing in lime-saturated tab water, continuous exposure to 5% sodium sulphate solution, and continuous exposure to 5% ammonium nitrate solution. The results were presented in term of expansiveness and compressive strength. The replacement of cement by crushed brick up to 10% was found effective in controlling the expensiveness. However, 10% crushed brick was suggested as optimum with highest compressive strength compare to other percentage due to formation of C-S-H gel. Also a difference in the SiO_2, Al_2O_3, and CaO was observed between the ordinary Portland cement (OPC) and the crushed bricks. The OPC contain higher percentage of CaO (62.11%) compared to crushed bricks (4.30%). On contrast, the crushed brick contain higher percentage of SiO_2 (58.65%) and Al_2O_3 (24.30%) as compared to the percentage in OPC (SiO_2 = 21.01% and Al_2O_3 = 5.39%). The higher strength after the replacement of OPC by 10% crushed brick may be due to the higher percentage of SiO_2 and Al_2O_3, however, further study is needed in this regard.

Mahzuz et al. (2011) investigated the possibilities of partial replacement of natural sand by stone powder [7]. Mortar with natural sand and with tone powder was prepared in three different ratios (1:2.75, 1:3, and 1:3.5) and the compressive strength after 3, 7, and 28 days was studied. An increase in compressive strength by 24.98% was observed after 28 days for the proportion of 1:2.75. However, for the proportion of 1:3, the increase in strength after 28 days was observed as 18.2%. Similarly, the strength was observed to increase by 20.52% after 28 days for the 1:3.5 ratios. Similar observation was also made in the concreter prepared by partial replacement of cement by stone dust. In over all, the stone powder was found more effective as compared to natural sand.

Naceri et al. (2009) made an investigation on the possible replacement of cement by brick dust in mortar [8]. The cement was replaced by 5%, 10%, 15%, and 20% of brick dust. The result was presented in term of flexural and compressive strength. The mechanical strength was observed to increase for 10% replacement of cement by brick dust. The increase in strength was discussed in term of SEM and XRD.

Bazaz et al. (2006) studied the performance of concrete produced with crushed bricks as fine aggregate in concrete [9]. The result is presented in term of compressive strength, porosity, water absorption, soundness, freezing-thawing, and degradation of the concrete developed using the crushed bricks. The result shows that an increase in crushed brick percentage causes the loose of compressive strength. However, the strength was observed to increase with the number of curing days. The study also compared the gain in strength du to replacement of crushed granite with crushed fine bricks. The crushed granite was found more effective compared to crushed bricks. In overall, it was observed that the quality of bricks is very low compared to natural rocks.

III. CONCLUSIONS

Based on the study, it can be recommended that partial replacement of cement can be done with brick dust. The cost of cement can be reduced drastically in large scale. A small step for better environment can be achieved since pollution is decreased from the cement industries. The strength of mortar is higher while replacing 10% of cement compared with convention cement mortar.

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