USE OF QUARRY WASTE AS BUILDING MATERIAL: A REVIEW

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Abstract: Quarry activity is a highly unsustainable process as it produces land, water, air and noise pollution. It adverselyaffect the ecology of surrounding areas and generating tons of waste. It has been estimated that of entire quarrying process, about 30% to 40% of quarry product is unfit for commercial use and is discarded as waste. This waste is either thefilled back in quarry pit or disposed of in landfill which has its own drawbacks. Various research has been conducted which show that this waste has potential to be used as construction and building material like cement, concrete, bricks,etc. This paper provides a review of such recent studies conducted around the world and gives a general overview of the potential areas where this quarry waste can be used as partial, to full replacement of conventional materials.

Keywords: Quarry Waste, Sustainable Development, Construction Material, Building Material, Recycled Waste.

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I. INTRODUCTION

A quarry is excavation site from where minerals like rocks, dimensional stones,and other non-metallic minerals are excavated to be used for commercial purposes(DeDrace, 1974). Activities like drilling, blasting, and cutting is used for extraction of this non-metallic mineral. These operations produce alot of waste in the form of dust, boulders and rock chips(Dolley, 2016). The waste generated is either filled back in quarry site or is disposed of in the landfill. These processes are highly unsustainable and possess health hazard. Waste filled back in quarry site occupies a considerable part of mining space and hinder further quarry process which in turn hamper the overall profit. Apart from this, it also risks health and safety of quarry workers. They are exposed to airborne dust which, on prolonged exposure create respiratory diseases. Also, an unconsolidated waste poses a risk of falling during further quarry operation. Hence the use of this disposal method is generally not preferred by quarry owners(Mehta and Mehta, 2015). The other way of disposal,i.e., dumping the waste on landfill site has its own drawbacks. With constant disposalmassive pile of waste leads to gradual deterioration of land and result in negative visual impact. It also gives rise to possibilities of slope erosion, landslide,and risk of acuteenvironmental degradation(Saxena et al., 2014). Fine particles get carried with theprevailing wind and get deposited in nearby vegetation which leads to destroying flora and fauna. It can contaminate surrounding water sources by infiltrating groundwater or get mixes with adjacent water source. Increased accumulation of quarry waste also leads to thehealth problem of workers and local communities of the area(Geological Survey of India, 2007). Studies and survey conducted by various government institutions and NGO's are available where thederogatory effect of this mismanaged waste lead to migration of native species, affectingbehavior and health of indigenous fauna and emergence of various respiratory diseases among people locals working and living in the area(Lahiri-Dutt, 2015). With time, there has been a surge in quarrying and processing of the stone (Ministry of Mines, 2015), and with it, the quantity of waste disposed of has also increased at an exponential rate(Gautam et al., 2017). To manage the waste disposal, government organization around the world have taken several steps but have failed to provide a concrete solution(Rajasthan State Pollution Control Board, 2011, Wang, 2014, Black, 1996), thereason being theabsence of a practical solution for already accumulated waste.

Several studies have been conducted which established the fact that the quarry waste has the potential to be reused as construction and building material. Few of which have been mentioned in section below.

II. USE OF QUARRY WASTE IN CEMENT AND CONCRETE

(Torkaman et al., 2014)used limestone powder waste, rice husk ash,and wood fiber waste as acement replacement in lightweight concrete. Each waste was added in replacement ration of 25% to cement and was tested for physical, mechanical and durability properties. The test result showed that among the mixed waste materials, the best compressive strength was observed with theaddition of limestone quarry waste. It was also noted that using limestone quarry

waste as replacement of cement reduced the bulk density of mix and produced acomparably lighter block. A similar study was conducted by (Aliabdo et al., 2014) used marble quarry waste in theproduction of cement and concrete. Marble dust was added to cement in ratio of 5%, 7.5%, 10% and 15% as cement replacement with 0.5 and 0.4 water-cement ratio. To study the effect of marble dust in concrete mix, it was used as areplacementfor cement, and sand. Samples were subjected to physical property test, compressive strength test, split tensile strength test, steel-concrete bond test, ultrasonic pulse velocity and porosity, followed by amicro-study using scanning electron microscope. Based on the experimental investigation it was established that inclusion of marble dust as replacement of cement had no major influence in initial setting time and final setting time of cement and has no noticeable role in hydration process as well. However, thecompressive strength of cement increased with theinclusion of marble dust in cement. For concrete, use of marble dust up to 15% as cement replacement gave comparable compressive strength values to control mix. The compressive strength increased with theinclusion of marble dust as asand replacement up to 15% of sand by weight. The study also reported that use of marble dust as asand replacement is more effective with thelower water-cement ratio. Improvement in tensile strength, better steel-concrete bond strength was also recorded with inclusion of marble dust in the mix. Overall the study concluded use of marble dust as replacement of sand in concrete has asignificant effect on mechanical properties of concrete compared with cement replacement.(Ilangovana et al., 2008)evaluated possibility of using quarry rock dust as full replacement of conventional fine aggregate in concrete. In this study, specimen werecasted for three grade of concrete,i.e. M20, M30 and M40. Each specimen was tested for consistency, shrinkage compaction factor, permeability, compressive strength, and durability properties. The test result showed that inclusion of quarry dust gave greater shrinkage values, higher water absorption as compared to control mix.Permeability of mixwas reduced,and compressive strength and durability properties were observed to improve with theinclusion of quarry dust in each mix. Overall the study concluded that use of quarry dust as afine aggregate is possible in concrete. Use of granite quarry waste as replacement of river sand was evaluated by (Singh et al., 2016). In this study, granite quarry waste was used as partial replacement of river sand at substitution percentage of 10%, 25%, 40%, 55% and 70% at water-cement ratio of 0.30, 0.35 and 0.40. The concrete mixes were tested strength, durability, abrasive resistance, permeability, water absorption, carbonation,and corrosion. Inclusion of waste gave reduced workability, improved compressive strength and better abrasion resistance than control mix design. However, no difference was observed in flexure properties of the mixes. It was observed that at 55% replacement, granite waste reduced water permeability and water absorption of mixes, which improved its resistance to chemical attacks like chloride, sulphates,and alkalis. Overall the study concluded that use of granite waste as 25-40% replacement of riversand had positive influence on strength and durability properties of mixes. Use of polished granite quarry waste was also utilized by (Sharma et al., 2017). In this study, M30 grade concrete with water cement ratio of 0.38, 0.4 and 0.42 was designed. In each design mix, polished granite waste replaced conventional 20mm size aggregates at aninterval of 10% till 40% replacement level,i.e., 10%, 20%, 30%,and 40% replacement level. This study also used superplasticizer to achieve thedesired workability. The mixes were evaluated on the basis of change in compressive strength, flexure strength, resistance to abrasion and pull off strength. The test resultwasin align withprevious studies, and it was observed that a proportion of waste increased, compressive strength, flexure strength reduced which was attributed to weak bonding between aggregate waste and cement paste. Use of granite coarse aggregates reduced theporosity of concrete which in turn provided better packing and reduced water penetration. Similarly, (Medina et al., 2017) used granite quarry waste to design new blend of cement in which 10-20% of clinker was replaced by granite sludge. The mix produced were then evaluated for change in chemical, rheological, mechanical and microstructural properties. The test result showed that cement containing 10% and 20% granite had chloride content less than 0.1% and sulphates content less than 4% by weight and desired volume stability requirements hence meeting the code standards. It was also noticed that with theinclusion of 10% and 20% granite quarry waste, the initial setting time was reduced by 28% and 19% respectively. The strength obtained was found to decrease with increase of waste in mixes, however,fulfilled minimum. The overall conclusion from the study was that the use of granite to design low clinker cement is possible and its practice would lower the extraction of raw material and reduce the risk to human health posed by thedumping of granite quarry waste.

III. USE OF QUARRY WASTE IN BRICKS

(Shakir et al., 2013) use quarry dust for construction of clay bricks. For this study, three wastei.e., fly ash, quarry dust,and billet scale was used for theconstruction of clay bricks. The cement and quarry dust was first dry mixed for 2 minutes and then billet scale and fly ash were added in various proportion, after which water was added. Each mixture was tested for consistency first using flow consistency test. Depending upon test result water quantity was adjusted. After which samples were prepared and

tested for density. Test samples of dimensions 200x90x60 cmwereprepared and tested for hardness test, durability test, and compressive strength test. IRS test was used to estimate the amount of water absorbed by brick when contacted with mortar. The compressive strength of brick increased with increase in combined proportion of quarry dust and billet scale in mix design. The study concluded that the use of quarry dust as aconstruction material for bricks is feasible as should be adopted to conserve natural resources. Study on thesimilar ground was also conducted by (Bilgin et al., 2012), where, theeffect of marble waste in properties of clay brick was evaluated. The waste was added upto 80% by weight of clay and test was evaluated for physicomechanical properties at three different temperature of 900°C, 1000°C and 1100°C. The study concluded that addition of marble waste beyond 10% increased hardness characteristics, flexure characteristics and water absorption characteristics of the mixes at every temperature. (Sutcu et al., 2015) studied the effect of marble quarry waste on physical, mechanical and durability properties of fire clay bricks. The waste was added as 5%, 10%, 15%, 20%, 30% and 35% replacement of clay. Each mixture was subjected to physical, mechanical and durability test. Test result showed that inclusion of marble waste increased porosity in bricks which enable it to sustain heavy temperature. A similar finding was of (Munir et al., 2017)where waste marble sludge was used to produce energy efficient burnt clay. The waste was added to the ratio of 5%, 10%, 15%, 20% and 25% by weight of clay. The performance was examined on the basis of physicomechanical and thermal properties. The test result showed that addition of marble dust beyond 15% reduced the compressive strength of bricks. The test result showed that inclusion of marble dust increased porosity and water absorption characteristics of bricks. The porous interconnected structure leads to improved thermal insulating properties of the bricks. However, this also decreased with 15% addition of marble dust in the mix. Overall, thestudy suggested that use of marble up to 15% replacement of clay gave a satisfactory performance and using it can help in saving natural clay resource and reduce theoverall cost of construction.

CONCLUSION

Based on the above studies its evident that the waste generated during quarrying process has potential to be reused as partial to full replacement of conventional construction and building materials like cement, concrete, fine aggregates, bricks etc. Utilizing this waste as replacement of raw material will not only help in conserving the non-renewable resources but will also provide a viable solution to dispose the already accumulated quarry waste, decrease the pollution and reduce the overall cost of construction, thus, providing a sustainable aspect to construction.

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