Impact Assessment of Waste Granite Slurry in Construction Industries Application – A Review

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Abstract— Today with the increasing cost of construction materials, there is a need to curtail the cost by using cheaper substitutes. This review deals with How Granite Slurry Waste can be used to produce new products or can be used as admixtures. For sustainable development natural resources are used more effectively and efficiently so that the environment is protected from waste deposits. Granite stone industry generates both solid waste and stone slurry. Granite powder is one of the materials which severalty affects the environment and health problems. It is produced from sawing, shaping, and polishing process. Nevertheless, Natural sources are limited that's why new materials might be able to play a role as cement and sand constituents in the future. It remains to be seen to what extent they could substitute to a significant degree. This review study showing various use of granite slurry waste as replacement of cement and sand in several industrial applications such as mortar, concrete, composite material and bricks.

Key words: Waste Granite, mortar, concrete

I. INTRODUCTION

Concrete is a composite material which is used most widely as a leading construction material for over a century. In the past few years, great emphasis was given on green concrete as it results in sustainable development. Green concrete implies of industrial wastes to reduce consumption of natural resources, save energy and minimize pollution of the environment. Solid waste disposal is a major environmental issue in cities around the world including India. Among the various varieties of solid industrial wastes generated the stone waste is one of those. India alone produces 16% of total world's stone. India accounts for 30% of world export of high quality natural stone like granite marble and sandstone. Granite industry is one of the most environmental unfriendly industries. Granite is an igneous rock made up essentially of feldspar orthoclase and quartz minerals.The granite industry in India is concentrated mainly in the state of Karnataka, Andhra Pradesh, Tamil Nadu and Rajasthan. The data available from the literature, the granite industry produce the amount of wastes generated in production is reached about 15 to 20% of its global production, meaning millions of tons of colloidal waste per year. In India, about 6 million tones of wastes from marble and granite industries are being released through cutting, polishing, processing and grinding. (Pappu et al., 2007)

Granite slurry wastes (generates through cutting and polishing process), have pozzolanic and or cementitious property and can possibly be used in concrete mixtures. Replacing natural raw materials with wastes may offer a much sought after opportunity to mitigate today's waste management problems. These wastes were studied by many researchers for its use in several industrial applications such as cement, concrete, mortar, ceramics, composite materials, bricks manufacturing and others that showed positive results and benefits.

So these waste material needs to be utilized meaningfully in an economic way, utilization of these waste material is very essential to reduce its harmful impact on environment as well as living entity.

II. GRANITE WASTE

Various types of waste generated quarry/cutting/sawing and polishing through granite industry:

1) Solid Waste (through blocks squaring and piece cutting)
2) Slurry Waste (through cutting and polishing process)

Fig. 1: Environmental Problem Associated with Slurry Waste

III. IMPACT OF WASTE GRANITE SLURRY IN MORTAR

Marmol et al. (2010) examined the value of granite sludge wastes (GS) in cement-based mortar formulations by assessing their potential as structural components and pigments. Full characterization of GS was accomplished by X-ray fluorescence (XRF), X-ray diffraction (XRD), laser diffraction and scanning electron microscopy. GS were found to be an effective filler or pozzolanic material for mortars. GS were easily converted into a reddish pigment by calcination at low temperatures (700–900°C) for a short time. UV–Vis–NIR spectra, colourimetric parameters and XRD analysis confirmed the presence of a Fe2O3 in the pigment. The preparation of coloured mortar with good compressive strength can be an attractive, environmentally friendly method of managing granite sludge wastes.

Ramos et al. (2013) analyzed the effect of granite sludge waste on mortar as a partial replacement of cement in terms of strength and durability. Various tests like chemical analyses, laser particle size distribution and scanning electron microscopy of granitic quarry sludge, as well as mechanical strength, expansion due to alkali silica reaction and chloride penetration resistance on mortars containing different dosages of cement replacement with granitic quarry sludge waste ground to different fineness levels. Results showed that granitic quarry sludge waste, if ground to sufficient fineness, produces a denser matrix promoting up to 38% reduction in expansion due to ASR and almost 70% improvement in resistance to chlorides, without compromising workability and strength.

IV. IMPACT OF WASTE GRANITE SLURRY AS SAND AND CEMENT REPLACEMENT IN CONCRETE

A. Sand Replacement:

Vijayalakshmi and Sekar (2013) investigated the suitability of granite powder (GP) waste as a substitute material for fine/natural aggregate in concrete production. The experimental parameter was percentage of granite powder substitution. Concrete mixtures were prepared by 0%, 5%, 10%, 15%, 20% and 25% of fine/natural aggregate substituted by GP waste. Various mechanical properties such as compressive strength, split tensile strength, flexural strength; ultrasonic pulse velocity (UPV) and elastic modulus were evaluated. The durability properties such as water permeability, rapid chloride penetration (RCPT), carbonation depth, sulphate resistance and electrical resistivity were also determined. The obtained test results were indicated that the replacement of natural sand by GP waste up to 15% of any formulation is favorable for the concrete making without adversely affecting the strength and durability criteria.

Arulraj et al. (2013) investigated the possibility of using granite powder as partial replacement of sand in various % 0, 5, 10, 15, 20 and 25 by its weight. To improve the workability of concrete 0.5% Superplasticiser was added. Fifty four cubes and 36 cylinders were cast. Compressive strength and split tensile strength were found. The test results indicated that granite as partial replacement of sand has beneficial effect on the mechanical properties of compressive strength and split tensile strength of concrete.

Joel (2010) analyzed and investigated the suitability of granite fine (GF) to replace river sand in concrete production for use in rigid pavement. Slump, compressive and indirect tensile strength tests were performed. As result 28 days Peak compressive and indirect tensile strength values of 40.70 N/mm2 and 2.30 N/mm2 respectively were obtained, with the partial replacement of river sand with 20% GF, as against values of 35.00 N/mm2 and 1.75 N/mm2, obtained with the use of river

sand as fine aggregate. Based on economic analysis and results of tests, river sand replaced with 20% GF is recommended for use in the production of concrete for use in rigid pavement.

Williams et al. (2008) investigated the performance of concrete made with granite powder as fine aggregate. Sand was replaced with granite powder in steps of 0, 25, 50, 75 and 100% and cement was replaced with 7.5%Silica fume, 10% fly ash and 10% slag. They added 1% superplasticiser to improve the workability. The effects of curing temperature at 32oC and 1, 7, 14, 28, 56 and 90 days compressive strength, split tensile strength, modulus of elasticity, drying shrinkage and water penetration depth were examined. Experimental results indicated that the increase in the proportions of granite powder resulted in a decrease in the compressive strength of concrete. The highest compressive strength was achieved in samples containing 25% granite powder concrete, after 90 days. The overall test performance revealed that granite powder can be utilized as a partial replacement of natural sand in high performance concrete.

B. Cement Replacement:

Elmoaty & Mohamed (2013) investigated physical, mechanical properties and reinforcement corrosion resistance of concrete modified with granite dust. The cement pastes modified with granite dust were examined using TGA, X-ray and SEM. Granite dust cement replacement or addition of 5.0%, 7.5%, 10.0% and 15.0% were used. The test results showed an improvement on concrete compressive strength at 5.0% granite dust as cement replacement and improvement on compressive strength at most levels of granite dust as cement addition. Also, the use of 5.0% granite dust increased the corrosion cracking time and no significant reduction in cracking time was observed at granite dust contents greater than 5.0%.

Abubaker et al. (2014) carried out an experimental investigation on strength properties of concrete made with replacement of cement by granite quarry dust from 2.5% to 20%. The cement used of 53 grade of Ramco brand and fine aggregates was also carried out as per IS: 2386(part-I) and found to be in zone-II. Superplasticizer was used master glenium sky 8233 which is a high performance super plasticizers. The test was carried out to find the compressive strength, splitting tensile strength & flexural strength on specimens. Upto 7.5% replacement of cement by granite quarry dust, there was no reduction in compressive strength, splitting tensile strength and flexural strength on specimen. Use of quarry dust in concrete will reduce carbon emission as a result of reduced cement consumption inhibiting the culture of green building and technology and reduction of landfill cost using such waste products.

Rubanincheran and Ganeshan (2014) examined the durability test like chloride ion permeability test, fire resistance test, sulphate resistances on fibre concrete for 7 and 28 days using partial replacement of cement by granite powder. An experimental investigation has been carried out on M20 grade concrete. The percentage of granite powder added by weight were 0, 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 & 1% of steel fibers used for increasing tensile strength. Steel structural fibers were used to modify the ductility/toughness of hardened concrete. It improves impact resistance, fatigue endurance and shear strength of concrete. OPC 43 grade cement used was confirming to IS: 8112 (1989). Rapid chloride permeability of concrete specimen was determined according to ASTMC-1202. This method determines the electrical conductances of concrete. 25% granite powder specimen having highest residual compressive strength is most durability against fire and at least sulphate deterioration factor, is most economical of specimen.

Allam et al. (2014) investigated to re-use of granite sludge in producing green concrete and find out compressive strength of green concrete mixes produced by replacing sand and cement by natural stones sludge. A total of 63 cubes specimen (150mm*150mm*150mm) were prepared in order to determine properties of fresh concrete and compressive strength after curing at different ages (7, 28 and 90 days). Replacing cement with granite waste caused decrease of compressive strength at all ages with any replacement properties. A significant decrease b/w 28-42% of compressive strength was noticed when 15% replacement was used. Exceeding 5% of cement replacement by granite waste caused a dramatic decrease in compressive strength compared to control mix.

Arulraj et al. (2013) investigated to preparation of concrete with granite powder as partial replacement of sand.The percentages of granite powder added by weight to replace sand by weight were 0, 5, 10, 15, 20 and 25.This test perform for M20, M30 and M40 grade of concrete and 0.5% superplasticiser was added for improve the workability of concrete. Size of cylinders 150mm x 300 mm were used to determine the split tensile strength. The density of granite was between 2.65 to 2.75 g/cm3 and compressive strength was greater than 200 MPa. Replacement of fine aggregate with granite powder was found to improve the strength of concrete. The optimal dosage of replacement was found to be 15%.

Divakar et al. (2012) carried out the experimental investigation on behaviour of concrete with use of granite fines. In this work, find out compressive strength of concrete, split tensile strength and flexural strength, concrete is produced by granite fines as a replacement of fine aggregates in 5 different percentages namely 5%, 15%, 25%, 35% and 50%. According to experimental, so results were available here, compressive strength has increased by 22% with use of 35% replacement of fine aggregates with granite powder. Split tensile strength remains same for 0%, 25% and 35%. For 5% replacement of fine aggregates, there is an increase of 2.4 % of strength and if 15% replacement of fine aggregates then there is reduction of tensile strength by 8%. Upto 5% decrease of flexural strength at 15%, 25% and 35% replacement with granite fines as compared to M20 conventional concrete without reinforcement. Water cement ratio has been taken 0.6 for this experiment for better result. Overall increase in strength with 35% replacement of fine aggregates with granite fines.

V. IMPACT OF WASTE GRANITE SLURRY AS SAND AND CEMENT REPLACEMENT IN HIGH STRENGTH AND HIGH PERFORMANCE CONCRETE

A. Cement and Sand Both Replacement:

Felixkala (2013) carried out experimental study of using granite powder as fine aggregate and partial replacement of cement with admixtures in the production of HPC with 28 days strength to the maximum of 60 MPa. The specimens of concrete were produced by adding the percentage of granite powder by weight was 0, 25, 50, 75 and 100% as a replacement of sand used in concrete and cement was replaced with 7.5 % silica fume, 10% fly ash, 10% slag and the dosage of superplasticiser added 1% by weight of cement. The test results show clearly that granite powder of marginal quantity, as partial sand replacement has beneficial effect on the mechanical properties. The highest strength has been achieved in samples containing 25% granite powder together with admixtures. Based on the results, it can be concluded that concrete mixture can be prepared with granite powder as an additive together with admixtures to improve the strength of concrete structure.

B. Sand Replacement:

Felixkala T and Sethuraman V.S. (2013) carried out study on shrinkage properties of concrete made with 25% of granite powder as a replacement of sand and with 10% of Fly ash, 10% of ground granulated blast-furnace slag, 7.5% of silica fume and 1% of superplasticiser as a replacement of cement were considered. The results indicated that concrete specimens produced with admixture and granite powder has lesser shrinkage parameters like maximum length of crack, minimum width of crack, total number of cracks as compared with conventional concrete specimens. The test results also indicated that the values of both plastic and drying shrinkage strains of concrete in the granite powder with admixture concrete specimens were greater than those of ordinary concrete specimens.

M.THANIGAI SELVAN (2014) carried out experimental investigation on the suitability of GP waste as a substitute material for fine/natural aggregate in high performance concrete (HPC) production. And aimed to study the Physical and chemical properties of the granite powder by-product as well. The experimental parameter was percentage of granite powder substitution. The concrete cubes and cylinder specimens were prepared with 0%, 5%, 10%, 15%, 20% and 25% of natural sand is substituted by GP by-product. Various mechanical properties such as compressive strength, split tensile strength and flexural strength were evaluated. The GP by-product showed a very high specific surface value of about 340kg/m2 and the chemical analysis results showed the examined material contains about 77% of silica (Sio2). Experimental results revealed that, rough texture and high specific area of the GP by-product significantly decreased the workability of the HPC especially for the substitution rate of 20% and 25%. The obtained test results shows that the substitution of GP by-product up to 15% does not affect the mechanical and fresh concrete properties of the concrete and it was recommended that the replacement of natural sand by GP by- product up to 15% of any formulation is favorable for the HPC production.

C. Cement replacement:

Saranyadevi et al. (2014) analyzed and compared the effect on strength properties of high strength concrete by partial replacing cement. by 5%, 10%, 15%, 20%, 25% of mass of cement by GP using constant dosage of Super Plasticizer (SP) and Silica Fume (SF). M70 grade concrete cubes of 150x150x150 mm size were cast for conducting compressive strength test. From the test results found that the strength achievement decreases as percentage replacement of granite powder increases.

VI. IMPACT OF WASTE GRANITE SLURRY IN BRICKS

A. Soil replacement:

S. V. Ribeiroa, J. N. F. Holandaa,(2014) investigate the reuse of granite-cutting sludge as an alternative raw material into a soil-cement bricks body, replacing soil by up to 30 wt.%. The granite-cutting sludge and soil samples were characterized regarding chemical composition, X-ray diffraction, and particle size distribution. Soil-cement bricks are uniaxially pressed and cured for 28 days. The effects of the sludge addition on the technological properties (e.g., volumetric shrinkage, water absorption, and compressive strength) have been determined. From the experimental results, the granite-cutting sludge proved to be a good alternative raw material to the manufacture of soil-cement bricks, and at the same time, this application could help in reducing the environmental impacts of the ornamental rock industry.

VII. CONCLUSIONS

1) According to earlier experimental studies, it concludes that by using granite waste in concrete mix proved to be very useful to produce green concrete. Therefore, it is recommended to re-use these wastes in concrete to move towards sustainable development in construction industry.
2) Granite slurry waste can replace cement and/or fine aggregate in concrete or mortar mixes with different percentages. Due to its high fineness and high silica content provides good cohesiveness of the mix.
3) Industrial wastes are capable of improving the physical and chemical properties. Use of granite slurry waste shows a great performance due to the efficient micro filling ability.
4) As per the study its shows that when granite slurry waste when replacing with sand upto certain percentage shows increase in strength due to silica content in slurry.
5) According to the study, granite slurry waste has some cementitious properties. Because of these properties of granite slurry, it can be used and fulfills the economical and environmental problems.

6) Permeability tests demonstrated that the permeability of green concrete (using granite slurry) is less compared to that of conventional concrete.
7) Green concrete produced using natural or recycled aggregate with 5% granite dust replacement of cement and 25% granite dust replacement of sand had strengths comparable to or better than, equivalent control mixes.
8) For high performance concrete it was found that 15% replacement of fine aggregate does not affect fresh and mechanical properties.
9) Finally, it was very difficult to make an accurate comparison between the results of previous studies due to the different origins of materials used granite wastes as each type had its own chemical and physical properties although each fall in the different range of chemical constituents.
10) Although several researchers had undertaken efforts in re-using granite slurry waste in concrete from different points of view, rare researches were conducted on durability tests like acid attack, water penetration and fatigue testing. Therefore, it is recommended to make more future efforts to study the effects of using granite waste in concrete properties

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