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ENHANCEMENT OF STRENGTH IN CEMENT MORTARS CONTAINING GRANITE POWDER

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***Abstract* - Solid waste management is a big challenge in all around the world. Granite slurry generated from granite stone processing industry is a prime source of solid waste produced in Rajasthan. The generated slurry is indiscriminately dumped on vacant lands, river banks or forest areas. These slurry particles being fine enough are capable of filling pores of the soil, preventing water percolation and making the land futile. In this experimental study, granite powder (dried granite slurry) was used for the production of 1:4 and 1:6 cement mortar mixes. In order to improve performance parameters of mortars containing granite powder (GP), it was planned to use coarse sand (CS) of zone-II to negate the effect of excessive fines. Ratio of 60:40 and 70:30 of CS:GPsatisfied gradation recommended by standards for plaster and masonry mortars. For 1:4 mortar proportion, the adhesive strength increased by 21% and 23% for CS30 and CS40 mixes, respectively as compared to control mortar (FS). On exposure of mortars to a 5% sulphuric acid medium, portlandite and katoite are converted into gypsum and ettringite, No significant variation in performance across all the mixes was observed when mortar mixes were subjected to 20 cycles of alternate wetting and drying. Hence, granite powder as partial substitute (30- 40%) of sand in cement mortar mixes has no adverse effect on mechanical as well as durability properties of cement mortar.**

***Keywords:* Compressive strength, Workability, Tensile bond strength, Adhesion test.**

I INTRODUCTION

Development of society demands the urbanisation. Urbanisation requires a good infrastructure to achieve economic growth. In order to achieve the economic growth a rapid industrialization is required in society. The industrialization promotes the consumption of natural resources and generates waste as by-product. Such wastes are dumped in open lands which create a lot of pollution for surroundings. The waste also has disturbed the ability of nature to self-regulation of temperature and atmosphere. For the betterment of upcoming generation, an adoption of sustainable development of society should take place which would balance both living and non-living being on earth. 1.2 Waste Management Total population on this planet in 20th century was six billion about seven years ago (Hammed et al., 2012). Now this population has reached at 7.2 billion (Dong et al., 2017). This increase in population demands increase in infrastructure. About 30 billion tonnes of raw materials are required for construction of necessary infrastructure each year worldwide (Behera et al., 2014). Creating infrastructure and industrialization generates a lot of waste during processing. Total quantity of solid waste generated in India is 69 million tonnes. Out of this only 12 million tonnes waste is treated and remaining waste is dumped on open lands. This untreated waste creates a lot of problems to surroundings (Mohan et al., 2018).

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Approximately 25% need of nutrients for crop can be achieved from recycled agriculture waste. Most of wastes generated from agriculture are bio-degradable which can be used as composts and for production of bio-fuel. One of agriculture wastes is rice husk ash which has potential to be used in manufacturing of bricks (Hwang and Huynh, 2015) and concrete (M. Jamil et al., 2016). Self-compacting concrete prepared with 10% metakaolin and 10% rice husk ash improves its compressive strength by 27% (Gill and Siddique, 2018). Developing countries have recycled 80% of waste generated from electronics industry (Ohajinwa et al., 2018). European regulations has made it mandatory to use 85% components of automobile of recyclable products

(Ortego et al., 2018). Cathode ray tube glass waste was used as fine aggregate in high density concrete after treatment by nitric acid (Xiao et al., 2018). Construction and demolition (C&D) waste also has potential for utilization in new construction. But, it requires a lot of energy to process it for the use of construction as an ingredient. Coarse aggregate obtained from C&D waste was used by 50% of total coarse aggregate with 10% glass powder in place of cement for the production of concrete without compromising its performance (Akhtar and Sarmah, 2018). In upcoming paragraph, requirement of construction industry which also has potential to use waste is discussed. 1.3 Industrial waste used as ingredient for cement composites A good number of researches are available which have proved that the industrial wastes have potential to be used as cement and aggregates (both coarse and fine aggregate) in concrete as well as in mortar. Some of recommendations are given in standards. IS 455:1989 recommended that 65% ordinary Portland cement (OPC) can be replaced by ground granulated blast furnace slag (GGBFS). Recommendations for 25% replacement of OPC by fly ash has been given by ARE 1489:1991. Use of recycled aggregate, steel slag, iron slag and bottom ash as fine and coarse aggregate in both plain and reinforced concrete to some extent has been allowed by IS 383:2016.

Chawla et al. (2018) and Kore and Vyas (2016) have used the marble waste as conventional coarse aggregate in concrete mixes. Kumar et al. (2017) have used sandstone waste as coarse aggregate with higher dose of admixture in concrete. Singh et al. (2015) prepared concrete with 25% granite cutting waste as fine aggregate which have shown better performance against adverse condition. Rana et al. (2016) have successfully used Kota stone slurry (dimensional lime stone) as fine aggregate in concrete. Siddique et al. (2018) prepared concrete with ceramic waste as fine aggregate without compromising its durability. Tripathi et al. (2013) used a toxic waste i.e. ISF (Imperial Smelting Furnace) slag as fine aggregate for the production of concrete. Bisht and Ramana (2018) produced concrete with 21% discarded beverage glass as fine aggregate which have improved it`s mechanical properties.

Thomas and Gupta (2016) produced high strength concrete of strength more than 60MPa by using 12.5% crumb rubber as fine aggregate. Natural fine aggregate in concrete also replaced successfully by 20% sanitary-ware waste as reported by farinha et al. (2012). 2 Singh et al. (2017) prepared cement mortar with 50% ISF slag and 50% Marble powder as fine aggregate and found that compressive strength was 63% higher than that of conventional mortar. Khayaliya et al. (2017) reported that performance of lean cement mortar with 25% marble waste as fine aggregate against aggressive environment was improved. Kabeer and Vyas (2018) obtained dense microstructure with 20% substitution of river sand by marble powder in cement mortar. Strength parameter was improved with 40% replacement of natural fine aggregate by dimensional lime stone slurry in cement mortar as documented by H.S. Chouhan et al. (2018). H.K. Kim et al. (2012) obtained 10-20% increment of flow of mortar with fine bottom ash aggregate.

II LITERATURE REVIEW

High demand of fine aggregate with limited sources has raised the question for alternatives in the construction industry. There are a number of sites where wastes like marble, granite, Kota stone etc. generated from stone processing industries are dumped. These dumping sites (as seen in Figure 2.1) create lots of problems for the surroundings as these wastes are non-biodegradable. By realising the problem of limited natural fine aggregates for construction industry and surplus waste generated from stone industry, a good number of research works are available where attempts have been made to reduce the burden of such stone wastes by utilizing it in concrete and mortar mixes.

Granite is available in plenty and most widely used in flooring work by the construction sector. Most of the industries cut the block of granite and convert into small pieces suitable for flooring. During this process waste is generated in the form of boulders and fine particles slurry. The boulders are again converted into aggregate and used in construction activities. Slurry part keeps accumulating around the processing industry.

Abukersh and Fairfield (2011) have examined the potential of red granite dust (RGD) as partial replacement of cement in concrete. The RGD particles passing through 75 µm sieve were used. The substitution level for RGD was 20, 30, 40 and 50%by mass. The parameters like workability, compressive strength, flexural strength, split tensile strength, density, ultrasonic pulse velocity and elastic modulus were evaluated. Concrete prepared with 30% RGD was reported to possess improved fresh properties than control concrete. The increment in slump was due to availability of free water which was available because of less absorption capacity of RGD than cement. The compressive strength, flexural strength and split tensile strength decreased with addition of RGD. Density of concrete prepared with 30% RGD was slightly higher at 56 days and 90 days than that of control mortar. This behaviour was due to the gradual development of improved pore structure by continued cement hydration as reported by authors. The range for UPV observed by authors was between 4.65 to 5.00 km/s for all concrete mixes including control concrete which is termed as excellent as per specifications of standard followed.

Abd Elmoaty (2013) studied concrete modified with granite dust as cement replacement and addition. The ratio of control concrete was 1:1.2:1.2 which had 45 MPa strength after 28 days of curing. The reduction in w/c ratio as per BS 882 is shown in Figure 2.2.The addition and replacement of granite dust were 0, 5%, 7.5%, 10% and 15% by the weight of cement. During the replacement of cement, there was insignificant effect on initial, final setting times and expansion of cement paste. An increment of 8.2% in compressive strength was observed in concrete prepared with 5% replacement of cement by granite dust and it was maximum in all cases of replacement of cement in concrete. It was due to the filling effect by extremely fine granite dust. The pattern for tensile strength of concrete manufactured with granite dust as cement replacement was similar to the pattern obtained in compressive strength.

E. Bacarji et al. (2013) used mix of marble and granite waste (MGR) in concrete as cement replacement. Total three type of MGR (named A, B and C) were used in this experimental study. The chemical analysis of all MGR`s revealed that silica was maximum and approximately similar in percentage. The particle diameter of MGR used was 0.7-71µm (for A) and 0.7-90µm (for B and C). The substitution level was 5%, 10% and 20%. Mechanical properties i.e. compressive strength, elastic modulus and water absorption were determined. These mechanical properties remained unaltered when 5% substitution was done by MGR-A. A numerical analysis was also conducted by authors to evaluate the effect on the internal microstructure of concrete. The numerical analysis showed that MGR acts as filler would not change the chemistry in concrete. Also there was no contribution of MGR in the pozzolanic reaction in concrete.

K.C. Reddy et al. (2015) prepared M25 grade of concrete with granite fines as replacement of cement in four different proportions namely 2.5, 5, 7.5 and 10%. There are total four parameters such as workability (slump and compaction factor), compressive strength, flexural strength and splitting tensile strength were assessed. The workability of blending mixes were decreased with addition of granite fines. The replacement of cement by granite fines up to 7.5% increases the mechanical properties. The compressive strength, split tensile strength and flexural strength were increased by 10%, 22% and 16%, respectively at 7.5% substitution of cement. The mechanical properties for blending mix were also comparable with control mortar at 10% replacement.

H. Li et al. (2016) used granite dust as a supplementary cementitious material replacing fly ash in manufactured sand concrete. The replacement level was 10%, 20% and 30%. The parameters like slump (workability), compressive strength, bending strength, elastic modulus, chloride penetration, frost resistance and drying shrinkage were checked. With the replacement of fly ash by granite dust, workability of concrete was reduced because granite particles were of angular in shape than spherical particle of fly ash. The compressive and bending strength was found to be increased at 20% substitution of fly ash by granite dust due to compactness by granularity optimization. Long term drying shrinkage of concrete prepared with 30% granite dust was enhanced because of availability of free water which has evaporated due to less cement content. Concrete prepared with 20% granite dust had shown maximum reduction of 2.9% in dynamic modulus after 350 cycles of frost action. The resistance to chloride penetration was reduced with the substitution of fly ash by granite powder, but it was still in low permeability zone as per specifications of standard followed. The overall conclusion of this investigation was found that 20% granite dust can be successfully used in place of fly ash in concrete. A.O.

Mashaly et al. (2018) used granite sludge by 10%, 20%, 30% and 40% of the total weight of cement. The physical properties like water absorption, oven dry density and apparent porosity, mechanical properties like compressive strength and flexural strength and durability properties like abrasion resistance, freeze–thaw resistance and sulphate resistance were evaluated. The increment of granite sludge in concrete was decreased the physical parameters but at 20% replacement physical parameters satisfy the requirements of the standardfollowed. The mechanical properties also decreased with the increment of granite sludge in concrete. Concrete with 20% granite sludge showed better performance against freeze-thaw and sulphate action. The resistance of abrasion of concrete prepared with granite sludge decreases with increment of replacement of cement due to availability of less binder.

III MATERIALS AND METHODS

Properties of different constituents of mortar like cement, natural sand and granite powder have been presented in this chapter. Procedures of all the mechanical and durability tests performed during the experimental study have been discussed.

A Constituents of mortar :

The constituents like Portland pozzolana cement (PPC), natural river sand and granite powder were used for the production of mortar in this experimental study. Characterization of these materials are discussed in subsequent paragraphs.

B Portland pozzolana cement

For the experimental program, Portland pozzolana cement

(PPC) was utilized conforming to the specifications set by IS 1489 - Part 1 (1991). The physical properties are presented in Table 1 The scanning image of PPC is shown in Figure 1.

Table 3.1 Physical properties of PPC

Property	**Value**
Specificgravity	2.9
Bulkdensity(kg/m3)	1100
Normalconsistency(%)	33
Initialsettingtime(min)	129
Finalsettingtime(min)	231
Compressivestrengthafter 28thdaysofcuring(MPa)	36

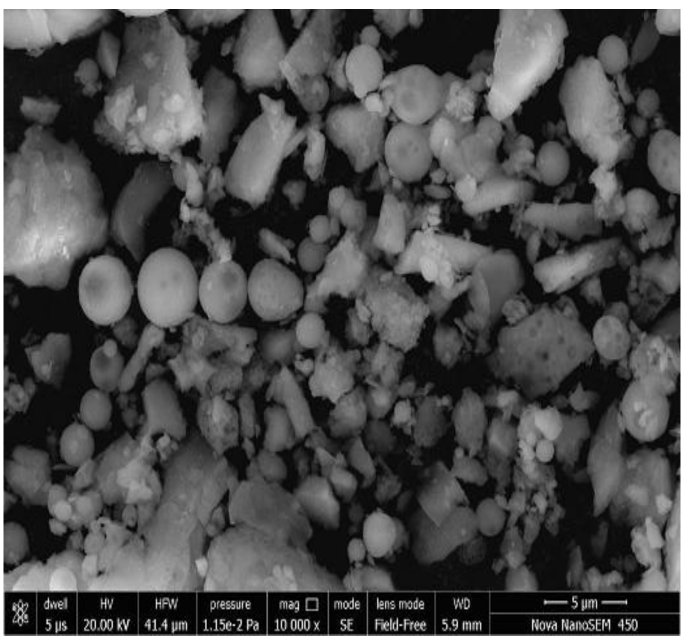

Figure 1: Scanning Image of PPC

Natural river sand Two types of conventional natural river sand were used: (i) Coarse river sand (CS), conforming to zone-II as per IS: 383 and (ii) Fine river sand (FS), conforming to IS: 2116- 1980 (sand for masonry mortar) and IS: 1542-1992 (sand for plaster). Both conventional natural river sands were procured locally. Based on the particle size distribution which is represented in Figure 2, they were designated as coarse sand (CS) and fine sand (FS).

Physical properties of both sands are enlisted in Table 3.2. The SEM image of both sands are shown in Figures 3.3 and 3.4. From SEM image it is clearly observed that both natural sands have smooth and rounded surface.

Table 3.2 Physical properties of CS, FS and GP

Fineaggregate	**Specificgravity**	**Waterabsorption(%)**	**Loosebulkdensity (kg/m³)**	**FinenessModulus**
Coarseriversand(CS)	2.68	7.05	1597	2.65
Fineriversand (FS)	2.65	8.83	1545	1.65
Granitepowder(GP)	2.46	15.29	1368	0.9

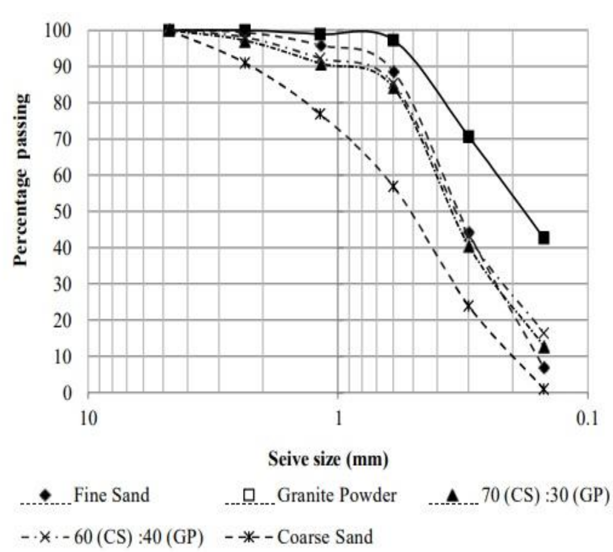

Figure 2 Particle size distribution of used fine aggregates

A Experimental methodology

The procedure followed in tests tabulated in Table 3.6 to evaluate the physical, mechanical and durability properties of cement mortars are discussed below.

B Flow table test: The flow table test was used to fix the water content of mortars to achieve the necessary workability in their fresh state. The test was performed on each mortar mix as per guidelines mentioned in IS 2250 (1981). For each mortar mix, water requirement was expressed in terms of water cement ratio. Flow value for each mortar mix was kept constant in the range of 105 to 115% of diameter of base of standard frustum. The mould having top and bottom diameter of 70 and 100 mm, respectively and height of 50 mm was filled in two layers by the fresh mortar. Each layer was tamped 20 times. The mould was taken away from the mortar and the flow table was dropped immediately through a height of 12.5 mm, 25 times in 15 seconds.

Figure 3: Flow table test of control mortar

C Compressive strength test

The compressive strength test was experimented on 7 and 28 days water cured mortar cubes as per IS 2250 (1981). For each selected curing period (7 and 28 days) four cubes of size 50 mm were tested using a compressive strength testing machine and the achieved values were recorded. The load was applied at a uniform rate of 2 to 6 N/mm2 per minute on the specimen. The average of the four values was recorded as the compressive strength at the selected age.

Figure 4: Compressive strength of mortar

IV RESULTS AND DISCUSSIONS

Properties of rich and lean cement mortar trial mixes prepared with air dried granite powder were evaluated and compared with those of reference mortar. After this a gradation as per BIS 1542 and BIS 2116 was attempted by mixing coarse river sand (CS) and granite powder (GP) in order to achieve the required specifications of fine aggregate in mortar. The recommended proportion was 70:30 and 60:40 for CS:GP mortar mixes. Mechanical and durability properties were evaluated for mortar mixes 1:4 and 1:6. The results and discussions are presented in detail in subsequent paragraphs. 4.2

A Phase-I: In this stage, fine river sand (FS) conforming to BIS 1542 and BIS 2116 was replaced by granite powder (GP) for preparing cement mortar. This replacement was done in the range of 10 to 100% by volume. Two volumetric mix proportions i.e. 1:4 and 1:6 were studied. Properties like workability, fresh bulk density, compressive strength, water absorption and permeable voids were examined for above mentioned mixes. The findings of above results are discussed below.

B Workability: The requirement of water for required flow as per BIS 2250 (1981) is shown in Figure 5 The required flow for mix 1:4 was achieved at 1.2 water-cement (w/c) ratio for reference mortar specimen and at 1.59 for mix containing 100% GP. An appreciable increase in w/c ratio was observed as 27% for maximum utilization of GP in mortar. For other mix 1:6 the increase in water demand was 22%.

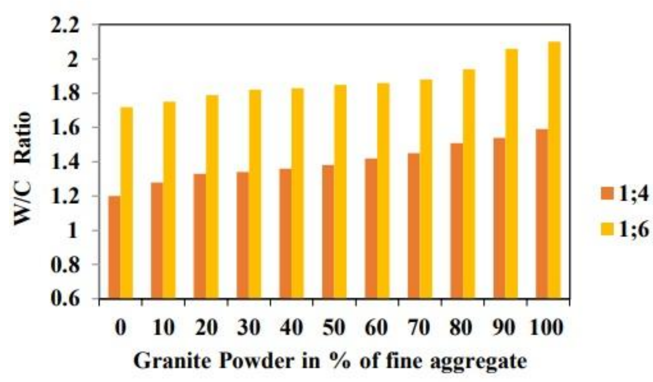

Figure 5: Water-cement ratio of mortars

The rough and angular texture of GP (refer SEM in Figure 3.7) was reason behind this increment in water-cement ratio. Due to such texture of GP resistance to flow of mortar was increased which required more water to attain required flow. The greater water absorption by GP as compared to FS may also be another reason for increment in water demand.

CONCLUSIONS

Granite powder as partial substitute (30-40%) in cement mortar mixes has no adverse effect on mechanical properties. It was observed that water demand reduced to achieve the required workability. Compressive strength, adhesion and tensile bond strengths in mortar mixes were slightly improved as compared to those of reference mortar. Durability parameters like resistance to acid-sulphate solutions, alternative wetting and drying etc. improved. Drying shrinkage in lean mixes exceeded the normal value. Hence broadly 30- 40%part of fine aggregate as GP can be used in mortar mixes in all the construction activities.

REFERENCES

[1] Abukersh, S.A., Fairfield, C.A., 2011. Recycled aggregate concrete produced with red granite dust as a partial cement replacement. Constr. Build. Mater. 25, 4088–4094. https://doi:10.1016/j.conbuildmat.2011.04.047

[2] Agarwal, S.K., Gulati, D., 2006. Utilization of industrial wastes and unprocessed micro- fillers for making cost effective mortars. Constr. Build. Mater. 20,999–1004. https://doi.org/10.1016/j.conbuildmat.2005.06.009

[3] Akhtar, A., Sarmah, A.K., 2018. Construction and demolition waste generation and properties of recycled aggregate concrete: A global perspective. J. Clean. Prod. 186, 262– 281. https://doi.org/10.1016/j.jclepro.2018.03.085

[4] ASTM C 1148, 2002. Standard Test Method for Measuring the Drying Shrinkage of Masonry Mortar. Annual Book of ASTM Standards (Pennsylvania, USA). https://doi.org/10.1520/C1148-92AR08.2

[5] ASTM C 1403, 2006. Standard Test Method for Rate of Water Absorption of Masonry Mortars. Annual Book of ASTM Standards (Pennsylvania, USA). https://doi.org/10.1520/C1403-15.2

[6] ASTM C 185, 2002. Standard Test Method for Air Content of Hydraulic Cement Mortar.Annual Book of ASTM Standards (Pennsylvania, USA). https://doi.org/10.1520/C0185-08.2

[7] ASTM C 267, 2001. Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes. Annual Book of ASTM Standards (Pennsylvania, USA).

[8] ASTM C 307, 2003. Standard Test Method for Tensile Strength of Chemical - Resistant Mortar, Grouts, and Monolithic Surfacings. ASTM International (Pennsylvania, USA).

[9] ASTM C 348, 2002. Standard Test Method for Flexural Strength of Hydraulic-cement Mortars. Annual Book of ASTM Standards (Pennsylvania, USA).

[10]ASTM C 642, 2006. Standard Test Method for Density, Absorption, and Voids in Hardened Concrete. Annual Book of ASTM Standards (Pennsylvania, USA). https://doi.org/10.1520/C0642-13.5.

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