Partial replacement of fine aggregate with Copper slag and marble dust powder in geo- polymer concrete: A review

Amrinder Singh¹, Shalika Mehta²

¹ME Transportation engineering, Civil Engineering Department, Chandigarh University, Mohali, Punjab, India.

²Assistant professor, Civil Engineering Department, Chandigarh University, Mohali, Punjab, India.

Abstract –As of late the ascent of substantial creation costs has consistently been a worry of substantial makers and customers. Using current waste to override concrete and some bit of all can diminish its cost and environmental dirt of all out can decrease its cost and natural tainting. The mark to the purpose of this paper to audit the shot at powder made from marble dust close by the copper slag as an in part substitution to fine aggregate all out in geo-polymer concrete. Marble dust powder was used in mix in comprise copper slag as in part substitution to fine aggregate in level of 10%, 20%, 30%, 40% and 50%. The strength of geo-polymer concrete was tested after 7 & 28 days. Result shows that compressive strength is increased after the replacement of 60% of copper slag and marble dust powder to fine aggregate and also flexural strength and split tensile strength increases strength upto 60% and 80% after replacement. These discoveries of the examination express that powdered marble dust will be utilized as the conceivable substitution material to fine aggregate to give maximum strength copper slag geo-polymer concrete.

Key points: Geo-polymer concrete, copper slag, marble dust powder, partial replacement.

1. Introduction
The most widely used material on the planet is concrete. With the extending speed of people improvement, system to ought to be developed rapidly to fulfill the necessities of people and for this load of a tremendous proportion of resources are required. The critical one of them is complete. Regardless, the unnecessary usage of these resources will make a natural ungainliness. Hence, we have decided to displace these critical component of the improvement business with marble powder and copper slag separately. Geo-polymer was given the name by Joseph Diadovits in1978 to materials that portrayed by means of chains, networks, or inorganic particles. Geo-polymer is a natural just as inorganic waste like as polyvinyl chloride squander which is creating a thousand number of tons consistently. The decay of this
plastic waste in the climate is hurtful to individual. A little measure of Geo-polymer can give steadfast outcomes yet in excess, it decreases the strength of cement [1].

Marble is a transformative stone produced using the change of pure limestone. The whiteness in the marble represents its pureness. The developing pace of marble utilization is bringing about increasingly more creation of marble dust. As of now, the mining business in Rajasthan is creating 4500 tons (1800 m³) each year. Copper slag is made as a result of the decontaminating pattern of copper by the metal business [2–4]. Slag is a degradation that goes with the metal minerals when warmed in the radiator every one of the defilements start to skim at the most noteworthy mark of the warmer. According to this research copper slag and marble dust powder will partially replaced the fine aggregate in geo-polymer concrete effect concrete strength, compressive strength, split tensile strength, and flexural strength at various percentages of copper slag and marble dust powder [5–7].

2. Materials
Fly Ash: In this experiment, Fly ash of class F was used. Fly ash has a density of 2.14.
Coarse Aggregate: The coarse aggregate utilised this research has a maximum size of 20mm and a S.G. of 2.78.
Fine aggregate: Casting specimens are made from naturally accessible fine aggregate. The fine Aggregate had a specific gravity of 2.68 and was sieved at 4.75mm.
Alkaline activator solution: Catalytic liquid system is used, it is a combination of solutions of silicates and hydroxide, besides distilled water. The sodium hydroxide solids in pellets were of a research centre quality structure with 99% virtue, acquired from nearby providers in Chennai. Dissolving the pellets (a small, adjusted, packed mass of a sodium hydroxide material) in water created the sodium hydroxide arrangement. The mass of NaOH solids in a solution altered depending on the centralization of the arrangement conveyed down to the molar level, M. A sodium silicate arrangement (water glass) was obtained from local Chennai suppliers. The sodium silicate arrangement was made up of 8% Na2O, 28% SiO2, and 64% water by mass. The antacid fluid is shaped by a combination of Na2OSiO2 and NaOH arrangements [8,9].

COPPER SLAG: Copper slag is an outcome gotten during matte purging and copper refinement. Production of 1T of copper creates generally 2.2–3 ton of copper slag. Specific gravity of copper slag 3.1.
Marble dust powder: Marble is ordinarily used for animating and extraordinary purposes. 20% of the marble quarried is gets changed over into powder structure in view of the cutting of marble [10–12]. Marble dust powder has a specific gravity of 2.5. Copper slag and marble dust powder were analyzed chemically, as detailed in table – 1

Table – 1: Chemical Composition of Copper Slag and Marble Dust Powder

| Constituent | Copper slag | Marble dust powder |
|-------------|-------------|--------------------|
| SiO2        | 97.01       | 18.67              |
| Al2O3       | 0.095       | 8.7                |
| Fe2O3       | 1.05        | 6.31               |
| CaO         | 1.064       | 53.86              |
| MgO         | 0.118       | 5.74               |
| SO3         | 0.008       | 1.2                |
| K2O         | 0.028       | -                  |
| Na2O        | 0.118       | -                  |
| TiO2        | 0.12        | -                  |
| Mn2O3       | 0.002       | -                  |
| CuO         | 0.183       | -                  |
Sulphide sulphur | 0.082 | -
Water insoluble residue | 98.48 | -
Chloride | 0.35 | -
Loss on ignition | 0.19 | 5.52

**Water:** Water is essential issue being developed controlling strength, all that else being same, is the proportion of water used per pack of cement and reestablishing reason they used.

3. **OBJECTIVE:**

- To assess the ideal percentage of copper slag and marble dust powder.
- To assess the compressive strength, split elasticity and flexural strength of the geo-polymer concrete by utilizing copper slag and marble dust powder in various extents at various ages.
- To look at the properties of geo-polymer concrete after partially replacing geo-polymer concrete with fine aggregate, copper slag, and marble dust powder.

4. **METHODOLOGY:**

Figure 1 represent the Ratio of Copper slag in percentage 10%, 20%, 30%, 40% and 50% to be used and marble powder percentage 10%, 20%, 30%, 40% and 50% to be used are partially replaced in geo-polymer concrete instead of fine aggregates. For the copper slag and dust marble powder partial replacement for fine aggregate in geo-polymer concrete, 1:1.82:3.37 (M30) mix proportion is adopted [13,14], as shown in Table 3.

- Calculation of M30 grade Geo-polymer concrete is as per IS Code - 456:2000. The ratio of Fly ash, Fine aggregates, Course aggregate, Water i.e.

  1:1.82:3.37:0.21

- Here the table given below its calculation for 1m³ shown in table 2.

- Concrete grade M30 compressive strength, split tensile strength, and flexural strength are calculated for 2cube, 2cylinder, and 2 beam:

| Materials       | Quantity(kg) |
|-----------------|--------------|
| Fly ash         | 405          |
| Fine aggregate  | 683.13       |
| Coarse aggregate| 1268.43      |
| Water           | 108.35       |

Table 2: calculation for 1m³

| %Copper Slag and Marble Dust Powder | Fly Ash | Coarse Aggregate | Fine Aggregate | NaOH | Na2O|SiO2 | Copper Slag | Marble Dust Powder | Water |
|-------------------------------------|---------|-----------------|----------------|------|-----|-----|-------------|---------------------|-------|
| 0,0                                 | 14.04   | 39.51           | 18.66          | 2.37 | 4.25|     | 0           | 0                   | 7.83  |

Table 3: Mix Proportions
5. RESULT AND DISCUSSION:
5.1 Compressive Strength:
For variable copper slag and marble dust substance as a replacements of fine aggregate at 7 & 28 days curing time, 150mm*150mm*150mm cube specimens were used. According to the findings, the use of marble dust powder and copper slag increased the compressive strength of the geopolymer concrete. The values for compressive strength grew over time. The maximum compressive strength have been received for 60% of fine aggregate replacement by copper slag and marble dust powder. At 28 days, the specimen comprise 30percent copper slag & 30% marble dust powder had a compressive strength that was 3.06% higher than geo-polymer concrete, see figure 2 and 3.
5.2 Split Tensile Strength:
The size of used specimen cylinder is $150*300$ for split tensile strength test. The split tensile strength for geo-polymer concrete were 2.71mpa and 4.52mpa for 7 and 28 days. At 40 percent copper slag + 40 percent marble dust powder, geo-polymer concrete made with copper slag & marble dust had equivalent strengths of 2.98 MPa and 4.98 MPa, respectively. The split tensile strength of geo-polymer mixes with 40% copper slag and 40% marble dust is higher than that of nominal geo-polymer mixes, as shown in the above data and figure. The above outcomes show that utilization of marble dust powder and copper slag in geo-polymer concrete works on the split tensile of geo-polymer concrete, see figure 4.
Figure 4: Percentage Replacement
5.3 Flexural Strength:
After 7 & 28 days of cure, the flexural strength of beam specimens measuring 100mm*100mm*500mm for varied copper slag, marble dust powder percentage (%) as a fine sand replacement was tested which is shown in figure 7. The nominal flexural strength of geo-polymer concrete was 3.29 MPA for 7 days and 5.02 MPA for 28 Days. Geo-polymer concrete formed with copper slag & marble dust powder (Thirty percent Copper Slag + Thirty percent Marble Dust Powder) had the following strengths: 3.45mpa & 5.28mpa respectively, see figure 5.

![Flexural Strength Graph](image)

**Figure 5 : Percentage Replacement**

6. Conclusions:

The following conclusions can be drawn from the current study:

1. The addition of up to 60% copper slag & marble dust powder raised the compressive strength of the geo-polymer concrete by 3.06 MPa over the standard geo-polymer concrete; however, the compressive strength was reduced by the addition of more copper slag & marble dust powder.

2. By replacing 80% of the sand with marble dust powder and copper slag, geo-polymer concrete's split tensile strength is increased by 0.46mpa.

3. The flexural strength of geo-polymer concrete is raised by 0.26mpa when 60% of the sand is replacement with copper slag & marble dust powder. When fine aggregate is replacement with copper slag & marble dust powder, the split tensile and flexural strength of concrete is larger than standard geo-polymer concrete.

4. The compressive and flexural strengths of copper slag are raised due to its high toughness.
7 References:

[1] Sanghamitra J, Ramakanta P and Ananya B S 2020 Experimental Investigation on Geo-Polymer Concrete by Using Steel Slag at Higher Temperature *IOP Conference Series: Materials Science and Engineering* vol 998 (IOP Publishing Ltd)

[2] Ramesh V and Koniki S 2021 Comparison of mechanical properties of flyash-GGBS based GPC and flyash-alccofine based GPC with different concentrations of alkaline activators *AIP Conference Proceedings* vol 2358, ed K S S P B A Babu B.S. Kumar K. (American Institute of Physics Inc.)

[3] Dasgupta K. Sudheesh T.K. P K I U K G K P E J S S 2021 1st International Conference on Structural Engineering and Construction Management, SECON 2020 *Lect. Notes Civ. Eng.* 97

[4] S M K, Shobha M S, Tanu H M and Reshma T V 2021 Ternary Blended Geo-Polymer Concrete - A Review *IOP Conference Series: Earth and Environmental Science* vol 822 (IOP Publishing Ltd)

[5] Loganathan K. Mohanraj M. S P S M 2021 1st International Conference on Advances in Computational Science and Engineering, ICACSE 2020 - Advances in Computational Civil Engineering *Journal of Physics: Conference Series* vol 1964 (IOP Publishing Ltd)

[6] Loganathan K. Mohanraj M. S P S M 2021 1st International Conference on Advances in Computational Science and Engineering, ICACSE 2020 - Advances in Computational Physics and Material Sciences *Journal of Physics: Conference Series* vol 1964 (IOP Publishing Ltd)

[7] Loganathan K. Mohanraj M. S P S M 2021 1st International Conference on Advances in Computational Science and Engineering, ICACSE 2020 - Advances in Computational Mathematical Sciences *Journal of Physics: Conference Series* vol 1964 (IOP Publishing Ltd)

[8] Loganathan K. Mohanraj M. S P S M 2021 1st International Conference on Advances in Computational Science and Engineering, ICACSE 2020 - Advances in Computer Science Engineering *Journal of Physics: Conference Series* vol 1964 (IOP Publishing Ltd)

[9] Murali K and Meena T 2021 An experimental investigation on the mechanical properties of glass fibre reinforced geopolymer concrete *Indian Concr. J.* 95 23–30

[10] Singh D, Kumar V and Kaur M 2019 Single image dehazing using gradient channel prior *Appl. Intell.* 49 4276–93

[11] Gairola P, Gairola S P, Kumar V, Singh K and Dhawan S K 2016 Barium ferrite and graphite integrated with polyaniline as effective shield against electromagnetic interference *Synth. Met.* 221 326–31

[12] Singh U and Rattan M 2014 Design of linear and circular antenna arrays using cuckoo optimization algorithm *Prog. Electromagn. Res. C* 46 1–11

[13] Sidhu B S, Sharda R and Singh S 2021 An assessment of water footprint for irrigated rice in punjab *J. Agrometeorol.* 23 21–9

[14] Chohan J S, Kumar R, Singh T B, Singh S, Sharma S, Singh J, Mia M, Pimenov D Y, Chattopadhyaya S, Dwivedi S P and Kaplonek W 2020 Taguchi S/N and TOPSIS Based Optimization of Fused Deposition Modelling and Vapor Finishing Process for Manufacturing of ABS Plastic Parts *Materials (Basel).* 13 5176