EXPERIMENTAL INVESTIGATION OF CEMENT AND FINE AGGREGATES BEING PARTIALLY REPLACED BY NATURAL WASTE MATERIAL LIKE MARBLE POWDER AND COPPER SLAG IN CONCRETE

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ABSTRACT

Due to rapid exponential growth in waste materials, there is a huge negative impact causing high rate of pollution in the environment. In order to decrease the environmental pollution it is necessary to reutilize the waste products by adopting various techniques. This paper highlights about the feasibility for obtaining sufficient strength as well as economy by substituting cement and fine aggregates with waste by-product like marble powder and copper slag. Here, addition of marble powder is done by increasing percentage of 5% of cement and copper slag at the increasing percentage of 10% by weight of fine aggregates. This project focuses in concrete when cement is partially replaced with marble powder and fine aggregates by copper slag in M35 grade concrete. In this project, four proportions such as 0%, 5%, 10% and 15% of cement has been partially replaced with marble powder and six proportions of fine aggregates such as 0%, 10%, 20%, 30%, 40% and 50% has been partially replaced with copper slag. Various types of destructive test for strength are examined at 7 and 28 days.

KEYWORDS: Concrete, Marble Powder, Copper Slag, Strength, Cement, Fine Aggregate

Received: Jun 10, 2020; **Accepted:** Jun 30, 2020; **Published:** Jul 21, 2020; **Paper Id.:** IJMPERDJUN2020405

INTRODUCTION

Due to the evolution of concrete technology, pollutants which are hazardous to environment as well as humans are highly reduced. Several waste products are generated by different industries and dumping of these waste materials causes various problems. Every year the waste that is generated in industries is in terms of tons which are directly dumped in open space. So, recycling becomes mandatory. Both marble powder and copper slag are the by-products which is found in industries. Using such alternative material will make concrete more sustainable and also make eco-friendly material. Also, for manufacturing economic and long-lasting concrete, these waste materials will help the civil engineer fraternity to fulfill the economy in various infrastructural projects and also it will help in reducing degradational problem in the environment. In civil engineering, concrete is considered as one of the essential material widely used in various construction purposes. Approximately, 7% of Ordinary Portland Cement is produced which is directly emitted in the atmosphere. Generally, marble powder is an after-effect material which is obtained at a time of marble cutting. Marble Dust Powder is generally composed of recrystallized carbonate minerals. It can also be used as an admixture in the concrete so as to increase its strength. Marble dust powder is considered as an economical material but adding to it, marble powder also shows improvement in the concrete. Marble dust has a better advantage since voids in the concrete can be filled and gives adequate compression strength.

Waste copper slag which is also an industrial by-product, retains its original properties. Copper slag has a shiny appearance and the material is black in color. Copper slag contains SiO_2 which makes its properties similar with that of sand. Aluminum oxide, high iron and silica are included in the chemical composition of copper slag. Therefore, it can be utilized further for partially replacing with fine aggregates. In copper metal production, nearly about huge amount of waste slag ranging from 2 to 2.5 tons is produced. Some of the properties in which copper slag can be used are given below:

- It can be used as a construction material in many different industries related to buildings.
- For the manufacturing of different types of abrasive tools, copper slag has been widely used.

Investigation has been done to judge various strength in the concrete mixes.

METHODOLOGY

Material Properties

Table 1: Cement Properties

Sl. No.	Properties	Values
1	Cement Grade (OPC)	43
2	Specific Gravity	3.3
3	Fineness	2.27
4	Normal Consistency	30.5%
5	(a) Initial Setting Time	29 min
	(b) Final Setting Time	549 min

Table 2: Aggregate Properties

Sl. No.	Properties	Values
1	Specific Gravity of Fine Aggregates	2.6
2	Fineness Modulus of Fine Aggregates	3.12
3	Specific Gravity of Coarse Aggregates	2.67
4	Fineness Modulus of Coarse Aggregates	8.09

Table 3: Admixture Properties

Sl. No.	Properties	Values
1	Specific Gravity Marble Powder (g/cm^3)	2.71
2	Surface by Blaine (cm^2/gm)	4372
3	Physical Form of Copper Slag	Angular Granules
4	Moisture Content in Copper Slag	<0.1%

Experimental Work

Mix Design and Proportion: In this paper, M35 grade concrete was prepared as per IS 10262: 2019. 1:1.6:2.92 is the mix proportion used and water cement ratio 0.38 was kept constant throughout the mix.

Sample Mix Preparation: For testing compression strength of cubes, mould size of 150×150×150mm was used. Likewise, for flexure test the size used is 100×100×500mm and also, for split tensile strength the size used is 150mm×300mm. The samples were made for 7 and 28 days testing. Total 252 samples were casted for testing, out of which 72 samples (24 cubes, 24 beams, 24 columns) was prepared for cement partially substituted with marble powder, 108 samples (36 cubes, 36 beams, 36 columns) for partial substitution of fine aggregates by copper slag and 72 samples (24 cubes, 24 beams, 24 columns) of cement and fine aggregates when partially substituted by both marble powder and copper slag.

For the combination of cement and fine aggregates when partially substituted with marble dust and copper slag, the replacement percentage of marble powder was kept constant at 5%. And for copper slag, the replacement percentage varied from 20-40% i.e. (5%+20%, 5%+30%, 5%+40%, 5%+50%). Marble powder was kept at 5% constant as it gave the maximum strength as per the data in table 4.

TESTING AND RESULTS

As per the experiment work done in concrete, compression, flexural and split tensile test were conducted and following values were drawn:

Table 4: Compression, Flexural and Split Tensile Test Results

Sl. No.	Materials	Percentage Replacement	Compression Strength Results (N/mm ²)		Flexure Strength		Split Tensile Strength	
			7 Day	28 Day	7 Day	28 Day	7 Day	28 Day
1	% Replacement of Cement by Marble Powder.	0%	26.4	35.7	4.6	7.1	2.2	3.6
		5%	29.8	38.5	6.4	8.7	2.4	4.1
		10%	28.4	37.04	5.3	8.1	2.6	3.8
		15%	27.6	36.8	5.1	7.9	2.3	3.7
2	% Replacement of Fine Aggregate by Copper Slag.	0%	26.8	35.7	9	7.1	2.53	3.6
		10%	26.9	36.3	5.25	8.4	2.56	3.8
		20%	28.4	39.7	5.5	8.9	2.70	3.9
		30%	31.2	40.2	6.03	9.1	2.73	4.3
		40%	30.7	38.3	6.3	8.4	2.73	4.6
		50%	27.3	37.1	5.25	8.2	2.63	4.3
3	Marble Powder + Copper Slag.	5% + 20%	27.8	38.3	6.3	8.4	2.53	3.9
		5% + 30%	30.9	39.8	6.82	9.3	2.59	4.6
		5% + 40%	29.1	42	6.03	8.9	2.67	4.9
		5% + 50%	28.6	40.6	5.48	8.7	2.56	4.1

Compression Test Results

Figure 1: Variation in Compression Strength of Marble Powder.

Figure 2: Variation in Compression Strength of Copper Slag.

Figure 3: Variation in Compression Strength for Combination with Marble Powder and Copper Slag.

Flexural Test Results

Figure 4: Variation in Flexural Strength of Marble Powder.

Figure 5: Variation in Flexural Strength of Copper Slag.

Figure 6: Variation in Flexural Strength for Combination of Both Marble Powder and Copper Slag.

Split Tensile Test Results

Figure 7: Variation in Split Tensile Strength of Marble Powder.

Figure 8: Variation in Split Tensile Strength of Copper Slag.

Figure 9: Variation in Split Tensile Strength for Combination of Marble Powder and Copper Slag.

CONCLUSIONS

- When cement gets partially replaced by marble dust, optimum percentage replacement of 5% shows highest strength after which the strength goes on decreasing.
- When fine aggregates get partially substituted by copper slag, the optimum percentage replacement of 30% shows highest strength.
- Furthermore, with the combination of both marble powder and copper slag when it is replaced partially by 5% cement and by 20%,30%,40%,50% fine aggregates, 40% replacement shows high strength after which the strength gradually decreases.
- Properties of strength such as compression, flexural and split tensile shows positive significant change when fine aggregates are replaced partially by copper slag.
- Concrete mix (5% marble powder + 40% copper slag) shows that there is an increase of 17.64% in compression strength, 36.11% increment in split tensile. While in flexural, it (5% marble powder + 30% copper slag) gives an increment of 30.98%.
- When compared to cement, marble dust powder gives sufficient strength and also helps in maintaining the ecological balance.

REFERENCES

1. Al-Jabri, K. S., Hisada, M., Al-Oraimi, S. K., & Al-Saidy, A. H. (2009). Copper slag as sand replacement for high performance concrete. *Cement and Concrete Composites*, 31(7), 483–488. doi:10.1016/j.cemconcomp.2009.04.007
2. Ergün A. (2010) Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete. *Construction and Building Materials*, 25(2), 806–812. doi:10.1016/j.conbuildmat.2010.07.002
3. Prof. P.A. Shirulea, AtaurRahmanb& Rakesh D. Gupta, “Partial Replacement of Cement with Marble Dust Powder,” *International Journal of Advanced Engineering Research and Studies*, Vol-1, Issue-8, October 2012 E-ISSN2249–8974.
4. Vijayaraghavan, J., Jude, A. B., &Thivya, J. (2017). Effect of copper slag, iron slag and recycled concrete aggregate on the mechanical properties of concrete. *Resources Policy*, 53, 219–225. doi:10.1016
5. Singh, M., Srivastava, A., &Bhunia, D. (2018). Long term strength and durability parameters of hardened concrete on partially replacing cement by dried waste marble powder slurry. *Construction and Building Materials*, 198, 553–569. doi:10.1016/j.conbuildmat.2018.12.005
6. IS 8112:2013. (2013). Ordinary Portland Cement, 43 Grade. Indian Standard.
7. IS 10262:2019. (2019). Concrete Mix Proportioning. Indian Standard.
8. IS 382:2016. (2016). Coarse and fine aggregates for concrete. Indian Standard.
9. IS 5816:1999. (1999). Splitting tensile strength of concrete. Indian Standard.
10. IS 9103:1999. (1999). Specification for Concrete Admixtures. Indian Standard.
11. R. Elamaram, K. Srinivasan & S. Vimala, ”Use of Copper Slag for Partial Replacement to Fine Aggregate in Concrete”, *International Journal of Recent Technology and Engineering (IJRTE)*, Volume-7, Issue-5S3, February s2019.
12. S. Govindhan & P. Papitha, “Experimental Study of Concrete with Copper Slag for Partial Replacement of Fine Aggregate”, *International Research Journal of Engineering and Technology (IRJET)* Volume: 06 Issue: 03 | Mar 2019.
13. Abhisheka H Honnakkalavar, T Krishna & K Narayan, “Experimental Study on concrete using Copper Slag as Replacement Material of Fine Aggregate”, *International Research Journal of Engineering and Technology (IRJET)* Volume: 05 Issue: 05 | May-2018
14. Ms. Ruchi Chandrakar& Mr. Avinash Singh, “Cement Replacement in concrete with Marble Dust Powder”, *International Research Journal of Engineering and Technology (IRJET)* Volume: 04 Issue: 05 | May -2017.
15. Raghvendra& Prof. M. K. Trivedi, “Partial Replacement of Cement with Marble Dust Powder in Cement Concrete”, ISSN: 2321-9653 *International Journal for Research in Applied Science & Engineering Technology (IJRASET)* Volume 5 Issue V, May 2017.
16. S. Kalaiselvi, S.Prabhakaran&Jagadeesan.K , “An Experimental Investigation on Partial Replacement of Copper Slag as Fine Aggregate in Paver Block”, *International Journal of ChemTech, Research* Vol.10 No.9, pp 306-310, 2017.
17. Zine Kiran Sambhaji&Prof.Pankaj B. Autade., “Effect of Copper Slag As A Fine Aggregate on Properties of Concrete”, *International Research Journal of Engineering and Technology (IRJET)*, Volume: 03 Issue: 06 | June-2016
18. Mr. Ranjan Kumar &Shyam Kishor Kumar, “Partial Replacement of Cement with Marble Dust Powder,” Mr. Ranjan Kumar *Int. Journal of Engineering Research and Applications*, ISSN: 2248-9622, Vol. 5, Issue 8, (Part - 4) August 2015, pp.106-114

19. Paresh Tiwari & Anil Kumar Saxena, "A Review on Partial Substitution of Copper Slag with Sand in Concrete Material," *International Journal of Engineering Research & Technology (IJERT)*, ISSN: 2278-0181 Vol. 5 Issue 12, December-2016.
20. Pranshu Saxena & Ashish Simalti, "Scope of Replacing Fine Aggregate with Copper Slag in Concrete- A Review," *International Journal of Technical Research and Applications e-ISSN: 2320-8163, www.ijtra.com Volume 3, Issue 4 (July-August 2015), PP. 44-48.*
21. Bakhoun, E S, G L Garas, and M E Allam. "Sustainability Perspective of Saw-Gang Granite Waste in Concrete Mixes." *International Journal of Civil Engineering (IJCE)* 4.5 (2015):1-10.
22. Singh, Saurabh Kumar, et al. "A Review on Effect of Mineral Admixture on Self Compacting Concrete." *International Journal of Civil Engineering (IJCE)* 3.3 (2014):79-90.
23. Hashim, Ameer Mohsin, and V. C. Agarwal. "Experimental study on strength and durability of concrete with marble and granite powder." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)* 4.2 (2014): 147-156.
24. Wani, Saqib Fayaz, et al. "Study on mix design & hardened properties of self-compacting concrete." *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)* 5.4 (2015): 1-10.