Evaluation of Properties of Concrete by using Marble Dust as Partial Replacement of sand

Zeeshan Ullah[1], Shah Jahan[2], Saleh Hayat[2], Faheem Ahmed Soomro[3], Muhammad Irfan[4], Rustam Ali Khan[5]

[1]*Department of Construction Engineering & Management (CE&M), NITSCEE, NUST, Islamabad, Pakistan*
[2]*The University of Lahore Gujarat Campus, Pakistan*
[3]*Khairpur Medical College, Khairpur, Pakistan*
[4]*Civil Engineering Department KFUEIT Rahim Yar khan, Pakistan*
[5]*Hexagon Engineering Private, Peshawar, Pakistan*

Abstract: **High demand of infrastructure has generated enormous focus on the concrete industry to produce a large amount of high strength concrete. The concrete strength depends on its constituent and their properties and qualities. Sufficient mixing of the constituents in desirable quantities gives reasonable strength to concrete. Due to fast-growing concrete structures, natural resources are depleting and consequently concrete industry giving devotion towards a suitable fine aggregate that can replace the natural river sand. Utilization of factory by-products or aggregates obtained as waste material probably decrease the adverse environmental impact and waste management cost, reduction in concrete cost and possibly improve concrete strength. The optimum percentage of marble dust to replace sand is determined on the basis of compressive strength and splitting tensile strength of concrete. This investigation is done to contemplate the impact of marble dust on compressive quality and elasticity when fused in concrete as a halfway substitution of sand. In this study, sand is partially replaced with marble dust in the ratios of 0%, 3%, 6%, 9%, 12%, and 15% to improve the performance and quality of concrete. The results show at 12 % of replacement of sand by marble dust, the compressive strength of concrete increased 13.34 % and splitting tensile strength increased 21.19 %. When increased in marble dust percentage the slump value of concrete decreased due to water absorption properties of marble dust. At optimum percentage of replacement of marble dust, some other mechanical properties of concrete like binding properties, spalling resistance, cracks and micro cracking control have also improved.**

Keywords: **Compressive Strength, Splitting Tensile Strength, Partial Replacement of sand**

I. INTRODUCTION

Advance and rapid growth in the infrastructures have made concrete the most widely and generally developed construction material all around the world. Utilization of factory by-products or aggregates obtained as waste material probably decrease the adverse environmental impact and waste management cost, reduction in concrete cost and possibly improve concrete strength(Chawla, 2016). The compressive strength of concrete increases when cement, sand, and aggregate are properly mixed together in correct proportions. Fine aggregate acts as the filler in concrete and forms an essential part of the concrete. The most commonly used fine aggregate is the natural river sand (Vigneshpandian, Shruthi, Venkatasubramanian, & Muthu, 2017). The mix design should also fulfil the required workability of fresh concrete so as to prevent segregation, bleeding and to achieve the desired ease of placement. Normally a concrete mix comprises of 10% to 15% cement, 25% to 30% and 40% to 45% aggregate. Admixtures are also used in fresh concrete to improve its properties and quality. This research concerns about the use of marble dust in concrete, which may reduce both environmental impacts and the cost. Improvement of concrete properties in the construction field is critical. Marble waste is full of calcium oxide which has cementing property but it creates many environmental hazards too if left in an environment or in water (Ashish, Verma, Kumar, & Sharma, 2016). Marble dust is one of such material that can be utilized as another option to enhance the compressive quality of concrete(Chawla, 2016).
Marble dust in the substitution of sand in solid, it diminishes the unfriendly ecological impact and additionally, it builds the compressive quality of cement. Marble dust in specific extents likewise expands the compressive quality, flexural quality and part rigidity of cement (Md Mahboob et. al., 2014).

II. LITERATURE REVIEW

Marble extraction and its processing as marble blocks are the most important minim activities. Due to a huge amount of marble sludge during the production of marble put adverse impact on the environment and causes air and water pollution. Almost 25% to 30% of marble block becomes waste marble dust and marble sludge. Because large amount of marble dust and marble sludge produced during the processing, strophe and dumping of these waste materials is not an easy task for the factory workers. It is very beneficial and acceptable for marble industries environmentally and financially when the waste marble dust used in the production of concrete (Gulden Cagin Ulubeyli et. al., 2015).
Utilizing of waste marble in the customary or self-compacting concrete as mineral added substances or fine total was decidedly influenced by these toughness properties of cement. For protection from carbonation of the solid blends, no huge contrast was viewed with other cement blends (Gulden Cagin Ulubeyli et. al., 2016). Mechanical properties and robustness of unrivaled bond are examined by using marble powder as deficient substitution of cement. At 15% substance of marble powder with a fineness modulus of 11500cm2/g in a chloride area, showed insistently contributes its durability in regards to migration of chloride particles and oxygen permeability and besides contributes firmly to the perfection of its mechanical properties. The examination contemplated that positive effect of marble powder on the properties of bond under hydrochloric mediums

(Vazzoler, Vieira, Teles, Degen, & Teixeira, 2018). The investigation presumed that waste marble is well and satisfactory as incomplete supplanting in concrete with total in the clearing piece (Osman Gencel et. al., 2012). The substitution extents which have been analyzed were 0.0%, 5.0%, 7.5%, 10.0% and 15% by weight. Water to powder extent (w/p) or water to the bond extent (w/c) were 0.50 and 0.40 if there ought to emerge an event of solid substitution and if there ought to be an event of sand substitution separately. Physical, mechanical and compound properties of bond and concrete changed with marble dust were inspected. Test outcomes of security paste and solid mortar show that the marble dust blended bond remains inside the acceptable extents of the Egyptian standards. Nonetheless, concrete made with marble dust as sand substitution achieved better execution appeared differently in relation to concrete made with marble spotless as bond substitution (Ali A. Abdo et. al., 50).

The stone clean is supplanted with sand by weight of 0%,5%,10%,15%,20%,25% and 30%.when it is utilized at 30% these are great in workability and give a high quality. When tested for 7, 14, and 28 days, the outcome is increased compressive strength. Keeping in view all the analysis, the motivation behind this examination to know the conduct of cement by supplanting of stone clean with sand and concrete (Ghorbani, Taji, Tavakkolizadeh, Davodi, & de Brito, 2018). This examination attested the difference in the physical and substance properties of bond with marble powder development; this shows the conceivably favored point of view of using this supplementary cementitious material (Rabah Chaid, et, al., 2015).The usage of such materials achieves security of normal resources and also has any kind of effect in keeping up awesome characteristic conditions. The present examination focuses in the examination of properties of mortar and cement in which Smashed Shake Powder (CRP) is used as a deficient and full substitution for trademark sand (Binici & Aksogan, 2018). For mortar, CRP is supplanted at 20% 40%, 60%, 80% and 100%. The key quality properties of concrete were analyzed by supplanting typical sand by CRP at substitution levels of 20%, 30%, and 40%. (Nagabhushana, et. al., 2011). The growing of marble powder extent as a substitution of concrete over the perfect measurement prompts the disconnection of aggregate and leaking of bond which incite decay in the security of concrete. Extending the marble powder extent substitution of concrete provoked the growing as the compressive quality by around (25% and 8%) for the marble powder substitution extents (5% and 7.5%) took a gander at to the control mix (Soliman, 2013).

III. METODOLOGY

Today large amount of marble wastes has been generated in marble plants that have negative impact on the environment and causes adverse effects on human beings. In order to reduce that effect an attempt is made to utilize that marble waste in concrete. This section is all about the methodology of research that explain the step by step road map of research. In the first step material has been procured followed by prilimanry tests of the material. Concrete mixture design has carried out and then samples has been casted for testing. At the end, sample testing has been carried to find out the suitable results. Figure 1 represents the methodology of this research.

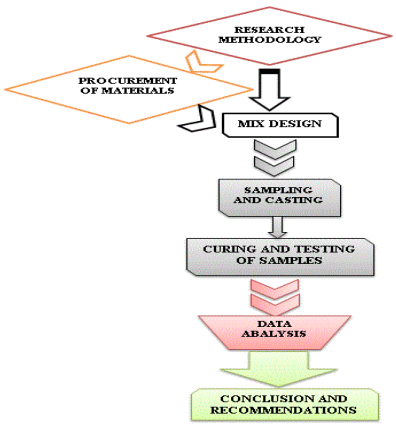

Figure 1: Flow Chart of Methodology

A. Materials Used

Concrete is a heterogeneous mixture of cement, sand, crush and water. Cement cover 15%-20% of the total volume of concrete mix. Concrete strength is depending on the quantity of cement. Aggregate which retained on sieve 4.75 mm is known as the coarse aggregate which covers 50%-60% and aggregates passing through 4.75 mm sieve, is known as fine aggregates which covers 25%-30% of total volume of concrete. Blend configuration is the way toward choosing appropriate elements of cement and deciding their relative amounts with the target of creating as financially as conceivable cement of certain base properties, for example, workability, quality and solidness. The blend proportion is 1:2:4 and water-bond proportion is 0.50. The objective quality of the solid barrels tests is 3000 psi.

In the first step, preliminary tests were performed to find out the basic properties of concrete ingredients along with the marble dust powder. After evaluating all the basic properties of materials, the concrete mixture was designed and prepared. For the sampling, cylinders have been casted to verify compressive strength and tensile of the mix. Size of 4-inch diameter and 8-inch height cylinders are used for casting of samples. Total 108 cylinders samples have been casted for testing with varying percentages of marble dust from 0% to 15 % by weight of sand. A set of three cylinders have been casted for testing at different ages like 3 days, 7 days and 28 days.

IV. DATA ANALYSIS

A. *Compression Test Results*

Total 108 samples were casted and tested to evaluate the effect of use of marble dust on compressive and tensile strength of concrete. Compression test was performed to find out the compressive strength of samples at different curing ages like 3 days, 7 days and 28 days and at different marble dust percentages that was added in concrete in replacement of sand like 3%, 6%, 9%, 12% and 15 %. Comparison of average compressive strength of samples at different curing ages and with different percentages of marble dust in concrete has been given below in the graph.

Table 1: Comparison of Compressive Strength of Concrete

Sr. No	Age of Sample	Average Stress (Psi) at Different %ages of Marble Dust				
		3%	6%	9%	12%	15%
1	3-Days	2013.56	2055.54	2105.05	2205.81	1998
2	7-Days	2597.6	2610.12	2630.99	2764.57	2580
3	28-Days	3269.66	3497.46	3579.75	3692.46	3435

The samples were tested at different ages to find out the rate of gain of compressive strength in concrete. It is clear from the above figure and table that with the increase in marble dust powder in concrete mix the compressive strength of concrete also increased. This trend has been seen from 0% to 12% addition of marble dust in concrete while at 15% replacement of marble dust the compressive strength of concrete has been reduced. It means 12% is the threshold value of replacement of marble dust in concrete. It is because, there is some contents of calcium oxide in marble dust powder which has binding properties and excel the compressive strength of concrete.

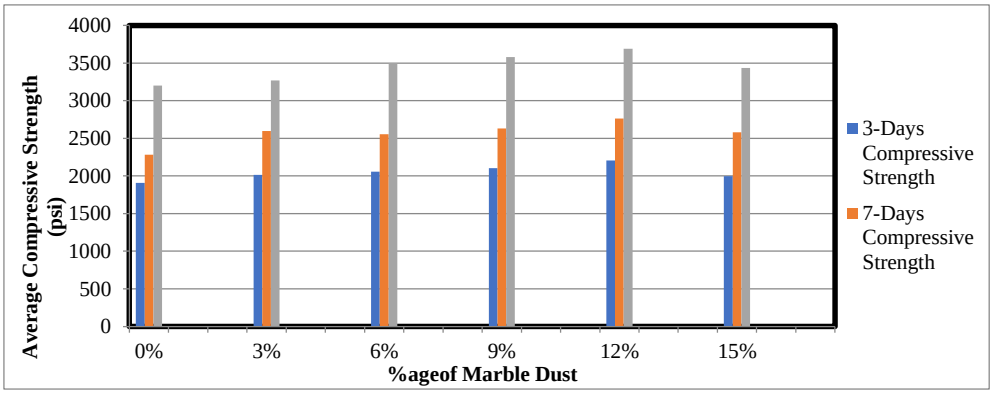

Figure 2: Compressive Strength Comparison

B. *Split Cylinder Test Results*

The concrete samples were casted and tested to evaluate the effect of use of marble dust on tensile strength of concrete. Split cylinder test was performed to find out the tensile strength of samples at different curing ages like 3 days, 7 days and 28 days and at different percentages of marble dust that was added in concrete in replacement of sand like 3%, 6%, 9%, 12% and 15 %. Comparison of average tensile strength of samples at different curing ages and with different percentages of marble dust in concrete has been given below in the graph.

Table 2: Comparison of Tensile Strength of Concrete

Sr. No	Age of Sample	Average Stress (Psi) at Different %ages of Marble Dust				
		3%	6%	9%	12%	15%
1	3-Days	241.18	256.38	276.95	280.98	229.4
2	7-Days	318.24	330.32	355.06	357.45	283.5
3	28-Days	416.47	436.9	454.48	458.51	389.8

The samples were tested at different ages to find out the effect of replacement of marble dust on concrete at different ages. Similar to the compressive strength results, there is an increase in tensile strength of concrete with the increase in marble dust

percentage in concrete. This trend has been seen from 0% to 12% addition of marble dust in concrete while at 15% replacement of marble dust the tensile strength of concrete has been reduced. It means 12% is the threshold value of replacement of marble dust in concrete same for tensile and compressive strength parameters.

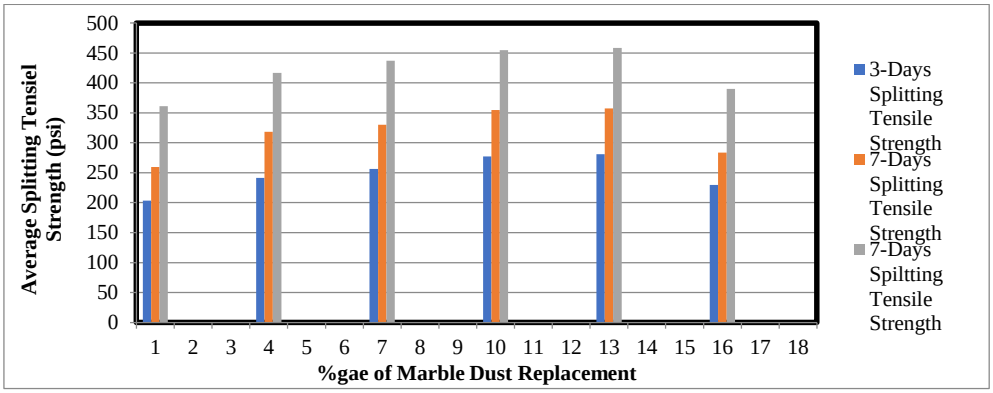

Figure 3: Comparison of Tensile Strength of Concrete

V. CONCLUSION

After the preliminary tests on materials, concrete mixture design and casting of samples, compression and tensile strength tests were performed on the samples. The samples contained different percentages of marble dust powder and were tested at different ages to find out the effect of marble dust powder on strength of concrete at those ages. Following are the major conclusions of this research study:

1. This experimental study concluded that the optimum value of marble dust in concrete is 12 %.
2. It is observed that there has been improvement in the properties of concrete in terms of its compressive strength and split tensile strength corresponding to the percentages of marble dust.
3. The investigations showed that at 12 % of replacement of sand with marble dust, there is 13.34 % increase in compressive strength and 21.19 % increase in splitting tensile strength of concrete at 28 days curing age.
4. Compressive and tensile strengths were reduced as the value of marble dust has been increased from 12 % to 15% by the weight of sand.
5. The particle size of marble dust powder is smaller than the particle size of sand that is why surface area of marble dust powder will eb more and it will absorb more water. Therefore, the slump value of concrete having marble dust powder has been reduced as compare to ordinary mxi concrete.
6. At optimum percentage of replacement of marble dust, some other mechanical properties of concrete like binding properties, spalling resistance, cracks and micro cracking are also improved.
7. The marble dust replacement in concrete will be cost effective as marble dust powder is available at free of cost while sand has high price.
8. The demand of sand will be reduced by adopted marble dust as patricidal replacement. This will helpful in improving the sustainability of natural resources.

VI. RECOMENDATION

Replacement of waste marble dust as a binding agent in concrete helping the access for further research in the given field. Following are the basic recommendations of this research work.

1. Marble dust powder is a waste material; therefore, it should be used in concrete as a replacement of sand to reduce the demand of sand.
2. Some suitable admixtures can also be used in the concrete to improve the concrete properties up to some extents.
3. With the varying percentages of marble dust and by adding some suitable admixtures in concrete the optimum value can be tested.

REFERENCE

[1] Ali A. Alibdo,Esraa M.Auda. (2014 Volume 50). Re-use of waste marble dust in the production of cement and concrete. *Construction and Building Materials*, 28-41.

[2] Chawla, A. (2016). *impact of use of marble waste on the properties of light transmitting concrete.* Jaipur: Malaviya natonal institute of technology jaipur, India.

[3] Deepankar Ashish, Surender Kumar Verma. (2016). Properties of Concrete incorporating sand and cement with waste marble powder. *Advances in Concrete Construction*, 2-17.

[4] Deepankar Kumar Ashish, S K Verma,Ravi Kumar, and Nitisha Sharma,. (2016). Properties of concrete incorporating waste marble powder as partial. *The 2016 Structures Congress, ,korea*,1-4.

[5] Gulden Cagin Ulubeyli, Turhan Bilir, Recep Artir. (2016). Durability Properties of Concrete Produced by Marble Waste as Aggregate or Mineral Additives. *World Multidisciplinary Civil Engineering-Architecture-Urban Planning Sympopsium WMCAUS*, 1-6.

[6] Gulden Cagin Ulubeylia,Recep Artirb. (2015). Properties of Hardened Concrete Produced by Waste Marble. *World Conference on Technology, Innovation and Entrepreneurship*, 1-10.

[7] Md Mahboob Ali, Prof. S. M. Hashmi,. (2014). An Experimental investigation on strengths characteristics of concrete with the partial replacement of Cement by Marble Powder dust and Sand by Stone dust. *International Journal for Scientific Research & Development*, 1-9.

[8] Nagabhushana, H. Sharada bai. (2011). Use of crushed rock powder as replacement of fine aggregate in mortar and concrete. *Indian Journal of Science and Technology*, 1-6.

[9] Osman Gencel, Witold Brostow. (2012). Properties of Concrete Paving Blocks made with Waste Marble. *Journal of Cleaner Production, volmue 21*, 62-70.

[10] Rabah Chaid, Arnaud Perrot,Youcef Ghernouti. (2015). Durability of Concretes with Marble Powder. *International Conference on Environment Science and Engineering*, 1-8.

[11] Soliman, N. M. (2013). Effect of using Marble Powder in Concrete Mixes on the Behavior and Strength of R.C. Slabs. *International Journal of Current Engineering and Technology*, 1-8.