IJMRSETM

e-ISSN: 2395 - 7639

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

Volume 9, Issue 7, July 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.580

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 7, July 2022 |

| DOI: 10.15680/IJMRSETM.2022.0907020 |

Marble Dust Mix with Concrete to Test Compressive Strength

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ABSTRACT: This article focuses on using marble waste powder in cement and concrete and achieved the following results and conclusions. Since Ethiopian Marble Processing Enterprise's marble waste powder met EN 197-1, we used it to produce Portland limestone cement. A comparison was made between the natural fineness of marble waste and the fineness of current cements, and it was discovered that the natural fineness of the marble waste was equivalent. The compressive strength of marble waste powder substituted for up to 5% of conventional Portland cement is the same as that of regular Portland cement made up of 100% ordinary Portland cement. Replacing 10%, 15%, and 20% of the original cement results in lower compressive strength than replacing 100% of the original cement with regular Portland cement. Cements with replacement ranges of 5 to 15 percent meet the requirements for high early strength class 42.5 MPa according to the EN 197-1 standard, whereas cements with replacement ranges of 20 percent meet the criteria for high early strength class 32.5 MPa according to the standard. The total compressive strength of the mixture is diminished when more marble debris is added to conventional Portland cement. Blended cements generated from marble waste have other qualities that fit within the acceptable criteria of the different standards in terms of consistency, setting times, insoluble residue and sulphate residue. The drop of concrete mixtures is enhanced when marble waste powder is used to replace up to 20% of the sand in the mixture, according to the results of the experiment. On the other hand, when marble waste powder is utilised to replace up to 20% of the cement in a concrete mixture, the slump improves. The compressive and flexural strengths of marble waste-free concrete specimens may be achieved by substituting marble waste powder for 5% of the cement in concrete manufacturing. The total strength of the concrete decreases when the replacement percentage rises over 5%. The same degree of strength may be achieved by substituting up to 20% of the sand in concrete with waste powder from marble, both when the concrete is new and after it has aged. The water penetration depth is reduced when marble waste powder is utilised to replace 5% of the cement in concrete examples. However, the water penetration depth of concrete specimens increases when the replacement range exceeds 5%.

KEYWORDS: Manufacturing of Cement, Compressive Strength, Concrete Manufacturing

I. INTRODUCTION

Concrete that is made with Portland cement is most likely the man-made material that is put to use the most frequently across the entire planet. In spite of this, the production of concrete is one of the global issues that has an effect on the surrounding environment. The most significant of these impacts is global warming, which is caused by CO_2 emissions that occur during the production of cement. It is estimated that the production of cement is responsible for approximately 3 percent of the world's anthropogenic emissions of greenhouse gases and 5 percent of the world's anthropogenic emissions of CO_2.Since the combustion of limestone results in the decomposition of approximately half of the CO_2 that is produced during the manufacturing of cement, blending is regarded as a highly effective method for reducing CO_2 emissions. The majority of the blending materials utilised in cement production and included in either plants or sites are various types of industrial waste. This is due to the fact that recycling industrial wastes as blending ingredients provides benefits in the areas of technology, economics, and the environment, in addition to reducing CO_2 emissions produced during the manufacturing of cement. The term "performance improvement of concrete" is used to express the significance, from a technical standpoint, of the utilisation of wastes and by-products in the production of concrete.The economic benefit is typically attributed to the reduction in the amount of costly and/or scarce ingredients by replacing them with materials that are less expensive. When industrial wastes are recycled, not only are CO_2 emissions reduced, but residual products from other industries are also reused, which results in less material being dumped as landfill and more natural resources being saved [5]. Recycling industrial wastes also has a positive effect on the environment.Because of their reactive nature, also known as their pozzolanic behaviour, industrial wastes such as flyash, blast furnace slag, and silica fume are most commonly used in place of cement in the production of concrete.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 7, July 2022 |

| DOI: 10.15680/IJMRSETM.2022.0907020 |

Other inert by-products and waste materials, in addition to pozzolanas, have been used in the production of concrete and mortar as an inert filler for reasons that are analogous to those of pozzolanas.

Among these, marble dust powder, which is a by-product of a marble processing factory, has been studied by many researchers for its use in concrete and mortar production as an alternative to sand or cement.In the majority of cases, researchers found favourable outcomes and advantages. It is necessary to conduct similar research in our country in order to incorporate it in concrete and cement production for the purpose of reducing environmental pollution and making sustainable use of natural resources. This is because the chemical composition of the by-product, which is the powder, varies depending on the parent marble rocks, which in turn varies depending on the locality, degree of metamorphism, and other factors.

Because marble is a derivative of limestone and has a composition that is comparable to that of limestone, and because in the marble industry both limestone and marble that can be polished are considered to be marble and are worked together in the factory, the formation and properties of both limestone and marble are represented in this literature review. Marble is a derivative of limestone and has a composition that is comparable to that of limestone.

In addition, because calcium carbonate filler that was derived from marble or limestone is commonly referred to as limestone filler, previous studies of limestone filler in cement and concrete are presented for the purpose of developing theories and concepts.

II. MATERIALS USED IN STUDYING THE PROPERTIES OF MARBLE WASTE POWDER BLENDED CEMENTS

2.1Clinker

For the production of laboratory cements, clinker from Mugher cement factory was chosen. For thistest purpose, the sample of the clinker was collected from the clinker silo which was collected afterpassing the full clinker zation process by controlling the raw materials in such a way that theirchemicalcompositionwere within thenorm of thefactory.

To have consistent product and to keep the quality of cement, the factory used to control therawmaterialmixby chemical lanalysisandcomputerizedcontrolsystem.Forthispurpose,fromexperience, it sets its norm chemical range for each raw material such that the clinker is expected tobe consistent and be within the standard. It corrects any deviation, of the raw material chemicalcomposition from the range, by adjusting the raw material proportion and or using corrective rawmaterials. The clinker used for the test was also produced from raw materials whose chemicalcompositionwaswithin thenorm ofthe factory.

The sample of the clinker was tested for its chemical and mineralogical composition and the testresultsareshown in Table2.1 and 2.2 below.

Table 2.1: Chemical composition of Mugher clinker used for the test

Chemical composition	Test result (%)
SiO_2	20.03
Fe_2O_3	3.73
Al_2O_3	5.94
CaO	66.31
MgO	1.07
SO_3	1.14
K_2O	
Na_2O	
LOI	0.08
IR(insolubleresidue)	0.12
F-CaO(free calcium)	1.94
$CaCO_3$	77.87

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Table 2.2: Mineralogical composition of Mugher clinkerusedforthe test

Mineralogical composition	Test result (%)
C_3S	61.25
C_2S	11.23
C_3AF	9.42
C_4AF	11.38

2.2 Gypsum

The gypsum used for the test was also taken from the source of Mugher cement factory. Before itwas used in the Portland cement production, the gypsum was crushed in raw material grinding milland dried in the lab. The chemical composition of the gypsum was tested to check its conformity tothenormofthe factory. Thetest results areshown in Table 2.3 below.

Table2.3:Chemicalcomposition ofgypsumusedforthetest

Chemical composition of gypsum	Norm (%)	Sample gypsum (%)
H_2O		10
SiO_2	0.2-15	16
Fe_2O_3	0.5-1.5	1.2
Al_2O_3	1-4.3	3.5
CaO	28-34	30
MgO	0.6-3	0.45
SO_3	28-43	35
K_2O	<=0.3	Negligible
Na_2O	<=0.3	Negligible
LOI	12.6-24.5	9

2.3 MarbleWastePowder

Before using marble waste powder for the test, four samples, collected on different times from thethree factories of The Ethiopian Marble Processing Enterprise were examined for their fineness andchemical composition. Thetestresultsareshown in Table 2.4and 2.5 below.

Table2.4:Chemicalcompositionofmarblewastepowdersamples

Chemical composition	Marble waste 1 (%)	Marble waste2 (%)	Marble waste3 (%)	Marble waste4 (%)
SiO_2	0.62	1.08	3	1.14
Al_2O_3	0.16	0.4	0.25	0.2
Fe_2O_3	0.10	0.12	0.56	0.24
CaO	54.91	53.79	52.45	53.57

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Table2.5:Finenessofmarblewastepowdersamples

Physical property	Marble waste 1	Marble waste 2	Marble waste 3	Marble waste 4
Fineness (averageof5tests) (Blaine)	3571cm^2/	4843cm^2/	4843cm^2/	4843cm^2/

Thentwosamples,onewithfinenessof3571cm^2/g(sample1)andanotherwith finenessof4843cm^2/g (sample 2) were selected and used for the test as all the samples are similarin chemicalcomposition.

2.4 CENStandardSand
The sand used for the study to determine the strength of cement was CEN standard sand with wellgradedroundedparticlesandhasaSilicacontentof98%asspecifiedinEN196-1standardrequirement. This CEN sand is delivered in plastic bags with a content of 1350 gm.It is importedfrom Germanybythe Mugher cement enterprise for qualitycontrol ofcement production.

2.5 Chemicals
For determination of the chemical and mineralogical composition as well as sulphate and in soluble residue, different chemicals were used as per the specified method of testing cement based on theEuropeanstandardEN 196.2.

2.6 Water
Throughout the investigation, tap water supplied for drinking consumption at Mugher was used forcuring the hardened mortarsamples. For allphysicaland chemicalanalysisdistilled water wasused.

III. MATERIALS USED IN STUDYING CONCRETE PROPERTIES

3.1 Cement

For studying the effects of marble waste powder on the properties of concrete, it was proposed touse Mugher OPC; however as Mugher was not producing OPC and also as other factories wereconcentrating on production of PPC, it was difficult to get any OPC in and around Addis Ababaduring the studying period. Therefore, it was a must to search and use another comparable cementthatMossobo OPC was collected fromMekele and wasused fortheexperiment.
That is, for all concrete specimens casted for the investigation, cement of Mossobo OrdinaryPortland, which was manufactured according to Ethiopian standard ES-1177-1-2005 and Europeanstandard EN-197-1-2000, was used. Its typical chemical and mineralogical compositions are showninTable 3.6 and 3.7 below:

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Table3.6:Typical chemical composition nnofMossobo OPC

Chemical composition	Percentage by
SiO_2	20.0
Fe_2O_3	5
Al_2O_3	3.70
	4.75
CaO	63.9
MgO	4

Table 3.7: Typical mineralogical composition of MossoboOPC

Mineralogical composition	Percentage by weight
C_3S	60.41
C_2S	13.19
C_3A	6.32
	11.27

Itsfinenessasmeasuredinsthelab,byBlaine, was4320cm^2/g.

3.2 Aggregates

Throughout the experiment, river sand and basaltic crushed stone from local market, with thefollowingphysicalcharacters,were usedas fineand coarseaggregate respectively.SiltContentofFineAggregateThepresenceofdust,loamandclaymaterialswithsanddecreasesthebondbetweenth ematerialsto be bound together thereby decreases the strength of concrete besides decreasing the quality ofconcrete.Accordingly,thesandfortheexperimentwastestedforsiltcontentandwasfoundto have 13% silt content.This is above the maximum valuerecommended by Ethiopian standard.Therefore,thesand,beforeusedin all tests,was washeduntil clearwater cameout.Gradationof Fineand Coarse AggregateAggregate grain size distribution or gradation is one of the properties of aggregates which influencethe quality of concrete. Therefore, fineaggregate and coarse aggregate with gradation satisfying thegradingrequirementofEthiopianstandard(ESC.D3.201asshowninTable3.8and3.9respectively)wereusedthroughout theexperiment.

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Table3.8: Gradationoffineaggregateusedforthetest

Sievesize	Weight Retained (gm)	Percentage retained	Cumulative coarser (%)	Cumulative passing (%)
9.5mm	0	0	0	100
4.75m	17	2.53	2.53	97.4
m2.36	30	4.48	7.01	7
mm1.1		14.1	21.17	92.9
8mm60	95	6		9
	158	23.5	44.72	78.8
0µm30	186	5	72.44	3
0µm15	126	27.7	91.22	
		2	100	

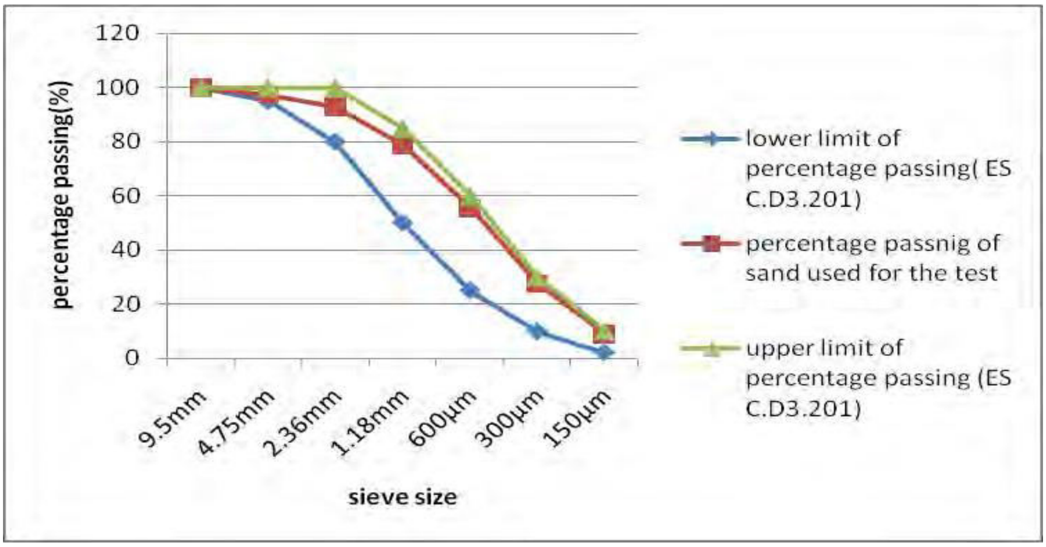

Fig 3.1: Gradation of sand used for the test

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

| Volume 9, Issue 7, July 2022 |

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Table3.9:Gradationofcoarseaggregate usedforthetest

Sievesize (mm)	Weightr etained (gm)	Percentage retained	Cumulative coarser (%)	Cumulative passing (%)
	0	0	0	100
37.5	0	0	0	100
25*	901	11.33	11.33	88.67
19.5	1495	18.79	30.12	69.88
12.5*	3144	39.53	69.65	30.35
9.5	1379	17.34	86.99	13.01
4.75	927	11.65	98.64	1.36
Pan	107	1.36	100	

*intermediate sieve

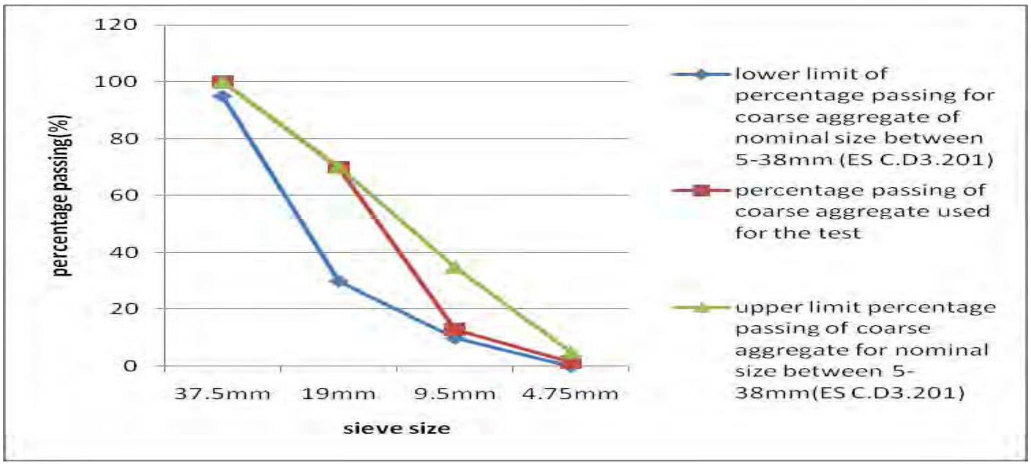

Fig3.2: Gradation ofcoarseaggregateusedforthetest

UnitWeight,SpecificGravityandAbsorptionCapacityofAggregatesAs unit weight, specific gravity and absorption capacity affect the type and quality of concrete andas such parameters are input for mix designing, these parameters were determined for both fine andcoarse aggregate. Thedetermined valuesareshownin Table 3.10.
Table3.10:Physicaltest resultsofaggregatesusedforthetest

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Typeofaggregate	Unitweight (kg/m^3)	Specific gravity (Bulks SD)	Absorption capacity(%)
Fineaggregate	1484.86	2.77	7.82
Coarse	1484.80	2.72	1.93

3.3 MarbleWastePowder

In this test, commercially called marble waste powder but geologically limestone mixed marblewastepowder,marbleprocessingfactoryby-product,fromTheEthiopianMarbleProcessingFactory, (Sample 4 type as indicated in Table 3.4 with Blaine fineness value of 4843cm2/g) wasusedas cement and sandreplacingfiller.Althoughfoursamplesfromthethreesourcesweretaken,onlysample4wasusedinthisexperimentsince sample 2, 3 and 4 were similar.Sample one was dropped as it was coarser thanthecement usedforthe test.

IV. CONCLUSIONS

Every part of the world ought to do its part to preserve the natural world and practise environmentally responsible management of its natural resources. In the same way that construction industries in other countries have benefited from recycling of wastes, Ethiopia's construction industries need to do the same. As a result, the findings of the study led to the formulation of the following recommendations.

1. Marble waste from The Ethiopian Marble Processing Enterprise can be used as a partial replacement for sand in the production of concrete; however, the current disposal methods of the waste by the enterprise do not make it possible to use the waste in a comfortable manner. As a result, the Ethiopia Marble Enterprise ought to conduct research into how and where it is possible to get rid of it in a manner that will make it simple for people to get to the waste.

2. Marble waste produced by the Ethiopian Marble Processing Enterprise can be utilised in the production of Portland Limestone cement as well as in OPC cement at a percentage of 5 percent as a calcareous filler. The fact that there is currently no cement factory in close proximity to the marble processing factory means that making use of this by-product is not economically feasible. Mugher, on the other hand, will soon finish the construction of its expansion factory, which is located 25 kilometres away from The Marble Processing Factory. This distance is significantly less than that of Mugher's raw material quarry, which is located 100 kilometres away. As a result, the Enterprise ought to collaborate with the Mugher factory in order to conduct further research and make applications.

3. Marble waste powder is one alternative material that can be used as cement blending material, and it can be directly applied by consumers in Ethiopia according to their requirements. At the moment, cement is delivered to consumers in Ethiopia in cement bags; however, in the future, cement delivery to consumers may begin in bulk, and if this occurs, the marble waste powder may become a viable alternative.

4. In this research, only some basic studies of using marble waste in the production of cement and concrete are investigated; as a result, further research is required on the following areas:

It is recommended that research be conducted by grinding marble waste powder together with cement using varying degrees of fineness and types of cements, as well as increasing the percentage of marble waste replacement.

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| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580|

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Impact Factor:
7.580

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