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# The Behavior of Slurry Infiltrated Fibrous Concrete with Waste Marble Dust as a Filler

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**Abstract:** In developing countries' construction industry the use of conventional construction material and conventional construction technologies makes construction expensive and hazardous to the environment so that the use of alternative construction material and construction technologies in our construction industry is very important. In this study the behavior of slurry infiltrated fibrous concrete with waste marble dust as filler are studied. Slurry infiltrated fibrous concrete is special type of steel fiber concrete (SFC) with a high volume fraction of fiber it possesses high ductility and high mechanical properties with special application of SIFCON lamination for structural member of buildings and It improves the strength of concrete structural members up to 25% for normal concrete and up to 40% for fibrous reinforced concretes and used for remedial works for weaken concrete structural members of buildings. This type of concrete uses a matrix consisting of very fine particles or filler to enhance its fibrous interlock properties. The purpose of this paper is to study the possibility of using marble waste powder as fine fillers in slurry infiltrated fibrous concrete production. from previous studies the use of marble waste powder filler for concrete production improves property of flow able concrete up to a certain limit so that for this purpose four different serious of concrete were prepared by adding different dosage of WMP (0%, 10%, 20%, 30%, 40%) by weight of cement. To study the performance of SIFCON a total of eighteen samples were prepared with the addition of waste marble powder with different additional range (0%, 10%, 20%, 30%, 40%) for each replacement C-30 were prepared the testes were on the mechanical properties of SIFCON that is compressive, tensile and flexural strength of the concrete and UPV test are conducted to check the porosity of the samples. The results indicate that the amount of ingredients (cement, sand) is reduced up to 10% because the fresh volume increased up to 15%. Finally XRD is conducted to observe the microstructure of the samples. The use of waste marble powder in SIFCON as fine filler improves the consistency and workability up to 30% usage so that from previous literature that is because the lubricating power of very fine limestone particle and also compressive strength, tensile, flexural strength shows progress up 30% usage and the optimum usage is 30% more than this percentage I observed reduction in workability and also in compressive, tensile and flexural strength of SIFCON.

**Keywords:** Fine Filler, Waste Marble Dust, Compressive Strengths, Flexural Strength and Tensile Strength

## 1. Introduction

### *1.1. Background of the Study*

Concrete is the most commonly used construction material in the world. [11] It is basically composed of two components: paste and aggregate. The paste contains cement, water and sometimes other cementations' and chemical admixtures, whereas the aggregate contains sand and crushed stone. In developing countries like Ethiopia the demand for construction is very high but deliveries of construction at affordable rates and quality for the low and medium earners have not been successful. We can give many reasons for this problem but cost and technological advancement in construction is one of the reasons for this problem when we say cost of construction is directly related with cost of construction material.

Concrete is extensively used and an important construction material and it is used in the construction industry due to its high compressive strength and its durability. Nowadays various studies have been conducted to make concrete with waste material with the intention of reducing cost and unavailability of conventional materials. [10].

Use of conventional material as a single source is causing so many problems to the construction industry for the reason that the cost of those materials will be high and will be difficult to afford and the exploitation and production process will be dangerous for the environment. On the other hand there are wastes which can cause serious damage to the environment if they are disposed unwisely. Recently, one of the main concerns of most countries is coming up with a low impact material to be used in construction which can meet the needs and desires of both contractors and consumers and at the same time fulfill the principles of a new but fast growing trend and sustainable development.

On one hand, excessive exploitation and limited availability of raw materials and, on the other hand, the problem with the increasing number of industrial waste and the lack of landfills, have led to the development of studies related to potential use of waste materials in building material production. [9].

Leaving the waste materials to the environment directly can cause environmental problems. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. Marble stone industry generates both solid wastes and stone slurry. [16] Utilization of marble powder has become an important face shift towards the efficient utilization in concrete for improved properties. [18].

Slurry Infiltrated Fiber Concrete (SIFCON) is a type of fiber reinforced concrete in which formwork molds are filled to capacity with randomly-oriented steel fibers, usually in the loose condition, and the resulting fiber network is infiltrated by cement-based slurry. Infiltration is usually accomplished by gravity flow aided by light vibration, or by pressure grouting. [8] SIFCON has many applications such as remedial works of high strength concrete structure which needs high ductility specially SIFCON laminate for strengthening existing structures and for doing remedial works for damaged building structural members.

It is special type of still fibrous reinforced concrete the only difference is its volume of still fiber and it needs high amount of fiber filler material and fluidity, compactablity, and fillingablity properties are very important for this type of concrete to infiltrate through interlocked fibers and from the previous researches marble waste powder has the capacity to improve those properties.

The use of special concrete in our construction industry is considered as extravagance because of the cost of material and the cost of admixture but it is not always true because the use of special concrete by incorporating with available cost effective material will makes it easy to use those special concrete to get cost and performance advantage and this marble waste powder filler is almost admixture without any cost so I used it for the production of slurry infiltrated fibrous reinforced concrete by considering its physical and chemical properties.

### *1.2. Research Objective*

#### *1.2.1. General Objective*

The general objective of the study is to study the behavior of slurry infiltrated fibrous concrete with waste marble powder as filler.

#### *1.2.2. Specific Objectives of the Study*

1. To examine the fresh properties of slurry infiltrated fibrous concrete when waste marble is added as filler.
2. To investigate the compressive, tensile and flexural strength of slurry infiltrated fibrous concrete when waste marble powder is added as filler.
3. Investigating the optimum percentage of WMD in concrete production.

## 2. Materials and Methodology

This chapter focuses on overall methodology and materials used for the research and includes the experimental investigations, mix proportioning and method of analysis. In order to fulfill the research objectives first physical and chemical tests were performed for concrete ingredients Then, based on the test results concrete making materials proportioning have been executed and by referring to previous related research paper and trial mixes. Mix design was prepared for C-30 slurry infiltrated fibrous concrete. After that, by following the appropriate three samples were casted for each percentage addition of marble waste and for different mechanical property tests for different date 14$^{th}$ and 28$^{th}$ day test. The prepared concrete samples have been tested for fresh and hardened states. The results obtained from the experiment are discussed and presented in tables and figures and the collected data were analyzed in a qualitative method Finally, conclusions are drawn and recommendations have been forwarded. This chapter elaborates SIFCON making materials used for the research, mix design, proportion, and concrete production process. Then before starting my work I investigate the availability of materials especially marble waste and the appropriate type of admixture. All the physical tests were conducted in AASTU construction material laboratory whereas chemical properties of marble waste powder is conducted in Ethiopian geological survey company.

### *2.1. Mix Design*

Based on ACI 544.4 recommendation and based on previous research, proportioning for the trial mix is prepared. Generally for SIFCON the percentage of fibers can be from 2 to 20 percent. Normally for making SIFCON, the mix ratio of cement and sand can be 1:1, 1:1.5 or 1:2 and the water cement ratio varies from 0.3 to 0.45. Different specimens are taken with variation of steel fiber content. The strength characteristics like compressive strength and tensile strength are evaluated [24].

They studied the performance of SIFCON by partially replacing sand with fly ash for their research and using the following proportioning cement and sand generally used for making SIFCON are 1:1, Fly ash equal to 50%by weight of cement is used in mix. W/c is 0.45 and super plasticizers are 2% weight of cement used. The percentage of fibers by volume was 6% they use C-30 MPa Grade of concrete throughout their research work. [13].

In this study the effect of still types on the flexural strength of SIFCON was studied. To conduct this research he used the following mix design cement to fine aggregate is 1:1.5 and water to cement ratio is 0.45. The percentage of fibers by volume was 2% and by using this proportioning he can achieve flexural strength 8.6 MPa. [20].

To study the effects of slag on SIFCON he use The slurry mix consisted of partial replacement of cement with different percentage of slag (15, 30, 45%, 60% & 75%) for getting an optimum dosage of slag in the matrix and rich mix proportion of 1:1 with water binder ratio of 0.4 were maintained for fabrication of the SIFCON specimens containing a constant 10% of fiber content was adopted. [23] During mixing of slurry a high range water reducing admixture (Super plasticizer) was added for improving more workable and easy infiltration capacity into the pack of fiber. The matrix was compacted well manually to verify the complete penetration of the slurry into the pre-packed fiber bed. To study the flexural behavior of reinforced SIFCON beams with varying fiber content (6%, 8% & 10%) and incorporation of an optimum dosage of slag (30%) for enhancing the ductility, stiffness and toughness characteristics. Reinforced cement concrete specimen of mix proportion 1:1 and water cement ratio of 0.39 was adopted for comparison. The mix ratio of different mixes were presented in he gets compressive strength 65MPa and tensile strength 12.05 MPa.

In general by referring different researcher and there mix proportion proportioning for SIFCON will be as follows:

(1) The percentage of still fibers can be from 2 to 20 percent by volume.
(2) Normally for making SIFCON mix ratio of cement and sand or can be 1:1, 1:1.5 or 1:2 and
(3) The water cement ratio varies from 0.3 to 0.45. Different specimens are taken with variation of steel fiber content. The strength characteristics like compressive strength and tensile strength are evaluated [24].

For this research slurry infiltrated fibrous concrete were casted experimental design was used for the research design and by laboratory results for c-30 MPa concrete.

***Table 1.*** *Mix design.*

| Cement | Sand | Super plasticizer | w/c | Still fibrous |
|---|---|---|---|---|
| 1 | 1.54 | 2.62 | 0.45 | 10% |

### *2.2. Method of Casting*

From the previous research and two trial mixes the above mix design is designed. all the ingredients and weighted in weight balance and first sand is added to the mixer then cement is added for each mix Bache 1 minute dry mixing and 2 minutes wet mixing for cement and sand for each mix then water and admixture is added to the dry mix and mixed for 2 minutes. Then the fresh mix is checked for work ability and casted The methods of casting have similarity with fibrous reinforced concrete initially the mold will be placed on a smooth surface and the sides of mold are oiled so as to enable easy removal of specimen or form work. And for beaching of the materials Cement, marble waste, sand, water and super plasticizer will be weighed accurately and mixed for making slurry. Fibers' are weighted according to the percentage by volume and SIFCON beams will be made by using three layer technique. This system follows the filling of fibers to one third depths of mold and then slurry being poured to the pre-packed fibers up to this layer. A little hand Compaction is done to ensure complete infiltration of slurry into the fiber pack. The process is repeated till the entire mold is filled and compacted. After 24 hrs of casting, beams will be de molded and cured in water for 28 days. After curing days, specimens will be dried in the air. And test for compressive, tensile and flexural strength and ultra pulse velocity (UPV).

***Table 2.*** *Sampling procedure and sample size.*

| % of marble addition | Number of sample | | | | | total |
|---|---|---|---|---|---|---|
| | For compressive strength | | | For flexural and split tensile strength. | | |
| | $7^{th}$ | $14^{th}$ | $28^{th}$ | $7^{th}$ | $28^{th}$ | |
| 0 | 3 | 3 | 3 | 3 | 3 | 15 |
| 10 | 3 | 3 | 3 | 3 | 3 | 15 |
| 20 | 3 | 3 | 3 | 3 | 3 | 15 |
| 30 | 3 | 3 | 3 | 3 | 3 | 15 |
| 40 | 3 | 3 | 3 | 3 | 3 | 15 |

### *2.3. Data Collection Process*

The data for this research will be collected from laboratory results. In the study analytical data will be collected.

Sampling Procedure and Sample Size:

The sampling procedure was purposive sampling, therefore the sample size was determined according to the test specimen number required to conduct compressive strength, flexural, Split tensile strength for concrete. Therefore there will be 3 samples for compressive strength, flexural and split tensile strength tests in each% addition and age each sample will be 15cm*15cm*50cm.

### 2.4. Material

#### 2.4.1. Cement

Cement from the available market Dangote ordinary Portland cement (OPC) grade 42.5 used for the study.

#### 2.4.2. Fine Aggregate

Locally available river sand passing through 4.75mm sieve conforming to the recommendation and the Specific gravity of fine aggregate is used for the study. The sand is from the langano area but I buy this sand from construction material shops around tulu dimtu area.

#### 2.4.3. Super Plasticizer

Water reducing super plasticizer conforming to ASTM C-494 type F will be used.

#### 2.4.4. Steel Fiber

Stainless steel fiber will be used according to ASTM- A 820 TYPE I.

#### 2.4.5. Marble Dust Used for the Experiment

The specific gravity of marble is 2.7 Local available white Marble wastes will be used. That is from the national mining corporation processing plant that is located around Gotera Street.

***Table 3.*** *Steel types.*

| | |
|---|---|
| Diameter | 0.6 mm |
| Length | 30mm |
| Aspect ratio | 50 |
| Tensile strength of the wire | >1450Mpa |

***Table 4.*** *Chemical property of marble powder.*

| | |
|---|---|
| color | white |
| form | powder |
| odor | odorless |
| Specific gravity | 2.6 gm/cm |

### 2.5. Material Preparation

#### 2.5.1. Fine Aggregate

All sand samples were air dried to reduce the moisture content before the commencement of the laboratory test. Half of the sand sample selected for the study was washed with potable water by using 75µm sieve in order to be free of clay/silt content and sun dried on a clean platform.

#### 2.5.2. Marble Waste Powder

European standard EN13139 (2002) fillers are fine materials that pass through 0.063mm sieve size.

### 2.6. Experimental Investigation

#### 2.6.1. Tests for Fine Aggregate Physical Properties

***Table 5.*** *Summary of results fine aggregate.*

| no | Physical property of fine aggregate | | result |
|---|---|---|---|
| 1 | Silt content | | 3.11 |
| 2 | Finesse modulus | | 2.96 |
| 3 | Unite weight | Compacted unit weight | 1488 |
| | | Loses unit weight | 1405 |
| 4 | Specific gravity | Bulk specific gravity | 2.39 |
| | | Bulk specific gravity (SSD) | 2.42 |
| | | Apparent specific gravity | 2.64 |
| 5 | Absorption capacity | | 1.08% |
| 6 | Moisture content | | 1.08% |

#### 2.6.2. Marble Dust Powder

The marble waste powder used for this research is taken from National Mining Corporation that is found in kirkos sub city near to agona cinema it is found in slurry form then it is dry by sun and sieved until I get appropriate size.

***Table 6.*** *Chemical property of waste marble.*

| Collectors code | $SiO_2$ | $AI_20_3$ | $FeO_3$ | CaO | MgO | $Na_2O$ | $K_2O$ | MNO | $P_2O_3$ | $TIO_2$ | $H_2O$ | LOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 4.46 | <0.01 | <0.01 | 28.44 | 21.78 | <0.01 | <0.01 | 0.02 | 0.09 | <0.01 | 0.08 | 44.3 |

### *2.6.3. Tests for Cement*

***Table 7.*** *Summarized Test Results for Cement (OPC).*

| Item no. | Description | | Test Result |
|---|---|---|---|
| 1 | Fineness of Cement | | 94% passing |
| 2 | Specific Gravity | | 3.15 |
| | | W/C ratio (%) | 32% |
| 3 | Cement Consistency Test | Water (gm) | 160 |
| | | Penetration (mm) | 9.3 |
| 4 | Setting Time | Initial | 48 min. |
| | | Final | 8hr. 38min. |

### *2.7. Properties of Control Concrete and Concrete with Marble Dust*

#### *2.7.1. Workability*

The V-funnel and L-box test are adopted to assess the fresh properties of (SIFCON) concrete. in this study workability of slurry infiltrated fibrous concrete is tested by slump flow test method at each percentage replacement of marble waste powder 0%, 10%, 20%, 30%, 35%, 40% to achieve the desired flowability (workability) so that Slump Flow Test for Measuring Flowability, V-funnel test, L-box Test, J-ring testes was conducted.

#### *2.7.2. Hardened Property Testes*

(1) Compressive Strength Test (ASTM C - 109).
(2) Flexural- Strength Test (ASTM C - 78).
(3) Splitting Tensile Strength Test (ASTM C – 496).

## 3. Result and Discussion

This chapter investigates laboratory test results on the property of slurry infiltrated fibrous concrete mixture produced in the study. Fresh and hardened properties of the slurry infiltrated fibrous were assessed in detail under this chapter.

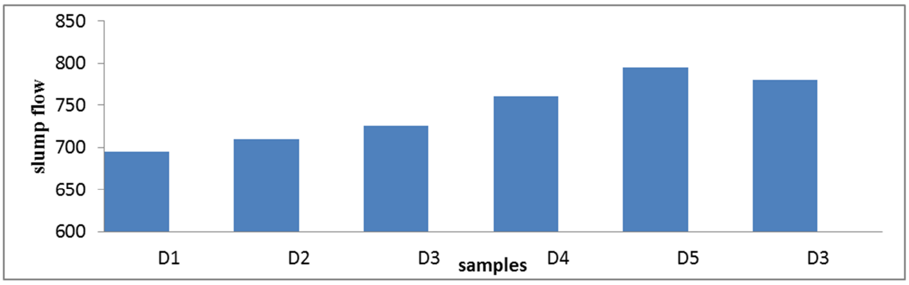


***Figure 1.*** *Slump flow result.*

### *3.1. Properties of Control Concrete and Concrete with Marble Dust*

Workability Tests
(1) Slump cone test method

The Slump Flow test can give an indication about the filling ability of slurry infiltrated fibrous concrete and an experienced operator can also detect an extreme susceptibility of the mix to segregation. However, this information cannot be obtained from numerical results alone, a substantial previous experience in using the test and carrying out construction in slurry infiltrated fibrous concrete is essential.

According to EFNARC standard, for flowable concrete with a slump flow diameter ranging from 650mm to 800mm was considered to be a good flowable concrete.

(2) T500mm Slump Flow

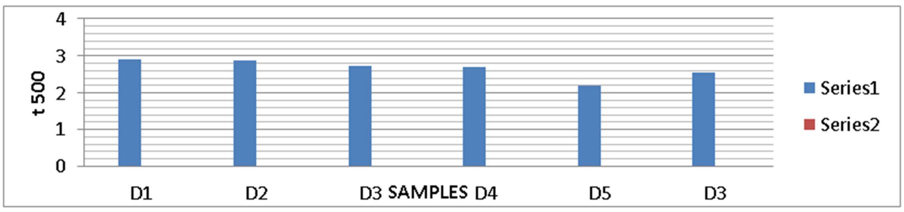


***Figure 2.*** *The result of T500.*

According to the result since the mixes are very flowable the time taking to reach T50 or 50cm diameter is between the ranges but after 30% addition the flowability was decreasing in this case the time taken to reach 50cm was increasing and this shows also the addition should not be exceed 30% if it is above this percentage the workability will decrease and the demand for water increases so that the mechanical property of the concrete will be affected.

(3) L- Box Test:

The L-box test method uses a test apparatus comprising a vertical section and a horizontal trough into which the concrete is allowed to flow on the release of a trap door from the vertical section passing through reinforcing bars placed at the intersection of the two areas of the apparatus The concrete ends of the apparatus H1 and H2 measure the height of the concrete at both ends. The L-box test can give an indication as to the filling ability and passing ability. [27].

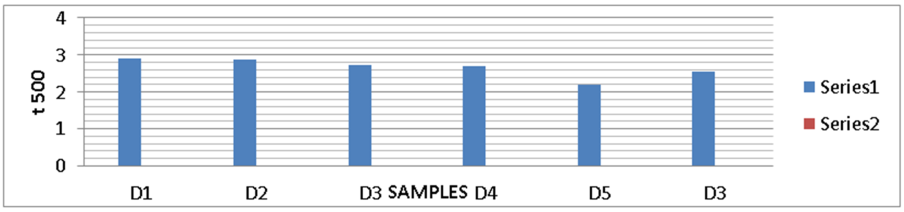


***Figure 3.*** *The result from L-box test.*

(4) Passing ability of Fresh Concrete by using J-Ring.

When the result is compared with that of the result which is recommended by EFNARC all the results are between the limit that is because there is no coarse aggregate in the matrix and that is because of the flowability property of SIFCON. And because of the following property of lime containing marble powder, the passing ability of concrete is improved up to a certain percentage of addition.

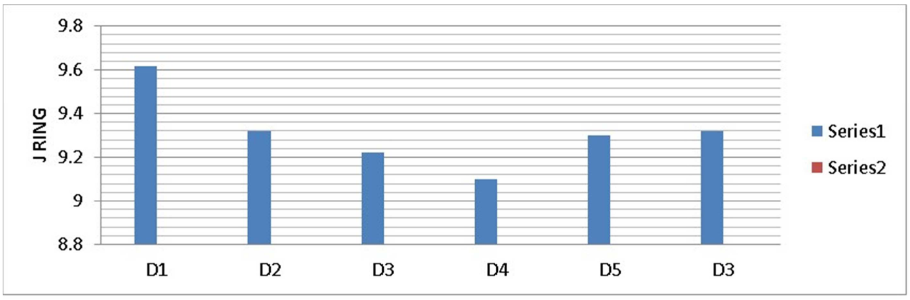


***Figure 4.*** *The test result for J-ring.*

When I see the results it was satisfactory and the result was directly increasing with the increase of marble powder but after some increasing the value starts to decrease it can be observed by the increase of the value.

***Table 8.*** *Summary of result for workability tests.*

| method | unit | D1 | D2 | D3 | D4 | D5 | D3 | Typical range | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | min | max |
| Slump Flow by Abram Cone | mm | 695 | 710 | 725 | 760 | 795 | 780 | 650 | 800 |
| T50cm Slump Flow | sec | 2.9 | 2.89 | 2.73 | 2.7 | 2.2 | 2.56 | 2 | 5 |
| J-Ring | mm | 9.62 | 9.32 | 9.22 | 9.1 | 9.3 | 9.32 | 0 | 10 |
| L-box | (h1/h2) | 0.962 | 0.91 | 0.89 | 0.87 | 0.88 | 0.92 | 0.8 | 1 |

The flowability, fillingablity, compactablity, and passing ability properties are very important properties of SIFCON. Since for SIFCON concrete the amount of still fiber used is very high when it is compared to the ordinary steel fiber reinforced concrete due to this the slurry has to have good flowability property.

### *3.2. Hardened Property for SIFCON*

#### *3.2.1. Compressive Strength*

For compressive strength cubes with dimension of (15cm*15cm*15cm) was casted and six samples for each percentage replacement three for seven days.

***Table 9.*** *Compressive strength for c-30 SIFCON concrete.*

| Effect of waste marble dust on compressive strength of concrete mix | | | | | |
|---|---|---|---|---|---|
| Waste marble dust | w/c ratio | 7th day | | 28th day | |
| | | Failure Load (kN) | Comp. strength (MPa) | Failure Load (kN) | Comp. strength (MPa) |
| 0 | 0.45 | 638.16 | 28.36 | 859.61 | 38.205 |
| 10 | 0.45 | 639.67 | 28.43 | 878.62 | 39.05 |
| 20 | 0.45 | 647.55 | 28.78 | 919.575 | 40.87 |
| 25 | 0.45 | 662.62 | 29.45 | 953.1 | 42.36 |
| 30 | 0.45 | 691.2 | 30.72 | 1000.1 | 44.45 |
| 35 | 0.45 | 668.9 | 29.73 | 956.25 | 42.5 |

***Table 10.*** *Effect of waste marble dust on Flexural strength of concrete.*

| Wmd% added | 28 day flexural strength | |
|---|---|---|
| | Failure load (kn) | Flexural strength (mpa) |
| 0 | 10.42 | 4.61 |
| 10 | 11.29 | 4.91 |
| 20 | 12.84 | 5.53 |
| 25 | 13.34 | 6.04 |
| 30 | 15.54 | 6.94 |
| 35 | 13.48 | 6.02 |

### *3.2.2. Effect of Waste Marble Dust on Flexural Strength of Concrete*

Since this type of concrete contain high volume of still fibers good results is expected with flexural and tensile strength and also the addition of fine marble powder increases the fibour interlock between still fibers and this cause the increasing in flexural and split tensile strength and when we see the results with the addition of marble powder the flexural strength was increasing.

### *3.2.3. Experimental Results and Discussion on Split Tensile Strength of Concrete*

Split Tensile strength of concrete is tested on cylinders at different percentages of marble powder Content in concrete. The strength of concrete has been tested on cylinders at 7 days curing and 28 days. A 7 days test has been conducted to check the gain in initial strength of concrete. The 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder was taken out of water and dried and then tested.

***Table 11.*** *Result of split tensile strength.*

| Addition of marble waste | Split tensile strength | |
|---|---|---|
| | $7^{th}$ day | $28^{th}$ day |
| 0% | 4.05 | 4.56 |
| 10% | 4.61 | 5.01 |
| 20% | 4.75 | 5.32 |
| 30% | 4.560 | 5.96 |
| 35% | 4.4 | 5.67 |

### *3.2.4. Ultra Pulse Velocity (UPV)*

In this test structure, the ultrasonic heartbeat is made by the transducer which is held in contact with one surface of the strong part under a test. In the wake of examining a known way length (L) in the strong, the beat of vibrations is changed over into an electrical sign by second transducer held in contact with various surfaces of the strong part and an electronic sorting out circuit associates with the improvement time (T) of the beat to be evaluated. The beat speed (V) is given by V=L/T (km/s). Bond is term of consistency, rehash or nonattendance of inside blemishes, parts and partition, etc average for the fragment of workmanship used, would have the decision to be assessed using the principles given in the table underneath which have been made for depicting concrete in structures the degree that the ultrasonic heartbeat speed. [22].

***Figure 5.*** *UPV test.*

***Table 12.*** *UPV result.*

| samples | UPV | |
|---|---|---|
| | 7 day | 28 day |
| 0 | 2.39 | 3.69 |
| 10 | 3.51 | 3.57 |
| 20 | 4.58 | 4.6 |
| 30 | 4.69 | 4.69 |
| 40 | 4.89 | 4.91 |
| 35 | 4.89 | 4.91 |

From the above result it is observed that ultra pulse velocity was increasing it is showed by the decreasing of the time taken to pass through the concrete so that the addition fine marble powder increase the compact ability of concrete so that because of the addition of marble powder the void will be compacted and it is shown by the above result.

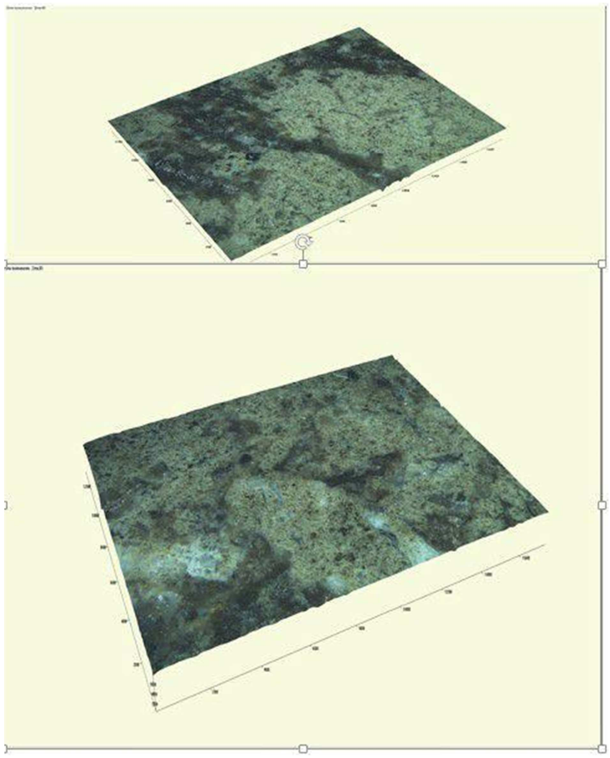

***Figure 6.*** *Micro structure of SIFCON.*

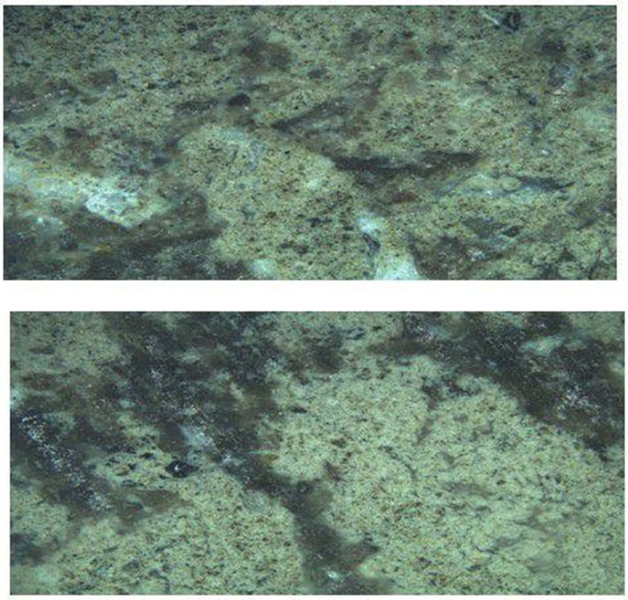

***Figure 7.*** *Micro structure of SIFCON.*

#### *3.2.5. XRD and SEM Analysis*

Micro structural study on concrete is a unique technique to find out the morphological features of concrete. X-Ray Diffraction Analysis (XRD), Scanning Electron Microscope (SEM) and Energy Dispersive Spectroscopy (EDS) are the general techniques used to visualize the micro structural behavior of concrete during the hydration process. The specific characteristics within the concrete can be visualized through these modern techniques. The mineral data obtained from the micro structural study will help to interpret the unique behavior of concrete and presence of minor compounds inside the hardened cement paste of concrete. The hydration process in concrete will lead to formation of C-S-H gel, $Ca(OH)_2$ crystals, and other mineral compounds which influences the individual properties of concrete.

The powder method of X-ray diffraction was adopted in the present study. Although X-ray diffractometry does not provide any reliable quantitative information, the technique is sensitive. An on-line search of a standard database (JCPDS database) for X-ray powder diffraction pattern enables phase identification for a large variety of crystalline phases in a sample. Since this equipment has no element identifier I cannot identify any chemical reaction formation of C-S-H gel, $Ca(OH)_2$ crystals.

## 4. Conclusion and Recommendation

Based on the above results the following conclusions and recommendations are forwarded on the effect of WMD filler on the properties of slurry infiltrated fibrous concrete.

### *4.1. Conclusion*

This research investigates the behavior of slurry infiltrated fibrous concrete using marble waste powder as filler. Such as fresh properties (fillingablity, compactablity, flowability) and hardened properties of SIFCON (compressive, flexural, tensile strength) based on the above results different conclusion are drawn and the use of waste marble dust as a filler for slurry infiltrated fibrous concrete has been confirmed.

The fresh property of SIFCON is improved such as.

1. The fillingablity of the slurry infiltrated fibrous concrete is improved with the addition of waste marble dust filler due to this the water demand to produce workable (fillingable) concrete is reduced and has a direct effect on the mechanical property of hardened concrete.
2. The flowability property of finer limestone powder helps SIFCON to decrease the demand of water and super plasticizer.
3. The addition of marble waste powder more than 30% this percentage reduces the compressive strength because the presence of finer particles in the concrete increases the water demand.
4. The presence of fine filler improves the fiber lock property of SIFCON.
5. Generally the use of marble powder filler for slurry infiltrated fibrous concrete production can be recommended up to 30%.

### *4.2. Recommendation*

Based on the above results and conclusion the following recommendation is drawn.

1. Recommendation for marble processing companies.
   a. The disposal of marble powder to the environment or to rivers is very dangerous for the environment and if this material handled and prepared this material can be an input for the production of concrete and they can generate additional money so they have to handle and prepare it to be used for the special concrete production.
   b. They have to support research to sustain the use of their product with scientific evidence.
2. For construction owners.

The use of this marble waste powder as a filler material decreases the cost of concrete up to 10% by increasing the strength and by increasing the fresh volume without scarifying any hardened properties so use this very cheap filler for your projects.

3. For contractors.
   a. The use of marble waste powder as a filler in slurry infiltrated fibrous concrete shows many improvements such as compressive strength was improved until 30% usage and flexural split tensile strength was also improved so the use of this filler for concrete is checked so that contractors can use this filler up to 30% for their flowable concrete production and they can consider this material as very cheap admixture.
   b. They have to think of slurry infiltrated fibrous concrete as an alternative material for strengthening structural works and for the remedies of older buildings.

c. The use of conventional material and technology makes our construction industry expensive and dangerous for the environment so the use of industrial wastes for.

4. For further work.

For this research I use only one type of marble that is white marble but there are different types of marble with different chemical composition so different tests have to be conducted with different types of marble powder.

# List of Abbreviation

| | |
|---|---|
| SIFCON | slurry infiltrated fibrous concrete. |
| MWP | marble waste powder. |
| ACI | American concrete institution. |
| ASTM | American Standard Testing Material |
| MPa | Mega Pascal |
| ES | European standard |
| BS | British standard |
| ETB | Ethiopian Birr |
| EFNARC | European Federation of National Trade Associations Research Center |
| Kg | Kilogram |
| mm | Millimeter |
| MPa | Mega Pascal |
| OPC | Ordinary Portland cement |
| AASTU | Addis ababa science and technology university |
| SCC | self compacting concrete |

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