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# Experimental Study of Waste Marble Dust on Strength Properties of Concrete

Sourabh Verma,Rahul Sharma

M. Tech Scholar, Department of Civil Engineering, Prashanti Institute Of Technology & Science, M.P.,

Assistant Professor, Department of Civil Engineering, Prashanti Institute Of Technology & Science, M.P.,

**Abstract**

The "Study on Effect of Waste Marble Dust on Strength Properties of Concrete" delves into a comprehensive exploration of the impact of waste marble dust as a partial replacement for cement in concrete. In the realm of sustainable construction materials, the utilization of waste products has gained significant attention due to environmental concerns and the quest for resource optimization. This study contributes to the growing body of knowledge in this field by investigating the potential of waste marble dust as a supplementary cementitious material in concrete production. Cement, a fundamental ingredient in concrete, has a significant carbon footprint associated with its production. Therefore, incorporating waste materials that would otherwise contribute to environmental concerns presents an avenue for both waste management and enhancing the properties of concrete. Waste marble dust is generated as a byproduct during the cutting and shaping of marble in industries. Its indiscriminate disposal can contribute to environmental challenges, and thus, exploring its application as a construction material is of paramount importance. The central objective of this study is to assess the effects of partial cement replacement with waste marble dust on the strength properties of concrete. The study involves a range of replacement percentages, namely 5%, 10%, 15%, and 20%, and the impacts are evaluated through various mechanical tests, such as compressive strength, split tensile strength, and flexural strength. These tests provide insights into the behavior of concrete with waste marble dust under different loading conditions, offering a comprehensive understanding of its potential as a construction material. The study methodology encompasses a systematic approach, beginning with the collection and characterization of waste marble dust. The material's properties, including its fineness, chemical composition, and particle size distribution, are meticulously analyzed to ensure accurate replacement proportions. The concrete mix design is formulated following standard procedures, taking into account the specific replacement percentages. The study utilizes Ordinary Portland Cement (OPC) of 43-grade as the base material. Upon preparation of the concrete mixes, a range of tests are conducted to evaluate the properties of both fresh and hardened concrete. The workability of concrete is assessed through slump cone tests, providing insights into its flow characteristics. Subsequently, the compressive strength, a crucial indicator of concrete's load-bearing capacity, is measured at both 7 and 28 days of curing. Additionally, the split tensile strength and flexural strength are determined, showcasing the concrete's resistance to tensile and bending stresses, respectively. The results of the study reveal significant insights into the effects of waste marble dust on concrete properties. Notably, up to a 10% replacement of cement with waste marble dust, the compressive strength increases by 8%, showcasing the potential for enhancing concrete's load-bearing capacity

## Introduction

Concrete, a fundamental building material, plays an indispensable role in the construction industry due to its remarkable durability, versatility, and cost-effectiveness. However, the production of conventional cement, a crucial component of concrete, has substantial environmental impacts including high energy consumption, carbon dioxide emissions, and depletion of natural resources. As sustainable construction practices gain prominence, researchers and engineers are exploring innovative approaches to enhance the environmental friendliness of concrete production.

One promising avenue in this quest for sustainability is the utilization of waste materials as supplementary cementitious materials (SCMs) in concrete. Waste materials, often byproducts of industrial processes, have the potential to partially replace cement without compromising the structural integrity and performance of the resulting concrete. Waste marble dust, generated from the processing of marble and other natural stones, represents an intriguing candidate for such partial replacement due to its fine particle size, chemical composition, and abundance.

This study delves into the concept of partial replacement of cement with waste marble dust in concrete, aiming to address both environmental concerns and performance requirements. By reusing waste marble dust as a cementitious material, not only can the environmental impact of cement production be reduced, but also the disposal challenges associated with these waste materials can be mitigated. The incorporation of waste marble dust can potentially lead to improved properties in concrete such as enhanced workability, compressive strength, and durability.

## Objectives of the project:

The primary objective of this research is to contribute to a more ecologically sustainable environment by mitigating the concerns related to pollution, waste disposal, and waste management stemming from industrial and household activities. Additionally, this investigation represents a strategic move towards reducing expenses in concrete construction through the utilization of discarded materials. The subsequent section outlines the specific goals pursued in this study:

• To test the effect of partially replacing cement with waste marble dust on concrete compressive strength. • To test the effect of partially replacing cement with waste marble dust on concrete split tensile strength. • To test the effect of partially replacing cement with waste marble dust on concrete flexural strength.

• Estimation of cost savings in concrete construction as a proportion of total costs.

## Result & Discussions

Table4.1Testresultof OPC43gradecement

| Test | Result |
|---|---|
| SpecificGravity | 3.15 |
| initial settingtime | 35 minutes |
| finalsettingtime | 363 minutes |
| 7days compressivestrength | 32.9 |
| 28days compressivestrength | 45.32 |
| fineness | 9% |
| Consistency | 27% |

All thetest results forcement arewithin the specified limits outlined in IS8112-20.

Table2 Resultoffineaggregate

| Test | Results |
|---|---|
| Specific gravity | 2.62 |
| Finenessmodulus | 2.43 |
| Waterabsorption | 1.2% |
| Gradingzone(as per IS383-1970) | ConfirmingtoZONE3 |

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Table3Grading offineaggregate aspersieveanalysis

| s.no. | ISSieve | weight retained | cumulative weightretained | cumulative percentretained | cumulative percentPassing |
|---|---|---|---|---|---|
| 1 | 10mm | 0 | 0 | 0% | 100.00% |
| 2 | 4.75mm | 26 | 26 | 5% | 94.80% |
| 3 | 2.36mm | 53 | 79 | 16% | 84.20% |
| 4 | 1.18mm | 79 | 158 | 32% | 68.40% |
| 5 | 600µ | 53 | 211 | 42% | 57.80% |
| 6 | 300µ | 158 | 369 | 74% | 26.20% |
| 7 | 150µ | 105 | 474 | 95% | 5.20% |
| 8 | PAN | 26 | 500 | | |
| | Total | 500 | | 263% | |

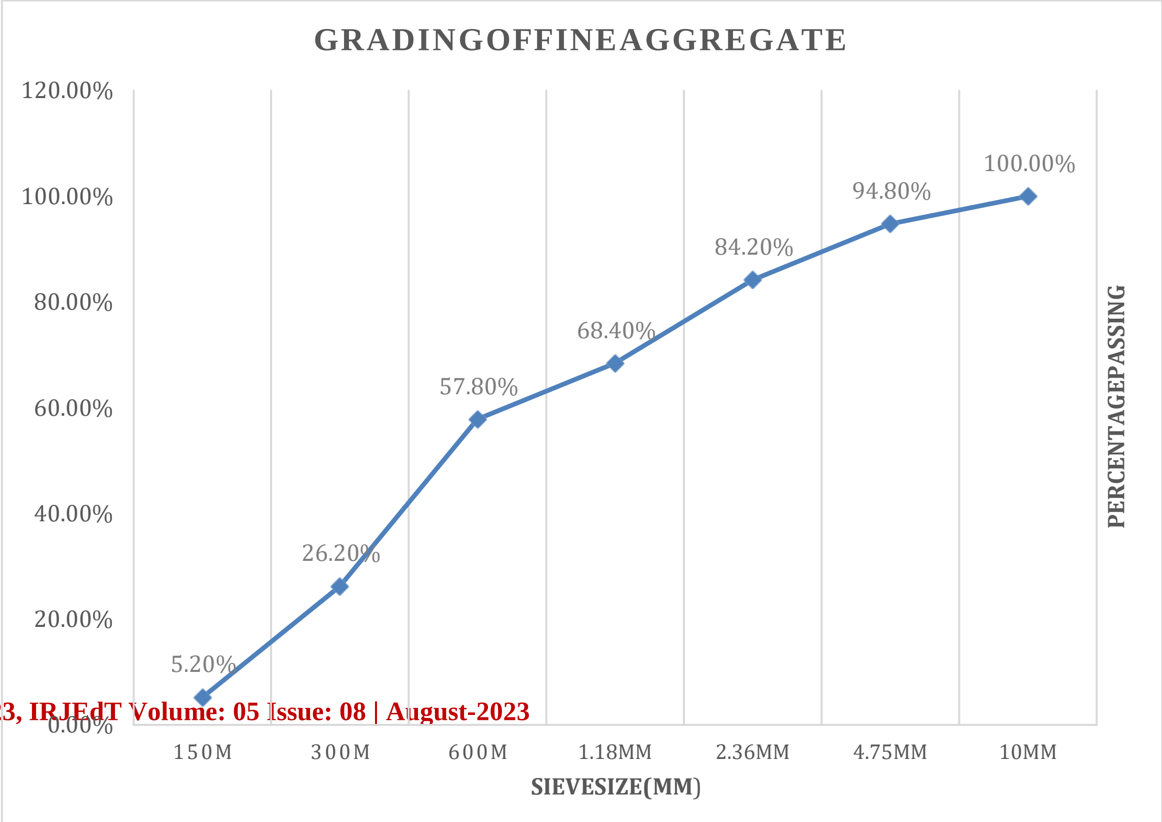

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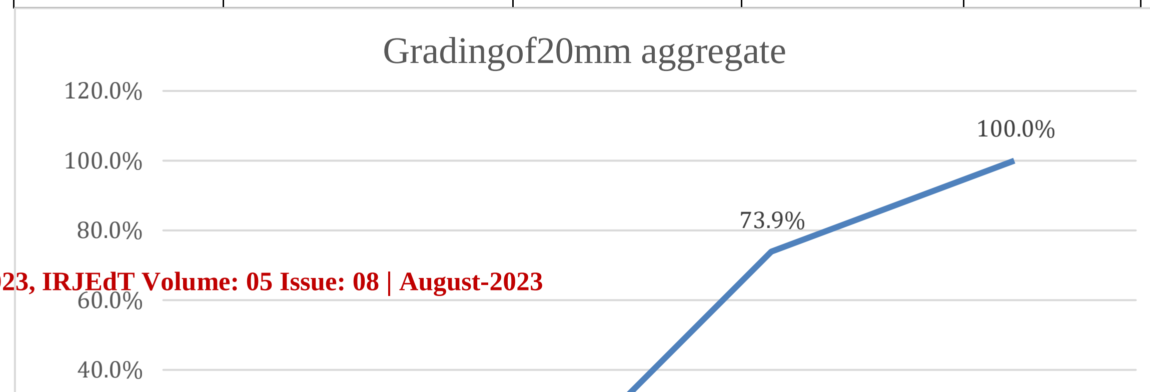
**Figure1 Grading offineaggregate**

Table4Test resultsofcoarseaggregate

| Test | Result |
|---|---|
| Specific gravity | 2.91 |
| Waterabsorption | 0.61 % |
| Aggregate crushingvalue | 21.9% |
| Aggregateimpactvalue | 18.02% |
| AggregateAbrassionvalue | 20.2% |
| Density | 1743.2kg/$m^3$ |

Table5Gradingof20mmaggregate

| sieve | weightretained(gram) | %retained | cumulative% retained | %passing |
|---|---|---|---|---|
| 40mm | 0 | 0% | 0% | 100.0% |
| 20mm | 2610 | 26% | 26% | 73.9% |
| 10mm | 6980 | 70% | 96% | 4.1% |
| 4.75mm | 410 | 4% | 100% | 0.0% |
| Total | 10000 | | | |



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percentagepassing

*F*igure 2 Grading of 20mm aggregate

Table6Gradingof10mmaggregate

| sieve | weightretained(gram) | %retained | cumulative% retained | %passing |
|---|---|---|---|---|
| 20mm | 0 | 0% | 0% | 100.00% |
| 10mm | 590 | 12% | 12% | 88.20% |
| 4.75mm | 4096 | 82% | 94% | 6.28% |
| 2.36mm | 145 | 3% | 97% | 3.38% |
| pan | 169 | 3% | 100% | 0.00% |
| Total | 5000 | | | |

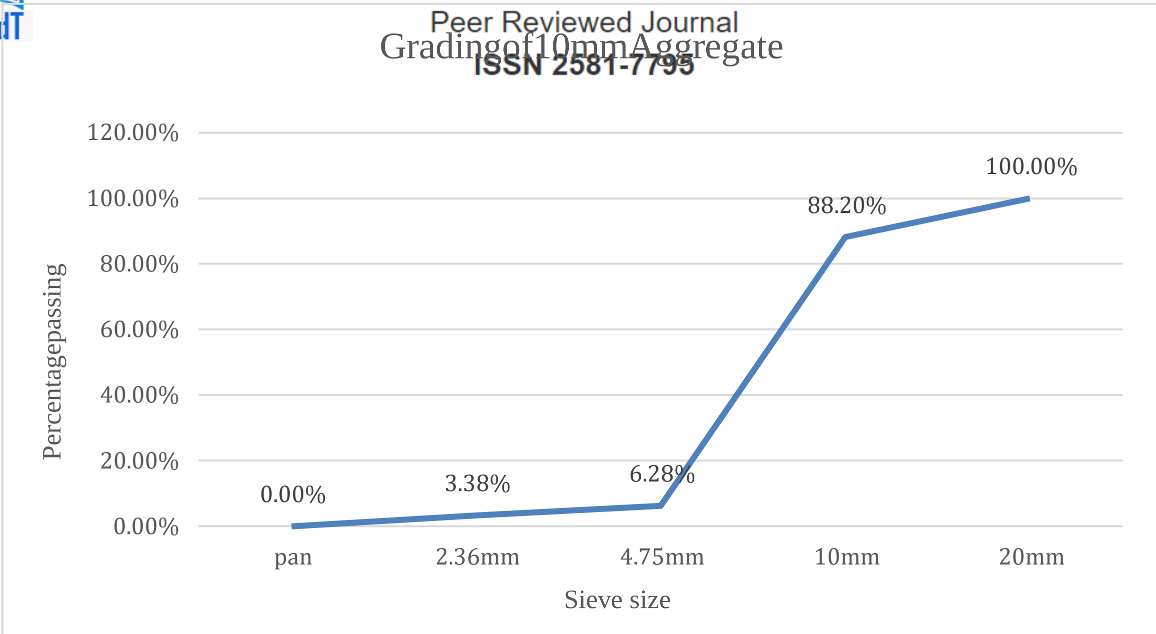


Figure3Gradingof 10mmaggregate

Table7Gradingof mixedaggregate

| sievesize | Aggregatesize | | Blended Aggregate | DesiredP roportion |
|---|---|---|---|---|
| | 20mm(50%) | 10mm(50%) | | |
| 40mm | 100.0% | 100.00% | 100.00% | 100 |
| 20mm | 73.9% | 100.00% | 86.95% | 90 to 100 |
| 10mm | 4.1% | 88.20% | 46.15% | 25 to 55 |
| 4.75mm | 0 | 6.28% | 3.14% | 0 to 10 |

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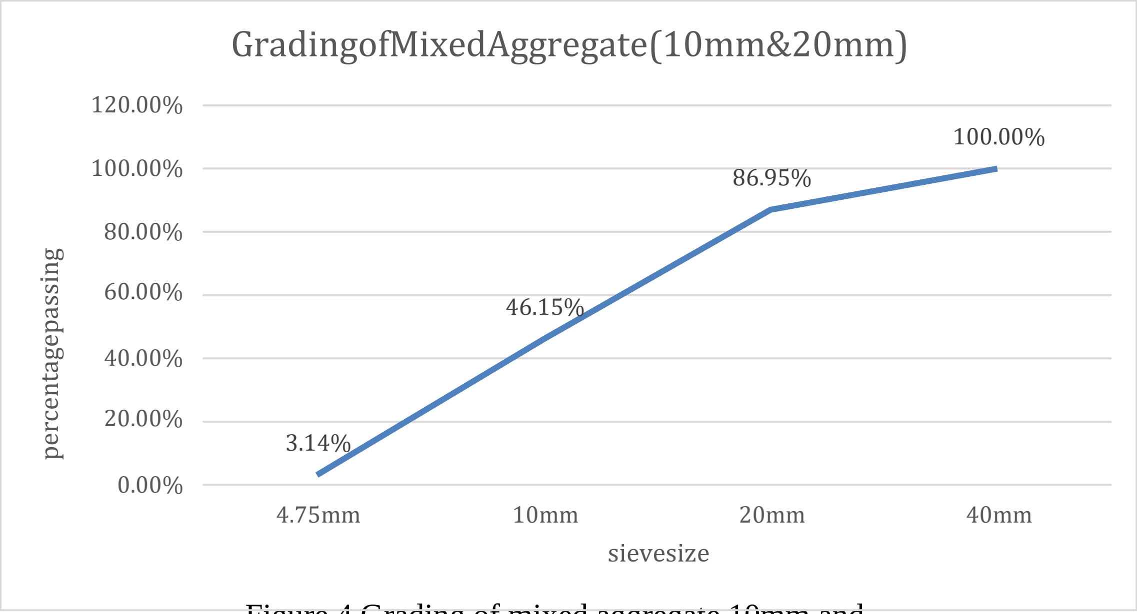


Figure 4 Grading of mixed aggregate 10mm and

20mmTable8 Grading offineand coarseaggregate

| **Sievesize** | **Aggregate** | **sand** | **BlendedP roportion** | **DesiredP roportion** |
|---|---|---|---|---|
| 40mm | 100.00% | 100.00% | 100.00% | 100 |
| 20mm | 86.95% | 100.00% | 91.39% | 95 to 100 |
| 4.75mm | 3% | 94.80% | 34.30% | 30 to 50 |
| 600µ | 0% | 57.80% | 19.65% | 10 to 35 |
| 150µ | 0% | 5.20% | 1.77% | 0 to 6 |

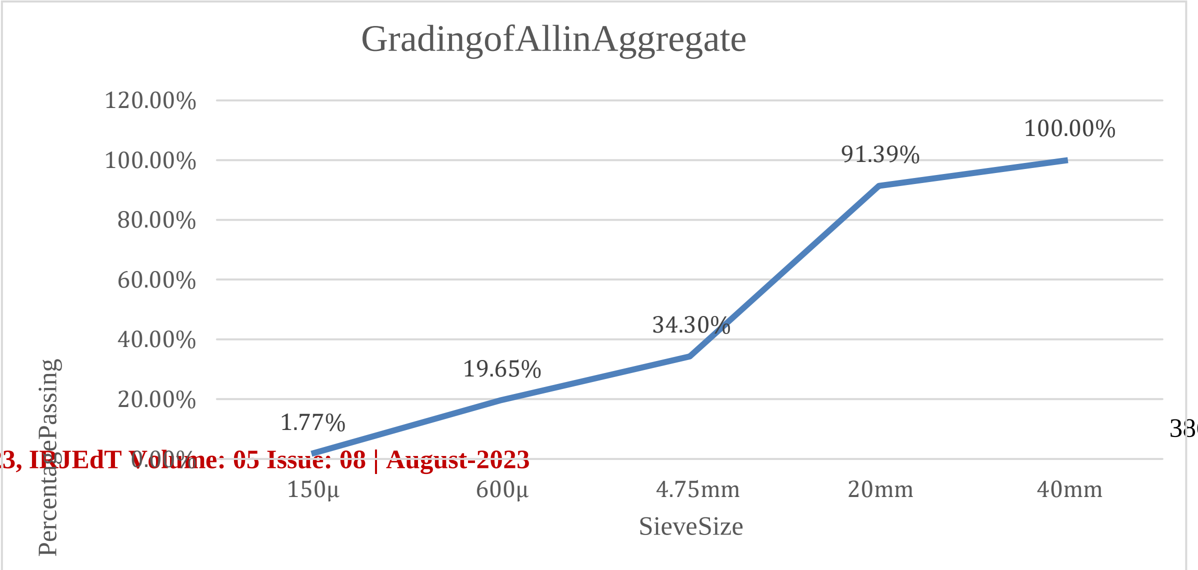

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**Figure5Gradingof allaggregate**

## TestsonConcrete

Twoessentialtestsareperformedonconcrete:theworkabilitytestforfreshconcreteand the strength test for hardenedconcrete. These tests include:

1. Workabilitytest(slump cone test)
2. Compressivestrengthtest
3. Flexuralstrengthtest

Followingtest results ofconcrete are discuss below-

Table4.9CompressiveStrengthofconcretewithcementreplacementbywastemarbledust

| Typeof mix | %replacementofcementbyWMD | CompressiveStrength(N/mm$^2$) | |
|---|---|---|---|
| | | 7days | 28days |
| C | 0% | 22.89 | 36.83 |
| C1 | 5% | 25.98 | 39.76 |
| C2 | 10% | 29.73 | 44.32 |
| C3 | 15% | 21.43 | 32.69 |
| C4 | 20% | 19.24 | 29.93 |

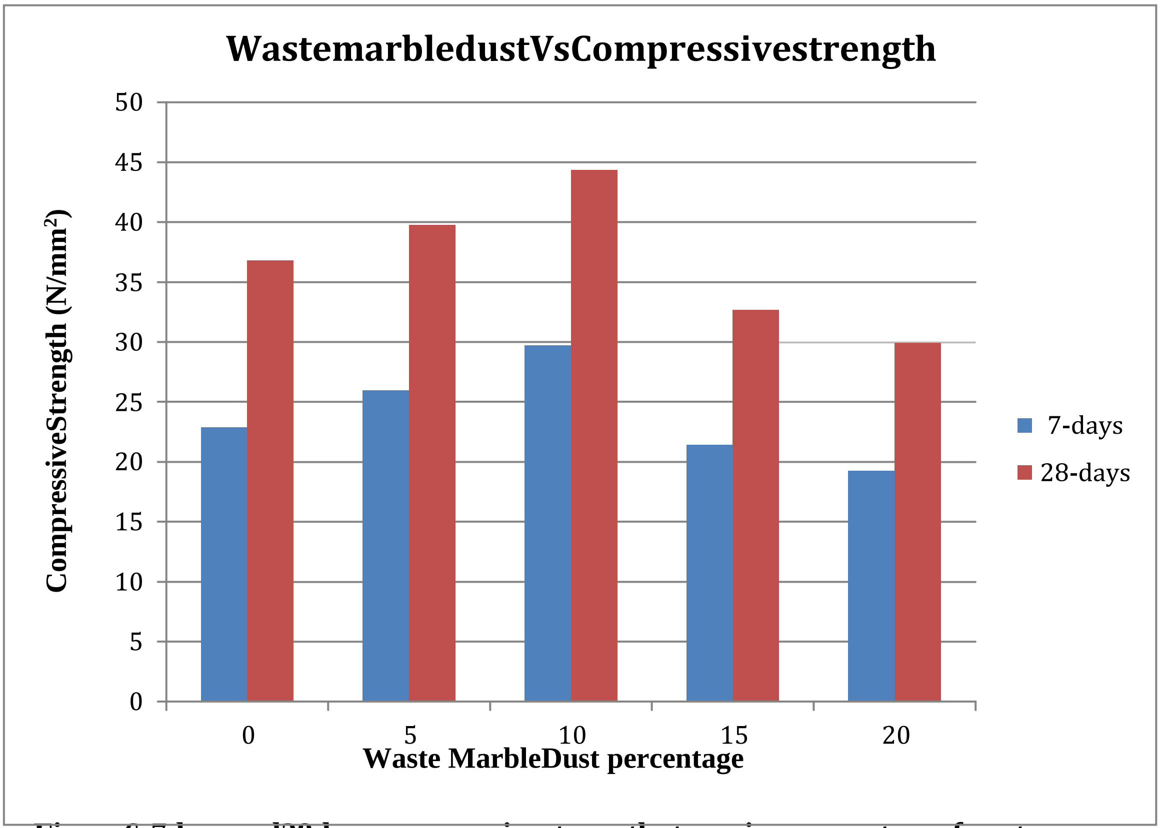


**Figure6:7daysand28dayscompressivestrengthatvaryingpercentageofwastemarble dust**

Table10FlexuralStrengthofconcretewithcementreplacementbywastemarbledust

| Typeof mix | %replacementofcementbyWMD | FlexuralStrength(N/mm$^2$) | |
|---|---|---|---|
| | | 7days | 28days |
| C | 0% | 2.48 | 3.94 |
| C1 | 5% | 2.53 | 4.01 |
| C2 | 10% | 2.78 | 4.42 |
| C3 | 15% | 2.09 | 3.12 |

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| | | | |
|---|---|---|---|
| C4 | 20% | 1.97 | 3.05 |

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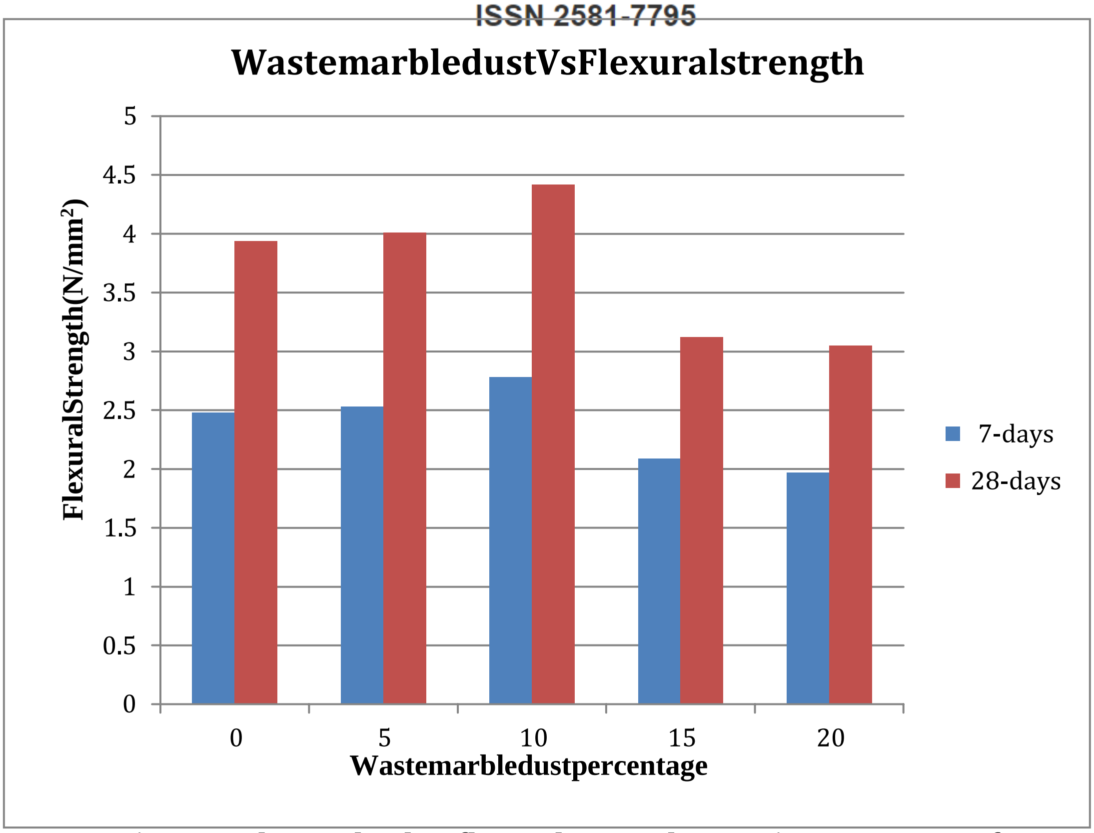


**Figure7:7daysand28daysflexural strengthatvaryingpercentage of wastemarbledust**

Table4.11SplitTensileStrengthofconcretewithcementreplacement bywastemarbledust

| Typeof mix | %replacementofcementbyWMD | SplitTensileStrength(N/mm$^2$) | |
|---|---|---|---|
| | | 7days | 28days |
| C | 0% | 2.09 | 3.18 |
| C1 | 5% | 2.34 | 3.43 |
| C2 | 10% | 2.47 | 3.76 |
| C3 | 15% | 1.89 | 3.01 |
| C4 | 20% | 1.43 | 2.82 |

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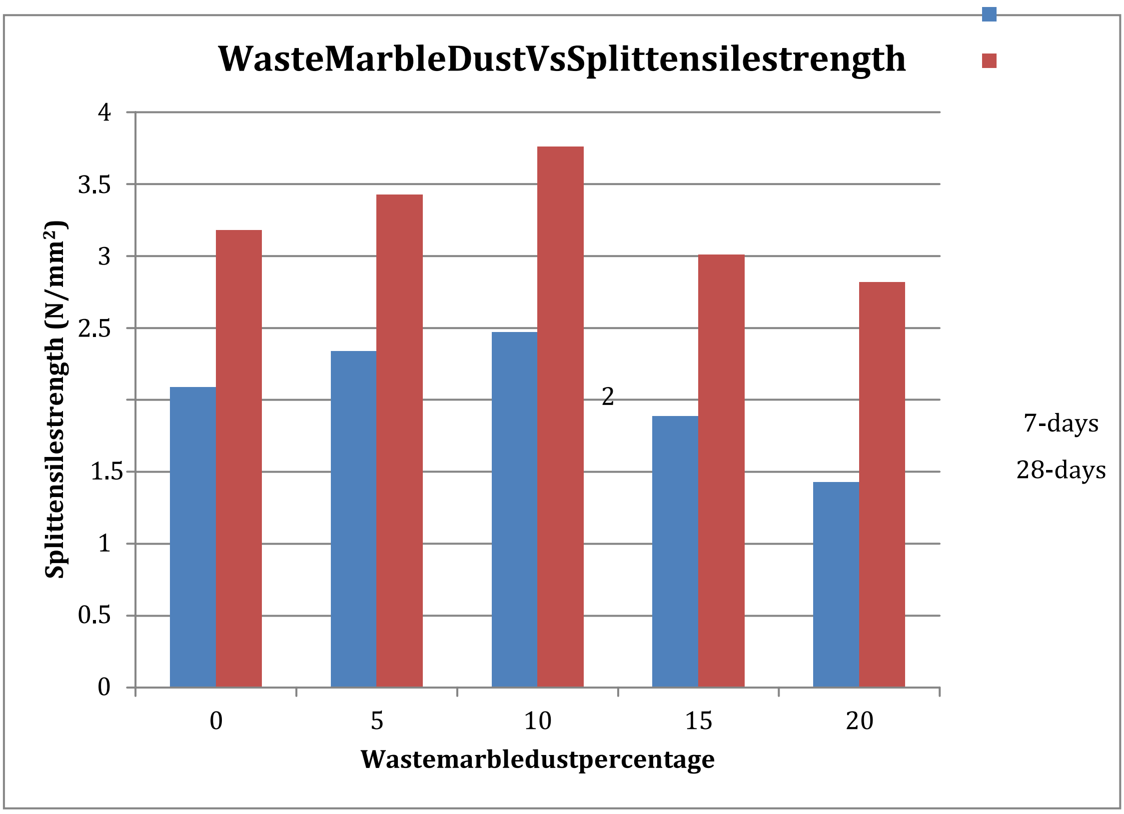


**Figure8:7daysand28dayssplittensilestrengthatvaryingpercentageofwastemarble dust**

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T
able4.14Valueofslumpfordifferentconcretemix

| Typeof mix | % replacement of cementbywastemarble dust | Slumpvalue(mm) |
|---|---|---|
| C | 0 | 78 |
| C1 | 5 | 79 |
| C2 | 10 | 80 |
| C3 | 15 | 85 |
| C4 | 20 | 90 |

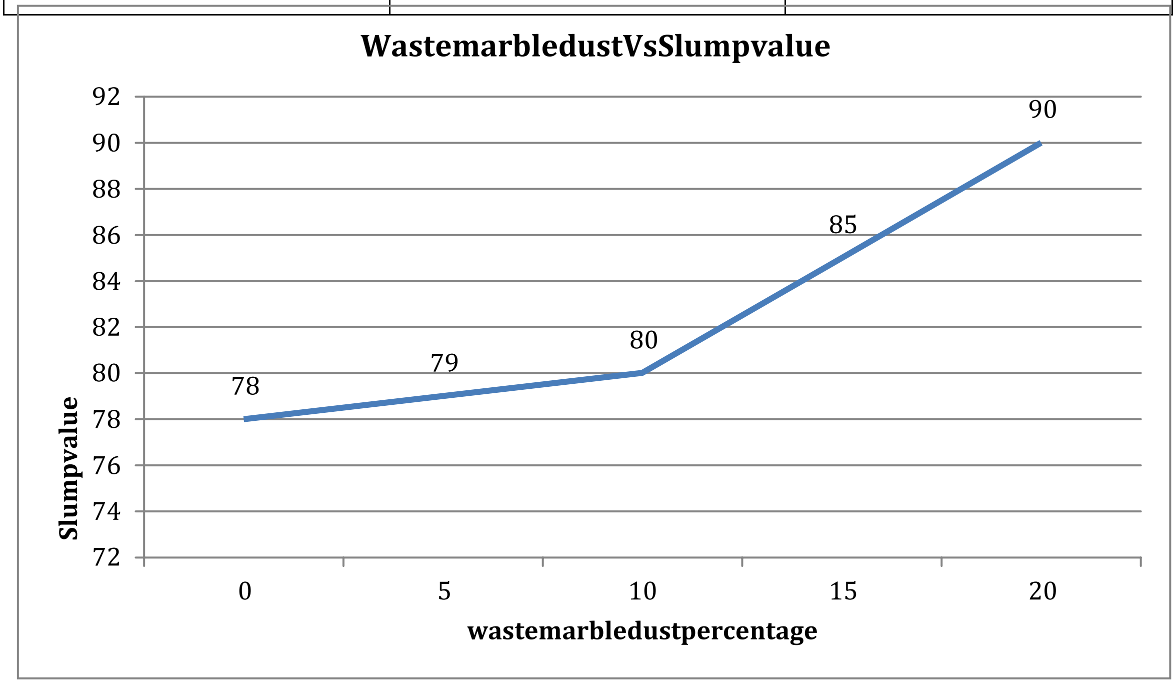


**Figure12Slumpvalueatvaryingpercentage wastemarbledust**

Table18Rateof materialsasperCPWD,2021

| S. No. | Item | Unit | Rate (₹) |
|---|---|---|---|
| 1 | Cement | tonne | 5000 |
| 2 | Sand | cum | 900 |
| 3 | CoarseAggregate(10mm) | cum | 1350 |
| 4 | CoarseAggregate(20mm) | cum | 1400 |
| 5 | Plasticizer | kg | 29 |

Source:(CentralPublicWorksDepartment2021)

Table4.19CostAnalysisof percubicmeterof controlledconcrete

| SNo. | Item | Weight(Kg/M$^3$) | Rate(₹/Kg) | Cost(₹/Kg) |
|---|---|---|---|---|
| 1 | Cement | 348 | 5 | 1740 |
| 2 | Sand | 697 | 1.3 | 906 |
| 3 | CoarseAggregate | 1347 | 1.03 | 1387 |
| | **Total** | | | **4034** |

**Table22CostAnalysisofpercubicmeterofvariousreplacementpercentagesof wastemarble dust**

| Replacement%Cement | Cement | Sand | CoarseA ggregate | WMD | Cost(₹/M$^3$) |
|---|---|---|---|---|---|
| 5% | 330.6 | 697 | 1347 | 17.4 | 3946.51 |
| 10% | 313.2 | 697 | 1347 | 34.8 | 3859.51 |
| 15% | 295.8 | 697 | 1347 | 52.2 | 3772.51 |
| 20% | 278.5 | 697 | 1347 | 69.6 | 3686.01 |

Table 4.23 Saving of Cost in by replacing cement with various percentages ofwastemarble dust

| **Replacement%Of Cement** | **Cement** | **Sand** | **CoarseA ggregate** | **WMD** | **Cost(₹/M$^3$)** | **Saving (%)** |
|---|---|---|---|---|---|---|
| 5% | 330.6 | 697 | 1347 | 17.4 | 3946.51 | 2.16 |
| 10% | 313.2 | 697 | 1347 | 34.8 | 3859.51 | 4.32 |
| 15% | 295.8 | 697 | 1347 | 52.2 | 3772.51 | 6.48 |
| 20% | 278.5 | 697 | 1347 | 69.6 | 3686.01 | 8.62 |

## Conclusions

Followingconclusions areobserved from theexperimental study:

- Onreplacementof cementwithWMD, theworkabilityincreaseslinearly.
- The compressive strength of concrete containing WMD increases up to certain10% of replacement and then it shows decrement. So, the optimum percentagereplacementis 10%.
- The split Tensile strength of concrete containing WMD increases up to 10% ofreplacementwithcement.Thenitshowsdecrement,whichshowsincorporating WMDisgoodupto10%.Furthermore,at15%itgivescompatiblestrength ofcontrolled mix.
- The Flexural strength of concrete containing WMD increases up to 10% ofreplacementwithcement.Thenitshowsdecrement,whichshowsincorporating WMDisgoodupto10%.Furthermore,at15%itgivescompatiblestrength of controlled mix.
- The increase in strength is may be due to almost similar composition of WMDand cement and also the silicate content is high in WMD which results in theformationof C-S-Hgel and C-H.
- The other thing is densification of concrete by adding WMD the concretedensifies because the size of WMD is less than cement, due to which the mixdensifiesandgive betterstrength.
- On increasing the percentage of WMD after 10% shows decrement in

strengthit may be because by increasing the amount of WMD it can form sludge whichisnot good forconcrete.

- Utilization of WMD in concrete reduces the cost of construction up to 4.32%and it also downscales the harmfuleffect onenvironment, can be consideredasgreen initiativein modern world.

CONSIDERING THE STRENGTH CRITERIA, THE REPLACEMENT OF CEMENT BY WASTE MARBLE DUST ISFEASIBLE

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