

A Survey on Experimental Analysis of Concrete Using Metakolin Powder

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ABSTRACT: Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. Leaving the waste materials to the environment directly can cause environmental problem. 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. Hence the reuse of waste material has been emphasized. The overall performance of reinforced concrete composite material is affected then the individual performance of the concrete itself. This led to the search for new material. In this research the mechanical properties of concrete is studied by replacing cement with GGBS and addition of metakolin with different weight fractions with respect to cement. The concrete industry is constantly looking for supplementary material with the objective of reducing the solid waste disposal problem.

KEYWORDS: Metakolin, Compressive strength, Split tensile strength, Flexural strength, Coarse Aggregate, Fine aggregate,

I. INTRODUCTION

1.1 General

Production of every one tonne of OPC emits about one tonne of carbon dioxide (CO₂) into the atmosphere, causing global warming. Statistics expose that the Cement industry constitutes about 5 % of the total emission of greenhouse gases (GHG) in India. Every one tonne of OPC requires 1.2 to 1.5 tonnes of lime stone as raw material and around 0.2 tonnes of coal as fuel for burning, causing depletion of natural resources. Metakaolin is a supplementary cementing material which is produced from carefully calcining kaolin clay between 600 and 800°C to make it reactive. Exceeding this temperature can cause the metakaolin be less reactive or even inert. Metakaolin is composed mainly of alumina and silica phases, which can vary by approximately 10% and 8% respectively depending on the kaolin source. Metakaolin has the general form Al₂O₃•SiO₂. When blended with Portland cement in appropriate amounts, typically below 20%, it will enhance the strength and durability of the concrete. Metakaolin improves concrete performance by reacting with available calcium hydroxide to produce secondary calcium silica hydrate (C-S-H) as well as other hydrates (C₂ASH₈ [stratlingite], C₄AH₁₃, C₃AH₆). Not only improving concrete performance, metakaolin also makes concrete greener because metakaolin production does not produce chemical CO₂ as opposed to cement and also requires lower temperatures to produce. Sand becomes a scarce material, alternative for sand is needed all over, and also providing good strength than conventional concrete and some additional advantages. This study gives a new alternative for fine aggregate. Resistant nature to weathering is very useful for buildings in future. Quartz is the most abundant silica mineral. Pure Quartz is colourless and transparent. It occurs in most igneous and practically all metamorphic and sedimentary rocks. Quartz is mainly made up of silica. The formula for it is SiO₂. It has a hardness of 7 on the Mohs scale. It is highly resistant to both mechanical and chemical weathering. This durability makes it the dominant mineral of mountaintops and the primary constituent of beach, river and desert sand.

1.2 Background of Marble Dust and Metakolin

1.2.1 MarbleDust

Construction materials are more judged by their ecological characteristics because of the continual depletion of quarry aggregates. In India huge amount of marble waste is being generated because of lack of technology and also unscientific methods of quarrying marble. Due to generation of marble waste there is a direct exposure of this material with the environment because of which serious environmental problems occur. Fig. 1 shows the marble dust powder. Also the marble cutting industry generates a high volume of wastes



Fig. 1. Marble Dust Powder

Importance of using Marble dust in concrete-

- Reduces the cement content which results in cost reduction.
- Helps in improving durability.
- Helps in attaining and maintaining strength at specific days.

Need of using Marble dust-

Huge amount of marble waste is being generated from marble cutting plants and mineral industries. As these wastes have adverse effect on our environment, it is very essential to find the safe disposal method for this type of waste or to find a proper solution for the utilization of this waste. The research presents an eco-friendly solution for the utilization of marble waste and helps in preserving our ecosystem.

Advantages of Marble dust-

It intensifies the properties of mortar and concrete.

Huge amount of Marble waste is generated and so cost of procuring of this waste is low

Disadvantages of Marble dust-

- Marble does not take part in the hydration process.
- Marble waste is not available in all regions and so additional transportation cost will be added for its procurement.

1.2.2 Metakaolin:

Metakaolin is a cementitious material used as admixture to produce high strength concrete. In Korea, the utilization of this material remained mainly limited to fireproof walls but began recently to find applications as a replacement for silica fume in the manufacture of high performance concrete. In order to evaluate and compare the mechanical properties and durability of concrete using metakaolin, the following tests were conducted on concrete specimens using various replacements of metakaolin mechanical tests such as compressive, tensile and flexural strength tests. Strength tests revealed that the most appropriate strength was obtained for a substitution rate of metakaolin to binder ranging between 10% and 15%.

Advantages of using metakolin in Concrete: The Empire State Building, Burj Khalifa, Burj Al Arab, etc. are all buildings that will leave you in admiration of their architecture and design. Apart from that you will also be bowled over by their towering height and just how strong their structure comes across as. Their beautiful architecture too is designed in a way that gives them an aesthetic character without compromising on their sturdiness. So what is it that sets these buildings apart from others. To start with, it's the planning and designing along with the use of premium-quality construction materials like high strength concrete. Here are 3 advantages of using premium quality concrete for constructing buildings.

Durability – Concrete is used to give a form to the skeleton of the building. It is a material that is used right from the very foundations of the building. For this reason, use of the right cement, one that is of premium-quality, is integral to defining the durability of the building. Premium-quality concrete will ensure that the building has strength built in to it

right from the very roots and also as its form is developed. Use of these good materials means that the building will have a sturdy structure that can withstand the test of time and can also combat any harsh climatic conditions. Weather is something that no-one has control over so the best way to cope with it is to ensure that the building can endure weathering as well as a little bit of bad weather conditions.

Robust structure – High strength concrete will give the building a structure that is more robust than other structures. A robust structure is one that gives the building an impressionable form and helps that form last for years to come. It ensures that the concrete is not the porous kind, which can make it hollow, but rather is strong and sturdy that can withstand any cracks caused by bad weather conditions or by any renovations and attachment of fixtures. Often buildings seem sturdy and as though they can endure nearly every kind of pressure, however, once they begin to be inhabited, the footfall or any renovation, fixtures, etc. seem to cause significant damage to the building, internally as well as externally

Cost-effective – The cost of something serves as a huge influencer in whether people make a purchase and people often choose to opt for the cheaper way out. However, the more important thing is to take into consideration the ‘cost-effectiveness’ rather than just the cost itself and then make a decision. As is understood, using such kind of concrete would not only impact the overall costing of constructing the building but also improve the quality of the building and make it more sturdy, robust and durable. The cost-effectiveness of using highstrength concrete is a major reason why construction companies should make use of high quality concrete while constructing

1.3 Problem Statement

The demand of better concrete is increasing day by day. Improved quality of concrete will only perform better if concrete improves workability, durability, flow ability & resistance to chemical attack/corrosion and reduce w/c ratio, heat of hydration & segregation mainly. For the fulfilment of above properties waste produced from the marble industries & other industries are used for effective & efficient strength & durability of concrete with the addition of metakolin

1.4 Scope of project

The scope of this research work is limited to the development of the samples prepared on by addition of marble dust with 5%, 7.5%, 10%, 12% by weight of concrete and 2.5%, 5% and 7.5%, 10% with metakolin only.

The main aim of this project is to highlight the importance of metakolin as Supplementary cementations material in construction industries and to increase the use of marble powder waste in concrete.

1.5 Objective

1. To study the physical properties concrete combined with Marble powder and metakolin by conducting workability tests
2. To study the flexural behaviour of Marble powder and metakolin mixed concrete beams by experimental investigations.
3. To conduct compression tests on Marble powder and metakolin mixed concrete cubes
4. To compare the flexural performance of Marble powder and metakolin composite beam with conventional concrete beams.

II. LITERATURE REVIEW

2.1 General

The basic objective of this chapter is to get inside into the previous findings so that it will help to know the gap in earlier studies and to justify the research problem selected by me for the study purpose. The idea of adding a waste or fibres into concrete in order to increase strength and fracture energy goes back to a patent dated 1918 by H. Alfsen and this fact is reported by Katzer. Alfsen described a process to improve the tensile strength by adding longitudinal bodies (fibres) of different materials into the concrete. Afterwards several patents of different fibres and waste materials were proclaimed. In this chapter the literature is reviewed on Marble dust and Alccofine, experimental behaviour of concrete added with marble dust and mix design manuals for design purposes and on experiments/development/practices. The prominent areas covered in the present literature of reviewed are studies related to concept, model, system, functions, experimental tests and IS code recommendations, specifications, guidelines for detailed analysis and casting of beam and cube specimens. Indian and international studies are studied

2.2 The Research Carried Out by Various Researchers

The extensive literature review was carried out by referring standard journals, reference books, I.S. Code and conference proceeding. The major work carried out by different researchers is summarized below:

1) Investigation on Strength Properties of Concrete with Partial Replacement of Cement by Marble Powder and Fine Aggregate by Granite Powder

R.Anuradha et al, have studied the mechanical properties of concrete mixtures in which fine aggregate (sand) and cement were partially replaced with Granite powder and marble powder. The replacement is done by 5%, 10%, 15%, 20%, and 25% of cement by marble powder and 5%, 10%, 15%, 20%, 25% of fine aggregate by granite powder to evaluate the effect of presence of these replacement materials on the strength of specimens. This project also describes the feasibility of using the marble sludge and granite powder in concrete production as partial replacement of cement and fine aggregate. It should be designed to have a higher workability, high mechanical properties and greater durability than those of traditional concrete.

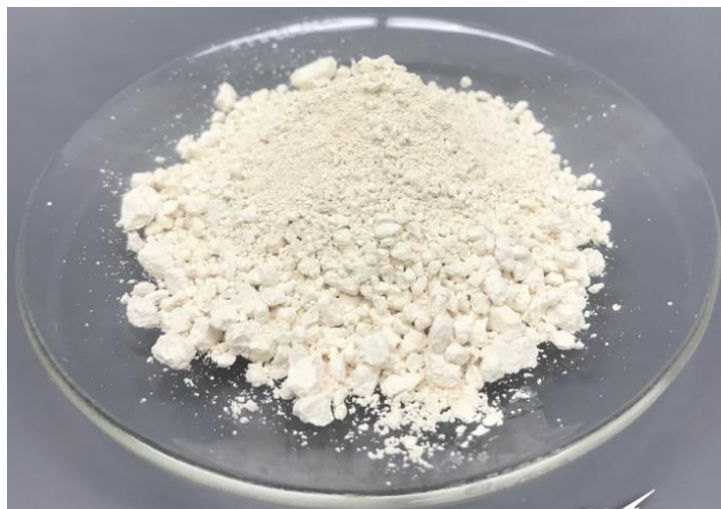


Fig2.1. Marble dust

Experimental investigation:

Mix proportions:

The following table shows the mix proportions of aggregates and marble dust and granite dust

Results

a) Compressive Strength. On partial replacement of OPC by 5% and 10% of marble powder and fine aggregate by granite powder gives a gradual increase in compressive strength when compared to conventional mix. Whereas at 15% the compressive strength is equal to that of conventional concrete compressive strength decreases at 20% and 25%

b) Split tensile strength On partial replacement of OPC by 5% and 10% of marble powder and fine aggregate by granite powder gives a gradual increase in tensile strength when compared to conventional mix. Whereas at 15% the tensile strength is equal to that of conventional concrete tensile strength decreases at 20% and 25% .

2) Partial Replacement of Cement with Marble Dust Powder

Mr.Ranjan Kumar et al, have studied that, the effect of marble dust powder (MDP) in concrete on strength is presented. Five concrete mixtures containing 0%, 5%, 10%, and 20% MDP as cement replacement by weight basis has been prepared. Water/cement ratio (0.43) was kept constant, in all the concrete mixes. Compressive strength, split tensile strength & flexural strength of the concrete mixtures has been obtained at 7 and 28 days. The results of the laboratory work showed that replacement of cement with MDP increase, up to 10% for compressive strength, & up to 15% for split tensile strength & flexural strength of concrete.

Objective of investigation

In this project main objective was to study the influence of partial replacement of cement with MDP. The compressive strength, tensile strength & flexural strength of ordinary M25 grade of concrete are obtained. Similarly compressive strength, tensile strength & flexural strength were obtained for 5%, 10%, 15%, & 20% replacement of cement with MDP by weight. The water cement ratio (0.43) kept constant throughout the investigation of this project work.

- To study the physical properties of Marble dust powder
- To characterize the particle size of Marble dust powder
- MDP as a replacement of cement material.
- To study the effect of MDP inclusion on the properties of concrete.

Results

Conclusion drawn from this research

The usage of MDP in concrete improved its quality in terms of strength. The following conclusions were based on the study on the test result.

- a) The Compressive strength of Concrete increases up to 10% replacement of cement by MDP and further increasing of percentage of MDP leads to decrease in compressive strength of concrete.
- b) The Split tensile strength of concrete increases up to 15% replacement of cement by MDP & further increasing of percentage of MDP leads to decrease in Split tensile strength of concrete.
- c) The Flexural strength increases up to 15% replacement of cement by MDP and further increases in the percentage of MDP leads to decrease in flexural strength.
- d) It is concluded that the MDP can be used as a replacement material of cement, and 10% replacement of cement with MDP gives an excellent result in strength, as compared to the normal concrete.
- e) Use of these waste material leads to sustainable development in construction industry.
- f) To save the environment, MDP may be used as better partial substitute as a replacement of cement in concrete.

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3) Study on Marble Powder as Partial Replacement of Cement in Normal Compacting Concrete

Dr. B. Krishna Rao et al, have studied that, the 40% of marble waste is generated worldwide during quarrying operations in the form of rock fragments and 30% waste generated during processing. It is being dumped either in nearby empty pits, roads, riverbeds, pasturelands, agricultural fields or landfill leading to wide spreading environmental pollution. Marble powder contains high calcium oxide content of more than 50%. The potential use of marble dust can be an ideal choice for substituting in a cementations binder as the reactivity efficiency increases due to the presence of lime. A total of five concrete mixes, containing 0%, 5%, 10%, 15% and 20% partial replacement of cement with marble powder are investigated in the laboratory. These mixes were tested to determine compressive strength, split tensile strength and flexural strength for 7, 28 and 56days.

Conclusions:

It can be seen from the results of this study that use of marble dust replacement of cement in the production of concrete for the construction industry should be encouraged where there comparative cost advantage, the following conclusions can be made from this study.

- The workability increased with increase of marble powder.
- The mechanical properties increased with increasing of curing days.
- The compressive strength increased with increase of marble powder up to 10% replacement
- It was observed that 2.81%, 2.92% and 4.58% of strength increased compared to normal mix with 10% replacement of marble powder at 7, 28 and 56days respectively.
- It was observed that 0.43%, 11.6% and 5.6% of split tensile strength increased at 10% of marble powder compared to normal mix at 7, 28 and 56days respectively.

- It was noticed that 11.22%, 20% and 14.8% of flexural strength increased at 10% replacement of marble powder compared to normal mix at 7, 28 and 56 days respectively.
- Considerable reduction in strength was observed at 15% and 20% replacement of marble powder.
- For compressive strength, split tensile strength and flexural strength 10% replacement with marble powder is found to be a best alternative for replacement as increase in percentage of strength is high compared to other variations in the mix.

4) Use of marble powder as a partial replacement of cement:

Mrs. Shalaka S. Utkar et al, have studied that, improving the properties of concrete by addition of waste marble powder is becoming more popular now a day because it helps in achieving the economy and is a superior alternative for the concrete ingredient, which offers high strength. In this project we are going to test the cubes with varying percentage of waste marble powder and then test them on Compression Testing Machine (CTM). The focus of our project will be strengthening concrete by replacing cement by marble powder in the most economical way by using the proper grade of concrete for increasing Load Carrying Capacity

Objectives of this research:

1. To study the influence of partial replacement of cement with waste marble powder, and to compare it with the compressive strength of ordinary M20 concrete.
2. To determine and find the percentage of marble powder replaced in concrete that makes it economical.
3. As marble powder acts like a pollutant so by partially replacing cement with marble powder there will be reduction in pollution. From above graph we get clear idea about the compressive strength variation of concrete.

Conclusion:

The compressive behaviour of Concrete of cube was studied. The Cubes of varying percentages like 0%, 5%, 10%, 15%, 20% and 25% were casted and cured at specific days of internal and tested on Compressive Testing Machine. After the testing the result analysis is made and cost analysis is made from that result following Conclusion is made.

1. Due to waste marble powder, it proved to be very effective in assuring very good cohesiveness of mortar and concrete.
2. From the above study, it is concluded that the waste marble powder can be used as a partial replacement material for cement; and 20% replacement of marble dust gives an excellent result in strength aspect and quality aspect and it is better than the conventional concrete.
3. The results showed that the substitution of 20% of the cement content by waste marble powder induced higher compressive strength, and improvement of properties related to durability.
4. The best possible way of disposal of waste material like waste marble powder can be by using it in concrete, which will reduce environmental burden

5) Effect of using Marble Powder in Concrete Mixes on the Behaviour and Strength of R.C. Slabs

Noha M. Soliman et al, have studied that, in recent years Marble is considered one of the most important decorative building materials. Marble powder is one of the materials which severally affects the environment and health problems. It is produced from sawing, shaping, and polishing process. This research aims to study the effect of using marble powder as partially replace of cement on the properties of concrete. The influence of using marble powder on the behaviour of reinforced concrete slabs is also investigated. The main variable taken into consideration is the percentage of marble powder as partial replacement of cement content in concrete mixes. The experimental results showed that, using definite amount of marble powder replacement of cement content increases the workability, compressive strength and tensile strength. Using marble powder enhanced also the structural performance of the tested slabs as it increased the stiffness and the ultimate strength compared to the control slabs.

Analysis and Discussion of the Test Results:

The following conclusions are derived based on the conducted experiments

1. Workability was increased by using small amount of marble powder ratio as a replacement of cement and leads to increase the compaction and the strength of concrete.
2. The increasing of marble powder ratio as a replacement of cement over the optimum dosage leads to the segregation of aggregate and bleeding of cement and aggregates lead to decrease the resistance of concrete.
3. Increasing the marble powder ratio replacement of cement led to the increasing as the compressive strength by about (25% and 8%) for the marble powder replacement ratios (5% and 7.5%) compared to the control mix.
4. Increasing the marble powder ratios higher than 5% decreased the compressive strength of concrete mixes.
5. Increasing indirect tensile strength and modulus of elasticity was recast of the by using marble powder ratios (5% and 7.5%) compared to the control mix.

6. Increasing the marble powder up to 7.5% decreased the indirect tensile strength and the modulus of elasticity.
7. Increasing in the initial crack and the ultimate load values were recorded when using 5% of marble powder replacement of cement in reinforced concrete slabs compared to the control slab.
8. Using 5% marble powder replacement of cement decreased the deflection of the R.C.Slabs compared to the control slabs.
9. Using 5% marble powder replacement of cement increased and the stiffness of the concrete slabs

6) Experimental Investigation on Strength Characteristics of Concrete Using Waste Materials

TomarRitu et al, have studied that, the replacement of materials offers cost reduction, energy savings and protection of environment. The quality of concrete mix is assessed through various mechanical properties like compressive strength and split tensile strength are carried out to analyse the performance of HPC. This study helps in identifying influence of Alccofine, Fly Ash, Rice Husk ash and Marble Powder on strength characteristics of HPC. The use of alternative material of Portland cement leads to reduction of emission gases and impact on production capacity of cement plant. This study also provides a strategy to reducing the cost of waste disposal and its related gains. The objective of this study is to evaluate the structural strength of high performance concrete by utilizing green and pozzolanic material as supplementary cementitious material and potential use of non-destructive testing devices for in-situ strength parameters of HPC during and after construction. About 720 concrete specimens of different for different mix proportions were analyzed in the study. This research study primarily focuses on the development of empirical correlations for estimating the 21 & 28 days' compressive strength and split tensile strength for diverse range of water/binder ratio for binary and ternary concrete mixes. Results shows that the workability and compressive strength and split tensile strengths of concrete are increased with partial replacement of cement by Fly Ash, Metakaoline and waste marble powder between 10% to 25%.

7) Influence of Mineral Admixture (Alccofine-1203) On the Properties of Hybrid Fiber Reinforced Concrete

Manisha M. Magdum et al, have studied that, the contribution of mineral admixture i.e. Alccofine-1203 to the mechanical properties of hybrid fibre reinforced concrete with high strength and workability is investigated. It reduces thermal, shrinkage cracks and increases strength as compared to conventional concrete. Fiber volume fraction (VF) 1.5% by volume of concrete was added with Alccofine-1203 contribution of 5%, 7.5% and 10% by weight of cement. Hybrid fibers contribute to increase the flexural strength while the Alccofine-1203 boosts the compressive strength of concrete

8) A Review on Alccofine : A supplementary cementitious material

Saurabh Gupta et al, have studied that, Supplementary cementitious materials (SCM) are becoming popular in the construction industry as these materials are bringing technical revolution in the field of civil engineering. Alccofine is a new generation micro fine concrete material for high Strength Concrete which is important in respect of workability as well as strength. The aim of this paper is to highlight the importance of Alccofine as Supplementary cementitious materials in construction industries. This can be used as a SCM due to its ultrafine size and high content of calcium oxide (CaO), Alccofine1203 is essential in terms of reducing heat of hydration and strength at all stages whereas Alccofine 1101 can be used as a grouting purpose.

9) To Study the Behaviour of Marble Powder as Supplementary Cementitious Material in Concrete

Pooja J. Chavhan et al, have studied that, marble powder is replace by sand the research is carried out by using M25 grade concrete with replacement of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50% marble powder by sand and is carried out to determine the optimum percentage of replacement at which maximum compressive strength and also split tensile strength is achieved There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. The physical, chemical and mechanical properties of the waste are analysed.

Conclusions drawn by the author:

Based on the results presented above, the following conclusion can be drawn:

1. Compressive strength increases with increase of marble powder
2. Compressive strength increases with 30% replacement and also 45%, 50% replacement by sand
3. The maximum 28 days split tensile strength was obtained with 45% marble powder replaced with fine aggregate.
4. We have put forth a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available; more importantly.
5. We have also stepped into a realm of saving the environmental pollution by cement production; being our main objective as Civil Engineers.
- 6 Marble slurry utilization in black cotton soil is one of the best ways to improve soil properties and to protect the environment up to some extent from the harmful effects of disposal of marble slurry in land and water.

III. CONCLUSION

The good results will be founded by the substitution of metakolin&Marble dust i.e. 7.5%, 10%.

To find the force of concrete, the concrete evaluated for the test of compression force of high strength concrete in which the replacement of material metakolin&Marble dust testing 7days, 28days.

In every trail mix of our concrete mix will be tested by compressive, flexural Test.

The Compressive Strength increases with the use of Alccofinmaterial. The maximum strength achieved in concrete having 7.5% metakolin, 10% marble Dust i.e., Mix 3.the strength increased 2.3% as compare to CC.

The Flexural-Strength(force) also shows the enhancing in concrete strength with the presence of metakolin, The maximum strength achieved in concrete having 10% metakolin, 12% GGBS i.e., Mix4.the strength increased 1.6% as compare with the normal concrete.

Hence for an above experimental research has concluded that cement with metakolin 10% &Marble Dust 12% partial replacement gives an optimum good result of forces and also helps in the strength & durability improvement properties of high strength concrete.

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