Studies of Effects of Marble Powder on the various Strength Parameters of Concrete

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Abstract— Marble dust is generated as a waste during the process of cutting and polishing. Marble industry produces large amount of marble powder which causes environmental problems. Cement being the costliest material of concrete, there is an urgent need to replace cement in concrete. Hence, to reduce disposal and pollution problems the innovative use of marble powder in concrete by replacing cement and fine aggregate with this material is another alternative of the traditional concrete. The aim of this research is to replace cement and sand by marble waste accordingly in range of 0%, 5%, 10%, 15%, 20% for M30 grade concrete. This research is concerned with the experimental investigations on workability and strengths of concrete and optimum percentage of partial replacement of cement and sand via 0%, 5%, 10%, 15%, 20% of marble powder. Three test mixes were prepared to test the suitability of marble dust in concrete. Mix-I contains 0%, 5%, 10%, 15% and 20% replacement of cement with marble dust in M30 grade of concrete. Mix-II has 0%, 5%, 10%, 15% and 20% addition of marble dust in traditional mix of M30 grade of concrete. Mix-III has 0%, 5%, 10%, 15% and 20% of marble dust as replacement of sand in M30 concrete grade. Ultimately it was observed that strength decreases on replacing cement in concrete, while strength increases on replacing sand in concrete due to filler effect of marble powder.

Key words: Marble Dust, Cement, Sand, Workability, Compressive Strength, Filler Material

I. INTRODUCTION

Now a day, the most widely used construction material is concrete, commonly made by mixing cement with sand, crushed rocks and water. Last year only in US 63 billion tons of Portland cement were converted into 500 billion tons of concrete, five times the consumption by weight of steel. In many countries the ratio of concrete consumption to steel consumption exceeds ten to one. The total world consumption of concrete is estimated at 11billion metric tons every year. Man consumes no material except water in such tremendous quantity.

Despite this fact, worldwide the concrete production is major concern that affects the environment with major impact being global warming due to CO2 emission during production of cement. It is estimated that cement production is responsible for about 3% of the global greenhouse gas emission and for 5% of the global CO2 emission. Since 50% of the CO2 released during cement production is concerned with the decomposition of limestone during burning, the mixing of clinker with supplementary materials is considered to be very effective way to reduce CO2 emission.

Most common blending materials used for cement production are industrial wastes. This is due to the fact that recycling of industrial wastes has technical, economical and environmental benefits besides the reduction of CO2 emission from cement production. The technical reason of using wastes and by-products in concrete production is the improvement of performance of concrete and this will be economical too.

Generally fly ash, blast furnace slag and silica fume are used industrial wastes in cement and concrete production due to their pozzolanic behavior. In addition to pozzolanic materials, other inert by-products and waste materials are also used in concrete and cement production as inert filler material. Among these, marble waste powder, a by-product of marble processing factory is suggested by many researchers for its use in concrete production as sand replacing or cement replacing material. Most of the researches showed positive results and benefits.

A. Marble Production in India

India is among the top world exporters of marble stone. The Indian marble industry has been growing steadily at an annual rate of around 10% per year.

The cutting of stones produces slurry, rock fragments and dust. About 20 to 30% of marble blocks are converted into powder. It was recorded that 3,172 thousand tons of marble dust was produced in year 2009-10.

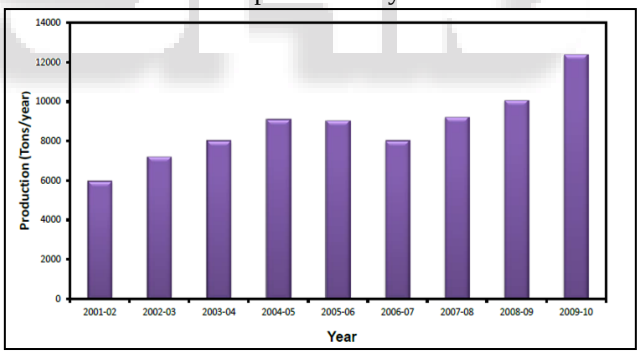

Fig. 1: Showing marble production in India
(Source: Amar Sharma, Gazala Habib & Vasant Matsagar "Reuse of Marble dust as fine aggregate in UHPC" Department of Civil Engineering, IIT Delhi, ISWA World Congress, Vienna, Austria)

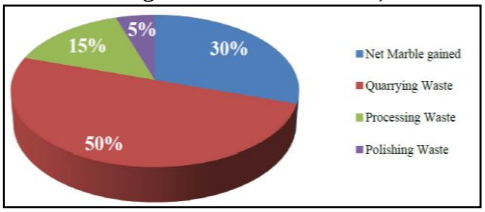

Fig. 2: Showing % of mined out marble product and waste
(Source: Amar Sharma, Gazala Habib & Vasant Matsagar "Reuse of Marble dust as fine aggregate in UHPC" Department of Civil Engineering, IIT Delhi, ISWA World Congress, Vienna, Austria)

B. Justification of Title

Two types of by-products are obtained in marble processing; 30% of the stone (in case of unprocessed stone) because of being smaller size and/or irregular shape and the other waste material is slurry. It is basically the water containing marble powder. The water is reused till it gets thick enough (70% water and 30% marble powder) to be reused. It can be safely estimated that 1 ton of marble stone processed in gang-saw or a vertical/horizontal cutter produces almost 1 ton of slurry (70% water) which implies that 30% of this mineral is lost as waste. Currently the amount of loss as waste is increasing as more and more processing units are launched. In addition to loss, disposal of this waste material is causing following environmental problems:

1) Since the waste is disposed on soils, the porosity and permeability of topsoil is getting reduced and the fine marble dust reduces the fertility of the soil by increasing its alkalinity.
2) When the waste is dumped and dried out, the fine marble dust suspends in the air and slowly spread out through wind to the nearby area.
3) When dumped along a catchment area of natural rainwater, it results in contamination of over ground water reservoir and also cause drainage problem.

Therefore, this is necessary to study the use of marble waste powder in construction industry to solve environmental problems due to the waste and to find alternative cement and sand based material and for efficient use of natural resources. And, since the strength is the most important property of concrete to be looked for, hence main focus in this study is to check the effects of marble powder on the strength of concrete.

II. LITERATURE REVIEW

A. Awol Abrar "Using Marble Waste Powder in Cement and Concrete Production" March 2011.

This study shows the possibility of using marble powder in concrete production by studying the effects of cement blended with marble powder on physical and chemical properties of cement paste and studying the effects of blending of marble waste powder with cement and sand on the performance of fresh and hard concrete.

B. Prof. P.A. Shirule, Ataur Rahman, Rakesh D. Gupta "Partial replacement of cement with marble dust powder"

The inclusion of Marble powder the strength of concrete gradually increases the strength of concrete upto a certain limit and then gradually decreases. With the inclusion of Marble powder upto 10% the gain in initial strength is high. At 10% there is 27.4% increase in initial Split Tensile strength for 7 days. At 10% there is 11.5% increase in initial Split Tensile strength for 28 days. The initial strength gradually decreased by 15%.

C. Baboo Rai, Khan Naushad H, Abhishek Kr, Tabin Rushad S, Duggal S.K "Influence of Marble powder/granules in Concrete mix"

The workability of the concrete obtained from waste marble granules mix is almost same in the same w/c ratio, same cement content and same type of marble granules. Degree of workability is medium conforming to IS: 456 – 2000. The average strength of all concrete mix with marble granules was 6-10% higher than the standard concrete conforming to IS: 456 - 2000.The flexural strength of marble mixed concrete increased with the increase of the waste marble ratio in these mixtures.

D. Vaidevi C "Study on marble dust as partial replacement of cement in concrete"

This research concludes that the marble dust can be used for replacing cement. Test results shows that the 10% of marble dust in the cement concrete gave good results. And also increasing the no. of curing days will increase the strength of marble dust mixed concrete when compared from 14 to 28 days.

E. V. M. Sounthararajan and A. Sivakumar "Effect Of The Lime Content In Marble Powder For Producing High Strength Concrete"

High strength concrete was achieved when 10% cement was replaced with marble powder in concrete. The workability decreased when the marble powder content increased. To maintain workability at low water cement ratio use of polycarboxylate ether based superplasticizer was found to be necessary. Considering the strength criteria, its feasible to replace cement by marble powder a maximum compressive strength at 28 days and it is recommended that the utilization of marble powder upto 10% in concrete as cement replacement is possible.

F. Bahar Demirel "The effect of the using waste marble dust as fine sand on the mechanical properties of the concrete"

The test result indicates that the unit weight of the concrete increases when certain proportions of marble dust is added to the concrete as a substitute for fine aggregate. This can be due to the high filler effect of marble dust because it has high specific surface area than fine aggregate. Compressive strength of the concrete increased with increasing percentages of marble powder at all curing ages. The highest compressive strength was achieved by specimen having 100% replacement of 0.25mm fine aggregate, especially at early curing ages.

G. Nutan Patel, Amit Raval, Jayeshkumar Pitroda "Marble Waste: Opportunities for Development of Low Cost Concrete"

The workability of the concrete obtained from waste marble granules mix is almost same in the same w/c ratio, same cement content and same type of marble granules. Degree of workability is medium conforming to IS: 456 – 2000. The average strength of all concrete mix with marble granules was 6-10% higher than the standard concrete conforming: 456 - 2000.The flexural strength of marble mixed concrete increased with the increase of the waste marble ratio in these mixtures.

H. Animesh Mishra, Abhishek Pandey, Prateek Maheshwari, Abhishek Chouhan, S. Suresh, Shaktinath Das "Green Cement for Sustainable Concrete using Marble Dust"

Concrete cylinder of size 150 mm dia and 150 mm height and 150 mm size concrete cubes, were tested to determine the compressive strength. Compression testing was done as per IS: 516-1959. The 7 days and 28 days compressive strength of concrete is 17.05% and 18.59% higher than controlled concrete respectively.

I. Hassan A. Mohamadien "The Effect of marble powder and silica fume as partial replacement for cement on mortar"

Using marble powder up to 15% as replacement for cement improves the compressive strength up to 32.5%. Marble powder can be used with silica fume as alternative materials for mortar.

J. Md Mahboob Ali, Prof. S.M.Hashmi "An Experimental Investigation on Strengths Characteristics of Concrete with the Partial Replacement of Cement by Marble Powder Dust and Sand by Stone Dust"

- The Compressive strength of Cubes increased with addition of marble powder up to 10% replacement by weight of cement and further addition of marble powder the decreases compressive strength.
- The Split Tensile strength of Cylinders increased with the addition of waste marble powder up to 10% replacement by weight of cement and further any addition of waste marble powder the decreases Split Tensile strength decreases.
- The flexure strength increased with addition of waste marble powder up to 10% replacement by weight of cement and further any addition of waste marble powder decreases the Tensile strength.
- Thus we find that optimum percentage for replacement of cement by marble powder is almost 10% of the total cement to be used for concrete.
- workability decreases as the replacement level increases, and hence water consumption will increase.
- Optimum percentage replacement of sand and cement with MP is 20% and 10%.

K. Valeria Corinaldesi, Giacomo Moriconi, and Tarun R. Naik "Characterization of marble powder for its use in mortar and concrete"

The high fineness of marble powder proves to be very effective in assuring good cohesiveness of mortar and concrete, even in the presence of superplasticizers, provided that w/c ratio was adequately low. In terms of strength, 10% substitution of sand by the marble powder in the presence of a superplasticizer achieved maximum compressive strength at the same workability level.

L. Er.Ranjodh Singh, Er.Rohin Kaushik, Er.Gurniwaz Singh "Study of Self Compacting Concrete Using Brick Dust and Marble Powder"

- All concrete mixes using marble powder fulfilled the performance criteria for fresh and hardened concrete.
- Good strength was achieved by the concretes with 25% marble powder which can be considered as the optimum content for high compressive strength.
- The properties of the hardened SCCs were improved at 28 days due to greater hydration of cement.
- Marble powder and brick dust can be efficiently used to produce good quality scc with satisfactory slump values and setting time.

M. Pooja J.Chavhan, Prof. S. D. Bhole "To Study the Behaviour of Marble Powder as Supplementry Cementitious Material in Concrete"

- Compressive strength increased with increase of marble powder content.
- Compressive strength increased by 30% cement replacement and also 45%,50% by sand replacement.
- The maximum 28 days split tensile strength was obtained with 45% replacement of fine aggregate.

N. Prof. Veena G. Pathan, Prof. Md. Gulfam Pathan "Feasibility and Need of use of Waste Marble Powder in Concrete Production"

The physical and chemical properties of marble waste are suitable for its proposed use. None of the mineral constituents in waste are in undesirable concentration. Test results show that marble wastes are capable of improving concrete performance. The combined use of marble powder and quarry rock dust exhibits excellent performance due to efficient filling ability. Therefore, the results provide a strong recommendation for the use of marble powder and quarry rock dust as fine aggregate in concrete production. Marble powder incorporation had a positive effect on density, shrinkage and plasticity. The use of marble dust in construction is cost effective because this waste is available free of cost.

O. Noha M. Soliman Ȧ "Effect of using Marble Powder in Concrete Mixes on the Behavior and Strength of R.C. Slabs"

- Workability was increased by using small amount of marble powder as a replacement of cement and leads to increased strength of concrete.
- The increasing percentage of marble powder as a replacement of cement over the optimum dosage leads to the bleeding of cement and segregation of aggregate and decreases the durability of concrete.
- the compressive strength increased by about (22% and 10%) for the cement replacement by MP (5% and 10%) compared to the control mix.
- Increasing the marble powder content higher than 5% decreased the compressive strength of concrete mixes.
- Increasing the marble powder up to 10% decreased the modulus of elasticity and tensile strength.
- Increasing initial crack and the ultimate load values were recorded when using 5% of marble powder as replacement of cement in rcc slabs compared to the pcc slab.
- Using 5% marble powder as replacement of cement decreased the deflection of the rc slabs compared to the pcc slabs.

P. Dr.G.Prince Arulraj, Mr.A.Adin and Mr.T.Suresh Kannan "Granite powder concrete"

Replacement of fine aggregate with granite powder improves the strength of concrete. The optimal dose of replacement was found to be 15%. Use of granite powder will reduce the disposal problems and other environmental issues. Utilizing granite powder will reduce the use of river sand and protect natural resources.

Q. Ronak Malpani, Sachith Kumar Jegarkal, Rashmi Shepur, Ravi Kiran H. N, Veena Kumara Adi "Effect of Marble Sludge Powder and Quarry Rock Dust as Partial Replacement for Fine Aggregates on Properties of Concrete"

The physical and chemical properties of marble waste are suitable for its proposed use. None of the mineral constituents in waste are in undesirable concentration. Test results show

that marble wastes are capable of improving concrete performance. The combined use of marble powder and quarry rock dust exhibits excellent performance due to efficient filling ability. Therefore, the results provide a strong recommendation for the use of marble powder and quarry rock dust as fine aggregate in concrete production. Marble powder incorporation had a positive effect on density, shrinkage and plasticity. The use of marble dust in construction is cost effective because this waste is available free of cost.

R. M. Shahul Hameed and A. S. S. Sekar "Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate"

The whole experimental data shows that the addition of industrial wastes improves the mechanical properties. Due to high fineness of the marble powder it proves to be very effective in assuring high cohesiveness of concrete. The above study concludes that the quarry rock dust and marble powder may be used as a replacing agent for fine aggregates.

- The chemical compositions of quarry rock dust and marble powder are comparable with that of cement.
- The replacement of fine aggregate with 40% marble powder and 40% Quarry rock dust shows an excellent improvement in strength and quality aspects. The result shows that the mix inhibits higher compressive strength, higher splitting tensile strength.
- Increasing the marble powder content by more than 40% improves the workability but reduces the compressive and split tensile strength of concrete.
- Green concrete inhibits higher workability and satisfies the SCC performance i.e. the slump flow of 657mm without affecting the strength of concrete. Slump flow increased with the increase of marble powder content. Test results show that some industrial wastes are capable of improving the performance of hardened concrete.
- Green concrete enhancing fresh concrete behavior and can be used in architectural concrete mixtures containing white cement.
- Permeability test results clearly shows that the permeability of green concrete is low as compared to that of standard concrete.
- The water absorption of green concrete is higher than standard concrete.
- The durability of green concrete under sulphate attack is higher than that of standard concrete. The results after 90-day immersion shows that the mortar specimens with green concrete in 10% sulphate solution have similar effect with those immersed for 28 days.

  Therefore, the results provide a strong recommendation for the use of marble powder and quarry rock dust as fine aggregate in concrete production. Marble powder incorporation had a positive effect on density, shrinkage and plasticity. The use of marble dust in construction is cost effective because this waste is available free of cost.

S. Er. Tanpreet Singh and Er. Anil Kumar Nanda "Influence of Marble Powder on Mechanical Properties of Mortar and Concrete Mix"

When cement is partially replaced by marble powder; there is a marked reduction in compressive strength values of concrete mix with increasing marble powder content when compared with standard sample at all curing ages.

The workability of the concretes obtained from waste marble granules mix shows negligible effect as compared to standard concrete mix. Degree of workability is medium conforming to IS: 456 – 2000. The average strength of all concrete mixes with marble powder was 5-10% higher than the concrete conforming to IS: 456-2000. The flexural strength of waste marble mix concrete increased with the increase of the waste marble percentage in these mix.

T. Rishi, Dr. Vanita Aggarwal "Effect on Partial Replacement of Fine Aggregate and Cement by Waste Marble Powder/ Granules on Flexural and Split Tensile Strength"

The results obtained in this study indicates that partially its fine to replace the fine aggregate and cement by marble powder for improving the strength of concrete but the strength get decreased when replaced the fine aggregate and cement by waste marble powder by 20%, thus in combination the cement and sand cannot be replaced. The optimum dose of replacement by MP is found to be 10% against sand as this mix gave maximum Flexural and Split Tensile Strength at 28 days.

U. Amar Sharma, Gazala Habib, Vasant Matsagar "Reuse of Marble Dust as Fine Aggregate in Ultra High Performance Concrete"

- The physical and chemical properties of marble dust were found suitable for its proposed use.
- None of the mineral constituents in waste is in undesirable concentration.
- The compressive strength of cubes, flexural strength of beams and splitting tensile strength of cylinders were increased with addition of waste marble dust up to 5% replacement by weight of sand and further any addition decreased the strength.
- Due to the high fineness of marble dust, it proves to be effective in assuring good cohesiveness of concrete in the presence of a superplasticizers, provided that water to cement ratio was just adequate.
- The use of marble dust in construction might be cost effective as this waste is available free of cost.
- It will help in improving environmental problem raised by disposal of huge waste generated from marble industries.

V. Seema Karami "Using By-product Industrial Materials to Replace All Cement in Construction Products"

The source of by-product materials in different mix, even from the same source, can affect physical and chemical properties of materials. Therefore the results of each research project may not be reliable and useful for other projects. Therefore, for every novel product using wastes as raw material, checking tests should be carried out. For industrial processes in-line analysis should be done as in cement manufacturing. Waste materials need to be modified. Physical treatments such as drying, grinding and sieving should be done to make them more effective.

W. Omar M.Omar, Ghada D.Abd Elhameed, MohamedA. Sherif, Hassan A.Mohamadien"Influence of limestone waste

as partial replacement material for sand and marble powder in concrete properties"

- The workability of concrete did not get affected by the lime stone waste content.
- Using lime stone waste up to 50% replacement increase the compressive strength about 15% at 28days.
- Increasing the cement content from 350Kg/cm3 to 450 Kg/cm3 in presence of the lime stone waste with different percentage increased the compressive strength about 7% at 28 days.
- Cement content of 350Kg/m3, has better performance, and more economical than cement content of 450Kg/m3.
- Indirect tensile strength increased about 19% when using 50% lime stone waste and 20% marble powder with different cement content.
- Flexural strength increased about 9% when using 50% lime stone waste and 20% marble powder with different cement content.
- Using marble dust up to 20% as admixture increases the compressive strength.

X. Taner Kavas, Asim Olgun "properties of cement and mortar incorporating Marble dust and crushed brick"

- The general effect of marble powder and crushed bricks is to retard the setting time of cement.
- The replacement of Portland cement by marble powder and crushed bricks influences significantly the strength of concrete. The strength of the concrete containing waste materials was lower than that of the normal concrete.
- Depending on the crushed bricks resource, the incorporation of marble powder and crushed bricks results in an increased flexural strength compared to the concrete containing marble dust only.
- The cement containing industrial by products demands higher water content than Portland cement.

Y. Rahul, Jamsheed, Shanil, Geo, And Jagdeesh "project on partial replacement of cement with marble powder"

The test result indicates that the unit weight of the concrete increases when certain proportions of marble dust is added to the concrete as a substitute for fine aggregate. This can be due to the high filler effect of marble dust because it has high specific surface area than fine aggregate. Compressive strength of the concrete increased with increasing percentages of marble powder at all curing ages. The highest compressive strength was achieved by specimen having 100% replacement of 0.25mm fine aggregate, especially at early curing ages.

Z. Hüseyin Yılmaz Aruntaş, Metin Gürü, Mustafa Dayı, İlker Tekin "Utilization of waste marble dust as an additive in cement production"

In this experiment, the usability of WMD as an additive material in blended cement has been investigated. For this purpose, waste marble dust added cements have been prepared by inter grinding marble dust with Portland cement clinker at different blend ratios: 5.0%, 7.5% and 10% by weight. 40 × 40 × 160 mm mortar prisms were prepared with the obtained cements. Strength tests have been carried out on mortar specimen at 7, 28, 60 and 90 days. Waste marble dust cements have been compared to each other as well as to control cements with respect to their physical, chemical and mechanical properties. Obtained results showed that Waste marble dust cements conform to EN 197-1 standard and thus 10% Waste marble dust can be used as an additive material in cement manufacturing.

AA. Ahmed N. Bdour "Utilization of waste marble powder in cement industry"

The test results in this paper shows the feasibility of using waste marble dust in cement industry as a substitute for limestone. Also, it describes the formulation of new cementitious materials obtained from these industrial wastes. The characterization includes chemical composition, determined by thermal behavior, X-ray fluorescence and particle size distribution. Also, physical parameters such as the specific surface area and the percent of weight retained in a fixed sieve (75 µm) were introduced. Test results show that this waste marble dust based cement is capable of improving performance of hardened concrete performance up to 12%, improving fresh concrete behavior and can be used in architectural concrete mixes containing white cement.

BB. İlker Bekir Topçu, Tayfun Uygunoğlu,Turhan Bilir "Effect of waste marble dust content as filler on properties of self-compacting concrete"

The utilization of the waste marble dust in self-compacting concrete (SCC), as filler material, is the main objective of this research. since, the marble dust is used directly without performing any additional processes. Thus, it is another advantage for this objective. For this purpose, marble dust has replaced binder of self-compacting concrete at certain contents of 0, 50, 100, 150, 200, 250 and 300kg/m3. After then, slump-flow test and L-box test were conducted on fresh concrete. Furthermore, compressive strength, ultrasonic velocity, flexural strength, compactness and porosity were determined at the end of 28 days for the hardened concrete specimens. The effects of waste marble dust usage as filler material on capillarity properties of self-compacting concrete were also investigated. the test results concludes that the workability of fresh self-compacting concrete has not been affected up to 200 kg/m3 marble dust content. However, the mechanical properties of hardened self-compacting concrete have been decreased by using marble dust, especially just above 200kg/m3 of marble dust content.

CC. P. Valdez , B. Barragán, I. Girbes, N. Shuttleworth, A. Cockburn "Use of waste from the marble industry as filler for the production of self-compacting concretes"

This research evaluates the possibilities of using residual marble slurry for the production of self-compacting concrete. The study considers the replacement of 20% of cement by the waste material, and assessed the effects on self-compacting concrete properties in fresh and hardened states. Rheological characteristics were evaluated for the paste and concrete. Pastes and concrete properties using waste marble as filler are compared with mixes that includes limestone filler, either added to the concrete or to cement. For the same dose, an improvement in the flowability was observed in self-compacting concrete with marble powder filler. The mechanical properties of the self-compacting concrete adopting marble waste are equivalent to the self-compacting concrete with limestone filler. The research proves that residual slurry obtained from the marble industry represents

as an appropriate filler to be used in self-compacting concrete.

DD. Tej Prakash and R.C.Chhipa "Opportunities for Marble Powder Waste as an Eco-Friendly Use in Adaptive Construction Materials"

In this experiment the effect of using marble powder as constituent of fines in concrete by partially replacing natural sand as fines has been studied in terms of the relative workability & compressive and flexural strengths. Upon testing it is concluded that strength decreases with increasing marble content. Waste marble powder can be used instead of the conventional aggregate in the paver block production.

EE. Deborah .O.Olanrewaju Experimental study on the partial replacement of cement by marble dust on concrete"

This research investigates the containing marble dust as 0, 5, 10 and 20% replacement of properties of hardened concrete Portland cement. The investigation was done to find solution to the disposal problem of marble dust by making use of it in concrete production for sustainable construction. The results so far have yielded some benefits. Result obtained for 28-day compressive strength confirms that marble dust concrete is suitable for light weight concrete with more than 20 MPa compressive strength at 5% replacement. This results less production of carbon dioxide and thereby enhances the urban environment.

FF. Candra Aditya, Abdul Halim, Chauliah Fatma Putri "Waste Marble Utilization from Residue Marble Industry as a Substitution of Cement and Sand within Concrete Roof tile Production"

- The use of waste marble powder as fine aggregate and river sand replacement material in concrete tiles and produces a lighter weight up to 3.6 % - 12.3 %.
- Replacement of Portland cement and river sand with marble powder leads the increase in water absorption.

GG. Jayesh Patel, Prof. M.A.Jamnu "Study on Properties of Concrete Using Marble Dust and Rise Husk Ash"

- Literature shows that the use of marble dust up to 10% in concrete gives maximum strength to the normal concrete. Maximum strength for 10% replacement of marble dust in concrete and Maximum compressive and tensile strength by about 10% replacement of rise husk ash for cement content so both materials can be used up to 10% replacement of cement content for maximum strength.
- It is depicted from this study that the marble dust is very cheap and waste material and improves the strength compared to the normal concrete and rise husk ash is an agricultural waste so its cost is low and improves the workability and increases compressive strength.
- Combined use of marble dust and rise husk ash as replacement of cement improves the properties of hardened concrete and retard the cracks and decrease the cost of concrete.

HH. Pathariya Saraswati C, Rana Jaykrushna K, Shah Palas A, Mehta Jay G,Assistant Prof. Patel Ankit N "Application of Waste Foundry Sand for Evolution of Low-Cost Concrete"

- Compressive strength increases on increasing the percentage of waste foundry sand as compared to traditional concrete.
- In this research, maximum compressive strength is obtained at 60% replacement of sand by waste foundry sand.
- Split tensile strength decreases on increasing the percentage of waste foundry sand.
- Use of waste foundry sand in concrete reduces the production of waste through metal industries i.e. it's an eco-friendly building material.
- The problems of maintenance cost of land filling and disposal is reduced.
- Application of this study results in developing innovative building materials.
- The result of percentage cost change reduces up to 3.5% for 60% replacement of waste foundry sand. This proves that the concrete produced is economical.

II. Ankit Nileshchandra Patel, Prof. Jayeshkumar Pitroda "stone waste as a groundbreaking conception for the low cost concrete"

- Compressive strength increases when the replacement percentage of stone waste increases when compared to traditional concrete.
- Replacement of ordinary Portland cement with this stone waste material provides maximum compressive strength at 25% replacement.
- Replacement of Portland pozzolana cement with this stone waste material provides maximum compressive strength at 15% replacement.
- The Cost reduction is 22.63% when replacement of stone waste percentage is 25% of the ordinary Portland cement when compared to standard concrete.
- The Cost reduction is 14.24% when replacement of stone waste percentage is 15% in Portland pozzolana cement when compared to standard concrete.
- Waste utilization makes it more ecofriendly.
- For the safe disposal of Stone waste it is the possible alternative solution.
- Longer setting time makes it more workable than ordinary Portland cement.

JJ. V. M. Shelke, Prof. P. Y. Pawde, Dr. R. R. Shrivastava "Effect of marble powder with and without silica fume on mechanical properties of concrete"

- The workability of concrete is decreased, with addition of marble powder with and without silica fume while replacing cement.
- The compressive strength of cube & cylinder decreases marginally, by using 5%, 10% & 15% replacement of cement with marble powder in concrete.
- The compressive strength of cube is increased up to 4%, 9% at 7 &28 days of curing by 5% replacement of cement with silica fume.
- The compressive strength of cylinder increased up to 8% & 6% at 7 days & 28 days of curing by using 5% replacement of cement with silica fume.

- The compressive strength of cube & cylinder is decreased marginally by using 10% marble powder & 10% silica fume at 7 & 28 days of curing.
- For other combinations, the compressive strength of cube & cylinder is decreased marginally by using 16% marble powder & 4% silica fume at 7 & 28 days of curing.
- The optimum result of compressive strength for cube is found at 10% silica fume and 10% marble powder with replacement of cement in concrete that is 1.62%, 3.95% at 7 & 28 days of curing.
- The optimum result of compressive strength for cylinder is found at 10% silica fume and 10% marble powder with replacement of cement in concrete that is 2.73%, 1.71% at 7 & 28 days of curing.

III. Objective of Study

- To study the effects of percentage replacement of cement by marble powder on strength of concrete.
- To study the effect on strength of standard mix of concrete by addition of marble powder in it.
- To study the effects of percentage replacement of sand by marble powder on strength of concrete.

IV. Material

- Cement
- Aggregates
- Marble Powder

V. Method

Material	Quantity in m3	Quantity in Kg
Cement	0.137	206.29
Sand	0.210	336.42
Coarse aggregate	0.3288	537.26
water	0.061	61

Table 1: Quantity of materials consumed in preparation of specimens of each group.

Mix	% of replacement	Cement (Kg)	MP (Kg)	Sand (Kg)	Coarse Aggregate (Kg)	Water (Kg)
M 30	0%	41.25	0	67.28	107.45	12.2
	5%	39.18	2.0625	67.28	107.45	12.2
	10%	37.125	4.125	67.28	107.45	12.2
	15%	35.0625	6.1875	67.28	107.45	12.2
	20%	33	8.25	67.28	107.45	12.2

Table 2: Mix Proportion of concrete when cement is replaced with MP.

Mix	% of replacement	Cement (Kg)	MP (Kg)	Sand (Kg)	Coarse Aggregate (Kg)	Water (Kg)
M 30	0%	41.25	0	67.2	107.45	12.2
	5%	41.25	2.06	67.2	107.45	12.2
	10%	41.25	4.12	67.2	107.45	12.2
	15%	41.25	6.18	67.2	107.45	12.2
	20%	41.25	8.25	67.2	107.45	12.2

Table 3: Mix Proportion of concrete when MP is added to the standard mix.

Mix	% of replacement	Cement (Kg)	MP (Kg)	Sand (Kg)	Coarse Aggregate (Kg)	Water (Kg)
M 30	0%	41.25	0	67.2	107.45	12.2
	5%	41.25	3.36	63.9	107.45	12.2
	10%	41.25	6.72	60.5	107.45	12.2
	15%	41.25	10.0	57.1	107.45	12.2
	20%	41.25	13.4	53.8	107.45	12.2

Table 4: Mix Proportion of concrete when sand is replaced with MP.

VI. Observation

Workability as Slump value in mm				
% of replacement	w/c	Replacement of cement with MP	Addition of MP	Replacement of sand with MP
0	0.45	78	78	78
5	0.45	67	74	82
10	0.45	62	67	89
15	0.45	58	65	92
20	0.45	54	62	96

Table 5: Indicating the effect of marble powder on workability of each mix

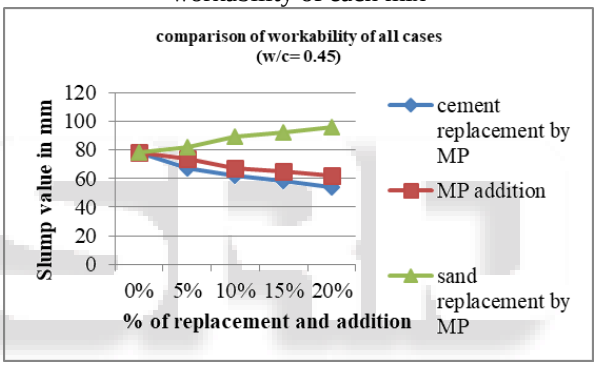

Fig. 3: Indicating the comparison of workability of concrete prepared for all of the three cases.

Strengths achieved on replacing cement with marble powder					
% of Replacement	Samples code	Compressive strength in N/mm2		Flexural strength in N/mm^2	Split tensile strength in N/mm^2
		7 days	28 days		
0%	S1	27.42	38.09	4.32	4.18
	S2	27.45	38.25	4.34	4.2
	S3	26.67	37.21	4.27	4.09
5%	S1	26.42	36.27	4.21	3.98
	S2	26.12	36.41	4.22	4.01
	S3	26.4	36.96	4.25	4.06
10%	S1	22.001	31.67	3.93	3.48
	S2	23.17	32.59	3.99	3.58
	S3	23.16	32.52	3.99	3.57
15%	S1	20.62	28.88	3.76	3.17
	S2	20.41	28.72	3.75	3.15
	S3	20.29	28.1	3.71	3.09
20%	S1	17.82	25.92	3.56	2.85
	S2	17.39	24.47	3.46	2.69
	S3	18.91	26.38	3.59	2.9

Table 6: Indicates the values of strengths achieved when cement replaced with MP

Strengths achieved on addition of marble powder in concrete					
% of addition	Samples code	Compressive strength in N/mm2		Flexural strength in N/mm^2	Split tensile strength in N/mm^2
		7 days	28 days		
0%	S1	27.42	38.09	4.32	4.18
	S2	27.45	38.25	4.34	4.2
	S3	26.67	37.21	4.27	4.09
5%	S1	27.13	37.85	4.30	4.16
	S2	27.40	38.21	4.32	4.20
	S3	27.18	37.92	4.31	4.17
10%	S1	24.70	34.46	4.10	3.79
	S2	24.72	34.48	4.11	3.79
	S3	24.52	34.21	4.09	3.76
15%	S1	23.18	32.33	3.98	3.55
	S2	23.15	32.29	3.97	3.55
	S3	22.40	31.25	3.91	3.43
20%	S1	19.34	26.98	3.63	2.96
	S2	19.13	26.69	3.61	2.93
	S3	19.02	26.54	3.60	2.91

Table 7: Indicates the values of strengths achieved when marble powder is added to the standard mix

Strengths achieved on replacing sand with marble powder					
% of Replacement	Samples code	Compressive strength in N/mm2		Flexural strength in N/mm^2	Split tensile strength in N/mm^2
		7 days	28 days		
0	S1	27.42	38.09	4.32	4.18
	S2	27.45	38.25	4.34	4.2
	S3	26.67	37.21	4.27	4.09
5	S1	29.00	40.46	4.45	4.45
	S2	29.08	40.56	4.45	4.46
	S3	28.98	40.42	4.45	4.94
10	S1	30.02	41.87	4.52	4.60
	S2	30.80	42.97	4.58	4.72
	S3	30.77	42.92	4.58	4.72
15	S1	29.49	41.14	4.48	4.52
	S2	29.51	41.17	4.49	4.52
	S3	29.47	41.11	4.48	4.52
20	S1	27.69	38.63	4.35	4.24
	S2	27.83	38.82	4.36	4.27
	S3	27.85	38.85	4.36	4.27

Table 8: Indicates the strengths achieved when sand replaced with MP

Average values of strengths achieved on replacing cement with marble powder				
% of Replacement	Compressive strength in N/ mm^2		Flexural strength in N/ mm^2	Split tensile strength in N/mm^2
	7days	28days		
0	27.18	37.85	4.31	4.15
5	26.25	36.54	4.22	4.01
10	22.77	32.26	3.97	3.54
15	20.44	28.56	3.74	3.13
20	18.04	25.59	3.53	2.81

Table 9: Indicates the average values of strengths achieved on replacing cement with MP

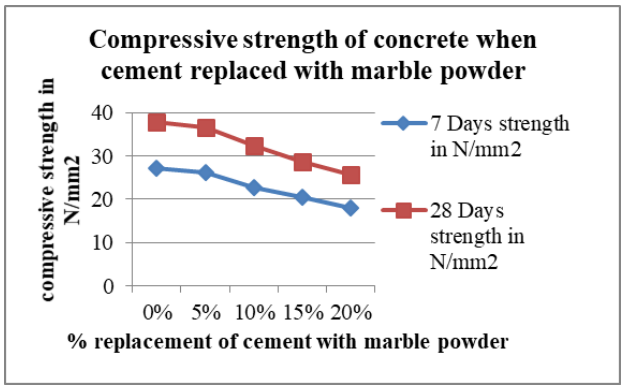

Fig. 4: Indicates the compressive strength of concrete when cement replaced with MP

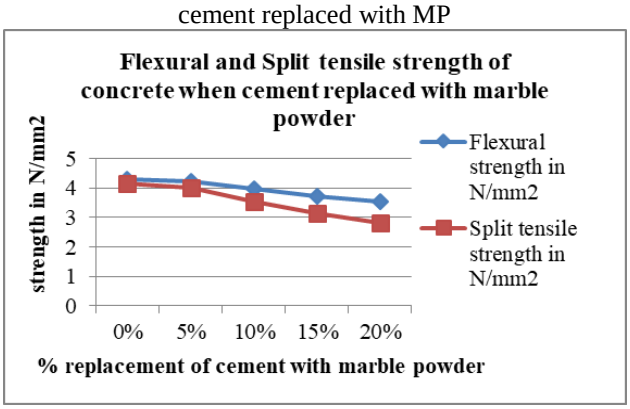

Fig. 5: Indicates the Flexural and Split tensile strength of concrete when cement replaced with marble powder

Average values of strengths achieved on addition of marble powder in concrete				
% of Addition	Compressive strength in N/mm2		Flexural strength in N/mm^2	Split tensile strength in N/mm^2
	7 days	28 days		
0	27.18	37.85	4.31	4.15
5	27.23	37.99	4.31	4.17
10	24.65	34.38	4.10	3.78
15	22.90	31.95	3.95	3.51
20	19.22	26.82	3.62	2.95

Table 10: Indicates the average values of strengths achieved when marble powder is added to the standard mix.

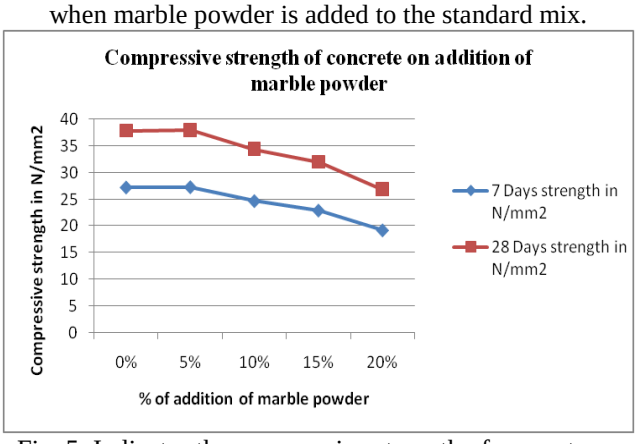

Fig. 5: Indicates the compressive strength of concrete on addition of MP to the standard mix.

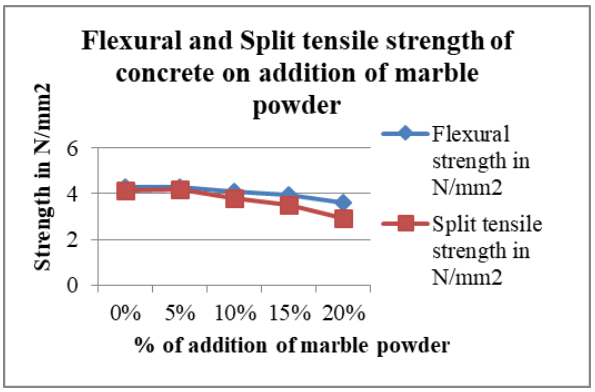

Fig. 7: Indicates the Flexural and split tensile strength of concrete on addition of MP to the standard mix.

Average values of strengths achieved on replacing sand with marble powder				
% of Replacement	Compressive strength in N/mm^2		Flexural strength in N/mm^2	Split tensile strength in N/mm^2
	7 days	28 days		
0	27.18	37.85	4.31	4.15
5	29.02	40.48	4.45	4.45
10	30.52	42.58	4.56	4.68
15	29.49	41.14	4.48	4.52
20	27.79	38.76	4.35	4.23

Table 11: Indicates the average values of strengths achieved when sand replaced with MP

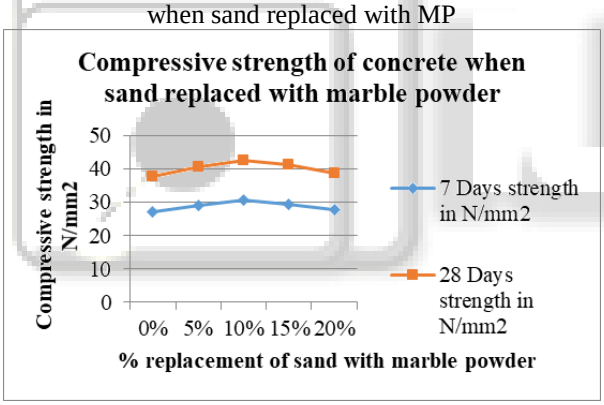

Fig. 8: Indicates the Compressive strength of concrete when sand replaced with marble powder.

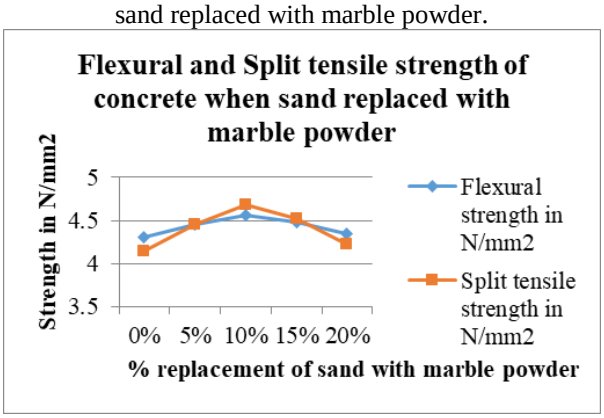

Fig. 9: Indicates the Flexural and Split tensile strength of concrete when sand replaced with marble powder

Now the comparative results are as follows:

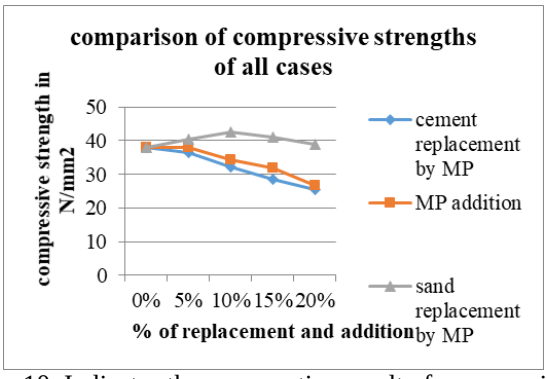

Fig. 10: Indicates the comparative result of compressive strength in all three cases.

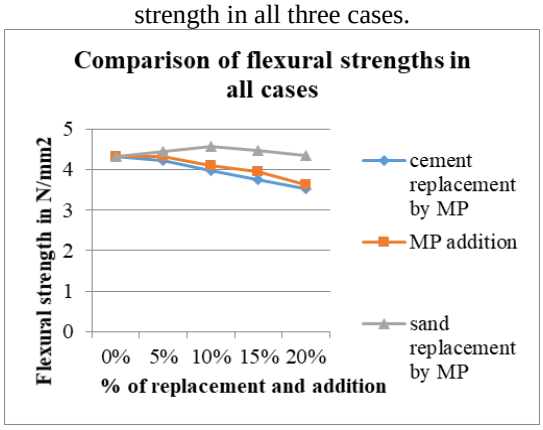

Fig. 11: Indicates the comparative result of flexural strength in all three cases.

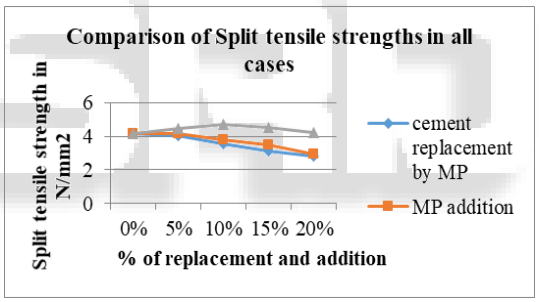

Fig. 12: Indicates the comparative result of split tensile strength in all three cases.

VII. CONCLUSION

1) The physical and chemical properties of marble dust were found suitable for its proposed use.
2) None of the mineral constituents in waste is in undesirable concentration.
3) The workability of concrete increases when sand is replaced with marble powder.
4) The compressive strength of cubes, flexural strength of beams and splitting tensile strength of cylinders were decreased when cement was replaced by marble powder.
5) The compressive, flexural and split tensile strengths were increased slightly on addition of 5% of marble powder (5% of cement). On further increment in the quantity of marble powder strengths were reduced. But the rate of reduction in strength was low as compared to the strengths obtained when cement was replaced with marble powder.
6) Increment in the compressive, flexural and split tensile strengths were observed when sand was replaced by marble powder. Maximum increment was obtained on

10% replacement of sand with marble powder. After that the reduction in strength was observed. But overall values of strength were higher than the strength of standard mix.

7) In concrete production, replacing of sand up to 20% by marble waste powder gives similar strength as of concrete mixes with 100% sand both at early and latter ages.
8) The result indicates that the marble powder up to 20% can replace sand with performance improvement of concrete strength.
9) Due to high fineness of marble powder, it proves to be effective in assuring good cohesiveness of concrete.
10) As this waste is available free of cost, the use of marble powder in concrete might be cost effective.
11) It will help in improving environmental problems as it will prevent the indiscriminate disposal of large quantity of waste generated from marble industries.

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