Effect of Marble Powder on Environment, Mechanical ,Physical and Micro structural Property of concrete- A Review

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1. Abstract;This paper is highlighting a study on partial replacement of waste marble powder dust with fine aggregate and cement in concrete and somehow its environmental effect . A comparison of normal concrete by partial replacement of marble powder with fine aggregate and cement and its environmental effect using the UMBERTO NXT life cycle analysis software with instruction of midpoint and endpoint methods and a detailed cost analysis study to justify the use of marble powder in concrete was done .The strength study in terms of air entrainment ,permeability,shrinkage,soundness,consistency,initial and final setting time, compressive strength,tensile strength,misrostructure analysis using SEM,XRD studied .

Keywords: Waste marble powder, permeability, consistency, strength

2. Introduction: : Rajasthan is known as state of marble , as more than 4000 marble mines in sixteen district of Rajasthan along with 1100 marble processing units are present. The marble when quarried from natural stones gives its waste in two form: solid and semi-liquid slurry .Waste slurry after drying results in environmental pollution in dust form and land pollution by making soil infertile .Thus it proves that due to marble waste air and land pollution generated. When marble is extracted from ores 30% of marble is in waste form due to its non uniform shape and size .Ceramic and construction industry are exclusively using marble. Sustainable development by using natural resources as additive like marble powder leading to reduce the environmental pollution .The emission of carbon dioxide due to use of concrete results in climate change as green house gases evolved and is equivalent to reducing GDP by five percent per year. Life cycle assessment (LCA) is used to judge the cycle of of production from raw material input to final product output. To study the effect of partial replacement of sand and cement with marble powder in normal concrete LCA is used. Economical and environmental uses are provided by applying marble powder in concrete which leads to sustainable development.

Marble industry producing huge volume of mud and other residues obtained from marble and granite processing results in environmental deterioration by air, , water and soil pollution .Reuse of these waste in any products prevent our environment from pollution and also help in growth of economy. As marble is finished after mining process almost half amount of marble is waste and out of that 90% powder are less than 200 μm in size. One of the advantage of using marble powder waste was as its increased percentage in concrete improved permeability .When marble dust is Disposed of on ground it results in loss of water permeability of that ground. Marble powder near processing unit contaminates air because when slurry dryies it leaves a surface residue .Due to rains this waste also contaminates natural resources of water.

3 Literature Review

ANN has been used in prediction model synchronized with results obtained . 10%, 15%, 20% and 25%. of cement was replaced by dried marble slurry to study the effect of concrete made up of locally available resources in air pressure meter, Figg's air and water permeability, electrical resistivity and pull out test .The w/b ratio is kept common as 0.45 except for the investigation on effect of w/b ratios on compressive strength. On the mixes X-ray diffraction (XRD), thermo gravimetric analysis (TGA) and scanning electron microscope (SEM) was performed for Micro-structural analysis . Conclusively artificial neural network (ANN) was used in prediction model of compressive strength The ANN are plotted for compressive strength obtained v/s predicted compressive strength experimentally for 28 days's concrete. Waste marble slurry in wet form was braught from Makrana(Rajasthan) India and oven dried at a temperature of 100 ± 10 ºC for 24 hours. and then sieved in 300-micron sieve. Marble slurry was passing through IS sieve of 300-lm diameter opening is approximately 60% by weight.XRD results show that calcite and dolomite were present in crystalline phases mainly. Standard consistency, initial-final setting time Standard slump cone test , soundness tests were done according to Indian standard IS 4031 (2014) part 4, [6], part 5 [7]] respectively. Cylindrical specimens were casted and tested according to IS 5816 (2004) [15] and ASTM C496 in size of 150 mm diameter and 300 mm height. [2]

The use of super plasticizer results in improving the particle packing by dispersion of the fine particles, thereby increases the strength. Microscopic studies conducted describe that cement pastes become more denser with filler and more homogenous structure were formed . Filler in concrete improves the pore structure. The amount of large pores decreases the number of smaller pore increases, which enhances the strength and durability. Particles with a maximum size of 125 microns as fine particle can affect the concrete in three ways: (i) On the physical level (ii) On the surface chemical level (iii) On the chemical level. On the physical level when added as filler particles fill the intergranular voids present in cement particles as a result improve the compactness of the concrete. On the surface chemical level filler particles enhances hydration as nucleation sites become integrated part of the cement paste. On the chemical level when filler particle added chemically react as an example with calcium hydroxide and thus form cement gel. Thus the effect of addition of fillers in concrete can be seen in three ways: on the physical, surface chemical, and the chemical levels Pozzolanic effect can only be detected in case long-term strength is to be measured. that the Distribution of the filler around the aggregates, improves particle packing and reduces the wall effect. Many types of by-products of the mineral and metallurgical industry can be replaced in place of cement into concrete which improves the strength, durability and rheology.[17]

Two aspects. are discussed in the paper one on varying percentage of marble powder with other studies and another on environmental impact assessment and cost with replacement of waste material
The important point arrived as a result of study. 10-15% replacement by marble powder increases the compressive strength whereas 15-20% of marble powder increases split tensile strength. The w/c reduces due to use of plasticizers .Similarly replacing marble powder with sand in the ratio of 35-50% improves the compressive and split tensile strengths. There was savings in cost by 9.077% by replacement of 15% cement by marble powder whereas on 25 % sand replacement a loss in cost is 3.27% but it is immaterial compare to saving of natural resources i.e. aggregate.Thus a marble powder replaced concrete compare to normal concrete saves environment. Because of the filler effect of marble powder compaction of mixes improved. The carbon footprint of one ton of structural conventional concrete is 410 kg/m^3 which reduces upto 350 kg/m3 with 15%marble powder replacement by cement. 1.05% less energy consumption is there by 15% cement replacement by marble waste .Concrete when disposed leads to fossil depletion, ozone depletion and agricultural land use.[1]

On the other hand there was reduction of 6% and 12% in compressive and tensile strength respectively on 5% replacement with marble dust The strength parameter gradually decreased on increase of MP content up to 30%. The test gave optimum results on 10% replacement with marble powder . In the paper author has replaced 5-30% of cement in concrete by waste Marble powder and test samples were fabricated .
Application of marble powder are:
1.it can be used n rubber industry
2. It can be used in power coating ,paints and ceremic industry.
3.It can be used in Reinforced polyester glass fibre
4. It can be used in leather,cloth and flooring application.
5 In the manufacture of sheet and optical glasses in glass industry.

4.**Reasons to use Marble Dust:**

1. Low cost 2. Acts as a filler in concrete 3.it can be used as an admixture in concrete

4. Reduced the environmental pollution. 5.In manufacture of white cement. etc

5Test peroformed on concrete made up of marble powder

5.1. Consistency: The normal consistency reduces as the percentage of marble slurry increases.The reason came into notice is amount of water require will be more in case of concrete with marble slurry compare to normal concrete because of fineness of marble.[6]

5.2.Soundness and Setting characteristics: Setting time increases upto25% addition of marble.This help in transportation and placing of concrete.soundess when tested comes in desired limit on addition of marble ,The probable reason for it may be high presence of magnesia in marble compare to cement[7]

5.3Percentage air content: As amount void spaces reduces which can clearly be seen if SEM of concrete with addition of marble is done .so with increase in percentage of marble amount of entrained air reduced. Researches are shown upto 25% replacement of cement with waste marble slurry.[2][11]

5.4. Drying shrinkage: Amount of drying shrinkage get reduced as marble acts as filler in void spaces .This in turn save reinforcement from corrosion and environmental effect .

5.5. Compressive strength of mortar mix: Up to 10% addition of marble slurry the compressive strength of mortar cubes increases. On further addition beyond 10% the strength decreases because of reduction in amount of C3A and C2S required for hydration process.

5.6 Thermo gravimetric analysis: This analysis is done in four endothermic phases .In first phase range of 30–110 ^oC was kept and in this phase there is loss in percentage of surface moisture as fine partcicles added absorb more moisture and releases it on high temperature and results in weight loss.

In second phase range of temperature from 110– 410 ^oC results in the dehydration of calcium aluminate hydrate and calcium silicate hydrate.THE third phase results in decomposition of calcium hydroxide observed range is from 410 to 460^oC and in the last phase the decarbonation of calcium carbonate is there in concrete.

5.7. X-ray diffraction analysis (XRD) : Marble slurry being an inert material does not take chemically involved in process .

5.8.Permeability Test: Cylinder was soaked in water to test permeability by blaine apparatus fully automatic used to test the permeability of water soaked cylinder sample.Upto 10% replacement of cement with marble dost the voids were filled but after increasing the percentage beyond 10% the mass of concrete increases and it acts as overburden.the increase in permeability is upto 32%.For water retaining structures upto 10% replacement is suggested.[22][2]

5.9.Particle size gradation of waste marble dust: waste marble dust has lumps of size more than 80mm,while the waste marble powder size varies from0.321mm to 15mm[22]

5.10. Compressive Strength of concrete: As percentage of marble powder replaced with cement in concret increases the results had shown decreasing trend in compressive strength of concrete.[13][22]

5.11.Split tensile strength of concrete: Results have shown decrease in strength with percentage increase of waste marble powder in concrete.[22]

5.12.Slump test : Waste marble dust added upto replacement of 10% is accepted as it does not affect the workability.Beyond 10% the workability decreases.The workability is affected by shape and size of fine aggregate. The ratio of fine aggregate to coarse aggregate also affect the workability of concrete.[22]

6. Outcome of study :

1. For reducing carbon dioxide emissions of concrete addition of Ground-granulated blast furnace-slag (GGBS) was recommended As compared to Portland cement (PC), Fly ash considerably improves sustainability. [20]

2. ISO 14040 guidelines has been used in life cycle as assessment (LCA) of concrete made up of marble. Environmental impact assessment are measured using four stages – goal and scope definition, inventory analysis, impact assessment, and interpretation [21]. LCA is used to study the effect of partial replacement of sand and cement with marble powder in concrete along with normal concrete and to access its environmental effect .Researches used UMBERTO-NXT software to know the production process of concrete. As density of concrete is not affected by transportation of concrete having marble powder so its effect is not considered. Models with different composition of concrete have been prepared,Ist designated as normal for normal concrete , IInd designated as C15 for cement replacement and third designated as S25 for sand replacement. IS 10262 design of concrete code was used for M20 grade concrete mix design. To study the effect of partially replacing is that the energies and materials required in marble processing would be 0.8 times that of granite .

In order to measure the Impact assessment midpoint and endpoint methods have been used. For 7 different categories Climate Change, Human Toxicity, Agricultural Land Use ,Stratospheric Ozone Depletion ,Fossil depletion, Particulate matter and Water depletion environmental impact is measured .As sand extraction require 0.07 GJ/ton embodied energy it do not affect the life cycle assessment process but indirectly its impact on the ecosystem is almost in equal proportion to that of cement.

3. Very optimum quantity of cement and sand are replaced by marble powder. The reason for this optimum use of marble powder is it acts as a filler on concrete rather than increasing the strength according to the study

4. Maximum reduction on impact for cement replacement in end point assessment is observed as maximum amount of energies involves in production process of cement.
5. Around 1.18 GJ/ton energy utilized in cement production, so 15% replacement of cement by waste marble powder reduced energy consumption by 1.05%.Thus there is positive utilization of energy to dump waste marble powder . Mining of sand has bad effect on erosion and the local wildlife of the area.
6.Human health is affected by the production of cement and the use of electricity in mixing concrete.
Large amount of natural resources as coal utilized in Production of electricity. Thus ecosystem is affected.
7. As Sand, water and gravel are obtained from natural resources have very smaller effect on the production. The disposal of inert waste concrete has impact on ozone depletion and agricultural land use. By reutilizing waste crushed concrete as granular fill for sub grades of pavement reduces the impact of disposing of concrete.
8.Study describe that the cost of 1 meter cube of OPC M20 grade of concrete is 34.78 USD whereas 1 meter cube concrete of 15% partial replacement of cement with marble powder cost 31.70 USD and 25% partial replacement of sand by marble powder cost 36.06 USD. The cement replacement case a benefit of 9.077% is there while the sand replacement case a loss of 3.4% is there. But from environment point of view sand replacement by marble powder has huge impact. As use of sand in construction industry is in large amount and it will affect future availability of sand for construction activities which will enhance its future cost.
9.A percentage deduction in cement with waste marble powder reduces the cost of concrete production, and also provides better strength and durability

10.On increase of marble waste powder concentration the concrete become denser as most of void spaces were filled by filler as shown in SEM diagram below as percentage of marble powder increases the void spaces decreases .

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