To study the mechanical properties and effect of Carbonation on marble dust Concrete

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Abstract: Worldwide development in overall Scenario will be carbon lessening and vitality sparing. This increasing trend in concrete production and automatically the increasing demand of its ingredients poses a significant impact on the environment. it also threatens the natural resources due to its over utilization and less replenishment. The cement manufacturing involves the emission of carbon dioxide and it seriously affects the environment and is a cause of global warming. Durability is one of the major concerns for concrete structures subjected to harsh environments. Nature's impact on environment highly influences the durability of reinforced concrete Structures. Carbonation is one of the major factors responsible for structure deterioration. The corrosion of steel in concrete is a major deterioration problem, mainly due to carbonation and the presence of chloride ions at the reinforcement level..Carbonation occurs in concrete because the calcium bearing phases present are attacked by carbon dioxide of the air and converted to calcium carbonate. Cement paste contains 25-50 % of calcium hydroxide (Ca(OH)2), which mean that the pH of the fresh cement paste is at least 12.5. The pH of a fully carbonated paste is about 7. Carbonation of concrete is associated with the corrosion of steel reinforcement and with shrinkage. However, it also increases both the compressive and tensile strength of concrete, so not all of its effects on concrete are bad. The higher the grade of concrete, the slower will be the rate of carbonation. In case of less permeable concrete the rate of carbonation is slower and vice versa. Definitely the concrete which are protected are less prone to carbonation. This work studies the cement is partially replaced by marble dust with percentage ratio of 0%,5%,10% and 15% and the concrete will be prepared for varying water cement ratio of 0.35 and 0.45. This Study has shown that some variation in carbonation depth at varying w/c ratio of 0.35 and 0.45 and to evaluate the optimum mix in terms of strength, durability and production cost.

Keywords: Marble dust Concrete, Carbonation, mechanical properties

I. INTRODUCTION

Carbonation occurs in concrete because the calcium bearing phases present are attacked by carbon dioxide of the air and converted to calcium carbonate. Cement paste contains 25-50 % of calcium hydroxide ($Ca(OH)_2$), which mean that the pH of the fresh cement paste is at least 12.5. The pH of a fully carbonated paste is about 7.

The concrete will carbonate if CO_2 from air or from water enters the concrete according to:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

When $Ca(OH)_2$ is removed from the paste hydrated CSH will liberate CaO which will also carbonate. The rate of carbonation depends on porosity & moisture content of the concrete. The carbonation process requires the presence of water because CO_2 dissolves in water forming H_2CO_3. If the concrete is too dry , CO_2 cannot dissolve and no carbonation occurs. If on the other hand it is too wet CO_2 cannot enter the concrete and the concrete will not carbonate. Optimal conditions for carbonation occur at a RH of 50% (range 40-90%).

However, Carbonation of concrete is associated with the corrosion of steel reinforcement and with shrinkage. However, it also increases both the compressive and tensile strength of concrete, so not all of its effects on concrete are bad.

Factors affecting Rate of carbonation

- presence of pore water
- Grade of concrete
- Permeability of concrete
- Protected or unprotected concrete
- Depth of cover
- Time

If pores in the concrete are dry then CO_2 remains in gaseous from and does not react with hydrated lime and carbonation cannot take place.The higher the grade of concrete, the slower will be the rate of carbonation. In case of less permeable concrete the rate of carbonation is slower and vice versa. Definitely the concrete which are protected are less prone to carbonation.

Marble Dust

India is the third largest producer of marble in the world. Marble is cut into the required dimensions during mining and about 5–6 Mt of MD is generated each year through over marble cutting, polishing, processing and grinding. In these operations, an average 20% of the total extracted marble ends up as MD (Gupta, 1998; Mohamed, 2013; Pappu et al., 2007) and is one of the major environmental problems around the world. An approach for the sustainable use of Marble Dust in the construction industry was undertaken in this study, so that environmental threats could be reduced in a scientific manner. If marble dust is used as a construction material it will not only contributes in pollution free environment but also saves energy and effective in making economical concrete. By utilizing marble powder as construction material one can have following advantages:

- It can be used as an additive in industrial brick production.
- The unit weight of concrete is increased when marble dust is used as a substitute for fine aggregates.
- The use of marble dust offer cost reduction, energy savings and reduces environmental hazards.

II. LITERATURE REVIEW

Shigeyoshi Nagataki, Hiroyuki Ohga(1986) This paper reports the long term results of experiments carried out since 1969 to investigate the carbonation phenomena in concrete with and without fly ash. They were carried out for different mix proportions by varying cement factor, replacement ratio of fly ash and water-cement ratio. The specimens were cured indoors and outdoors after water curing for periods of 1, 7, 28 and 91 days. It was found that the carbonation and the corrosion is considerably affected by mix proportions, initial curing period in water and exposure conditions. Depths of the carbonation of concrete cured indoors increase with age, short initial curing period in water and high water-cement ratio. Corrosion of reinforcing bar embeded occurred due to the carbonation.

Linhua Jiang,Yuebo Cai(2000) The carbonation process and the factors affecting concrete carbonation are presented. A mathematical model based on carbonation process for predicting the carbonation depth of high-volume fly ash (HVFA) concrete was developed. An accelerated carbonation test was conducted on ordinary Portland cement (OPC) concrete and HVFA concrete. The depths of carbonation predicted from the model are compared with the test results. It is shown that the effective water/binder ratio and the cement content are the key factors affecting HVFA concrete carbonation. The increase of curing period can improve the carbonation behavior of HVFA concrete. The carbonation behavior of HVFA concrete with appropriate mix proportion can meet the requirements of structural concrete. The agreement between test results and the prediction from the model is good. The model can be used to predict the evolution of carbonation depth with time.

P. Sulapha,S.F Wong(2003) This study deals with the carbonation of concrete incorporating ground granulated blast-furnace slag (GGBS), fly ash (FA), and silica fume (SF). It is observed that a decreased water-to-binder ratio and replacement level of GGBS, FA, or SF, or an increase in GGBS fineness and curing age in water, led to better carbonation resistance. However, compared to a plain concrete, the concrete incorporating mineral admixtures (except GGBS with higher fineness and SF) generally showed lower resistance to carbonation, possibly due to the dominating effect of the reduction in calcium hydroxide over pore refinement. Hence, adequate curing is recommended for enhancing the resistance of concrete containing GGBS, FA, and SF to carbonation. It is also found that both the carbonation coefficient and compressive strength served as good indicators for the carbonation rate of concrete with and without mineral admixtures.

Cheng Feng Chang,Jing Wen Chen(2006) In this study Phenolphthalein indicator has traditionally been used to determine the depth of carbonation in concrete. This investigation uses the thermalgravimetric analysis (TGA) method, which tests the concentration distribution of $Ca(OH)_2$ and $CaCO_3$, while the X-ray diffraction analysis (XRDA) tests the intensity distribution of $Ca(OH)_2$ and $CaCO_3$. The Fourier transformation infrared spectroscopy (FTIR) test method detects the presence of C–O in concrete samples as a basis for determining the presence of $CaCO_3$. Concrete specimens were prepared and subjected to accelerated carbonation under conditions of 23 °C temperature, 70% RH and 20% concentration of CO_2. The test results of TGA and XRDA indicate that there exist a sharp carbonation front. Three zones of carbonation were identified according to the degree of carbonation and pH in the pore solutions. The TGA, XRDA and FTIR results showed the depth of carbonation front is twice of that determined from phenolphthalein indicator.

Vagelis GPapadakis(2009) In this work the durability of Portland cement systems incorporating supplementary cementing materials (SCM; silica fume, low- and high-calcium fly ash) is investigated. Experimental tests simulating the main deterioration mechanisms in reinforced concrete (carbonation and chloride penetration) were carried out. It was found that for all SCM tested, the carbonation depth decreases as aggregate replacement by SCM increases, and increases as cement replacement by SCM increases. The specimens incorporating an SCM, whether it substitutes aggregate or cement, when exposed to chlorides exhibit significantly lower total chloride content for all depths from the surface, apart from a thin layer near the external surface. New parameter values were estimated and existing mathematical models were modified to describe the carbonation propagation and the chloride penetration in concrete incorporating SCM.

Kazim Turk, Mehmet Karatas(2012) In this paper, ASTM C 618 Class F Fly Ash (FA) at 25%, 30%, 35% and 40% and Silica Fume (SF) at 5%, 10%, 15% and 20% replacement of Portland Cement (PC) CEM I 42.5 in SCC was used to evaluate the effect of types and quantity of powder additions on compressive strength and permeations properties of SCC. To this end, eight types of SCC were designed, in comparison with Vibrated Traditional Concrete (VTC). The results indicated that SCC specimens with SF15 had the highest compressive strength with 73.87 MPa for 130 days. The sorptivity values of SCC specimens with FA and SF were lower than those of VTC specimens regardless of type and quantity of powder additions. On the other hand, the carbonation resistance of VTC was higher than that of SCC specimens containing both SF and FA for all accelerated carbonation periods. Consequently, it can be said that type and quantity of powder additions had an important effect on the correlation among the compressive strength and permeation properties of SCC.

Nishant Malay et.al (2015): in this paper the carbonation test was carried out to study the carbonation of concrete by partially replacing cement with marble dust by 0%,5%,10%,15% and 20%. The experimental results concluded that carbonation depth slightly decreases with increase in marble powder. There is improvement in mechanical properties of concrete with addition of marble dust as wells as depth of carbonation reduces. It was found that at 10% replacement by marble dust, the optimum mix was obtained for both the cases.

Shaik Hussain et.al (2016) This paper investigates the effect of carbonation on the mechanical properties, durability properties and permeability of concrete. The study was carried out at varying water cement ratio of 0.35,0.50 and 0.65 are chosen. The results concluded that volume of permeable voids of concrete has decreased with an increase in compressive strength as well as flexural strength. Depth of carbonation increases with increasing proportion of CO_2.

Liwu Mo et.al (2017) In this paper steel slag has been used as supplementary cementeous material and as a aggregate marterial. 60% of steel slag is used as replacement of cement and upto 100% as aggregates replacement. The concrete was exposed to the carbonation curing with 99.9% CO2 for duration period of 1 day, 3 ady and 14 days.the experiments were performed for carbonation front, compressive strength and volume stability for concrete. The results showed that compressive strength of concrete containing slag after carbon dioxide curing has increased.

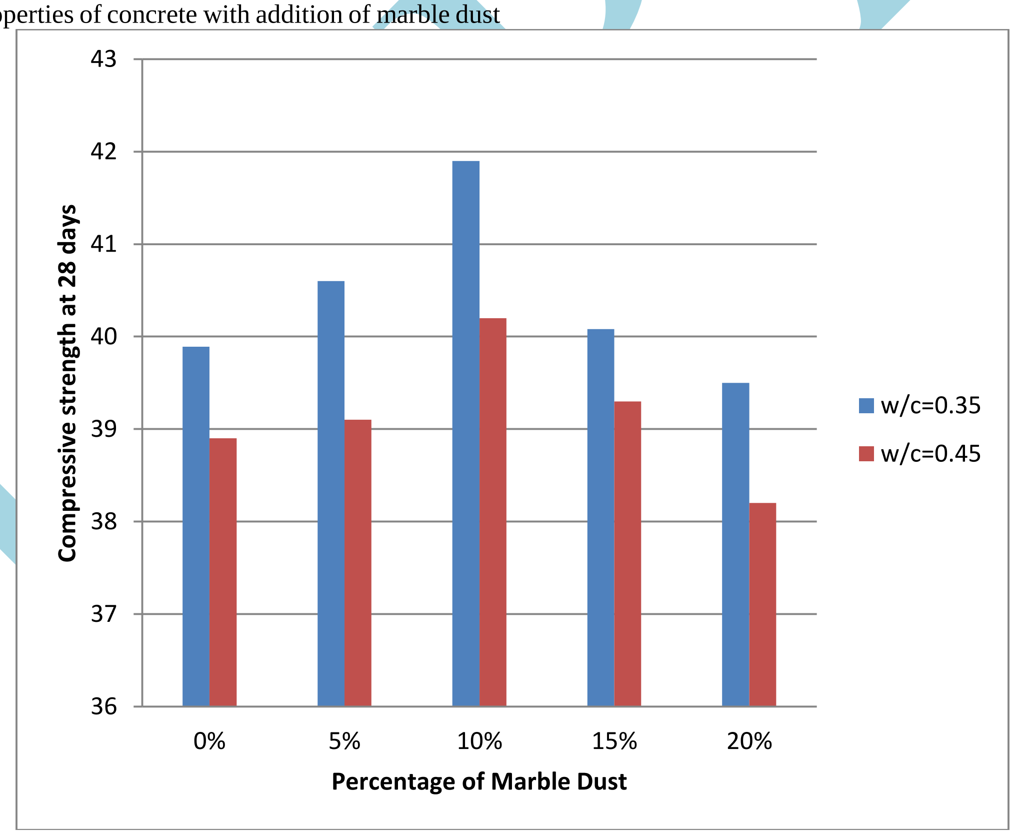

Fig. 1 Compressive strength at 28 days with varying Percentage of Marble dust at different w/c ratio.

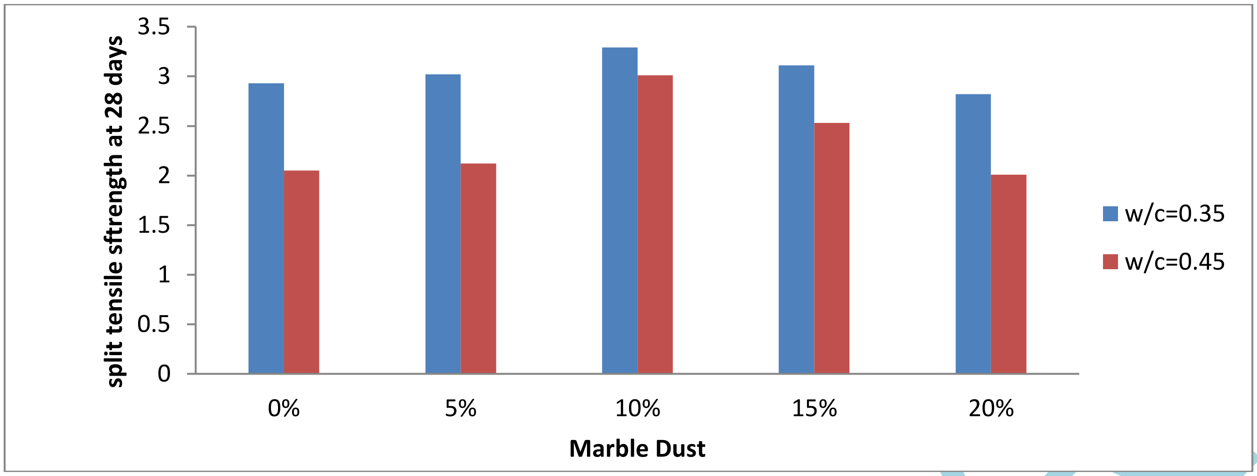

Fig. 2 Split tensile strength at 28 days with varying Percentage of Marble dust at different w/c ratio.

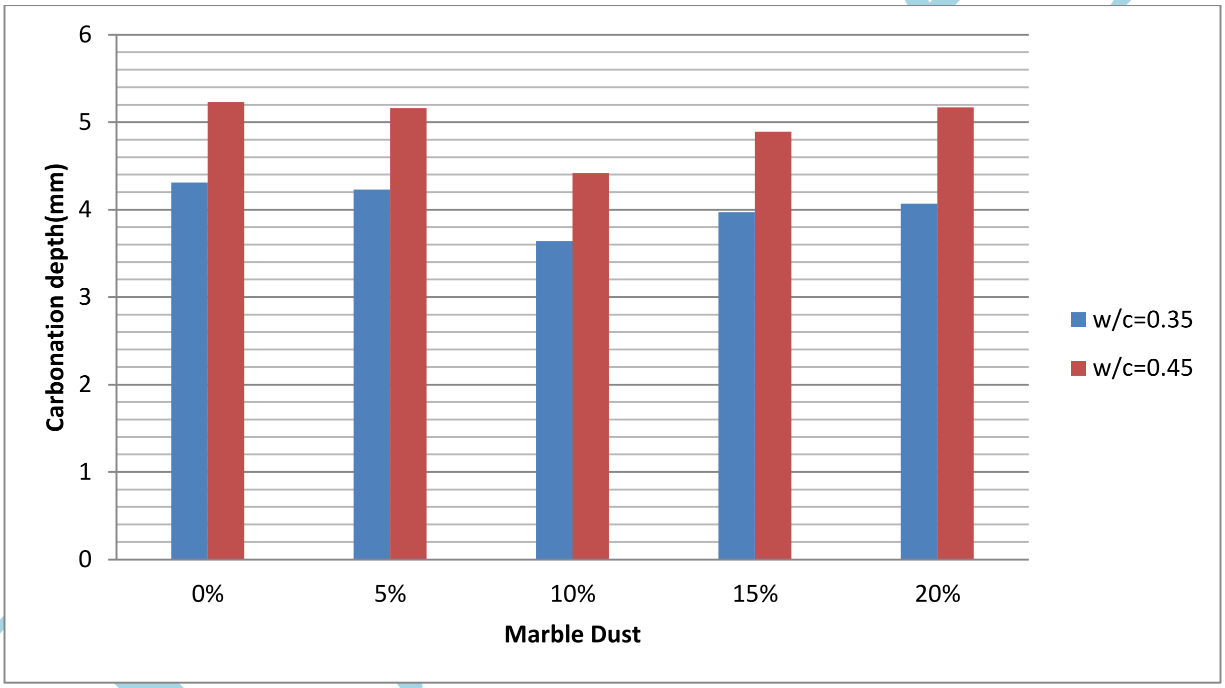

Fig. 3 Variation of carbonation depth

III. CONCLUSIONS

1. The compressive strength of concrete increases with increasing percentage of marble dust upto 10% thereafter it decreases. The increase in strength may be due to fineness of marble dust and its filler effect.
2. It was also concluded that with the increase of w/c ratio the compressive strength of concrete decreases. This may be due to less cement available for binding of ingredients and making it homogeneous mass.
3. The concrete mix CM10 i.e concrete produced by replacement of cement by 10% marble dust can be considered as optimum mix in terms of strength as it has the maximum value of compressive strength.
4. The results of split tensile shows the similar results as that of compressive strength.
5. The maximum split tensile strength was observed at concrete mix CM10. The percentage increase in split tensile strength for CM10 mix was found to be increased by 12.28% and 13% at w/c=0.35 &0.45 respectively.
6. The concrete mix CM10 can be considered as optimum mix in trems of strength properties as well as from economic perspective also.
7. Carbonation test results revealed that depth of carbonation increases with increasing ratio of water cement. This may be due to increased porosity of concrete by increasing water cement ratio.
8. It can also be concluded that with increasing percentage of marble dust upto 10% decreases the

carbonation depth. This may be due to maximum packing density is achieved at 10% marble dust.

9. The minimum Carbonation depth for both water cement ration was attained at CM10. Hence concrete with marble dust replacement at 10% can be effectively used for reinforced concrete structures.
10. The cost of concrete construction will be reduced as marble dust is cheaply or free of cost is available in market.

IV. FUTURE SCOPE

1. Mechanical properties of concrete can be checked for other types cements like PPC, SCC.
2. Both mechanical and durability properties of concrete can be computed for higer grades of concrete.
3. Carbonation studies can be advanced by using other supplementary cementeous materials.
4. Carbonation rate can be analyzed for higher duration periods.
5. For different water cemet ratio and water binder ratio, the carbonation test should be performed.

V. REFERENCES

[1]. Manish kumar (2015). Effect of partial replacement of cement by marble dust on compressive strength and carbonation of PPC Concrete in UKIERI Concrete Congress-Concrete research driving profit and Sustainability.

[2]. N Venkant Rao et.al (2017). A review on carbonation study in concrete in ICSET-2017 in materials science and Engineering 263.

[3]. Shaik Hussain et.al (2016) An experimental investigation of accelerated carbonation on properties of concrete in engineering journal vol. 20 issue 2 ISSN 0125-8281.

[4]. Kenichiro Nakarai(2015) Effect of carbonation on strength development of cement-treated Toyoura silica sand in Soils and Foundations 2015;55(4):857–865

[5]. Rabah Chaid (2015). in Durability of Concretes with Marble Powder in 2015 5th International Conference on Environment Science and Engineering Volume 83 of IPCBEE (2015) DOI: 10.7763/IPCBEE. 2015. V83.6

[6]. Manish Kumar (2017). Study of natural carbonation of concrete incorporating marble dust in *in* Construction Materials · January 2018

[7]. Liwu Mo (2017). Accelerated carbonation and performance of concrete made with steel slag as binding materials and aggregates in cement and concrete composites 83(2017) 138-145.