Studies on Strength Characteristics of Normal conventional Concrete with Diatomite and GGBS as Admixtures

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Abstract - Concrete is the most widely used construction material in civil engineering constructions because of its good compressive strength and stability. The concrete industry is looking for supplementary cementitious material or industrial by- products with the objective of reducing the carbon dioxide emission which is harmful to environment. Dolomite powder is the supplementary cementitious material obtained by powdering mineral dolo stone . This paper deals with the effective utilization of diatomite powder in concrete production as a partial replacement of cement. The mechanical properties of M20 grade concrete are studied with partial replacement of cement by dolomite powder in the percentages of 5%,10%,15%,20% and 25%.The optimum percentage of dolomite in concrete corresponding to maximum strength will be identified, keeping this optimum percentage of diatomite as constant, cement is further replaced with GGBS in percentages of 5%,10%,15% and 20%.The test results indicate that the maximum strength was observed in a mix consisting 10%dolomite with 10%GGBS.This paper focus on investigating behaviour of M20 concrete by partial replacement of cement by diatomite powder and granulated blast furnace slag.

KEYWORDS: Diatomite, GGBS, Compressive strength, Flexural strength, Split tensile strength, M30 grade concrete.

I.INTRODUCTION

Concrete is the basic civil engineering material used in most of the civil engineering structures. Cement, fine and coarse aggregates, admixtures and water are the basic constituents of concrete. Cement is the most important constituent material, since it binds the aggregates. Many materials are used to manufacture good quality concrete. Diatomite may be preferred as one of the construction materials to replace cement partially in concrete due to its higher surface hardness and density. Diatomite is a rock forming mineral with a chemical composition of CaMg(Co3)2. Diatomite is formed by the replacement of calcium in a calcium carbonate limestone deposit with magnesium. In diatomite calcium and magnesium ions exists in separate layers in crystalline matrix form. Diatomite has alternate layers of calcium and magnesium carbonate layers. It is hard and denser than lime stone, chemically inert and more impervious to acid attack Diatomite also preferred as a filler material in asphalt concrete applications due to its higher strength and hardness. Ground granulated blast furnace slag (GGBFS) is a by-product is a solid waste discharged by the iron and steel industry in large quantities. GGBS is obtained by quenching molten iron slag from blast furnace in water or steam. The quenching optimizes the cementitious properties and produces a glassy, granular product similar to the coarse sand. The product is dried and ground into fine powder called GGBFS. Diatomite and GGBFS combinely used as replacing materials to cement as filler and binder materials in concrete.

II.LITERATURE REVIEW

Deepa Balakrishnan et.al [1] had studied the work ability and strength characteristics of self-compacting concrete containing fly ash and dolomite powder. she made high volume fly ash self-compacting concrete with12.5percent, 18.75percent, 25percent and 37.5percentof the cement (by mass) replaced by fly ash and 6.25percent, 12.5percent and 25percent of the cement replaced by dolomite powder The mixes were then tested for mechanical properties like, cube compressive strength at 7th day, 28th day and 90th day, cylinder compressive strength at 28th day, split tensile strength, and flexural strength at 28th day. From the results she concluded that better mechanical and physical properties of concrete can be obtained with the replacement of cement with fly ash from 12.5% to 18.75%.

Kamal M.M, et al [2] evaluated the bond strength of self-compacting concrete mixes containing dolomite powder. Either silica flume or fly ash was used along with dolomite powder to increase the bond strength considerably. Seven mixes were proportioned and push-out test was carried out. The variation of the bond strength for different mixes was evaluated. The steel concrete bond adequacy was evaluated based on normal bond strength. The result showed that the bond strength increased as the replacement of Portland cement with dolomite powder increased. All SCC mixes containing dolomite powder up to 30 % yielded bond strength that is adequate for design purpose. The availability of this type of concrete provided unique merits for faster construction. From the results he concluded that the shear strength of RC beams were better than that of the conventional SCC without dolomite powder.

SalimBarbhuiya [3] studied the effects of fly ash and dolomite powder on the properties of self-compacting concrete. His research work deals with the utilization of an alternative material, dolomite powder instead of limestone powder, for the production of scc five concrete mixes with different proportions of fly ash and dolomite powder (1:0,3:1,1:1,1:3,0:1) each having the same water binder ratio of 0.38 were casted, and the test results shows that mix containing fly ash and dolomite powder in the ratio 3:1 satisfies the requirements of EFNARC for making scc.

OlesiaMikhailova [4] studied the effect of dolomite limestone powder on the compressive strength of concrete. His present study describes the effect of fine ground dolomite limestone on important physics and mechanical properties of concrete. He casted the mixes containing finely ground dolomite from 0% to 30% by weight of cement were prepared with water cement ratio of 0.5.the specimens were tested at 14 and 28 days. The test results showed that the compressive strength increased at 25% replacement of cement with dolomite powder. This examination indicates that the use of dolomite limestone as component instead of limestone is a viable solution for producing Portland dolomite limestone cement.

Prince Arulraj G [5] studied the effect of cement with dolomite powder on the mechanical properties of concrete. His study examines the possibility of using dolomite powder as a partial replacement material to cement. The replacement percentages tried were 0%, 5%, 10%, 15%, 20% and 25% by weight of cement. The compressive strength, split tensile strength and flexural strengths of concrete with dolomite powder were compared with those of the reference specimens. The results indicate that replacement of cement with dolomite powder increases the compressive strength at 10% replacement of cement and split tensile strength at 15% replacement of cement and the flexural strength at 10% replacement of cement. Thus the results shows that the replacement of cement with dolomite powder improves the strength of concrete.

MaciejZajac et.al [6] studied the effect of CA Mg $(Co_3)_2$ on hydrate assemblages and mechanical properties of hydrated cement pastes at 40 degree Celsius and 60 degree Celsius. The effect of additions of limestone and dolomite powder on the properties of blended cements cured at 40 and 60 degree Celsius was investigated using a multi-method approach. The presence of limestone leads to the formation of hemi-and mono-carbonate and to the stabilization of ettringite at 40 degree Celsius. An increase of temperature to 60 degree Celsius results in the destabilization of ettringite and formation of monosulfate in the limestone cement. The dolomite is almost depleted in the cementations matrix over the hydration time at the studied temperatures. As a result, the formation of hydroalcite is observed which binds part of the alumina from clinker dissolution. At 60 degree Celsius no monosulfate is found and the c-s-h contains less alumina in the presence of dolomite in comparison to when limestone is present. The dolomite dissolution increases the strength at higher temperatures as a result of the additional hydrotalcite formation.

Milosz Szybilski et.al [7] studied the effect of dolomite additive on cement hydration. The effect of dolomite on alite hydration was investigated in order to elucidate the effect of dolomite addition in cement hydration. The rate of heat evolution both in cement-dolomite and alite-dolomite system was taken as a starting point. Subsequently the chemical shrinkage, conductivity of liquid phase and rheological parameters of pastes were characterized. The observations of micro structure were carried out under SEM and the hydration degree of alite was determined by XRD. The accelerating effect of additive was proved. At low percentage dolomite plays a role of cement replacement, at higher dosage the dilution effect can be observed. However, increasing dolomite content is accompanied by higher amount of hydration products, as a results of crystallization on the fine dolomite grains and better absorption of water. The hydration degree of alite increases as well.

Deepthi C.G [8] had studied the compressive strength of concrete with dolomite powder and crushed tiles. Her study aim is to create a better concrete in low cost and is focused on the compressive strength of the concrete by partially replacing cement with dolomite powder and coarse aggregates with crushed tiles. In first phase the coarse aggregate was replaced with crushed ceramic tiles at 10%, 20%, 30% and 40%. The test results showed that the compressive strength increased at 30% replacement of coarse aggregate with crushed ceramic tiles. In second phase the optimum strength obtained by replacing coarse aggregate is kept constant and the cement is replaced with dolomite powder at 5%, 10%, 15% and 20%. The test results showed that the compressive strength increased at 30% replacement of coarse aggregate and 10% replacement of cement.

S.Arivalagan [9] studied the sustainable studies on concrete with GGBS as a replacement material in cement. His paper deals with the effort to quantify the strength of ground granulated blast furnace slag (GGBS) at various replacement levels and evaluate its efficiencies in concrete. His research evaluates the strength and strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of ground granulated blast furnace slag for M_{35} grade of concrete at different ages. From his study, it can be concluded that, since the grain size of GGBS is less than that of ordinary Portland cement, its strength at early ages is low, but it continues to gain strength over a long period. The optimum GGBS replacement as cementation material is characterized by high compressive strength, low heat of hydration, resistance to chemical attack, better workability, good durability and cost effectiveness.

III. PREPARATION OF SPECIMENS

Ten concrete mixes designated as A(Control Mix), B(5% Dolomite), C(10% Dolomite), D (15% Dolomite) E(20% Dolomite), F(25% Dolomite), G(10% Dolomite+ 5% GGBFS), H(10% Dolomite+ 10% GGBFS),I(10% Dolomite+15% GGBFS),J(10%Dolomite+ 20%GGBFS) ,K(10%Dolomite+ 25% GGBFS) were used in the investigations presented in this report. Mix proportions are designed according to the principles of mix design of IS 10262-1982 and SP 23-1982 for M30 grade concrete. The water cement ratio used for the entire mixes is 0.45.

Table 5.Mix Proportions for Mixes A to K

Mix Designation	Cement (Kg/ m^3)	Diatomite (Kg/m^3)	GGBFS (Kg/ m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m3)	Water (Kg/ m3)
MIX A(Control Mix)	425	–	–	662	1206	192
MIX B(5% Diatomite)	403.75	21.25	–	662	1206	192
MIX C(10% Diatomite)	382.5	42.5	–	662	1206	192
MIX D(15% Diatomite)	361.25	63.75	–	662	1206	192
MIX E(20% Diatomite)%	340	85	–	662	1206	192
MIX F(25% Diatomite)	318.75	106.25	–	662	1206	192
MIX G(10% Diatomite+5%GGBS)	361.25	42.5	**21.25**	662	1206	192
MIX H((10% Diatomite+10%GGBS)	340	42.5	**42.5**	662	1206	192
MIX I((10% Diatomite+15%GGBS)	318.75	42.5	**63.75**	662	1206	192
MIX J((10% Diatomite+20%GGBS)	297.5	42.5	**85**	662	1206	192
MIX K((10% Diatomite+25%GGBS)	276.25	42.5	**106.25**	662	1206	192

IV. PREPARATIONS AND TESTING OF SPECIMENS

The exact proportions of cement, sand, coarse aggregate, Diatomite powder, GGBS powder were weighed accordingly as given in Table 5 and mixed thoroughly in the tray with water to the required quantities as per the design calculations according to I.S: 10262-2009. Test specimens were compacted on the vibrating table and kept for set for 24 hours. They are demoulded a day after casting and cured well in water up to the date of testing. Concrete cubes(150 x150x150 mm),cylinders(150x300 mm),prisms(100x100x500 mm) of standard sizes were casted and tested for 28-day compressive strength, split tensile strength and flexural tensile strength properties respectively the mean strength values are presented in Tables 6,7 and 8 respectively. Casting and testing of specimens are presented in photo 1 and 2.

Table.6 Compressive Strength of M20 concrete

Mix Designation	Compressive strength in MPa (28 DAYS)
Mix A	31.48
Mix B	32.51
Mix C	36.37
Mix D	32.28
Mix E	28.27
Mix F	27.03
Mix G	37.23
Mix H	38.34
Mix I	34.45
MixJ	38.62
MixK	25.48

Table.7 Split tensile strength of M20 concrete

Mix Designation	Split tensile Strength (28 days)
Mix A	2.78
Mix B	2.94
Mix C	3.32
Mix D	2.82
Mix E	2.80
Mix F	2.64
Mix G	3.43
Mix H	3.56
Mix I	3.13
MixJ	2.9
Mix K	2.7

Fig.1. Flexural Strength test in UTM

Fig.2. Flexural Strength test in UTM

Fig.3. Flexural Strength test in UTM

V. RESULTS AND DISCUSSION

The 28-day cube compressive strength was determined by conducting tests on standard concrete cubes (150 x 150 x 150 mm) at the age of 28 days. It is observed that the compressive strength is increased gradually upto10% replacement of cement by Diatomite powder. It is decreased for mixes with dolomite powder ranging from 15% to 25% replacement levels. The compressive strength is observed to be maximum (46.37 N/mm2) for Mix C with Diatomite alone at 10% replacement level. Similarly it is maximum for Mix H at 10% replacement of cement, individually with the combination of Dolomite and GGBS (48.34 N/mm2). The28-day Split tensile strength was determined by conducting tests on standard concrete cylinders (150 x 300 mm) at the age of 28 days. It is observed that the split tensile strength is increased gradually up to 10% replacement of cement by Diatomite powder. It is decreased for mixes with diatomite powder ranging from 15% to 25%. The split tensile strength is observed to be maximum (3.32 N/mm2) for Mix C with Diatomite alone at 10% replacement level similarly, it is maximum for Mix H at 10% replacement of cement individually with the combination of Diatomite and GGBS (3.56 N/mm2). The 28-day Flexural tensile strength was determined by conducting tests on standard concrete prisms (100 x 100 x 500 mm) at the age of 28 days. It is observed that the flexural strength is increased gradually up to 10% replacement of cement by Diatomite powder. It is decreased for mixes with diatomite powder ranging from 15% to 25%. The flexural strength is observed to be maximum for Mix C (3.87 N/mm2) with Diatomite alone at 10% replacement level similarly it is maximum for Mix H at 10% replacement of cement individually with the combination of Dolomite and GGBS (3.98 N/mm2). The maximum values of compressive strength, tensile strength in split tension and flexural tension at the age of 28 days for Mixes A to K are shown graphically in Figures 1 to 6 respectively. The high calcium content present in the dolomite powder may cause increase in the compressive strength of concrete. This increase in strength has been observed up to 10% replacement level. No significant increase in strength has been observed for the replacement levels of Diatomite powder above 10%.The same trend has been observed for the increase in split tensile as well as flexural strength for Mixes A to K. Fineness of Dolomite powder may be the reason for developing the strength as it is incorporated as a filler material to replace cement partially.

VI. CONCLUSIONS

The following conclusions can be drawn from the experimental investigations. 1) Dolomite powder along with GGBS can be used as pozzolonic materials to replace cement partially up to 10% in preparing concrete. Use of dolomite powder along with GGBS may enhance strength at 28 days. 2) Dolomite along with GGBS may act as a filler material which acts as a volume matrix to reduce the porosity of concrete. 3) Workability characteristics of concrete admixture with Dolomite and GGBS are similar to those of normal conventional concrete. 4) Plastic and Shrinkage properties in concrete with Dolomite powder and GGBS are yet to be investigated. 5) Dolomite and GGBS may be used partially to enhance the strength properties of concrete which makes the mix economical than conventional concrete. 6) Based on the experimental investigations, the strength properties of concrete are significantly improved with the use of Dolomite powder and GGBS in preparing concrete

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