Study of the effect of composition on compressive strength of Magnesia Cement

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ABSTRACT

Mgnesia cement was discovered by S.T. Sorel in 1867. It is superior to the ordinary Portland cement (quick setting , higher fire resistance, lower thermal conductivity, better resistance to abrasion and chemicals. It is much research interest cement due to energy saving and environmental protection consideration. Author has been find out the compressive strength of different composition of magnesia cement. The effect of concentration of $MgCl_2$ solution on the compressive strength of magnesia cement has also been investigated by author. The results show that compressive strength is decreased on increasing temperature of $MgCl_2$ solution within experimental limits and magnesia cement prepared with 1:1 dry-mix composition has good cementing characteristics

Keywords: Magnesia Cement, Composition, Compressive Strength.

I INTRODUCTION

Magnesia cement has many superior properties to Portland cement (1-7). It is a high strength, high bonding and quick setting cement with high early strength. It does not need wet curing, has high fire resistance, low thermal conductivity, good resistance to abrasion. It is a tough, stone like fire proof compound that can be used for light or heavy floorings ((4,8,9). Magnesia also bonds very well to a variety of inorganic and organic aggregates, such as, saw dust, wood floor, marble floor, sand and gravel, giving a cement that has high early strength, insecticidal properties, resilient, conducting and is unaffected by oil, grease and paints. The major commercial applications of this cement, are industrial flooring, fire protection, grinding wheels.

The main bonding phases found in hardened cement pastes are $Mg(OH)_2$, $3Mg(OH)_2 .MgCl_2 .8H_2O$ (3-form) and $5Mg(OH)_2.MgCl_2 .8H_2O$ (5-form) (10-14). 5-form is the phase with superior mechanical properties and is formed using a molar ratio of $MgO :MgCl_2 :H_2O = 5:1:13$ with a slight excess of MgO and the amount of water as close as possible to theoretical required for formation of the 5-form and hydration of the excess MgO to form $Mg(OH)_2$(15-16). Effect of some additive on setting, strength and moisture resistance on Magnesia has been studied by various researchers (15). Despite many merits associated with this cement, its poor resistance to excessive exposure to water has restricted its outdoor applications. There are only a few reports available worldwide on magnesia cement concrete. Therefore, there is exigent need to develop data through laboratory work for evolving the standards and codes of practice for magnesia cement so that the excellent bonding properties of this cement can be fully and effectively utilized in areas where such materials are urgently needed.

Magnesia cement compositions were prepared in the laboratory by mixing lightly calcined magnesite (magnesia) and inert filler (dolomite) in the ratio of 1:0, 1:1, 1:2 and 1:3. Dry-mixes gauged with magnesium chloride solution of different concentrations (20^{o}Be,24^{o}Be,28^{o}Be,32^{o}Be&35^{o}Be) and different temperatures 30^{o}C, 35^{o}C, 40^{o}C & 45^{o}C. Compressive strength of various magnesia cement compositions were determined after 28 days. The results of these investigations have been discussed in this paper.

II MATERIALS AND METHODS

Materials

The raw materials used in the study were calcined magnesite (magnesia), magnesium chloride and dolomite powder.

Calcined magnesite: Magnesia used in the this study was of Salem (Chennai) having following characteristics – (i) Bulk density 0.85 Kg/I (ii) 95% passing through 75 micron (200 IS sieve) (iii)minimum magnesium oxide 90% (iv) Ca0 < 1.5% (v) Ignition loss at 100^{0}C ~ 2.5 ± 0.5%.

Magnesium chloride ($MgCl_2.6H_20$): Magnesium chloride used in the study was Indian Standard Grade 3 of Indian Standard: 254 – 1973 with following characteristics: (i) Colorless, crystalline, hygroscopic crystals. (ii) Highly soluble in water. (iii) Magnesium chloride hexahydrate minimum 95% (iv) Magnesium sulphate, calcium sulphate and alkali chlorides (NaC1) contents were less than 4%.

Inert filler (dolomite) : Dolomite dust with following grading was used as an inert filler : (i) 100% passing through 250 micron Indian Standard Sieve (ii) 50% retained on 125 micron IS Sieve (iii) Ca0~28.7% (iv) Mg0~20.8% (v) Insoluble and other sesquioxide contents were less than 1.0%

2.1 Preparation of magnesium chloride solution

Magnesium chloride solution was prepared in water. Flakes of magnesium chloride were transferred into plastic containers to which potable water was added to prepare concentrated solution. This solution was allowed to stand overnight so that insoluble impurities settle at the bottom. The supernatant concentrated solution was taken out in other plastic containers and well stirred after each dilution before determining the specific gravity. Concentration of the solution is expressed in terms of specific gravity on Baume scale (°Be).

2.2 Determination of compressive strength

Effect of composition of magnesia cement on compressive strength have been investigated by prepared different dry-mix compositions in 70.6 X 70.6 X 70.6 mm^3 cubes as described in the standards procedure. The results of these investigations are summarized in the Tables: 1 to 4.

Table: 1 Compressive strength of magnesia cement prepared with 1:0 dry-mix composition

Dry-mix composition: **1:0*** Humidity-85 ± 5%

S.No	Concentration of gauging solution	Temperature of gauging solution			
		30°C	35°C	40°C	45°C
		Compressive strength (in MPa)			
1.	20°Be	58.174	54.162	44.132	34.102
2	24°Be	60.180	58.174	50.150	40.120
3	28°Be	64.192	60.180	54.162	42.126
4	32°Be	68.204	62.186	56.168	46.138
5.	35°Be	60.180	54.162	48.144	34.102

*One part by weight of magnesia and no part by weight of dolomite

Table: 2 Compressive strength of magnesia cement prepared with 1:1 dry-mix composition

Dry-mix composition: **1:1*** Humidity-85 ± 5%

S.No	Concentration of gauging solution	Temperature of gauging solution			
		30°C	35°C	40°C	45°C
		Compressive strength (in MPa)			
1.	20°Be	56.168	52.156	40.120	38.114
2	24°Be	58.174	54.162	48.144	46.138
3	28°Be	60.180	58.174	52.156	48. 144
4	32°Be	64.192	60.180	54.162	50.150
5.	35°Be	58.174	50.150	46.138	44.132

*One part by weight of magnesia and one part by weight of dolomite

Table: 3 Compressive strength of magnesia cement prepared with 1:2 dry-mix composition

Dry-mix composition: **1:2*** Humidity-85 ± 5%

S.No	Concentration of gauging solution	Temperature of gauging solution: 30°C	35°C	40°C	45°C
		Compressive strength (in MPa)			
1.	20°Be	50.152	48.144	36.108	34.102
2	24°Be	52.156	50.150	44.132	42.126
3	28°Be	54.162	52.156	48.144	44.132
4	32°Be	58.174	54.162	50.150	48.144
5.	35°Be	56.168	48.144	44.132	42.126

*One part by weight of magnesia and two parts by weight of dolomite

Table: 4 Compressive strength of magnesia cement prepared with 1:3 dry-mix composition

Dry-mix composition: **1:3*** Humidity-85 ± 5%

S.No	Concentration of gauging solution	Temperature of gauging solution: 30°C	35°C	40°C	45°C
		Compressive strength (in MPa)			
1.	20°Be	38.114	34.102	34.102	30.09
2	24°Be	48.144	42.126	38.114	36.108
3	28°Be	50.150	44.132	40.120	38.114
4	32°Be	54.162	48.144	44.132	42.126
5.	35°Be	50.152	44.132	42.126	40.120

*One part by weight of magnesia and three parts by weight of dolomite

III DISCUSSION

The effect of temperature and concentration of gauging solution on compressive strength of magnesia trial blocks is shown in the Table:1 to 4. From the table, it is clear that both factors (temperature and concentration) shown great effect on compressive strength of magnesia. Effects of temperature and concentration of magnesium chloride solution on compressive strength of moulds prepared by 1:0 dry-mix composition are recorded in the table 1. It is noticed that compressive strength decreases as temperature of $MgCl_2$ increases from 30 to 45^oC at all concentration. This can be explicable due to more exothermic reaction occur during the reaction between MgO and $MgCl_2$ at higher temperature. Because of this more heat is evolved which is responsible for decomposition of Ca/$MgCO_3$ present in matrix and liberation of free lime and CO_2. Hence, compressive strength decreases. Same trend is followed at each concentration.

It is also revealed from the Table: 1 to 4 that compressive strength of magnesia trial bocks first increases with increasing concentration of gauging solution from 20^{o}Be to 32^{o}Be, and then decreases for highly saturated gauging solution (35^{o}Be) for each dry-mix composition ratio. The increasing trend of compressive strength is possibly because of increased amount of magnesium chloride in the wet-mix. More perfect three dimensional network of interlacing crystals of strength giving forms (F5-five form and F3- three form) is formed. This contributes to increase in mechanical strength. Abnormal decrease in compressive strength of the standard blocks when almost saturated (35^{o}Be) $MgCl_2$ solution is used may be attributed to the uncombined gauging solution presence in blocks matrix in each ratio of magnesia. Reduced workability of highly viscous wet-mixes at saturation (35^{o}Be) of magnesium chloride results in reduced strength of the sample cubes. Hence, more dense gauging solution reduces the mechanical strength of product.

The dry-mix 1:1 gauged with 20^{o}Be solution has 28 days compressive strength as 56.168 MPa at 30^{o}C temperature of gauging solution in table: 2. If same mix is gauged with 24^{o}Be solution the strength comes out to be 58.174 MPa and with 28^{o}Be solution it becomes 60.180 MPa till with 32^{o}Be it reaches 64.192 MPa. Similarly, dry-mix 1:2 has 28 days compressive strength as 50.150 Mpa with 20^{o}Be solution at 30^{o}C temperature of gauging solution (Table: 3). When the Concentration of gauging solution is increased to 24^{o}Be, the strength of the same mix comes out to be 52.156 MPa. This further increase with higher concentration (32^{o}Be) of the solution to 58.174 MPa. Compressive strength of 1:3 dry-mix compositions is obtained quite low. As proportion of the fillers is increased from 1:1 to 1:3 dry-mix compositions (Table: 2 to 4), compressive strength gets reduced. Dry-mix 1:0 moulds have highest compressive strength and the moulds of 1:3 dry-mix compositions have lowest strength results. This is due to fact that only magnesia is present in the dry-mix matrix (1:0) to react with gauging solution which forms the strength giving composition ($MgO.MgCl_2.8H_2O$). But in case of other composition, amount of magnesia content is reduced and dolomite powder is used as filler with magnesia. Dolomite is double carbonate of calcium and magnesium. During the preparation of wet-mixes, calcium carbonate decomposes in lime and released CO_2.

IV CONCLUSIONS

- **a.** Use of the saturated gauging solution ($35^o \pm 1^o$Be) should be avoided for commercial purpose, as the high viscosity of the wet-mixes at these concentrations may result improper compaction and sweating of the cement under humid condition.
- **b.** The composition to be used for the desired strength should be worked for the given mixture to facilitate the formation of strength giving compositions. Temperature of gauging solution should preferably be $30^o \pm 5^o$C and concentration of gauging solution should preferably be $30^o \pm 2^o$Be.
- **c.** Higher temperature of gauging solution > 35^oC should be avoided due to higher exothermic reaction proceed during wet-mixing, resulted reduce mechanical strength.
- **d.** Magnesia cement prepared with 1:1 dry-mix composition has good cementing characteristics.

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