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Effect of Value Added Admixture Zeolite on Setting Time and Compressive Strength of Magnesia Cement

R.N. Yadav[1] and Ramkishan[2]*

Department of Chemistry, Govt. RR (PG) College, Alwar 301001, India

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ABSTRACT

In 1867,S. T. Sorel discovered Magnesia Cement in an aqueous solution byreacting magnesium chloride with magnesia. In comparison to Portland cement, this has versatile cementing characteristics. As an inert filler to absorb the heat evolved during the exothermic formations of magnesia cement Dolomite is used. Authors in this research paper have prepared Dry-mixes composition of magnesia and dolomite (inert filler) in the ratios of (1s And then these are gauged with 24°Begauging -solutions $MgCl_2$ and the impact of admixture on their setting time -initial and final and compressive strength can be found. The initial and final setting time was observed to be increasing remarkably. With increase in percentage of admixture (zeolite) time of the cement blocks increased in the initial and final setting time also ratio of inert filler (dolomite) in the each dry-mix composition was observed and recorded. In the results it was found that to the percentage composition of admixture (zeolite) both initial and final setting time of cement blocks and also the ratio of inert filler in the dry-mix composition itis directly proportional. Quantity of magnesia cement drastically increases with Incorporation of zeolite and this further remarkably increases and improves strength of the cement. Magnesia cement could in fact act as carbon sinks, acting to favorably reduce greenhouse gas emissions. It is eco friendly cement.

***Key words:** Magnesia cement, Inert filler, Gauging solution, Setting time*

Introduction

In 1867, discovery of excellent cement which was formed by combining magnesium oxide and concentrated solution magnesium chloride. Bydifferent names, this cement type is known such as -magnesium oxychloride cement, Sorel cement and magnesia cement. In comparison to Portland cement, there are many superior properties this cementhasas mentioned in the 30^{th} Report of the carriage and Wagon Standards Committee for flooring Compositions; Indian Railways, Altiner and Yildirim, (2017); Beaudoin *et al.* (1977); Bougue, (1955); British Standard, (1963); Chandrawat and Yadav, (2000). The main environmental advantage associated with magnesia cements is that the starting material, magnesia, is readily obtained from the calcining of magnesite. The process of magnesite decomposition occur at temperatures around 400 °C less than that of limestone so it requires considerably less energy to manufacture. The carbonation reaction resulting in the formation of the main bonding phase from magnesia can consume atmospheric $C0_2$. This suggests that such cements could in fact act as carbon sinks, acting to favorably reduce greenhouse gas emissions. It is eco friendly cement. This does not needwet– curing, has low thermal conductivity, has good resistance to abrasion, and has resistance to highfire. This also has high bonding, high strength and sets quickly with high early strength. As it is tough it can be used in heavy or light floorings as a fire proof compound by Beaudoin *et. al.* (1977);

Chandrawat and Yadav, (2001); Chandrawat, (1976). Altimer and Yildirin, (2017) investigated the properties of magnesia cement formed from dolomite ore as filler. With the addition offiller, thermal conductivity and density decreased while compressive strength remained the same. MOC (magnesium oxychloride cement) carbon sequestration potential has been determined by evaluating the effect of curing- temperature and mole ratio of $H_2O/MgCl_2$ on mechanical strength and phase structure of MOC (magnesium oxychloride cement).

As per Ye and Power *et. al.,*(2017); Kusiorowski and Zaremba, (2018) investigated the capability of chrysotile asbestos and cement asbestos in using as fillers in magnesia cement. In Comparison to cement asbestos, favorable results were found in the usage of chrysotile asbestos for setting time and compressive strength of magnesium oxychloride cement have been studied by incorporating fly ash in the formation of an energy efficient andeco-friendly MOC cement by Chau *et al.* (2009). Li *et al.* (2013), examined in MOC (magnesium oxychloride cement) the effect of fly ash admixtures and granite wastes. Chengdong and Hongfa (2010); Ummisalma and Reddedmma, (2015) stated that with the addition of fly ash admixtures and silica fumes in magnesium oxychloride cement the water resistance capacity was found to be improved. In modulus of rupture the maximum value for flyash was found to be 40% and stone dustsubstitution 25% of MgO. The effects of pulverized fuel ash (PFA) additive and CO_2 curing on the water resistance property of MOC mortar was conducted and examined by He *et al.* (2017). PFA (pulverized fuel ash) when immersed in water decreased the expansion of cement mortar. This decrease was associated with reduction in content of excess MgO and formation of an amorphousgellayer which is insoluble that prevented hydration of MgO. This effect was further enhanced by CO_2 curing. The findings of the studies were supported by Quantitative-X-ray diffraction (Q-XRD), Fourier Transformed Infrared (FTIR) and Scanning electro-microscope (SEM). (Tooper and Cartz, 1966) studied the structure of magnesium oxychloride cement and from ascanning electron microscope its figure was taken. Various researchers (Yadav, 1989 and Dauksys *et. al.,* 2009) studied Effect of some admixture on setting the moisture resistance, strength on magnesia cement. In this paper to study the effect of admixture (zeolite) on setting cementing characteristics of Magnesia cement with different proportions (1:0 and 1:1) of inert filler with 24°Be densities of gauging solution $MgCl_2$this study has been carried out.

Materials and Methods

Magnesium chloride, admixture zeolite, calcined magnesite (magnesia) and dolomite powder are the raw materials used in the study.

Magnesium chloride ($MgCl_2.6H_2O$): In this study the magnesium chloride that has been used was Indian Standard Grade 3 that has the following characteristics: Indian Standard, (1973; IS-254). i) Highly soluble in water ii) Colorless, crystalline, hygroscopic crystals iii) at least 95% Magnesium chloride hexahydrate iv) calcium sulphate, Magnesium sulphate and alkali chlorides (NaC1) less than 4% content.

Calcined magnetite: In this study the Magnesia used was of Salem (Chennai) that has the following characteristics; as per Indian standard institution, (1982; IS-657) and Indian standard institution, (1982; IS-10132). i) at least 87% of magnesium oxide ii) Bulk density 0.85 Kg/I and through 75 micron 95% should pass through (200 IS sieve). ii) Ignition on loss CO_2, H_2Oat < 8% iii) Carbon dioxide (CO_2) < 2.5%. iv) CaO< 2.5%.

Admixture (Zeolite): as Sodium Oxide Average chemical composition of sodium zeolite is reported (17%), Water (22%), Aluminum Oxide (28%) and Silicon dioxide (33%). $NaAlSi_2O_6.H_2O$ this is theformula of sodium zeolite.

Inert filler (dolomite): as an inert filler Dolomite dust with following grading was used i) Indian Standard Sieve 250 micron 100% must passii) IS sieve125 micron 50% retainediii) MgO content 20.8% iv) CaO content 28.7% v) less than 1.0% were content of Insoluble and other sesquioxide.

Preparation of Magnesium Chloride Solution

In water, Magnesium chloride solution was prepared. Firstly magnesium chloride flakeswere transferred into plastic containers then potable water was added to prepare a solution that is concentrated. In order to make the insoluble impurities settle at thebottom, throughout night the solution was allowed to stand. In other plastic containers, the supernatant concentrated solution was taken out and after each dilution it was well stirred before determining the specific gravity - Indian Standard Institution, 1982. In terms of specific gravity on Baume scale (°Be) Concentration of the solutionis expressed.

Determination of Setting Time: for determining setting times Wet-mixes prepared for is consistencies were used. Indian Standard Institution, (1982); Mathur, (1986); Yadav, (2008, 1989 and 2018) - byusing Vicat apparatus setting times (initial and final) were determinedas per IS-10132-1982. In Table 1 and 2 the observed results of initial and final settings are recorded.

Determination of compressive strength: as per standard procedure British Standard, (1963); Indian Standard Institution, (1982); (Gupta, 1976; Yadav, 1989) investigated the effect of additive (Zeolite) on compressive strength of magnesia cement which was prepared with different dry-mix compositions (1:0 and 1:1) have been carried out by using 70.6 X 70.6 X 70.6 mm^3 moulds. After 30days these cubes were tested. In Table 3 and 4 the results have been shown.

Table 3. Effect of zeolite on compressive strength of magnesia cement

Table 1. Effect of Zeolite on setting characteristics of magnesia cement

Gauging solution: 24^0Be Humidity: 75 ± 5%

Dry-mix composition: 1:0* Temperature: 32^0C

Observations	% Admixture (Zeolite) 0			5			10			15			20		
	M-1	M-2	AST	M-1	M-2	AST	M-1	M-2	AST	M-1	M-2	AST	M-1	M-2	AST
IST (In minute)	78	80	79	74	76	75	72	74	73	70	72	71	68	70	69
FST (In minute)	198	200	199	210	208	209	208	204	206	200	208	204	220	224	222

IST: Initial setting Time; FST: Final Setting Time; AST: Average setting Time; M: Mould

*One part by weight of magnesia and zero parts by weight dolomite (filler)

Table 2. Effect of Zeolite on setting characteristics of magnesia cement

Gauging solution: 24^0Be Humidity: 75 ± 5%

Dry-mix composition: 1:1* Temperature: 32^0C

Observations	% Admixture (Zeolite) 0			5			10			15			20		
	M-1	M-2	AST	M-1	M-2	AST	M-1	M-2	AST	M-1	M-2	AST	M-1	M-2	AST
IST (In minute)	78	80	79	115	117	116	136	140	138	140	144	142	140	142	141
FST (In minute)	198	200	199	264	260	262	271	273	272	325	323	324	300	304	302

IST: Initial setting Time; FST: Final Setting Time; AST: Average setting Time; M: Mould

*One part by weight of magnesia and one parts by weight dolomite (filler).

Gauging solution: 24^0Be; Temperature: 32^0C

Dry-mix composition: 1:0*

Humidity: 75 ± 5%

Results and Discussion

The effect of zeolite proportions on the setting char-

% Admixture (Zeolite)	Compressive strength (in kilo Newton) M-1	M-2	ACS
0%	204	202	203
5%	250	160	205
10%	240	180	210
15%	190	250	220
20%	205	400	302.5

*One part by weight of magnesia and zero parts by weight dolomite (filler).

M: Mould; ACS: Average Compressive Strength

Table 4. Effect of zeolite on compressive strength of magnesia cement

Gauging solution: 24^0Be; Temperature: 32^0C

Dry-mix composition: 1:1*

Humidity: 75 ± 5%

% Admixture (Zeolite)	Compressive strength (in kilo Newton) M-1	M-2	ACS
0%	355	358	356.5
5%	135	190	162.5
10%	230	130	180
15%	160	215	187.5
20%	194	185	189.5

*One part by weight of magnesia and one parts by weight dolomite (filler).

M: Mould; ACS: Average Compressive Strength

acteristics of magnesia cement for (1:0 and 1:1) dry mix composition has been revealed in Table 1 and 2. Asin the ratio 1:0 and 1:1 dry-mixes composition respectively, setting time of that of both initial and final increases. As the proportion of filler increases from 1:0 to 1:1 it has been seen that the setting time increases simultaneously. Therefore asthe proportion of fillers increases, the setting time increases because the heat is absorbed by the inert filler which during the reaction between MgO and $MgCl_2$ evolves.

$$MgO \rightarrow +MgCl_2.6H_2O5Mg(OH)_2.MgCl_2.8H_2O/\ 3Mg(OH)_2.MgCl_2.8H_2O\ +Exothermic$$
(Magnesia cement)

It was established that the initial setting time decreases and the final setting time increases when the percentage composition of admixture (zeolite) increases Table 1. As shown in Table 2 both the initial and final setting time increased when the percentage composition of admixture (zeolite) increased. Therefore from the above discussion we can affirm that it takes more setting time when dry–mix composition 1:1 with 15% and 20% admixture (zeolite) is used in comparison to for the samead mixture when 1:0 compositions is used. This in fact, as filler the dolomite powder used in the dry-mix in the ratio 1:1 (one part of dolomite and other of MgO), which have in content have carbonates of calcium and magnesium. Due to their content the setting process due to its de carbonation increases by dolomite filler.

$$Ca/MgCO_3 \rightarrow CaO + MgO + CO_2$$

Small amount of CO_2 is still contained inthis magnesia CO_2 and with over burnt/dead burnt magnesia and calcium oxide it is contaminated which for magnesia cement isnot suitable. Forall dry-mixes composition similar trends have been found.

Research related to effect of zeolite on compressive strength of magnesia cement which in the ratio of 1:0 and 1:1 dry-mix composition with 24^0 Be concentration of magnesium chloride solution was used has been summarized in the Table 3 and 4. IN the case of 1:0 ratio of dry-mix compositions only magnesia was present With magnesium oxy chloride solution the dry-mix reacts to from strength giving phase- five. For development of strength, dualrole is played by zeolite. As a source for zeolite pozzolanic reaction this excess time released during hydration of cement is used and additional Z-M gel that has binding properties is produced. As long as time is fore sent in the pores of wet mix this property of zeolite with excess times continues and additional strength to it in parts.

As "micro aggregates", at one hand the inactive portions of zeolite behaves and inthe matrix it fills up. As a consequence, strength of cement and packing effect is enhanced with increasing amount of zeolite in 1:0 dry -mix composition strength increases. In Table 4 it has been shown the increase in percentage of zeolite, at first the compressive strength of cement is decreased then increases slightly due replacement of inert filler dolomite by 50% magnesia contentin the ratio of 1:1 dry mix composition. At the time of preparation the contents of wet -mixes dolomite are converted into its respective oxides $CaCO_3/MgCO_3$and that of carbon dioxide are repelled. Therefore indry mixes composition, compressive strength reduces as the amount of inert filler increases.

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Conclusion

Following important conclusions have been drawn from the results of the effect of admixture (zeolite) on setting time, compressive strength and environmental effect of magnesia cement.

(i) Setting time and compressive strength of magnesia cement increases when zeolite isused as an admixture.

(ii) In the dry-mix composition, to the ratio of inert filler (dolomite) Setting times of cement blocks are directly proportional.

(iii) On setting time as well as compressive strength 1:0 dry-mix cement composition has good admixing effect.

(iv) The production of MgO requires far lower temperature than the clinkerisation of Ordinary Portland Cement, which makes this material as attractive prospect for reducing CO_2 emission.

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