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Admixing effect of Ceramic Waste on setting properties and strength of Magnesia Cement- An Eco-friendly Cement

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ABSTRACT
Magnesia cement was first discovered by a French chemist S. T. Sorel in 1867.It is prepared by an exothermic reaction between reactive MgO powder and concentrated MgCl2 solution. Cements are basically the inorganic mineral binders having unique adhesive properties that can bind different materials (such as sand, stones, bricks, gravels) into a compact whole. In comparison to Portland cement, it has versatile cementing characteristics. As an inert filler to grasp the temperature developed through the exothermic formations of magnesia cement when Dolomite is used in it. Authors in this research paper have prepared Dry-mixes composition of magnesia and dolomite in the ratios of (1:0 and 1:1) By weight with in-corporation of admixture- (ceramic waste) 5%, 10%, 15%, 20%, respectively in each ratio and then these are gauged with 24°Begauging -solutions $MgCl_2$ and the impact of admixture on their setting initial and final time, there compressive strength can be found. The final and initial setting time is observed to be increasing remarkably. With rise in percentage of admixture (ceramic waste) time of the cement blocks decreased in the final and initial time of setting, with ratio of inert filler (dolomite) in the each dry-mix composition increased and observed recorded. In the results it is found that the percentage composition of admixture ceramic waste both final and initial setting time of cement blocks is inversely proportional and the ratio of inert filler in the dry-mix composition is directly proportional.
Key Words: *Magnesia cement, inert filler, gauging solution, setting time.*

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INTRODUCTION

In 1867, magnesia cement was discovered by S.T. Sorel. Magnesia cement was prepared by an exothermic reaction between concentrated solution of magnesium chloride and magnesium oxide powder. Cements are basically the inorganic mineral binders having unique adhesive properties that can bind different materials (such as sand, stones, bricks, gravels) into a compact whole. This cement is known by different names, such as magnesium oxychloride cement, Sorel cement, and magnesia cement. It is a non-hydraulic cement which does not require water for its setting. The two important phases of magnesia cement are phase-3 and phase-5 thatexistat room temperature. These are represented by the following formulas –

$$3Mg(OH)2.\ MgCl2.\ 8H2O(Phase\text{-}3)\ /\ (3.1.8)$$
$$5Mg(OH)2.\ MgCl2.\ 8H2O(Phase\text{-}5)\ /\ (5.1.8)$$

The phase-5 of magnesia cement provides mechanical strength by intergrowth and interlocking tendency of its needle like crystals. Magnesia cement exhibits some superior properties in comparison to ordinary Portland cement. It is a quick setting cement with high early strength. It is also characterized by high compressive strength ranging in between 9000-45000 psi.

The camanchacas mentioned in the 30th Report of the carriage and Wagon Standards Committee for flooring Compositions; [1-3, 5-7]. This does not require wet– curing, it has low thermal conductivity, abrasion by nice resistance, and has resistance to high fire. It also has high bonding, high strength that sets quickly. As it is tough and has a fireproof compound property, it can be used in heavy or light flooring [2, 4, 7, 8] investigated the properties of magnesia cement formed from dolomite ore as filler. With the addition of filler, thermal conductivity and the density decreased while compressive strength remained the same. The carbon sequestration capacity of MOC (magnesium oxychloride cement) was investigated by examining the effect of treating temperature and the mole ratio of H2O/MgCl2 on the automatic strength and phase structure of MOC. The capability of cement asbestos and chrysotile asbestos in using as fillers in magnesia cement [17, 21].The use of chrysotile asbestos for time of setting and compressive potency of magnesium oxychloride cement by integrating fly ash in the development of an eco-friendly and energy efficient MOC cement in comparison to cement asbestos [10]. The influence of ash admixtures and granite wastes on MOC was investigated [11]. The addition of fly ash admixtures and silica fumes in magnesium oxychloride cement through water resistance capacity was found to be improved [18]. Magnesia cement binds well with many different types of aggregates, e.g. sand, stone chips, fibrous material, perlite, fly ash, etc. to the extent of 1:20 weight by weight. Magnesia cement binds to all things cellulose (plant fibres, wood chips, etc.) spontaneously and extremely well, earning it the nickname "Living cements" or "Eco-friendly cement." This is in contrast to Portland cement, which is cellulose-repellent. Thus by using different aggregates in the dry mix, the products with different characteristics can be obtained. Some applied work in this connection has been performed at the Central Building Research Institute. Roorkee (India) CRRI, New Delhi and R.R. College, Alwar.

In modulus of rupture the maximum value for fly ash was found to be 40% and stone dust substitution 25% of MgO [23]. The effects of powdered fuel ash addition and CO_2 curing the resistance water performance of MOC mortar. PFA (pulverized fuel ash) when submerged in water decreased the growth of cement mortar [20]. This decrease was associated with reduction in content of additional MgO and development of an amorphous gel layer which is insoluble that prevented hydration of MgO. This effect was further enhanced by CO_2 curing. Quantitative X-ray diffraction (Q-XRD), FTIR, and examining electron microscopy were applied to back up the findings of the research. The structure of magnesium oxychloride cement and from a scanning electron microscope its figure was taken [22]. The Effect of some admixture on setting the moisture resistance, strength on magnesia cement. In this paper study the effect of admixture (ceramic waste) on setting cementing characteristics of Magnesia cement with different proportions (1:0 and 1:1) of inert filler with Be at 24^o densities of gauging solution $MgCl_2$ [12, 25].

MATERIAL AND METHODS

Magnesium chloride, admixture, calcined magnesite (magnesia) and dolomite powder are raw materials that used for this study.

- **Magnesium chloride ($MgCl_2.6H_2O$):** In this study the magnesium chloride has been used for the Indian Standard Grade 3 that has following characteristics: Indian Standard, (1973; IS-254).

i) Highly water soluble
ii) Colorless, crystalline, hygroscopic crystals
iii) atleast 95% Magnesium chloride hexahydrate
iv) alkali chlorides, calcium sulphate and Magnesium sulphate 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) Volume density 0.85 Kg/I and 75micron 95% should pass through (200 IS sieve).
iii) Ignition on loss CO_2, H_2Oat < 8%

Table1: Chemical composition ofmagnesia in wt%

MgO	SiO_2	CaO	Fe_2O_3	Al_2O_3	L O I
71.80%	10.18%	6.72%	0.19%	0.75%	9.82%

Admixture (ceramic waste):-

Table2: Chemical composition of Ceramic Waste in wt%

SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	L O I	Na_2O	K_2O
69.06%	1.40%	1.20%	1.40%	18.60%	4.71%	1.24%	2.10%

Inert filler (dolomite):As an inert filler Dolomite dust with subsequent grading was applied.

i) Indian Standard Sieve 250 micron 100% must pass.
ii) IS sieve125 micron 50% retained.
iii) Chemical composition of dolomite is:-

Table3: Chemical composition of dolomite filler in wt%

SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	L O I
0.75 %	31.08 %	20.10 %	0.85 %	0.22 %	46.50%

PREPARATION OF MAGNESIUM CHLORIDE SOLUTION

In water, Magnesium chloride solution is planned. Firstly, magnesium chloride flakes are transported into containers of plastic then clean water is combined to formulate a blend that is concentrated. To settle down the impurities at the bottom, throughout night the mixture is permitted to stand. In other plastic containers, the supernatant determined mixture is carried out and after each dilution it is well stirred

before determining the specific gravity - Indian Standard Institution, 1982. The concentration mixture that indicated in words of precise gravity on the Baume scale (°Be).
Calculation of the Setting Time: For determining setting times, Wet mixtures for various consistencies were employed [19, 24-26] -setting times (initial and final) are obtained using the Vi cat apparatus according to IS-10132-1982. The observed outcomes of the initial and final settings are given in Tables 4 and 5.

Table 4: Impact of ceramic waste on setting time of Magnesia cement

Observation	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 (sec)	110	130	**120**	143	153	**148**	117	125	**121**	116	106	111	100	112	**106**
FST (sec)	198	202	**200**	210	192	**201**	190	198	**194**	173	165	169	170	160	**165**

Temperature: 32 ^{0}C Dry-mix composition: 1 0*
Gauging solution: 24° Be% Admixture (ceramic waste)
FST: Final setting Time, IST: Initial setting Time, AST: Average setting Time, M-1: Moduld-1: M-2: Mould-2
*One part by weight of magnesia and zero parts by weight dolomite (filler)

Table *5*: Effect of ceramic waste on setting traits of Magnesia cement

Observation	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(sec)	162	158	**160**	152	148	**150**	146	144	**145**	140	136	**138**	124	116	**120**
FST(sec)	327	323	**325**	324	316	**320**	315	305	**310**	296	304	**300**	300	290	**295**

Temperature: 32 ^{0}C Dry mix composition: 1 1*
Gauging solution: 24° Be Humidity: 75+5%
FST: Final setting Time, IST: Initial setting Time, AST: Average setting Time, M-1: Moduld-1: M-2: Mould-2
*One part by weight of magnesia and zero parts by weight dolomite (filler)

Calculation of compressive strength**:** The influence of addition (quartz) on strength (compressive) of magnesia cement made with two dry-mix compositions (1:0 and 1:1) was tested using 70.6 x 70.6 x 70.6 mm^3 moulds by British Standard, (1963) [6]; Indian Standard Institution, (1982) [14]; Gupta,1976 [13]; Yadav,1989 [25]. These cubes put to the test after 30 days. The results are demonstrated in Table 3 and 4.

Table 6: Effect of Ceramic waste on compressive strength of magnesia cement

	Compressive strength (MPa)		
% Additive (C.W.)	M-1	M-2	ACS
0%	36.31	35.91	36.11
5%	34.11	35.71	34.90
10%	32.50	31.70	32.10
15%	32.90	32.10	32.5
20%	20.06	20.46	20.26

Gauging solution: 24
Temperature: 32^{0}C Dry-mix composition: 1:0*,
Humidity: 75± 5%
*One part by weight of magnesia and zero parts through weight dolomite.
M: Mould; ACS: Average Compressive Strength

Table 7: Effect of Ceramic waste on compressive strength of magnesia cement

	Compressive strength (MPa)		
% Additive (C.W.)	M-1	M-2	ACS
0%	49.15	49.75	49.45
5%	48.55	49.15	48.85
10%	35.51	35.71	35.61
15%	34.91	34.51	34.71
20%	38.12	38.52	38.32

Gauging solution: 24 be: Temperature: 32^{0}C
Dry-mix composition: 1:1* Humidity: 75± 5%
*One part by weight of magnesia and zero parts through weight dolomite.
C.W.; ceramic waste
M: Mould; ACS: Average Compressive Strength

RESULT AND DISCUSSIONS

The impact of Ceramic waste amounts on the set characteristics of magnesia cement for (1:0 and 1:1) dry mix arrangement are revealed in Table 4 and 5. As in the ratio 1:0 and 1:1 dry-mixes composition respectively, setting time of both initial and final decreases. As the proportion of filler increases from 1:0 to 1:1 it has been seen that the setting time increases simultaneously. Therefore, as the proportion of fillers increases, the setting time increases because the heat is absorbed by the inert filler during the action between MgO and $MgCl_2$ evolves.

$$MgO \longrightarrow MgCl_2.6H_2O5Mg(OH)_2.MgCl_2.8H_2O/3Mg(OH)_2.MgCl_2.8H_2O + \text{Exothermic}$$

(Magnesia cement)

It is established that the early setting time declines as well as the setting of final time decreases when the percentage composition of admixture (ceramic waste) increases as shown in Table 1. As show in Table 5- both the final and initial setting time decreased when the percentage composition of admixture (ceramic waste) increased. Therefore, from the above discussion it can affirm that it takes more setting time when dry–mix composition 1:1 with 0% and 5% admixture (ceramic waste) is used in comparison to the same admixture when 1:0 compositions is used. This in fact, as filler the dolomite powder used in the dry mix in the ratio1:1 (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 of the de- carbonation increases by dolomite filler.

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

Small amount of CO_2 is still contained in this magnesia CO_2 and with over burnt magnesia and calcium oxide it is contaminated which for magnesia cement is not suitable. For all dry-mixes composition similar trends have been found.

Research related to impact of Ceramic waste of magnesia cement on compressive strength, that is in the ratio of 1:0 and 1:1 dry-mix composition withBe at 24^0 concentration of magnesium chloride solution was used that has been summarized in the Table- 6 and Table-7. In the case of 1:0 ratio of dry-mix compositions there is only magnesia was present with magnesium oxy chloride and the dry-mix solution reacts to from strength giving phase- five. For development of strength, dual role is played by ceramic waste. As a source for ceramic waste 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 passes, the pores of wet mixture added the property of Ceramic waste-5% and the additional strength to its parts.

As "micro aggregates", at one hand in the active portions of Ceramic waste behaves and in the matrix it fills up. As a result, cement strength and packing effect are improved. The strength of a 1:0 dry-mix composition increases as the proportion of filler(dolomite) increases as compare to 1:1. Table -7 shows that when the percentage of Ceramic waste grows, the compressive potency of cement decreases, then slightly increases due to the substitution of inert filler dolomite with 50 % magnesia content in a 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 excluded. Therefore, in dry mixes composition, compressive strength reduces as the amount of inert filler increases.

CONCLUSION

The results of the effect of admixture (ceramic waste) on compressive strength and setting time have led to several noteworthy conclusions: the flexural strength, compressive strength and tensile strength of cementitious materials reduced through incorporation and the MgO content increases, irrespective of the material being added to the mix, when ceramic waste is added as an admixture, the setting time of magnesia cement increases, but the compressive strength improves with 5%ceramic waste added as admixture in dry-mix, and the cement block setting times are related to the ratio of inert filler (dolomite) in the dry-mix composition and setting time as well as compressive strength has 1:0 dry-mix cement composition has good admixing effect.

The material has generated renewed interest due to its potential application in the construction of dams in geological repositories in saline environments. The production of MgO requires far lower temperatures than the clinkerization of OPCs, which makes this material an attractive possibility to reduce CO_2 emission.

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