HUNGARIAN JOURNAL OF
INDUSTRY AND CHEMISTRY
Vol. 54(1) pp. 35–42 (2026)
hjic.mk.uni-pannon.hu
DOI: 10.33927/hjic-2026-05

IMPACT OF GUM ARABIC AND SILICA GEL G ON THE SETTING PERIODS, COMPRESSIVE STRENGTH AND MOISTURE RESISTANCE OF MAGNESIUM OXYSULFATE

MEENA JAT[1], MANJU CHOUDHARY[1] AND MEENAKSHI[1]*

1 Department of Chemistry, University of Rajasthan, Jaipur,302004, INDIA

Magnesium oxysulfate (MOS) cement exhibits excellent adhesion and binding properties. It is lightweight, cheap and easy to use as well as has very good cementing properties compared to ordinary Portland cement. It is used in many types of aesthetic applications due to its white color, moreover, can be easily prepared by simply combining magnesia and a concentrated solution of Epsom salt. Gum arabic and silica gel G were used as additives with MOS to enhance water resistance and strength. The results showed that the incorporation of different amounts of gum arabic and silica gel G in MOS enhances the compressive strength of the modified product and lengthens setting times.The results showed that among all the compositions, MOS cement containing 5% additives (2.5% gum arabic and 2.5% silica gel G) significantly enhanced the long-term strength and water resistance of MOS cement.

Keywords: Magnesium oxysulfate cement, Epsom salt, gum arabic, compressive strength, water resistance

1. Introduction

French scientist Stanislas Sorel discovered magnesium oxychloride cement (MOC) in 1867 [1]. Magnesium oxysulfate (MOS) cements are similar to MOC cements, except that $MgSO_4$ is used instead of $MgCl_2$. MOS cements have gained popularity since the hygroscopicity of magnesium sulfate is lower compared to magnesium chloride, therefore, is purported to be more resistant to weathering. MOS has many more excellent properties than Portland cement, e.g. a 1.5 times higher abrasion resistance than Portland cement [2],[3]. This material exhibits excellent characteristics like rapid setting, high initial strength, strong cohesion, low thermal conductivity, superior wear resistance as well as excellent resistance to fire and corrosion [4],[5]. It is suitable for producing lightweight insulation boards, refractory materials, decorative materials, oil well plugging, etc. This is a type of air-dried magnesia-based cementitious material formed through a exothermic reaction between lightly calcined MgO and $MgSO_4$ solution [6]-[10].

The cementing effect of MOS is dependent on its ternary cementing system of $Mg(OH)_2$-$MgSO_4$-H_2O. Demediuk et al. identified four primary phases in MOS ([11],[12]):

- $3Mg(OH)_2 \cdot MgSO_4 \cdot 8H_2O$ (3·1·8 phase),
- $5Mg(OH)_2 \cdot MgSO_4 \cdot 8H_2O$ (5·1·8 phase),
- $Mg(OH)_2 \cdot MgSO_4 \cdot 5H_2O$ (1·1·5 phase) and
- $Mg(OH)_2 \cdot 2MgSO_4 \cdot 3H_2O$ (1·2·3 phase).

Among these, the phases 5·1·8 and 3·1·8 are mainly responsible for promoting the strength of MOS cement. They also claimed that the 3·1·8 phase is only the main phase at ambient temperature, resulting in the strength of MOS cement often being poor. According to Dinnebier et al., the 3·1·8 phase is unstable within the $Mg(OH)_2$–$MgSO_4$–H_2O ternary cementing system, which can lead to reduced long-term strength and cracking in magnesium oxysulfate cement [13].

Beaudoin and Ramachandran discovered that the excessive porosity of MOS cement is primarily responsible for its low water resistance. As a result, an abundance of $Mg(OH)_2$ tends to form during the early stages of magnesium oxysulfate cement hydration because of the reaction of MgO with water alone, which contributes to its unreliable strength [14].

In order to improve the mechanical properties of magnesium oxysulfate cement, some additives are employed to enhance the formation of stable magnesium subsulfate phases while suppressing the generation of the $Mg(OH)_2$ phase [15].

Mathur et al. reported that incorporating formaldehyde into magnesium oxysulfate cement prolongs the setting time and enhances its compressive strength [16].

Received: 12 Aug 2025; Revised: 27 Sep 2025;
Accepted: 6 Oct 2025
*Correspondence: meenakshialwaraj@gmail.com

Wu et al. [17],[18] observed that by altering the hydration process, the addition of phosphoric and citric acid as well as phosphate could boost the compressive strength of magnesium oxysulfate cement.

Zheng et al. observed that citric acid significantly enhances the compressive strength of magnesium oxysulfate cement [19].

Wu et al. found that $5Mg(OH)_2 \cdot MgSO_4 \cdot 7H_2O$ (5·1·7 phase) can act as a seed crystal modifier, serving as a nucleation site that accelerates the hydration process of magnesium oxysulfate cement in both the presence and absence of citric acid [20].

Li et al. studied that compared to phosphoric acid, citric acid is more conducive to the formation of the 5·1·7 phases and the microstructure of the sample containing citric acid becomes denser than the one containing phosphoric acid [21].

Chen et al. reported that the incorporation of Portland cement into magnesium oxysulfate cement significantly deteriorates its mechanical properties [22].

While the addition of Portland cement to magnesium oxysulfate cement in large amounts significantly reduces its mechanical properties, incorporating a small amount can effectively shorten the setting time while retaining most of its compressive strength. Miao et al. reported that incorporating 0.33% phosphoric acid as an admixture in MOS cement composite plates led to the most notable improvements in both compressive and flexural strength, indicating that an optimal dosage of this admixture can significantly enhance the mechanical performance of MOS composites [23].

Zhang et al. studied that combining mineral admixtures like low-calcium fly ash (L-FA), granulated blast-furnace slag (G-BS) and silica fume (SF) enhances the water resistance and compressive strength of magnesium oxysulfate cement by optimizing hydration products and pore structure, while H-FA and SF increase the hydration rate but do not improve water resistance due to the lack of further optimization of the micropore structure [24].

A study on alkali-activated ground granulated blast furnace slag (GGBS) mortar found that increasing the NaOH molarity improved the 28-day compressive strength (up to 67.5 MPa at 10 M) but reduced the workability and setting time, while introducing 5% SF instead of GGBS lowered the compressive strength and flowability without affecting the setting time [25].

A study by Yu et al. demonstrates that roasted boron mud can be effectively used to produce high-performance magnesium oxysulfate plates, achieving optimal flexural strength (15.1 MPa) and meeting F-grade requirements of industry standard T/CMMA 8-2020, thus offering a sustainable application of boron mud [26].

Brzyski [27] observed that gum arabic (3–5%) as a partial replacement for the binder in lime–metakaolin paste enhanced both the flexural and compressive strength significantly despite increased porosity. In hemp concrete, it improved its compressive strength by up to 92% and reduced water absorption by over 10%.

Mouanda et al. [28] found that incorporating up to 20% calcined kaolin (CK) and 0.6–0.8% gum arabic improves the mechanical strength and durability of concrete, while higher CK levels negatively affect performance. Gum arabic-enhanced cement composites exhibit improved adsorption, flexural strength, shear bond strength and microstructural densification, rendering them highly suitable in durable building-repair applications [29].

Although numerous additives have been investigated to improve the strength of MOS cement, comparatively little attention has been paid to improving its water resistance and long-term stability. This study aims to evaluate the impact of a combined mixture of gum arabic and silica gel G on the setting time, moisture resistance and the compressive strength of magnesium oxysulfate cement.

2. Experimental

2.1. Materials

The raw components used in this study for the preparation of MOS cement include industrial-grade magnesium oxide, technical-grade magnesium sulfate and dolomite as an inert filler.

- Magnesium oxide [30]: In this study, lightly calcined magnesia of industrial grade - obtained from Sukhsa Exports in Jaipur, Rajasthan - was utilized. The composition of the magnesite powder used was: SiO_2: 4.51%, CaO: 2.80%, MgO: 89.70%, Fe_2O_3: 0.12%, Al_2O_3: 0.96%, Loss on ignition (LOI): 3.42%.
- Magnesium sulfate (Epsom salt) [31]: Technical grade magnesium sulfate was used in the synthesis of MOS cement. The chemical composition of Epsom salt is: $MgSO_4$: 96.80%, Fe_2O_3: 0.02%, Al_2O_3: 0.07%, CaO: 1.40% and acid-insoluble content: 0.11%.
- Dolomite [32]: Dolomite served as an inert filler, absorbing the excess heat generated during the reaction between MgO and $MgSO_4$. To prepare MOS, locally available commercial-grade dolomite powder was utilized as an inert filler, passing through a 150-micron sieve while 50% was retained on a 75-micron sieve. The chemical composition of dolomite is: SiO_2: 8.45%, CaO: 36.68%, MgO: 11.80%, Fe_2O_3: 0.73%, Al_2O_3: 0.13%, LOI: 41.80%, $CaCO_3$: 65.50%, $MgCO_3$: 24.78%, brightness: 89.20%, whiteness: 92.60%.
- Gum arabic was purchased from a local shop in Jaipur, Rajasthan, India.
- Silica gel G was obtained from the store of Department of Chemistry, University of Rajasthan, Jaipur.

2.2. Methods

Experiments were performed to explore how admixing gum arabic with silica gel G influences the setting characteristics, moisture resistance, compressive strength and thermal properties of MOS. Each experimental

Table 1: Compositions of each sample

Sample No.	Composition of each sample		
	MgO:Dolomite	% of gum arabic	% of silica gel G
M0	1:0	0	0
M1	1:1	0	0
5% MOSGA	1:1	2.5	2.5
10% MOSGA	1:1	5.0	5.0
15% MOSGA	1:1	7.5	7.5
20% MOSGA	1:1	10.0	10.0

Figure 1: Sample preparation for investigating the setting time

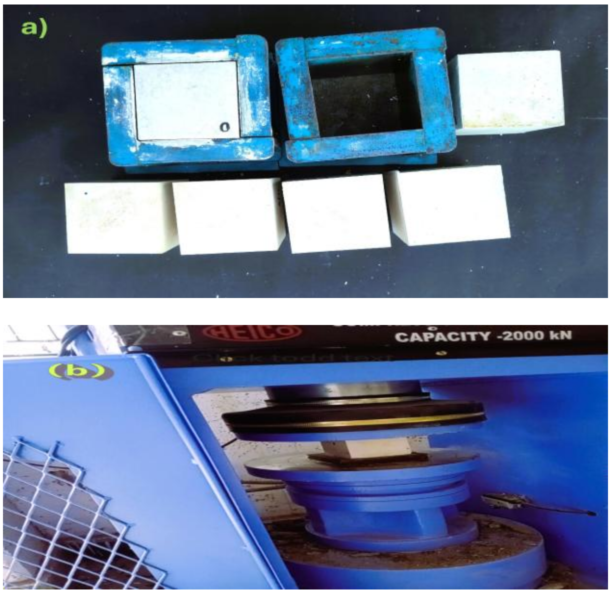

Figure 2: Compressive strength testing: (a) prepared samples - molds and blocks (b) MOS block analyzed by a universal testing machine

procedure was repeated five times and the average calculated. The compositions of each sample (M0, M1, 5% MOSGA, 10% MOSGA, 15% MOSGA, 20% MOSGA) are displayed in *Table 1*.

The combined use of gum arabic and silica gel G significantly enhances the properties of MOS cement. Gum arabic improves interfacial adhesion, flexibility and crack resistance through hydrogen bonding and polymeric film formation, while silica gel G reacts with $Mg(OH)_2$ to generate M–S–H gel that densifies the matrix and improves water resistance. Their combined effect creates an organic–inorganic hybrid network, balancing toughness and durability, thereby significantly enhancing the performance of MOS cement.

2.2.1. Setting characteristics investigation

To determine the setting times of MOS in the presence and absence of additives, different blocks in which it can set were prepared. The prepared samples of the experiments are shown in *Figure 1*.

Additives were used in the best composition of MOS, namely a 1:1 ratio of MgO to dolomite and a $MgSO_4$ solution with a concentration of 25°Be [33]. The amounts of the powdered additive gum arabic (2.5, 5.0, 7.5 and 10.0%) and silica gel G (2.5, 5.0, 7.5 and 10.0%) were calculated on the basis of MgO.

A Vicat needle apparatus was used to calculate the initial and final setting times of various MOS samples according to standard procedures [34].

2.2.2. Moisture resistance investigation

The MOS blocks without (M0 and M1) and with containing various amounts of additives (MOSGA) were cured for 60 days under identical conditions of temperature and humidity and then these MOS blocks were heated in boiling water for 30 hours in a closed steam bath. The relative water vapor transmission rate is represented as a function of time.

2.2.3. Compressive strength investigation

To investigate the effect of gum arabic and silica gel G on the compressive strength of MOS cement, identical 50 cm² cubes (70.6 × 70.6 × 70.6 mm) were cast using pastes of standard consistency containing varying proportions of the gum arabic and silica gel G mixture [35]. The prepared samples of each experiment and the blocks being tested for their compressive strength are shown in *Figures 2a* and *2b*, respectively.

The different types of MOS blocks were subjected to a 28-day curing period under identical conditions before being compressed to the point of rupture using compressive strength testing equipment as per standard procedure [35].

2.2.4. Spectral analysis

Functional group and microscopic analyses as well as thermal investigations were performed by FT-IR, SEM and TGA analyses, respectively, on different types of MOS samples.

Table 2: Effect of gum arabic and silica gel G on MOS

Sample No.	Total % of additives	MgO:Dolomite	Setting time (min)	
			Initial	Final
M0	0	1:0	25	37
M1	0	1:1	68	206
5% MOSGA	5	1:1	113	242
10% MOSGA	10	1:1	125	270
15% MOSGA	15	1:1	140	291
20% MOSGA	20	1:1	147	300

3. Results and discussion

3.1. Effect of gum arabic and silica gel G on the setting time of MOS

The setting time is a vital property of cement that directly influences its rate of hardening. The setting time of MOS cement prepared in the presence and absence of different amounts of gum arabic and silica gel G is shown in *Table 2*.

The setting time of the M0 sample was short compared to that of the MOS samples containing gum arabic and silica gel G. Since magnesium oxide (MgO) and $MgSO_4$ solutions react exothermally, the heat generated is responsible for the early setting of the M0 sample. In M1, as half of the magnesium oxide amount is replaced by dolomite powder, just half the amount of heat is generated by the exothermic reaction and the rest is absorbed by the dolomite powder which behaves as an inert filler through the three-body collision mechanism. Therefore, the initial and final setting times of M1 are longer than those of M0.

The initial and final setting times steadily lengthened as the additive dosage increased. Gum arabic absorbs water and slows down the hydration of MgO and $MgSO_4$, while silica gel G contributes towards densifying the matrix but also retains moisture. The setting time lengthens as the additive concentration increases, suggesting that gum arabic delays the start of the setting process due to its organic nature, which can slow down hydration reactions. The final setting time also lengthens as the additive content increases, demonstrating that it takes longer for the cement to completely harden as more gum arabic and silica gel G were added. Although the silica gel G, being inert or just slightly reactive, may have a minor effect on the setting time, the gum arabic plays a dominant role in retarding setting due to the interaction of its functional groups with MOS. This retardation can be favorable in terms of its workability, however, excessive amounts (15-20%) may delay setting beyond practical limits.

3.2. Effects of gum arabic and silica gel G on the moisture resistance of MOS

Moisture resistance is the inverse of moisture ingress. The effect of gum arabic and silica gel G on the moisture ingress parameters of MOS is shown in *Table 3*. It can be clearly seen that the addition of gum arabic and silica gel G improves the water-tightness of MOS and makes the product more durable.

Table 3: Effect of gum arabic & silica gel G on the moisture ingress characteristics of MOS

Sample No.	Total % of additives	MgO:Dolomite	Trial sample blocks kept in boiling water for					
			0-5 hrs	5-10 hrs	10-15 hrs	15-20 hrs	20-25 hrs	25-30 hrs
M0	0	1:0	a					
M1	0	1:1	….	….	….	….	….	….
5% MOSGA	5	1:1	….	….	….	….	….	….
10% MOSGA	10	1:1	….	….	….	….	….	….
15% MOSGA	15	1:1	….	….	….	….	….	….
20% MOSGA	20	1:1	….	….	….	….	….	….

a = Cracked;
…. = No Effect

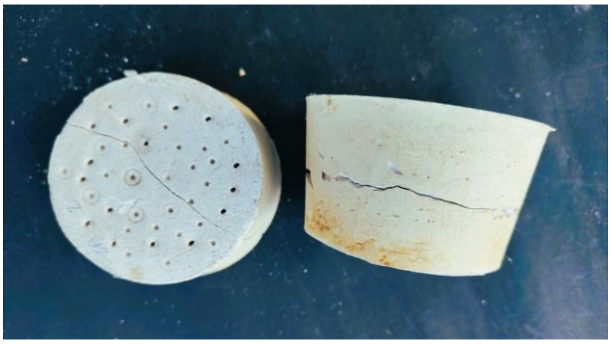

Figure 3: Cracking in the setting time testing blocks of M0 during curing

Figure 4: Crack formation in compressive strength testing block of M0 during curing

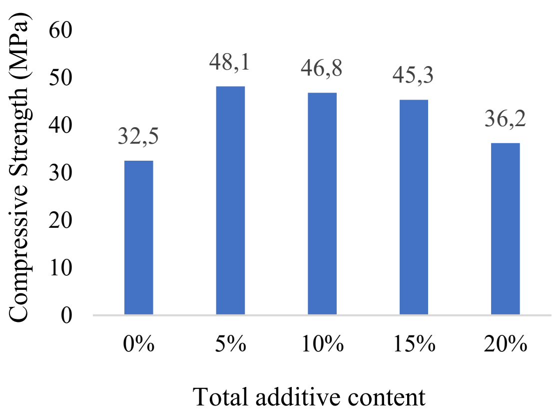

Figure 5: Compressive strength of blocks of MOS cement with different additive contents

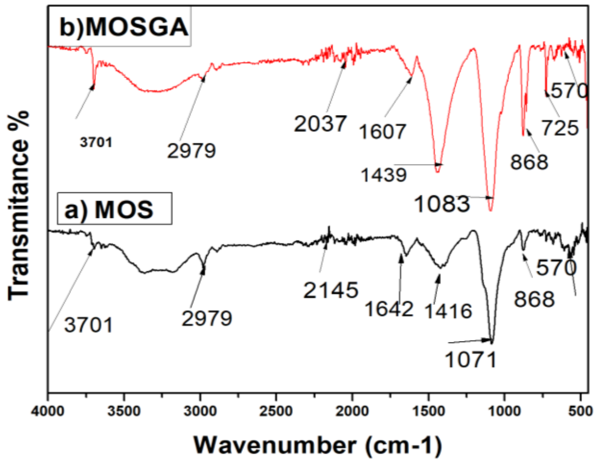

Figure 6: FT-IR spectra of MOS and 5% MOSGA samples

3.3. Effect of gum arabic and silica gel G on the compressive strength of MOS

In MOS cement, cracks are observed in M0 during curing, which are noticeable in *Figures 3* and *4*. Therefore, M0 is not suitable for construction applications. As a result, compressive strength tests were only carried out on M1 as well as 5, 10, 15 and 20% MOSGA samples.

The incorporation of gum arabic (GA) and silica gel G (SG) in equal proportions significantly affects the compressive strength of MOS (*Figure 5*). Optimum performance was observed at an additive content of 5% (48.1 MPa), likely due to enhanced particle packing and improved bonding within the matrix. At 10%, the strength slightly decreased but remained above that of the control. However, further increases to 15 and 20% resulted in a sharp decline in compressive strength, suggesting that an excessive additive content disrupts the hydration process or leads to poor structural integrity. Therefore, controlled use (preferably at 5% or between 5 and 10%) is essential for maximizing mechanical performance.

4. Spectral analysis

4.1. FT-IR analysis

The combined FT-IR spectrum of the MOS and 5% MOSGA samples is shown in *Figure 6*. FT-IR spectral analysis determined the formation of new bonds by compound intermixing.

The FT-IR spectra exhibit both common structural features and distinct additional bands arising from the additives. In both samples, a broad absorption band between 3400 and 3700 cm^{-1} corresponds to O–H stretching vibrations associated with structural hydroxyl groups and physically adsorbed water in hydrated magnesium phases such as $Mg(OH)_2$ and magnesium oxysulfate hydrates (e.g. the 5·1·8 phase). The H–O–H bending mode of bound water is observed between 1600 and 1650 cm^{-1}. The characteristic asymmetric stretching vibrations of sulfate groups (SO_4^{2-}), arising from $MgSO_4.nH_2O$ and MOS phases, appear prominently between 1100 and 1150 cm^{-1}. Mg–O stretching modes typically appear between 400 and 600 cm^{-1}. In the modified MOS system, additional vibrational bands are observed due to the incorporation of gum arabic and silica gel G. The C–O–C glycosidic bonds and C–O stretching modes of gum arabic polysaccharide chains result in distinct peaks between

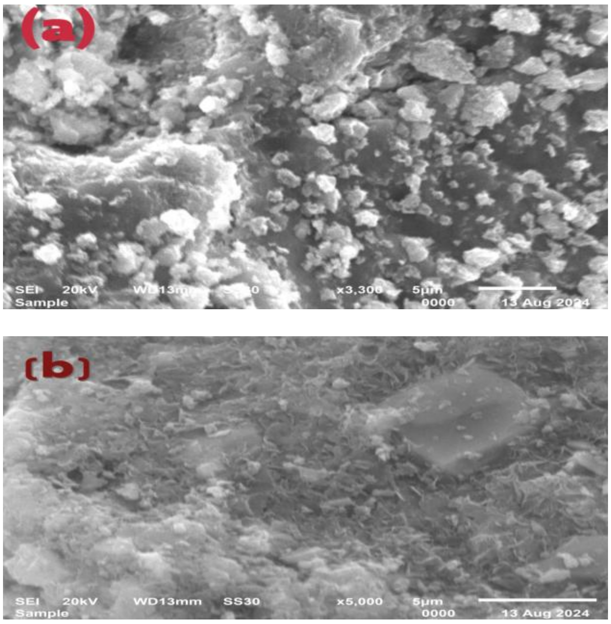

Figure 7: Microstructure of (a) MOS and (b) 5% MOSGA

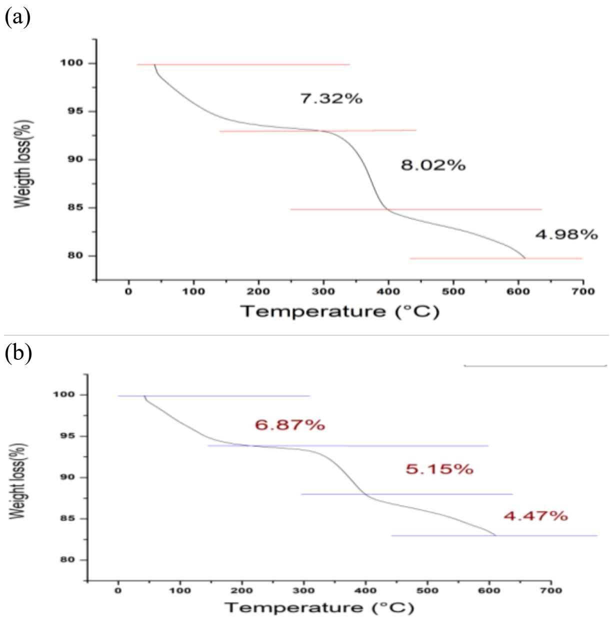

Figure 8: TGA curves of (a) MOS and (b) 5% MOSGA

1020 and 1083 cm⁻¹. Weak but identifiable C–H stretching bands attributed to gum arabic are noted near 2980 cm^{-1}. The presence of silica gel G is confirmed by Si–O–Si asymmetric stretching modes overlapping at approximately 1100 cm^{-1}. Furthermore, minor peaks between 1400 and 1450 cm^{-1} as well as at ~870 (868) cm^{-1} correspond to ν3 and ν2 carbonate vibrations, respectively, indicating partial carbonation of the matrix upon exposure to atmospheric CO_2.

The appearance of these additional bands in the modified samples is indicative of successful chemical incorporation as well as the interaction between gum arabic and silica gel G within the MOS matrix, potentially altering its hydration behavior, microstructural development and mechanical properties.

4.2. SEM analysis

The SEM images of simple MOS and the microstructure of MOS containing 5% additives (2.5% gum arabic + 2.5% silica gel G) are presented in *Figures 7a* and *7b*, respectively. Compared to simple MOS, the microstructure of the MOSGA mixture appears more homogeneous and compact, featuring interwoven needle-like crystals. This interlacing of needle-shaped crystals likely contributes to enhanced mechanical interlocking, which is considered a determining factor in increasing the strength of MOS cement. The addition of gum arabic significantly enhanced the microstructure of the cement, indicating the effectiveness of the curing procedure in improving the structural cohesion of the cement.

4.3. TGA analysis

The TGA curves of the MOS (or M1) and 5% MOSGA cement samples are presented in *Figures 8a* and *8b*, respectively. The TGA curves show that the thermal decomposition of the MOS and MOSGA samples takes place over three stages. At temperatures between 25 and 300 ºC, dehydration of the magnesium oxysulfate hydrate phases such as 5-phase ($5Mg(OH)_2 \cdot MgSO_4 \cdot 8H_2O$) or 3-phase ($3Mg(OH)_2 \cdot MgSO_4 \cdot 8H_2O$) takes place. Over a three-stage process, magnesium hydroxide ($Mg(OH)_2$) transforms into magnesium oxide (MgO) and water (vapor), which is shown in the following equations:

$$Mg(OH)_2 \cdot MgSO_4 \cdot x\,H_2O \rightarrow Mg(OH)_2 \cdot MgSO_4 + \\ + x\,H_2O\ (vapor) \qquad (1),$$

$$Mg(OH)_2 \rightarrow MgO + H_2O\ (vapor) \qquad (2),$$

$$MgSO_4 \rightarrow MgO + SO_3\ (g) \qquad (3).$$

The first stage of decomposition, namely dehydration of MOS 5-phase or 3-phase, is presented in *Equation 1*, while the second and third stages of decomposition are shown in *Equations 2* and *3*, respectively.

By comparing MOS and MOSGA, the weight loss that occurs in the first stage of MOS is slightly higher than that of the MOSGA sample. In the second stage of decomposition, a major weight loss in unmodified MOS is observed compared to modified MOS cement between 300 and 400 ºC. However, above 400 ºC, a small weight loss in unmodified MOS and modified MOSGA is seen. The overall weight loss in MOS and MOSGA was 20.32 and 16.49%, respectively, which specifies that modified MOSGA is more thermally stable than unmodified MOS cement.

The presence of silica gel G enhances the overall thermal stability of the system, leading to a greater amount of final residue compared to the unmodified MOS, while the addition of gum arabic introduces additional decomposition steps linked to its organic nature.

5. Conclusions

M0 is not suitable for construction purposes because of the formation of cracks. Due to its high strength, moisture resistance and the absence of cracks, M1 is more suitable than M0.

The MOS cement containing 5% additives (2.5% gum arabic and 2.5% silica gel G) prolongs the setting time, enhances water resistance and compressive strength as well as increases the thermal stability of the MOS cement matrix. Both additives contribute to improved moisture resistance. Gum arabic acts as a moisture barrier, while silica gel G absorbs free water and reduces porosity, improving the durability of the cement matrix. Gum arabic and silica gel G enhance the compressive strength of MOS cement containing 5% additives, achieving a compressive strength of over 48.1 MPa after 28 days, which is 48% higher than that of a simple MOS sample. At higher additive dosages (up to 20%), the strength of the cement sample may decrease due to possible agglomeration or interference with hydration.

The FT-IR and SEM analyses suggest improved gel formation and fewer microcracks in the MOS cement containing an appropriate proportion of additives. The additives promote the formation of dense phase-5 (5.1.8 phase) and reduce the number of voids. The presence of gum arabic and silica gel G enhances the overall thermal stability of the system.

Acknowledgements

The authors are thankful to Department of Chemistry, University of Rajasthan, Jaipur, Rajasthan, India for providing laboratory facilities.

REFERENCES

[1] Sorel, S.T.: A new magnesium cement, *C. R. Acad. Sci.*, 1867, **65**, 102-104

[2] Zhang, N.; Yu, H.; Gong, W.; Liu, T.; Wang, N.; Tan, Y.; Wu, C.: Effects of low- and high-calcium fly ash on the water resistance of magnesium oxysulfate cement, *Constr. Build. Mater.*, 2020, 230, 116951, DOI: 10.1016/j.conbuildmat.2019.116951

[3] Tayeh, B,A.; Hamada, H.M.; Almeshal, I.; Bakar, B.H.A.: Durability and mechanical properties of cement concrete comprising pozzolanic materials with alkali-activated binder: A comprehensive review, *Case Stud. Constr. Mater.*, 2022, **17**, e01429, DOI: 10.1016/j.cscm.2022.e01429

[4] Jiang, Y.-Z.; Wang, C.-Y.; Xu, Z.-S.; Zhang, Z.-Y.; Surface modification mechanism of magnesium oxysulfate whiskers via wet chemical method, *Rare Met.*, 2016, **35**(11), 874–880, DOI: 10.1007/s12598-015-0543-0

[5] Prasanthni, P.; Priya, B.; Dineshkumar, G.; Gobinath, G.N.: Mechanical properties of coal ash concrete in the presence of graphene oxide, *Int. J. Coal Prep. Util.*, 2024, **44**(4), 377–387, DOI: 10.1080/19392699.2023.2284991

[6] Ba, M.; Zhu, J.; Liu, J.: Effects and mechanism of early temperature and humidity on properties of modified magnesium oxy-sulfate cementitious materials, *Mater. Rev.*, 2017, **31**(10), 107–113, DOI: 10.11896/j.issn.1005-023X.2017.020.023

[7] Ba, M.; Gao, Q.; Ma, Y.; Zhu J.; Du, Y.: Improved hydration and properties of magnesium oxysulfate (MOS) cement using sodium silicate as an additive, *Constr. Build. Mater.*, 2021, **267**, 120988, DOI: 10.1016/j.conbuildmat.2020.120988

[8] Yan, X.; Xu, Q.; Dong, S.; Sun, Y.; Ma, L.; He, X.; Hai, C.; Zhou, Y.: Improved stabilization of loess soil using magnesium oxysulfate cement-based ecological composite binder, *Constr. Build. Mater.*, 2024, **445**, 137865, DOI: 10.1016/j.conbuildmat.2024.137865

[9] Guo, T.; Wang, H.; Yang, H.; Cai, X.; Ma, Q.; Yang, S.: The mechanical properties of magnesium oxysulfate cement enhanced with 517 phase magnesium oxysulfate whiskers, *Constr. Build. Mater.*, 2017, **150**, 844–850, DOI: 10.1016/j.conbuildmat.2017.06.024

[10] Gong, P.; Huang, K.; Huang, Y.; Wu, Y.; Mei, K.; Wei, T.; Zhang, C.; Cheng, X.: Mechanism of graphene oxide inducing the orderly growth of $CaCO_3$ and C-S-H seed crystals in cement slurry-solid transition: Application in CCUS cementing, *Constr. Build. Mater.*, 2024, **449**, 138268, DOI: 10.1016/j.conbuildmat.2024.138268

[11] Demediuk, T.; Cole, W.F.; Hueber, H.V.: Studies on magnesium and calcium oxychlorides, *Aust. J. Chem.*, 1955, **8**(2), 215–233, DOI: 10.1071/CH9550215

[12] Demediuk, T.; Cole, W.F.; A study of mangesium oxysulphates, *Aust. J. Chem.*, 1957, **10**(3), 287–294, DOI: 10.1071/ch9570287

[13] Dinnebier, R.E.; Pannach, M.; Freyer, D.: $3Mg(OH)_2 \cdot MgSO_4 \cdot 8H_2O$: a metastable phase in the system $Mg(OH)_2$-$MgSO_4$-H_2O, *Z. Anorg. Allg. Chem.*, 2013, **639**(10), 1827–1833, DOI: 10.1002/zaac.201300128

[14] Beaudoin, J.J.; Ramachandran, V.S.: Strength development in magnesium oxysulfate cement, *Cem. Concr. Res.*, 1978, **8**(1), 103–112, DOI: 10.1016/0008-8846(78)90063-7

[15] Chen, X.; Zhang, T.; Cheeseman, C.; Bi, W.; Wang, S.: Production of rapid-hardening magnesium oxysulfate cement containing boric acid, *J. Mater. Civ. Eng.*, 2022, **34**(5), 04022045, DOI: 10.1061/(ASCE)MT.1943-5533.0004178

[16] Mathur, R.; Sharma, S.K.; Chandrawat, M.P.S.: Effect of formaldehyde as an additive on some properties of magnesium oxysulphate cement, *Mater. Sci. Res. India.*, 2008, **5**(2), 313–320, DOI: 10.13005/msri/050209

[17] Wu, C.; Yu, H.; Dong, J.; Zheng, L.: Effects of material ratio, fly ash, and citric acid on magnesium oxysulfate cement, *ACI Mater. J.*, 2014, **111**(3), 291–298, DOI: 10.14359/51686723

[18] Wu, C.; Chen, W.; Zhang, H.; Yu, H.; Zhang, W.; Jiang, N.; Liu, L.: The hydration mechanism and performance of Modified magnesium oxysulfate cement by tartaric acid, *Constr. Build. Mater.*, 2017, **144**, 516–524, DOI: 10.1016/j.conbuildmat.2017.03.222
[19] Zheng, Z.; Zhan, B.G.: Research on modification effects of citric acid on magnesium oxysulfate cement, *J. Hefei Univ. Technol.*, 2013, **36**(4), 83–86
[20] Wu, C.; Luo, K.; Zhang, H.; Yu, H.: Effect of 5·1·7 phase seed crysral on performance of magnesium oxysulfate cement, *J. Adv. Concr. Technol.*, 2019, **17**(10), 603–615, DOI: 10.3151/jact.17.603
[21] Li, Z.-G.; Ji, Z.-S.; Jiang, L.-L.; Yu, S.-W.: Effect of additives on the properties of magnesium oxysulfate cement, *J. Intell. Fuzzy Syst.*, 2017, **33**(5), 3021–3025, DOI: 10.3233/JIFS-169353
[22] Chen, Y.; Wu, C.; Chen, C., Chen, F.: Effect of Portland cement on magnesium oxysulfate cement using light-burned dolomite, *IOP Conf. Ser.: Earth Environ. Sci.*, 2018, **186**(2), 012033, DOI: 10.1088/1755-1315/186/2/012033
[23] Miao, M.; Wu, C.; Xing, S.; Zhou, J.; Zong, J.: Effect of different additives addition on basic magnesium sulfate cement composite sheet, *IOP Conf. Ser.: Earth Environ. Sci.*, 2019, **358**(5), 052021, DOI: 10.1088/1755-1315/358/5/052021
[24] Zhang, N.; Yu, H.; Ma, H.; Ba, M.; Ma, H.: Effects of compound mineral admixtures on the properties of magnesium oxysulfate cement, *Adv. Cem. Res.*, 2022, **34**(12), 560–573, DOI: 10.1680/jadcr.22.00006
[25] Mohamed, O.A.; Najm, O.; Zuaiter, H.A.; Saleem, S.K.; Ivak, S.; Al-Aribe, K.: Effect of activator concentration on setting time, workability and compressive strength of sustainable concrete with alkali-activated slag binder, *Mater. Today Proc.*, 2024, DOI: 10.1016/j.matpr.2024.04.103
[26] Yu, T.; Sui H.; Jiang, T.; Li, L.; Wen, J.; An, X.: Preparation of magnesium oxysulfate plates using boron mud solid waste and performance evaluation, *J. Sustain. Metall.*, 2025, **11**(2), 1616–1624, DOI: 10.1007/s40831-025-01051-0
[27] Brzyski, P.: The influence of gum arabic admixture on the mechanical properties of lime-metakaolin paste used as binder in hemp concrete, *Materials*, 2021, **14**(22), 6775, DOI: 10.3390/ma14226775
[28] Mouanda, G.F.M.; Abuodha, S.O.; Thuo, J.N.: Gum Arabic as an admixture in modified concrete mixed with calcined kaolin, *Civ. Eng. J.*, 2022, **8**(5), 985–998, DOI: 10.28991/cej-2022-08-05-010
[29] Sugumaran, B.; Neme, I.: Effect of adsorption interactions of Arabic gum with cement, *Mater. Res. Express*, 2024, **11**(6), 065503, DOI: 10.1088/2053-1591/ad51d8
[30] Indian Standard 10132 (1982): Method of test for materials for use in the preparation of magnesium oxychloride flooring compositions
[31] Indian Standard 2730 (1977): Magnesium sulphate (Epsom salt) [CHD 1: Inorganic Chemicals]
[32] Indian Standard 1760 (1962): Methods of chemical analysis of limestone, dolomite and allied materials
[33] Meenakshi.: Effect of Epsom salt concentration and Dry-Mix composition on bonding properties of magnesium oxysulfate, Asian J Chem., 2023, 35, 869–876, DOI: 10.14233/ajchem.2023.26992
[34] Indian Standard 5513 (1996): Specification for Vicat apparatus [CED 2: Cement and Concrete]
[35] Indian Standard 10080 (1982): Specification for vibration machine for standard cement mortar cubes