International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

Influence of Expansive Agent on the Dimensional Stability and Mechanical Properties of Gypsum Plaster

Raja M.A, Sophia M

Abstract*: Nowadays the use of gypsum plaster has gained momentum due to their economic and eco-friendly nature. The objective of this work was to study the influence of expansive agent such as CaO and MgO on the properties of the gypsum plaster. The effect of expansive agent on the physical, mechanical, water absorption and porosity were analyzed. The dimensional stability of the plaster with various percentages of Cao and MgO were also evaluated. From the results obtained it was confirmed that the addition of expansive agent increased the stability of the gypsum plaster to dimensional variation both during early hydration periods and also at hardened state without affecting the strength of the plaster.

***Keywords* : Gypsum plaster, expansive agent, Cao, MgO, dimensional stability**

I. INTRODUCTION

Gypsum plasters are now being a material of choice for construction due to its efficiency both from the aspects of performance and economy [1]. The ease of application, outstanding aesthetic appearance and excellent workability has made gypsum hold a predominant position as a finishing material in the global market. Despite its several advantages and enhanced thermal and acoustic performance the usage of gypsum plastering has been restricted to indoor applications. Swelling and shrinkage are the serious drawbacks of gypsum plaster which mitigates the use of gypsum plaster to external plastering applications [3, 4]. This occurrence of shrinkage is mainly due to the fact that the amount of water added to the gypsum plaster is usually higher than that required for the hydration of hemihydrate to dihydrate. It is a well established fact that the amount of stoichiometric water demand for the gypsum formation is 18.6 g per 100g of hemihydrates [6].

But the amount of water added to gypsum plaster is approximately 0.6 w/w of gypsum plaster in order to meet the required consistency and to obtain the higher workability for ease of application. This causes the setting expansion of gypsum plaster during the initial stages of the gypsum hydration. But as the time progresses the gypsum plaster undergo dimensional changes due to the loss of moisture and evaporation of excess water used for obtaining plasticity.

Several research works have been previously done to establish the effectiveness of various types of admixtures on the rheological and physico-mechanical properties of gypsum plaster [10]. The shrinkage reducing agents when added to cement and geo-polymeric mortars yielded positive results by minimizing the shrinkage effects as well as showed some beneficial effects on flexural and compressive strength as per previous research works [8]. Keeping this in view, this research work has been executed on the similar track so as to examine the variation of strength parameters such as compression and flexural strength as well as porosity characterization with varying percentages of shrinkage reducing agents CaO and MgO. The mechanism of shrinkage compensating agents commonly known as expansive agents can be stated as:

$MgO + H_2O \rightarrow Mg(OH)_2$, $CaO + H_2O \rightarrow Ca(OH)_2$

The hydration of MgO and CaO agents forms the final product magnesium hydroxide and calcium hydroxide respectively. These products formed are usually higher in volume than the initial constituents.

The effects of these expansive agents on properties of gypsum plaster have not been studied so far. This research work mainly aims at establishing the effect of addition of the expansive agents MgO and CaO on the physiological properties and does not study the chemical interactions of the gypsum plaster with the expansive agents. Moreover, the effect of these expansive agents on hardened state properties such as mechanical strength, water absorption and drying shrinkage characteristics were also investigated.

II. MATERIALS

The commercial hemihydrates plaster obtained from the local market is used for the study. The analytical grade CaO and MgO were chosen as the expansive agents. These expansive agents obtained were 98% pure so as to obtain the maximum accuracy in the results.

Manuscript published on November 30, 2019.
* Correspondence Author
Raja M.A*, M.E (Struc),MISTE, Department of Civil Engineering, Francis Xavier Engineering College, Tirunelveli, India.
Email: antojosephraja1@gmail.com
Sophia M, Research Scholar at Anna University Chennai, India. Email: sophiavarshini1992@gmail.com

III. MIX PROPORTION

In order to study the effect of expansive agent in the gypsum plaster the CaO and MgO were varied from 0.5, 1, 1.5, 2, 2.5, and 3%.

These wide variations of expansive agents were done with the view to clearly visualize the minute variations in the plaster properties. The mixture proportions are shown in table 1.

The water/gypsum ratio was maintained constant as 0.5 in order to neglect the effect of water gypsum ratio on the properties of plaster. The homogeneity in each mix was established by thorough mixing of the hemihydrates and the expansive agent in the dry state for about 20 seconds and then measured quantity of water was poured accompanied by continuous stirring so as to avoid the bulking of hemihydrates. The gypsum plaster which is unmodified without the addition of expansive agent was used as reference mix.

IV. CASTING AND CURING

The cubic specimens for compression and water absorption tests were cast for every mix and immediately after mixing they were poured into steel moulds of size 50 x 50 x 50 mm. The prismatic samples of size 160 x 40 x 40 mm were cast for dimensional measurements. They were demoulded after 24 hours maintained at laboratory temperature. The specimens were then kept in oven at 40 ± 2^0C until the constant mass is obtained.

V. METHODOLODY

A. Experimental methods

The compressive strength test was performed as per the Indian Standard 2542-1978. These values were reported as an average of three specimens in order to improve accuracy.

B. Dimensional variation

Since there is no standard procedure for measuring dimension variations, the measurements were done as per the procedures enlisted in the previous research works [7].The prismatic samples of size 160 x 40 x 40 mm with various percentages of expansive agents were cast to evaluate the dimensional changes both during the early stages of hydration as well as after the specimen has hardened. These prismatic specimens containing expansive agents were demoulded after 2 hours and their initial lengths were measured using length comparator. The demoulded specimens were then maintained in drying conditions at 20 ± 2^0C and the change in length was measured upto 48 days.

VI. RESULTS AND DISCUSSIONS

A. Compressive strength variation

The compressive strength variation of the gypsum plasters due to the addition of expansive agents CaO and MgO is shown in fig. It can be seen that the mechanical strength of the reference plaster was slightly improved with increasing percentages of expansive agent. Though the inclusion of expansive agents do not cause considerable increase in the compression strength these variations are significant because the addition of expansive agents have not caused any negative results. Thus it can be confirmed that expansive agents do not negatively influence the strength parameters of gypsum plaster. Moreover it can be further inferred that this strength attribution may be due to the chemical interaction of expansive agents with the water molecules of the gypsum plaster.

Furthermore the comparison of the two types of expansive agents in terms of their compressive strength showed that the MgO was more effective than the CaO agent. The maximum strength values were obtained at 2% of expansive agent. The compressive strength was increased up to 40 % more than the reference plaster for CaO and 42% for MgO expansive agent.

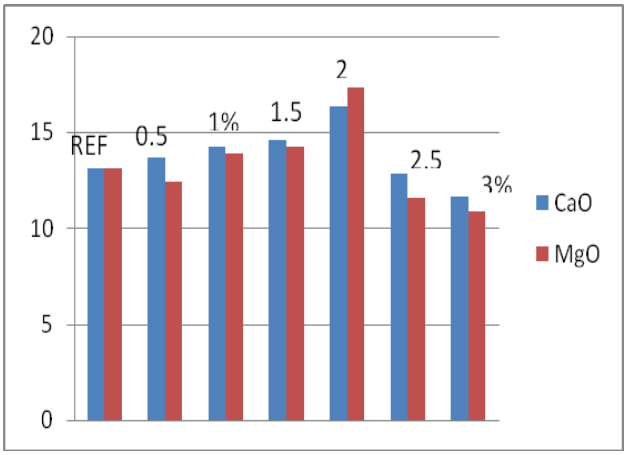

Fig. 1.Effect of expansive agents on the Compressive Strength of gypsum plaster

B. Dimensional changes

The dimensional variations of the gypsum plaster with and without the addition of expansive agents are shown from fig (7 – 10). It can be seen that the variation of dimension was very much influenced with increasing concentration of expansive agents. The variation of dimension during the early stages of hydration of gypsum plaster is always accompanied by initial shrinkage due to the loss of free water to be used in hydration of hemihydrates to dihydrates. All the later stages of hydration when the transformation of the hemihydrates to dihydrates has taken place then the swelling behavior sets in due to the cohesion and increase vanderwaals force within the pores of Gypsum plaster [7].

Furthermore after the gypsum plaster has completely set then the drying stage begins in which the water added to obtain consistency commonly known as over-stoichiometric water begins to evaporate which leads to further reduction in volume. The expansion agents CaO and MgO played crucial role at this drying stage as illustrated in fig 7 and fig 8. It shows that the loss of water accompanied by change in dimension was higher in the reference plaster compared to those with the expansive agents. The shrinkage values were much lesser as the days progressed due to the addition of expansive agents. This may be due to the expansive forces caused by the expansive agents thus loading to minute dimensional variation. From the comparison of CaO and MgO it was further clear that the MgO was much effective than CaO.

Retrieval Number: D7526118419/2019©BEIESP
DOI:10.35940/ijrte.D7526.118419
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

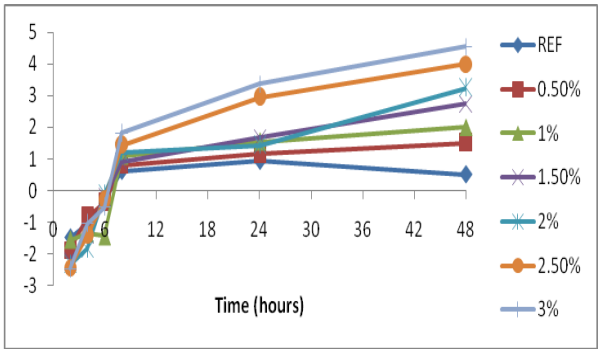

Fig. 2. Dimensional variations at initial stages of hydration with CaO expansive agent

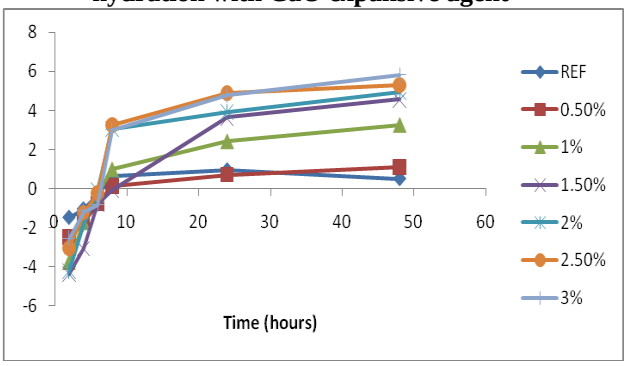

Fig. 3. Dimensional variation at initial stages of hydration using MgO expansive agent

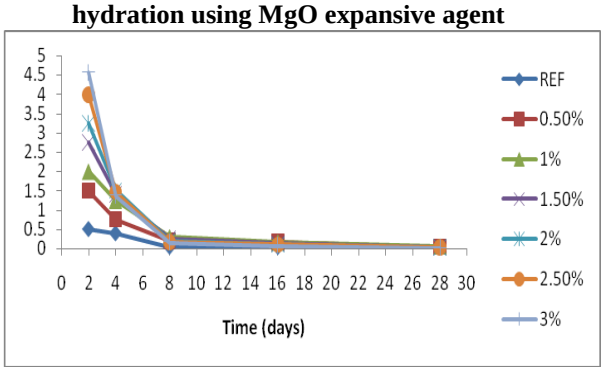

Fig. 4. Dimensional variation at after hardening using CaO expansive agent

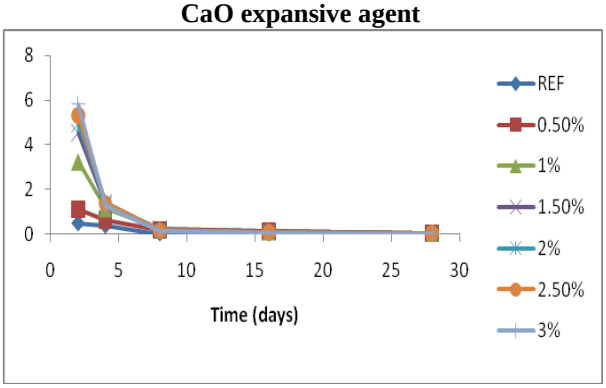

Fig. 5.Dimensional variation after hardening using MgO expansive agent

VII. CONCLUSION

From the results obtained the following conclusions can be withdrawn: The use of CaO and MgO as expansive agents has been found to be effective in increasing the compressive strength of the gypsum plaster. The strength variation was much significance when MgO is used as an expansive agent rather than CaO. The optimum percentages of these expansive agents were found to be 2% by weight of gypsum plaster above which caused a slight decrease in mechanical strength. The shrinkage values obtained proves that these expansive agents have little influence on the early stages of gypsum plaster formation whereas the hardened state the minimal effect of shrinkage values has been observed due to the effect of CaO and MgO. Furthermore this study can be extended for studying the chemical interactions of the expansive agents with the plaster by microstructure studies and thus investigation of the new crystalline phases can be executed.

The overall conclusion on the basis of the plaster with expansive studied in this work, it seemed that CaO and MgO can be used effectively to enhance the properties of gypsum plaster and also can be used to improve durability.

REFERENCES

1. Mridul Garg, Aakanksha Pundir, Investigation of properties of fluorogypsum-slag composite binders-Hydration,Strength and microstructure, Cement and concrete composites 45 (2014) 227-233.
2. Q.L.Yu, H.J.H.Brouwers, Microstructure and mechanical properties of β-hemihydrate produced gypsum: An insight from its hydration process, Construction and Building Materials 25 (2011) 3149-3157.
3. P.Padavet, P.Tesarek, Plachy, (2011) "Evolution of mechanical properties of gypsum in time", International journal of Mechanics, Issue 1, volume 5.
4. A.Gmouh, S.Eve, A.Samdi, R.Moussa, L.Tricha, B.Aazzab, J.Hmael and M.Gomina (2004), "Development and validation of a dimensional variation measurement set-application to the plaster setting", Materials Science and Engineering A 372, pp.123-127.
5. M Palacios and F Puertas (2007), "Effect of shrinkage-reducing admixtures on the properties of alkali-activated slag mortars and pastes", Cement and Concrete research, pp.691-702.
6. N.B.Singh, B.Middendorf, Calcium sulphate hemihydrates hydration leading to gypsum crystallization, Progress in crystal Growth and characterization of Materials 53 (2007) 57-77.
7. Mario Collepardi, Antonio Borsoi, Silvia Collepardi, Jean Jacob Ogoumah Olagot, Roberto Troli (2005), "Effects of Shrinkage reducing admixture in shrinkage compensating concrete under non-wet curing conditions", Cement and Concrete Composites, Vol.27(6), pp.704-708.
8. Mykola Zaichenko, Antonina Nazarova and Qosai Marshdi (2014), "Effect of expansive agent and shrinkage-compensating concrete under hot-dry curing environment", Teka. Commision of Motorization and Energetics in Agriculture, Vol.14, No.2, pp.170-178.
9. Bentz. D P (2005), "Curing with shrinkage reducing admixtures beyond drying shrinkage reduction", Concrete International, Vol.27, No.10, pp.55-60.
10. Bentz D P, Geiker M R and Hansen K K (2001), "Shrinkage-reducing admixtures and early-age desiccation in cement pastes and mortars", Cement and Concrete research, Vol.31, pp.1075-1085.
11. Chen W and Brouwers H J H (2012), "Hydration of mineral shrinkage-compensating admixture for concrete: An experimental and numerical study", Construction and Building Materials, Vol.26, pp.670-676.
12. Gettu R, Roncero J and Martin M A (2002), "Long-term bahavior of Concrete incorporating a shrinkage-reducing admixture", Indian Concrete Journal, Vol.76, No.9, pp.586-592.
13. Mo L, Deng M and Tang M (2010), "Effects of MgO-based expansive additive on compensating the shrinkage of cement paste under non-wet curing conditions", Cem. Concr. Comp., Vol.34, pp.377-383.
14. Mora-Ruacho J, Gettu and R, Aguado A (2009), "Influence of shrinkage-reducing admixtures on the reduction of plastic shrinkage cracking in concrete", Cement and Concrete Research, Vol.39, pp.141-146.
15. Newberry C (2001), "Using shrinkage-reducing admixtures to minimize shrinkage cracking", Quality Concrete, Vol.7, No.11-12, pp.179-181.

16. Sakthieswaran N, Sophia M, Ganesh Babu O (2016),” Gypsum as a Construction Material- A Review of Recent Developments”, International Journal for Innovative Research in Science & Technology, Volume 2, Issue 12.
17. IS: 2542-2002 (Part I). “Methods of test for gypsum plaster, concrete and products”, Bureau of Indian Standards, New Delhi, India.
18. IS: 2542-1997 (Part II), “Methods of test for gypsum plaster, concrete and products” Bureau of Indian Standards, New Delhi, India.

AUTHORS PROFILE

Raja.M.A, M.E(Struc),MISTE, Assistant Professor Department of civil engineering – Francis Xavier Engineering College, Tirunelveli. Completed BE Civil Engineering in Balaji Institute of Engineering and Technology and ME Structural Engineering in Dr.Sivanthi Aditanar College of Engineering

Sophia M, Research Scholar at Anna University Chennai. Completed BE Civil Engineering in Anna University of Technology-BIT Campus and ME Structural Engineering in Anna University Regional Campus-Tirunelveli.