Construction and Building Materials 179 (2018) 675–691

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Effect of superplasticizers on the properties of latex modified gypsum plaster

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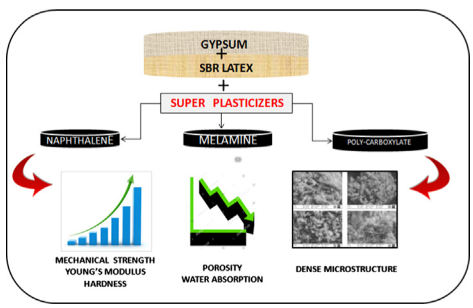
HIGHLIGHTS

- The properties of gypsum latex blend with various superplasticizers at different concentrations were studied.
- Outstanding mechanical strength, water stability and thermal stability were obtained.
- Maximum reduction in porosity due to latex and superplasticizer addition without causing hindrance to the hydration of dihydrate plaster was observed.
- Denser, compact and high crystalline structure of gypsum plaster is evident from SEM image.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 6 July 2017
Received in revised form 15 May 2018
Accepted 18 May 2018

Keywords:
Gypsum-latex blend
Super plasticizer
Mechanical strength
Porosity
Micro structure studies

ABSTRACT

This present work aims at analysing the combined effects of SBR latex and various types of superplasticizers on the properties of gypsum plaster. Three commercially available superplasticizers were added to the latex-gypsum blends at various percentage increments of 0.2–1%. The characterization of superplasticized latex plaster blends was done by measuring the wide range of properties of latex-gypsum plaster. Initially the combined effects of latex and super plasticizer concentration on the fresh state properties of the plaster were analyzed. The fresh state results showed that the water demand was much reduced without affecting the workability. The mechanical properties investigation proved that the properties of the plaster were much enhanced with improved water resistance behaviour. The microstructure studies using Scanning Electron Microscopy confirmed the denser and compact gypsum grains with mass reduction in porosity. The significant improvement in thermal stability and electrical conductivity of the plaster was also observed in the superplasticizers-latex blended gypsum plaster.

1. Introduction

The gypsum plaster chemically known as Calcium sulphate hemihydrate is one of the widely used building materials and its utilisation can be traced back to several thousand years ago [1]. The Calcium sulphate hemihydrates were commonly known as "green cements" due to their healthful contribution to environment and pollution abatement by reducing CO_2 emissions [2]. The extra-ordinary performance and the aesthetic appearance have made gypsum based renders and plasters as a material of choice for indoor applications [3]. The main disadvantages of the plaster compared to cement products are its brittleness and high affinity to water. Though gypsum hemihydrate is sparingly soluble in water, its usage has not been extended for outdoor applications due to their poor mechanical properties attributed by the low

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https://doi.org/10.1016/j.conbuildmat.2018.05.150
0950-0618/

cohesive force between the gypsum grains and lack of interlocking mechanisms between grains leading to high porosity [5,6].Several attempts have already been done to increase the mechanical properties of gypsum plaster by adding deflocculating agents , seeding of gypsum grains [4], reinforcing with fibres [5,6], adding acrylic polymers [7,23], adding water soluble polymers [8,9], adding clay minerals [24], blending with supplementary cementitious materials [12,18] and superplasticizers [10,11].

The polymer modifications to cement mortar [19,20] and gypsum plaster [17] are being widely practiced in the construction industry. The polymer emulsion in forms of Styrene butadiene rubber latex is the commonly used modifier for cement based binder materials [13].The water soluble polymers provide better consistency as well as contribute to improved adhesion and plasticizing property of gypsum plaster [14]. The latex concentration plays a major role on the variation of the magnitude of physical, mechanical and durability properties of modified gypsum plasters. Adnan Colak studied the characteristics of latex modified gypsum plaster demonstrating the remarkable reduction in the water gypsum ratio due to the latex addition [17].However the water adsorption value of latex modified plaster were almost same as the plain plaster but the reduction in water-gypsum ratio caused a reduction in the water absorption of the composites.

The superplasticizers also known as fluidity enhancer has found to increase the strength and water resistance capacity of the gypsum matrix [10]. The chemical composition of the superplasticizer mainly classified them into four broad categories namely, sulfonated naphthalene formaldehyde condensate, sulfonated melamine formaldehyde condensate, modified lignosulfonate and poly-carboxylate condensate [11]. The superplasticizers are relatively low molecular weight water soluble polymers that contribute high workability accompanied with large reduction in water content [15].

The knowledge from the previous research works showed that a number of investigations have been performed on the latex modified cement and concrete products. The effect of the various types of the superplasticizers in modifying the water resistant and engineering properties of the hemihydrate plaster were performed previously [10,11]. To our knowledge no studies have been previously attempted characterize the behaviour of latex-superplasticizer blended gypsum plaster.

Evidences from the previous studies showed superior performance of gypsum plaster due to the individual additions of superplasticizer and latex. The combined effect of latex and superplasticizers have also proved to be beneficial in improving the properties of cement mortar both in fresh [15] and hardened [16] state as observed by some researchers. Along the same track the present study is aimed to investigate the combined effect of various types of superplasticizers and SBR latex on the properties of hemihydrate plaster. The extensive mechanical characterisation was done and the micro structural studies were performed using Scanning Electron Microscopy and Infrared spectroscopy. Moreover the thermal characteristics of the plaster due to the incorporation of gypsum and superplasticizers were evaluated using thermo gravimetric analysis technique.

1.1. Research significance

Nowadays latexes have been frequently used in gypsum plasters for improving the mechanical strength parameters of the composites. Though the inclusion of latex improves the consistency the addition of latex diminish the flowability of the gypsum plaster due to high viscosity and the water content required to produce the latex-gypsum blends with greater workability remains nearly constant [8]. Hence a wide range of superplasticizers were considered for use in combination with SBR latex to modify the disadvantages of latex blended gypsum.

The stoichiometric amount of water required for complete hydration of hemihydrate to dihydrate is only 0.186 by mass of hemihydrates [29]. However a high amount of excess water is added to improve the workability and ease of handling known as over-stoichiometric water. This excess water may be removed during the curing period due to evaporation that causes high porosity and voids which is undesirable. Hence reducing this over-stoichiometric water by using high range water reducing admixtures proves to be the only solution.

2. Materials

The material used in the present study includes the binder which is mainly composed of calcium sulphate hemihydrate ($CaSO_4$ ½ H_2O) commonly called as Plaster of Paris. The hemihydrate plaster is stored in an air tight container to avoid hydration. The particle size distribution of the hemihydrate plaster as obtained by particle size analyzer is shown in Fig. 1.

2.1. Latex

The polymer latex used is Styrene Butadiene Rubber (SBR). The technical specifications of the SBR latex as mentioned in the product datasheet are shown in Table 1.

2.2. Superplasticizer

The commercially available three different superplasticizers with three different chemical bases namely naphthalene, melamine and polycarboxylate were used. Table 1 indicates the technical specifications of various super plasticizers used in this study as given by the manufacturer's product data sheet.

2.3. Mix proportioning

The Gypsum plaster mixes were prepared using 15% Styrene Butadiene rubber as partial substitute for Gypsum binder and is taken as the reference mix (REF). This proportion was chosen as per the previous works conducted on SBR Gypsum plasters [3,6,9]. The superplasticized gypsum-latex specimens were manufactured by adding naphthalene, melamine and polycarboxylate super plasticizers individually at concentrations of 0.2–1% and were named N1-N5, M1-M5 and PC1-PC5 depending on the concentration of naphthalene, melamine and polycarboxylate super plasticizers respectively. This wide range was chosen with a view to examine the minute behavioural changes in the gypsum-latex blend due to super plasticizer addition. No other additives were added in order to analyze the effect of super plasticizer concentration as the only influential parameter on the latex modified gypsum plaster.

3. Casting and curing

The casting of the specimens was done according to the standards established in the previous research works [10,11]. The cubic specimens of size 50 × 50 × 50 mm were cast for the compression testing for each concentration of superplasticizer and constant latex proportion. The prismatic samples of size 160 × 40 × 40 cm were produced for the flexural strength test. The water-gypsum ratio was varied in the modified gypsum plaster to obtain a fixed consistency in all modified gypsum plaster. The specimens were demoulded after 24 h and maintained in the room temperature up to 28 days until they were tested.