# Mitigation of H2S Emissions by Recycling Discarded Gypsum Wall Boards in CLSM

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## Abstract
This paper highlights the benefits of incorporating wastes such as powdered gypsum wall boards (PGP) or drywalls, ground granulated blast furnace slag (GGBS) and quarry dust on improved performance of Controlled low strength materials (CLSM), which is a self-flowing cementitious backfill material. Drywalls, a construction demolition waste, are known to pollute atmosphere by releasing harmful H2S gas when dumped at landfills. In literature, ternary binder combination of powdered gypsum wall boards, fly ash and cement resulted in reduced compressive strength values of CLSM specimens at 56 days when compared with 28 days. This paper investigates fresh and hardened properties of novel CLSM mixtures, and emphasizes on the incorporation of GGBS instead of fly ash which is efficient and helps to overcome the reduced compressive strengths at later ages. However, this was observed to be more effective only at lesser water contents.

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***Index terms***— H2S; gypsum wallboard; ggbs; quarry dust; recycle.

# 1 I. Introduction

onstruction and Demolition (C & D) wastes are generated in large quantities due to increase in construction activities such as construction of new buildings, demolition of old and obsolete buildings, renovations of existing buildings, etc; and gypsum wall boards are contributing in huge numbers to these wastes as they are most commonly used construction material for interior works. About fifty percent of the C & D wastes are dumped at landfills and remaining are being recycled [1]. These wastes from construction activities are usually re-used as recycled concrete aggregates [2]. The waste drywall pieces are thrown away and piled as debris near the construction sites and later local public waste disposal vehicles transport them to nearby landfills. It is reported that certain sulphur reducing bacteria's react with these gypsum wall board wastes; and as these wastes are composed of calcium and sulphate, with availability of necessary temperature, moisture and anaerobic conditions at landfills, hazardous H 2 S (hydrogen sulphide) gas is released to atmosphere [3][4][5][6][7]. From public health point of view and also increasing public interest litigations necessitates that these wastes should be recycled in large numbers instead of being dumped at landfills. In literature [7], an attempt was made on possible re-use of wasted drywalls in concrete. It was concluded that about 60% (by weight) of total binder i.e. cement may be replaced by the combination of Class C fly ash and gypsum wall boards, and only 10% (by weight) of the total cement content could be replaced by powdered gypsum wall board. Cement replacement of 10% (by weight) will not help for large scale re-use of these gypsum wall board wastes. Hence an alternative should be encouraged possible re-use of these gypsum wall board wastes in large quantities for sustainable development of concrete industry.

Controlled low-strength material (CLSM) is an obvious choice for re-use of many types of waste materials such as GGBS, fly ash, C & D wastes, etc in large quantities [8][9] ??10]. Hence an attempt was made for possible re-use of gypsum wall board wastes in CLSM. Fly ash is a coal combustion product having fine particles which are responsible for pollution of atmosphere and environment as a whole resulting in disturbed ecological cycles and hazardous environment, and it has been popularly used, as a replacement to binder, in cement [11,12], CLSM [13], geomaterials [14] and concrete [15,16]. Quarry dust is a waste from stone industry collected out of many processes involved in the manufacture of final product such as overburden, screening, sludge and fragments. Seventy eight to fifteen percent of total quarried material is collected as quarry dust [17,18] and this waste is being used as a replacement to aggregates in CLSM and concrete [19][20][21]. Ground granulated blast furnace slag (GGBS) is an industrial by-product and its use in concrete industry is recognized by Leadership in Energy and Environmental Design (LEED). Hence use of GGBS in CLSM will add points towards LEED certification and improve the sustainability of the project. GGBS is widely used as secondary cementitious material in CLSM [13,22,23], pozzolanic cements [24] and concretes [25].

In this paper, CLSM mixes were proportioned for 1(binder):1(fine aggregate) ratio. Powdered gypsum wall board + Ground granulated blast furnace slag (GGBS) + cement; comprised the binder. Additional mixtures were produced with soda ash as an activator, to activate the ternary binder blend, and the results were compared with those without soda ash. Quarry dust fines were used in total replacement to natural river sand. About seventy four to eighty seven percent by weight of total binder content was replaced by binary blend of gypsum wall board + GGBS, and sixty one to fifty two percent by weight of total binder content was replaced by powdered drywall wastes. Soda ash if used as an activator has no appreciable increase in strength values. In literature [26] Class F fly ash was used and the CLSM mixes were named as GF series; it was reported that the 56 days strength reduced when compared to 28 days strength values, due to use of gypsum wall boards. However, in the present research work, GGBS was used instead of Class F fly ash; and it was found that the reduced compressive strengths was not observed at 56 days age for GGBS based CLSM mixes at 45% (by weight) water contents only [23]. This paper investigates the engineering properties of sustainable CLSM mixtures with generation of strength and flow phenomenological models [22], for possible re-use of these wastes as binders (fly ash or GGBS + powdered drywalls) and fine aggregates (quarry dust), in a total of twenty mixture combinations. Although the materials described in this paper, the flow and strength results discussed, are the same which are described in the literatures [23,26]; the density and settlement results of GG series are investigated and reported to facilitate practical applications. However, an attempt has been made in this paper to comprehensively review the results as well as the phenomenological models which are described in the literatures [23,26].

# 2 II. Materials And Methods

# 3 a) Experimental Investigation

Twenty CLSM mix proportions were generated. Strength, density, settlement and flow properties were analyzed and assessed. CLSM mortar mixes using ground granulated blast furnace slag (GGBS) and powdered gypsum wall boards (PGP) as secondary cementitious material and quarry dust as fine aggregates, were termed as GG series. First, trial mixtures were produced to determine variations of water content, by measuring spread flow diameter and thereby calculate RFA values.

Table 1 gives the mixture proportions for GG series with respect to GGBS/C [Ground granulated blast furnace slag (GGBS) to cement (C)] and PGP/C [Powdered gypsum wall boards (PGP) to cement (C)] ratio variations, respectively. Water content for GG series were varied from 45% to 60% so as to get desired flow values in terms of RFA ranging from 5-15 [13], which is required for self-flowing and self-leveling consistency of the mix. For each series 80 specimens were cast i.e. 20 specimens were cast for each B/w (binder/water) ratio; five specimens each were tested at the increasing age of 3, 7, 28 and 56 days respectively. A total of 400 specimens were cast and tested for GG Series.

# 4 c) Material Properties

The materials adopted in this research are the same which are described in the literatures [23,26].

Ordinary Portland cement (C) of 53 grade was used and its physical properties were determined according to IS: 12269 [27] specifications. Initial and final setting times of cement were found to be 43 min and 218 min, respectively with a specific gravity of 3.09. Ground granulated blast furnace slag (GGBS) was used as secondary cementitious material and was procured from JSW Steel Ltd., at Toranagallu, Bellary -Hospet, Karnataka, India; having a specific gravity of 2.82. Waste gypsum wall board sheets were used as secondary cementitious material which were sourced from new construction sites and demolition sites in Bangalore, and was crushed manually. Powdered gypsum wall board passing through 4.75 mm sieve size was used with a specific gravity of 1.76. The specific surface area determined by Blaine's permeability method for cement, GGBS, powdered gypsum wall board and stone dust were 307m 2 /kg, 327m 2 /kg, 169m 2 /kg and 381m 2 /kg, respectively. Stone dust having a specific gravity of 2.46 was sourced from stone quarry waste dump site at Bidadi, Bangalore, Karnataka, India. Table 2 gives the elemental compositions of cement, powdered gypsum wall board, GGBS and quarry dust, obtained from the Scanning Electron Microscopy (SEM)-Energy Dispersive X-ray Spectroscopy (EDS). The particle size distribution of materials is illustrated in Fig. 1.

# 5 d) Engineering Properties of CLSM

The spread flow test [26,28] was conducted using an open ended cylinder of 75 mm diameter and 150 mm height, according to standard [29]. The flow diameter (D) measured in six directions was averaged and relative flow area (RFA) was calculated using the formula (D/75) 2 -1. Marsh flow test [26] was conducted using a brass cone of 10mm smooth aperture diameter, according to standard ??30]. The Marsh flow time was averaged out of three trials. Un-confined compression strength tests [26] were carried out at 3, 7, 28 and 56 days age, respectively; using a modified CBR apparatus. The results from minimum of five specimens were recorded and averaged. The density of CLSM was measured at fresh state and at the increasing ages of 3, 7, 28 and 56 days. As soon as CLSM mix was poured into the acrylic moulds of 40mm diameter and 80mm height, the weight of the mix at the fresh state was recorded. Later the weight and volume of CLSM specimen was measured at increasing ages. Finally the density was calculated by dividing the weight of specimen with the volume of the hardened cylindrical specimen. Settlement of CLSM was measured by recording the reduction in the height of hardened CLSM specimens at increasing ages of 3, 7, 28 and 56 days. The heights of the hardened CLSM specimens were measured at increasing ages. The difference in the height of CLSM specimen at fresh state and height of specimen at increasing ages gives the settlement of CLSM. For each series and with any particular water content minimum of five cylinders were measured and averaged to calculate settlement in Millimeters.

# 6 e) Analytical Investigation i. Phenomenological Model

To generate phenomenological model for flow evaluation, a RFA value at particular water content is identified as reference RFA, such that the RFA values ranged from 5-15 which is required for self-flowing and self-leveling consistency [13,22]. For GG and GF series [23,26] 55% water content is suitable water content whose RFA values are taken as reference values in the generation of flow models since the RFA values are not exceeding 15. In the development of flow model all flow values were normalized with respect to a reference flow value at w=55% (by weight). The normalized values were plotted and the trend line equation represents the flow model in terms of RFA. The validation of this model for an independent set of data is also examined. Development of Phenomenological model for strength prediction a reference value of suitable B/w ratio was identified. Normalized strength values were calculated. For GG and GF series [23,26] 1.1 is suitable B/w ratio whose strength values are taken as reference values in the generation of strength models. The linear models were obtained by plotting normalized strength values of all the selected series against B/w ratios.

Fig. ?? and 3, gives the generalized flow (at w=55%) and strength (at B/w=1.1) models based on the results of GG1, GG2, GG3 and GG5 series only. The generalized flow model for GG series is "{RFA / (RFA@w=55%)} = 0.066w -2.6". The generalized strength models for GG series at 3, 7, 28 and 56 days are "{S / (S@B/w=1.1)} = 1.93 (B/w) -0.926"; "{S / (S@B/w=1.1)} = 1.338 (B/w) -0.357"; "{S / (S@B/w=1.1)} = 1.806 (B/w) -0.839"; "{S / (S@B/w=1.1)} = 2.569 (B/w) -1.481"; respectively.

# 7 III. Results And Discussion

# 8 a) Flow and Strength

Average flow and strength results of GG series are given in Table 3, where the relative flow area (RFA) values are obtained from spread flow diameter as per equation (1). The RFA values of GF and GG series mixes ranged from 3.84 to 20.78 and 3.84 to 17.20, respectively. Almost all mixes have flow in the range of 5 -15 RFA values are required for self-leveling and flowing consistency of the mixes [22]. Increase in water contents resulted in increased flow values. Higher water demand was recorded for GF and GG series CLSM mixes due to increase in cement and quarry dust contents which have large surface areas (307m 2 /kg and 381m 2 /kg, respectively). Increase in water demand was observed for mixes with higher dosages of drywalls, GGBS and stone dust. This is due to high surface area and fine particle sizes of all the ingredients involved.

The Marsh flow time of GG and GF series mixtures ranged from 44 -72 seconds and 39 -110 seconds, respectively for water content of 60% (by weight of total mixture weight). Marsh flow time was zero seconds for all mixes with 45 -55% water contents as flow did not occur at these water contents. Increased Marsh flow time was recorded for increased F/C and PGP/C ratios (by weight) due to the increased water demand with large contents of Class F fly ash and powdered drywalls, related to their fine particle sizes shown in figures of literature [26]. Comparing the spread flow and Marsh flow values it can be see that flow time increased with decreased flow diameter for CLSM mixtures at 60% water contents, hence a high drywall content of sixty one percent by weight of binder is responsible for increased water demand when compared to other mixtures with lesser percentages of drywall contents i.e. about fifty two percent. Bleeding type of segregation was observed for all mixes with large water contents. CLSM mixes with zero Marsh flow was observed in CLSM mixes containing binder blend of cement + Class F fly ash + powdered drywalls [26]. Compared to GF series i.e. literature [26], GG series mixes have reduced Marsh flow time for higher dosages of drywalls, GGBS and stone dust. The fine particles of quarry dust with the largest specific surface area (381m 2 /kg) contributed to the increased demand of water; particle size and physical characteristics are shown in Fig. 1 and Table 2. ??—————————————— K ——— ——— ——— ——— 4.06 3.63 ——— ——— Na K ——— ——— ——— ——— ——— ———**2**——— ——— ——— ——— K K 0.93 0.51 ——— ——— ——— ———**3**

# 9 E

The unconfined compressive strength results at 3, 7, 28 and 56 days for Class F fly ash based CLSM mixtures [26] ranged from 0.13 to 0.92 MPa, 0.35 to 2.10 MPa, 0.36 to 3.49 MPa and 0.26 to 2.53 MPa, respectively. The unconfined compressive strength results at 3, 7, 28 and 56 days for GGBS based CLSM mixtures ranged from 0.98 to 2.55 MPa, 1.68 to 3.92 MPa, 2.28 to 4.92 MPa and 1.77 to 5.28 MPa, respectively. The strength values are within the prescribed limits of 8.3 MPa [31] and most of the values are less than 2.1 MPa, hence suitable for applications requiring re-excavation. In Class F fly ash based mixes [26] 21% to 43%, 40% to 97% and 95.61% to 100% of the maximum strength is obtained at 3, 7 and 28 day age, respectively. While in GG series mixes 30.22% to 48.3%, 67.34% to 95% and 93.18% to 100% of the maximum strength is obtained at 3, 7 and 28 day age, respectively. CLSM mixtures with high drywall contents resulted in high early age strength development, owing to the significant presence of calcium, given in Table 2. It was observed that the strength increased at increasing ages of 3, 7 and 28 days for all the CLSM mixes of GF and GG series. Presence of sulfates in drywalls has a detrimental effect on strength values and resulted in reduction of strength values at 56 days age. In literature [26] about seven to thirty six percent strength reduction was noted at 56 days age when compared to that of 28 days age, for Class F fly ash based mixtures. The strength values reduced after 28 days i.e. at the age of 56 days, for GGBS based CLSM mixes of higher water contents of 50%, 55% and 60%. The comparison of the microstructure for GG1 series specimen powder, as shown in Fig. **??** and 7, clearly indicates the superiority of the lower water content mixtures (w=45%) in terms of closer bonding of ingredient materials with more formations of ettringite needles which is an indication of hydration activity, whereas, disintegration of ingredient materials with lesser or no indication of ettringites is observed in all higher water content mixtures. This reduced compressive strength values is due to the presence of sulfates in drywalls [23] used (refer Table 2) and their detrimental effects on hardened CLSM specimens leading to expansive cracks [7]. Similar behaviour was observed in GF series as reported in the literature [26] for CLSM mixes produced using the binder blend of cement + Class F fly ash + powdered gypsum wall board. Decrease in strength values were not observed for GGBS based CLSM mixes having the lowest water content of 45%. Hence it may be noted that binder blend of cement + GGBS + drywalls and lesser water contents, are effective in resisting the detrimental effects of sulfates present in drywalls. About 0.5-25% reduction in strength with respect to 28 day age strength was observed at 56 day age, in case of GGBS based CLSM mixtures. Compared to literature [26], GG series mixes have high early age strength development and lesser percentages of strength reduction at 56 days age, due to the presence of sulfates in gypsum wall board. Marginal increase in strength values of GF and GG series CLSM mixes with soda ash may not be necessary for usual applications of CLSM. Strength values decreased with decrease in cement content and increase in water contents for both GG and GF series mixes. Considering increase in compressive strength values at increasing age for the mechanical evaluation on indication of pozzolanic activity, it may be observed that binder blend of drywall with Class F fly ash or GGBS resulted in pozzolanic activity with the cement hydration up to 28 days only and later reduction in cement hydration reduced pozzolanic activity and allowed sulphates present in drywall carry out detrimental effect leading to reduced strength values. In literature [7] concrete mixture made of ternary binder blend comprising of Class C fly ash, cement and drywalls was investigated. It was observed that this ternary blend had similar chemical compositions to that of another ternary binder blends comprising of Spray-dryer ash, Class C fly ash and cement; and clean coal ash, Class C fly ash and cement; which were adopted as blended cements and binder in concrete [12,16]. Microstructure, hydrated products and pozzolanic activities were also investigated [12,16]. According to literature [7] the concrete cylinders cracked and worst early age strengths were recorded due to excessive expansive reactions indicating the detrimental effects of sulfates present in drywalls. 4 and 5, respectively. The settlement values ranged from 1 to 4 mm and 1 to 2 mm, for the GF and GG series CLSM mixes, respectively [26]. Early age settlement was observed and later ages it remained same. Settlement values are high when compared to that suggested in ACI-229R [31], since subsidence i.e. water and entrapped air being released while the CLSM mix specimen tries to consolidate itself; is not deducted from the final settlement readings. GF and GG series mixtures fresh density results ranged from 1611.44 to 1830.28 kg/m 3 and 1651.23 to 1800.44 kg/m 3 , respectively [26]; which are less than and equal to the suggested range of 1840 to 2320 kg/m 3 [31] Majority of these results are within the suggested limits of 1440 to 1600 kg/m 3 for a CLSM mixture made of water, fly ash and cement [31]. Except for few mixtures high density was observed for GF3 series mixes and lower density for GF1 mixes. It was observed that in all the CLSM mixtures high density mixes did not result in high strength. The densities of GF and GG series mixes were almost in the same range and no significant difference was observed between both of these CLSM mixture combinations. It is desirable to cast and test specimens at later ages to better understand the pozzolanic activity of the binder blend (GGBS + gypsum wallboard + cement) used, and efforts should be made to find out the possible new applications of this CLSM mix and wide spread use of predictive models and different material constituents involving more waste materials [26]. The results of such studies would directly benefit the society and environment protection initiatives.

# 10 IV. Conclusions

The below mentioned conclusions can be drawn based on the experimental results: 1) CLSM mixtures containing ternary binder blend of cement, ground granulated blast furnace slag and drywalls, reported reduced compressive strength values after 28 days age. However, the reduction in strength was not observed for mixes with water content of 45%. About -0.5 to -0.25% of strength reduction was observed for mixes with water contents of 50%, 55% and 60%, respectively. However, CLSM mixtures containing ternary binder blend of cement, drywalls and Class F fly ash, resulted in reduced compressive strengths at 56 days when compared to 28 days age at all water contents. 2) Use of GGBS instead of Class F fly ash along with cement and stone dust, is recommended for production of CLSM mixes with lesser water contents to effectively overcome the detrimental effects of sulfates present in drywalls. The lesser water content required may be determined based on the self-flow and consolidation criteria of a particular application. 3) Water demand of CLSM mixtures increased due to use of drywalls, GGBS and stone dust, in large quantities. Same was reported in GF series with use of Class F fly ash. 4) Spread flow and Marsh flow time for GGBS based CLSM mixes reduced when compared to Class F fly ash based mixes and Marsh flow time was recorded only for mixes of 60% water contents as other water contents resulted in zero flow. 5) Reduced GGBS/C and PGP/C ratios increased 3 days strengths, leading to high strengths up to 28 days age. Soda ash as an activator is not necessary for the production of CLSM mixtures containing drywalls. Same was reported in GF series with use of Class F fly ash. 6) Settlement of gypsum wall board CLSM mixes was observed more during early ages similar to conventional CLSM mixes. 7) Density results of drywall CLSM mixes were similar to that of conventional CLSM mixes. 8) GG4 and GF4 mixes flow and strength results were validated against the predicted values. The predictive models can be used for engineering applications. Same was reported in GF series with use of Class F fly ash. ) Wasted drywalls re-use in CLSM will reduce pollution of atmosphere due to release of H 2 S gas at landfills. Recycle of GGBS, drywalls and stone dust, which are by-products and waste materials, will reduce the burden on landfills and hence add to sustainability achievement of industries.

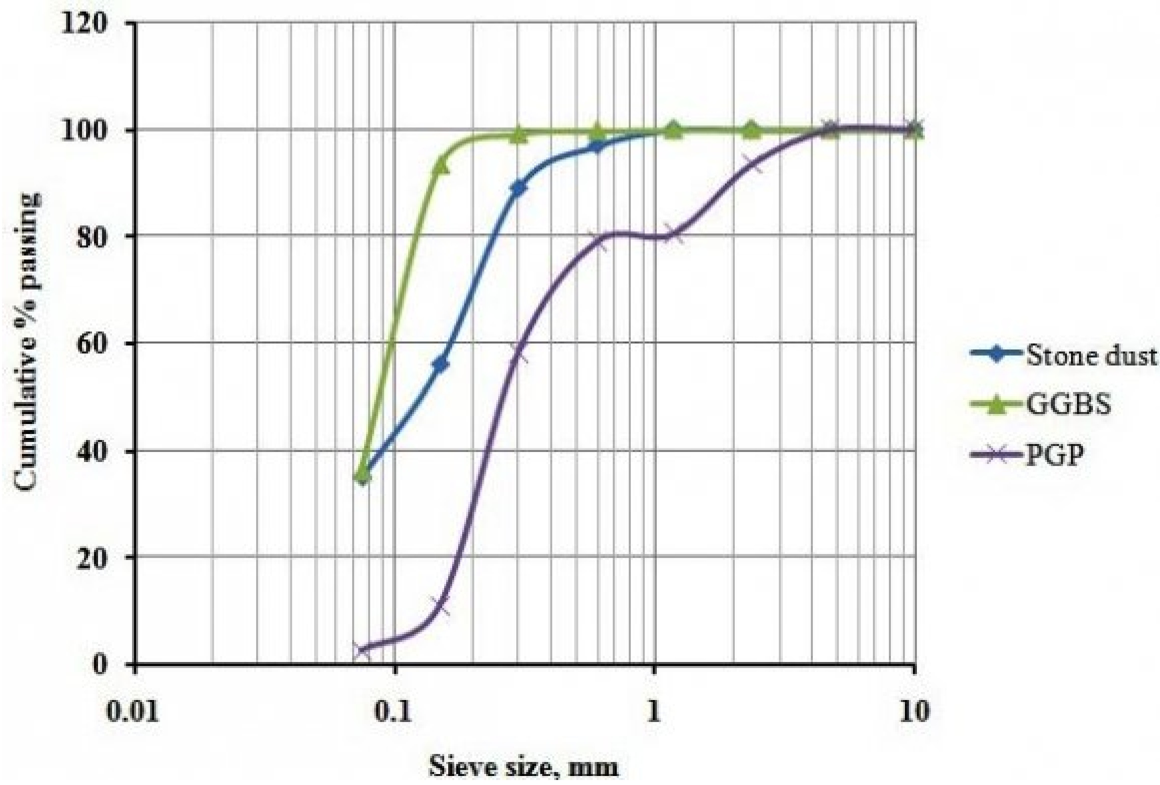


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Figure 1: Fig. 1 :

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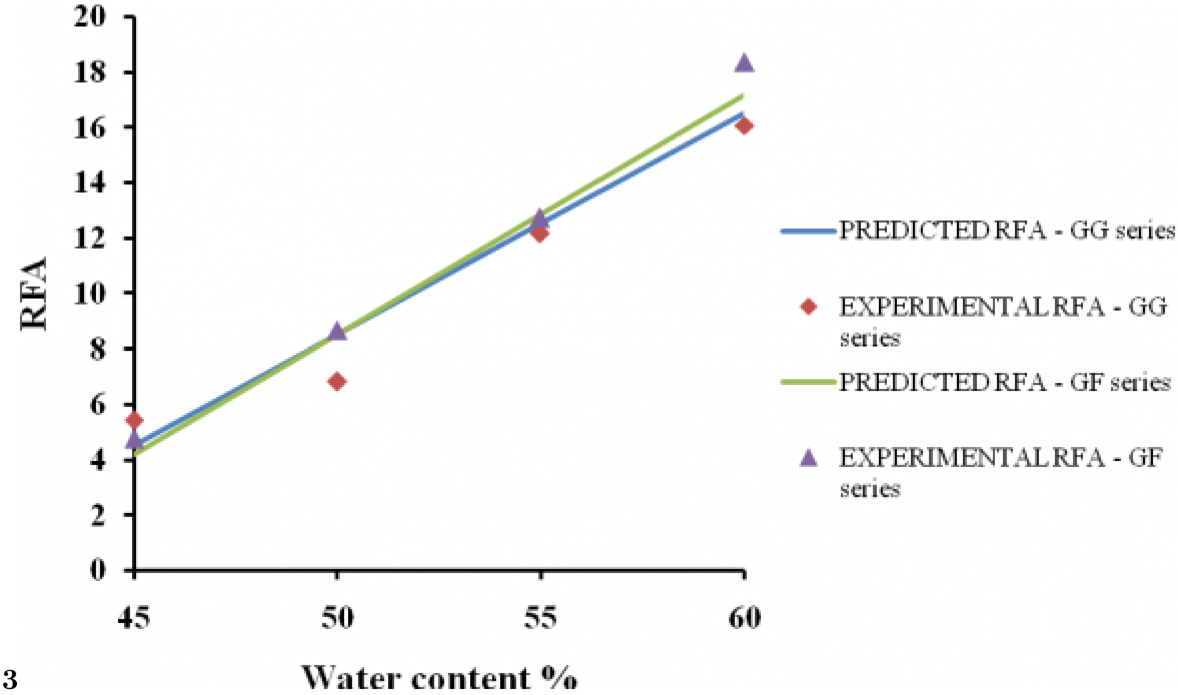


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Figure 2: Fig. 2 :Fig. 3 :

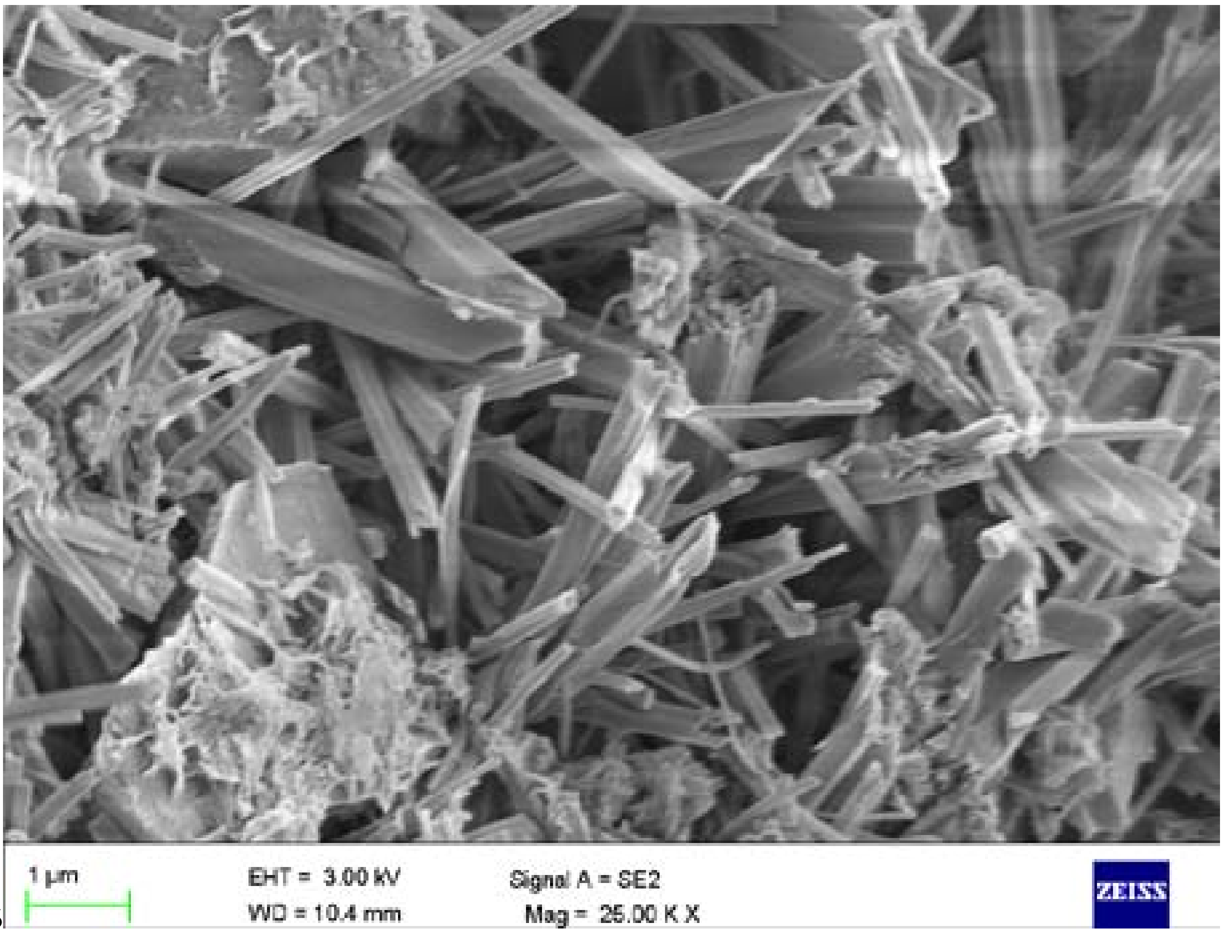


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Figure 3: Fig. 4 :Fig. 5 :

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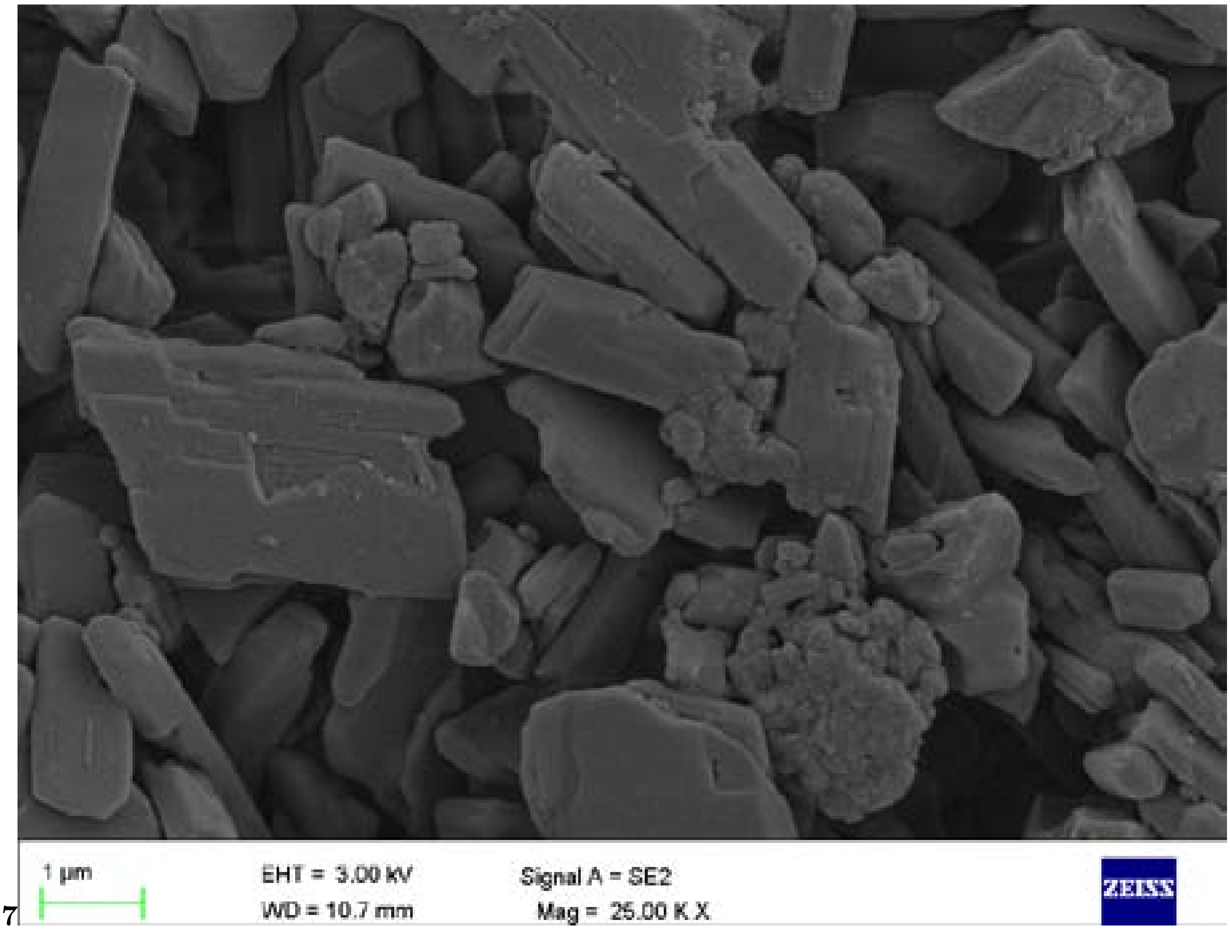


Figure 4: Fig. 6 :Fig. 7 :

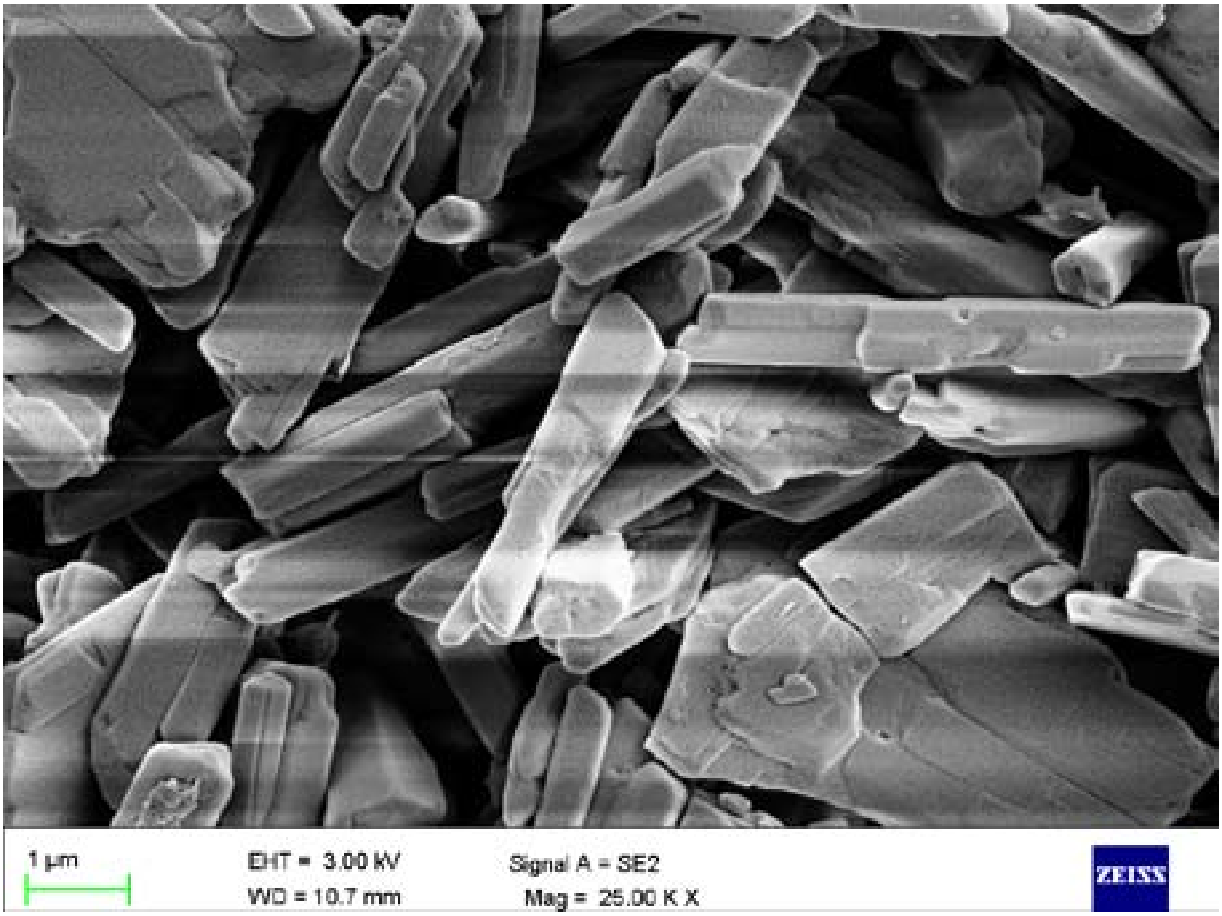


Figure 5:

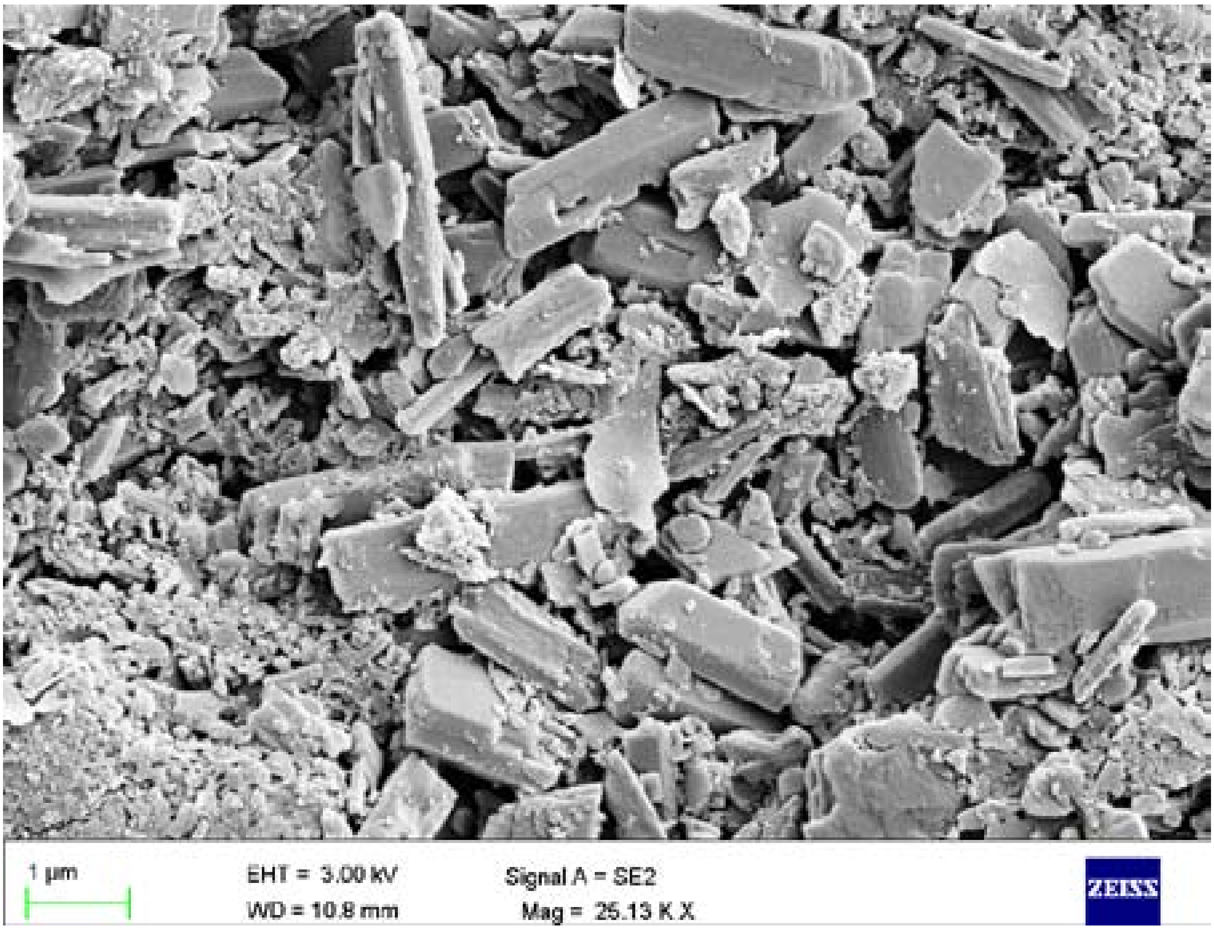


Figure 6:

**1**

| Mixture Name | GGBS/C ratio | PGP/C ratio | Cement (C), g/100g | Powdered Gypsum Wall Board (PGP), g/100g |
|---|---|---|---|---|
| GG1 | 2 | 4.67 | 6.52 | 30.43 |
| GG2 | 1.5 | 3.5 | 8.33 | 29.17 |
| GG3 | 1.2 | 2.8 | 10.00 | 28.00 |
| GG4 | 1 | 2.33 | 11.54 | 26.92 |
| GG5 | 0.86 | 2 | 12.96 | 25.93 |

Note:

b) Materials used and items of investigation

1) Binders

i. Cement (C)

ii. Ground granulated blast furnace slag (GGBS)

iii. Powdered Gypsum Wall board (PGP)

2) Fine Aggregates:

i. Quarry dust

3) Type of Curing:

i. Air cured at standard room temperature ?24ºC

*[Note: iv. Powdered gypsum wall boards to cement ratio (PGP/C): 4.67, 3.5, 2.8, 2.33 and 2 v. Water content (w %): 45%, 50%, 55% and 60% vi. Compressive strength, settlement and density tests: 3, 7, 28 and 56 days.]*

Figure 7: Table 1 :

**2**

PREDICTED 3 DAY UCS
EXPERIMENTAL 3 DAY UCS -GG4
PREDICTED 7 DAY UCS
EXPERIMENTAL 7 DAY UCS -GG4
PREDICTED 28 DAY UCS
EXPERIMENTAL 28 DAY UCS -GG4
PREDICTED 56 DAY UCS
EXPERIMENTAL 56 DAY UCS -GG4

Figure 8: Table 2 :

**3**

| Mixture Name | w, % | B/w Ratio | RFA | Experiment results | | Un-confined Compressive | | Marsh time, Sec Fl |
|---|---|---|---|---|---|---|---|---|
| GG1 | 45 | 1.1 1.0 | 3.84 | 0 0 0 72 | 1.49 | 3.32 3.09 | 4.68 | 4.93 |
| G/C=2; | 50 55 | 0.9 0.8 | 5.08 8.20 | | 1.45 | 2.73 1.68 | 4.06 | 3.03 |
| PGP/C=4.67 | 60* | | 12.44 | | 1.07 | | 3.02 | 2.33 |
| | | | | | 0.98 | | 2.28 | 1.77 |
| GG2 | 45 | 1.1 1.0 | 5.25 | 0 0 0 71 | 1.91 | 3.44 3.17 | 4.78 | 4.8 3.33 |
| G/C=1.5; | 50 55 | 0.9 0.8 | 5.76 9.24 | | 1.55 | 2.87 2.04 | 4.12 | 2.95 |
| PGP/C=3.5 | 60* | | 12.69 | | 1.11 | | 3.15 | 2.16 |
| | | | | | 1.08 | | 2.61 | |
| GG3 | 45 | 1.1 1.0 | 4.92 6.47 | 0 0 0 68 | 2.11 | 3.52 3.23 | 4.81 | 5.02 |
| G/C=1.2; | 50 55 | 0.9 0.8 | 10.56 | | 1.67 | 2.88 2.44 | 4.27 | 3.88 |
| PGP/C=2.8 | 60* | | 14.73 | | 1.21 | | 3.21 | 2.97 |
| | | | | | 1.11 | | 2.71 | 2.66 |
| GG4 | 45 | 1.1 1.0 | 5.42 6.84 | 0 0 0 61 | 2.25 | 3.65 3.37 | 4.88 | 5.1 3.93 |
| G/C=1; | 50 55 | 0.9 0.8 | 12.15 | | 1.78 | 2.95 2.55 | 4.36 | 3.03 |
| PGP/C=2.33 | 60* | | 16.08 | | 1.33 | | 3.35 | 2.75 |
| | | | | | 1.16 | | 2.76 | |
| GG5 | 45 | 1.1 1.0 | 4.76 6.47 | 0 0 0 44 | 2.55 | 3.82 3.45 | 4.92 | 5.28 |
| G/C=0.86; | 50 55 | 0.9 0.8 | 11.02 | | 1.86 | 3.05 2.67 | 4.45 3.4 | 4.07 |
| PGP/C=2 | 60* | | 17.20 | | 1.43 | | 2.81 | 3.11 |
| | | | | | 1.18 | | | 2.39 |

Note: * Bleeding was observed

Figure 9: Table 3 :

**4**

| Mixture Name | w, % | B/w Ratio | Specimen Initial Height, mm | Settlement, mm 3 Day | 7 Day | 28 Day | 56 Day |
|---|---|---|---|---|---|---|---|
| GG1 | 45 | 1.1 | 80 | 1.00 | 1.00 | 1.00 | 1.00 |
| G/C=2; | 50 | 1.0 | | 1.00 | 1.00 | 1.00 | 1.00 |
| PGP/C=4.67 | 55 60 | 0.9 0.8 | | 1.00 2.00 | 1.00 2.00 | 1.00 2.00 | 1.00 2.00 |
| GG2 | 45 | 1.1 | | 1.00 | 1.00 | 1.00 | 1.00 |
| G/C=1.5; | 50 | 1.0 | | 1.00 | 1.00 | 1.00 | 1.00 |
| PGP/C=3.5 | 55 60 | 0.9 0.8 | | 1.00 2.00 | 1.00 2.00 | 1.00 2.00 | 1.00 2.00 |
| GG3 | 45 | 1.1 | | 1.00 | 1.00 | 1.00 | 1.00 |
| G/C=1.2; | 50 | 1.0 | | 1.00 | 1.00 | 1.00 | 1.00 |
| PGP/C=2.8 | 55 60 | 0.9 0.8 | | 1.00 2.00 | 1.00 2.00 | 1.00 2.00 | 1.00 2.00 |
| GG4 | 45 | 1.1 | | 1.00 | 1.00 | 1.00 | 1.00 |
| G/C=1; | 50 | 1.0 | | 1.00 | 1.00 | 1.00 | 1.00 |
| PGP/C=2.33 | 55 60 | 0.9 0.8 | | 2.00 2.00 | 2.00 2.00 | 2.00 2.00 | 2.00 2.00 |
| GG5 | 45 | 1.1 | | 1.00 | 1.00 | 1.00 | 1.00 |
| G/C=0.86; | 50 | 1.0 | | 2.00 | 2.00 | 2.00 | 2.00 |
| PGP/C=2 | 55 60 | 0.9 0.8 | | 2.00 2.00 | 2.00 2.00 | 2.00 2.00 | 2.00 2.00 |

*[Note: Mitigation of H2S Emissions by Recycling Discarded Gypsum Wall Boards in CLSM Global Journal of Researches in Engineering ( ) Volume XVIII Issue I Version I c) Further Research]*

Figure 10: Table 4 :

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