

# Properties of Lime Mortar and FAL-G with Urea

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**Abstract:** In traditional Indian lime mortar preparation, urine is added to improve the properties. In this research instead of urine, urea (fertilizer) is tried to give a sanitarily viable alternative. Urea is added in the various viz. 1%, 2%, 3%, 4%, 5% with Lime mortar 1:3 and also Fly Ash Lime Gypsum (FAL-G) paste. The resultant composites were cast into cubes of 50 sq.cm area and tested for weight density, water absorption and compressive strength. Results were compared with plain lime mortar cubes and plain FAL-G cubes. FAL-G shows better properties with 3% urea than lime mortar.

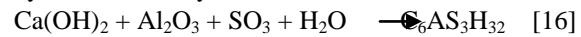
**Keywords :** Fly ash, Gypsum, Lime, mortar, urea, urine.

## I. INTRODUCTION

The ancient civilizations all over the world have used lime as binding material. Lime, is manufactured by calcining limestone, coral, oyster shells, etc. [1]. Lime based mortars are more commonly used since ancient times in the construction [2][3][4]. The initial known construction of buildings by lime dates to 4000 B.C. The lime plastering is done in pyramids of Egypt [5]. The hardening and strength gaining of the mortar is due to carbonation of the lime by carbon dioxide in the air [6]. Slow carbonation is one of the main factors in the decline in the use of lime-based mortars [7]. But Lime is the environment friendly cementitious material due to low energy consumption, lower CO<sub>2</sub> release in production and CO<sub>2</sub> assimilation by carbonation process there by creating carbon cycle thereby maintaining the CO<sub>2</sub> in atmosphere in constant percentage[8]. Another advantage of lime is that its mortars remain more flexible than cement sand mortars [9]. Lime is an extremely versatile material, used for both construction and finishing [10]. Further, lime binders are durable and allow moisture [11].

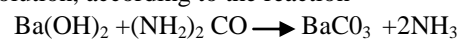
The mixture of Fly ash, lime and gypsum (FAL-G) is a patented invention of Dr N Bhanumathidas and N Kalidas [12]. It was invented by taking clue from the age old Roman Pozzolanic mixture of lime and volcanic ash. In India FAL-G mixture is widely used in manufacturing of bricks and hollow blocks. FAL-G bricks are ecofriendly alternative to burnt clay bricks [13] as this mixture uses fly ash. The fly ash generated in India is roughly 131.09 million-tonne [14]. Fly ash has more than 60% of silica, hence acts as a Pozzolanic material. Lime acts as binder individually and also along with Pozzolanic materials. Gypsum enhances the setting in lime-pozzolana binders while it retards setting of ordinary

Portland cement [15]. FAL-G is a calcium sulpho aluminate hydrate formed by reaction as follows:



Several admixtures were added to lime, lime mortar and lime concrete to improve various properties. Some of them are blood, egg whites, sugar, honey, ashes, and urine [17]. The admixture of animal urine or dung lessens shrinkage, improves hardness and good permeability. The main disadvantage is the ammonia smell during mixing [18]. Urine mainly acts as aerating agent.[19] Urine also improves dispersion of fines during mixing, reduces shrinkage, promotes drying and increases hardness. [20]. Human urine contains urea 9.3 g/l to 23.3 g/l.[21]. Hence the percentage is 1 to 2.3. Thus fertilizer urea was added to lime and FAL-G from 1 to 5% in this research.

Urea is used in restoration of ancient structures along with barium hydroxide [22]. The urea produces a slow, controlled precipitation of barium carbonate from the homogeneous solution, according to the reaction



The slow growth of carbonate crystals from the homogeneous solution results in a particularly well crystallized cohesive structure [23]. Barium Hydroxide and urea acts as accelerators in lime mortar [20].

Lewin and Baer (1974), suggests the use of a hot barium hydroxide solution containing 10% urea in water [23].

Kim Van Tittelboom used urea with bacteria to repair concrete cracks.[24]

## II. TEST PROCEDURE

### A. Properties of Ingredient materials

The fly ash belongs to ASTM class F, procured from Tuticorin Thermal power plant. Specific gravity of fly ash was 1.8, Fineness modulus of fly ash 1.62. Lime was procured from local retailer. The water used has total dissolved solids of water was 56 ppm, pH was 7 and chloride 35ppm. The river sand was used in lime mortar with specific gravity of 2.78. with a single size passing through 4.75mm sieve and retained in 2.4mm sieve.

### B. Research methodology

Lime mortar is prepared in the ratio of 1:3 with 5% of gypsum by weight of lime. FAL-G paste is prepared with lime 30%, fly ash 65% and gypsum 5%. Urea is added in the various percentages viz. 1%, 2%, 3%, 4%, 5% with Lime mortar 1:3 and also Fly Ash Lime Gypsum (FAL-G) paste. The percentage of urea is by weight of lime. All the cubes were cured by sprinkling water and covering by wet cloth for 21 days. Then tests were conducted on them.

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III. TEST RESULTS

Table- I: Weight comparison

| Type  | LM 1:3 in gms | FAL-G in gms |
|-------|---------------|--------------|
| PLAIN | 681.66        | 465          |
| 1%    | 701.66        | 466.66       |
| 2%    | 711.66        | 463.33       |
| 3%    | 710           | 470          |
| 4%    | 700           | 431.66       |
| 5%    | 663.33        | 458.33       |

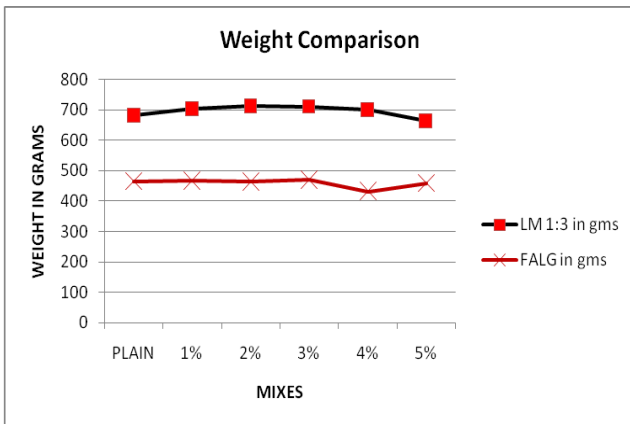


Fig. 1. Weight comparison

Table- II: Water absorption percentage Comparison

| Type  | LM 1:3 % | FAL-G % |
|-------|----------|---------|
| PLAIN | 7.10     | 19.33   |
| 1%    | 7.63     | 20.79   |
| 2%    | 6.06     | 21.93   |
| 3%    | 5.83     | 22.7    |
| 4%    | 5.2      | 21.63   |
| 5%    | 6.26     | 21.81   |

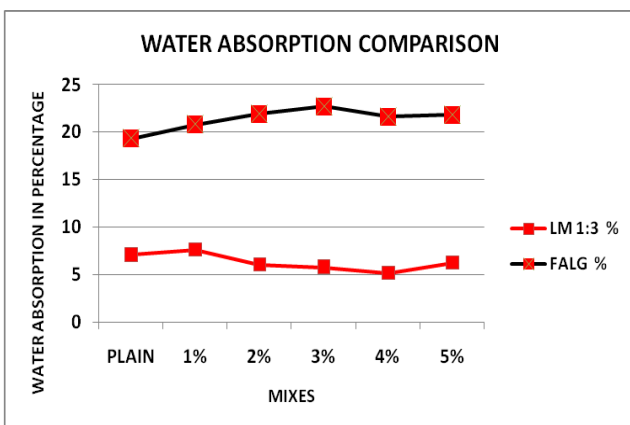


Fig. 2. Water absorption comparison

Table- III: Compressive strength Comparison

| TYPE  | LM 1:3 N/mm2 | FALG N/mm2 |
|-------|--------------|------------|
| PLAIN | 0.468        | 1.29       |
| 1%    | 0.366        | 1.467      |
| 2%    | 0.682        | 1.73       |
| 3%    | 0.718        | 2.39       |

|    |       |       |
|----|-------|-------|
| 4% | 0.634 | 1.04  |
| 5% | 0.250 | 0.944 |

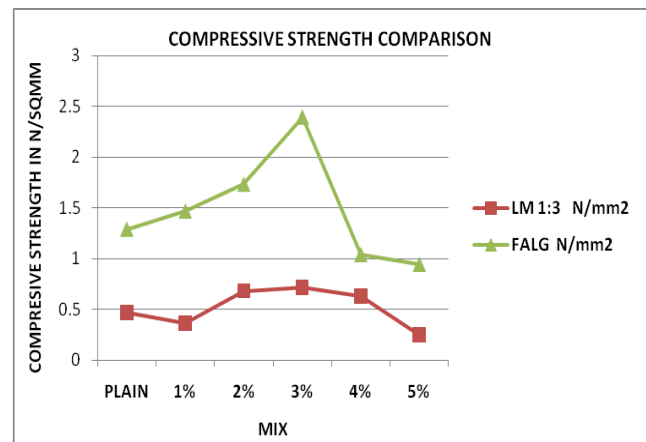


Fig. 2. Compressive strength comparison

IV. RESULT AND DISCUSSION

Following are the salient observations from the test results:

- 1) In weight comparison it is evident that FAL-G paste has lower density than lime mortar because fine aggregate i.e. sand is absent. The weight doesn't vary significantly for various percentages of urea in both lime mortar and FAL-G.
- 2) FAL-G shows much higher water absorption percentage around 20 to 25%, while lime mortar shows water absorption within 8%. The water absorption of FAL-G goes on increasing upto 3% of urea then stabilizes around 22% of water absorption. While Lime mortar shows downward trend in water absorption with increase in percentage of urea.
- 3) The compressive strength of lime mortar is much lesser than FAL-G. Both lime and FAL-G show an upward trend in compressive strength with increase in urea upto 3% of urea then strength declines. The upward trend is moderate in lime mortar but steep increase in FAL-G.

V. CONCLUSION

Urea can be used upto 3% by weight of lime in both lime mortar and FAL-G. Urea increases the compressive strength of FAL-G steeply than for lime mortar. Hence urea is more compatible with FAL-G than lime mortar.

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**Mr. T. Raghunathan**, completed B.E. Civil Engineering from Coimbatore Institute of Technology and M.E. Structural Engineering in Anna University, has 9 publications in journals mainly on Dyeing industry sludge, geopolymer, lime with rice gruel, accelerated Carbonation of lime mortar, etc. Received Best Teacher award

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