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Effect of Pollutants on Strength of Burnt Clay Bricks

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Abstract: *This paper presents the influence of the aggressive environment on the durability of the burnt clay bricks in general and the effect of the salts on the strength in particular, which may be due to the salt crystallization produced by changes in its microstructure when the bricks are subjected to polluted environments like sulfates and chlorides which causes the crumbling of the bricks. The specimens were exposed to either full immersion or spraying in the solutions containing sodium chloride and magnesium sulfates and then the compressive strength were determined at the interval of 7 days. There is a deterioration of the bricks and reduction in strength of specimens subjected to polluted environment.*

Keywords: *Fired clay bricks, magnesium sulfate, sodium chloride, compressive strength, partial immersion, spraying.*

I. Introduction

Brick is one of the oldest manufactured building materials in the world. Bricks are produced in various numerous classes, types, materials and sizes which may vary with region and time period and are produced in bulk quantities. Brick is durable construction material and its durability depends on the condition in which it has been subjected. The main raw material for bricks is Clay. Clays used for brick making vary broadly in their composition and are dependent on the locality from which the soil originates. Different proportions of clays are composed mainly of silica, alumina, lime, iron, manganese, sulfur and phosphates. Clay bricks are very durable, fire resistant, and require very little maintenance. The principal properties of bricks that make them superior building units are their strength, fire resistance, durability, beauty and satisfactory bond and performance with mortar (Lynch, 1994; Hendry and Khalaf, 2001). The durability of the brick masonry unit is affected by the adverse effect of the dissolved salts present in the soil around the masonry unit which enters into the masonry with the help of moisture and in some cases through the ineffective DPC. According to Wan Ibrahim (M. H et al.2012) salt attack is a process that needs a combination of permeable masonry, moisture, soluble salt, and evaporation. It is one of the physical phenomena that is strictly controlled and prevented to make the material more durable. This phenomenon can cause the decay and deterioration of masonry material i.e., efflorescence, scaling, cracking, crumbling, and softening. Decay and deterioration occur when evaporation process takes place underneath the surface, leaving the salts to grow as crystals in the masonry pores. In addition, the growth pressure of developing crystals is sufficient to deteriorate masonry materials. The ability to resist salt attacks is one of the main considerations because salt attacks cause damage to masonry materials in sub-tropical and tropical climates (Philips and Zsembery, 1982). In practice, sodium sulfate and sodium chloride cause most cases of salt attacks (Zsembery, 2001). Sodium sulfate is normally present in many bricks and stones, in Portland cements, and in some groundwater. They are formed from sulfur dioxide and sulfurous acid in the atmosphere (Jordan, 2001). Chloride comes from the air near the sea through the mixture of water and groundwater. Salts in the masonry wall are either present in the masonry at the time of building or absorbed from the atmosphere or groundwater during the life of the building. The attack of sulfate and chloride ions should be considered as serious cases to the country because this situation clearly could cause damage or deterioration of building material when the brickwork material exposed to the surrounding environment for certain periods. They could affect the brickwork in terms of performance such as strength. This property is required by the designers of masonry structures. Any form of change in masonry material may affect the overall structure performance of masonry wall.

The main aim of this research work is to evaluate the effect of sulfate and chloride ions on the strength of fired clay bricks for which the samples are being selected in the region around Mysore, which are subjected to chloride and sulfate medium of controlled concentration (chloride ion concentration being 5%, 10% and 15% and for sulfate 1% and 2% by weight) either for full immersion or for spraying.

II. Literature review

Abu Bakar *et al* investigated the durability of fired clay brick masonry wall due to salt attack. Durability of brick normally affected when an external masonry walls are exposed to aggressive environment. Masonry structures, when subjected to salt attack or exposed to aggressive environment during their service life may suffer degradation due to the formation of crystallization pressure as a result of the evaporation of soluble salt in clay masonry structures. The crystallization pressures produce normally higher than tensile stress of clay brick and sufficient to damage the masonry structures. In selection of fired clay brick as a building material, the durability properties are very important and should be evaluated to ensure the integrity and service life of building materials. It is no doubt that soluble salt which is transported by the moisture from natural condition or environment could cause deterioration or decay on the performance of masonry walls. The common soluble salts found in brickwork are sodium sulphate and sodium chloride which carried from different source by moisture. They concluded that the decay is caused by the crystallization of salt in the pores structures of brick units which may generate the pressure that sufficient to rupture the material microstructure. He stated that the all main factors affecting the salt attack must be present in order the decay to occur and if any one factor is removed or incomplete the decay can be prevented. The sulphate attack will cause the formation of ettringite on cement based material when react with tri-calcium aluminate. This salt is very damaging and provides more extreme condition than chloride, but it is become ineffective due to the presence of chloride in the same process. Chloride could delay the sulphate attack and strictly reducing any decay or deterioration due to sulphate.

III. Methodology

In order to accomplish the aforesaid objectives, the investigation is divided into three major parts. They are:

1. Collection Materials
2. Preparation of solution
3. Testing methods

1. Collection Materials

Locally available materials i.e. clay bricks were collected in Mysuru. The Sodium chloride and Magnesium sulfate were prepared in the laboratory. Material collection is the basic and important phase in any project. Yet, the material that is used in a project should not cause any damage to the environment.

BRICKS

In this study, brick is the main constituent material. Bricks are the widely used construction material in Mysuru locality and therefore well burnt clay bricks were collected.

SODIUM CHLORIDE

Non iodized powdered salt is used which is collected from the laboratory.

MAGANESIUM SULFATE

The sulfate is another solution used in the present work in making 1% and 2% concentrated solution for immersed condition and also for spraying. The sulfate is obtained from laboratory.

Preparation of solution

1. Depending on size of the tray quantity of water required to fully immerse a specific number of brick samples is determined.
2. For the obtained quantity of water salt is weighed (i.e. sodium chloride and magnesium sulfate) to prepare 5%, 10% and 15% chloride solutions.
3. Similarly 1% and 2% sulfate solutions is prepared in separate trays.

Testing of bricks

Exposure condition

The specimens were exposed to sodium chloride (5%, 10% and 15% concentrations) and magnesium sulfate (1% and 2% concentrations) for full immersion in the solutions prepared and also spraying the prepared solutions by dissolving the salts on the surfaces of the bricks daily. For every 7 days 3 samples were taken out from the both full immersion condition and spraying conditions and then the compression test is conducted on the taken out samples after allowing them to dry for 24 hours at room temperature. Before doing the compression test the frogs and other uneven surfaces of the bricks are to be filled with the 1:3 cement mortars and then curing is done for 3 days. After curing for 3 days the compression test is done on the completely dried samples. As per the IS 3495(Part 1): 1992 the compression tests on the normal bricks and bricks exposed to pollutants are carried out to find the compressive strength.

IV. Results and discussion

Fig.1 shows compressive strength at failure of fully immersed bricks in chloride solution over a span of 10 weeks. It was observed that the highest reduction in compressive strength was seen in brick samples immersed in 15% solution followed by brick samples immersed in 10% solution and lastly by brick samples immersed in 5% solution. This is because more chloride ions present in the 15% solution were able to enter the pores present in the brick structure.

The reduction of compressive strengths of bricks in full immersion of chloride solution for 5%, 10%and 15% concentrations is around 50%, 55% and 60% respectively.

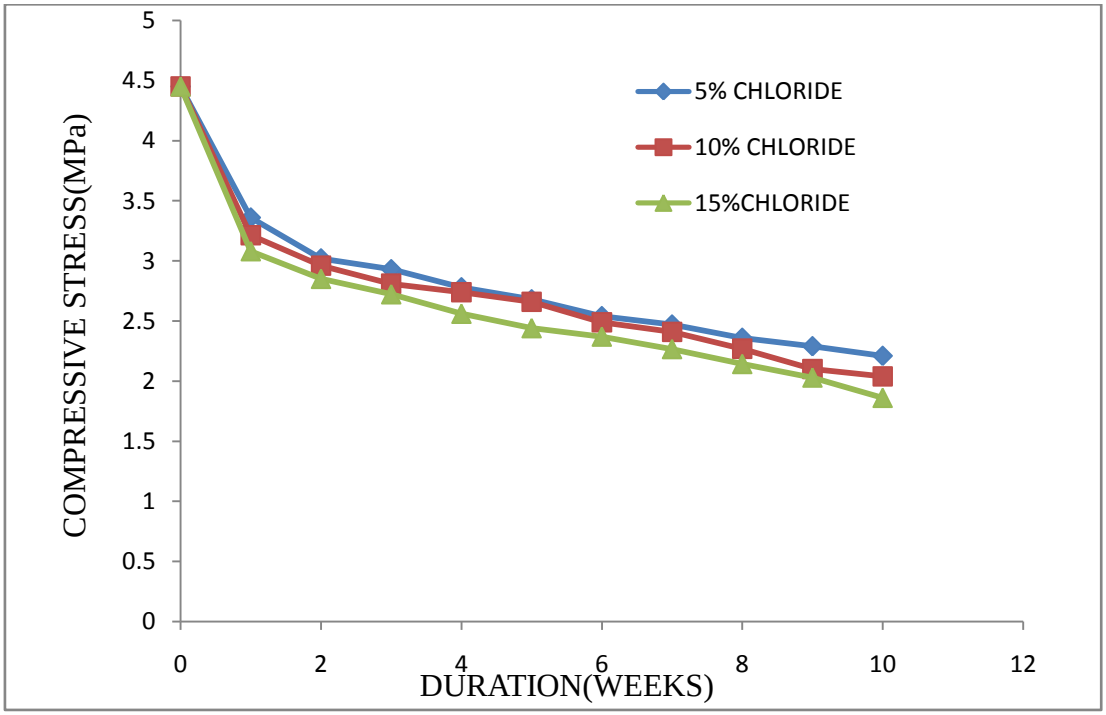

Fig.1 Comparison between compressive strength of bricks in full immersion of Chloride solution

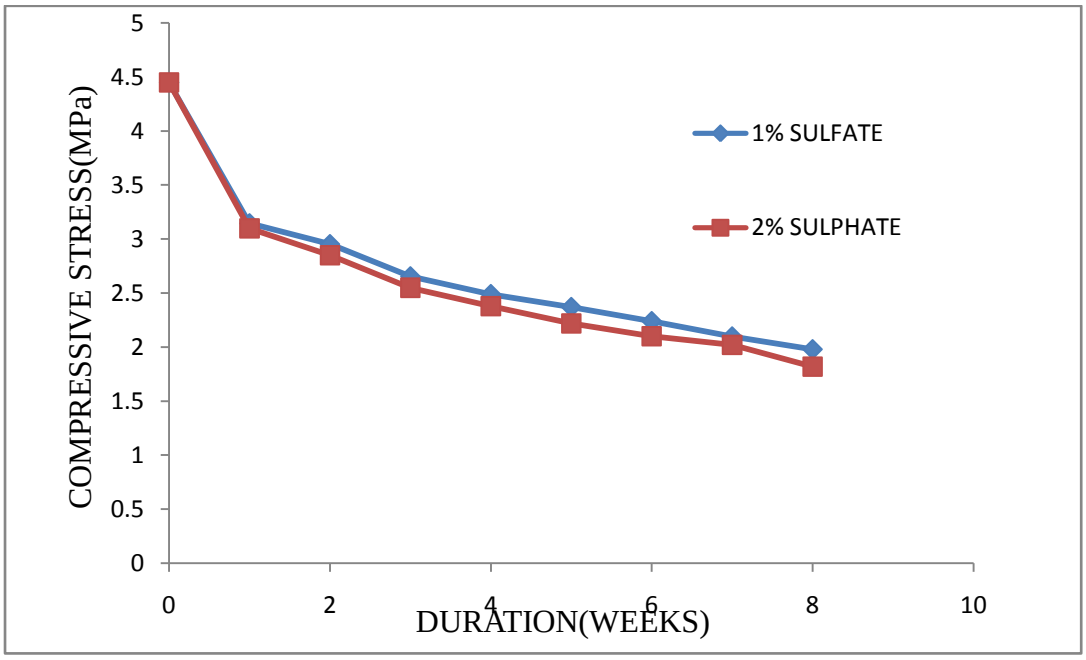

Fig.2 Comparison between compressive strength of bricks in full immersion of Sulfate solution

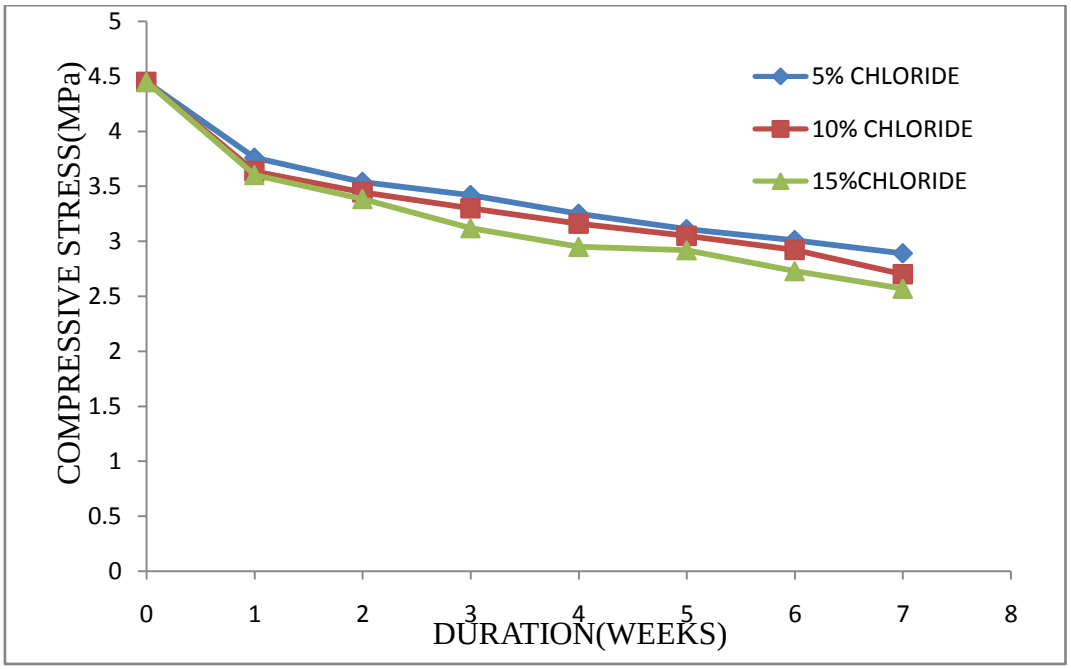

Fig.3 Comparison between compressive strength of bricks sprayed with chloride solution.

The variation of strength for 1% and 2% sulfate solutions are shown in fig.2. Fig.3 shows compressive strength at failure of bricks sprayed with chloride solution over a span of 7 weeks. It was observed that the highest reduction in compressive strength was seen in brick samples sprayed with 15% solution followed by samples sprayed with 10% solution and 5% solution. For full immersion of bricks in 1% and 2% concentrations sulfate solution the reductions are 55% and 60% respectively as shown in fig 2.
Fig.3 shows the reduction of compressive strengths of the brick sample which were sprayed with chloride solution for 5%, 10%and 15% concentrations is around 36%, 40% and 42% respectively.

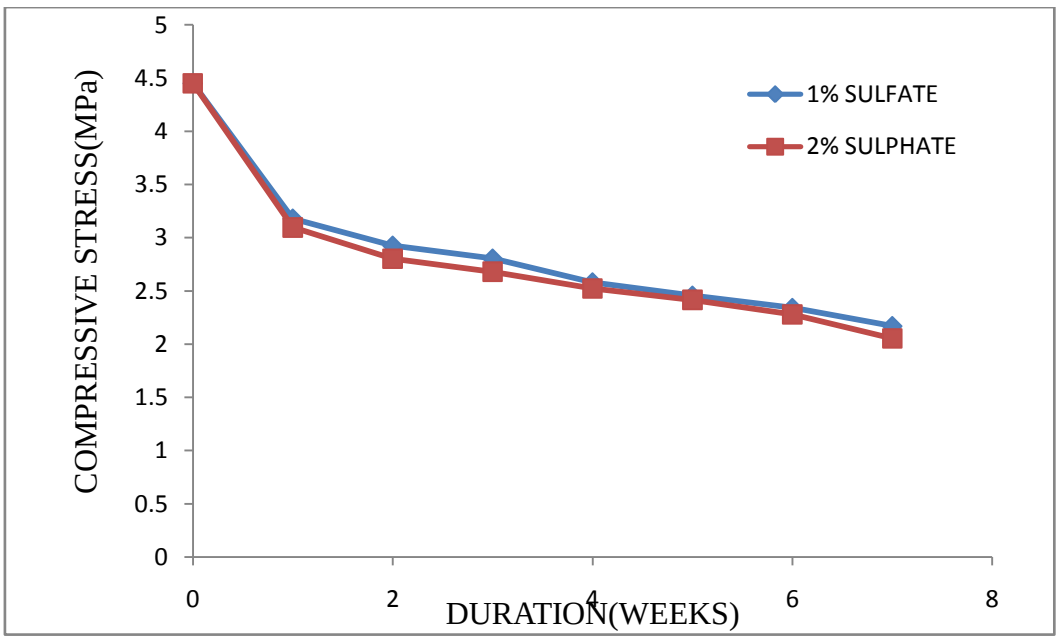

Fig.4 Comparison between compressive strength of bricks sprayed with Sulfate solution.

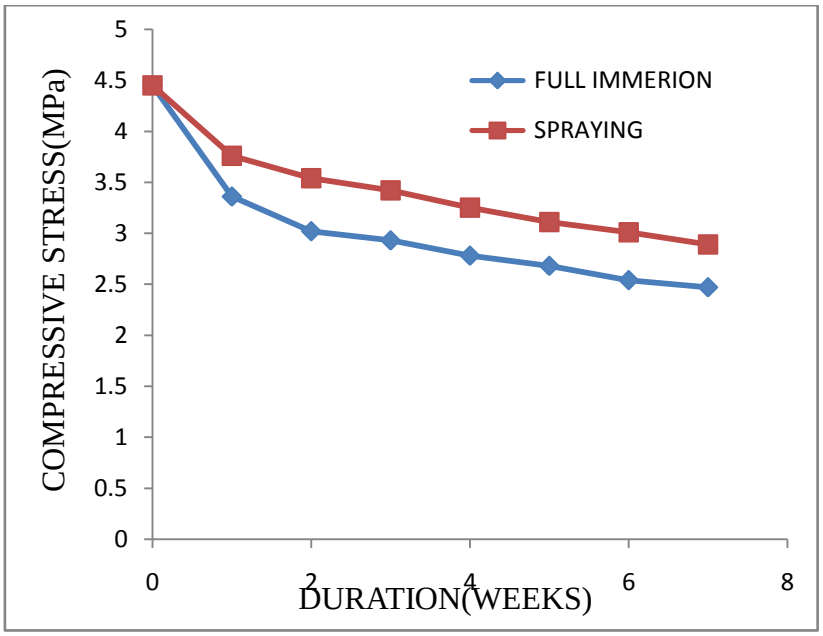

Fig.5 Comparison between full immersion and spraying test with 5% Chloride solution

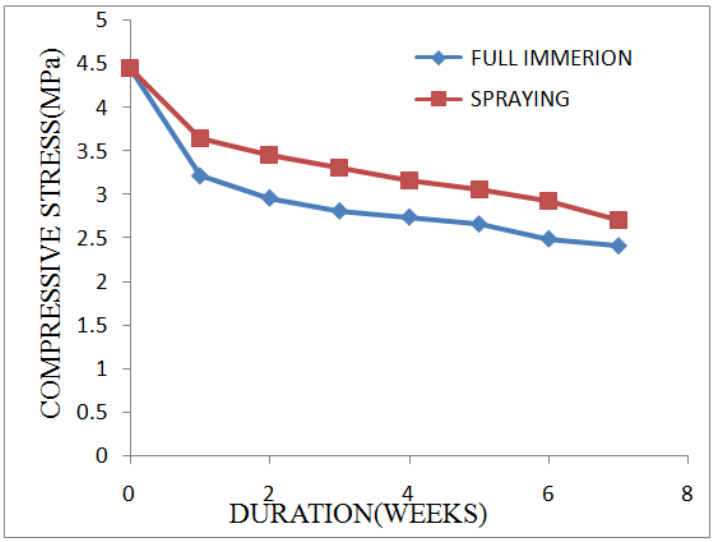

Fig.6 Comparison between full immersion and spraying test with 10% Chloride solution

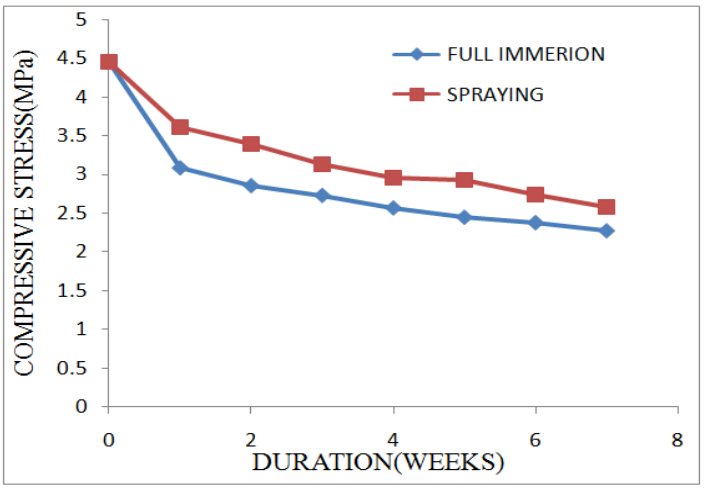

Fig.7 Comparison between full immersion and spraying test with 15% Chloride solution

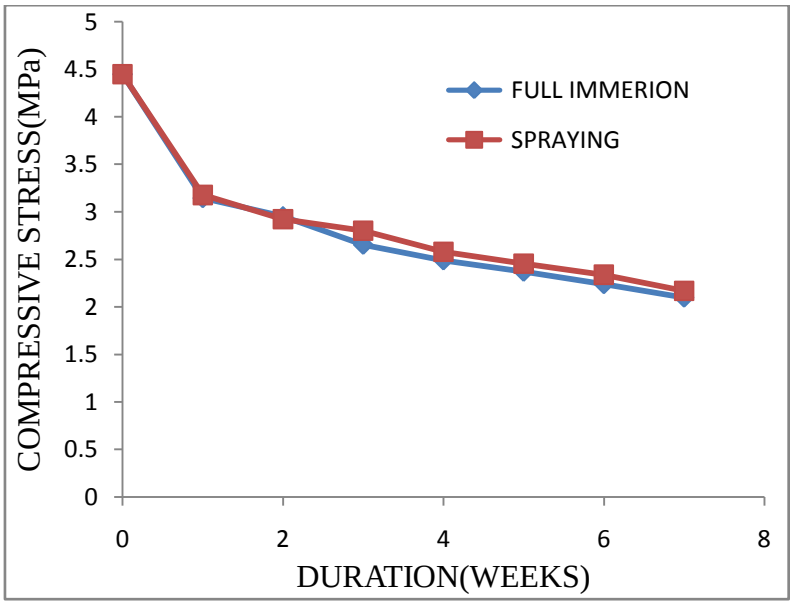

Fig.8 Comparison between full immersion and spraying test with 1% Sulfate solution

The comparison of compressive strength at failure of brick samples in full immersion in various concentrations of chloride and sulfate solutions and spraying with various concentrations of chloride and sulfate solutions are presented in figures Fig.5 to Fig.9. It has been observed that in 5%, 10% and 15% of chloride solution and 1% and 2% of sulfate solutions, the reduction in compressive strength of sprayed bricks is lower than in case of full immersed bricks. This is because the solution is only sprayed on surface of brick as opposed to complete immersion in case of full immersion.
Also, the bricks underwent a higher strength reduction in sulfate medium than in chloride medium.

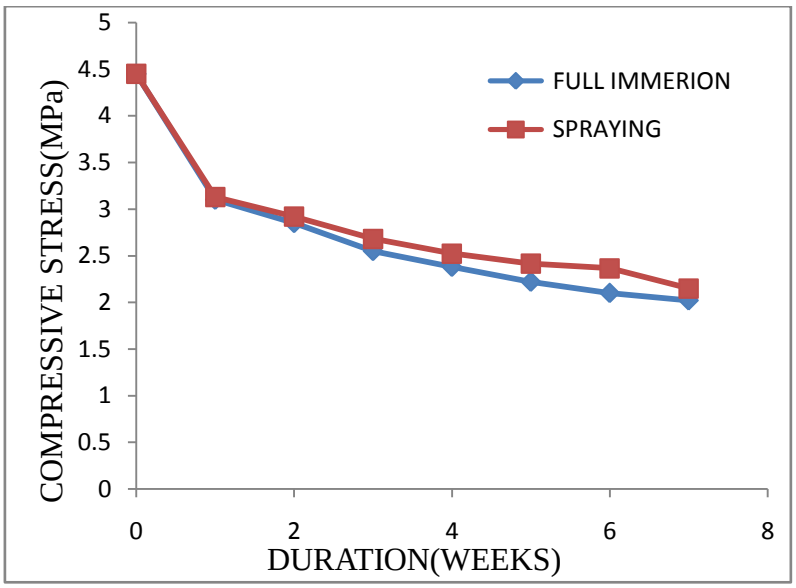

Fig.9 Comparison between full immersion and spraying test with 2% Sulfate solution

V. Conclusions

The following conclusions are made from the studies conducted

- The inherent randomness in water absorption of bricks from a single source is not much.
- The pollutants enter into the brick structure through the water which may seep in due to defective plastering or defective damp proof course leading to reduction of compressive strength.
- The reduction in compressive strength may be attributed to salt crystallization inside the brick structure.

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