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# Feasibility and Application of Sulfur In Concrete Structures

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***Abstract* --The availability of sulfur has considerably grown in many countries. This is mainly due to the petroleum and gas refining processes. Sulfur concrete has a relatively simple composition and manufacturing technique, extremely high corrosion resistance, mechanical strength and fast hardening. These make it a high performance material suitable for several applications, especially in which other materials fail. Production of one ton of cement produces one ton of carbon di-oxide. Thus an alternative concrete has to be created to reduce the global warming. Hence, an innovative proposal in concrete is introduced in which sulfur is used a binding material. The performance of sulfur as in sulfur concrete is excellent as per the literature reviews .This paper compares the properties of sulfur concrete with those of conventional concrete and discusses possible advantages and disadvantages of this new material. Some possible areas of application are also indicated..**

***Key words :refining. sulfur concrete***

## I. INTRODUCTION

Sulfur in its normal crystalline form is a pale-yellow element. Because of its properties sulfur has been considered as a possible cementing agent for different aggregates since the turn of the century. Proposed uses have ranged from pipe to industrial tanks and roofing as well as pavements,, coatings, and jointing or grouting compounds. The literature says that the sulfur was suitable for roofing conduits, pavements, ornamental figures, and the coating of steel ship hulls to prevent barnacle growth. The literature says that sulfur-aggregate compositions have potential use for construction and repair of acid tanks, flooring, and corrosion resistant pipe.

## II. SULFUR CONCRETE

One of the uses for sulfur which is again being considered is as the cementing agent in concrete instead of Portland cement. Recent reports and papers have considered the properties and potential applications for sulfur concrete. Members of the Department of Civil Engineering at the University of Calgary are actively engaged in studies which, it is hoped, will help to resolve some of the present uncertainties which impede use of this material.

It is useful to compare a new material such as sulfur concrete with a traditional construction material such as Portland cement concrete. Sulfur may be combined with fine and coarse aggregates to produce a concrete with strength of 6000 to 7000 psi. The volumes of cementing material and filler material are roughly the same. The cost of the materials for producing sulfur concrete may be expected to exceed Portland cement concrete in areas with high sulfur costs. However, even with a small cost differential, sulfur concrete warrants consideration where its special properties may be advantageous compared to Portland cement concrete.

## III. MANUFACTURE AND PROPERTIES

The main objective of this research was to develop a sulfur concrete with simple and clear formulation, using unmodified sulfur, and having adequate physical, mechanical and environmental properties for its utilization; this would prove, in addition, the feasibility of sulfur concrete manufacture using, as the binder, sulfur obtained as a by-product of petroleum refining process. Other interests were to understand the physico-chemical behavior of sulfur concrete analyzing its structure at micro-scale and to propose several applications for this material, especially those where it could offer a great potential or amplify the current range of uses.

The will to obtain a material that could be manufactured with locally available technology lead to the decision of using only unmodified sulfur, a fact that would also establish a basis of knowledge for future investigations on modified one. In order to control sulfur crystallization without chemical modification, a physical approach was taken: by the use of filler and well graded aggregate, the intention was to create a dense network of nucleation points. In this way, sulfur crystal growth would not be uncontrolled and a compact structure with small crystals would be obtained, in which the adverse effects mentioned before would not be significant enough to cause severe problems.

## IV. CHARACTERISTICS OF SULFUR CONCRETE

*Corrosion resistance*

The most common application of Sulfur concrete has been in corrosive industrial facilities. It is very resistant to attack by many aggressive environments such as acids and salts. Sulfur concrete is particularly advantageous in corrosive environments where the use of equipments, tools

or ambient conditions may damage the outer surface. It has the advantage of providing corrosion resistance in a structure that is not reliant on the integrity of a coating or membrane.

*Strength properties:*

Sulfur concrete can be designed to a wide range of strength characteristics. Typically, it has greater strength properties than Portland cement concrete. This includes abrasion resistance, compressive, tensile and flexural strength.

*Impermeability:*

Sulfur concrete contains no water in the mixing process, producing no connected pore structure. Thus, it has very low permeability and excellent freeze-thaw durability.

**Setting:**

Sulfur concrete sets and obtains strength as a result of the solidification (cooling) of sulfur. The actual reaction taking place here is the conversion of molten sulfur from monoclinic form to orthorhombic form. No chemical reaction is involved in this process.

*Mix Proportion*

There is no Standard Specification or Indian standard was not available for the mixing of the sulfur concrete the mix ratio was taken on the basis of trial and error mix ratio. The mixes are taken by studying various literatures and the results given in the literatures. The trail mix was done from 1:1 to 1:2 we have casted trail mixes for each 1:1 to 1:2. Here, the percentage of sulfur was calculated in powder form and not in molten stage. The fly ash is taken from Tuticorin.

| Silica | Alumina | Iron oxide | Ca O | Mg O |
|---|---|---|---|---|
| 65.43 | 20.67 | 6.18 | 1.26 | 0.82 |

**COMPRESSIVE STRENGTH REULTS(In N/mm$^2$)**

| Sample | 1:1 | 1:1.1 | 1:1.2 | 1:1.3 | 1:1.4 | 1:1.5 | 1:1.6 | 1:1.7 | 1:1.8 | 1:1.9 | 1:2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0%sand** | 20.58 | 21.35 | 21.49 | 22.56 | 23.78 | 24.87 | 26.02 | 26.87 | 26.89 | 29 | 32.54 |
| **25% sand** | 32.58 | 32.79 | 32.98 | 33.58 | 34.63 | 34.98 | 36.83 | 36.85 | 36.85 | 36.95 | 37.02 |
| **50 % sand** | 39.58 | 39.58 | 39.59 | 40.35 | 40.96 | 41.36 | 41.96 | 41.85 | 41.36 | 41.34 | 42.05 |
| **75%sand** | 47.56 | 47.98 | 48.36 | 48.96 | 49.36 | 52.56 | 54.36 | 54.98 | 57.36 | 52.58 | 51.03 |
| **100%sand** | 59.36 | 62.58 | 67.36 | 68.69 | 68.96 | 72.36 | 76.86 | 79.36 | 81.36 | 82.69 | 84.28 |
| **OPC** | 10.92 | 11.38 | 11.95 | 12.35 | 12.46 | 12.98 | 13.45 | 14.35 | 14.38 | 15 | 17.5 |



## V. APPLICATIONS OF SULFUR CONCRETE

*Precast elements*

Some of the precast elements that could be manufactured are elements related to road works (barriers, sidewalks, pedestals, etc.), tiles and setts for interior and exterior pavements, bricks for simple exterior structures, elements for sewer and drainage installations (sewer pipes, manholes), elements in marine environment, for shoreline protection or dock basements, railway and tramway sleepers, or electrolytic cells.

*Pavements and coatings*

The classical application of sulfur concrete has been, because of its extremely high chemical and abrasion resistance, the construction of pavements and coatings in corrosive industrial environments. This one can still be one of the main applications for this material, although taking into account that the areas in which these sulfur concrete pavements can be designed for can be diversified.

Some examples of the application of sulfur concrete in pavements and coatings are: chemical plants floors, especially for acidic environments, floors for food processing plants, roads and airport runways, paving in low temperature areas, coating of foundations, coating of elements in marine environment.

It must be pointed out that the previous experiences in this kind of applications, especially in the construction of corrosion resistance pavements, have been highly successful. The prolonged durability shown by sulfur concrete, keeping its properties during long periods of time, makes it one of the most promising applications field for this material

*Repairs*

One of the most interesting properties of sulfur concrete is the little time it takes to harden and attain a high percentage of its maximum strength. This characteristic propitiates a kind of application in which it can offer great advantages: repairing. Some examples may be the repairing of rigid (concrete) pavements and urgent repairs in big industries.Some repair experiences with sulfur concrete have taken place in the copper mining industry in Chile, specifically in the channels that evacuate constantly the highly abrasive liquid that comes from the mining process. Sulfur concrete has allowed not having to close the channel as much time as if the repair work had been made with conventional concrete.

This implies, obviously, a great economical advantage, because it minimizes the influence of repairs in the production, and it is especially important for big size industries, like the Chilean example

*Lunar Construction*

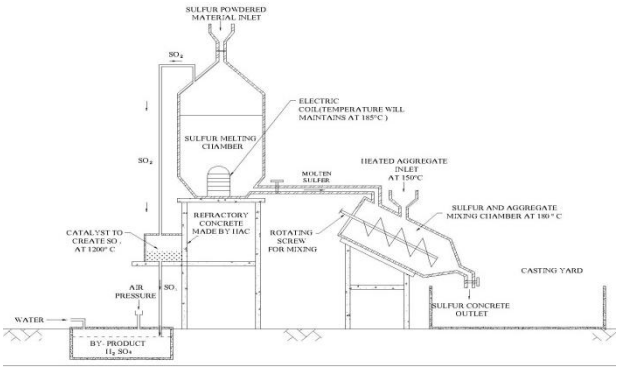
With the quantity, even the very existence of lunar water remaining unknown, alternatives to hydraulic concrete are needed. An alternative material able to bind the lunar soil aggregate and subsequently gain strength upon cooling is sulfur. Sulfur ranks eleventh in weight abundance among the elements in average lunar mare rocks,. Sulfur is found on the moon most commonly in troilitesoil(FeSVaniman et al. 1992).

Lunar regolith, particularly mare basalt, contains approximately 0.2% sulfur. Though this may not seem like a significant amount, the sulfur is found in conjunction with many other useful elements in the lunar regolith. Water and oxygen, along with others, are by-products of sulfur production on the moon. Oxygen and water are necessary for sustaining life, and sulfur is a product of their production. It is believed that any habitat or structure built on the moon will be a composite structure: Concrete with fiber reinforcement. Glass fiber can be produced from the lunar regolith and can be used as a reinforcing element for the brittle sulfur concrete.

*Mitigation effects*

The quick setting property of sulfur concrete can be employed in mitigation and rehabilitation works. The application of sulfur concrete in damage-prone areas can lead to quick recovery of working condition of structure without much delay.

This Sulfur concrete Production plant has been designed as per the difficulties faced during Casting of




specimens

## CONCLUSION

- The Strength of the concrete was increased 70% higher than the Normal OPC grade Concrete.
- The 28 – days Compressive Strength was attained just in 5 minutes hence used for Rapid Construction Demand Areas.
- The Sulfur Concrete is a new innovative Construction material for



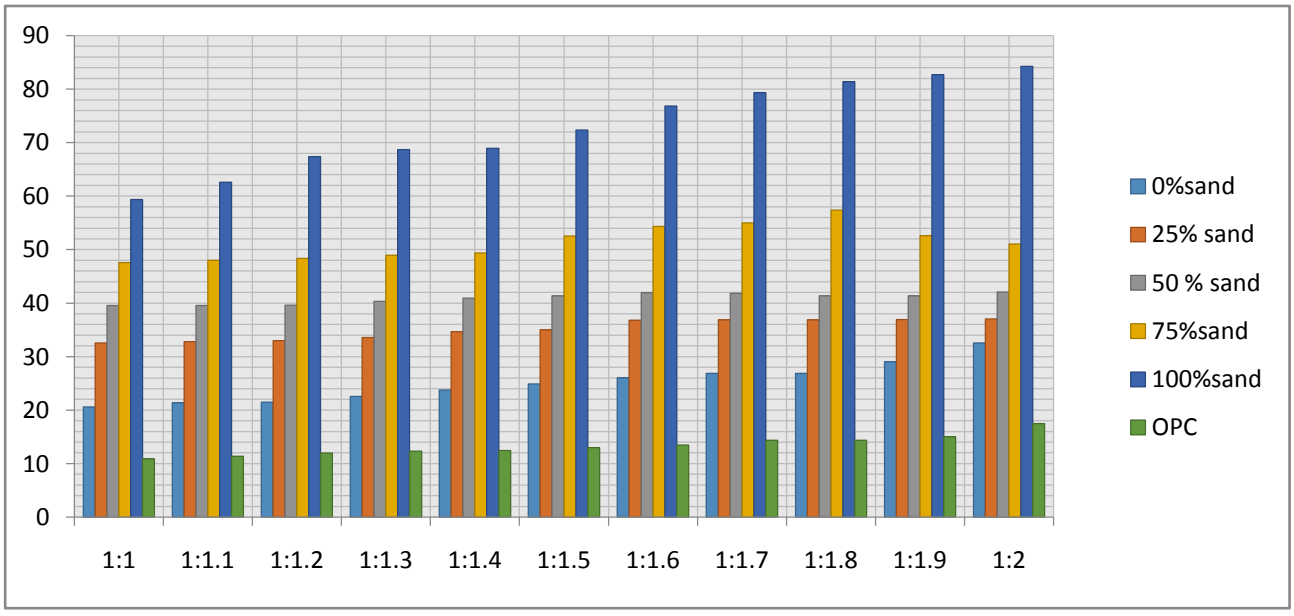



Figure : Compressive Strength Results

**SULFUR CONCRETE PLANT**

the Construction industry without cement and water there by reducing the carbon dioxide Emission creating a green Environment.

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