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EXPERIMENTAL INVESTIGATION OF SULPHUR INFILTRATED CEMENT MORTAR BY PARTIAL REPLACEMENT OF M-SAND

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Abstract:

In recent days many experimental work have been carried out in order to reduce the curing time and at the same time to increase the strength of the concrete. This experimental work is one of initiative of one such process which enhances the strength of concrete structures tremendously within a short period of curing time. In this present work, the cement mortar cube is cast normally with M20 grade concrete and it is adopted for sulphur curing. The work is carried out with M20 Grade concrete for which the M-SAND is replaced by 25% and 50% for fine aggregate. The sulphur is melted to its melting point at 115°C-130°C in a heating chamber. The air cured sample cast is immersed in hot molten sulphur and curing is carried out for 48 hours. It was analyzed that the strength has been increased to 20% within the 48 hours of time. It has also observed that the strength achieved is greater than normal cured at 28 days.

1. Introduction:

The intensified research of the 1970's led to the development of commercially feasible, durable, modified-sulphur mortars, concretes, and coatings by the Sulphur Development Institute of Canada in conjunction with Chevron Chemical and Chevron Research, by Sulphur Innovations Ltd. All of the methods of using sulphur as a binder for rigid concrete rely on the reaction of one or more modifiers to stabilize at least a portion of the polymeric form of sulphur in the hardened state. In all cases the sulphur must be heated to a liquid state to react with the modifier and to mix with and coat the aggregate and filler. Most systems require a dense-graded aggregate and, usually, mineral filler such as fly ash or limestone dust. Such a grading minimizes the amount of sulphur required.

2. Review of Literature:

Mines Branch work done in 1973 indicated that when conve ntional concrete specimens were submerged in molten sulfur they exhibited enormous increases in s t rength. Somewhat similar observations had been reported elsewhere by W. H. Kobbe in 1924 and Neils Thaulow in 1972. Sulfur is a cheap, inert material which is abundantly available in Canada and the United States. Because it has a low viscosity at 250°F (121°C), it warrants serious consideration for use in concrete. Consequently, the first experimentation at the Mines Branch on sulfur infiltration of concrete was initiated in two simple steps.

3. Material and their Properties:

Sulphur: Sulphur is a composite construction material.Sulphur is the fourteenth most common element in the earth's crust. Large quantities are required for the vulcanization of rubber, in the wood pulp industry, and for use as fertilizer. It is only recently that sulphur has been in sufficient supply to consider its use as a construction material. Sulphur is now being produced as a by-product of the fuel gas industry. Sulphur is pale yellow colour solid chemical element. It is insoluble in water and also the poor conductor of heat and electricity.

Table 3.1: Physical Properties

Colour	Pale Yellow
Phase	Solid
Melting point	115.21°C
Boiling point	444.6°C
Density	Alpha 2.07 g/cm³ beta 1.96 g/cm³ gamma1.92g/cm³
Solubility	Insoluble in water
Conductivity	A poor conductor of heat

Table 3.2: Chemical Properties

Chemical Formula	Properties
Compounds	Familiar compound are sodium sulfite, hydrogen sulfide and sulfuric acid.
Oxidation	The oxides are sulphur dioxide and sulphur trioxide, which when dissolved in water make sulfurous acid and sulfuric acid.
Reactivity	It is chemically reactive, especially upon heating and combines with all the elements. Upon heating sulphur reacts with metal forming the corresponding sulfides.

M-Sand: When rock is crushed and sized in quarry the main aim has generally been to produce course aggregate and road construction materials. M-sand is defined as a purpose made crushed fine aggregate produced from suitable source materials. Manufactured sand has been produced by variety of crushing equipment's including cone crushers, impact crushers; roll crushers, road rollers etc. The raw material for M sand production is the parent mass of rock. It is based on the parent rock that the

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chemical, mineral properties, texture, composition of sand would change. Before start testing aggregates use sieve analysis aggregates separate by size base.

Table 3.3: Properties of M-Sand

S.No	Property	Value
1	Specific gravity	2.68
2	Fineness modulus	5.2
3	Water absorption	4%
4	Surface texture	Smooth

Cement: Ordinary Portland cement 53 grade is used for concrete. The standard requires that it is made from 95 to 100 percent of Portland cement clinker and 0 to 5 percent of minor additional constituents. Minor additional constituents are one are more of the other cementation material or filler. Fillers defined as any natural or inorganic mineral material. Variation in its composition may produce a difference of up to + 20% in the compressive strength of concrete that is made with it, but uniform results are obtainable by drawing cement from one source of supply.

Table 4: Properties of Cement

S.No	Property	Value
1	Specific gravity	3.15
2	Fineness	97.25
3	Initial setting time	45 mints
4	Final setting time	385 mints
5	Fineness modulus	6%

River Sand: Locally available river sand is used for cement mortar. Before start testing aggregates use sieve analysis aggregates separate by size base. However, it is now known that the type of aggregate used for concrete can have considerable effects on plastic and hardened state properties of concrete.

Table 3.2: Properties of Fine Aggregate (River Sand)

S.No	Property	Value
1	Specific gravity	2.65
2	Fineness modulus	3.96
3	Water absorption	1%
4	Surface texture	Smooth

4. Mix Design:

M-20 Mix Designs as per IS-10262-2009 Indian Standard method for mix design concrete. Consequently the mixing Proportions are prepared by Trial mix method. Mass of fine aggregate is selected in total range of the cement mortar. Water cement ratio adopted between 0.45 - 0.50.

5. Mix Proportion:

In this research, three different mixes are prepared by varying the proportions of the m-sand. The mixes are designated as Mix M, Mix M1, and Mix M2. In this experimental work is 3 cubes are cast the mix M is the conventional mix with 0% of M-sand. The mix M1, M2 are the cubes with 25% and 50% of m-sand partially replaced by sand.

Table 4.1: Mix Proportion

Type of Mix	**Cement (g)**	**Sand (g)**	**M-Sand (g)**	**W/C Ratio (%)**
Conventional Mix (M)	229	343	-	0.45
M-SAND 25% (M1)	229	257.25	85.75	0.45
M-SAND 50% (M2)	229	171.5	171.5	0.45

6. Casting and Curing:

Cube Casting: The mould used was of size 7cm X 7cm X 7cm. Each mould was provided with a metal base plate having a plane surface. The base plate support the mould during the filling without leakage and it was attached to the mould by screws and coating of mould oil was applied between the interior surfaces of mould and the base plate. The cement mortar was filled into the mould in layers and each layer was compacted by using table vibrator after the top layer was smoothly finished by using a trowel.

Curing: The specimens were remoulded after 24 hours and cured for 28 days in curing tank and 48hours in melted sulphur. After curing period, the specimens were kept for drying and then tested using CTM 2000kN capacity.

Curing Procedure: The curing starts with a process of melting the sulphur at the temperature of 115°c to 130°c the powder sulphur is taken in a anti reactive container after the powder sulphur has achieved the molten state the air cured specimen is made to immerse complete in the hot molten sulphur the curing process should be done in a heat controlled chamber (that is the temperature is maintain). So that the sulphur will be maintain in a molten state throughout the completion of curing process. The immersed cube is curried for 48 hours in the molten sulphur after 48 hours the cube is taken out from the curing unit and it is air dried for 24 hours in order to dry out the liquid sulphur completely from the specimen after completion of the air curing process the specimen is tested for its compressive strength.

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Figure 6.1: Melting of Sulphur

Figure 6.2: Sulphur Curing

7. Results and Discussions:

Compressive Strength Test: The compressive test shows the compressive strength of hardened concrete. The compressive test show the best possible strength concrete can reach in prefect conditions. The compressive test measures concrete strength in a hardened state. Testing should always be done carefully. The test where carried out at the uniform stress of 140kg/cm²/minute after the specimen has been centred in the testing machine. Loading was continued till dial gauge needle just reverse its direction of motion. The dial gauge reading at the instant was noted which was the ultimate load. The ultimate load divided is the cross sectional area of the specimen is equal to the ultimate cube compressive strength. The test specimens cubical in shape, size are of 7cm X 7cm X 7cm. Compressive strength are made at recognized age of the specimens, preferably from different batches made for testing at each selected age. All the cubes were tested in saturated condition, after wiping out the surface moisture. For each trail mix, combination two cubes were tested at the age of 28 days, of curing using compression testing machine of 2000KN capacity as per BIS: 516-1959.

Figure 7.1: Compressive Testing Machine

Table 7.1: Comparison of Compressive Strength on Cement Mortar

S.No	Mix	M (N/mm²)	M1 (N/mm²)	M2
1.	M20	35.10	43.87	45.91
2	M20	37.34	44.44	48.97
Average		36.22	44.16	47.44

Six cube samples each for various percentage of river sand replaced by M-Sand were tested to determine the 28 days compressive strength using a 2000kN Compression Testing Machine. The compressive strength test on cubes is conducted as per standards. Compressive strength increases up to 50% replacement of M-Sand. Results of this test are show in table 7.1

Table 7.2: Comparison of Compressive Strength on Cement Mortar

S.No	Mix	M (N/mm²)	M1 (N/mm²)	M2
1.	M20	35.10	43.87	45.91
2	M20	37.34	44.44	48.97
Average		36.22	44.16	47.44

Six cube samples each for various percentage of river sand replaced by M-Sand were tested to determine the 48hrs in melted sulphur. Compressive strength using a 2000kn compression testing machine. The compressive strength test on cubes is conducted as per standards. Compressive strength increases up to 50% replacement of M-Sand. Results of this test are show in table 7.2

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Depth of Infiltration:

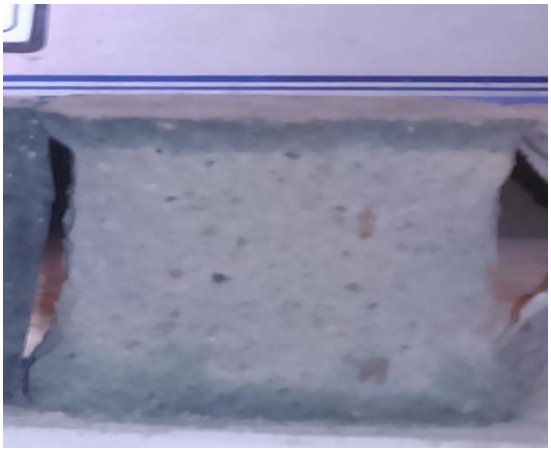

Figure 7.4: Four hours Sulphur Cure

As an analysis of compressive strength the following results were interpretation

- ✓ At 50% replacement of M-sand, the compressive strength is maximum
- ✓ The strength achieved by sulphur infiltrated cement mortar is 34.50% greater than the conventional concrete
- ✓ Also, the strength is achieved within a short duration of time (48 hours)

Durability Test:

Acid Attack Test: The acid attack testing procedure was conducted by immersing concrete cube specimens of 70mm size after the specified initial curing in a tub containing 5% H_2SO_4 for 72hours.The degree of attack was evaluated by measuring the expansion of concrete cubes, compressive strength, and weight losses of the specimens.

Table 7.3: Comparison of Weight Loss of Cement Mortar

Initial Weight (W1)	Final Weight (W2)	Weight loss in %
600gm	594gm	1.011

Sulphate Attack Test: The sulphate attack testing procedure was conducted by immersing concrete cube specimens of 70 mm size after the specified initial curing in a tub containing 5% Sodium Sulphate for 72hours. The sulphate solution was replaced whenever the pH value exceeded 9.5. The changes were noted as in previous case.

Table 7.4: Comparison of Weight Loss of Cement Mortar

Initial Weight (W1)	Final Weight (W2)	Weight loss in %
550gm	547gm	1.005

8. Conclusion:

The following conclusion have been made from the above stated experimental procedure,

- ✓ The sulphur can be used as a curing medium instead of water
- ✓ The strength achieved is maximum when it is sulphur cure
- ✓ The sulphur obtained as a waste material from rubber vulcanisation can be utilized in an effective way
- ✓ The M-sand can be replaced for sand up to 50% which gives the maximum result
- ✓ The strength achieved with M-SAND replaced sand and sulphur cured cement mortar mix has showed an increase of 34.50% in its compressive strength. Also the curing days is reduced to 2days from 28days.

9. References:

1. A. Jayaraman, V. Senthil Kumar. (2013). “Optimization of fully replacement of natural sand by m-sand in high performance concrete with nan silica”. International journal of emerging technology and advanced engineering ISSN 2250-2459, ISO 9001:2008 certified journal, volume 3, and issue 11.
2. Harold H. Weber. (2006). “New application and expanding markets for sulphur polymer cement concrete”. Director of industrial programme the sulphur institute Washington DC.
3. Hollis N. Walker., (1982) the use of sulphur as a rigid binder and form the impregnation of concrete, Virginia highway & transportation research council (vhtrc) 8 3-r19.
4. Malhortra, V. M., Painter, K. E. and Sales, J. A., "Development of High Strength concrete at Early Ages Using a Sulphur Infiltration Technique”, International Congress of Polymer Concretes, May 5-7, 1975, London, England.
5. Mariusz Książek, (2015). “The experimental research on special polymerized sulphur composite-impregnated concrete and cement mortar”. Vol.20 No.3 (Mar 2015) - The e-Journal of Non-destructive Testing - ISSN 1435-4934.
6. Mehta, H. C., Chen, W. F., Manson, J. A. and Vanderhoff, J. W., "Innovations in Impregnation Techniques for Highway Concrete”, Transportation Research Board, Washington, D. C., January 1975.
7. M. Adams Joe, A. Maria Rajesh, P. Brightson, M. Premanand. (2013) “Experimental Investigation on the Effect of M-Sand in High Performance Concrete”. American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-12, pp-46-51.

8. Narasimha C., Patil B.T., and Sanni S.H., (1999), "Performance of concrete with quarry dust as fine aggregate - An experimental study", Civil Engineering and Review, 12, pp 19-24.
9. Nimitha. Vijayaraghavan, Dr. A.S. Wayal, (2013). "Effect of manufactured sand on durability properties of concrete". American journal of engineering research (ajer) e-ISSN: 2320-0847 P-ISSN: 2320-0936 volume-02, issue-12, pp-437-440.
10. Priyanka A. Jadhav, Dilip K. Kulkarni, (2013). "Effect of replacement of natural sand by manufactured sand on the properties of cement mortar". International journal of civil and structural engineering volume 3, no 3.
11. Swoo-Heon Lee. "Influence of aggregate coated with modified sulphur on the properties of cement concrete". Department of Civil Engineering, University of Texas at Arlington, USA.
12. T. Shanmugapriya, R. N. Uma, (2012). "Optimation of Partial Replacement of M-Sand by Natural sand in High Performance Concrete with Silica Fume", International Journal of Engineering Sciences & Emerging Technologies, June 2012.Volume 2, pp.: 73.-80 IJESET.
13. V. M. Malhotra. "Sulphur-infiltrated concrete". Properties applications and Limitations, Canada Centre for Mineral and Energy Technology, Report 79-29,
14. W. C. Mcbee, T. A. Sullivan, H. L. Fike. "Sulphur construction materials".