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Experimental Study on Setting Time & Strength Characteristics of Cement by Partially Replacing Cement with "Steatite Powder"

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Abstract

Steatite is a talc-schist, subpart of metamorphic rock & compost 50% to 80% of talc & magnesium .It produced in a zone where tectonic plate broke the rock by heat & pressure but without melting .We can say dynamo thermal metamorphism and metasomatise phase.

Steatite is used for inland designs sculpture, coasters &kitchen (making bowl, cooking slabs etc.) & sinks. Inuit use soapstone for traditional carvings. Soapstone is a soft stone used to create moulds for creating objects & slick surface of soapstone allows finishing object to be easily removed.

Keywords: *Soapstone, Talc-schist, Metamorphic rock.*

INTRODUCTION

Now-a day's cement is the crucial factor in modern structures. As it's a binder material. Cement is the main element of infrastructural development in whole civil engineering sector. We can enhance the properties of structures by using suitable constituents.

Approximately 15-20% of total volume of concrete is made up of cement is used as a binder in concrete. Cement is a substance used for construction that sets harden to other materials, binding them together. Cement is a seldom used on its own, but rather to bind sand & gravel together. Cement used with fine aggregate to

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produce mortar masonary or with sand & gravel, aggregate to produce concrete.

But, cement has some limitations that we can not overlook like-

1) Less ductile.
2) Subjected to cracking.
3) Difficult to provide indenous curing condition.
4) Less aesthetic compared to composites.

To control these limitations, we adopted the methodology of replacement of cement with soapstone powder. (Also known as steatite or soap rock or talc-schist) cause from ancient times it has been used in India as a medium for carving. The mineral steatite, commonly known as soapstone, is a metamorphic rock composed mainly of talc (Mg3Si4O10 (OH) 2) and many other minerals such as magnesite and silica. The steatite is mostly used in electro techniques. This is used in ceramics due to its high resistivity, very low dielectric loss factor, and good mechanical strength. In this experiment the waste powder from extraction of steatite is partially replaced by cement. Addition of steatite powder increases the viscosity and mechanical properties of feed stock. The thermal properties of steatite are also good. By mass, "pure" steatite is approximately 63.37% silica, 31.88% magnesia and 4.74% water. It commonly contains minor quantities of other oxides such as cao or Al_2O_3.



Fig: steatite opowder

The main reasons behind replacing of cement by steatite powder are:-

1. Steatite powder reduces the initial & final setting time of cement.
2. Reduces the cracks.
3. Reduces emission of green house gases.
4. Increases compressive strength of structures.

BACKGROUND & RELATED WORK

Since the ancient times, steatite powder was used as a caving material in India. Steatite is sometimes used for construction of fireplace surrounds cladding on metal woodstoves & as the preferred material for wood burning. A weathered or aged appearance will occurs naturally over time as the Patina is enhanced. Steatite powder

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is most commonly used for architectural applications such as counter tops, floor tiles, shower bases & interior surfacing. There are active North American soapstone mines including one south of cubic city with products marketed by Canadian soapstone & company.

Welders & fabrications use soapstone as a marker due to its resistance to heat, it remains visible when heat applied as well as steatite used for smoking pipes; numerous examples have been found among artifacts of different cultures and are still in use today. Its low heat conduction allows for prolonged smoking without the pipe heating up uncomfortably. It has also been used for many years by seamstresses, carpenters, and other craftsmen as a marking tool because its marks are visible and not permanent.

Problem statement:-

1. **Reduction in setting times**: - The addition of steatite powder in cement as 5%, 10%, 15, 20%, 25% reduces the initial & final setting time due to the ultra fine structures of fine natural steatite powder with cement.
2. **Reduction in cracks**: -Cement is less ductile & brittle as compared to the soapstone powder. The addition of steatite results in increament in properties of the mixtures. Steatite improves the tensile strength & makes mixtures ductile. It helps in reduction in cracks due to more tensile & ductile property of steatite.
3. **Increasing compressive strength of structures**: - As ultra fine natural steatite powder is used, it increase the granular structure results in improved characteristics of mixture. It becomes more composite structures by addition of 5-25% of steatite powder in cement.
4. **Green house gases**: - Cement has an adverse effect on environment like emission of green house gases. Steatite have some hazards, since it contain some calcium contents. It is rich in magnesium Also, it contain hydrated magnesium silicates: (Mg3Si4O10 (OH) 2). As the percentage of magnesium is more than calcium. There will be a reduction in emission of green house gases.

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OBJECTIVES AND SCOPE OF THE STUDY

Objectives:

The Objectives of the Project are:-

- To perform laboratory tests that are related to workability, compressive strength by use of steatite powder in concrete.
- To compare the compressive and tensile strength using steatite powder with the given design mix
- To find the workability of concrete using natural sand & steatite powder separately and its comparison.
- To compare the cost of concrete using natural sand & steatite powder and its comparison.
- To study the effect of use of Steatite Powder on the mechanical properties of concrete.

SCOPE OF STUDY

The main focus of the project is to replacement of cement by soapstone powder. The main source of difficulty with cement is that the major hazards in concrete is carbon dioxide emission also the initial & final setting time can be reduced by replacing cement with steatite powder.

The compressive strength & ductility of cement can be improved by adding 20-25% steatite powder. It will enhance the physical & chemical properties of materials.

EXPERIMENTAL WORK

Material used:-

The Material Used For Preparing A Concrete Mixwere Described Below:-

Cement

Ordinary Portland cement is conforming to IS: 8112-1989 (Indian Standard Designation, IS: 8112-1989) is used for mortar mixtures; the cement used in this study belongs to type I of ASTM. The physical properties of cement are tabulated in TABLE I.

Table I. Physical Properties of Cement

Standard consistency	Specific gravity	Initial setting time in min.	Final setting time in min
32.5	3.13	34	554

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Fine Aggregates

Standard natural sand having hard, clean, strong, durable, uncoated particles and meeting the requirements of the specifications (ASTM C144-11) with specific gravity of 2.65 is used as fine aggregate.Physical properties of fine aggregates are given in TABLE II.

Coarse aggregates

The crushed aggregate were collected from the local quarry. The aggregates are locally available. The fractions from 20 mm to 4.75 mm are used as coarse aggregate. Specific gravity of aggregate is 2.75 and Fineness modulus of 6.73. Aggregates are the most mined material in the world. The coarse aggregate used in this experimentation were of 20mm and down size aggregate and tested as per IS: 2386-1963 (I, II and III) specifications. Physical and mechanical properties of coarse aggregates are given in TABLE III.

Water

In the present investigation, potable water is used for mixing and curing of concrete should be free from deleterious material. Therefore portable water was used in the present study in all operations demanding control over water quality.

Natural steatite

Natural steatite is also called soapstone or soap rock. It is a talc-schist (Mg3Si4O10 (OH) 2) which is a type of metamorphic rock. It is chiefly composed of the mineral talc and is thus rich in magnesium. Soapstone is moderately soft because of its high talc content, talc having a definitional value of 1 on the Mohs hardness scale. Softer grades may experience soapy when touched. There is no permanent hardness for soapstone because the amount of talc it contains varies broadly.

Table II. Physical Properties of Fine Aggregate

Property	Results
Specific gravity	2.68
Moisture content	0.65%
Fineness modulus	3.76
Grading	Zone-III
Bulk density a.Loose b.compacted	 14.67kN/m3 16.04 kN/m3

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Table III. Physical Properties of Coarse Aggregate

Property	Results	Permissible limit as per IS:2386-1963
Specific gravity	2.75 Property	In between range 2.6 to 2.8
Moisture content	0.7%	–
Fineness modulus	6.73	–

Table IV: Chemical Properties of Steatite (Provided By Suppliers)

Chemical Element	Results (%)
Sio2	44.73
Al2O3	3.70
Fe2O3	8.38
TiO2	<0.001
CaO	2.95
MgO	29.28
NaO2	<0.001
K2O	<0.001
MnO	0.13
P2O5	0.01
Loss of ignition	10.34

Concrete mix proportions

The mix design for M30 grade concrete was done according the Indian standard recommended method IS 10262-2009. The target mean strength was 26.6MPa for the control mixture, the total cement content was 372kg/m^3, fine aggregate is taken as 679.61 kg/m^3&coarse aggregate is taken as 1143.4kg/m^3 the water to cement ratio was kept as 0.5.

Cement, sand, steatite powder and coarse aggregate were properly mixed together in accordance with IS code before water and admixture was added and was properly mixed together to achieve homogeneous material. Water absorption capacity and moisture content were taken into consideration. The total mixing time was 7 minutes in concrete mixer. The slump cone test was performed to check the workability of concrete mix. 150mm x 150mm x 150mm cubes were used for casting. Samples were then casted and left for 24hrs before demoulding. They were then placed in the curing tank until the day of casting. The concrete specimens were cured in the tank for 7 and 28 days.

TEST PERFORMED:

Compressive Strength Test:

This is an important test which gives an idea about all the characteristics of

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concrete. By this single test one judge that whether Concreting has been done properly or not. For cube Test specimen's cubes of 15 cm X 15 cm X 15 cm are prepared. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. These specimens are tested by compression testing machine after 7 days and 28 days curing.



Fig Compression Testing Machine

Initial and Final Setting Time (IST and FST):-

We have calculated the initial and final setting time by Vicat apparatus.Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Start a stopwatch the moment water is added to the cement. Fill the vicat mould completely with the cement paste gauged as above. With the mould resting on a nonporous plate, smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

Determining initial setting time (ist). Place the test block under the rod bearing the needle. Lower the needle gently in order to make contact with the surface of the cement paste. Release quickly, allowing it to penetrate the test block. Repeat the procedure till the needle fails to pierce the test block to a point 5.0-0.5 mm measured from the bottom of the mould. Initial setting time is the period elapsing when water is added to the cement and the needle fails to pierce the test block by 5.0-0.5 mm measured from the bottom of the mould.

Final setting time(fst). Replace the above needle by the one with an annular attachment. The cement is considered to finally set, when the gentle application of the needle makes an impression therein, while the attachment fails to do so. Final setting time is the period elapsing when water is added and the needle makes an impression on the surface of the test block.

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Initial setting time and final setting time:- the test was performed to evaluate the initial and final setting time of cement by partially replacing steatite powder.



Fig 4.1:-vicat appratus

Compression Test:-Compression test was performed to measure compressive strength of concrete cubes for a time period of 7 days and 28 days independently. The results are shown in tables below…

Table: Compressive Test for 7 Days

Sr. No.	Description	Identified Mark	Compressive Strength N/mm^2	Avg. Strength N/mm^2
1.	**0%**	**C 1**	**22.95**	**23.175**
		C 2	**23.40**	
2.	**5%**	**S 1**	**23.80**	**23.95**
		S 2	**24.10**	
3	**10%**	**SA 1**	**26.01**	**26.37**
		SA 2	**26.74**	
4.	**15%**	**SB 1**	**24.48**	**24.19**
		SB 2	**23.90**	
5.	**20%**	**SC 1**	**21.80**	**21.51**
		SC 2	**21.23**	

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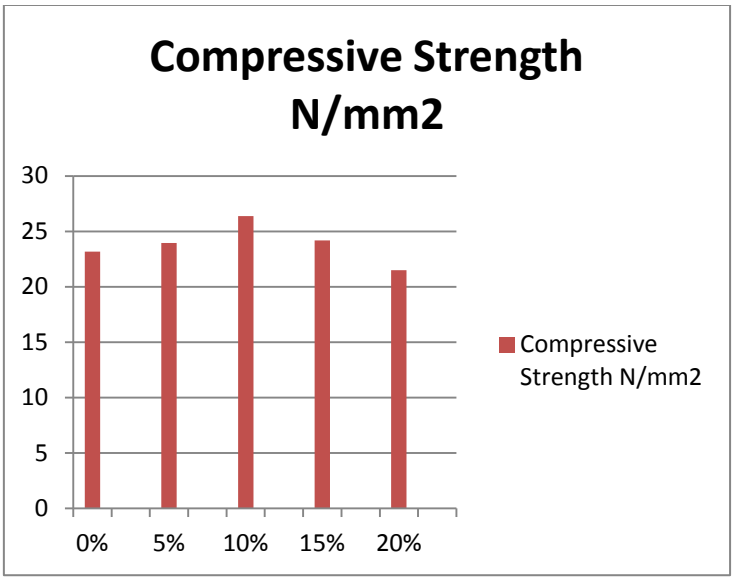


Table: Compressive Test for 28 Days

Sr.no	description	Identified mark	Compressive strength	Avg. Strength
1.	0%	C1	37.68	37.65
		C2	37.45	
2.	5%	S1	39.45	39.85
		S2	40.25	
3.	10%	SA1	43.75	43.32
		SA2	42.90	
4.	15%	SB1	37.19	37.065
		SB2	36.94	
5.	20%	SC1	30.12	29.85
		SC2	29.58	

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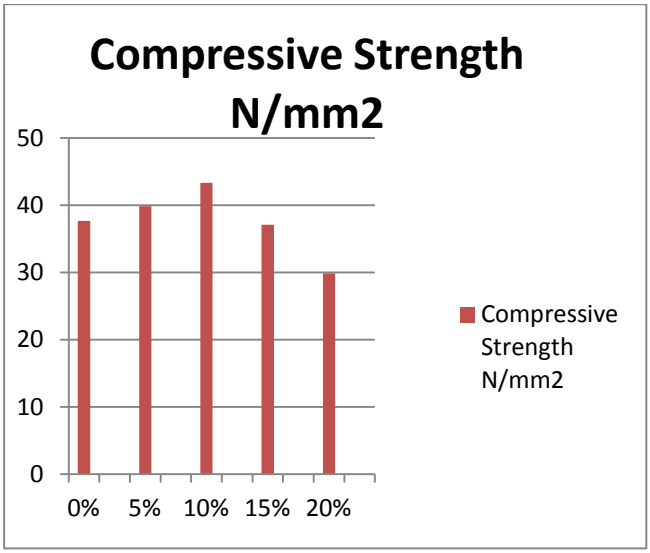
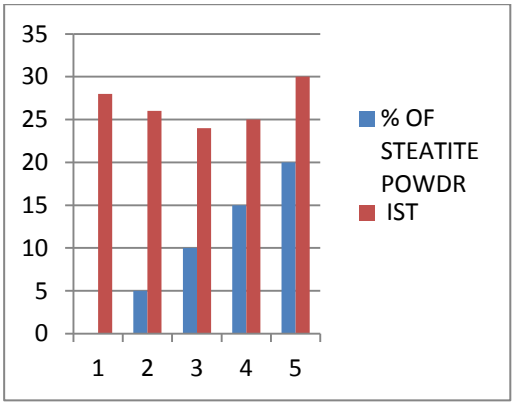


Table: Initial Setting Time and Final Setting Time

Sr no.	Mix IDs	% replacement of steatite powder.	% consistency of water for binder.	IST in min	FST in min
1	SP 0	0	22	28	350
2	SP 5	5	26	26	330
3	SP 10	10	27	24	300
4	SP 15	15	29	25	340
5	SP 20	20	32	30	360

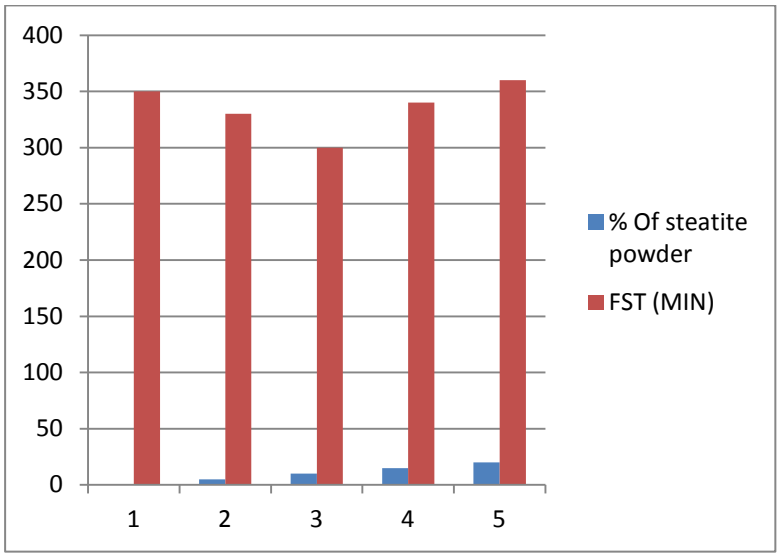
Initial Setting Time



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Final Setting Time



CONCLUSION

- from the study it was clear that the use of steatite powder advantageously improves the compressive strength the increase in the content of percentage of steatite powder increases the compressive strength marginally.

- the difference between compressive strength of concrete with steatite powder and plain concrete at 7 days is very less as compared with the 28 days strength, thus strength of concrete with steatite powder with the age of concrete

- It was observed that the initial and final setting time reduces as percentage of steatite powder increases.

- the workability and ductility characteristics have improved with the addition of the steatite powder

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