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Study on Mechanical Properties of Self-curing Concrete with Partial Replacement of Granite Powder as Fine Aggregate

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Abstract

The study of compressive strength and split tensile strength of self-curing concrete utilizing Super Absorbent Polymer(SAP) together with granite powder as partial substitution of fine aggregate (River sand). Super absorbent polymer utilized in this extend is sodium polyacrylate which gives the self-curing property. The 0.5 percentage of SAP is kept as a consistent amount all through the test. The granite powder is included in steps of 5 percentage from rate to 25 percentage. Seven mixes and forty two tests were compared with reference concrete. The fresh concrete testings and hard concrete testings were done. The fresh concrete testing like slump cone test is performed. The mechanical properties such as compressive strength and split tensile strength were tried and after that the results were compared with the control specimens. The qualities were checked for 7 days and 28 days curing periods. It is to check whether the self-curing concrete has predominant properties compared to ordinary cured concrete.

Keywords*: - Self-curing concrete, Granite powder, Curing agent, Super absorbent polymer, Cement, Coarse aggregates.*

INTRODUCTION

Over the top vanishing of water (inner or outside) from new concrete ought to be avoided; something else, the degree of cement hydration would get brought down and subsequently concrete may create inadmissible properties. Curing operations ought to guarantee that satisfactory sum of

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water is accessible for cement hydration to happen. In this way the correct curing is accomplished by utilizing self-curing. When the mineral admixtures respond totally in a mixed cement framework, their request for curing water (outside or inside) can be much more noteworthy than that in a customary ordinary Portland cement concrete.

Often specially in HPC, it isn't effectively conceivable to supply curing water from the beat surface at the rate required to fulfill the continuous chemical shrinkage, due to the greatly low permeabilities regularly achieved. In this extend, the partial substitution of fine aggregate (river sand) with granite powder is made. A consistent water cement proportion of 0.45 is utilized. M25 grade of concrete is utilized. Two control examples are utilized, one with 0% of granite powder, 0% of Super Absorbent Polymer (SAP) together with River sand and cement and another example with 5% of granite powder, 0% of Super Absorbent Polymer(SAP) together with river sand and cement. The granite percentage is shifted in steps of 5% from 0% to 25% and their mechanical properties (compressive strength and split tensile strength) are found. The gotten result is compared with these control examples. Super absorbent polymer (too called slush powder) can retain and hold greatly huge sums of a fluid relative to their possess mass.

Super absorbent polymers are presently commonly made from the polymerization of acrylic acid mixed with sodium hydroxide within the presence of an initiator to create a poly-acrylic acid sodium salt (sometimes referred to as sodium polyacrylate). This polymer is the foremost common sort of SAP made within the world today. SAPs can act as an inner water source to supply hydration process which absorbs water particles from the fresh concrete mixture. At that point releases it in a afterward stage in the event that its relative humidity decreases since of the hydration process. When SAPs have got their last sizes, they set up steady, water filled incorporations; at that point water will be sucked from these incorporations into littler capillary gaps and expended by the cement hydration activity.

SAPs can be utilized to advance inside curing of concrete; hence moderate its autogenous shrinkage. Typically since inside curing permits curing to be 'from interior to outside' by the made internal reservoirs; in this way gives water throughout the mix not fair infiltration for

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a number of millimeters. Moreover, the made gel can progress both the workability and stability due to successful mortar properties are the consistency and the setting times. Fine aggregate is a fundamental component of concrete. The foremost commonly utilized fine aggregate is natural river sand. The demand of natural river sand is very tall in developed nations owing to infrastructural development. The non-availability of adequate amount of conventional river sand for making cement concrete is influencing the growth of construction industry in numerous parts of the nation. On the other hand, the granite waste produced by the industry has amassed over a long time. As it were inconsequential amount has been utilized and the rest has been dumped unscrupulously coming about in contamination issues. With the colossal increment within the amount of waste requiring disposal, acute deficiency of dumping locales, sharp increment within the transportation and dumping costs require the need for successful use of this waste. By doing so, the objective of decrease of cost of construction can be met and it will moreover offer assistance to overcome the issue related with its transfer counting the natural issues of the region.

SELECTION OF CURING AGENT

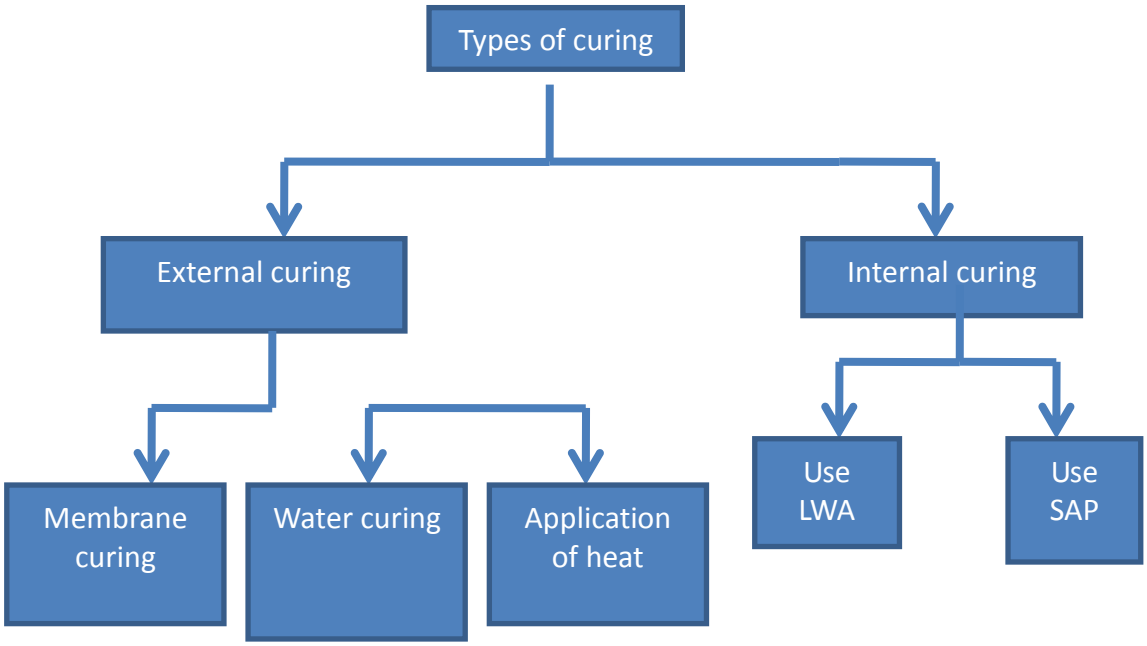


Figure 1: Types of Curing

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These days curing could be a dull process. It is incomprehensible for total curing within the high rise building. Thus the strategy of inner curing came into existence. There are two sorts of inside curing one is utilizing lightweight aggregate (LWA) and other is super absorbent polymer (SAP). There are diverse sorts of LWA accessible, are lytag, aglite, leca, solite, pellite. The thickness of coming about concrete will depend on the sort of total utilized.

Light weight aggregate may be utilized for the coarse aggregate in conjunction with normal fines or light weight can be utilized for both coarse and fine aggregates. The commonly utilized light weight aggregate is LYTAG, a sintered fly ash, moreover known as pulverized fuel cinder (pfa). Other aggregate, made from a assortment of crude materials. SAP is polymeric materials that have the capacity to retain an expansive sum of liquid from the environment and hold it inside their structure. It has a place to the gather of so-called "smart materials" that in a controlled way altogether alter their properties in reaction to the outside stimulus. When it is uncovered to water, they swell and when hence subjected to drying, they reversibly shrink. These key properties can effectively be utilized in connection to concrete. It has numerous preferences such as its impact on quality, shrinkage decrease, frost assurance, Rheology adjustment. It has extraordinary water absorption characteristics. It moreover acts as a implies to control porosity, which is another vital property for concrete.

The generation of self-curing concrete utilizing SAP can be a simpler work and cheap arrangement for creating nations whereas comparing with water cured concrete. SAP mortars have the most noteworthy autogenous shrinkage decrease than Light weight aggregates. The mortar containing SAP appeared less mass loss than mortar containing light weight aggregate. All these focal points of SAP over Light weight aggregate make it a choice for this project.

SELECTION OF GRANITE POWDER

Granite powder is an industrial byproduct gotten from smashing of stone and granite stone cleaning industry in a powder frame. It is additionally created from reusing marble tops, terrazzo, granite pavers, and stone scraps and disposes of. In case cleared out on its possess and isn't appropriately collected and put away, the fine granite powder can be effectively be airborne and will cause health issues and

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environmental pollution. Inhalation of granite powder fine particles could be a health risk and may be a cause of lung infections particularly for people living close granite plants.

In this display work, granite powder is utilized as partial substitution of sand in concrete in several rate and the related compressive strength, flexural, and split tensile strengths of concrete have been assessed. By doing so, common resources of sand can be protected and the health risks of these industrial wastes are minimized. Reusing of granite dust will anticipate these wastes from finishing up in landfills and give reasonable, eco-friendly, strong stone for different uses. They highlight the focal points of utilizing such reused materials in concrete since of potential cost, administrative and green certification benefits.

MATERIALS USED

The concrete blends were made within the research facility as per Indian standard and it was made utilizing the following materials.

Cement

The cement utilized in this study was conventional Portland cement (OPC) of grade 53.The specific gravity of cement is 3.15.

Super Absorbent Polymer

Super absorbent polymer is the Polycarboxylate based on acrylic corrosive. It is also known as waterlock, may be a sodium salt of polyacrylic corrosive with the chemical equation [−CH2−CH (CO2Na) −]n and wide application in customer items. This super absorbent polymer has the capacity to retain as much as 200 to 300 times its mass in water.

Fine aggregate

Fine aggregate was river sand taken from Ettaiyapuram which has the specific gravity of 2.64.

Granite Powder

The granite powder was collected from granite crushing and polishing destinations together with partial substitution of fine aggregate. Replacing the fine aggregate which is able offer assistance in filling up the pores within the concrete. The particular gravity of granite waste was 2.98 and its size was less than 90 microns. The fineness modulus of granite waste was 2.9.

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Table 1: Chemical Compositions of Granite powder

Compound	Symbol	Percent
Silica	SiO_2	72.04%
Alumina	Al_2O_3	14.42%
Potassium oxide	K_2O	4.12%
Sodium oxide	Na_2O	3.69%
Lime	CaO	1.82%
Ferrous oxide	FeO	1.68%
Ferric oxide	Fe_2O_3	1.22%
Magnesium oxide	MgO	0.71%
Titanium oxide	TiO_2	0.30%
phosphorus pentoxide	P_2O_5	0.12%
Manganese oxide	MnO	0.05%



Figure 2: Granite powder

Coarse aggregate

Coarse aggregates are purchased from a nearby crusher in Sankarankovil. Coarse aggregate with a nominal maximum size of 20mm and 12.5mm were used in this study.

PROPERTIES OF CEMENT

Standard Consistency

Standard Consistency of Cement = 32%

Initial Setting Time

Table 2: Initial Setting Time

Sl. No	Time(minutes)	Pointer Reading From Bottom(mm)
1	0	0
2	10	0.5
3	20	1
4	30	1.5
5	40	2
6	50	4
7	60	6

Initial setting time of Cement = 60 minutes

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Final Setting Time

Table 3: Final Setting Time

Sl. No	Time (minutes)	Pointer Reading From Bottom (mm)
1	240	41
2	300	42
3	360	42.5
4	420	43.5
5	450	44

SUPER ABSORBENT POLYMER

Chemical properties of Super Absorbent polymer

These sorts of SAPs moreover have a milder and stickier gel arrangement. High cross-link thickness polymers show lower permeable capacity and swell, but the gel quality is firmer and can keep up molecule shape indeed beneath unassuming pressure. Water-absorbing polymers, which are classified as hydrogels when cross-linked, absorb watery solutions through hydrogen holding with water particles. A SAP's capacity to absorb water depends on the ionic concentration of the watery solution. In deionized and refined water, a SAP may absorb 300 times its weight (from 30 to 60 times its possess volume) and can gotten to be up to 99.9% liquid, but when put into a 0.9% saline solution.



Figure 3: Super Absorbent Polymer

PROPERTIES OF FINE AGGREGATE

Fineness modulus

The sizes of sieves utilized for the investigation are 4.75mm, 2.36 mm, 1.18 mm, 600 microns, 300 microns, and 150 microns. The fine aggregate was sieve through sieves. The weight of test on each sifter was gotten and the aggregate rate weight retained was found out.

Table 4: Sieve analysis for fine aggregate

Is Sieve Designation	Percentage Passing	Is Recommended Range Zone II
4.75	100	90-100
2.36	90.91	75-100
1.18	67.23	55-90
600	37.15	35-59
300	8.30	8-35
50	0	0-10

Fineness of Modulus of Fine Aggregate is **2.64**.

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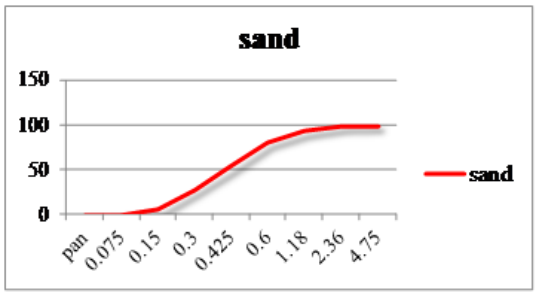


Figure 4: Graph for sieve analysis of fine aggregate (River sand)

Note: The fine aggregate conforms to grading **zone II of Table- B of BIS: 383 - 1970**.

Specific Gravity

To plan the concrete mix, specific gravity of granite powder is fundamental one. It is essential for calculation of yield of concrete or the amount required for a given volume of concrete.



Figure 5: Specific gravity

Specific Gravity = **2.64**

PROPERTIES OF GRANITE POWDER

Sieve analysis for granite powder

The sizes of sieves utilized for the investigation are 4.75mm, 2.36 mm, 1.18 mm, 600 microns, 300 microns, and 150 microns. The granite powder was sieve through sieves. The weight of sample on each sieve was gotten and the cumulative percentage weight retained was found out.



Figure 6: Sieve analysis for granite powder

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Table 5: Sieve analysis for granite powder

Is Sieve Designation	Percentage Passing	Is Recommended Range Zone II
4.75	100	90-100
2.36	90.91	75-100
1.18	67.23	55-90
600	37.15	35-59
300	8.30	8-35
50	0	0-10

Fineness of Modulus of granite powder is **2.64**.

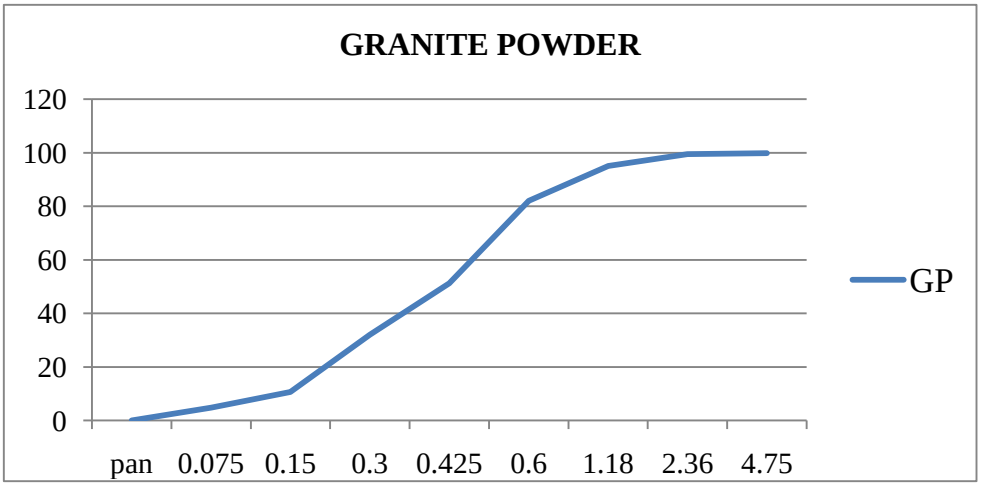


Figure 7: Graph for sieve analysis of fine aggregate (Granite powder)

Specific Gravity

To plan the concrete mix, specific gravity of granite powder is basic one. It is essential for calculation of yield of concrete or the amount required for a given volume of concrete. Specific Gravity = 2.64

PROPERTIES OF COARSE AGGREGATE

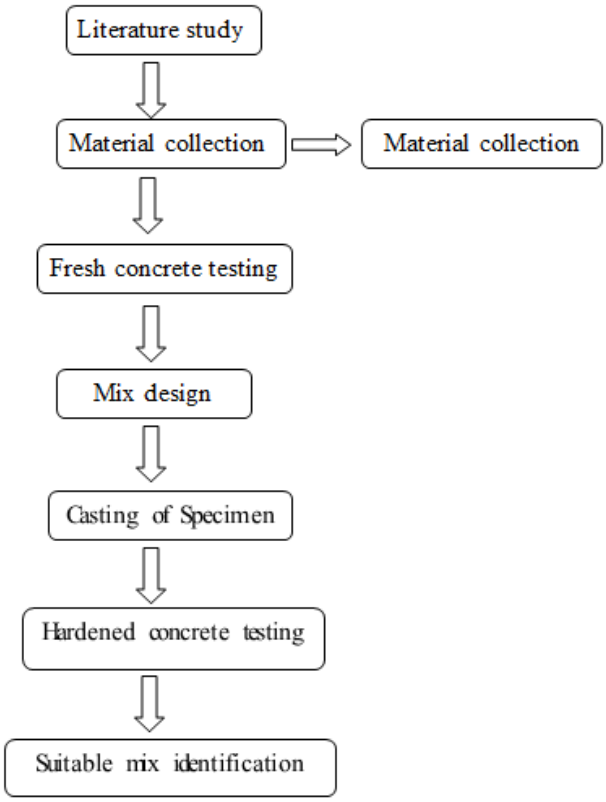
Coarse total of 20 mm and 12.5mm sizes are utilized and the properties of coarse total are found as takes after.

Table 6: Physical properties of coarse aggregate

SI. No	Particulars	Values
1	Specific gravity	2.78
2	Water absorption	0.5% of wt.
3	Fineness modulus	7.48

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METHODOLOGY



TRIAL MIX

By somewhat replacing granite powder with river sand in fine aggregate substance and different trial mixes were gotten to attain target mean strength but 0.5% of super absorbent polymer substance of cement is steady. The different trial mixes were appeared below

Table 7: Mix proportioning

Mix Id	Cement Content	SAP Content	Fine Aggregate	Granite Powder (%)	Coarse Aggregate	W/C Ratio
CC1	100%	0	100%	0	100%	0.45
CC2	100%	0.5%	100%	0	100%	0.45
M1	100%	0.5%	95%	5	100%	0.45
M2	100%	0.5%	90%	10	100%	0.45
M3	100%	0.5%	85%	15	100%	0.45
M4	100%	0.5%	80%	20	100%	0.45
M5	100%	0.5%	75%	25	100%	0.45

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FRESH CONCRETE TESTS

Slump cone test

Table 8

Mix Id	SLUMP VALUE (mm)
CC1	83
CC2	86
M1	89
M2	93
M3	94
M4	96
M5	97

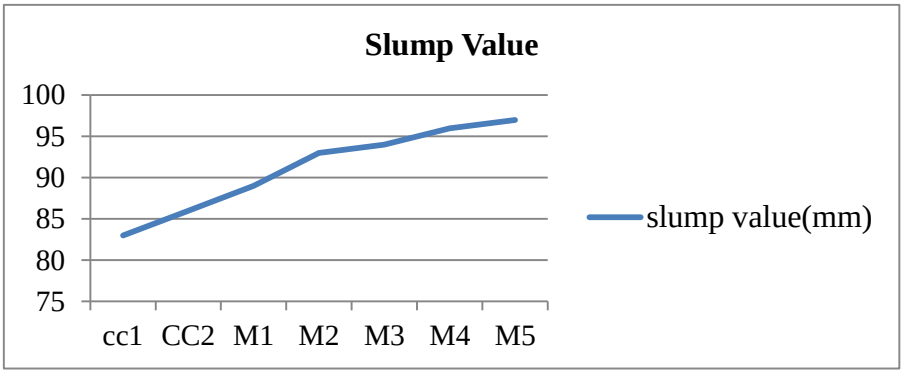


Figure 8: Graph of slump cone value

RESULT AND DISCUSSION

7 days Compressive strength

Table 9: Compressive strength of mixes for 7 days curing period

Mix Id	7 Days Compressive Strength (N/mm^2)			
	Cube 1	Cube 2	Cube 3	Average
Cc1	19.56	19.78	19.33	19.56
Cc2	19.64	19.86	19.91	19.80
M1	19.91	20.01	20.31	20.07
M2	20	20.4	20.44	20.28
M3	22.67	23.11	22.89	22.89
M4	21.33	21.11	20.89	21.11
M5	20.0	20.22	19.78	20.00

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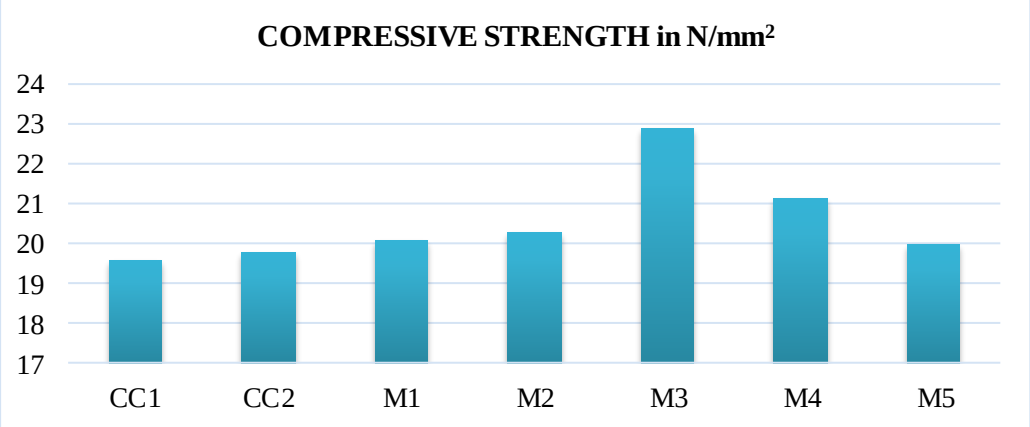


Figure 9: Graph of compressive strength results for 7 days curing period

28 Days Compressive strength

Table 10: Compressive strength of mixes for 28 days curing period

Mix Id	28 Days Compressive Strength (N/mm^2)			
	Cube 1	Cube 2	Cube3	Average
Cc1	27.48	27.53	28.67	27.89
Cc2	28.44	28.57	28.4	28.47
M1	28.76	28.84	28.93	28.84
M2	29.55	29.47	29.6	29.54
M3	**32.22**	**32**	**32.44**	**32.22**
M4	30.00	30.22	30.22	30.15
M5	29.11	29.33	29.11	29.18

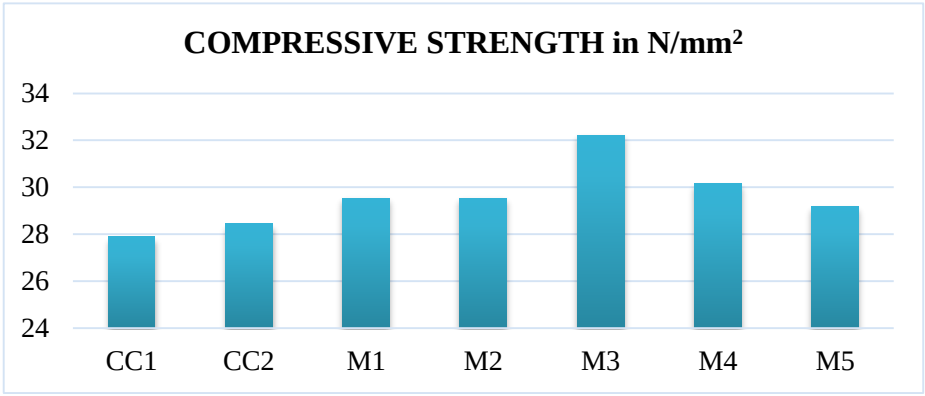


Figure 10: Graph of compressive strength results for 28 days curing period

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7 days Split Tensile strength

Table 11: 7 days Split tensile strength

Mix Id	7 Days Split Tensile Strength (N/Mm^2)			
	Trial I	Trial II	Trial III	Average
Cc1	2.13	2.05	1.98	2.05
Cc2	2.19	2.23	2.11	2.18
M1	2.33	2.42	2.53	2.43
M2	2.79	2.9	2.76	2.82
M3	2.9	3.04	3.4	3.11
M4	**3.18**	**3.47**	**3.23**	**3.29**
M5	2.97	2.9	2.83	2.90

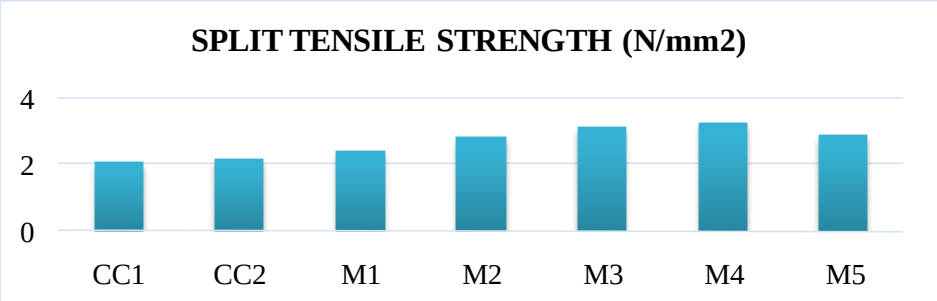


Figure 11: Graph of split tensile strength results for 7 days curing period

28 days Split Tensile strength

Table 12: 28 days Split tensile strength

Mix Id	28 Days Split Tensile Strength (N/mm^2)			
	Trial I	Trial II	Trial III	Average
Cc1	2.95	2.76	2.37	2.7
Cc2	2.89	2.90	2.93	2.91
M1	2.99	3.07	3.08	3.04
M2	3.24	3.29	3.21	3.25
M3	3.54	3.75	3.82	3.70
M4	**4.1**	**3.96**	**3.96**	**4.01**
M5	3.89	3.96	3.82	3.89

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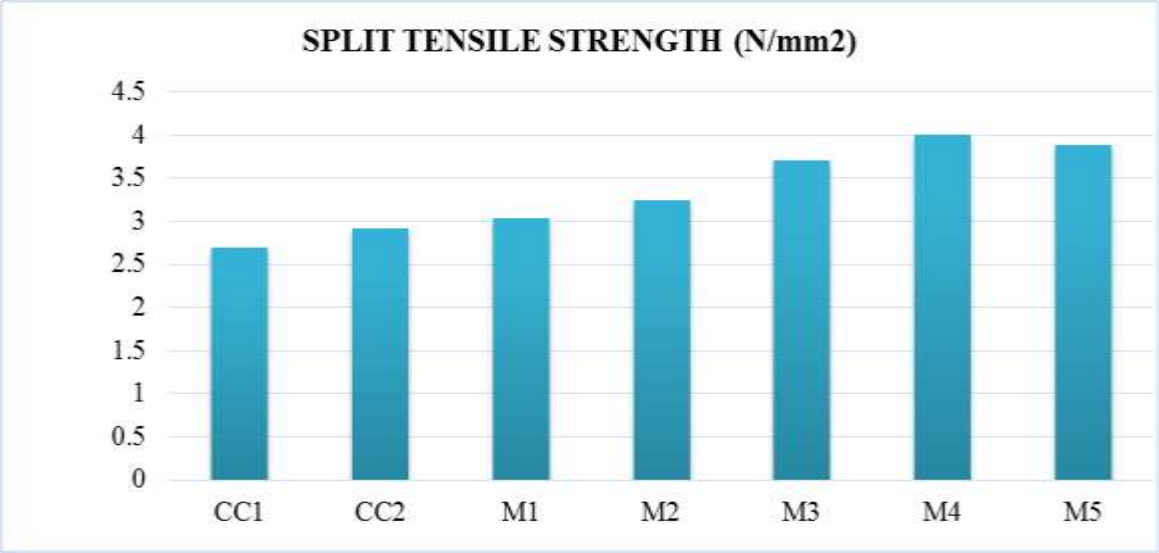


Figure 12: Graph of split tensile strength results for 28 days curing period

DISCUSSIONS

Compressive strength

- For 7 days curing period it is watched that the compressive strength for mix 3 of 15% Granite powder is most extreme when compared to that of all mixes.

- For 28 days curing period it is watched that the compressive strength for mix 3 of 15% Granite powder is greatest when compared to that of all mixes.

Split tensile strength

- For 7 days curing period it is watched that the split tensile strength for mix 4 of 20% Granite powder is greatest when compared to that of all mixes.

- For 28 days curing period it is watched that the split tensile strength for mix 4 of 20% Granite powder is greatest when compared to that of all mixes.

CONCLUSION

- The concrete mix made utilizing granite powder (GP) as partial substitution of sand appeared great workability and smoothness comparable to ordinary concrete mixes.

- Compressive strength of concrete increases with increase in granite powder substance from 5% to 25%.

- The Quality of concrete is accomplished on 15% of granite powder which is higher than target strength of 31.6 N/mm^2.

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- Maximum tensile strength is accomplished at 20% of stone powder.
- Thus from the test, the strength parameters were improved in self-cured concrete than that compared to water cured concrete.

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CONFLICTS OF INTEREST/ COMPETING INTERESTS

There is no conflict of interest.

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