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Investigation on Partial Replacement of Fine Aggregate with unexpanded Perilite in Concrete

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Abstract

This report is about the investigation on partial replacement of fine aggregate with unexpanded perilite in concrete and to determine the compressive strength and thermal resistivity. It was done on the mixtures prepared with ACC cementitious material containing perilite at 15%, 20%, and 30% of sand replacement. The polypropylene fiber content of 0, 0.5%, 1%, 1.5% and 2% by volume was also added to the mixture. The samples were heated at different temperature like 400, 600° c and 900°c and the effect of temperature on concrete were studied. The compressive strength of concrete for 7, 14, 28 days are calculated. It is clear that 40% of perilite possess maximum compressive strength and split tensile strength. Perilite concrete withstands 1.5 times the thermal resistivity compared to the normal concrete.

Keywords: Perilite, Compressive strength, Portland cement, coarse aggregate, Thermal resistivity,

Introduction

Generally, Concrete is a material produced by mixing coarse and fine aggregates (Portland cement, and water) and allowing the mixture to harden. Portland cement may also be manufactured from any number of raw materials, provided that they are combined to yield the necessary amount of lime, iron, silica, and alumina. Perilite is a volcanic rock with acidic to intermediate composition which forms in the wet condition or aqueous environment. The spatial density of concrete depends on methods of manufacturing, amounts and types of its components. All light concretes are because of existing of air in their structure. Light concrete with a density of 300 to 1000 kg per cubic meter can be used for insulation systems as well as fillers and bearing loads. Some scientists believe that perilite is formed from hydration of obsidian, and it contains water as hydroxyl and ion Most of the high grade pallets are related to third and fourth geology era Its application is as follows; Ceramics, abrasives, cement, Elect Composition, explode materials, fiber and leach colander, glassy fibers composition and synthetic salt. There are many uses for perilite. These uses can be broken down into three general categories: construction applications, horticultural applications, and industrial applications. Because of perilite's outstanding insulating characteristics and light weight, it is widely used as loose-fill insulation in masonry construction. In this application, free-flowing perilite loose-fill masonry insulation is poured into the cavities of concrete block where it completely fills all cores, crevices, mortar areas and ear holes. In addition to providing thermal insulation, perilite enhances fire ratings, reduces noise transmission and it is rot, vermin and termite resistant. Perilite is also ideal for insulating low temperature and cryogenic vessels. When perilite is used as an aggregate in concrete, a lightweight, fire resistant, insulating concrete is produced that is ideal for roof decks and other applications. Perilite can also be used as an aggregate in Portland cement and gypsum plasters for exterior applications and for the fire protection of beams and columns. Other construction applications include under-floor insulation, chimney linings, paint texturing, gypsum boards, ceiling tiles, and roof insulation boards.

Ibrahim turkmen et al(7).(2006) analyzed & studied the effect of expanded perilite aggregate and different curing conditions on the drying shrinkage of self-compacting concrete. The study investigates drying shrinkage of self-compacting concrete including mixtures of expanded perilite and natural aggregate at six different curing conditions.ulger bulut(11) in 2009 used perilite as a pozzolanic addition in lime mortars & the aim of his study was to invent a hydraulic cementitious material which is not soluble in water and which has efficient strength.dragan v.petrovic et al. Used Perilite as a filtering product in 2010.borvorn israngkura na ayudhya(5) (2011) investigated the concrete containing perilite aggregate and polypropylene fiber subjected to high temperature. The experiment was done on the mixtures prepared with ACC cementitious material containing perilite at 15%, 20%, and 30% sand replacement. The polypropylene fiber content of 0, 0.5%, 1%, 1.5% and 2% by volume was also added to the mixture. Amr aly gamal(1) (2012) utilized perilite as foam in cement bricks.s.bakhtiyari et al(9). (2013) conducted study on expanded perilite aggregate and zeolite powder additives. Modification of fire resistance property of self-compacting concrete with the specimens was exposed to high temperature, up to 1000°c and their effect on compressive strength was studied.usret bozkurt(8) (2013) found the effect of high temperature on concrete containing perilite powder. For that study, concrete samples were produced with perilite percentage of 0%, 5%, 10%, 15% and 20%. The samples were heated at different temperature like 400, 600°c and 900°c and the effect of temperature on concrete were studied.

Hamid h.hussein(6) (2013) done an experimental work and thermal analysis to determine the temperature distribution and thermal gradients in hot weather through the sections of the mass concrete units of dimensions 400*200*200 mm with thermal power distribution apparatus Using polystyrene beads and perilite, analysis of temperature gradients for mass concrete units .

Atila gurhan celik et al (4). (2013) found the use of expanded perilite aggregate as a lightweight construction raw material. The study was done to investigate the use of expanded perilite as a construction raw material by determining its characteristic properties, as well as its physical properties at different temperature up to 600°c.

Materials and methods

2.1 Cement

In the most general sense of the word, cement is a binder, a substance that sets and hardens independently, and can bind other materials together. In this project Portland Pozzolana Cement of 53 grade was used.

2.2 Fine Aggregate

Fine aggregate generally consist of natural sand or crushed stone with most particles passing through 4.75 mm sieve. Fine aggregate are inert granular materials such as sand, gravel or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. River sand is used as fine aggregate in this project.

2.3 Perilite

Perilite is natural hydrated volcanic glass. It is also classified into two types based on the expanding property namely expanded perilite and unexpanded perilite. There are two main processes that cause hydration of perilite. Primary hydration occurs during formation of the rock before it is cooled; secondary hydration occurs after the rock has cooled. In our project unexpanded perilite is been used.

2.4 Coarse Aggregate

Coarse aggregate are any particles greater than 4.75 mm in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Angular aggregate increase the void content. Larger sizes of well graded aggregate and improved grading decreases the void content. Here in this project, we are using coarse aggregate which passes through IS sieve – 12.5mm and retains on IS sieve -4.75mm.

2.5 Water

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration.The role of water is important because the water to cement ratio is the most critical factor in the production of 'perfect concrete'. Too much water reduces concrete strength, while too little will make the concrete unworkable. Concrete needs to be workable so that it may be consolidated and shaped into different forms. Because concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete.

MIX DESIGN

3.1 Design stipulations for proportioning

a Grade designation: M20
b Type of cement: PPC 53 grade, IS 8112
c Maximum nominal size of aggregate: 20 mm
d Minimum cement content: 320 kg/m3
e Maximum water cement ratio: 0.5
f Workability: 75 mm (slump)
g Exposure condition: Mild
h Degree of supervision: Good
i Type of aggregate: Crushed angular aggregate.
j Maximum cement content: 450 kg/m3
k Chemical admixture: Not used

3.2 Test data for materials

a Cement used: PPC 53 grade
b Specific gravity of cement: 3.15
c Specific gravity of
(i)Coarse aggregate: 2.64 (ii) Fine aggregate: 2.55

3.3 Water absorption

a Coarse aggregate: 2 %
b Fine aggregate: 3 %

3.4 Free (surface) moisture

a Coarse aggregate: Nil (Absorbed moisture full)
b Fine aggregate: Nil

3.5 Sieve analysis

Coarse aggregate: Conforming to Table 2 of IS 383 b. Fine aggregate: Conforming to Zone 2 of IS 383

3.6 .Target strength for mix proportioning

F'ck= *f'ck*+ ks

Standard deviation, s = 4 N/mm^2. Therefore target strength = 20+1.65 x3.6 = 25.94 N/mm^2.

3.7 Selection of water content

Maximum water content = 186 liters

(For 25mm – 50 mm slump range and for 20 mm aggregates) Estimated water content for 75 mm slump = 186 + 3/100 x 186 = 191.6 liters.

3.8 Calculation of cement content

Water cement ratio = 0.50. Cement content = 191.6/0.5 =383 kg/m3 >320 kg/m^3 (given).

From Table 5 of IS 456, minimum cement content for mild exposure condition = 300 kg/m3,

3.9 Proportion of volume of coarse aggregate and fine aggregate content

Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone 2) for water-cement ratio of 0.45 =0.55.

3.10 Mix calculations

The mix calculations per unit volume of concrete shall be as follows

- a Volume of concrete = 1 m^3.
- b Volume of cement =mass of cement/specific gravity of cement x 1/1000 [383.16/3.15] x [1/1000] = 0.122 m.
- c Volume of water = [191/1] x [1/1000] = 0.191 m^3.
- d Volume of all in aggregates [a – (b + c)]
- e Volume and weight of fine aggregates =559 kg

3.11 Mix proportions for trial number 1

Cement = 383 kg/m3 Water = 191.6 kg/m3
Fine aggregate = 559 kg/m3 Coarse aggregates = 1189 kg/m3
Water cement ratio = 0.45(+0.05 for absorption 0f C.A &F.A)

Preparation of Concret

4.1 Batching

Volume batching is not good method for proportioning because of difficulty it offers to measure granular material in terms of volume. Volume of moist sand loose conditions weigh much less than the same volume of dry compacted sand. The amounts of solid granular materials in cubic meter are indefinite quantities because of this for quality concrete materials have to measure by weigh only. Weigh batching is the correct method of measuring material. For important concrete invariably, weigh-batching system should be adopted. Use of weigh system should be adopted. Use of weigh system in batching, facilitates accuracy, flexibility and simplicity.

4.2 Mixing

Through mixing of the material is essential for the production of uniform concrete. The mixing should ensure that the mass become homogeneous, uniform in colour and consistency. There are two methods, adopted in mixing concrete.

4.3 Hand mixing Machine mixing
Hand mixing is practiced for small scale unimportant concrete works. As the mixing cannot be through and efficient, it is desirable to add 10% more cement to cater for the interior concrete produced by this method.

4.4 Placing
The concrete must be placed in systematic manner to yield optimum result. For the purpose of predicting the compressive strength and split tensile strength, the concrete is placed in a steel mold of 150*150*150* mm and cylinder with 15 cm dia & 30 cm depth respectively.

4.5 Compaction
Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. In the process of mixing, transporting and placing of concrete air is likely to get entrapped in the concrete. The lower the workability higher is the amount of air entrapped. In other words, stiff concrete mix has high % of entrapped air and therefore would need higher compacting effort than high workable mixes.

If it is not removed fully the concrete loses its strength considerably. The relationship between loss of strength and the air voids left due to lack of compaction. It can be seen that 5% voids reduce the strength of concrete by above 30% and 10% voids reduce the strength by over 50%. Therefore, it is imperative that 100% compaction of concrete is one of the most important aim to be kept in mind in good concrete making practices.

Hand compaction of concrete is adopted for concrete work of small magnitude. Sometimes, these methods are also applied in such situation, where a large quantity of reinforcement is used, which cannot be normally compacted by mechanical means. When compaction is adopted, the consistency of concrete is maintained at a higher level. The thickness of layer of concrete is limited about 15 to 20 cm. Rodding is nothing but packing the concrete with about 2m long 16mm dia rod to pack the concrete between the reinforcement and sharp corners and edges. Sometimes instead of iron rod, bamboos are also used for rodding purpose.

4.6 Curing
Concrete derives its strength by the hydration of cement particles. The hydration of cement is not momentary action but a process continuing for long time. It is by far the test method of curing as it satisfies all the requirement of curing namely promotion of hydration, elimination of shrinkage and absorption of the heat of hydration.

Tests on Hardened Concrete
Testing of hardened concrete plays an important role in controlling and conforming the quality of cement concrete works. Systematic testing of raw material fresh concrete and hardened concrete are inseparable part of any concrete with regard to both strength and durability the test methods should be simple, direct convenient to apply one of the purpose of testing hardened concrete is to conform that the concrete

used at site has developed the required strength. If the strength of concrete is to be known in the early period, accelerated strength test can be carried out to predict 28 days strength. Tests are made by casting cubes or cylinder from representative concrete. It is to be remembered that standard compressive test specimen give measure of the potential strength of the concrete and not of the concrete structure. The different types of test conducted for this project are,

5.1 Compressive Strength Test

Compressive strength is one of the important properties of concrete. Concrete cube of 150*150*150 mm were cast. After 24 hours the specimen were remolded and subjected to water curing. After 7, 14, 28 days of curing of 45 cubes were taken and tested in compression testing machine.

Compressive test is most common test conducted on hardened concrete, partly because it is an easy to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compressive test is carried out on specimens cubical or cylindrical in shape. The cube specimen is of the size 150*150*150 mm.

Compressive strength = Load /area=P/bd

In our project we used 150*150*150 mm size cube. The compressive strength of concrete for 7, 14, 28 days are calculated.

5.2 Split Tensile test

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure**.**

Apart from the flexure test the other methods to determine the tensile strength of concrete can be broadly classified as (a) direct methods, and (b) indirect methods. The direct method suffers from a number of difficulties related to holding the specimen properly in the testing machine without introducing stress concentration, and to the application of uniaxial tensile load which is free from eccentricity to the specimen. As the concrete is weak in tension even a small eccentricity of load will induce combined bending and axial force condition and the concrete fails at the apparent tensile stress other than the tensile strength.As there are many difficulties associated with the direct tension test, a number of indirect methods have been developed to determine the tensile strength. In these tests in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses developed in the specimen. The tensile stress at which the failure occurs is termed the tensile strength of concrete. The magnitude of this tensile stress S_P (acting in a direction perpendicular to the line of action of applied loading) is given by the formula (IS: 5816- 1907):

Where, P= compressive load at failure

SP= 2P/□DL, L= length of cylinder, D=diameterofcylinder.


Results and Discussions

6.1 Compressive Strength Test

The following table gives us the details of the test results obtained for the compression test for 7 days of curing. The compressive strength obtained for different mixes considered are listed below.

Table 1: Compressive Strength At 7 Days.

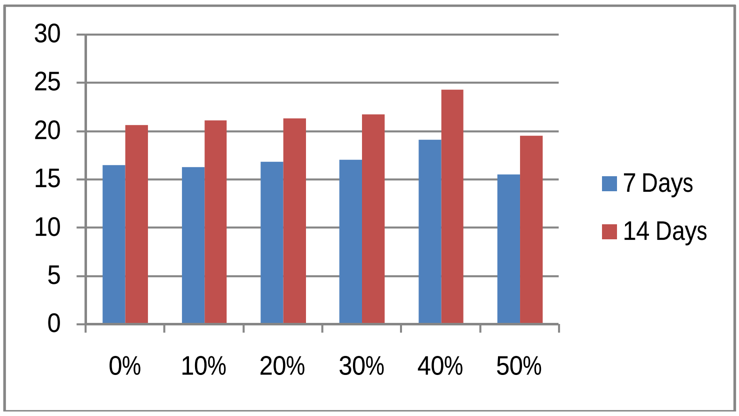
S.no.	Perlite %	Compressive strength @ 7days (N/mm^2)			
		Sample 1	Sample 2	Sample 3	Average
1	0	16.5	16	17	16.5
2	10	16.3	16.7	15.9	16.3
3	20	16.8	17.2	16.4	16.8
4	30	17.7	18.2	17.2	17.7
5	40	19.1	19.3	18.9	19.1
6	50	15.75	15.55	15.95	15.75

The following table gives us the details of the test results obtained for the compression test for 14 days of curing. The compressive strength obtained for different mixes considered are listed below.

Table 2: Compressive Strength At 14 Days

S.no.	Perlite %	Compressive strength @ 14 days (N/mm^2)			
		Sample 1	Sample 2	Sample 3	Average
1	0	20.2	20.6	21	20.6
2	10	20.5	21	21.5	21
3	20	22	21.1	20.2	21.1
4	30	22.25	21.75	21.25	21.75
5	40	24	24.25	24.5	24.25
6	50	20	19.52	19.04	19.52

Compressive strength (7 & 14 days) (N/mm^2)



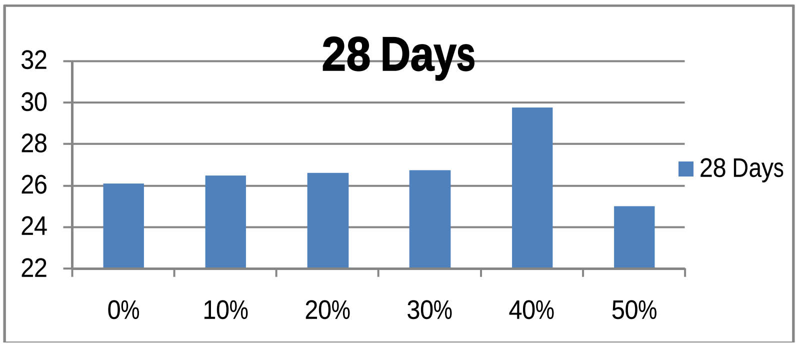
Above graph shows the variations of compressive strength for different mixes after 7 and 14 days of curing.

The compressive strength increases gradually with the increase in % of perilite up to 40%. The % of perilite above 40% tends to reduce the compressive strength. From the graph it is clear that 40% of perilite possess maximum compressive strength at both 7 and 14 days.

The following table gives us the details of the test results obtained for the compression test for 28 days of curing. The compressive strength obtained for different mixes considered are listed below.

Table 3: Compressive Strength At 28 Days

S.no.	Perlite	Compressive strength @ 28 days (N/mm^2)			
		Sample 1	Sample 2	Sample 3	Average
1	0	26.5	25.7	26.1	26.1
2	10	26.65	26.35	26.5	26.5
3	20	27	26.2	26.6	26.6
4	30	26.5	28	27.25	27.25
5	40	30	29.5	29.75	29.75
6	50	24.5	25.5	25	25



6.2 **Compressive Strength At 28 Days**

The above graph shows the variations of compressive strength for different mixes after 28 days of curing. From the graph it is clear that 40% of perilite possess maximum compressive strength. The compressive strength increases gradually with the increase in % of perilite up to 40%. The % of perilite above 40% tends to reduce the compressive strength.

6.3 SPLIT TENSILE TEST

The following table gives us the details of the test results obtained for the split tensile strength for 7 days of curing. The split tensile strength obtained for different mixes considered are listed below.

Table 4: Splitensilestrength At 7 Days

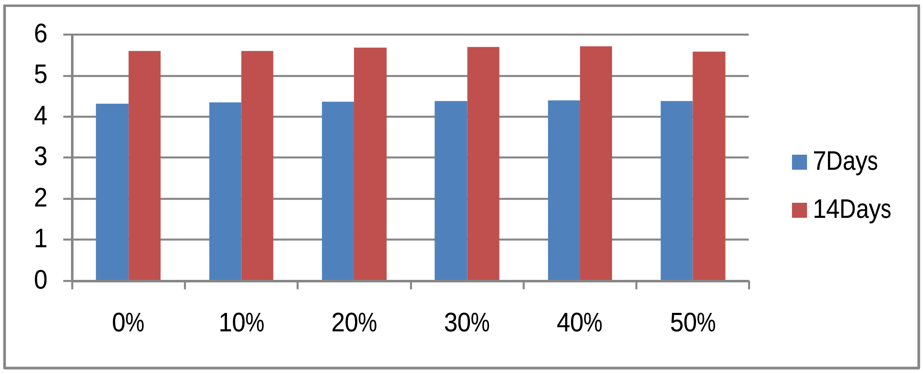
S.no.	Perlite %	Split tensile strength @ 7 days (N/mm²)			
		Sample 1	Sample 2	Sample 3	Average
1	0	4.06	4.31	4.56	4.31
2	10	4.34	4.64	4.04	4.34
3	20	4.22	4.37	4.52	4.37
4	30	4.37	4.42	4.32	4.37
5	40	4.25	4.4	4.55	4.4
6	50	4.5	4.26	4.38	4.38

The following table gives us the details of the test results obtained for the split tensile strength for 14 days of curing. The split tensile strength obtained for different mixes considered are listed below.

Table 5: Split Tensile Strength At 14 Days

S.no.	Perlite	Split tensile strength @ 14 days (N/mm²)			
		Sample 1	Sample 2	Sample 3	Average
1	0	5.59	5.63	5.55	5.59
2	10	5.42	5.78	5.6	5.6
3	20	5.63	5.71	5.67	5.67
4	30	5.69	5.85	5.53	5.69
5	40	5	5.71	6.61	5.71
6	50	4.86	5.58	6.3	5.58

Split Tensile Strength At 7 & 14 Days

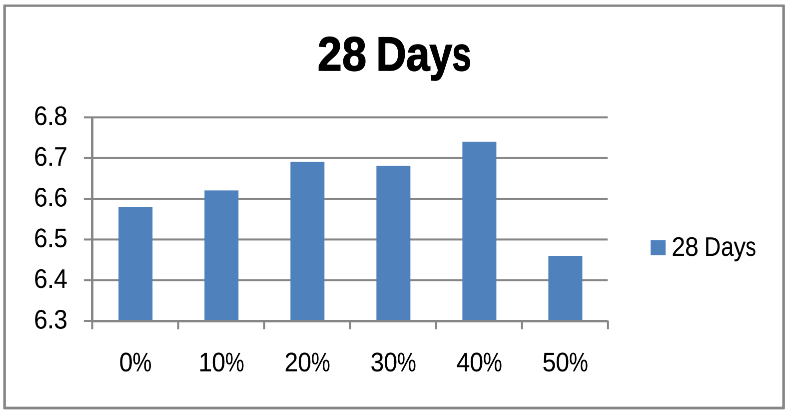


The above graph shows the variations of split tensile strength for different mixes after 7& 14 days of curing. From the graph it is clear that 40% of perilite possess maximum split tensile strength. The split tensile strength increases gradually with the increase in % of perilite up to 40%. The % of perilite above 40% tends to reduce the compressive strength.

The following table gives us the details of the test results obtained for the split tensile strength test for 28 days of curing. The split tensile strength obtained for different mixes considered are listed below.

Table 6: SPLIT TENSILE STRENGTH AT 28 DAYS

S.no.	Perlite	Split tensile strength @ 28 days (N/mm²)			
		Sample 1	Sample 2	Sample 3	Average
1	0	6.54	6.63	6.58	6.58
2	10	6.54	6.62	6.7	6.62
3	20	6.69	6.73	6.65	6.69
4	30	6.63	6.73	6.68	6.68
5	40	6.74	6.8	6.68	6.74
6	50	6.5	6.46	6.42	6.46

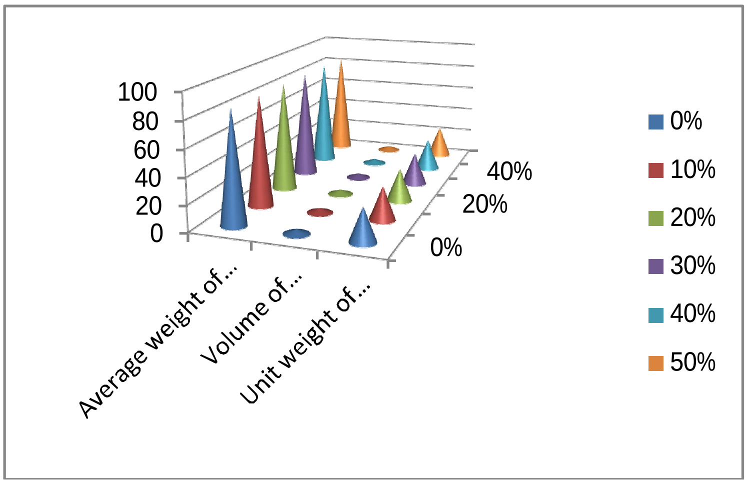


6.5 UNIT WEIGHT OF CONCRETE.

The above graph shows the variation of density of concrete with respect to percentage of perilite.

Table 7: Unit Weight Of Concrete

S.no.	% Of perilite	Average Weight of Specimen (N)	Volume of Specimen (*10^{-3} m^3)	Unit weight of Concrete (KN/m^3)
1	0	85.83	3.375	25.43
2	10	85.34	3.375	25.28
3	20	85.16	3.375	25.2
4	30	84.75	3.375	25
5	40	84.36	3.375	24.9
6	50	83.77	3.375	24.78



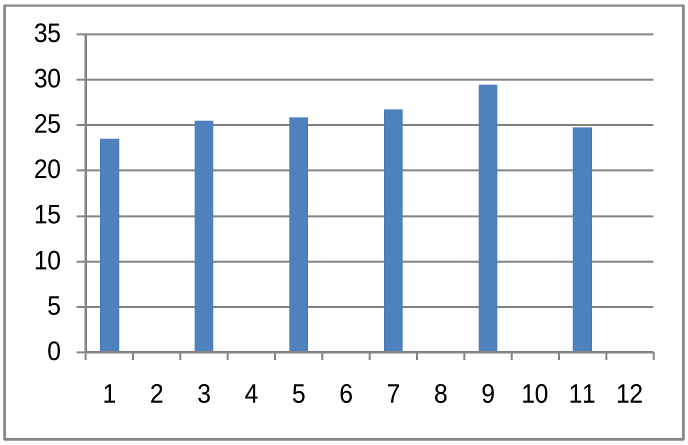
From the graph we can come to the conclusion that the unit weight of concrete decreases gradually with increase in percentage of perilite when compared to ordinary concrete. Hence perilite can be added to the concrete and utilized for light weight structure.

6.6 CORRELATIONS BETWEEN RESIDUAL STRENGTH OFHEATEDAND UNHEATED SPECIMEN.

The following table gives the residual compressive strength of the specimenwith different percentage of perilite heated at 350 C.

Table 8: Residual Compressive Strength Of Heated Specimen At 350°C

S.no	% Of Perlite	Heated Temperature° C	Residual Compressive Strength (N/mm^2)
1	0	350	23.49
2	10	350	25.44
3	20	350	25.802
4	30	350	26.705
5	40	350	29.4
6	50	350	24.75



6.7 COMPRESSIVE STRENGTH OF HEATED SPECIMEN AND UNHEATED SPECIMEN.

The above graph shows the variation of residual compressive strength of the unheated specimen& the heated specimen @350°c with different mix proportion having different percentage of perilite. It is evident from the above graph that; the residual compressive strength increases with increase in percentage of perilite.

Conclusion

1. Based on the above experimental study, following conclusions can be drawn Regarding the properties of perilite concrete:
2. The compressive and tensile strengths of perilite concrete increase with increase of perilite content.
3. 40% replacement of sand with perilite yields the highest strength.
4. By utilizing the perilite in concrete the density tends to decreases, which in turn makes the concrete light in weight.
5. Based on the test results, there had been evidence that perilite concrete withstands 1.5 times the thermal resistivity compared to the normal concrete.

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