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Experimental investigation of pervious concrete by replacing coarse aggregate by coconut shell, sea shell and soda cap

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Abstract- *The objective of our project is to study the effect of pervious concrete is a concrete which consist of coarse aggregate and cement paste with little fine aggregate or without fine aggregate. The pervious concrete also termed as non-fine aggregate is also used in structural application and it is treated as "Green building". It requires fewer materials than the conventional concrete. It helps in recharge the ground water in pavement applications, direct drainage of water and also have superior insulation properties when used in walls. Pervious concrete has a tailored-property concrete with higher water permeability which allow the passage of water to flow through the interconnected large pore structure. The result of an experimental investigation in the development of pervious concrete with reduced cement content and coarse aggregate for sustainable permeable pavement construction. And also we used a super plasticizer conplast SPC430 to reduce the amount of water content. The compressive strength properties of pervious concrete were determined by the age of 14 days. The result about the properties like void ratio and compressive strength of concrete.*

I. INTRODUCTION

A. General

Pervious concrete is considered to be an advanced pavement material in the terms of the environmental benefits arising from its basic feature – high water-permeability. The Objectives of this work is to improve compressive strength at which the strength achieves better permeability. Various properties of pervious concrete, such as compressive strength, split tensile- strength, flexural strength, porosity, and permeability are studied. This material has wider application for construction of parking pavements, residential street, side- walks, walk -ways, Apartments ways where there is light traffic and load intensity is low, which is also used for building green house. Used as pavement also.

This cement concrete only consists of coarse aggregate and cement paste. It consumes less raw-material than normal concrete. The first pervious concrete has been used in Europe. Pervious concrete is traditionally used in parking areas, walk ways. Its- important application for the sustainable construction and is one of many low impact development techniques used by builder to protect water quality.

B. Pervious concrete

Pervious concrete is a zero-slump, open graded material consisting of hydraulic cement, coarse aggregate, admixtures and water. In the absent of fine aggregate, pervious concrete has connected pores size range from 2 to 8mm, and the void content usually ranges from 15% to 25% with compressive strength of 2.8MPa to 28MPa (however strength of 2.8 to 10MPa are common). The draining rate of pervious concrete pavement will vary with aggregate size and density of the mixture, but will generally fall within the range of 81 to 730L/Min/m^2.

The pervious concrete also termed as no fine- aggregate is a natural choice for use in structural applications, and it is treated as "green building". It requires less raw- material than the conventional concrete. Pervious concrete helps in recharge the ground water in pavement applications, direct drainage of water and also have superior insulation properties when used in walls, pervious concrete has a tailored-property concrete with higher water permeability which allow the passage of water to flow through the inter connected large pore structure. The figure shown below is the image of pervious concrete.

Figure 1.1 Pervious concrete

C. Importance of pervious concrete

Pervious concrete is one of the most important emerging technologies for sustainable facilities and infrastructure. Application of pervious-concrete includes residential alleys, roads, driveways, sidewalks and pathways, parking lots, pavement and edge drains. It is considered as a green material can be easy to install and produced from readily available materials. According to current situation the natural resources are limiting and the natural aggregate cost can be expected to rise with scarcity of supply and increasing haul distance. So other sources need to be evaluated for the use. Regarding the materials like sea shell, coconut shell and plastics, in Kerala fish farming, Coconut tree farming produce lots of sea shell and coconut shell per year. These activity, generate lots of sea shell and coconut shell and they are considered as waste. For the moment plastic is also an important solid waste. Using this, materials in pervious concrete has multiple advantages to the environment.

D. Objectives of the study

- This work investigated to use sea shell, coconut shell, soda cap in pervious concrete (PC) and produce an even more environmentally – friendly product.
- Reduce runoff & storm water management system
- To encourage the use of waste materials as construction materials
- To produce an economical product by replacement of coarse aggregate

E. Scope of the study

It is possible to use the eco-friendly material in India. For the smart cities the use of pervious concrete will be suitable specifically for parking lots, pedestrian ways in the green spaces, morning walkways and in rural areas. The roads around the houses in rural and even in urban areas could be successfully construct in pervious concrete and surfacing inside the compound can be made with pervious concrete. The objectives however should be to improve the ground table. Most of our find acute shortage of water in summer and the situation is horrible in cities. It is the most essential that the urban spaces use pervious concrete and retain the filtered storm water for summer. This is another method of water harvesting which is quite safe and systematic for the states like Gujarat, Tamil Nadu, and Kerala where residents do not get water for days together.

F. Relevance

In designing the concrete pavements for infrastructures and transportation planning, the porous pavements made from pervious concrete can help in reducing storm water runoff and recharging the ground water. The excess runoff can be prevented during heavy rainfall. Pervious concrete is environmentally friendly material and can be used in India. The research work in this direction is on the way.

G. Applications of pervious concrete

- Parking Lot pavements.
- Sub base for conventional concrete pavements.
- Light Traffic Streets.
- Road Shoulders.
- Bridge Embankments.
- Edge Drains.
- Driveways, Sidewalks.
- Patios, Tennis Courts.
- Low water crossings.
- Slope Stabilization.

II. LITERATURE REVIEW

I. General

The pervious concrete is highly porous concrete and is environmentally friendly material. This material has wider application for construction of parking pavements, residential streets, sidewalks, and walk ways, apartment- ways where there is light traffic and the loading intensity is low. It is also used for building green houses. The void-content in pervious concrete ranges from 15-30% with compressive strengths ranging from 3.5MPa to 28MPa.

II. LITERATURES

Murthy B.V.R discussed that, pervious concrete is a lightweight concrete because of less amount of fine aggregate. Because of its porous nature the water can easily passed through it. It is also termed as no fine aggregate when there is no fine aggregate in the making of this concrete. Pervious concrete is used for light traffic parking areas, pedestrian walkways and green houses. Sand is one of the natural resources of the earth's surface as a result of the natural disintegration of rocks. The need and the demand for the river sand have been increasing with the development era of construction industry. Therefore the use of river sand is substituted by the alternative material crushed granite dust in lower amounts as a fine aggregate in the pervious -concrete.

In this work the materials like cement, fine aggregates and coarse aggregates were collected from locally. The used cement was OPC 53 grade and the mix proportions were prepared for M25 grade concrete. The collected Sand had specific gravity of 2.66. The size of coarse aggregates passing through IS sieve 25mm, and retained on I.S. sieve 16mm named as S1.And aggregates passing through IS sieve 10mm and retain on IS sieve 6mm named as S2 were taken for this work. Tap water is used for mixing and the water cement ratio is 0.35 for all the mixes in the work.

In this present study the strength of pervious concrete is improved by adding 5%robo sand as fine aggregate and 100%(80%S1+20%S2) coarse aggregate in the mix.

Rama Mahalingam discusses, various properties of pervious concrete, such as the compressive strength, split tensile strength, flexural strength, porosity and permeability, are studied in this paper for two aggregate gradations with different aggregate to cement ratios. Although the higher cement content exhibited better results for strength properties, the porosity and permeability results were lower. This study also aims to evaluate the balance between the porosity, permeability and compressive strength of pervious fine aggregate and admixtures, were investigated in this paper. The experimental investigations were carried out to determine the compressive strength, split tensile strength, flexural strength, porosity, and permeability. Ten different pervious concrete mixes were tested. The compressive strength, split tensile strength, and flexural strength values change with aggregate content and aggregate sizes.

Rajesh Kumar. S discussed that, the characteristics of pervious concrete. In this, study deals with the effect of fine aggregate in strength and durability concrete for different acceptable permeability and strength values. The strength and hydraulic properties of pervious concrete containing two aggregate sizes of different aggregate content, without any properties of pervious concrete. A total numbers of 42 specimens were cast cured and tested for compressive strength, flexural strength, and void ratio. This research is total of seven different mixes were used such as with and without fine aggregates, two different coarse aggregates, of size 12mm and 20mm and with fine aggregate as Normal River sand and crusher stone sand. The mix M4 with river sand and 12mm coarse aggregate has shown superior performance in terms of higher void ratio than other mixes. It gives 83% more compressive strength 72% more flexural strength 51% less void ratio than M1 mix.

Shaikh Zaid A.Majeed discussed that, Pervious concrete has been gaining a lot of attention in recent years due to its various environmental benefits which include controlling storm water runoff, restoring groundwater supplies. It can be used for the construction of parking lots, low-volume roads, walkways, driveways, sidewalks and swimming pool decks. The permeability of the pervious concrete signifies its capacity to drain the ponding water from the concrete surface. The demonstration of drainage through pervious concrete.. The pervious concrete pavements also serve the purpose of reducing noise pollution to some extent so they are sometimes referred to as ‘low-noise road surfaces’. The proper utilization of pervious concrete is a recognized Best Management Practice by the U.S. Environmental Protection Agency (EPA) for providing storm water management. Green Building Council (USGBC), which sets the green building rating system known as the LEED program (The Leadership in Energy and Environmental Design).

I. Baskar, M. Thiruvannamalai and R. Theenathayalan dicusses that, Pervious concrete reduces the runoff from paved areas, which reduces the need for separate storm water retention ponds and allows the use of smaller capacity storm sewers. This allows property owners to develop a larger area of available property at a lower cost. Pervious concrete also naturally filters storm water and can reduce pollutant loads entering into streams, ponds and rivers. Pervious concrete functions like a storm water infiltration basin and allows the storm water to infiltrate the soil over a large area, thus facilitating recharge of precious groundwater supplies locally. All of these benefits lead to more effective land use. Accounting all these applications of pervious concrete, the strength and permeability studies are carried out with and without fibers.

N.V.L.N. Pavan Kumar Pervious concrete which has feasible surface quad service significantly to provide high permeability due to its interconnected pores. Pervious concrete (called porous concrete, permeable concrete) is a special case of Concrete with a high porosity used for concrete flatwork application that allows water from precipitation and other sources to passing game directly through and therefore reduces the overspill from a site and allowing groundwater recharge. Pervious concrete is made by using large sized aggregate without sum. Pervious concrete has been used in the United State for over thirty ages. Pervious concrete was first used in the 1800s in Europe as pavement surveneer and load bearing walls. It became popular again in the 1920s for two story homes in Scotland and England. It became most efficient in Europe after the Second World War due to the scarcity of cement. India is facing a typical problem of ground water table falling at a fast rate due to reduced recharge of rainwater into under soil and unplanned water secession for factory farm and industry by pumping. Pervious concrete if adopted for construction of pavements, platform, and parking lots designed for lighter load.

Nabeel Rahman discusses**,** Similar to percentage void, permeability of pervious concrete made with RB is higher in most of the cases. Permeability of pervious concrete made with CS varied from 15 mm/sec to 59 mm/sec with an average 31 mm/sec. Permeability of pervious concrete made with FB varied from 16 mm/sec to 51 mm/sec with an average of 27 mm/sec. Permeability of pervious concrete made with RB varied from 17 mm/sec to 49 mm/sec with an average of 30 mm/sec. Compressive strength ofpervious concrete made with different type of aggregate is shown in Figure 3(a). According to ACI 522-06, compressive strength of pervious concrete varies from 400 psi to 4000 psi. Present research indicates that compressive strength of pervious concrete made with CS varied from 760 psi to 1740 psi with an

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average 1130 psi. Compressive strength of pervious concrete made with FB varied from 630 psi to 1000 psi with an average 820 psi. Compressive strength of pervious concrete made with RB varied from 800 psi to 1000 psi with an average 900 psi. Pervious concrete made with CS shows higher compressive strength compared to FB and RB. RB shows higher average compressive strength compared to FB. It is due to the rough and porous texture of recycled aggregate which gives good bonding with cementecious matrix.

Alam and Ashraful discusses that ,the heterogeneous nature of pervious concrete is not only due to material variability, but also due to phase variability, with both solids and voids, with the voids ranging in size from the micropores, as typical in concrete, to the macropores unique to pervious concrete. In addition, when pervious concrete is placed in the field, the slab tends to have a unique vertical porosity distribution in addition to the multi-dimensional general porosity variability due to its phase heterogeneity. The vertical distribution has lower porosities on the top and higher porosities on the bottom mainly due to the surface compaction of its placement. Many of the specimens examined in previous studies had a variable vertical porosity distribution, which would impact the locations of excessive strains or stresses in these tests and the previous studies only examined a limited number of specimens. Many additional tests are needed to better understand porosity and its relationship to the mechanistic response variability due to the heterogeneous nature of pervious concrete.

Rasiah sriravindrarajah dicussed that, Pervious concrete, a tailored concrete with large-sized interconnected voids, allows the water to infiltrate easily through it. The porosity of pervious concrete ranges from 15 to 40 per cent and the pores sizes are between 2 mm to 8 mm (ACI (2006)). Typical pervious concrete mix designs used consist of cement, single-sized coarse aggregate, and a water to cement ratio ranging from 0.27 to 0.43. The pervious concrete

0.27 to 0.43. Reported properties of pervious concrete in the United States indicate that the 28-day compressive strength of pervious concrete ranges from 5.6 to 21 MPa, with void ratios ranging from 14% to 31%, and permeability ranges from 0.25 to 6.1 mm/s (2), compared to 1.2 x 10^{-4} mm/s for 15 MPa normal-weight concrete.

III. METHODOLOGY

A. General

The experimental study consists of collection of materials and the detailed study of its material properties. The detailed methodology is shown in fig 3.1

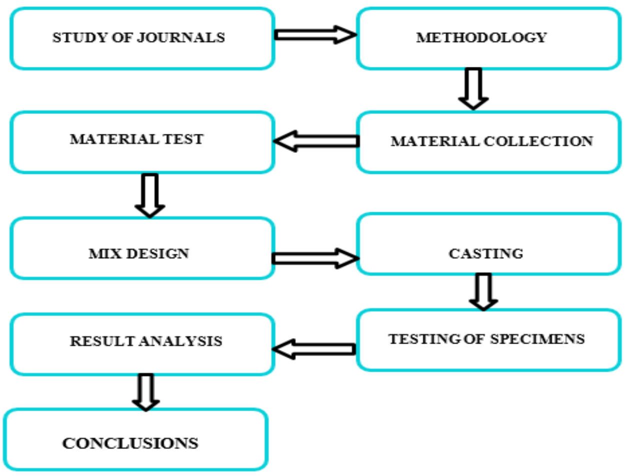

Figure 3.1 Methodology

B. Materials used

a. Cement

produced with cement and fly ash in equal weight proportion had the water permeability of 15 mm/s, the compressive strength of over 5 MPa and the 56-day drying shrinkage of 480 microstrain which is 21% less than that obtained with no fly, investigated the properties of pervious concrete with recycled concrete aggregate and 70% high fineness ground granulated blast furnace slag. For a given porosity, the use of recycled concrete aggregate reduces the compressive strength without affecting the water permeability.

R Sri Ravindrarajah discussed that,The high water permeability of pervious concrete makes it to be considered as an environmentally- friendly concrete. When the component materials of pervious concrete, environmentally unfriendly Portland cement is partially replaced by supplementary cementitious materials, such as fly ash and ground granulated blast-furnace slag (ggbfs), and coarse aggregate by recycled concrete aggregate, then the pervious

concrete could be considered as environmentally friendly oncrete for sustainable construction. Typical pervious concrete mix designs used consist of cement, single-sized coarse aggregate, and a water to cement ratio ranging from
The ordinary cement contains two ingredients namely argillaceous and calcareous. In argillaceous material clay predominates and in calcareous materials calcium carbonate predominates. OPC (Ordinary Portland Cement) of 53 grades conforming to IS 12269:1987 is used in the entire work. Cement is the binding material used in concrete mixtures; it binds the mixture and fills the voids in between the fine aggregate. Portland cement has become the most widely used material of its kind. Portland cement is a carefully controlled combination of lime, silica, alumina and iron oxide. When mixed with water, omposition of the ingredients in crystals of various complex silicates are formed, causing the mass to harden and set. Ordinary cement is shown in the figure below.

Figure 3.2 Cement

Figure 3.3 Coarse Aggregate

b. Aggregates

Fine aggregate content is limited in pervious concrete, and coarse aggregate is kept to a narrow gradation. Commonly-used gradations of coarse aggregate include ASTM C 33 No. 67 (¾ in. to No. 4), No. 8 (⅜ in. to No. 16), and No. 89 (⅜ in. to No. 50) sieves [in metric units: No. 67 (19.0 to 4.75 mm), No. 8 (9.5 to 2.36 mm), and No. 89 (9.5 to 1.18 mm)]. Single-sized aggregate up to 1 inch (25 mm) has also been used. ASTM D 448 also may be used for defining grading. A narrow grading is the important characteristic. Larger aggregates provide a rougher surface. Recent uses for pervious concrete have focused on parking lots, low-traffic pavements, and pedestrian walkways. For these applications, the smallest-sized aggregate feasible is used for aesthetic reasons. Coarse aggregate size 89 (⅜-in. or 9.5-mm top size) has been used extensively for parking lot and pedestrian applications, dating back 20 years or more in Florida. Figure 4 shows two different aggregate sizes used in pervious concretes to create different surface textures.

Generally, A/C ratios are in the range of 4.0 to 4.5 by mass. These A/C ratios lead to aggregate contents of between about 2200 lb/yd³ and 3000 lb/yd³ (1300 kg/m³ to 1800 kg/m³). Higher A/C ratios have been used in laboratory studies, but significant reductions in strength result.

Both rounded aggregate (gravel) and angular aggregate (crushed stone) have been used to produce pervious concrete. Typically, higher strengths are achieved with rounded aggregates, although angular aggregates are generally suitable. Aggregate for pavements should conform to ASTM D 448, while ASTM C 33 covers aggregates for use in general concrete construction. As in conventional concrete, pervious concrete requires aggregates to be close to a saturated, surface-dry condition, or close monitoring of the moisture condition of aggregates should allow for accounting for the free moisture on aggregates. It should be noted that control of water is important in pervious concrete mixtures. Water absorbed from the mixture by aggregates that are too dry can lead to dry mixtures that do not place or compact well. However, extra water in aggregates contributes to the mixing water and increases the water-to-cement ratio of the concrete.

Figure 3.4 Fine aggregate

c. Water

Water-to-cement ratios between 0.27 and 0.36 are used routinely with proper inclusion of chemical admixtures, and those as high as 0.40 have been used successfully. The relation between strength and water-to-cement ratio is not clear for pervious concrete, because unlike conventional concrete, the total paste content is less than the voids content between the aggregates. Therefore, making the paste stronger may not always lead to increased overall strength. Water content should be tightly controlled. The correct water content has been described as giving the mixture without flowing off of the aggregate. A handful of pervious concrete formed into a ball will not crumble or lose its void structure as the paste flows into the spaces between the aggregates. Water quality is discussed in ACI 301. As a general rule, water that is drinkable is suitable for use in concrete. Recycled water from concrete production operations may be used as well, if it meets provisions of ASTM C 94 or AASHTO M 157. If there is a question as to the suitability of a water source, trial batching with job materials is recommended.

d. *Coconut shell*

The high demand for concrete in the construction using normal weight aggregates such as gravel and granite drastically reduces the natural stone deposits and this has damaged the environment thereby causing ecological imbalance. There is a need to explore and to find out suitable replacement material to substitute the natural stone. In India, commercial use of non-conventional aggregates in concrete construction is not practiced yet. India is the third largest producer of coconut products in the world. Coconut trees are widely cultivated in the southern states of India, especially Kerala. Coconut shells as a substitute for coarse aggregates in concrete is gaining importance especially in this region in terms of possible reduction of waste products in the environment and finding a sustainable alternative for non-renewable natural stone aggregates. The properties of concrete using crushed coconut shell as coarse aggregate were investigated in experimental study. Coarse aggregate was replaced by crushed coconut shells in three different percentages namely 25%, 50% and 100%. Workability, compressive strength, flexural strength and splitting tensile strength of the above said mixes were compared with normal concrete properties. The results from the study are expected promote the use of coconut shell as a substitute for conventional coarse aggregate.

Figure 3.6 crushed coconut shell

e. *Sea shell*

Pervious concrete is a green alternative to conventional pavements with minimal fine aggregate and a high void - content. Pervious concrete allows water to infiltrate through the pavement, thereby reducing the runoff and the requirement for storm water management systems. Seashell By-Products (SBP) are produced in an important quantity in France and are considered as waste. This work investigated to use SBP in pervious concrete and produce an even more environmentally friendly product, Pervious Concrete Pavers. The research methodology involved substituting the coarse aggregate in the previous concrete mix design with 20%, 40% and 60% SBP. The testing showed that pervious concrete containing less than 40% SBP had strengths, permeability and void content which are comparable to the pervious concrete containing with only natural aggregate. The samples that contained 40% SBP or higher had a significant loss in strength and an increase in permeability and a void content from the control mix pervious concrete. On the basis of the results in this research, it was found that the natural aggregate can be substituted by SBP without affecting the delicate balance of a pervious concrete mix. Additional, it is recommended that the optimum replacement percentage for SBP in pervious concrete is 40 % direct replacement of natural coarse aggregate while maintaining the structural performance and drainage capabilities of the pervious.

Figure 3.7 Sea shell

f. *Soda cap*

Pavements porous concrete is a noble structure design in the urban management development generally enabling water to be permeated within its structure. It has also capable in the same time to cater dynamic loading. During the technology development, the quality and quantity of waste materials have led to a waste disposal crisis. Using recycled materials (secondary) instead of virgin ones (primary) have reduced landfill pressure and extraction demanding.

This study has reviewed the waste materials (Recycled crushed glass (RCG), Steel slag, Steel fiber, Tires, Plastics, Soda cap, Recycled Asphalt) used in the pavement porous concretes and report their respective mechanical, durability and permeability functions. Waste material usage in the partial cement replacement will cause the concrete production cost to be reduced; also, the concretes' mechanical features have slightly affected to eliminate the disposal waste materials defects and to use cement in Portland cement production.

C. *Test on materials*

a. *Test on cement*

i. Consistency of cement

ii. Setting time

a) Initial setting time

b)Final setting time

iii. Specific Gravity of Cement

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iv. Fineness of Cement

b. Test on coarse aggregate

i. Specific Gravity Test
ii. Shape Test
  (a) Elongation Index
  (b) Flakiness Index
iii. Sieve Analysis

a. *Test* on cement
  i. Determination of consistency of cement paste

1. Prepare a paste of weighed quantity of cement (300 grams) with a weighed quantity of portable or distilled water, starting with 26 % water of 300g of cement.

2. Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
3. The gauging time shall be counted from the time of adding water to dry cement until commencing to fill the mound. The vicat apparatus in shown in figure given below.
4. Fill the vicat mould with this paste, the mould resting upon a non-porous plate.
5. After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
6. Place the test block with in the mould, together with the non-porous resting plate, under the rod bearing the plunger (10mm diameter), lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.

Figure 3.8 Vicat apparatus

7. This operation shall be carried out immediately after filling the mould.
8. Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained.
9. Express the amount of water as a percentage by weight of the dry cement. Repetition of the experiment of fresh cement is to be taken.

SI No.	Weight of dry cement W_1(gm)	Weight of water added W_2(ml)	Penetration from the bottom of the mould (mm)	%water for Standard consistency $(W_2/W_1) \times 100$
1.	500	130	31	26
2.	500	140	33.5	28
3.	500	150	25	30
4.	500	160	17	32
5.	500	165	6	33

Table 3.1 Standard Consistency

Standard Consistency = 33 % As per IS specification this value should be between (33 - 35) %. Obtained value of standard consistency is 33 % is within the limit**.**

ii. Determination of setting time of cement paste

Procedure

1. Preparation of Test Block: - Prepare a neat 300gms cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Potable or distilled water shall be used in preparing the paste.
2. Start a stop-watch at the instant when water is added to the cement. Fill the Vicat mould with a cement paste gauged as above and the mould resting on a non-porous plate. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould.
3. Immediately after molding place the test block in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.
4. Determination of Initial Setting Time: - Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle lower the needle gently release, allowing it to penetrate into the test block.
5. . Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould shall be in the initial setting time.
6. Determination of final setting time:- Replace the needle of the Vicat apparatus by the needle with an annular attachment.

7. The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression there on, while the attachment fails to do so.

8. The period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of the test block while the attachment fails to do so shall be the final setting time.

Table 3.2 initial setting time

Time (minutes)	Penetration Mm
5	0
10	0
15	1
20	3
25	4
30	5

Initial setting time = 30 minute

iii. *Determination of specific gravity of cement*

Procedure

1. The Flask should be free from the liquid that means it should be fully dry. Weigh the empty flask, W1 =50g.

2. Next, fill the cement on the bottle up to half of the flask around 50gm and weigh with its stopper,W2 =100g

3. Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it. Weigh the flask with cement and kerosene, W3=133.225g

4. Empty the flask. Fill the bottle with kerosene up to the top and weigh the flask for counting W4=90g

$$S_G = \frac{W2-W1}{(W2-W1)-(W3-W4)W0.79}$$

$$= \frac{100-50}{(100-50)-(133.225-90)W0.79} = 3.15$$

Figure 3.9 Specific Gravity bottle

a. *Determination of fineness of cement*

Procedure

1. Accurately weigh 100gms of cement sample and place it over the test sieve. Gently breakdown the air set lumps if any with figures.

2. Hold the sieve with pan in both hands and sieve with gentle wrist motion, in circular and vertical motion for a period of 10 to 15 minutes without any spilling of cement.

3. Place the cover on the sieve and remove the pan. Now tap the other side of the sieve with the handle of brush and clean the outer side of the sieve.

4. Empty the pan and fix it below the sieve and continue sieving as mentioned in the step 2 and 3. Totally sieve for 15 minutes and weigh the residue (Left over the sieve).

Sieve no	Weight of sample W1 in g	Weight of residue W2 in g	Fineness= (W2/W1)x 100
1	100	7.5	7.5
2	100	8	8
3	100	7.2	7.2

Table 3.3 Fineness of cement

Fineness = 7.5 %

b. *Test on coarse aggregate*

i. *specific gravity test on coarse aggregates*

Procedure:

1. About 2kg of the aggregate sample is washed thoroughly to remove fines, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22ºC to 32ºC with a cover of at least 50mm of water above the top of the basket. Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and the aggregate should remain completely immersed in water for a period of 24 hours.

2. The basket and the sample are then weighed while suspended in water at a temperature of 22°C to 32°C. In case it is necessary to transfer the basket and the sample to a different tank for weighing. They should be jolted 25 times as described above in the new tank to remove air before weighing. This weight is noted while suspended in water W1 gm. The basket and the aggregate are then removed from water and allowed to drain for a few minutes. After which empty basket is then returned to the tank of water jolted 25 times and weight in water W2 gm.

3. The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in a single layer covered and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. 10 to 60 minutes drying may be needed. The aggregates should not be exposed to the atmosphere, direct sunlight or any other source of heat while surface drying. A gentle current of unheated air may be used during the first ten minutes to accelerate the drying of aggregate surface. The surface dried aggregate is then weighed W3 gm. The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110°C for 24 hours. It is then removed from the oven, cooled in an airtight container and weighed W4 gm.

4. Two tests are done and the average value to the nearest whole number is reported as aggregate abrasion value. Apparatus used for specific gravity test are given below.

A. Specific gravity of coconut shell aggregate:

- Weight of saturated aggregate suspended in water with the basket = W1 g = 3005 g
- Weight of basket suspended in water= W2 g = 1799 g
- Weight of saturated aggregate in water= (W1-W2) = Ws g = 3005 – 1799

  =1246 g
- Weight of saturated surface dry aggregate in air= W3 g =1988.6 g
- Weight of oven dried aggregate=W4 g =1958.6 g
- Weight of water equal to the volume of the aggregate=(W3-Ws) g = 1988.6-1246= 721.8g
- Specific Gravity= (Weight of aggregate/Weight of equal volume of water) =W4/ (W3-Ws) = 1978.6 /742.6 = 1.33
- Water absorption= percent by weight of water absorbed in terms oven dried weight of aggregates= [(W3-W4) / W4]x100=1000/1958.8=0.51%

B. Specific gravity of sea shell aggregate:

- Weight of saturated aggregate suspended in water with the basket = W1 g = 3056 g
- Weight of basket suspended in water= W2 g = 1799 g
- Weight of saturated aggregate in water= (W1-W2) = Ws g = 3056 – 1799

  =1257 g
- Weight of saturated surface dry aggregate in air= W3 g =1978.79g
- Weight of oven dried aggregate=W4 g =1968.8 g
- Weight of water equal to the volume of the aggregate=(W3-Ws) g = 1978.8-1257=721.8g
- Specific Gravity= (Weight of aggregate/Weight of equal volume of water) =W4/ (W3-Ws) = 1968.8 /721.8 = 2.78
- Water absorption= percent by weight of water absorbed in terms oven dried weight of aggregates= [(W3-W4) / W4]x100=1000/1968.8=0.5%

C. Specific gravity of soda cap aggregate:

- Weight of saturated aggregate suspended in water with the basket = W1 g = 2124.3 g
- Weight of basket suspended in water= W2 g = 1799 g
- Weight of saturated aggregate in water= (W1-W2) = Ws g = 2124.3 – 1799 =325.3 g
- Weight of saturated surface dry aggregate in air= W3 g =1948.3 g
- Weight of oven dried aggregate=W4 g =1939.8 g
- Weight of water equal to the volume of the aggregate=(W3-Ws) g = 1948.3-325.3= 1623 g
- Specific Gravity= (Weight of aggregate/Weight of equal volume of water) =W4/ (W3-Ws) = 1948.3 /1623 = 1.2
- Water absorption= percent by weight of water absorbed in terms oven dried weight of aggregates= [(W3-W4) / W4]x100=850/1948.3=0.43%

ii. Shape test on coarse aggregates

Following tests are conducted on coarse aggregates under shape tests:

- The elongation index of the given aggregates
- The flakiness index of the given aggregates

Apparatus for Shape Tests:-

The apparatus for the shape tests consists of the following:

1. A standard thickness gauge
2. A standard length gauge
3. IS sieves of sizes 63, 50 40, 31.5, 25, 20, 16, 12.5,10 and 6.3mm
4. A balance of capacity 5kg, readable and accurate up to 1 gm.

Procedure

1. Sieve the sample through the IS sieves (as specified in the table).

Take a minimum of 200 pieces of each fraction to be tested and weigh them.

2. To separate the flaky materials, gauge each fraction for thickness on a thickness gauge. The width of the slot used should be of the elongated materials, gauge each fraction for length on a length gauge. The width of the slot used should be of the dimensions specified in column (6) of the table for the appropriate size of the material.

3. Weigh the elongated dimensions specified in column (4) of the table for the appropriate size of the material.

4. Weigh the flaky material passing the gauge to an accuracy of at least 0.1 per cent of the test sample.

5. To separate the material retained on the gauge to an accuracy of at least 0.1 per cent of the test sample.

Figure 3.20 Apparatus for shape test

Table 3.4 Shape test on coconut shell aggregates

Size of aggregates		Weight of fraction consisting of at least 200 pieces,g	Thickness gauge size, mm	Weight of aggregates in each fraction passing thickness gauge,mm	Length gauge size, mm	Weight of aggregates in each fraction retained on length gauge,mm
Passing through IS Sieve, mm	Retained on IS Sieve, mm					
1	**2**	**3**	**4**	**5**	**6**	**7**
63	50	W_1= 0	23.90	X_1=0	–	–
50	40	W_2=0	27.00	X_2=0	81.00	Y_1=0
40	31.5	W_3=0	19.50	X_3=0	58.00	Y_2=0
31.5	25	W_4=0	16.95	X_4=0	–	–
25	20	W_5=363	13.50	X_5=363	40.5	Y_3=184.2
20	16	W_6=2296	10.80	X_6=400	32.4	Y_4=457
16	12.5	W_7=341	8.55	X_7=77	25.5	Y_5=62
12.5	10	W_8=0	6.75	X_8=0	20.2	Y_6=0
10	6.3	W_9=0	4.89	X_9=0	14.7	Y_7=0
Total	**W =**	3000	**X =**	840	**Y =**	703.2

Flakiness Index = $(X_1+ X_2+\ldots..) / (W_1 + W_2 + \ldots.)$ X 100

= (840/3000) x 100 = 28%

Elongation Index = $(Y_1 + Y_2 + \ldots) / (W_1 + W_2 + \ldots.)$ X 100

= (703.2)/ 3000 = 23.44%

Table 3.5 Shape test on sea shell aggregates

Size of aggregates		Weight of fraction consisting of at least 200 pieces,g	Thickness gauge size, mm	Weight of aggregates in each fraction passing thickness gauge,mm	Length gauge size, mm	Weight of aggregates in each fraction retained on length gauge,mm
Passing through IS Sieve, mm	Retained on IS Sieve, mm					
1	**2**	**3**	**4**	**5**	**6**	**7**
63	50	W_1= 0	23.90	X_1=0	–	–
50	40	W_2=0	27.00	X_2=0	81.00	Y_1=0
40	31.5	W_3=0	19.50	X_3=0	58.00	Y_2=0
31.5	25	W_4=0	16.95	X_4=0	–	–
25	20	W_5=350	13.50	X_5=350	40.5	Y_3=180
20	16	W_6=2125	10.80	X_6=458	32.4	Y_4=477
16	12.5	W_7=525	8.55	X_7=20	25.5	Y_5=78
12.5	10	W_8=0	6.75	X_8=0	20.2	Y_6=0
10	6.3	W_9=0	4.89	X_9=0	14.7	Y_7=0
Total	**W =**	3000	**X =**	828	**Y =**	735

Flakiness Index = $(X_1+ X_2+\ldots..) / (W_1 + W_2 + \ldots.)$ X 100

= (828/3000) x 100 = 27.6%

Elongation Index = $(Y_1 + Y_2 + \ldots) / (W_1 + W_2 + \ldots.)$ X 100

= (735)/ 3000 = 24.5%

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Table 3.6 Shape test on soda cap aggregates

Size of aggregates		Weight of fraction consisting of at least 200 pieces,g	Thickness gauge size, mm	Weight of aggregates in each fraction passing thickness gauge,mm	Length gauge size, mm	Weight of aggregates in each fraction retained on length gauge,mm
Passing through IS Sieve, mm	Retained on IS Sieve, mm					
1	**2**	**3**	**4**	**5**	**6**	**7**
63	50	$W_1= 0$	23.90	$X_1=0$	–	–
50	40	$W_2=0$	27.00	$X_2=0$	81.00	$Y_1=0$
40	31.5	$W_3=0$	19.50	$X_3=0$	58.00	$Y_2=0$
31.5	25	$W_4=0$	16.95	$X_4=0$	–	–
25	20	$W_5=323$	13.50	$X_5=323$	40.5	$Y_3=187$
20	16	$W_6=2146$	10.80	$X_6=452$	32.4	$Y_4=446$
16	12.5	$W_7=531$	8.55	$X_7=47$	25.5	$Y_5=63$
12.5	10	$W_8=0$	6.75	$X_8=0$	20.2	$Y_6=0$
10	6.3	$W_9=0$	4.89	$X_9=0$	14.7	$Y_7=0$
Total	**W =**	3000	**X =**	822	**Y =**	696

Flakiness Index = $(X_1+ X_2+\ldots..) / (W_1 + W_2 + \ldots.) \times 100$

= (822/3000) x 100 = 27.4%

Elongation Index = $(Y_1 + Y_2 + \ldots) / (W_1 + W_2 + \ldots.) \times 100$

= (696)/ 3000 = 23.2%

i. *Sieve analysis of coarse aggregates*

Procedure

i) The test sample is dried to a constant weight at a temperature of 110 + 5ºC and weighed.

ii) The sample is sieved by using a set of IS Sieves.

iii) On completion of sieving, the material on each sieve is weighed.

iv) Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.

v) Fineness modulus is obtained by adding cumulative percentage of aggregates retained on each sieve and dividing the sum by 100.

Table 3.7 Sieve analysis of coconut shell aggregates

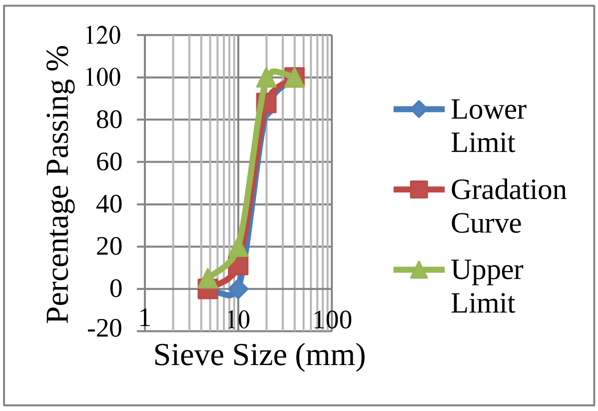

Fig. 3.12 Gradation curve for coconut shell aggregate

Sieve Size (mm)	Weight Retained (g)	Weight Retained (%)	Cumulative Weight Retained (%)	Weight Passing (%)	IS Range for Zone II
40	0	0	0	100	100
20	350	11.6	11.6	88.4	85 - 100
10	2125	70.8	82.4	17.6	0 - 20
4.75	525	17.5	100	0	0 – 5
2.36	0	0	100	0	
1.18	0	0	100	0	
0.6	0	0	100	0	
0.3	0	0	100	0	
0.15	0	0	100	0	
Fineness Modulus = 6.94					

Sieve Size (mm)	Weight Retained (g)	Weight Retained (%)	Cumulative Weight Retained (%)	Weight Passing (%)	IS Range for Zone II
40	0	0	0	100	100
20	363	12.1	12.1	87.9	85 - 100
10	2296	76.53	88.63	11.37	0 - 20
4.75	341	11.37	100	0	0 – 5
2.36	0	0	100	0	
1.18	0	0	100	0	
0.6	0	0	100	0	
0.3	0	0	100	0	
0.15	0	0	100	0	
Fineness Modulus = 7					

Table 3.8 Sieve analysis of sea shell aggregates

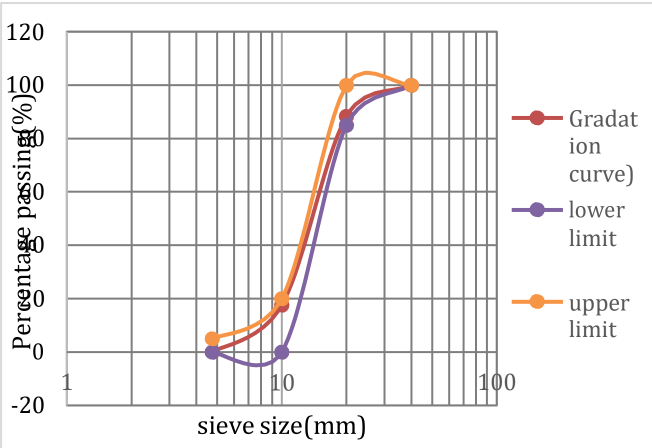

Fig. 3.13 Gradation curve for sea shell aggregate

Sieve Size (mm)	Weight Retained (g)	Weight Retained (%)	Cumulative Weight Retained (%)	Weight Passing (%)	IS Range for Zone II
40	0	0	0	100	100
20	323	10.7	10.7	89.3	85 - 100
10	2146	71.53	82.23	17.77	0 - 20
4.75	531	11.37	100	0	0 – 5
2.36	0	0	100	0	
1.18	0	0	100	0	
0.6	0	0	100	0	
0.3	0	0	100	0	
0.15	0	0	100	0	
Fineness Modulus = 6.92					

Table 3.9 Sieve analysis of soda cap aggregates

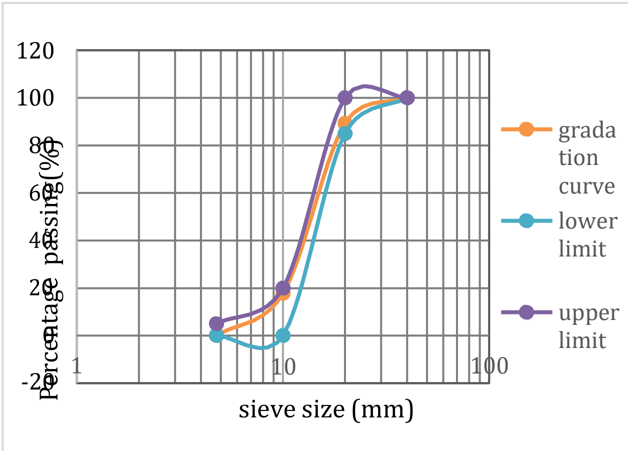

Fig. 3.14 Gradation curve for soda cap aggregate

iii. Impact test on coarse aggregate

Apparatus for Aggregate Impact Test

The apparatus as per IS: 2386 (Part IV) – 1963 consists of:

(i) A testing machine weighing 45 to 60 kg and having a metal base with a painted lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.
(ii) A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.

(iii) A metal hammer or tup weighing 13.5 to 14.0 kg the lower end being cylindrical in shape, 50 mm long, 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. Free fall of hammer should be within 380±5 mm.

Procedure

The test sample consists of aggregates sized 10.0 mm to 12.5 mm. Aggregates may be dried by heating at 100-110° C for a period of 4 hours and cooled.
(i) Sieve the material through 12.5 mm and 10.0mm IS sieves. The aggregates passing through 12.5mm sieve and retained on 10.0mm sieve comprises the test material.
(ii) Pour the aggregates to fill about just 1/3 rd depth of measuring cylinder.
(iii) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
(iv) Add two more layers in similar manner, so that cylinder is full.
(v) Strike off the surplus aggregates.
(vii) Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
(viii) Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
(ix) Raise the hammer until its lower face is 380 mm above the surface of aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an interval of not less than one second between successive falls.
(x) Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm. Also, weigh the fraction retained in the sieve.
Compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

Table 3.10 impact test on coconut shell aggregate

Observations	**Sample 1**	**SAMPLE 2**
Total weight of dry sample (W_1 gm)	340	340
Weight of portion passing 2.36 mm sieve (W_2 gm)	92.5	92
Aggregate Impact Value (percent) = W_2 / W_1 X 100	27.2	27.06

Aggregate Impact Value = 27.13

Table 3.11 impact test on sea shell aggregate

Observations	**Sample 1**	**SAMPLE 2**
Total weight of dry sample (W_1 gm)	350	350
Weight of portion passing 2.36 mm sieve (W_2 gm)	104.3	104.7
Aggregate Impact Value (percent) = W_2 / W_1 X 100	29.8	29.9

Aggregate Impact Value= 29.85

Table 3.12 impact test on soda cap aggregate

Observations	**Sample 1**	**SAMPLE 2**
Total weight of dry sample (W_1 gm)	345	345
Weight of portion passing 2.36 mm sieve (W_2 gm)	92.46	92.6
Aggregate Impact Value (percent) = W_2 / W_1 X 100	26.8	26.84

Aggregate Impact Value= 26.82

IV. MIX DESIGN

All the mixes were prepared corresponding to M20 grade concrete. The mix was designed in accordance with Indian Standard 10262-2009.

- *Stipulations for proportioning*

Grade Designation = M20

Type of Cement = OPC 53 Grade conforming to IS:8112

Maximum nominal size of aggregate = 20mm

Minimum water cement ratio = 0.45

Workability = 50-75 mm (Slump)

Degree of supervision = Good

Type of aggregate = Crushed angular aggregate

Maximum cement content = 470kg/m^3

- *Test data for materials*

Cement used = OPC 53 Grade

Specific Gravity of Cement = 3.15

Specific Gravity of Coarse Aggregate = 2.78

Specific Gravity of Fine Aggregate = 2.68

- *Design compressive strength for mix proportioning*

$f_{ck}' = f_{ck} + t \times s$

$f_{ck}' = 20 + 1.65 \times 4$

$= 26.6$ N/mm^2

- *Selection of water cement ratio*

From table 5 IS 456 maximum water cement ratio is 0.4.

Let us adopt water cement ratio as 0.4.

- Selection of water content

For 20 mm nominal sized aggregate water content is 186 litres,

Water content = 186 kg

- *Proportioning of volume of coarse and fine aggregate*

From table 3, IS 10262:2009 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate grading zone II = 0.62 per unit volume of total aggregate volume for water cement ratio of 0.4

Provided water cement = 0.4

Hence the volume proportioning of coarse aggregate

= 0.62 + 0.01 = 0.63

Volume of fine aggregate

= 1 – 0.63

= 0.37

- Mix calculations

a) Volume of concrete = 1 m^3

b) Volume of cement =

$$\frac{Mass\ of\ cement}{Specific\ gravity\ of\ cement} \times \frac{1}{1000} = \frac{465}{3.15} \times \frac{1}{1000}$$

=0.148 m^3

c) Volume of water = $\frac{Mass\ of\ water}{Specific\ gravity\ of\ water} \times \frac{1}{1000} = \frac{186}{1} \times \frac{1}{1000} = 0.186$ m^3

d) Volume of all in aggregate=(a) – (b + c)

=1 – (0.148 + 0.186)

=0.666 m^3

e) Mass of coarse aggregate =(d)x 0.62 x 2.78x 1000

- *Calculation of cement content*

Water cement ratio = 0.4

Water content = 186

Cement content = $\frac{186}{0.4}$

= 465 kg/m^3

From table 5 of IS 456, minimum cement content is 320 kg/m^3 and maximum cement content is 470 kg/m^3, thus safe=1748.4 kg

f) Mass of fine aggregate =(d)x0.37 x 2.68 x 1000

=660.4 kg

- *Final ratio obtained from mix proportioning*

Cement : Fine Aggregate : Coarse Aggregate: water =

1 : 1.42 : 3.76 : 0.4

The mix proportion for the M30 grade of concrete was arrived through a number of trial mixes. The mix was designed in accordance with IS 10262-2009. The mix proportion for M30 grade of concrete is shown in Table 6.1

Table 6.1 Mix proportion

Material	**Quantity (kg/m^3)**	**Mix Proportion**
Cement	465	1
Fine Aggregate	660.4	1.42
Coarse Aggregate	1748.4	3.76
Water Cement Ratio	0.4	0.4

V. TEST ON CONCRETE SPECIMEN

A. *Compressive strength test:*

PROCEDURE

1. Sampling of Materials - Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. The cement samples on arrival at the laboratory shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material.

2. Proportioning - The proportions of the materials, including water in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.

3. Weighing - The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight to an accuracy of 0.1 percent of the total weight of the batch.

4. Mixing Concrete - The concrete shall be mixed by hand or preferably in a laboratory batch mixer in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after molding the desired number of test specimens

5. Mould - Test specimens cubical in shape shall be 15 × 15 × 15 cm.

6. Compacting - The test specimens shall be made as soon as practicable after mixing and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance.

7. Curing - The test specimens shall be stored in a place free from vibration in moist air of at least 90 percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

8. Placing the Specimen in the Testing Machine - The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the

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surfaces of the specimen which are to be in contact with the compression platens.

9. In the case of cubes the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast that is not to the top and bottom.

10. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine.

11. The load shall be applied without shock and increased continuously at a rate of approximately 140kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.

12. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Compressive strength = crushing load

ross sectional area

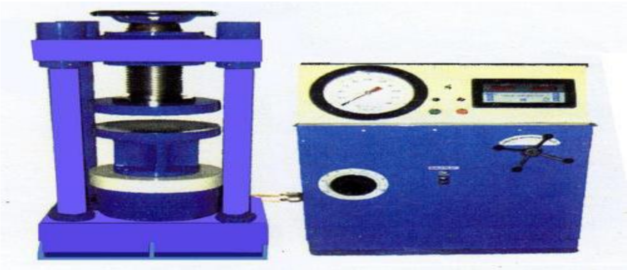


Figure 5.1 Compression testing machin

B. Permeability test:

The test setup was designed based on the constant head permeability method. One of the most important features of pervious concrete is its ability to allow percolation of percolation rate of pervious concrete is directly related to the air void content. The Polyvinyl chloride (PVC) pipe was placed on the pervious concrete specimen and was properly sealed with the contact surface of the specimen in order to avoid leakage. The permeability test was carried out when the quantity of water allowed to flow into the specimen through the PVC pipe was such that the constant head of water could be maintained at the desire water head in the inlet pipe. The water flow rate can be controlled by means of a valve. The flow rate of water can be determined by measuring the volume of water collected in the water tank over time for a particular head of water. The coefficient of permeability k in mm/sec can be expressed as,

K= (QL/Aht)

Where,

k- Permeability (mm/s)

Q- Total volume of water

(mm^3) L- Specimen length

(mm)

A- Cross sectional area of specimens (mm^2)

h- Water head (mm)

t- Time (s)

Figure 5.2 Permeability testing apparatus

C. *split tensile strength test:*

Procedure

Initially, take the wet specimen from water after 7, 28 of curing; or any desired age at which tensile strength to be estimated.

1. Then, wipe out water from the surface of specimen
2. After that, draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
3. Next, record the weight and dimension of the specimen.
4. Set the compression testing machine for the required range.
5. Place plywood strip on the lower plate and place the specimen.
6. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
7. Place the other plywood strip above the specimen.
8. Bring down the upper plate so that it just touch the plywood strip.
9. Apply the load continuously without shock at a rate within the range 0.7 to 1.4 MPa/min (1.2 to 2.4 MPa/min based on IS 5816 1999)

10. Finally, note down the breaking load (P)

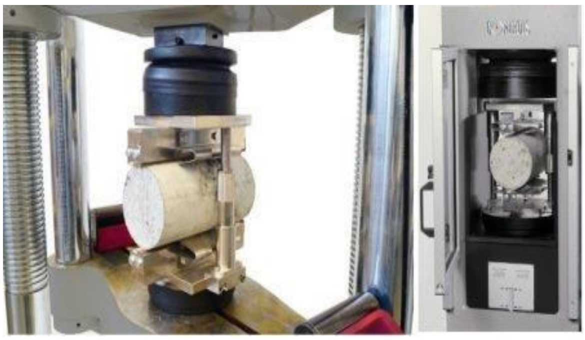


Figure 5.3 Split tensile strength testing apparatus

VI. RESULT ANALYSIS

A. *compressive strength*

The specimen is tested by compression test machine after 14 days curing. Load should be applied gradually till the specimen fails. Load at the failure divided by the area of specimen gives the compressive strength of concrete. The compressive strength of normal PC is shown in table.

Table 6.1 Compressive strength of normal PC

No.	Sample	Compressive strength (N/mm^2)
1.	Normal mix	12.7

The compressive strength of normal pervious concrete after 14 days is 12.7 N/mm^2.

i. *Compressive strength of coconut shell pc*

The specimen is casted by replacing coarse aggregate with 10% ,20%,30%,40%,50% and 60% of coconut shell and tested by compressive strength machine after 14 days curing. The obtained values are given below.

Table 6.2 Compressive strength of coconut shell PC

No.	Sample (%)	Compressive strength (N/mm^2)
1	10%	4.8
2	20%	2.13
3	30%	1.13
4	40%	0.62
5	50%	0.25
6	60%	2.13

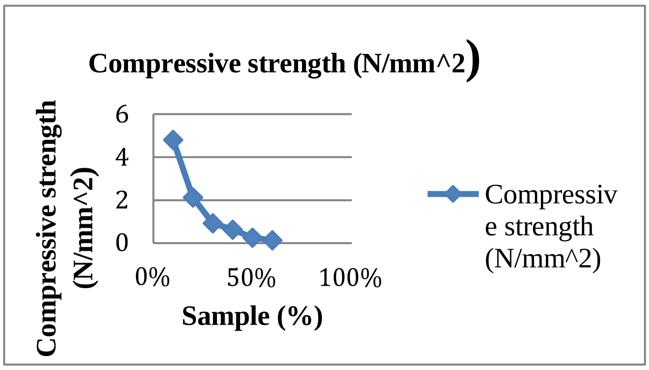


Figure 6.1 Compressive strength of coconut shell PC

Compressive strength is decreased with respect to the partial replacement of coarse aggregate from 10% to 60%. There was a significant drop in strength at 10% replacement of coarse aggregate.

ii. *Compressive strength of sea shell pc*

The specimen is casted by replacing coarse aggregate with 10%, 20%, 30%, 40%, 50% and 60% of seashell and tested by compressive strength machine after 14 days curing. The obtained values are given below.

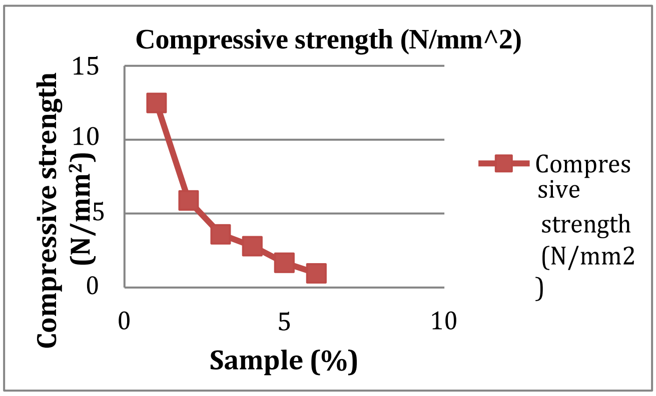


Figure 6.2 Compressive strength of sea shell PC

Table 6.3 Compressive strength of sea shell PC

No.	Sample (%)	Compressive strength (N/mm²)
1	10	12.48
2	20	5.9
3	30	3.6
4	40	2.8
5	50	1.68
6	60	0.97

Compressive strength is decreased with respect to the partial replacement of coarse aggregate from 10% to 40% .There was a significant drop in strength from 20% to 40% replacement of coarse aggregate. Compressive strength of PC with 10% replacement is almost equal to normal PC.

B. Compressive strength of soda pc

The specimen is casted by replacing coarse aggregate with 10% ,20%,30%,40%,50% and 60% of soda cap and tested by compressive strength machine after 14 days curing. The obtained values are given below.

Table 6.4 Compressive strength of Soda cap PC

No.	Sample (%)	Compressive strength (N/mm²)
1	10%	1.8
2	20%	2.13
3	30%	1.13
4	40%	0.62
5	50%	0.25
6	60%	2.13

Compressive strength is decreased with respect to the partial replacement of coarse aggregate from 10% to 40% .There

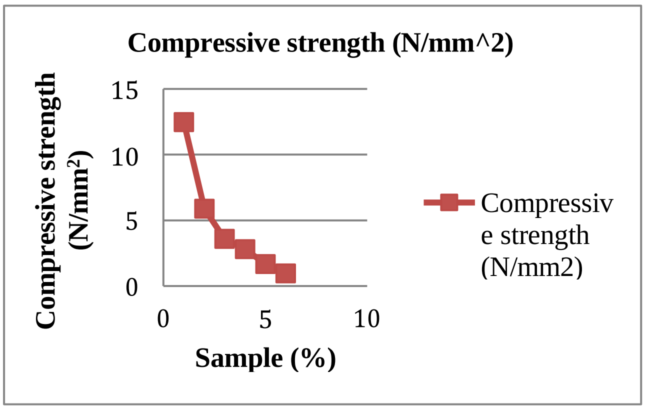


Figure 6.3 Compressive strength of Soda cap PC

C. split tensile strength test

The tensile strength of concrete is one of the basic and important properties .Split tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tensile due to its brittle nature and is not expected to resist the direct tensile forces. Thus it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members make cracks.

Table 6.5 Split tensile strength of normal PC

No.	Sample	Split tensile strength (N/mm²)
1.	Normal mix	1.20 N/mm2

a. Split tensile strength of coconut shell PC

The specimen is casted by replacing coarse aggregate with 10%, 20%, 30%, 40%, 50% and 60% of coconut shell and tested by split tensile strength machine after 14 days curing. The obtained values are given below.

Table 6.6 Split tensile strength of coconut shell PC

No.	Sample (%)	Split tensile strength (N/mm²)
1	10	0.67
2	20	0.25
3	30	0.19
4	40	0.14
5	50	0.125
6	60	0.1

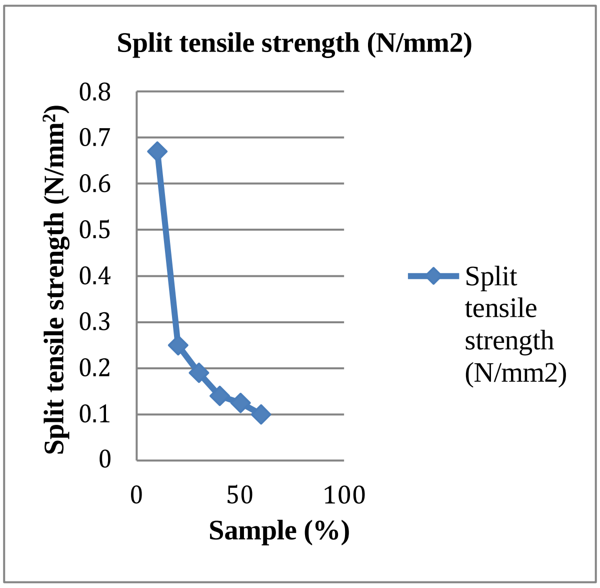


Figure 6.4 Split tensile strength of coconut shell PC

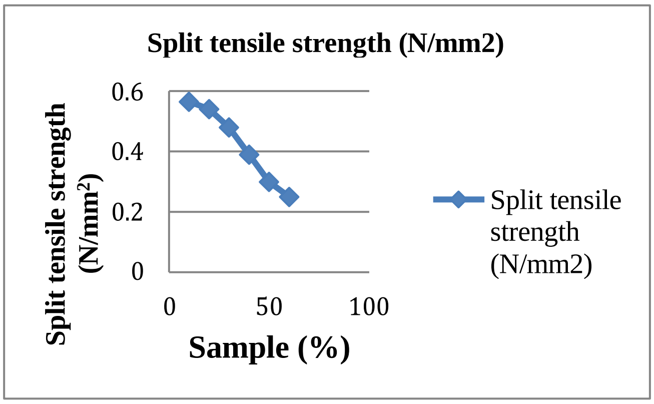
Split tensile strength is decreased with respect to the partial replacement of coarse aggregate from 10% to 60% .There was a significant drop in strength from 10% to 20% replacement of coarse aggregate.

b. Split tensile strength of sea shell PC

The specimen is casted by replacing coarse aggregate with 10%, 20%, 30%, 40%, 50% and 60% of seashell and tested by split tensile strength machine after 14 days curing. The obtained values are given below.

Table 6.7 Split tensile strength of sea shell PC

No.	Sample (%)	Split tensile strength (N/mm^2)
1	10	0.565
2	20	0.54
3	30	0.48
4	40	0.39
5	50	0.33
6	60	0.25



replacement of coarse aggregate. The strength is gradually decreasing from 10 % to 60%.

c. Split tensile strength soda caps of PC

The specimen is casted by replacing coarse aggregate with 10%, 20%, 30%, 40%, 50% and 60% of soda caps and tested by split tensile strength machine after 14 days curing. The obtained values are given below.

Table 6.8 Split tensile strength of soda cap PC

No.	Sample (%)	Split tensile strength (N/mm^2)
1	10	0.565
2	20	0.54
3	30	0.48
4	40	0.39
5	50	0.33
6	60	0.25

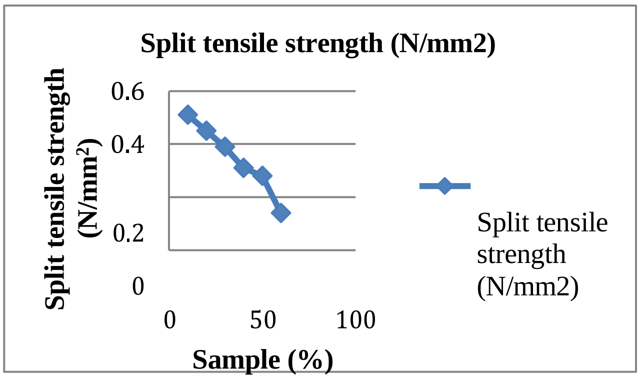


Figure 6.6 Split tensile strength of soda cap PC

Split tensile strength is decreased with respect to the partial replacement of coarse aggregate from 10% to 60% .There was significant drop in strength from 50% to 60% replacement of coarse aggregate. And almost straight line obtained from 10% to 40%.

C. *Permeability*

Permeability mainly depends on the size of interconnected pores. The cube specimen is tested by permeability testing machine after 14 days curing. Constant head method was done and results are shown in below.

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a. Coefficient of permeability (K) of Coconut shell PC

Table 6.9 Coefficient of permeability (K) of Coconut shell PC

Sample(%)	K (mm/sec)
10	0.39
20	0.38
30	0.40
40	0.43
50	0.46
60	0.50

As the percentage of coconut shell increases the permeability also increases.

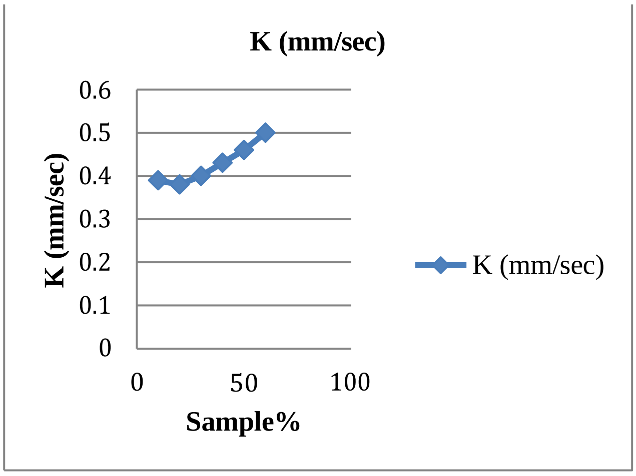

Table 6.11 Coefficient of permeability (K) of Soda cap PC

Sample (%)	K (mm/sec)
10	0.39
20	0.50
30	0.51
40	0.53
50	0.56
60	0.60

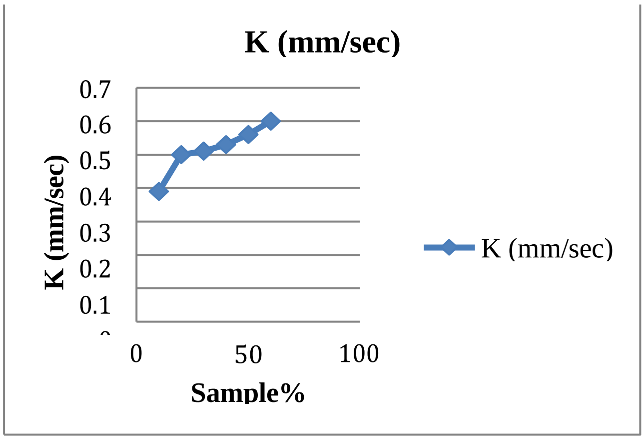

Figure 6.9 Permeability of Soda cap

Figure 6.7 Permeability of coconut PC

b. *Coefficient of permeability (K) of sea shell PC*

Table 6.10 Coefficient of permeability (K) of sea shell PC

Sample(%)	K (mm/sec)
10	0.53
20	0.56
30	0.58
40	0.62
50	0.66
60	0.69

Coefficient of permeability increases with increase in percentage of sea shell.

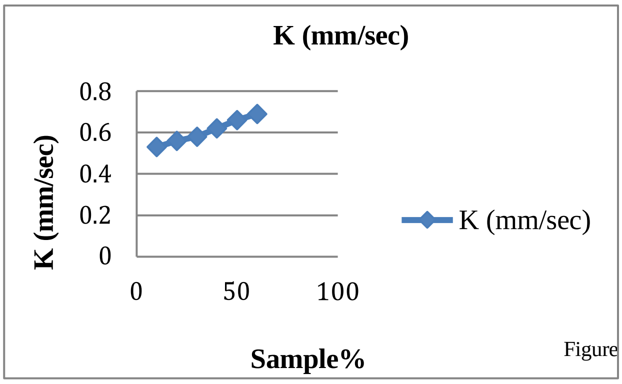

Figure 6.8 Permeability of sea shell PC

CONCLUSION

Compressive strength of coconut pervious concrete is decreased with respect to the partial replacement of coarse aggregate from 10 % to 20%.And there was a significant drop in strength at 10 % replacement of coarse aggregate. But in the case of pervious concrete made with sea shell, compressive strength is decreased with respect to the partial replacement of coarse aggregate from 10 % to 40%. And there was a significant drop in strength from 20 % to 40 % replacement of coarse aggregate. From the data its clear that, compressive strength of pervious concrete with 10 % replacement is almost equal to normal pervious concrete.

The percentage decrease in compressive strength in pervious concrete is 50 to 75% compared with conventional concrete. The percentage decrease in split tensile strength in pervious concrete is 45 to 50% compared with conventional concrete. The percentage of void ratio is increased to 4% in pervious concrete as compared with conventional concrete. So that the permeability also high. Density is 30% decreases in pervious concrete compared with conventional concrete. By observing the all parameters comparing between pervious concrete and conventional concrete both are quite different.

The strength and hydraulic properties of pervious concrete containing two aggregate sizes of different aggregate content, without any fine aggregate and admixtures, were investigated in this paper. The experimental investigations were carried out to determine the compressive strength, split tensile strength, flexural strength, porosity, and permeability. Ten different pervious concrete mixes were tested. The compressive strength, split tensile strength, and flexural strength values change with aggregate content and aggregate sizes. The compressive strength, split tensile strength and flexural strength values varied from 5 N/mm^2 to 16 N/mm^2, 1.15 N/mm2 to 1.7 N/mm^2, and 1.88 N/mm^2 to 3.21 N/mm^2, respectively, for two aggregate sizes with different mixes. It was established that porosity varies between 20.95 % to 28.26 %, and permeability between 8.60 mm/sec to 19.80 mm/sec. The increase in porosity leads to an increase in permeability and decrease in compressive strength. An optimum aggregate to cement ratio of 4:1 was obtained for both S1 and S2 aggregate types. From the curves obtained at this selected mix ratio of 4:1, an optimum result for the S1 aggregate type was obtained at the porosity of 22 %, compressive strength of 12 N/mm^2, and permeability of 12 mm/s. Similarly, the optimum result for the S2 aggregate type was obtained at the porosity of 23 %, compressive strength of 10 N/mm^2, and permeability of 16 mm/s. Based on experimental results, it can be concluded that, when runoff collection is of primary concern and strength is not a governing issue, the use of pervious concrete can be regarded as a suitable and sustainable choice in various storm water management application.

The applications of pervious concrete are: low-volume pavements and parking lots volume pavements and parking lots .Residential roads, alleys, and driveways Residential roads, alleys, and driveways, sound barriers, Slope stabilization structures, Sidewalks and pathways. Patios, tennis courts, swimming pool decks Patios, tennis courts, swimming pool decks .Pavement edge drains and gutters, Pavement edge drains and gutters , Seawalls, reefs and other hydraulic structures

From the previous work done on Pervious Concrete and advantages integrated concludes that pervious concrete can be used efficiently as building material. And by performing test such as Vebe, Slump test and Compassion Test accurate material for construction can be designed. Further plasticizer can also be used to increase the strength of the material. Since the mixture is porous in nature therefore strength issues are of main concern. Building cannot sustain unless the strength is present. Therefore, material such as steel fiber and plasticizer can be used to increase the strength.

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