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A Laboratory Study of Mechanical Properties of Pervious Concrete as A Pavement Material by Partial Replacement of GGBS in Cement with Addition of Cellulose Fibers

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Abstract: Among all the transportation systems roadways is most typically used transportation system. but in present scenario roads faces plenty of issues like potholes, cracks and plenty of other distresses. Not even these however water is additionally the main enemy to the pavement that causes deformations and changes the feel of subgrade soil leading to giant variation in performance. The total impervious Surface amendment (ISC) for Asian nation between 2000 and 2010 is 2274.62 km2 . This is one of the foremost significant issues thanks to speedy urbanization wherever there's a tremendous increase in construction of black topped and differing kinds of impervious pavements. This has associate adverse result on the setting because the storm water becomes stagnant over the surface of the pavement thanks to inadequate emptying conditions. The necessity for reducing stagnation and therefore the surface runoff has given the origination of pervious pavements surface. pervious concrete pavement may be a special style of its kind with high consistence with no or borderline fines which permit water to percolate through it and therefore the water that is accumulated over the surface ought to be collected and might be used for numerous purposes and basic wants. The present work studied the mechanical properties, sturdiness and permeability of pervious concrete of combine 1:3 mixture cement magnitude relation. The management combine is altered by partially replacing 30% of cement with Ground Granulated Blast furnace slag (GGBS), enclosed cellulose fibres of fifty of weight of the building material material and combination of each in one combine and compared the results obtained. The properties like compressive strength, porousness, indirect strength, flexural strength, are assessed by acting tests. it absolutely was discovered that there's a rise in Compressive Strength, Split strength, Flexure Strength and reduce within the permeability within the altered pervious concrete mixes when put next to the pervious concrete with no additives.

I. INTRODUCTION

Pavements are the hard and smooth bedded surface that allows or bear travel in a section. There are 2 varieties of pavements based on design considerations.

1) Flexible Pavement
2) Rigid Pavement

A. Rigid Pavement

The design of rigid pavement is predicated on providing a structural cement concrete slab of sufficient strength to resists the hundreds from traffic. The rigid pavement has rigidity and high modulus of elasticity to distribute the load over a comparatively wide space of soil. Minor variations in subgrade strength have very little influence on the structural capability of a rigid pavement. within the design of a rigid pavement, the flexural strength of concrete is that the major factor and not the strength of subgrade. due to this property of pavement, once the subgrade deflects below the rigid pavement, the concrete slab is in a position to bridge over the localized failures and areas of inadequate support from subgrade because of slab action.

B. Flexible Pavement

Flexible pavement is defined because the one consisting of a combination of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of appropriate quality in layers over the subgrade. Water certain macadam roads and stabilised soil roads with or while not mineral toppings area unit samples of flexible pavements. The design of flexible pavement is predicated on the principle that for a load of any magnitude, the intensity of a load diminishes because the load is transmitted downwardly from the surface by virtue of spreading over an increasingly larger space, by carrying it deep enough into the bottom through successive layers of granular material.

C. Pervious Concrete

Pervious concrete is outlined as an open graded or "no-fines" concrete that permits rain water to percolate through to the underlying sub-base [1]. The principal ingredients are quite similar to typical concrete: mixture, cement, admixtures, fine mixture (optional), and water. the main distinction is that the proportion of void space at intervals pervious concrete. Typical ranges of void area area unit between 15-25 nada [12]. The costs of asphalt pavements can grow the approaching years due to the predictable increase in oil costs. receptive Concrete is so an acceptable material to be thought-about for inflated usage within the developing property pavement. the foremost of the road roads area unit cement concrete roads that posses the strength over they need as majority of the road roads carry considerably low volume. The black topped roads can not be laid there because it needs additional work space in comparison to the cement concrete road and therefore the value of construction is high. At such places we will use these sustainable utile pavements like pervious concrete pavement.

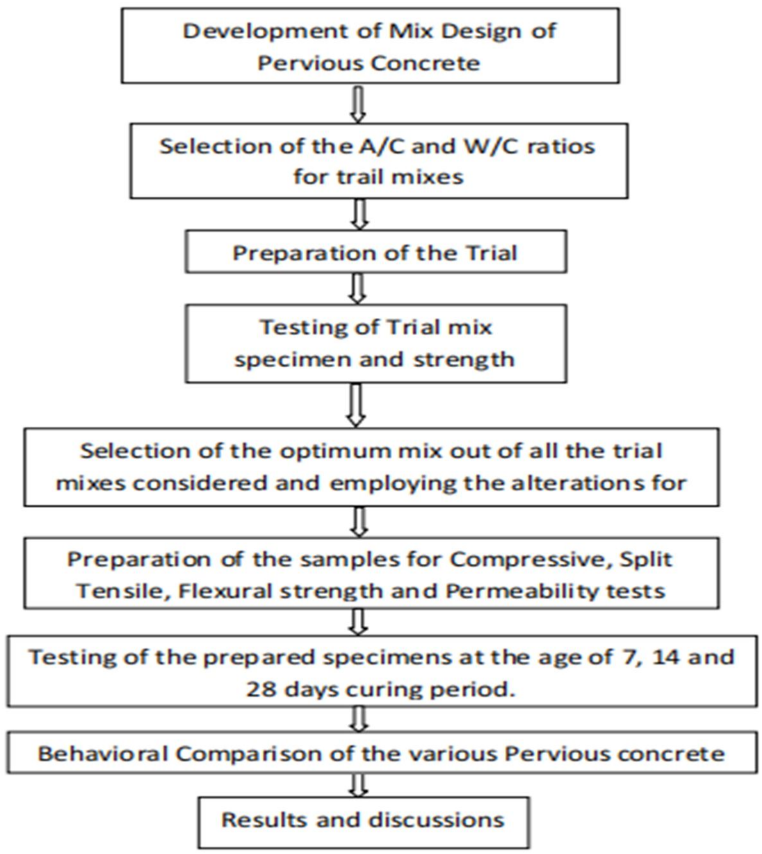
To create a pervious concrete pavement, the receptive concrete is placed on high of an aggregate base. this permits the impediment of the soil from percolating or penetrating up and impeding the pores of the concrete .Most of the cases the only sized coarse aggregates is employed. the only sized aggregates build a decent pervious concrete, which in addition to having giant voids and thus light in weight, conjointly offers architecturally engaging look. The single-sized coarse aggregates area unit enclosed and command along by a skinny layer of cement paste giving strength of concrete. the benefits of this sort of concrete area unit lower density (1600- 2000 kg/m3), lower value due to lower cement content, lower thermal conductivity, relatively low drying shrinkage, no segregation and capillary movement of water, better insulating characteristics then typical concrete owing to the presence of huge voids .The bond strength of pervious concrete is extremely low and, therefore, reinforcement isn't utilized in conjunction with pervious concrete.

II. REVIEW OF LITERATURE

1) Malhotra.V.M (1976) discussed pervious concrete as it relates to applications and properties. He also conducted multiple experiments on various test cylinders in an attempt to find a correlation between compressive strength and any of the material's properties. He concluded that the compressive strength of pervious concrete was dependent on the water cement ratio and the aggregate cement ratio. He also concluded that even the optimum ratios still would not provide compressive strengths comparable to conventional concrete.
2) Ghafoori Nader and S.Dutta (1995) conducted extensive research on various aspects of pervious concrete. He investigated various sites that have utilized pervious concrete paving systems. His investigation led to a comparison of compressive strength attained at each of these sites. He also examined failures in the various pavements if any had occurred along with the water cement and aggregate cement ratios. He deduced that compressive strength depends on the water cement ratio, the aggregate cement ratio, compaction, and curing. He also provided a chart which displays the effects of varying the aggregate cement ratio and compaction energy have on the compressive strength and permeability. The conclusions drawn as a result of these experiments indicated pervious concrete is comparable to conventional concrete when considering shrinkage and depth of wear.
3) Paul Klieger (2003) performed experiments studying the effects of entrained air on the strength and durability of conventional concrete. Although never utilizing the amount of voids seen in pervious concrete (15%-35%), his research clearly shows the impact of the presence of air has on the performance of concrete. He concluded that the reduction in compressive strength with the presence of air decreases as the size of aggregate decreases and as the cement content decreases.
4) Darshan Shah and Jayesh Kumar (2014) carried out an experimental study on hardened properties of pervious concrete. Micro fibers and admixtures were used to achieve adequate strength and durability of pervious concrete. Pervious Concrete has been casted with different concrete mix proportion such as 1:6, 1:8 and 1:10 with 18.75 mm and 9.375 mm gravel size using OPC 53 Grade and PPC Cement. Through their studies, it was concluded that pervious concrete made with smaller size of gravel (i.e. 9.375 mm) with 1:6 concrete mix proportion and with OPC 53 grade cement exhibited highest compressive strength (12.71N/mm2) and highest flexural strength (1.91 N/mm2)compared to any other mix proportion.
5) Huda Nema Khalifa (2015) discussed the effect of Adding Cellulose as Fiber and Crystal on Some Mechanical Properties of Concrete. The cellulose may work as super plasticizer which acts to lower the rate of water absorption and influence positively the strength and the elasticity. The test specimens was of standard cubic, the percentage of the improvement for the concrete when it was evaluated according to the standard concrete was 14 % for cellulose fiber and 6.5% cellulose crystal, and due to the improvement in the elasticity for fiber additive, it may work properly under the loading condition comparing to concrete standard specimen, while crystal improve the workability. It was found that the best percentage was found as 5% after 28 days curing period.

6) Selvaraj. R, Amirthavarshini. M (2016) carried out research on enhanced porous concrete and determined a method to quantify the permeability of pervious concrete. This research gives an in depth study of pervious concrete though it appears a simple method of casting and laying The larger the size of coarse aggregate, the larger the total void ratio Cube compressive strength and the flexural strength of pervious concrete drops down as the size of coarse aggregate is increased. Addition of sand will improve the mechanical strengths but at the same time the hydraulic conductivity will be reduced. The hydraulic conductivity increases as the size of coarse aggregate is increased.

III. METHODOLOGY



IV. CHARACTERISTICS OF MATERIAL USED

A. *Cement*

Cement could be a (binder, a substance that sets and hardens severally, and may bind alternative materials along. The word "cement" traces to the Romans, who used the term opus caementicium to explain masonry resembling trendy concrete that was made of crushed rock with burnt lime as binder. The volcanic ash and pulverized brick additives that were extra to the burnt lime to get a hydraulic binder were later observed as cementum, cimentum, cäment, and cement.

B. *Coarse Aggregates*

The material that is maintained on BIS check sieve range 4 (4.75mm) is termed as coarse aggregate. The broken stone is usually used as a stone combination. the character of work decides the maximum size of the coarse combination. domestically available coarse combination having the maximum size of 20mm was utilized in this work. usually observed as gravel it unremarkably consists of a distribution of particles, the minimum size being close to 3/8 in. in diameter and the most being outlined or restricted by the dimensions of the finished structure. A common maximum size for coarse combination in structural concrete is 1.5 inches.

C. Water
Water is a crucial ingredient of concrete because it actively participates within the chemical process with cement. Since it helps to create the strength giving cement gel, the standard and amount of water is needed to be looked into very rigorously. portable water is usually thought-about satisfactory. in the present investigation water was used for each mixing and curing functions.

D. Admixtures
"Chemical admixtures" are added to attain varied properties. These ingredients might speed or hamper the speed at that the concrete hardens, and impart several alternative helpful properties. "Mineral admixtures" are getting additional common in recent decades. the employment of recycled materials as concrete ingredients has been gaining popularity due to progressively strict environmental legislation, and therefore the discovery that such materials usually have complimentary and valuable properties. the foremost vital of those are fly ash, a byproduct of coal-fired power plants, and microsilica/silica fume, a by-product of commercial electric arc furnaces, Metakolin, GGBS from industry. the use of those materials in concrete reduces the quantity of resources needed because the ash and fume acts as a cement replacement. This displaces some cement production, associate energetically overpriced and environmentally problematic method, while reducing the quantity of commercial waste that has to be disposed in landfills.

V. EXPERIMENTAL INVESTIGATIONS

A. Compressive Strength Test
The following check procedure was undertaken throughout the compression test:
1) The checking of test specimens was undertaken as soon as possible when being removed from the curing tank.
2) The plates were cleansed when necessary to make sure no obstruction from little particles or grit. Any loose particles were removed from the uncrowned bearing surfaces of the specimens.
3) A force was applied at the desired rate shown by the rotating disc on the testing machine.
4) The maximum force applied to the cylinder was recorded and also the compressive strength calculated.

B. Indirect Tensile Test:
The procedure used to conduct the indirect tensile check follows:
1) The diameters of specimen within the plane in which it's being tested similarly because the lengths where the bearing strips are in touch were determined.
2) The bearing strips between the testing rig and also the test specimen were aligned.
3) The force was at the desired rate without shock (shown on inner disc of machine).
4) The most force applied to the concrete before failure was recorded.
5) The fracture type and look of concrete was additionally recorded.

C. Permeability Test
The following testing procedure was undertaken throughout the porosity test:
1) For every mix, using a identical cylindrical specimens were tested below falling head for water permeability permeability using a check created 150 mm diameter check cylinders 300mm. before the porosity check, the water was allowed to run freely through the specimen and the specimens were tapped to unleash the entrapped air within the specimens.
2) The water porosity check was conducted on every cylinder for 15cm falling head.
3) The check was continual for 3 times to boost the accuracy of the results.

D. Flexural Strength Check
The following testing procedure was undertaken throughout the flexural strength testing:
1) Prepared specimens shall be standing operating procedure by moldings concrete to a beam section, curing and storing in accordance with operating procedure. The section of the beam shall be sq. of 100 metric linear unit. The overall length of the specimen shall be 500mm.
2) The load shall be applied through 2 similar rollers mounted at the third points of the supporting span spaced at 13·3 crn centre to centre.
3) The specimen hold on in water shall be tested straight off on removal from water; while they are still wet. The check specimen shall be placed within the machine properly targeted with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be traditional to the direction of loading.

E. Young's Modulus check

The following testing procedure was undertaken throughout the modulus of physical property testing:

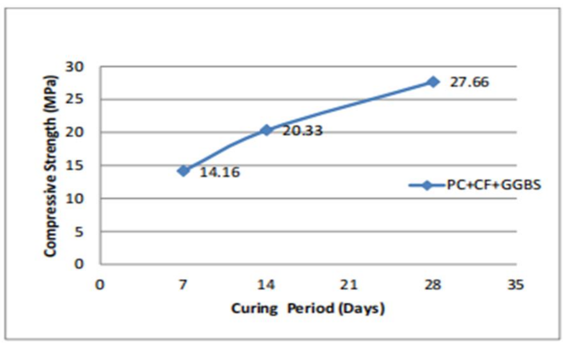
1) The initial dimensions of the specimen area unit determined before it's placed below compression testing machine.
2) The load is applied step by step on the specimen and also the load is noted down for each zero.05mm deformation.
3) The series of readings area unit taken for getting the relation between stress and strain.
4) The strain is obtained by dividing the dial gauge reading with the gauge length and stress is calculated by dividing the corresponding stress values with the cross section space.

VI. ANALYSIS OF TESTS

A. Compressive strength of Pervious Concrete with both Cellulose fiber and GGBS

The Compressive strength of Pervious Concrete with both Cellulose fiber and GGBS was calculated and the corresponding mean strength was tabulated.

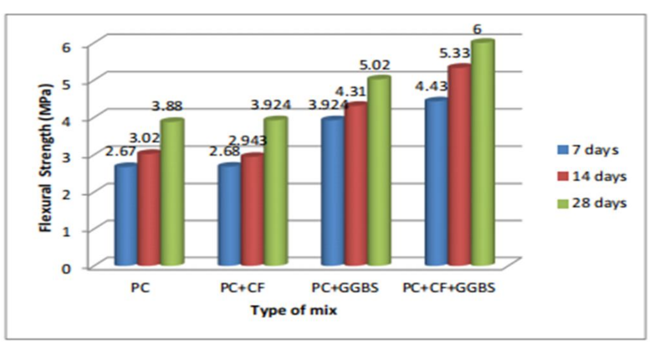
Curing period (Days)	Compressive Strength (MPa)
7	14.16
14	20.33
28	27.66



B. Flexural strength of Pervious Concrete with both Cellulose fiber and GGBS

The Flexural strength of Pervious Concrete with both Cellulose fiber and GGBS was calculated and the corresponding mean strength was tabulated in Table 5.13. The variation of the Flexural strength with curing period was plotted.

Curing Period (Days)	PC (MPa)	PC+CF (MPa)	PC+GGBS (MPa)	PC+CF+GGBS (MPa)
7	2.67	2.68	3.924	4.43
14	3.02	2.943	4.31	5.33
28	3.88	3.924	5.02	6



C. Comparison of Modulus of Elasticity

The Modulus of Elasticity of Pervious Concrete with Cellulose fiber, Pervious Concrete with GGBS and Pervious Concrete with both GGBS and Cellulose fiber are tabulated in table and compared with that of the Pervious Concrete with no additives. The figure depicts the variation of Modulus of Elasticity of various mixes with 28 day curing period.

Curing Period (Days)	PC (GPa)	PC+CF (GPa)	PC+GGBS (GPa)	PC+CF+GGBS (GPa)
28	20.000	20.347	30.666	31.111

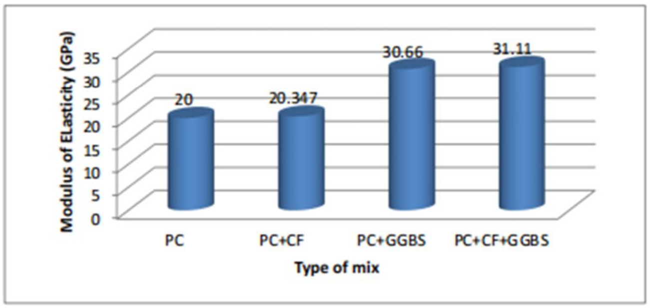
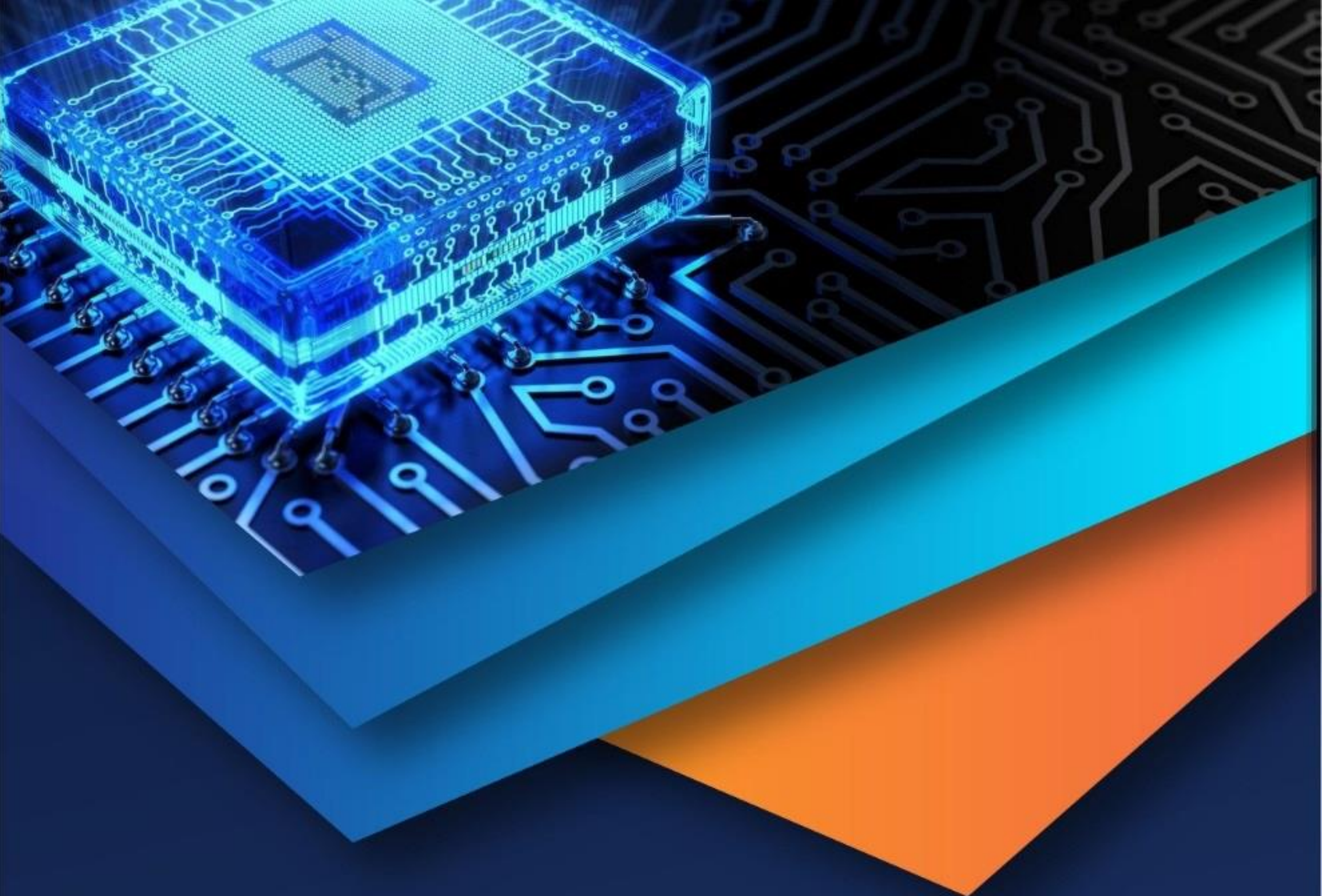


Fig 5.17.Comparison of 28 day Modulus of Elasticity

VII. CONCLUSION

From the experimental study following conclusions were obtained:

1) The trial mix with Aggregate-Cement ratio 3:1 and with water-cement ratio of 0.3 is observed to be the mix with highest strength of all the considered 12 trial mixes.
2) For Compressive strength, it was observed that there was an increment of 3.90% in case of Pervious Concrete with Cellulose fiber, 6.41% in case of Pervious Concrete with GGBS and 12% in Pervious Concrete with both Cellulose fiber and GGBS when compared to that of Pervious Concrete with no additives at 28 days curing period.
3) For Split Tensile strength, it was observed that there was an increment 3.73% in case of Pervious Concrete with Cellulose fiber, 5.59% in case of Pervious Concrete with GGBS and 16.04% in case of Pervious Concrete with both Cellulose fiber and GGBS when compared to that of Pervious Concrete with no additives at 28 days curing period.
4) For Flexural strength, it was observed that there was an increment of 1.13% in case of Pervious Concrete with Cellulose fiber, 29.31% in case of Pervious Concrete with GGBS and 54.63% in case of Pervious Concrete with both Cellulose fiber and GGBS when compared to that of Pervious Concrete with no additives at 28 days curing period.
5) For Coefficient of Permeability, it was observed that there was an decrement of 4.73% in case of Pervious Concrete with Cellulose fiber, 2.19% in case of Pervious Concrete with GGBS and 5.66% in case of Pervious Concrete with both Cellulose fiber and GGBS when compared to that of Pervious Concrete with no additives at 28 days curing period.
6) For Modulus of Elasticity, it was observed that there was an increment of 1.7% in case of Pervious Concrete with Cellulose fiber, 53.33% in case of Pervious Concrete with GGBS and 55.55% in case of Pervious Concrete with both Cellulose fiber and GGBS when compared to that of Pervious Concrete with no additives at 28 days curing period.
7) From the investigation it was observed that the Pervious Concrete mix with both Cellulose and GGBS is found out to be the best altered mix among all the considered Pervious Concrete mixes in this study. 8. From the study it was observed that there is a significant increase in the strength of Pervious Concrete when 30% of the cement is partially replaced with GGBS. There was also no considerable decrease in the permeability.



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