iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** III **Month of publication:** March 2023

DOI: https://doi.org/10.22214/ijraset.2023.49498

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

Laboratory Experimental Studies on Previews Concrete Pavements

Vinayaka G C
Department of Civil Engineering Dayananda Sagar College Of Engineering, Visveshvaraya Technological Univarsity India, Banglore

Abstract: Pervious concretes are sp ecial type of concrete gaining attention because of their environmental benefits. These are concretes generally having 15 to 35% voids and they are considered as eco friendly materials. The strengths of the pervious concrete are lower than conventional concrete due to their higher porosity. They are generally made up of coarse aggregates, cement and without or with small amount of fine aggregates. They are considered as sustainable material it has may environmental benefits like storm water management, ground eater recharge, mitigation the urban heat island effects, many traffic related benefits such as noise reduction improving skid resistance etc. These are generally adopted in low traffic areas such as foot paths, parking lots etc. because of their lower strength. Being an eco friendly materials research researches are carried to improve the strength so that they can be used for pavement.

I. INTRODUCTION

Roads are the important assets of the nation which influences the economy and development of the nation. In all its aspects such as walking, riding in passenger cars, carrying goods in commercial vehicles and goods vehicles, providing mobility services, and parking, pavements are critical to transportation. Pavements cover the large percentage of lands in the cities. There are two different types of the pavements such as flexible pavements which are surfaced with bituminous materials and they are flexible in nature and rigid pavements are surfaced with Portland cement concrete and are stiffer than flexible pavements. The existing flexible pavements absorbs large amount of heat and which increases the temperature of local air and environment. This effect in which the temperature of urban areas is high when compared to surrounding rural areas is termed ad urban heat island effects. These urban heat islands are mitigated by using special type of concrete pavements called as " Pervious Concrete Pavements". These are the different concrete material for pavement and it has also other advantages such as in managing storm water percolation and improving ground water quality.

A. Pervious Concrete Pavements

OverviewPervious concrete is different and special type of concrete which is prepared by using only coarse aggregates of typically 9.5mm and 12mm, cement, water and little amount of fine aggregates or without fine aggregates and admixtures. The pervious concrete has higher amount of interconnected pore structure and hence having higher porosity. The voids contents in the pervious concrete is typically ranged from 15 to 35%. Due to its higher porosity the pervious concrete has higher permeability which is the important property of pervious concrete, hence these concretes are also called as permeable concretes. The strength of the pervious concretes is normally lesser than that of the conventional concretes because of its high porosity.

Figure 1.1 : Pervious Concrete Specimens

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

B. History of Pervious Concrete

Main objective and motive to adopt this is cost efficiency due to decreasing in amount of cement. In 1920s it become popular in England and Scotland for two storey homes. It became increasingly effective in the Europe after the World War 2 because of the lack and scarcity of cement. It became popular in 2000 in India. This type of concrete has been in the use for more than 50 years in the countries like united states and Japan and main advantage is it prevent the pooling of water on the surfaces and supplying the rain water to plants and vegetation which affects the vegetation positively and maintains the quality of ground water. As the amount of smaller aggregate fractions increased resulted in concrete mixture having higher density and greater flexural strengths [9]. Due to its several environment benefits the use of pervious concrete in sustainable constructions continues to increase and the size of the pores of pervious concrete ranges from 2mm and up to 8mm depending on the size and type of the aggregates and compaction method [17]. Pervious concrete is an environmentally friendly material and its lower strength is due to high porosity and mechanical strengths are inversely proportional to permeability of the pervious concrete. Strength and the abrasion properties decreases as the aggregate size and ratio of aggregate to cement increases [48]. Streets and parking areas made with pervious concretes are shown in Figure 1.2

Figure 1.2 : Streets and Parking areas made with Pervious Concrete

C. Selection of Materials for Pervious Concrete

Selection of materials is important in order to achieve the required amount of inter connected pore structure. Generally aggregate gradation consisting of the single size of the coarse aggregates or secondary mixtures of the coarse aggregates and the size of aggregates will be in the range of 9.5-19 mm and in some studies 9.5 to 2.36 mm were used to improve the strengths. The cement used was OPC 53 grade conforming to ASTM C 150. Natural sand and M sand are used as fine aggregates. Recycled aggregates, admixtures, and polymers were also selected for the studies. Properties of the pervious concretes also depending on the properties and characteristics of the materials used. Many studies are carried out to select the materials and to study their effect on the properties of the pervious concrete.

D. Pervious Concrete

Pervious concrete is a different type of concrete consisting of cement, coarse aggregates, water and any admixtures and cementitious materials (if required) without any fine aggregates. Generally single size aggregates are used and they are bonded together at their points of contact by the cement paste. It can also be referred as no fines concrete, permeable concrete, open graded concrete and porous concretes. It is a special kind of concrete containing higher porosity because of no fine aggregates which allows the water to percolate through its body easily. The properties of pervious concrete varies from that of conventional concrete. The pervious concretes have lesser strengths and unit weight and higher permeability when compared to conventional concrete. The pervious concrete is mainly developed for draining the water, so that stormwater runoff is controlled and groundwater is recharged. Figure 1.3 shows the residential driveways made using pervious concretes.

Figure 1.3: Driveways made with previous concrete

The increase in growth of population and rapid urbanization leads to construction of the impervious pavements on the natural grounds which leads to changes in the surrounding temperatures and increase in storm water runoff [65] which results in necessity of the pervious pavements.
The pervious concrete is increasingly used in low impact construction activities because it is considered as a sustainable and eco friendly paving material [66]. The sizes of the interconnected pores generally ranges from 2 mm to 8mm and the void contents varies from 15% ti 40% [67].
The w/c of pervious concrete mixtures will be in the range of 0.28 to 0.40 [68] and the 28 days compressive strengths of the pervious concretes will be in the range of 3.5 to 28 MPa and coefficient of permeability 0.2 to 5.4 mm/sec [69]. The split tensile strength of pervious concrete generally ranged from 1 to 3 MPa. Generally the split tensile strength is determined by using ASTM guidelines i.e ASTM C 496 [73]. The Durability of the pervious concrete includes the abrasion resistance and freeze thaw durability. The durability of the pervious concrete depends on material properties and amount of voids present in it. In cold regions, the freezing and thawing cycles are severe. Since the pervious concretes have higher voids they will allow more water or moisture into their voids and so they are more susceptible to freezing thawing stresses and hence the durability problems of pervious concrete are different from conventional concrete. The damages caused by freezing and thawing includes surface scaling, cracking and deterioration of paste.
The freeze - thaw durability of the pervious concrete is evaluated according to ASTM C 666 [76] guidelines. Various test methods are suggested in literatures such as cantabro abrasion test, loaded wheel test and surface abrasion test and found that combined usage of latex and fiber in the pervious concrete resulted in good abrasion resistance evaluated using the above said three different methods [77].

E. Properties of Pervious Concrete

The important properties of the pervious concrete are strength properties (compressive, flexural and split tensile strengths), permeability and freeze thaw durability. The properties of the pervious concrete depends on many factors such as type binding material, type and size of aggregates, mix proportions, gradation of aggregates, voids content, w/c ratio, a/c ratio, method of compaction etc. Other properties of pervious concrete includes density, porosity and void ratio. All these properties are categorised into two groups i.e mechanical properties and hydrological properties.

F. Compressive Strength

The strengths of the pervious concrete pavements are generally lower than that of conventional concrete pavements due to their higher voids. The compressive strength of pervious concrete generally in the range of 3 to 28 MPa. The typical value or average value of the compressive strength is 20MPa. Since there is no universally accepted guidelines for testing the compressive strength of pervious concrete is determined by using ASTM C 39 [71]. We have adopted IS 516 procedure for conducting the compressive strength test. The strengths of pervious concrete depends on factors such as size and type of the aggregates, w/c, a/b, method of compaction and admixtures [70]. The strengths are improved by using smaller sized aggregates, fine aggregatets, admixtures and and supplementary cementitious materials.

II. MATERIALS AND METHODOLOGY

The pervious concretes are generally made up of the materials similar to that are used in conventional concrete. But the fine aggregate component is eliminated or used in small percentage to achieve the higher porosity. In this section the materials used for the pervious concretes and their properties are explained. The materials used for pervious concretes are cement, coarse aggregates, fine aggregates and admixtures.

A. Cement

The cement that is generally used for preparing pervious concrete is Ordinary Portland Cement (OPC) whose properties are conformed to ASTM C 150 [87]. Cement acts as binding material in the pervious concrete and plays important role in obtaining strength and durability of the pervious concrete. In this study the Ordinary Portland Cement of Grade 53 is used whose specifications are conforming to IS 11269-2013[88]. The physical properties of the cement are determined as per procedures given in IS 4031- Part 11 [89], Part 4 [98] and Part 5 [99]. The OPC 53 used in our study is shown in Figure 3.1. The physical properties of the cement are given in Table 3.1 with their limits as per IS 11269-2013 Code**.**

Figure 2.1: Ordinary Portland Cement of 53 grade used for the Study

B. Coarse Aggregates

Coarse aggregates are the major and main component of the pervious concrete. The size, shape, type and gradation and distribution of the coarse aggregate influences the properties of the pervious concrete. In compression test failure of concrete occurs at the interface of aggregate and cement paste. The pervious concretes are generally made up of large sized aggregates of sizes ranging from 19 mm to 9.5 mm so that sufficient voids can be maintained [90]. But smaller aggregates are also adopted in many studies. The properties of the coarse aggregates that are used for pervious concretes should be conformed to ASTM C 33 [91] and ASTM D 448 [92].

Figure 2.2: Coarse Aggregates and Cement used for the Study

The physical properties of the coarse aggregates adopted in the study are given in Table 3.2 which satisfies the specifications as per IS 2386 – Part 1 [93], Part 3 [100] and Part 4 [101].

C. Methodology

The methodology for the study was developed so as to conduct the research in orderly manner. The developed methodology includes various stages which includes test on materials, casting, curing and testing of pervious concrete etc. The various processes and the methodology adopted is explained in the flowchart.

D. Analysis Performed

The data of the various tests conducted on pervious concretes are collected and they are evaluated to find the effects of SCMs and steel slag on the properties of pervious concrete. Regression analysis was performed on the data to get best fit line between the various properties of the pervious concrete. The relationships among the properties of pervious concretes are also determined.

III. EXPERIMENTAL PROGRAMME

The pervious concrete mix proportions are calculated by adopting the mix design procedure given in IRC 44 - 2017 code book. The mix design is calculated using the material properties. First we have worked out and tested the trail mix of pervious concrete. The mix design calculations were given in the IRC 44-2017 for M10 concrete. We have studied this mix as trial mix. T he mix proportion values for the trail mix for both without fine aggregates pervious concrete and with 5% fine aggregate pervious concrete.

In IRC 44 -2017 the values are given for mix design of pervious concrete up to M20 grade. We have attempted to design M30 grade pervious concrete by taking IRC 44- 2017 as reference and to study their properties by incorporating the admixtures and SCMs mentioned in chapter 3.

The detailed calculations of the mix design are given in appendix A (4.1). The mix design values for M30 grade pervious are given in Table and the details of mixes studied with replacement of alccofines and steel slag.

A. Casting of Pervious Concrete Specimens

The stepwise procedure adopted for casting the pervious concrete specimens is explained. The specimens were cast as per IS 516 – 1959 [97] specifications. Firstly calculated the amount of cement, aggregates, admixtures and water in kg depending on the size of the specimen. All the ingredients are placed on clean tray and thoroughly mixed in dry condition to get homogeneous mix and then water is added slowly and mixed thoroughly so that it forms the uniform mix. Mixing was done manually. Moulds are oiled properly and are filled with concrete in three layers and each layer is given 25 blows and vibrated for 30 seconds using table vibrator. After 24 hours samples are removed from the mould and placed for curing in curing tank. We have tried gunny bag curing and water curing both for trial mix and selected the water curing for the study. We have casted cube specimens of 150mm x 150mm x 150mm for both compressive strength and permeability test, 3 cubes for each. The specimens were tested at 7 and 28 days according to Indian standard guidelines. The various stages of casting of pervious are shown in Figure 4.1. The Figure 4.1 (a,b) shows mixing of concrete, Figure 4.1 (c, d) shows compaction of concr ete by tamping rod, Figure 4.1 (e, f) shows pervious concrete specimens which are in the mould and removed from the mould after 24 hours and Figure 4.1 (g, h) shows curing of concrete which shows water curing and gunny bag curing.

Figure 3.1 : Mixing of Pervious Concrete

Figure 3.2 : Compaction of Pervious Concrete

Figure 3.3 : Pervious Concrete Specimens and Curing of Pervious concrete

B. Testing on Pervious Concrete

Various test are conducted on pervious concrete to determine their properties. The tests are conducted as per codal specifications. The tests such as compressive strength test, permeability test were conducted in this study. Also the workability, density and void content of the pervious concretes are also determined. The various tests conducted and their details are explained in this section. Compressive strength of the concrete is defined as the capacity of the concrete to withstand breaking.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

C. Permeability Test

Permeability is the important property of the pervious concrete. The permeability is defined as the rate of flow of water through the interconnected voids of the pervious concrete. The permeability of the pervious concrete was determined using procedure provided in IRC 44 and we used falling head permeameter for the test which is shown in Figure 4.3. The permeability test is conducted on cube specimens of the pervious concrete. The specimen should tested in wet condition i.e the specimen should be pre wetted before testing. Known volume of water is allowed to infiltrate through the specimen and time taken is recorded.

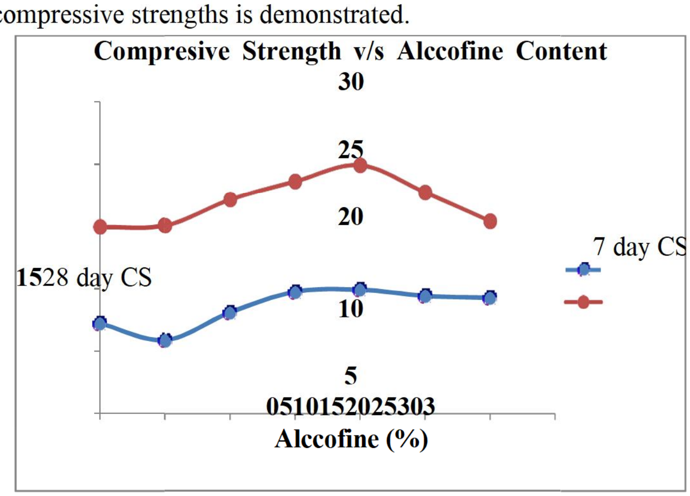
Figure 3.4: Permeability Test Apparatus

IV. ANALYSIS AND RESULTS

The cement is replaced by alccofines and steel slag. The effect of alccofines and steel slag on the properties of pervious concrete are explained in this section. The test results values of all the properties are presented of Appendix A.

A. Compressive Strength

The 28 day compressive strength of pervious concretes is in the range of 20.105 Mpa to 24.98 MPa for alccofine replacement and 19.75 MPa to 21.96 Mpa for steel slag replacement. The Figure 5.1, 5.2, 5.3 and 5.4 shows the results of the compressive strength test. The compressive strength increased with the alccofine and steel slag content up to 20% allcofine and 15% steel slag and then started decreasing with alccofine and steel slag content. The variation of compressive strength with alccofine and steel slag contents are shown in Figure 5.1 and 5.3. The highest strength value obtained is 24.98 MPa at 20% alccofine and 21.96 at 15% steel slag. The Comparison of 7day and 28 day compressive strengths is demonstrated.



International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

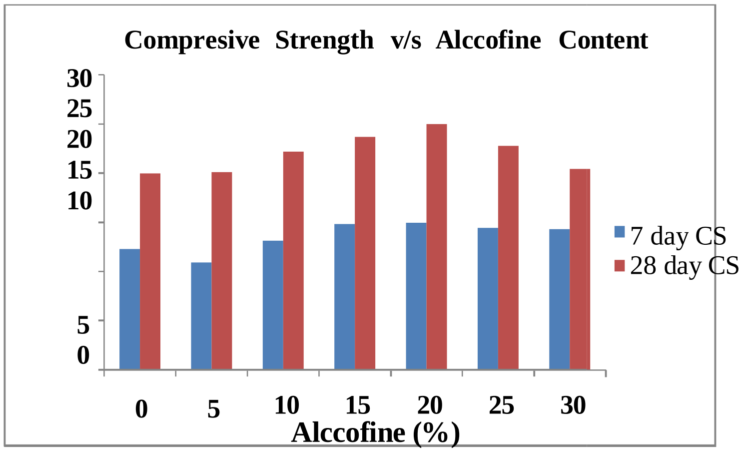


Figure 4.1: Comparison of 7 day and 28 day Compressive Strength of Pervious Concrete Containing Alccofines

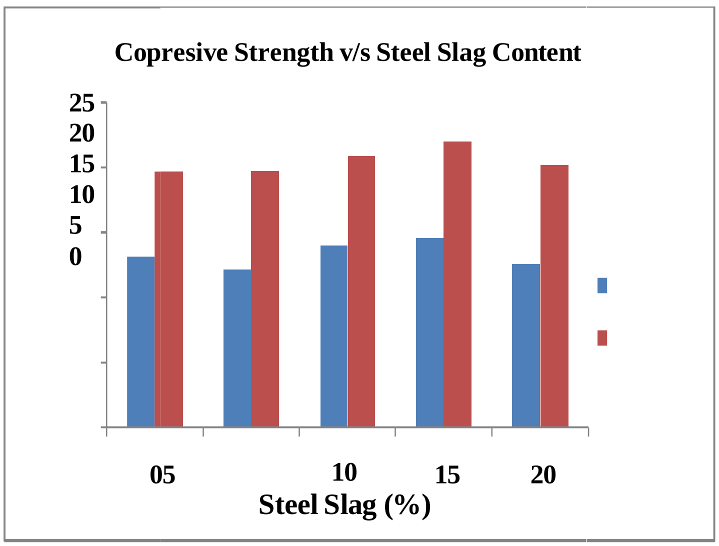


Figure 4.2: Comparison of 7 day and 28 day Compressive strength of Pervious Concrete Containing Steel Slag.

B. Flexural Strength

The 28 day Flexural strength of pervious concretes is in the range of 4.168 Mpa to 4.486 Mpa for alccofine replacement and 3.111 MPa to 3.280 Mpa for steel slag replacement.

The Figure 5.5 and 5.6 shows the results of the flexural strength test. The Flexural strength increased with the alccofine and steel slag content up to 20% allcofine and 15% steel slag and then started decreasing with alccofine and steel slag content. The highest strength value obtained is 4.486 MPa at 20% alccofine and 3.280 MPa at 15% steel slag.

The effects of alccofines and steel slag on the compressive strength, permeability, porosity and density are explained. Also the relationships among the various properties of the pervious concretes are developed by regression analysis. The permeability values of pervious concrete ranged from 5.198 mm/sec to 5.75 mm/sec for alccofine replacement and from 4.28 mm/sec to 5.05 mm/sec which is shown in Figure 5.7 and 5.9.

The variation of permeability with alccofine and steel slag content is shown in Figure 5.8 and Figure 5.10 and it is observed that the permeability of pervious concrete decreased with increase in alccofine and steel slag content. Also it is observed that the permeability values obtained from the test were close to the designed value, there is no much deviation and they are in the permissible range for the pervious concretes.

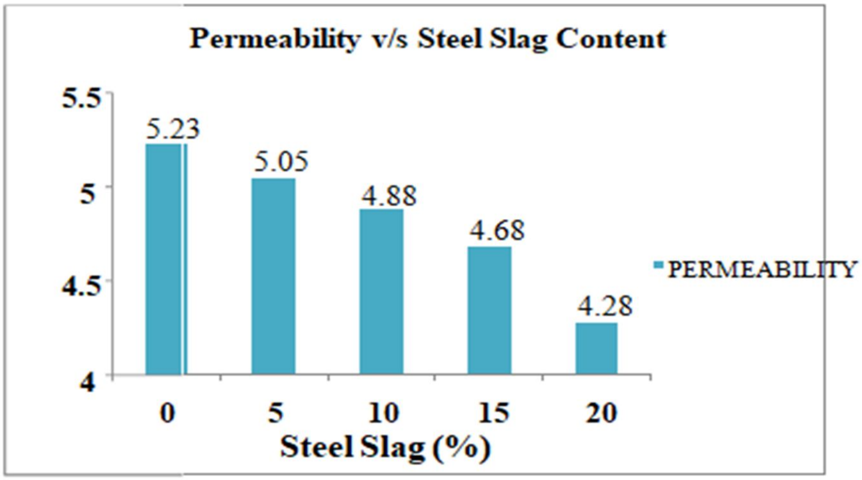
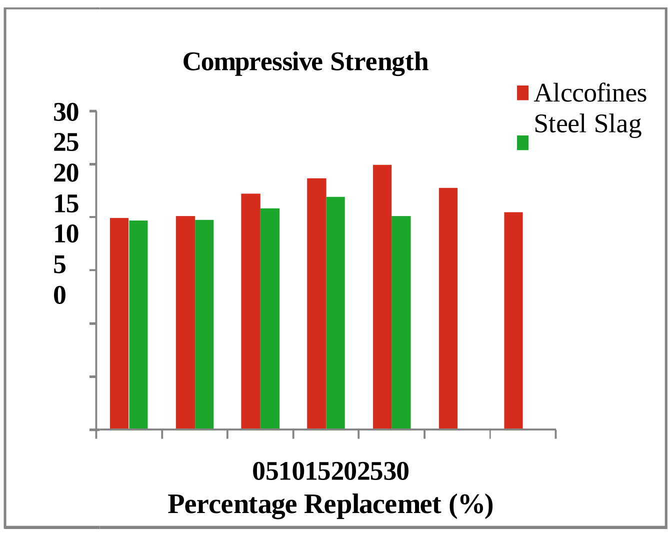


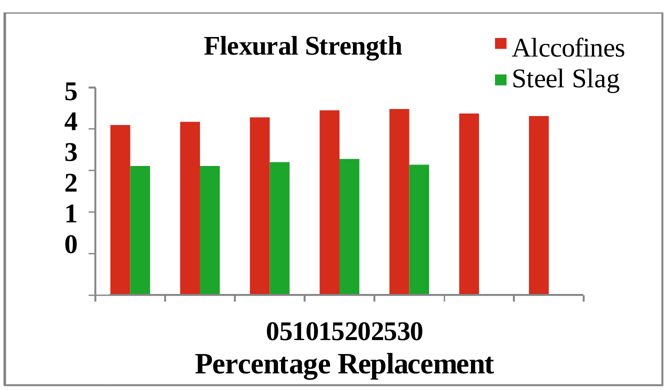
Figure 4.2: Permeability values of Pervious Concrete Containing Steel Slag

C. Comparison of Properties Pervious Concrete Containing Alccofines and Steel Slag

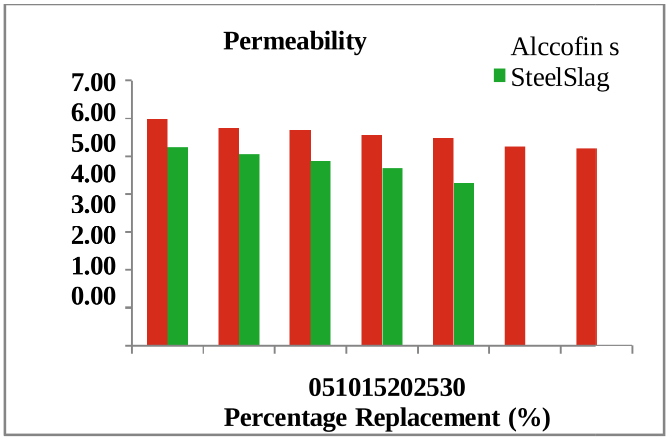
The properties of the pervious concrete containing alccofines and steel slag are compared and it if found that the values of properties such as compressive strength, permeability and porosity were higher in pervious concrete containing allcofine than that of containing steel slag. The Comparison of properties are Compressive strength Comparison, permeability Comparison, density comparition.



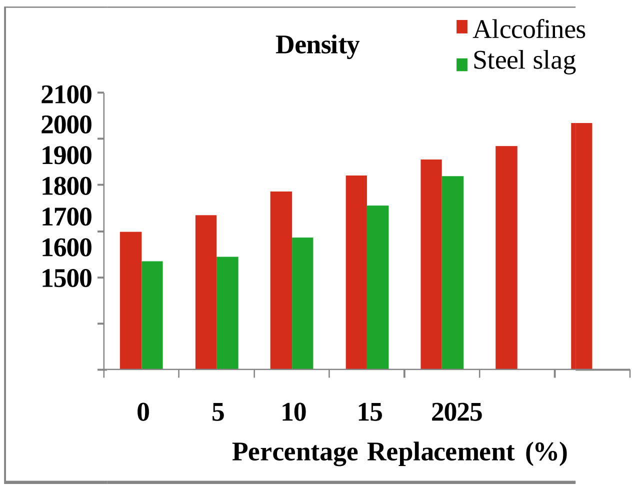
(a)



(b)



(c)



(d)

Figure 5.22: Comparison of Properties of Pervious Concrete, (a) Compressive strength, (b) Permeability, (c) Density

V. ACKNOWLEDGMENT

The conclusions obtained from the research are summarized as follows. The compressive strength and flexural strength increased with the replacement of alccofines and steel slag upto 20% and 15% respectively. These percentages were optimum for strength criteria. The compressive strength at 20% alccofine and 15% steel slag was 24.98 MPa and 21.96 MPa respectively. The increase in compressive strength was 25.15% at 20% replacement of alccofines and 11.53% at 15% replacement of steel slag. The flexural strength at 20% alccofine and 15% steel slag was 4.486 MPa and 3.2803 MPa respectively. The increase in flexural strength was 9.415% at 20% replacement of alccofines and 5.608% at 15% replacement of steel slag. The permeability of the pervious concrete decreased with increase in alccofines and steel slag content.

But the values were not much deviated from the design value. Values were satisfied the pervious concrete specifications. The strength and permeability values were higher in alccofine pervious concrete than steel slag pervios concrete. The density of the pervious concrete increased with alccofine and steel slag replacement and it is found that the higher density values were obtained in alccofine pervious concrete than steel slag pervious concrete.

Porosity values of the pervious concrete decreased with replacement of alccofines and steel slag, but the values obtained were within the pervious concrete specifications. The regression equations are developed to represents the relationship between various properties of the pervious concrete.

The regression equations were showing strong correlation between the properties of the pervious concrete. The density of pervious concrete is inversely proportional to porosity, but directly proportional to the compressive strength. The porosity of pervious concrete varies inversely with the compressive strength but varies directly with the permeability.

REFERENCES

[1] Cree, D., Green, M., & Noumowé, A. (2013). Residual strength of concrete containing recycled materials after exposure to fire: A review. Construction and Building Materials, 45, 208–223. https://doi.org/10.1016/j.conbuildmat.2013.04.005.

[2] Haselbach, L. M., Valavala, S., & Montes, F. (2006). Permeability predictions for sand-clogged Portland cement pervious concrete pavement systems. Journal of Environmental Management, 81(1), 42–49.

[3] Weng, Q., Lu, D., & Schubring, J. (2004). Estimation of land surface temperature- vegetation abundance relationship for urban heat island studies. Remote Sensing of Environment, 89(4), 467–483. https://doi.org/10.1016/j.rse.2003.11.005.

[4] Kolokotroni, M., Ren, X., Davies, M., & Mavrogianni, A. (2012). London's urban heat island: Impact on current and future energy consumption in office buildings. Energy and Buildings, 47, 302–311. https://doi.org/10.1016/j.enbuild.2011.12.019.

[5] Chen, Y., Wang, K., Wang, X., & Zhou, W. (2013). Strength, fracture and fatigueof pervious concrete. Construction and Building Materials, 42, 97–104. https://doi.org/10.1016/j.conbuildmat.2013.01.006

[6] Maguesvari, M. U., & Narasimha, V. L. (2013). Studies on Characterization of Pervious Concrete for Pavement Applications. Procedia - Social and Behavioral Sciences, 104, 198–207. https://doi.org/10.1016/j.sbspro.2013.11.112

[7] Zaetang, Y., Wongsa, A., Sata, V., & Chindaprasirt, P. (2013). "Use of lightweight aggregates in pervious concrete", Construction and Building Materials, 48, 585–591. https://doi.org/10.1016/j.conbuildmat.2013.07.077Y.

[8] Ibrahim, A., Mahmoud, E., Yamin, M., & Patibandla, V. C. (2014). "Experimental study on Portland cement pervious concrete mechanical and hydrological properties", Construction and Building Materials, 50, 524–529. https://doi.org/10.1016/j.conbuildmat.2013.09.022

[9] Ćosić, K., Korat, L., Ducman, V., & Netinger, I. (2015). Influence of aggregate type and size on properties of pervious concrete. Construction and Building Materials, 78, 69–76. https://doi.org/10.1016/j.conbuildmat.2014.12.073

[10] Torres, A., Hu, J., & Ramos, A. (2015). The effect of the cementitious paste thickness on the performance of pervious concrete. Construction and Building Materials, 95, 850–859. https://doi.org/10.1016/j.conbuildmat.2015.07.187

[11] Yu, F., Sun, D., Wang, J., & Hu, M. (2019). Influence of aggregate size on compressive strength of pervious concrete. Construction and Building Materials, 209, 463–475. https://doi.org/10.1016/j.conbuildmat.2019.03.140

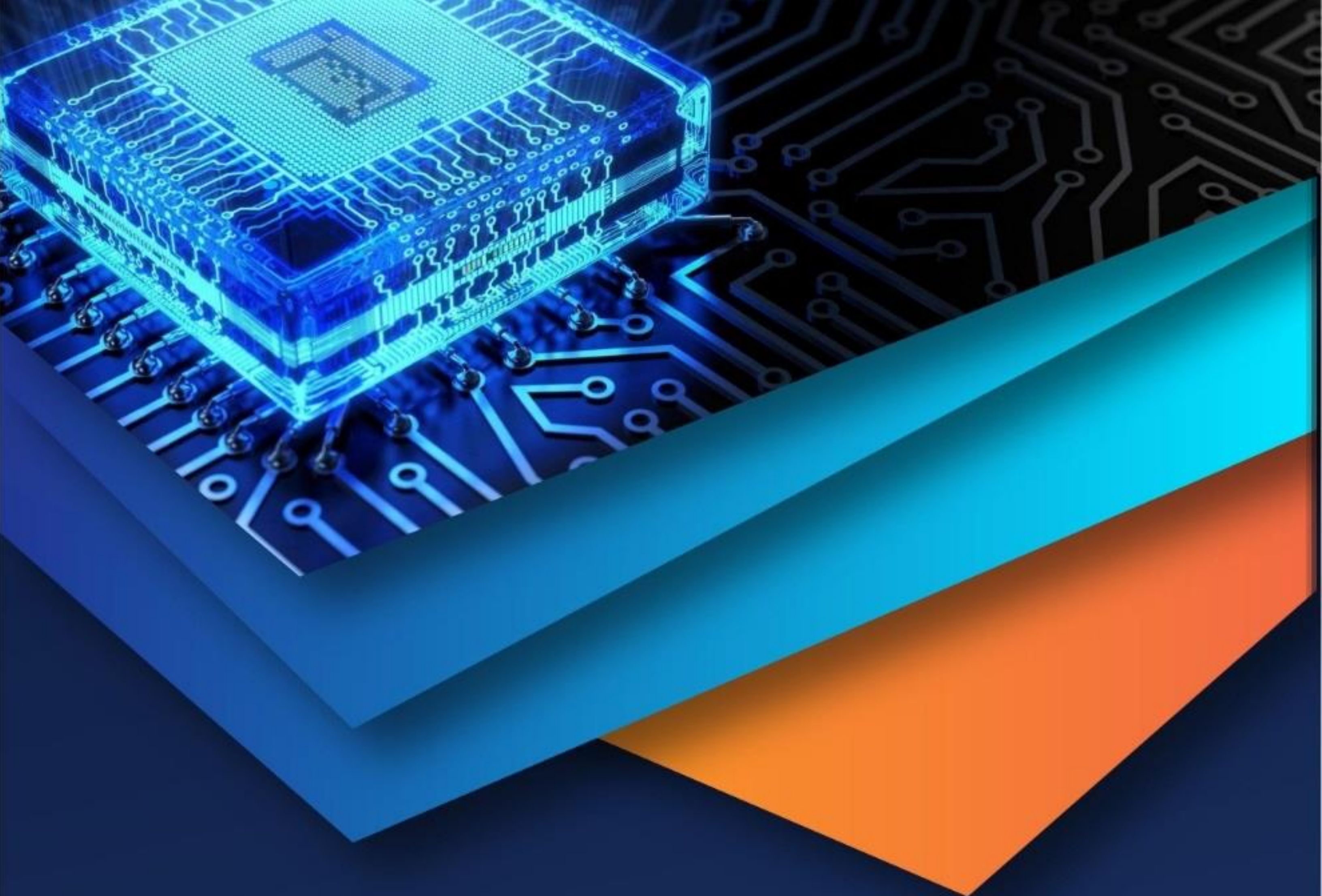
[12] Saboo, N., Shivhare, S., Kori, K. K., & Chandrappa, A. K. (2019). Effect of fly ash and metakaolin on pervious concrete properties. Construction and Building Materials, 223, 322–328. https://doi.org/10.1016/j.conbuildmat.2019.06.185

[13] Borhan, T. M., & Al Karawi, R. J. (2020). Experimental investigations on polymer modified pervious concrete. Case Studies in Construction Materials, 12. https://doi.org/10.1016/j.cscm.2020.e00335

[14] Lian, C., & Zhuge, Y. (2010). Optimum mix design of enhanced permeable concrete - An experimental investigation. Construction and Building Materials, 24(12), 2664–2671. https://doi.org/10.1016/j.conbuildmat.2010.04.057

[15] Nguyen, D. H., Sebaibi, N., Boutouil, M., Leleyter, L., & Baraud, F. (2014). A modified method for the design of pervious concrete mix. Construction and Building Materials, 73, 271–282. https://doi.org/10.1016/j.conbuildmat.2014.09.088

[16] Zhong, R., & Wille, K. (2015). "Material design and characterization of high performance pervious concrete", Construction and Building Materials, 98, 51–60. https://doi.org/10.1016/j.conbuildmat.2015.08.027



doi crossref

10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)