EFFECT OF DIFFERENT COMPACTION ON DETERMINING COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE – AN EXPERIMENTAL STUDY

[1]Chockalingam T, [2]Muruganantham R, [3]Jagan T, [4]Karthick Raja P

[1]Assistant Professor (Senior Grade), Department of Civil Engineering, Ramco Institute of Technology, Rajapalayam

[2]Assistant Professor (Senior Grade), Department of Civil Engineering, Ramco Institute of Technology, Rajapalayam

[3,4] Final Year Student, Department of Civil Engineering, Ramco Institute of Technology, Rajapalayam

[1]chocka30@gmail.com

ABSTRACT

In recent trends, the pervious concrete has grasped the attention of civil engineers' research fraternity because of its special application related to drainage aspects. From the past researches, indicated the significant importance of pervious concrete which is also called as permeable concrete or no-fines concrete, used in concrete flat applications allows water from precipitation and its associated sources to pass directly through, thereby decreasing runoff and permitting groundwater recharging. The method of compaction is one of the most important one in judging the mechanical and durability characteristics of any type of concrete. The current study focuses on the effect of the different types of compaction on the compressive strength of the pervious concrete. The types of compaction adopted in this experimental study are with no compaction, with a tamping rod, with a proctor hammer, with a Marshall hammer, and also with a table vibrator. The range of compressive strength of pervious concrete cubes using different compaction methodologies was arrived in the range of 1.18 MPa to 8.63MPa. Compaction by proctor hammer shows a remarkable increase in compressive strength in terms of 29%, 32%, 59%, and 86% over the Tamping rod, Marshall hammer, no compaction, and Table vibrator. Based on these experimental results, it was observed that table vibrator type of compaction was not suitable for pervious concrete, since cement paste was drained at the bottom of specimens.

Keywords: Pervious Concrete, Compaction, No Fines Concrete, Permeable Concrete

1 Introduction

Pervious Concrete is a special type of concrete made of cement, uniform coarse aggregate, water and meager or no fine aggregate has gained attention in recent years due to its benefits in achieving sustainable development. Using only coarse aggregate leads to a highly porous and permeable structure.Such pervious concrete pavements shall be adopted for quick drainage of stormwater. The porosity of pervious concrete ranges from 15% to 35% thereby percolating the water through its matrix [1]. For pervious concrete, infiltration rate is the important requirement instead of its strength, and continuity of the open porousness is the main concern in the production of pervious concrete. The highwater permeability of pervious concrete makes it to be considered as an eco-friendly concrete. The interconnected pores in pervious concrete lead to various advantages including stormwater management, groundwater recharge, and mitigation of the urban hear island effect [2]. One of the critical factors influencing the mechanical properties of pervious concrete is the type of compaction adopted while placing pervious concrete in the field. The effect of compaction plays a crucial role in determining the porosity, strength of pervious concrete [3]. Improper selection of compaction methodology can lead to enhancement or decrement of density, thereby affecting the infiltration rate and strength of pervious concrete [4]. Various compaction methodologies have been explored

including roller compaction, vibratory compaction and manual compaction [5]. Each method of compaction has its impact on the properties of the pervious concrete. Few researchers explored the effect of compaction on the strength of pervious concrete [6] while others focused on the permeability and porosity of pervious concrete [7].

However, there is still a need for comprehensive research to evaluate the influence of various compaction methods on the compressive strength of pervious concrete, particularly considering the variations in mix designs, aggregate gradations, and curing conditions. This study aims to provide an in-depth experimental investigation into the effect of different compaction techniques on the compressive strength of pervious concrete.

2 Research Significance

The effect of compaction on compressive strength and permeability of pervious concrete was studied by considering the size of the coarse aggregate and aggregate/cement ratio as independent variables. The following method of compaction methodologies is considered for this experimental work: No compaction, compaction by tamping rod, Proctor hammer, Marshall hammer, and Table vibrator.

3 Results and Discussion

3.1 Material Properties

The constituents used for the preparation of the pervious concrete were Portland Pozzolana Cement, Coarse aggregate of size 12.5 mm, and water. The physical properties of the raw materials used were presented in Table 1. All the tests were performed according to the guidelines provided by Indian standards.

Table 1: Physical Properties of Raw Materials

Properties	Cement	Coarse Aggregate
Consistency	36%	-
Initial setting time	35 minutes	-
Final setting time	230 minutes	-
Specific gravity	3.15	2.70
Water absorption	-	0.5%
Soundness	4 mm	-
Fineness modulus	340 m^2/kg	7.67%
Properties	Cement	Coarse Aggregate

3.2 Mix Proportion

Throughout this study, aggregate to-cement ratio and water-to-cement ratio were kept constant at 3.2:1 and 0.4 respectively. The details of the mix proportion were given in Table 2.

Table 2: Details of Mix Proportion

Mix Designation	Mix Ratio	Cement	Fine Aggregate	Coarse Aggregate
M1	1:0:3.2	320 kg/m^3	0 kg/m^3	1024 kg/m^3

3.3 Tests on Pervious Concrete

Tests such as density, compressive strength, and permeability were carried out on cubical and cylindrical specimens of pervious concrete according to the specifications given in various codes of practice as shown in Table 3.

Table 3: Shape and Size of Specimen

Tests	Shape of specimen	Size of Specimen
Density	Cube	150 x 150 x 150 mm
Compressive strength	Cube	150 x 150 x 150 mm
Permeability	Cylinder	Φ100 x 200 mm

3.4 Workability

The workability of the pervious concrete was measured with the help of a slump cone as per the guidelines prescribed in IS 1199 (Part 2): 2018. Due to the larger porous structure, the concrete stands stiff and recorded zero slump. The corresponding pictorial representation of the same is shown in figure 1.

Figure 1: Workability of Pervious Concrete

3.5 Types of Compaction

The different types of compactions adopted for this study and their corresponding pictorial representation were shown in Figure 2. Five different compaction methodologies were considered for this experimental work. They are as follows: 1. No compaction 2. Compaction using tamping rod 3. Compaction using Proctor hammer 4. Compaction using Marshall hammer and finally 5.Compaction using Table vibrator.

Figure 2: Different Compaction Methodologies

4 Results and Discussion

4.1 Density

The density of pervious concrete is measured using the weight of the specimens after subjected to curing by water for 28 days. Pervious concrete subjected to no compaction recorded the lowest density. This is due to the presence of large voids results in less weight, thereby density of the pervious concrete specimens got minimal density. On the other hand, pervious concrete subjected to proctor hammer yields more density. This is due to filling up of voids created by the coarse aggregate by the compaction effort made by proctor hammer. The densities of pervious concrete specimens subjected to different compaction effort was diagrammatically represented in figure 3.

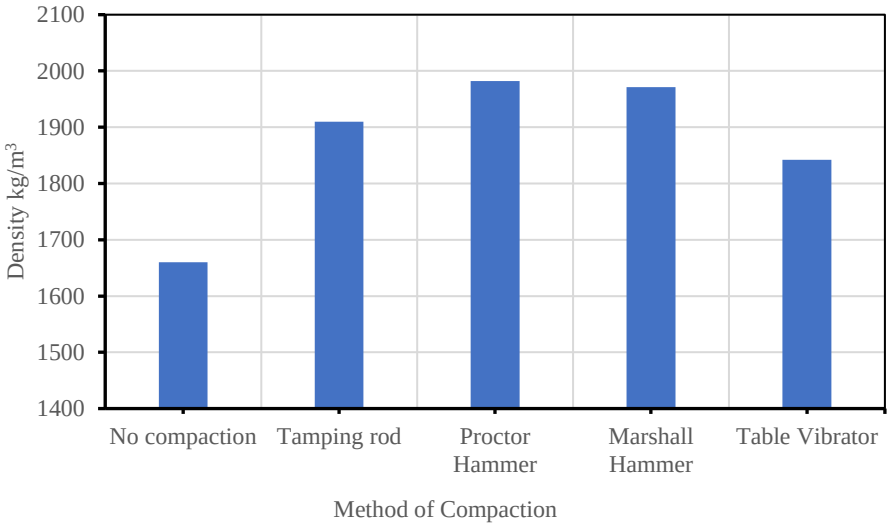

Figure 3: Density of Pervious Concrete

4.2 Compressive Strength

The compressive strength of pervious concrete subjected to various compaction methodologies were shown in table 4 and pictorial representation was depicted in figure 4. From table 4, it was observed that, pervious concrete subjected to table vibrator recorded the lowest compressive strength. This is due to the fact that, cement paste in pervious concrete specimens drained at the bottom due to excessive vibration made by table vibrator. This in turn impacts the permeability of pervious concrete. The corresponding pictorial representation of draining of cement paste at the bottom of the specimen was shown in figure 5.

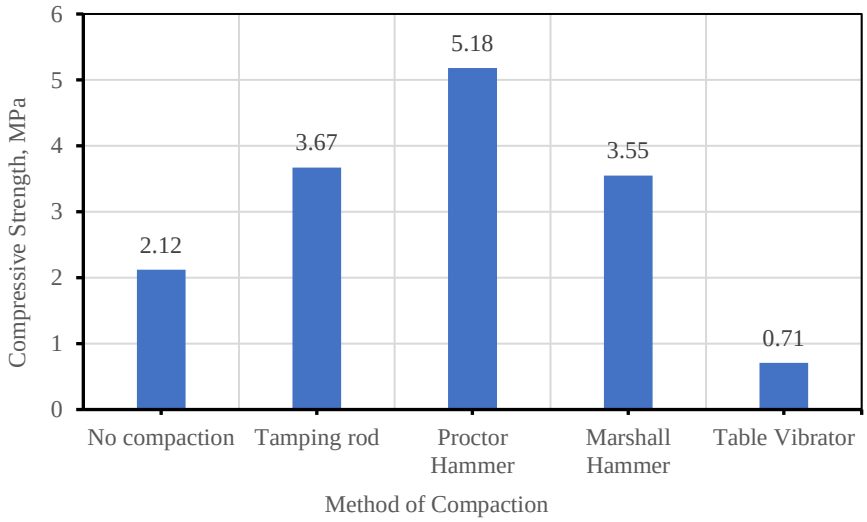

Fig. 4: Compressive Strength of Pervious Concrete

Fig. 5: Accumulation of Cement Paste at bottom

4.3 Permeability

Similar to the variation in compressive strength of pervious concrete due to various effects of compaction, the same was reflected in permeability too. But at the same time, the variation between each effort of compaction was minimal. The infiltration rate corresponding to various compaction methodologies were tabulated in table 5. The pictorial representation of the same is depicted in figure 6.

Table 5: Permeability of Pervious Concrete

Type of Compaction	Permeability (mm/s)
No compaction	10.4
Tamping rod	9.8
Proctor hammer	9.3
Marshall hammer	9.9
Table vibrator	10.9

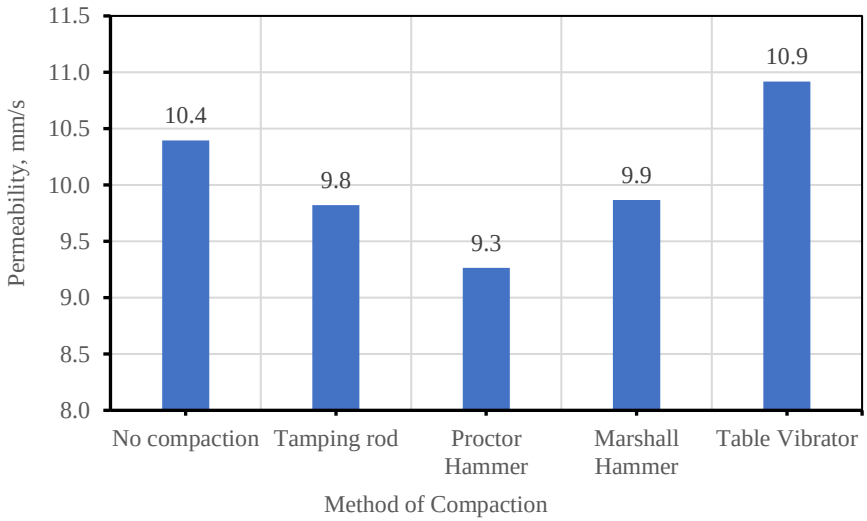

Fig. 6: Permeability of Pervious Concrete

5 Conclusions

This work investigated the effect of different types of compaction on the mechanical characteristics of pervious concrete including density, compressive strength and permeability. The results of this investigation led to the following conclusion.

- Effect of compaction playing a major role in achieving density and compressive strength of pervious concrete specimens.
- Density of pervious concrete using different compaction methodologies ranges from 1660 kg/m^3 to 1971 kg/m^3 which is less than conventional concrete specimens
- The range of compressive strength of pervious concrete cubes using different compaction methodologies ranges from 0.71 MPa to 5.18 MPa.
- Permeability of pervious concrete using different compaction methodologies ranges from 9. 3 mm/s to 10.9 mm/s.
- Pervious concrete compacted with table vibrator recorded the minimum compressive strength of 0.71 MPa. This is due to cement paste in pervious concrete cubes got drained at the bottom of the specimen. Based on the results, it was found that compaction by table vibrator is not suitable
- Pervious concrete subjected to no compaction led to second lowest compressive strength of 2.12 MPa and permeability of 10.4 mm/s.
- Compaction by proctor hammer yields highest compressive strength of 5.18 MPa with permeability of 9.3 mm/s.
- The impact of different types of compaction on pervious concrete not reflected much in the infiltration rate.

6 Declarations

6.1 Study Limitations

None

6.2 Acknowledgements

The authors wish to acknowledge Ramco Institute of Technology, Rajapalayam for providing facilities to carry out this study.

6.3 Funding source

None

6.4 Competing Interests

Declare any potential conflict of interest exist in this publication.

7 Human and Animal Related Study

7.1 Ethical Approval

Not required

7.2 Informed Consent

Not required

References

1. Tennis, P. D., Leming, M. L., & Akers, D. J: Pervious concrete pavements. Portland Cement Association, Skokie, Illinois, USA (2004).

2. Huang, B., Wu, H., Shu, X., & Burdette, E. G.: Laboratory evaluation of permeability and strength of polymer-modified pervious concrete. Construction and Building Materials, 24(5), 818-823 (2010).

3. Khankhaje, E., Salim, M. R., Mirza, J., Hussin, M. W., &Rafieizonooz, M.: Properties of sustainable lightweight pervious concrete containing oil palm kernel shell as coarse aggregate. Construction and Building Materials, 126, 1054-1065 (2016).

4. Gafoori, N., & Dutta, S.: Laboratory investigation of compacted no-fines concrete for paving materials. Journal of Materials in Civil Engineering, 7(3), 183-191 (1995).

5. Kevern, J. T., Schaefer, V. R., & Wang, K.: Effect of coarse aggregate on the freeze-thaw durability of pervious concrete. Journal of Materials in Civil Engineering, 23(4), 469-474 (2011).

6. Rizvi, R., Bhattacharjee, B., & Krishnamoorthy, S.: Compressive strength and porosity of pervious concrete. In Proceedings of the Institution of Civil Engineers-Construction Materials, vol. 162, No. 2, pp. 85-92. Thomas Telford Ltd (2009).

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