Experimental Investigations on Increasing the Strength and Infiltration Rate of Pervious Concrete by using Natural Fibers

Tejal V. Patil[1], Aarti P. Patil[2], Shubham M. Patil[3], Nishant C. Mhatre[4]

[1,2,3,4]*B.E Student, Dept. of Civil Engineering, Vishwaniketan (iMEET) college, Khalapur, Maharashtra, India*

Abstract - *Pervious concrete is concrete with high porosity that's allow water from precipitation. Also in permeable or pervious concrete has no fine aggregate. Due to its poor strength it is not useful in the construction of pavement for heavy traffic. The project aims at studying the engineering properties and prove the importance of natural fiber reinforced pervious concrete. In this work, we will analyze the effect of addition of various natural fibers on the strength and infiltration rate of pervious concrete. Natural fibers, include coconut fiber, banana, rice husk, banyan tree, and sugarcane. Natural fibers are cheap and locally available in many countries. So their use as a construction material for increasing properties of composites costs a very little and are sustainable. Literature review has done the review on mechanical performance of different natural fiber. This study aimed to determine the effect of the natural fibers to characteristics of porous concrete with addition of fiber variations. The objective of this work is to improve compressive strength at which the strength achieves better infiltration rate. The design mix is prepared for M20 consisting of 53 grade of cement, size of course aggregate which are passing through 12.5 mm IS sieve size and retained on 10 mm IS sieve size. The design mix is developed with constant percentage of coarse aggregate and W/C ratio maintained as 0.4 in all the cases. Tests were performed and the properties are compared with that of plain pervious concrete sample and steel fiber concrete sample. From the experimental results it is found that, the compressive strength and infiltration rate of the previous concrete is satisfactory at addition of natural fibers.*

***Key Words*: Pervious concrete, Natural fiber, compressive strength, tensile strength, infiltration rate.**

1. INTRODUCTION –

Pervious concrete pavement is a unique and effective means to address important environmental issues and support green, sustainable growth. By capturing storm water and allowing it to seep into the ground, porous concrete is instrumental in recharging groundwater, reducing storm water runoff.

In pervious concrete, carefully controlled amounts of water and cementitious materials are used to create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly.

The usage of natural fiber in construction are widely used in building materials engineering. However, using sugarcane fiber waste material as a natural in construction is very precious, because it can increase crack control and ductility, brittle concrete. Furthermore, the usage of sugarcane in construction can reduce of environmental pollution

1.1 Aim and Objectives - to determine whether there is an increase in the compressive and tensile strength of the concrete and infiltration rate. The main objectives of the project are as follows:

- To control the crack develop in the concrete by using fiber.
- To check the quality and to control cracks of concrete.
- To find out the compressive and tensile strength of 7, 14 and 28 days.
- To check the permeability and porosity properties of the concrete.
- To study on strength improvement of pervious concrete.
- To compare the behaviour of pervious concrete by various fibers.
- To design the pervious concrete for construction of pavement and check its properties.

1.2 Scope of Project –

- Addition of natural fibers in pervious concrete pavement increases the strength as well as the infiltration rate of the pavement.
- And the main benefit of using natural fiber is that it is economical, the waste could be reused, and fulfil all the requirements of a strong pavement.
- Due to increase of strength on pavement by addition of natural fiber it can be used on construction works carrying medium amount of load.

- Generally pervious pavement is used in low-volume pavements, residential roads, driveways, sidewalks and pathways, parking areas, etc. But by addition of fiber it can be used in wide range.

2. Methodology –

1. Test on coarse aggregate (10mm to12.5mm)

Table 1: Observation table

Sr No.	TEST	RESULT	CONCLUSION
1	Aggregate crushing test	26.6%	<30% hence it is okay
2	Abrasion test	12.9%	<20% Hence it is okay
3	Impact test	22.2%	is in between 20% to 30%, hence it is okay
4	1.Flakiness Index 2.Elongation index	14.29% 23.07%	<30%, hence it is okay <25% Hence it is okay

2. Concrete mix design

Table 2: Mix proportion of pervious concrete

1	Design grade of concrete	M20
2	Characteristic strength of concrete (MPa)	20
3	Target mean strength (MPa)	26.50
4	Exposure condition	Mild
5	Type of cement	OPC 53
6	Nominal size of aggregate	10mm– 12.5mm
7	Specific gravity of cement	3.15

Table 3: Concrete Mix Design for pervious concrete

Material	Cement	Coarse aggregate	Water
Proportion	1	1.90	0.40
1 bag of cement	50 kg	95 kg	20 litre

3.1 Compressive strength of pervious concrete

Table 4: Result of compressive strength on pervious concrete

Specimen	7 Days	14 Days	28 Days
NPC	18.32	22.53	26.7
Steel fiber 0.5% 1% 2%	18.21 18.34 18.29	22.64 23.76 24.78	28.22 28.45 29.02
Sugarcane fiber 0.5% 1% 2%	18.35 17.89 17.55	21.43 20.5 20.05	24.52 23.99 23.80
Banana fiber 0.5% 1% 2%	17.42 18.93 17.06	20.31 23.01 20.18	25.34 27 24.52
Rice husk 0.5% 1% 2%	18.30 18.26 17.96	20.46 21.34 20.26	23.72 23.85 24.28
Coconut fiber 0.5% 1% 2%	18.25 18.55 17.86	21.34 21.39 22.03	26.68 26.73 28.42
Banyan tree fiber	17.68 17.56 16	19.31 18.84 18.36	23.21 23.32 23.45

3.2 Split Tensile Strength of pervious concrete

Table 5: Result of split tensile strength on pervious concrete

Specimen	**7 Days**	**28 Days**
NPC	1.13	1.5
Steel fiber 0.5% 1% 2%	1.24 1.29 1.31	1.62 2.06 2.13
Sugarcane fiber 0.5% 1% 2%	0.86 0.98 0.84	0.93 1.12 0.97
Banana fiber 0.5% 1% 2%	1.09 1.10 0.85	1.2 1.29 1.14
Rice husk 0.5% 1% 2%	0.85 0.96 0.82	1.12 1.13 1.16
Coconut fiber 0.5% 1% 2%	1.14 1.15 1.13	1.23 1.31 1.21
Banyan tree 0.5% 1% 2%	1.14 1.17 0.98	1.96 1.98 1.14

3.3 Infiltration rate of pervious concrete slab

Formula used,

I = (KM)/ (D^2 x t)

Where, I – Infiltration rate

M – Mass of water

K –constant

D –diameter

t –time

Table 6: infiltration rate of pervious concrete slab

Specimen	**M (lb)**	**D (inch)**	**K (inch)**	**t (sec)**	**I (inch/hr)**
NPC	40	12	126870	38	927.41
Steel fiber	40	12	126870	39	903.63
Sugarcane Fiber	40	12	126870	41	859.55
Banana fiber	40	12	126870	42	839.08
Rice husk	40	12	126870	43	819.57
Coconut fiber	40	12	126870	39	903.63
Banyan tree	40	12	126870	41	859.55

4. Result

4.1Normal pervious concrete

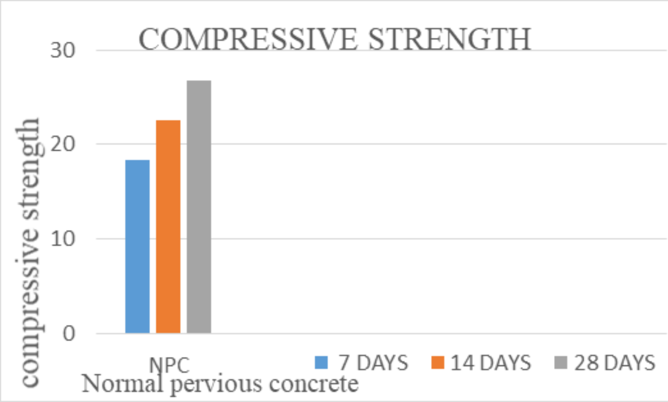

Fig 1 Fig no.4.1 Graph showing compressive strength of NPC

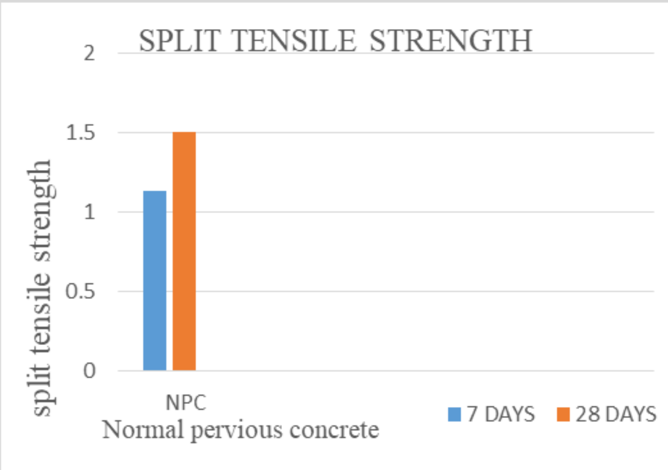

Fig no.4.2 Graph showing split tensile strength of NPC

4.2 Pervious concrete with addition of sugarcane fiber

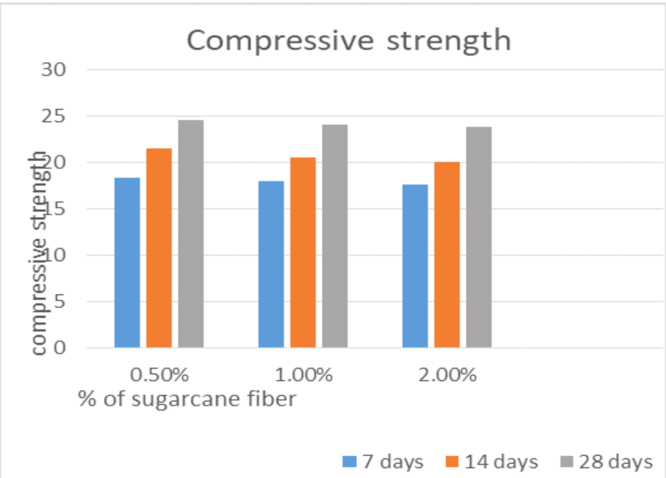

Fig no.3 Graph showing variation of compressive strength at varying % of sugarcane fiber

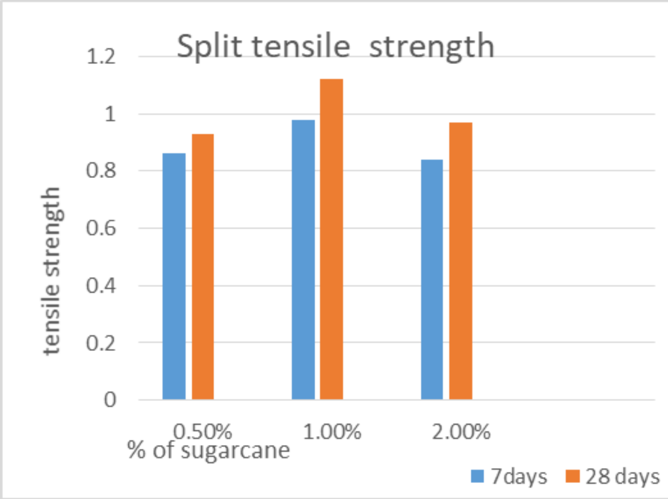

Fig no. 4 Graph showing variation of Split tensile strength at varying % of sugarcane fiber

4.3Pervious concrete with addition of banana fiber

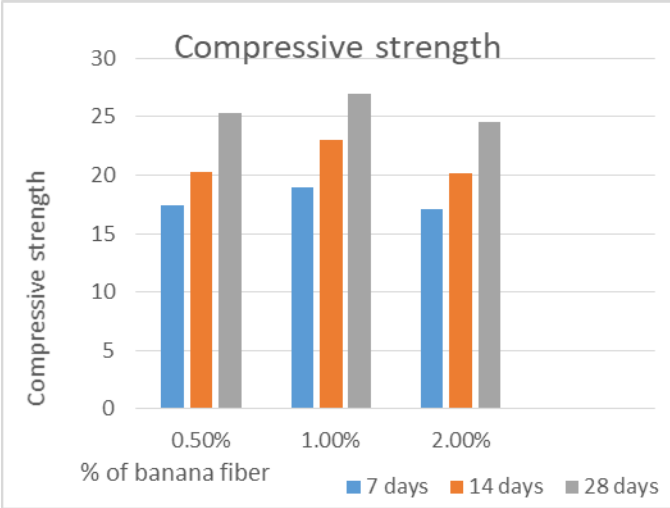

Fig no.5 Graph showing variation of compressive strength at varying % of banana fiber

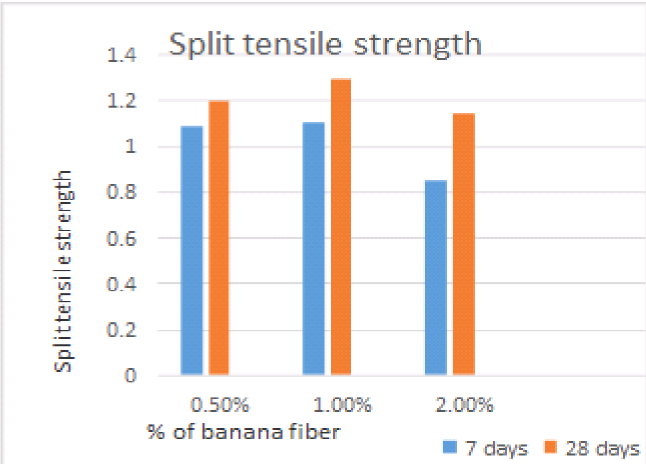

Fig no. 6 Graph showing variation of Split tensile strength at varying %banana fiber

4.4 Pervious concrete with addition of steel fiber

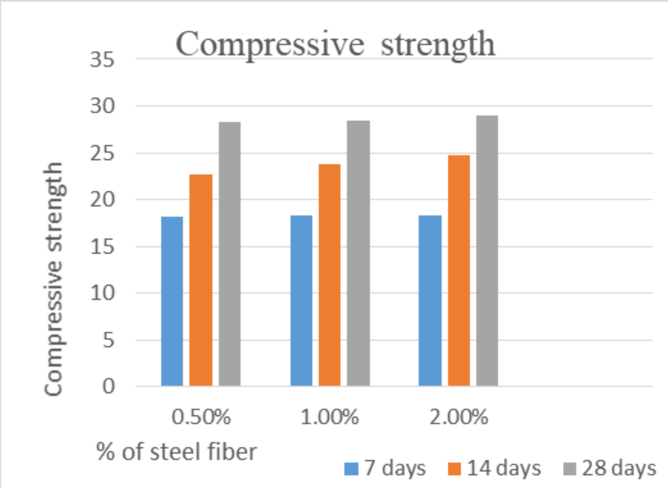

Fig no.7 Graph showing variation of compressive strength at varying % steel fiber

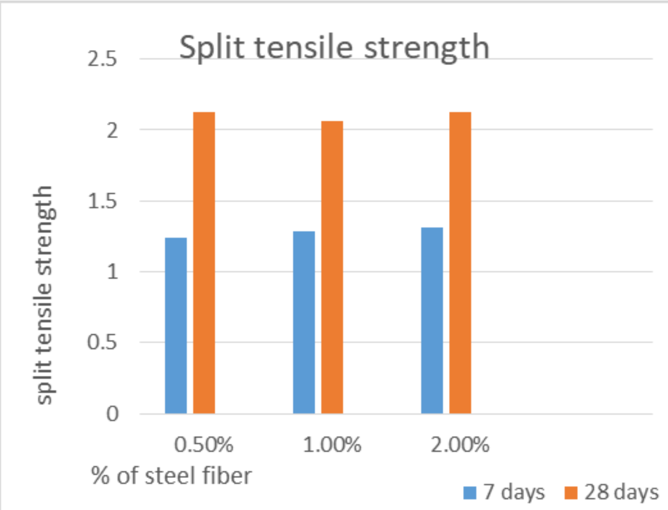

Fig no. 8 Graph showing variation of Split tensile strength at varying %steel fiber

4.5Pervious concrete with addition of rice husk fiber

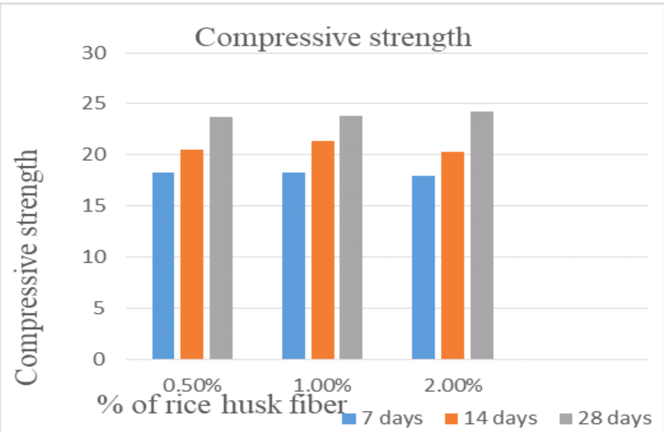

Fig no.9 Graph showing variation of compressive strength at varying % rice husk fiber

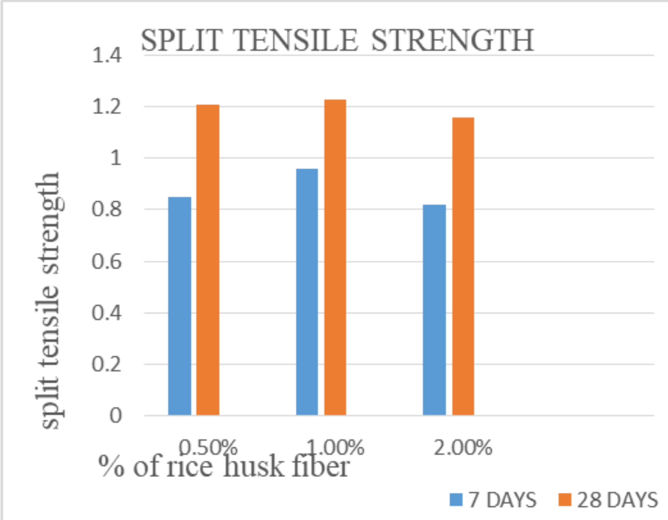

Fig no. 10 Graph showing variation of Split tensile strength at varying % rice husk fiber

4.6 Pervious concrete with addition of coconut fiber

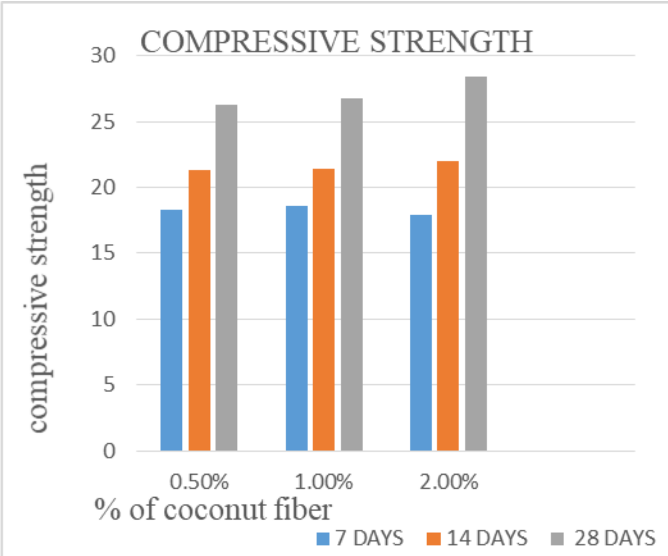

Fig no. 11 Graph showing variation of compressive strength at varying % coconut fiber

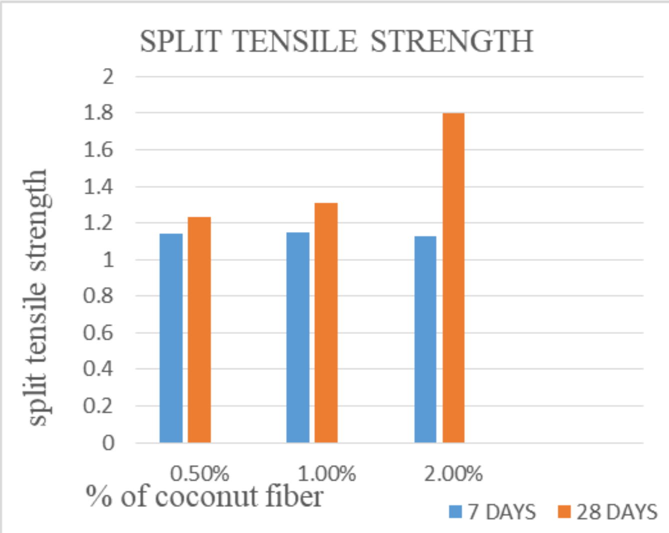

Fig no. 12 Graph showing variation of Split tensile strength at varying % coconut fiber

4.7 Pervious concrete with addition of banyan tree fiber (prop roots)

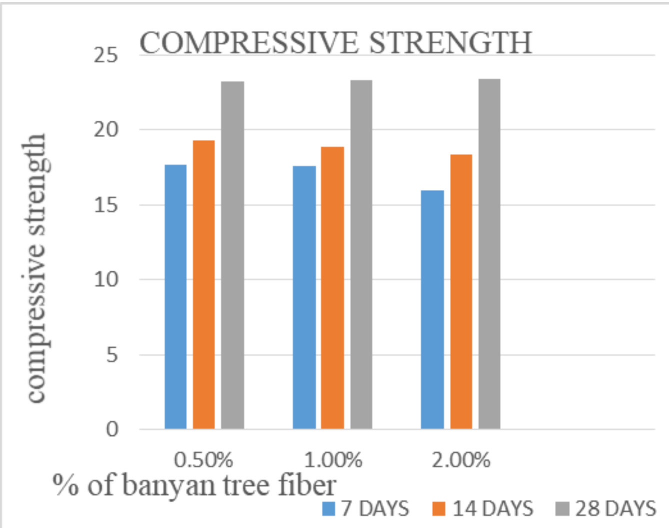

Fig no. 13 Graph showing variation of compressive strength at varying % of banyan tree fiber (prop roots)

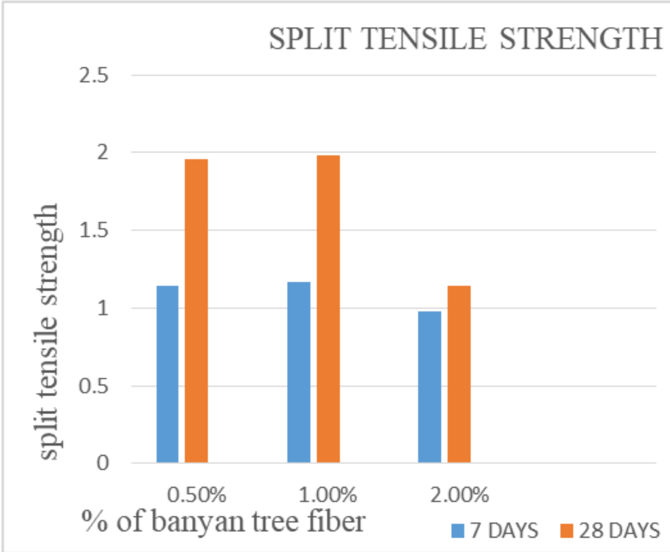

Fig no. 14 Graph showing variation of Split tensile strength at varying % of banyan tree fiber (prop roots)

5. CONCLUSIONS

- Small size of coarse aggregates (12.5 to 16 mm) should be able to give high compressive strength and at the same time produce higher permeability rate.
- The permeability of pervious concrete decreases with the addition of rice husk since the voids of the concrete gets filled with some percentage of rice husk
- Compressive strength of the concrete were decreased when the amount of sugarcane finer increased. The optimum percentage that give the higher compressive strength is 0.5% also optimum tensile strength of concrete with sugarcane fiber is 0.5 %. When the sugarcane fiber keep increasing the tensile as well as compressive strength of concrete was reduced. After adding sugarcane fibers, setting time of concrete have been extended for several hours depending upon amount of sugarcane fibers added.
- Banana fiber reinforced concrete gets its maximum value at 0.5% of banana fiber. We conclude that the amount of fiber used should be in the range of 0.5% to obtain pervious concrete with good strength and infiltration rate.
- We conclude that amount of coconut fiber used in concrete should not be more than 1%, as percentage of fiber increase compressive strength goes decreasing.
- Addition of banyan tree (prop roots) does not affect on strength but it avoids cracking.

- Comparing all the specimens using natural fiber reinforced concrete with steel fiber reinforced concrete we conclude steel fiber reinforced concrete gives highest strength. But taking economy into account natural fibers can reduce the cost of work as they are easily available and cheap.
- While considering all the natural fibers, it can be concluded that the coconut fiber and the banana fiber can be used for medium load traffic as it can provide good strength as well as good infiltration rate.
- As the waste is reused as natural fiber in the construction of pervious concrete, these fibers will not increase the cost of construction because they can be easily available, cheap and economical.

REFERENCES

1. T. Vijaya Kumar, 2Dr. K. V. Ramana and 3Dr. R B Chowdary, **"Tensile Behaviour of Banyan Tree Fiber Reinforced Composites"**,International journal of advance engineering research and studies, volume 1, issue 2 January- March 2012, 256-258

2. Muhamad Azani Yahya, Zulkifil Abu Hassan, Mohammed Alias Yusof, and Mohd Nazrin Mohd Daud, **"Usage of Sugarcane Bagasse as Concrete Retarder"**, International journal of business and technopreneurship, volume 3, issue 3, October 2013, 495-503

3. Faisal Sheikh Khalid, Herman Shah Herman, and Nurul Bazilah Azmi, **"Properties of Sugarcane Fiber on the Strength of the Normal and Lightweight Concrete"**, ISCEE 2016

4. Aiswarya Gopinath, Amala D, Anjitha G Nath, Drisya Vasudev A, and Justin Thomas, **"Fiber Reinforced Pervious Concrete Using Banana Fiber"**, International journal of engineering and management research, volume 7, issue 2, March-April 2017, 127-132

5. Saurabh Rahangadale, Shobhit Maran, Sumit Lakhmanil, and Mayuresh Gidde, **"Study of Pervious Concrete"**,International research journal of engineering and technology, volume 4, issue 6, June 2017, 2563-2566

6. V.Sai Uday and B.A jitha, **" Concrete Reinforced with Coconut Fibers"**, International journal of engineering science and computing, volume 7, issue 4 2017, 110436-10439

7. R.Chitra1 and M.P.Chockalingam **"Improving Strength Properties of Concrete Using Steel Fiber"** International journal of pure and applied mathematics, volume 116, issue 13 2017, 217-222

8. Arthur Daniel Limantara and Sri Wiwohe Mudja narko, **"Optimization of standard mix design of porous paving coconut fiber"**, 2018.

9. Shubham Kamerkar, Ashish Shende, and Puja Borkar, **"Analysis of Strength of Pervious Concrete by Adding Rice Husk Ash"**, International journal of research in engineering, science and management, volume 2, issue 3, March 2019.

10. Channappa and Pradeep Kuman Reddy, **"Experimental Study on Steel Fiber Reinforced Pervious Concrete"**, International research journal of engineering and technology, volume 6 ,issue 8 August 2019, 442-447

11. Neha Deshmukh, Sneha Vairalkar, Dipika Pande and Vrushali Mawal **"Comparative Investigation of Pervious Concrete Using Banana and Nylon Fibre "** 2019.

12. Muhammad Zeeshan **"A Study on Compressive Strength of Pervious Concrete"**,June 2020,2-13.

13. K Pareek and Y M Hong **"Prediction of Permeability and Compressive strength for Pervious Concrete"** ICAME 2020.

BIOGRAPHIES

Tejal V Patil
Bachelors of Engineering
Department of Civil Engg.
Vishwaniketan (iMEET) College
Khalapur, Maharashtra

Aarti P Patil
Bachelors of Engineering
Department of Civil Engg.
Vishwaniketan (iMEET) College
Khalapur, Maharashtra

Shubham M Patil
Bachelors of Engineering
Department of Civil Engg.
Vishwaniketan (iMEET) College
Khalapur, Maharashtra

Nishant C Mhatre
Bachelors of Engineering
Department of Civil Engg.
Vishwaniketan (iMEET) College
Khalapur, Maharashtra