International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Analytical Study of Structural Performance and Behavior of Composite Columns with Recycled E-Plastic Concrete

Safeera Ashraf[1], Bhagyasree Raj[2]

[1]PG Student, Dept. of Civil Engineering, MGM College of Engineering & Technology, Kerala, India
[2]Asst. Professor, Dept. of Civil Engineering, MGM College of Engineering & Technology, Kerala, India

---

Abstract - *Concrete is one of the most important material used in construction, and because of its suitable cost and strength, an improvement of its mechanical and chemical properties many alternative materials are used in the concrete. The abundance of waste plastic is a major issue for the sustainability of the environment. However, the versatile behavior of plastic can make it a replacement for or alternative to many existing composite materials like concrete. The recycled plastic concrete is a concrete formed by the addition of 0%, 10%, 20% & 30% of recycled waste E-Plastics as partial replacement, in concrete mix instead of coarse aggregate. Poisson's ratio and Elastic modulus of steel reinforcement used are 0.256 and 2.02 x 10^5 MPa . Poisson's ratio of 0.15 is used for composite concrete mix and the fck values are derived from the experimental work, by using these values Elastic modulus of concrete is calculated as per IS 456:2000.This project deals with partial replacement of coarse aggregate by recycled Polyethylene. Concrete columns are virtually created in ANSYS software and axial loading and lateral loading are applied and performance of concrete is studied by modelling a single skinned CFST column and double skinned CFST column with varying shapes and find out the buckling behavior, lateral behavior etc.*

Key Words: **E-Plastic, recycled plastic concrete, single skinned CFST column, double skinned CFST column, lateral behavior, etc**

1. INTRODUCTION

Concrete is one of the most commonly used construction materials in the world, mainly due to its low cost, availability, its long durability, and ability to sustain extreme weather environments. Concrete is a composite material made from several readily available constituents such as aggregates, sand, cement and water. The worldwide production of concrete is 10 times that of steel by tonnage. Concrete is a brittle material that has a high compressive strength, but a low tensile strength. Thus reinforcement of concrete is required to allow it to handle tensile stresses. Such reinforcement is usually done using steel. Many research works are carried out to find the effect of using waste material as partial replacement for coarse aggregate or fine aggregate.

Plastic waste is a silent threat to the environment and their disposal is a serious issue for waste managers. Now a day society doesn't have any alternative to plastic products like E-Plastic, plastic bags, plastic bottles etc. To overcome this issue many efforts were made in the past year to reuse the plastic waste but no significant results were achieved. Various experimental attempts were made to check the feasibility of plastic waste to be use partially in concrete with respect to various properties of strength, workability, durability, and ductility of concrete.

Very large quantity of plastic waste is produced every year. Recycling and reuse of plastic waste products amount for vast manpower and huge processing cost resultantly very small amount of plastic waste is recycled and used and rest going into landfills, incinerators and dumps. The utilization of waste in the construction industry has two glaring dividends, environmental impact and economic impact. By knowing the disposal issues of plastic waste, its utility in concrete is studied and experimented by various researchers. Researchers worked on the use of pulverized plastic in concrete as partial replacement of fine aggregate and use of plastic waste in concrete as partial replacement of coarse aggregate.

1.1 E-Plastic waste

E-waste or electronic waste delineates toss out electrical or electronic devices. Used electronics which are doomed for recycle, resale, salvage or disposal are considered as E-waste. By the use of E-Plastic waste in concrete will reduces the aggregate cost and furnishes good strength for the structures and roads. The E-Plastic waste consists of discarded plastic waste from the old computers, TVs, refrigerators, radios etc. By using E-Plastic in concrete reduces steel reinforcement requirements, improve resistance to explosives spalling in case of severe fire, comparatively lesser production cost, longevity and productivity. Plastics are having low bonding properties so that the strength of concrete gets reduced. Plastics production also involves the use of potentially harmful chemicals.

1.2 Objective of the study

The main objectives of the study are as follows:

- To evaluate the structural performance and behavior of composite columns with recycled plastic concrete.
- To study the performance of buckling of single skinned and double skinned CFST column under various mix designs.
- To investigate the performance of buckling of short CFST column and long CFST column under various mix designs.
- To evaluate the lateral performance of columns and performances in the basis of output parameters like lateral load and lateral displacement etc.

2. ANALYTICAL STUDY

Here, ANSYS 16.1 workbench is used for the analysis. Mainly two types of columns modeled, single skinned and double skinned CFST column with varying percentages of recycled E-Plastic waste are modeled and analyzed. Table 1 shows properties of concrete mix.

Table-1: Properties of composite concrete mix

% of E-Plastic	Modulus of Elasticity (MPa)	Poisson's ratio	Compressive strength (MPa)	Flexural strength (MPa)
0	34344	0.15	47.18	4.35
10	33193	0.15	44.07	4.4
20	24845	0.15	24.69	4.3
30	23532	0.15	22.15	2.5

2.1 Analytical Modelling of Single Skinned Octagonal CFST Column subjected to axial loading

The column has dimensions of 1500 mm height and (197 x 5) mm size. The column is infilled with concrete of grade M20. Crushed recycled E-Plastic waste mixed with concrete at 0 %, 10 %, 20 % and 30 %.

Properties of steel

Young's modulus = 2.02 x 10^5 MPa

Poisson's ratio = 0.256

Yield strength = 321 Mpa

Ultimate strength = 480 MPa

Modelling, meshing and analysis of Octagonal SSCFST is shown in fig 1 to fig 3.

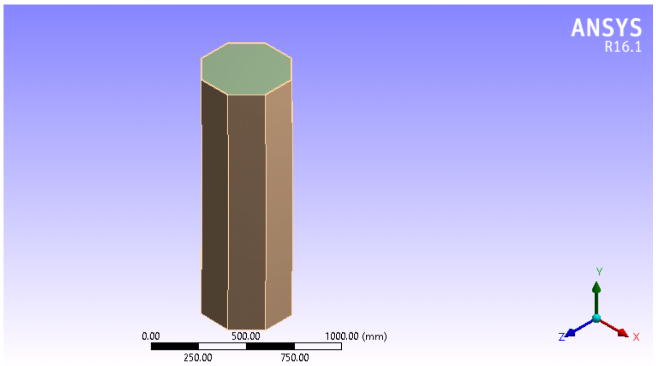

Fig-1: Geometry of Octagonal single skinned CFST column

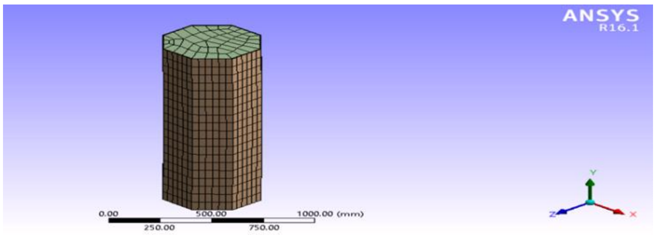

Fig-2: Meshing of octagonal single skinned CFST column

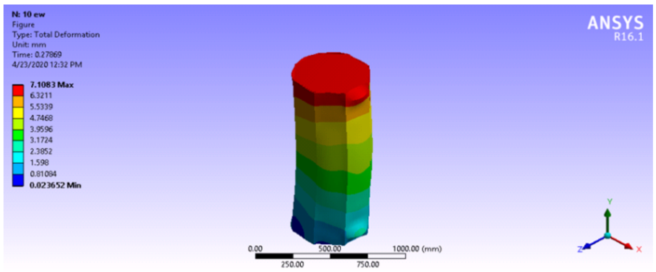

Fig-3: Total Deformation in single skinned CFST column

Table-2: Analytical values of columns

% OF E-WASTE	LOAD (kN)	DEFLECTION (mm)	% DECREASE IN LOAD
0	11758	19.866	1
10	11278	19.918	4.08
20	7809.1	27.962	33.584
30	7409.4	20.991	36.984

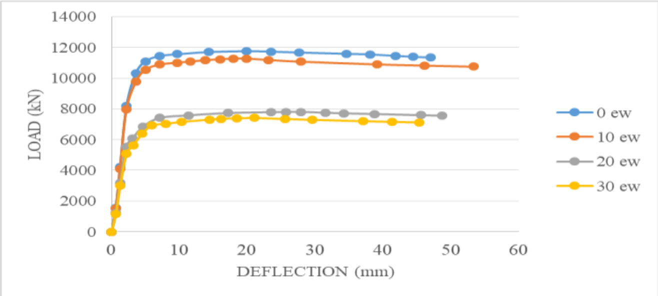

Fig-4: Load deflection curve of Octagonal SSCFST

Load-deflection curve and analytical values of Octagonal SSCFST column shown in fig-4 and table 2.

2.2 Analytical Modelling of Single Skinned Octagonal CFST Column with varying height subjected to axial loading

Octagonal SSCFST with 3000mm, 4000mm and 5000mm were modelled and the resulting best model is the column with 3000mm height. Total deformation of 3000mm column is shown in fig 5 and analytical values are tabulated in table 3.

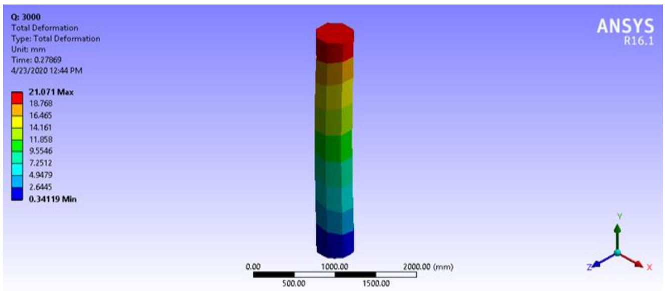

Fig-5: Total Deformation of 3000mm Column

Table-3: Analytical values of columns

MODEL	DEFLECTION (mm)	LOAD (kN)	% OF LOAD
H 1500	19.92	11278.00	1.00
H 3000	45.34	11384.00	0.93
H 4000	47.04	10991.00	-2.54
H 5000	21.38	10669.00	-5.40

Load-deflection curve and analytical values of Octagonal SSCFST column shown in fig-6 and table 6.

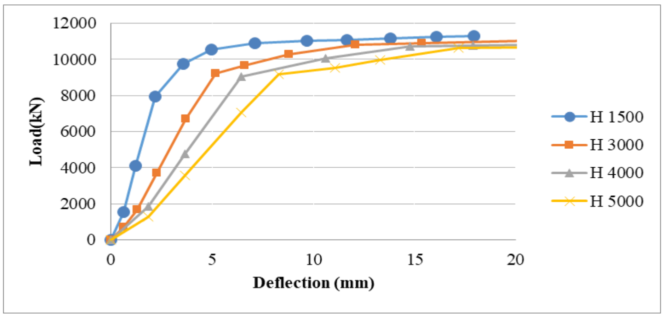

Fig-6: Load deflection curve of Octagonal SSCFST with varying height

2.3 Analytical Modelling of Single Skinned Circular CFST Column subjected to axial loading

The column has dimensions of 1500 mm height, 5 mm thickness, and diameter of 502 mm.

Modelling, meshing and analysis of Circular SSCFST is shown in fig 7 to fig 9

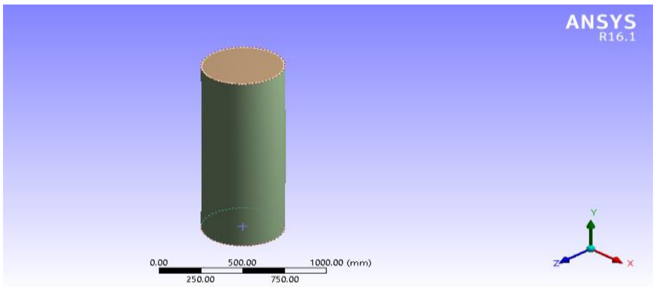

Fig-7: Geometry of Circular single skinned CFST column

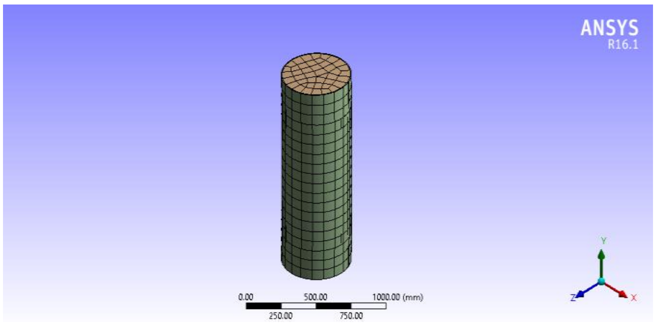

Fig-8: Meshing of Circular single skinned CFST column

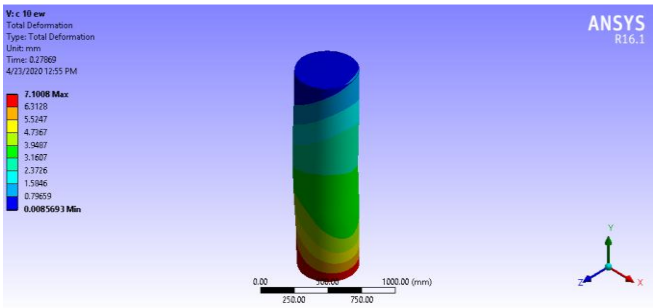

Fig-9: Total deformation of Circular single skinned CFST column

Table-4: Analytical values of columns

% of E-Waste	Load (KN)	Deflection (mm)	% decrease in load
0	8706	3.6912	1
10	8678	3.6921	0.322
20	8499.8	5.0849	2.368
30	8478.4	3.6911	2.614

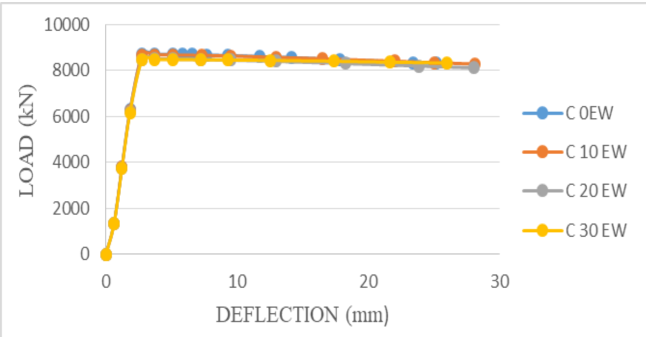

Fig-10: Load deflection curve of Circular SSCFST

Table 4 shows the analytical values of circular columns and
fig 10 shows the Load deflection curve of Circular SSCFST columns

2.4 Analytical Modelling of Double Skinned Circular-Octagonal CFST Column subjected to axial loading

Four various double skinned CFST columns (octagonal-octagonal, octagonal-circular, circular-circular and circular-octagonal) with 3000mm height, 260mm dia outer circular steel tube, 132.55mm edge length of inner octagonal steel tube 5mm thick inner and outer steel tube is infilled with 100mm thick concrete . From that circular-octagonal model shows best load carrying properties.

Modelling, meshing and analysis of Octagonal DSCFST is shown in fig 11 to fig 13. Table 5 shows the values of SSCFST and DSCFST column.

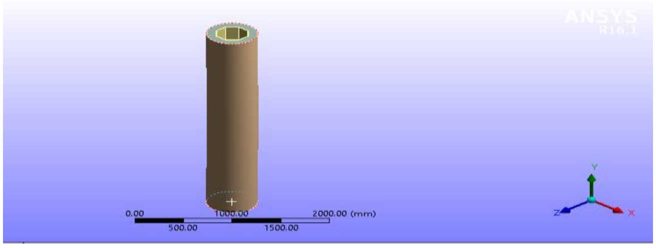

Fig-11: Geometry of Circular octagonal DSCFST column

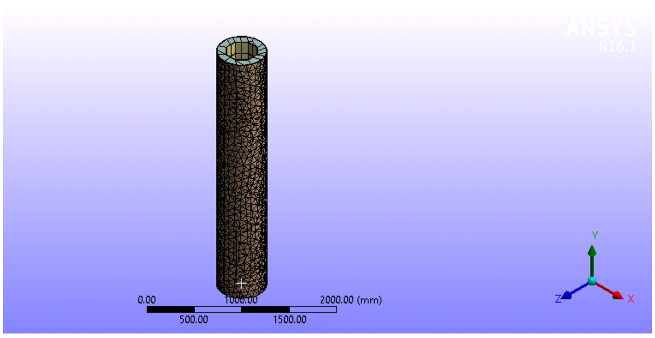

Fig-12: Meshing of Circular octagonal DSCFST column

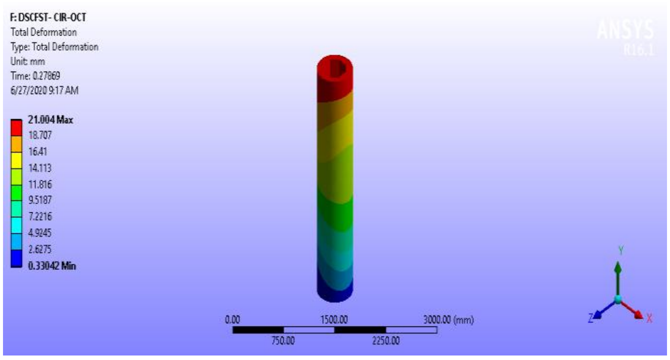

Fig-13: Total deformation of Circular octagonal DSCFST column

Table-5: Analytical values of SSCFST and DSCFST column

MODELS	DEFLECTION (mm)	LOAD (kN)	% OF LOAD
SSCFST	45.337	11,384.00	1.00
DSCFST OCT-OCT	54.85	10,832.00	-5.10

DSCFST OCT-CIR	53.38	11,174.00	-3.06
DSCFST CIR-CIR	59.60	12,302.00	13.57
DSCFST CIR-OCT	65.90	12,713.00	17.37

Fig 14 and table 5 shows the comparison of load deflection curves of octagonal SSCFST column and octagonal-circular DSCFST columns respectively.

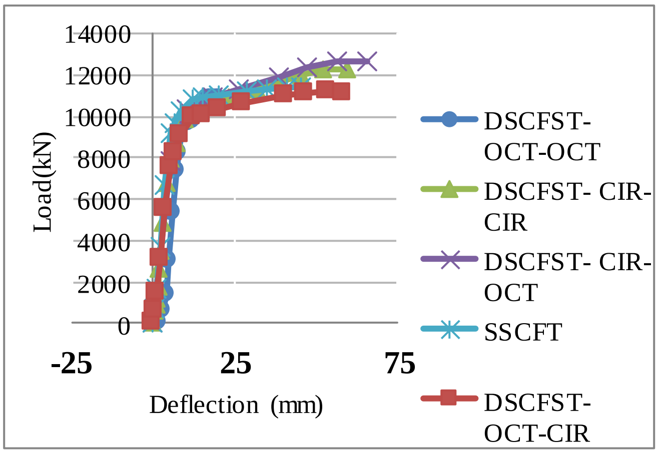

Fig-14: Load deflection curve of octagonal SSCFST and DSCFST

2.5 Comparison of CFST columns subjected to lateral loading

By comparing octagonal SSCFST and octagonal-circular DSCFST columns subjected to lateral loading, fig 15 and fig 16 shows the total deformations of both columns. Values are tabulated in table 6. The load deflection curve of octagonal SSCFST column and circular octagonal DSCFST column is shown in fig 17.

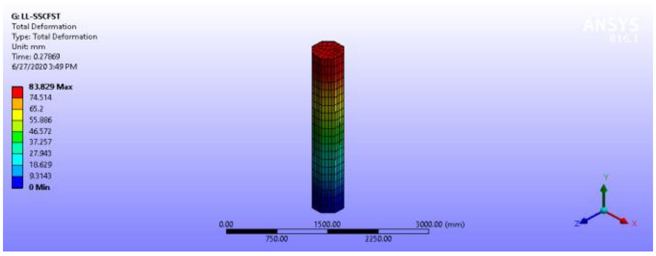

Fig-15: Total deformation of octagonal SSCFST column

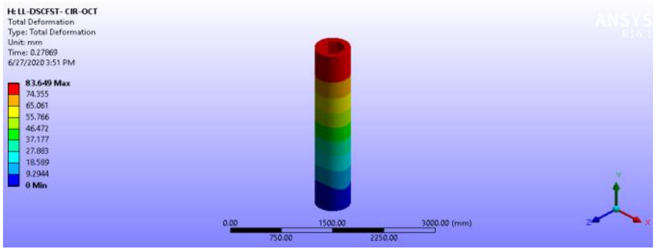

Fig-16: Total deformation of circular-octagonal DSCFST column

Table-6: Analytical values of octagonal SSCFST and circular-octagonal DSCFST column

MODELS	DEFLECTION(mm)	LOAD (kN)	% OF LOAD
LL - SSCFST-OCT	260.00	1,124.20	1
LL-DSCFST-CIR-OCT	303.15	1,438.10	21.83

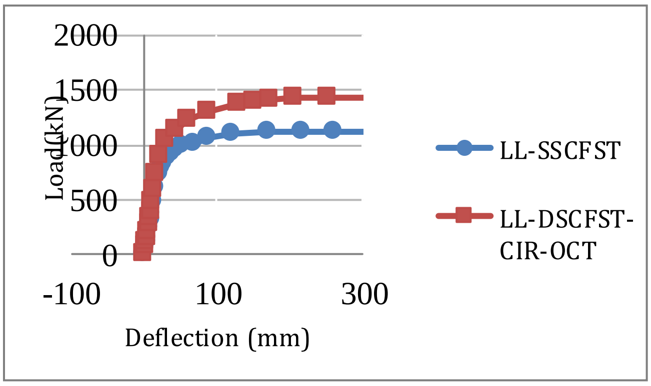

Fig-17: Load deflection curve of octagonal SSCFST and DSCFST

3. RESULTS AND DISCUSSIONS

From the analytical study of single skinned CFST columns subjected to axial loading octagonal column has a maximum load of 11278 kN and that of circular column is 8678 kN. Octagonal columns with 3000 mm height has a maximum load of 11384 kN . For the analytical study of double skinned CFST column circular-octagonal model shows a maximum load of 12713 kN. By comparing the two types of CFST subjected to lateral loading, the circular-octagonal column has a maximum load of 1438.10 kN.

4. CONCLUSIONS

Modelling and validation of specimens were done in ANSYS 16.1. Columns infilled with concrete containing 10% recycled E-Plastic waste shows the better load taking capacity. Single skinned octagonal CFST columns subjected o axial loading bears a decrease in percentage of load of about 4.08 and for 3000 mm height 0.93% of increase in load and for double skinned CFST increase in a load of 17.37 % . By comparing the results which is subjected to lateral loading there is an increase a load of 21.83 % for double skinned compared to single skinned CFST. From the results it is clear that double skinned CFST bears more load than single skinned CFST.

REFERENCES

[1] **Ankit Arora et.al** (2013), "Utilization of E-Waste and Plastic Bottle Waste in Concrete", International Journal of Students Research in Technology, Vol 01, Issue 04.
[2] **Ashwini Manjunath B. T.** (2016), "Partial Replacement of E-plastic Waste as Coarse-aggregate in Concrete", International Conference on Solid Waste Management, Procedia Environmental Sciences, Vol.35, Page No. 731-739.
[3] **Dhaarani D et.al** (2018), "Crushed plastic waste in concrete", International Research Journal of Engineering and Technology, Vol 05, Issue 03.
[4] **Fa-xing Ding et.al** (2016), "Composite action of octagonal concrete-filled steel tubular stub columns under axial loading", Thin walled structures 107, Page No. 453-461.
[5] **Gaikward M. N. et.al** (2018), "Experimental study on plastic waste as a coarse aggregate for structural concrete", International Journal on Recent and Innovation Trends in Computing and communication, Vol 06, Issue 04.
[6] **Govind V. Dhanani et.al** (2016), "Effect of Use Plastic Aggregate as Partial Replacement of Natural Aggregates in Concrete with Plastic Fibers", International Research Journal of Engineering and Technology, Vol 03, Issue 04.
[7] **Jaivignesh B. et.al** (2017), "Study on Mechanical Properties of Concrete Using Plastic Waste as an Aggregate", IOP Conference Series: Earth and Environmental Science, Vol 80, Page No. 1755-1815.
[8] **Kasib R Malik** (2015), "Use of waste plastic in concrete mixture as aggregate replacement", International Journal of Engineering, Education and Technology, Vol 03, Issue 02.
[9] **Khilesh Sarwe** (2014), "Study of Strength Property of Concrete Using Waste Plastics and Steel Fiber", The International Journal of Engineering and Science, Vol 03, Issue 05.
[10] **Pramod S Patil et.al** (2014), "Innovative Techniques of Waste Plastic Used in Concrete Mixture", International Journal of Research in Engineering and Technology, Vol 03, Issue 09
[11] **Praveen Mathew et.al** (2013), "Recycled Plastics as Coarse Aggregate for Structural Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Vol 02, Issue 03.
[12] **Subramani T. et.al** (2015), "Experimental Study On Plastic Waste As A Coarse Aggregate For Structural Concrete", International Journal of Application or Innovation in Engineering & Management, Vol 04, Issue 05.
[13] **Suganthy P. et.al** (2013), "Utilization of Pulverized Plastic in Cement Concrete as Fine aggregate", International Journal of Research in Engineering and Technology, Vol 02, Issue 06.
[14] **Vikram Kathe et.al** (2015), "Green Concrete Using Plastic Waste", International Journal of Engineering Trends and Technology, Vol. 19, Page No.4.
[15] **Vishnu Gate et.al** (2017),"A Review paper on the Performance of Structural Concrete using Recycled Plastics as Coarse Aggregate", International Journal of Advance Research, Ideas and Innovations in Technology, Vol 03, Issue 06.