INCREASING THE STRENGTH OF SOIL USING FLY ASH AND POLYPROPLENE FIBRE

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Abstract: - Infrastructure projects such as highways, railways, water reservoirs; reclamation etc. requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be hauled from a long distance. Quite often, large areas are covered with highly plastic and expansive soil properties, which is not suitable for such purpose.

As fly ash is freely available from Thermal Power Plants, it can be used for stabilization of expansive soils for various uses. The study presents the laboratory work on soil stabilized with fly ash (FA) and polypropylene fibre (PPF). The samples soils were collected from the Morni sub-division (Morni range) of district Panchkula, Haryana, India. Morni range forms a part of the Outer Shivalik Himalaya and its coordinates are 300 35' to 340 45' N latitude and 700 00' to 750 15' E longitude.

Fly Ash is itself an industrial waste which imposes many health and environmental hazards Dumping fly ash is not an environmentally suitable measure as it degrades the soil and water quality nearby the dumping area. Consistent infiltration of fly ash in the agricultural fields may render the crop area infertile. On similar lines, polypropylene too is an industrial waste which can be utilized in constructional activities. Of late polypropylene has been used in many road works all across the country. Rajagopalan Vasudevan, the 2018 Padma Shri awardees pioneered the art of using plastic in road construction works and through this study we aim to further find what different percentage of polypropylene can be used in road works when mixed with soil.

The Atterberg's limits, Specific Gravity, Standard Procter Test, and California Bearing Ratio (CBR) tests have been performed on raw and stabilized soils. The study focuses on investigating the increase of the strength of soil after addition of Fly Ash and Polypropylene Fibre. The investigation aimed at quantifying the optimum quantity of Polypropylene Fibre and Fly Ash on strength parameters which may find potential applications in the diverse field of civil engineering.

Key Words: - **Soil, Polypropylene Fibre, Fly Ash Maximum dry density, Optimum moisture content, Unconfined compressive strength (UCS)**

1. INTRODUCTION

Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be hauled from a long distance [1]. Quite often, large areas are covered with highly plastic and expansive soils, which is not suitable for such purposes. As fly ash is freely available from Thermal Power Plants, it can be used for stabilization of expansive soils for various uses. [2] This study presents the laboratory work on soil stabilized with fly ash (FA) and polypropylene fibre (PPF). The samples soils were collected from the Morni sub-division (Morni range) of district Panchkula, Haryana, India. Morni range forms a part of the Outer Shivalik Himalaya and its coordinates are 300 35' to 340 45' N latitude and 700 00' to 750 15' E longitude.[3][4]

Fly Ash is itself an industrial waste which imposes many health and environmental hazards Dumping fly ash is not an environmentally suitable measure as it degrades the soil and water quality nearby the dumping area. Consistent infiltration of fly ash in the agricultural fields may render the crop area infertile. On similar lines, polypropylene too is an industrial waste which can be utilized in constructional activities. Of late polypropylene has been used in many road works all across the country.[5] Rajagopalan Vasudevan, the 2018 Padma Shri awardee pioneered the art of using plastic in road construction works and through this study we aim to further find what different percentage of polypropylene can be used in road works when mixed with soil.[6]

2. OBJECTIVES: To study the engineering properties of the soil.

1. Optimization of soil with Fly Ash
2. To study the change in properties like O.M.C, Dry density, CBR with different percentage and size of polypropylene.
3. Analysis and interpretation of results.

3. EXPERIMENTAL STUDY

3.1 MATERIALS

Following are the materials which are used for stabilization of Clay soil:

a) POLYPROPYLENE FIBRE: - Polypropylene fiber to which does not absorb or respond with soil dampness or leachate. Warm and degree Celsius are different properties. The polypropylene filaments utilized as a part of this examination has physical properties, particular gravity of 0.91 and a normal measurement and length from 0.06mm to 20mm individually.

Fig.1:- Polypropylene Fibre

Table 1: Properties of polypropylene fibre

Sr. No.	Characteristics	Value
1	Fibre type	Single fibre
2	Unit weight	$0.91 g/cm^3$
3	Average diameter	0.04 mm
4	Average length	12mm
5	Breaking tensile strength	350Mpa
6	Modulus of elasticity	3500Mpa
7	Fusion point	160 degree
8.	Burning point	590 degree
9.	Acid and alkali resistance	Very good
10.	Dispersibility	Excellent

b) FLY ASH:- Fly ash is a non-crystalline pozzolanic and slightly cementitious material. Fly ash is non cohesive material having a relatively smaller specific gravity than the normal soils. The size of fly ash same as a silt. It consists of often hollow spheres of silicon, aluminum and iron oxides, and unoxidized carbon**.**

The chemical, physical and engineering property of ash depends on:

1. The type and source of coal used
2. Method and degree of coal preparation
3. Cleaning and pulverization
4. Type and operation of power generation unit, ash collection
5. Handling and storage methods

So, the properties of fly ash vary from plant to plant and even within the same plant. In this study I will use class F category fly ash collected from Panipat thermal power plant. Class F fly ash is obtained from the burning of anthracite and bituminous coals. It has low calcium content. Chemical and physical properties of fly ash as per Professor Ravi Kumar Sharma (Department of Civil Engineering, National Institute of Technology) given in tables.

Fig.2:- fly ash

Table 1:- Chemical properties of fly ash

CONSTITUENT	%age
Silica (SiO2)	59.50
Alumina (Al2O3)	27.10
Iron oxide (Fe2O3)	7.36
Calcium oxide (CaO)	2.30
Magnesium Oxide (MgO)	0.64
Sulphur tri oxide (SO3)	0.85
Loss of ignition	2.25

Table 3:- Physical properties of fly ash

Sr. No.	Characteristics	Value
1	Specific gravity	1.968
2	Liquid limit (%)	40.1
3	OMC (%)	31.5
4	MDD(gm/cc)	1.167
5	Coefficient of permeability(cm/s)	5.557 x 10-5

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3.2 EXPERIMENTAL INVESTIGATION

The following were tests performed for the present study in laboratory:-

1. Atterberg limits
2. Standard Proctor Test for determination of O.M.C and MDD
3. California Bearing Ratio Test
4. Direct shear test

In this research work an attempt has been made through extensive laboratory experimentation to utilize the Fly ash with Polypropylene fibre for stabilization of clayey sand soil. The soil samples were tested to examine their physical properties like Liquid Limit and Plastic Limit. The Maximum Dry Density and Optimum Moisture Content of the soil were obtained using Standard Proctor's Compaction Test. After examining the physical properties of clayey sand soil, the soil was mixed with different percentages of Fly ash and Polypropylene fibre and then CBR, Cohesion and friction angle values are determined. The main focus of the present investigation was to conduct systematic research work on the effect of Fly ash and Polypropylene fibre in stabilization of clayey sand soil, so that new method of application can be evolved.

3.2.1 OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY: - The clayey soil samples with Fly ash reinforced with Polypropylene fibre have been tested by using Standard Proctor Test at varied values of moisture content for the analysis of MDD and OMC. The results are illustrated as below.

Table 4:- Values of MDD and OMC for soil with different % of Fly ash

Sr.No.	% of Fly ash	MDD (γ_d)g/cc	OMC (w)%
1.	0	1.964	12
2.	3	1.986	12.1
3.	5	2.025	12.5
4.	7	2.127	13
5.	9	2.055	13.8

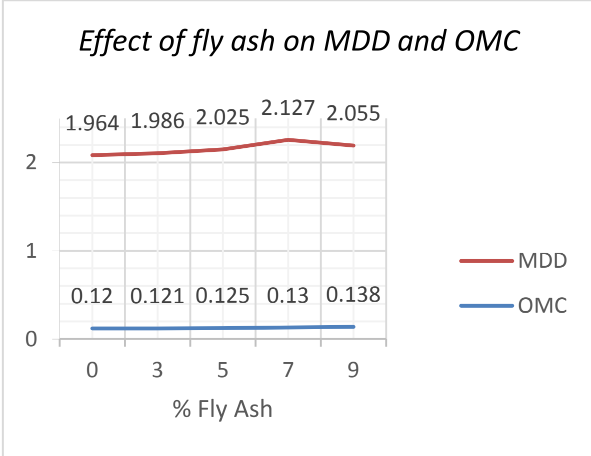

Chart1:- Values of MDD and OMC for the soil with Fly ash

Table 2:- Values of MDD and OMC for 7% fly ash soil reinforced with Polypropylene fibre

Sr.No.	% of waste materials (FA +polypropylene fibre)	MDD (γ_d)g/cc	OMC, (w)%
1.	7%+0.05%	2.05	13.5
2.	7%+0.1%	2.06	14.3
3.	7%+0.15%	2.04	15

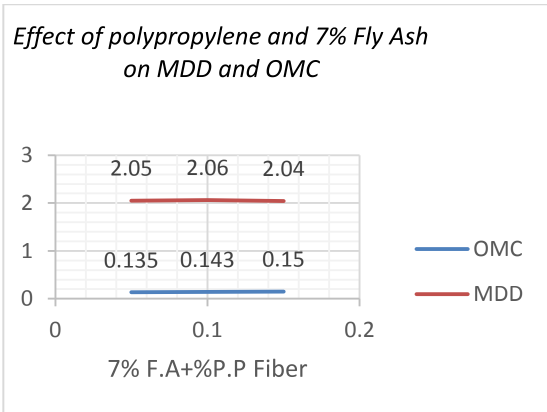

Chart 2:- Values of MDD and OMC for the Stabilized Soil.

To study the effect of addition of waste materials on OMC and MDD relationship discrete waste material at different proportion was mixed with clayey sand soil the optimum moisture content increases and maximum dry density decreases with addition of waste materials.

3.2.2 CALIFORNIA BEARING RATIO FOR THE REINFORCED SOIL: - The clayey sand soil samples are tested by using CBR at the maximum dry density and optimum moisture content as determined in the laboratory on soil at different combinations. The test results calculated at different combinations are given below in Table 6 and Chart 3.

Table 3:- CBR values of soil with different percentage of Flay ash

Sr.No.	% of Fly ash	CBR (kg/cm²)
1.	0	3.15%
2.	3	3.84%
3.	5	3.61%
4.	7	4.00%
5.	9	3.84%

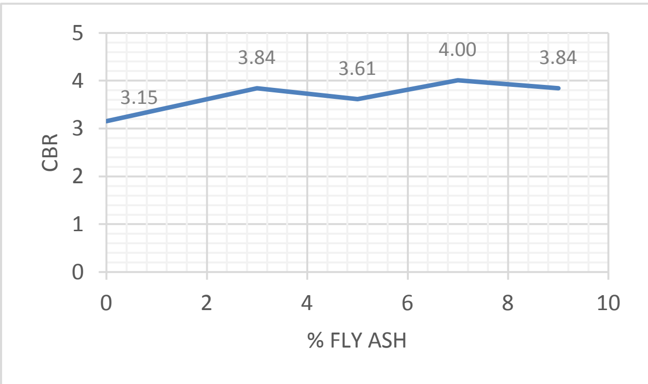

Chart 3:- CBR values of soil with Fly ash

Table 4:- Soaked CBR values of Stabilized Soil.

Waste % of materials (FA + polypropylene fibre)	Soaked CBR values of stabilized soil (%)
Virgin soil	3.15
7% + 0.5%	4.13
7%+ 0.1%	4.34
7%+ 0.15%	4.2

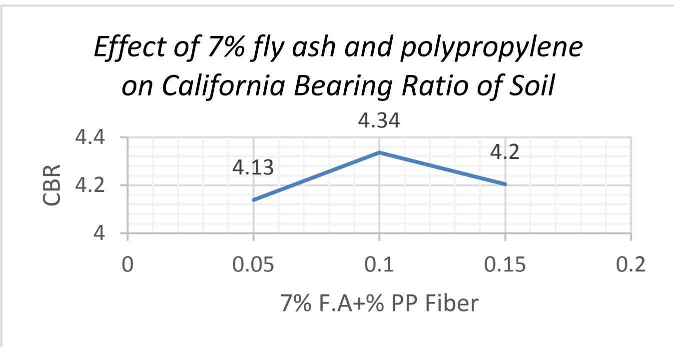

Chart 4:- Soaked CBR values of Stabilized Soil.

By the addition of waste materials the CBR values increases up to 7% F.A+0.1% PP Fibre after that it reduces.

3.2.3 DIRECT SHEAR TEST: - The clayey sand soil samples reinforced with Fly ash and Polypropylene fibre have been tested by using direct shear Test at the maximum dry density and optimum moisture content as determined in the laboratory on soil at different combinations for the analysis of Cohesion(c) and Angle of internal friction (φ) of soil. The results are illustrated as below.

Table 5:- Values of Cohesion(c) and Angle of internal friction (φ) for soil with different percentage of Fly ash.

Sr.No.	(%) of Fly ash	Cohesion kg/cm²	Angle of internal friction (φ)
1.	0	0.309	20.15°
2.	3	0.429	23.83°
3.	5	0.44	24.70°
4.	7	0.537	23.83°
5.	9	0.483	25.16°

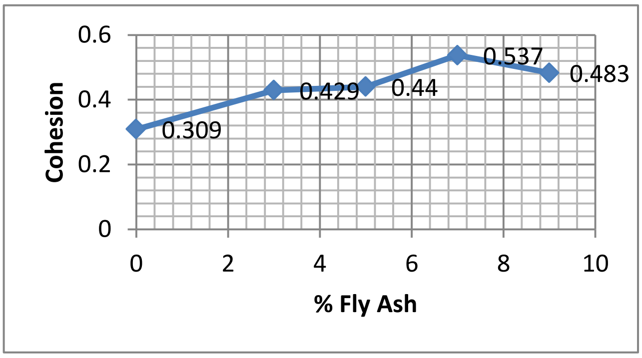

Chart 5:- Values of Cohesion for the soil with Fly ash

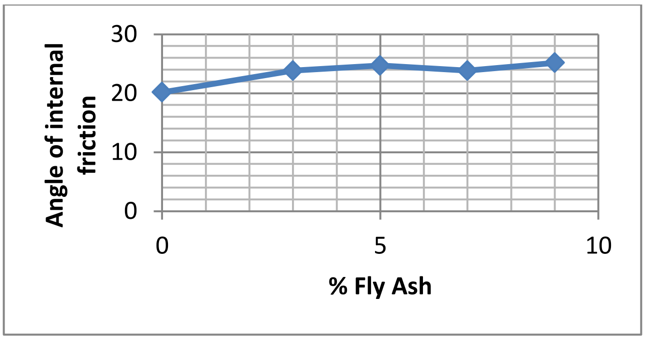

Chart 6:- Values of Angle of internal friction for the soil with Fly ash

Table 6 Values of Cohesion(c) and Angle of internal friction (φ) for 7% fly ash soil reinforced with Polypropylene fibre.

Sr.No.	Percentage of Waste material(Fly Ash + Polypropylene Fibre)	Cohesion kg/cm²	Angle of internal friction (φ)
1.	Virgin Soil	0.309	20.15°
2.	7%+0.05%	0.52	26.1°
3.	7%+0.1%	0.532	27.2°
4.	7%+0.15%	0.57	30.75°

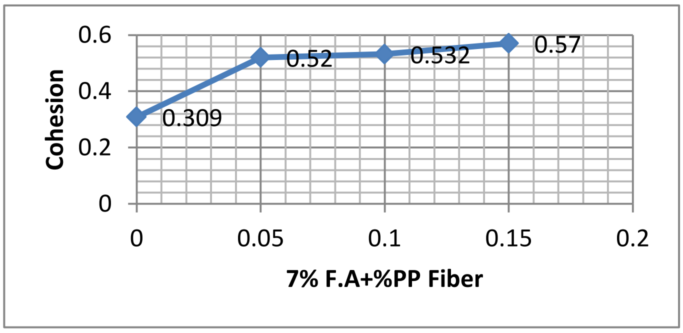

Chart 7:- Values of Cohesion for 7% fly ash soil reinforced with Polypropylene fibre

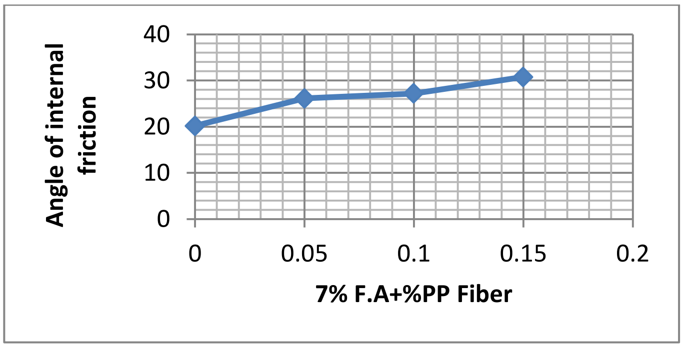

Chart 8:- Values of Angle of internal friction for 7% fly ash soil reinforced with Polypropylene fibre.

4. CONCLUSIONS

Based on the laboratory tests conducted for this study the following conclusions are given below.

1. The Optimum Moisture Content (OMC) and Maximum Dry Density values obtained from virgin soil were 12% and 1.965 g/cc respectively.
2. Through Standard Proctor Test, it was concluded that maximum dry density and optimum moisture content were obtained at 7% fly ash mixed in soil. Compared to virgin soil, a marginal 8.22% increase in Maximum Dry Density was observed.
3. At 0.1% polypropylene fibre mixed with 7% fly ash content, a marginal increase of 4.88% in MDD value was observed. At 7% fly ash content, MDD was found to be further improved as compared to just fly ash mixed with soil.
4. In comparison to virgin soil (Clayey Sand – SC group) the soil mixed with 7%fly ash gave a substantial increment of 26.98% in CBR value. Thus it was concluded to fix the percentage of fly ash a 7% to further analysis effect of polypropylene in the soil mix.
5. As compared to soil mixed with 7% fly ash, 0.1% polypropylene mixed with 7% fly ash gave CBR value of 4.33. Thus 8.25% increase in CBR value was observed.
6. In comparison to virgin soil, an overall gain of 37.46% of CBR value was obtained with 7%fly ash and 0.1% polypropylene fibre mix.
7. When virgin soil (Clayey Sand) mixed with 7%fly ash gave a substantial increment of 73.78% in Cohesion value and 18.26% in Angle Of Internal Friction. Thus it was concluded to fix the percentage of fly ash a 7% to further analysis effect of polypropylene in the soil mix
8. The shear quality parameters of clayey sand soil were determined by coordinate shear test delineates the value of cohesion enhanced for soil admixed with 7% Fly ash and various polypropylene fibre reinforcement of 0.05%, 0.1% and 0.15% are 68.28%, 72.16% and 84.46% respectively. The increment of the internal angle of friction (φ) was observed to be 29.53%, 34.99% and 52.61% individually. Thus, a net increase in the cohesion and the internal angle of friction φ were seen to be 84.46%, from 0.309 kg/cm2 to 0.57 kg/cm2 and 52.61%, from 27.82 to 30.75 degrees.
9. The fibrous mix develops resistance towards sudden failure by improvising upon grain contact of the overall mix.
10. With overall gain of 37.46% of CBR thickness of sub grade reduced to around 25 mm in rural roads as per IRC: SP72-2007.

5. FUTURE SCOPE

i) The waste materials i.e. fly ash and propylene fibre in varying size and percentage can be used in other regions with different soil properties.

ii) Varying percentage of Polypropylene Fibre can be combined with materials other than Fly ash such as Bottom ash, Pond ash, Steel Plants, Blast furnace slag; Granulated, blast furnace slag, Steel slag lime, and other such materials can be used together, and may be varied in quantity to obtain the best possible stabilizing mixture.

REFERENCES

- Arpan Sen, Rishabh Kashyap, (2012) "Soil Stabilization Using Waste Fiber Materials, 'Thesis, Nit,RourkelaConstructionEarthworksManual_Nov 2011
- S. Bhuvaneshwari, R. G. Robinson, S. R. Gandhi "STABILIZATION OF EXPANSIVE SOILS USING FLYASH" Fly Ash India 2005
- Raj Kumar, R.L. Ahuja, N.T. Singh, S.K. Ghabru, "Characteristics and Classification of Alkali Soils on Siwalik Hills of Satluj-Yamuna Divide, North-West India", Haryana Agricultural University, Hissar-125 004, 1995
- H. S. Chore, a a Kumthe, S. B. Abnave, S. S. Shinde, S. S. Dhole, and S. G. Kamerkar, "Performance evaluation of polypropylene fibres on sand-fly ash mixtures in highways." J. Civ. Eng., vol. 39, no. 1, pp. 91–102, 2011.
- Ghanshyam Dass, (1977), "Geology and Sedimentology of the lower tertiary rocks of Morni Sarahan Dadahu region Haryana and Himachal Pradesh", PhD. Thesis, Centre of Advanced Study in Geology, Panjab University, 1977
- R. Saravanan, R. S. Thomas, and M. Joseph, "A Study on Soil Stabilization of Clay Soil Using Flyash." vol. 1, no. 2, pp. 33–37, 2013.
- Mr.Redij Pushpak Vilas* Mr.Palkar Manish Pramod* Mr.Sawant Siddhesh Vasant Prof. Mr. P.B Rajmane "Use of Waste Polypropylene from Plastic Industry in Road Construction" International Journal of Engineering Technology, Management and Applied Sciences, 2017
- Hemant Kumar Gupta, Anant Kumar Gupta,Sarika Awasthi"Enhancement in Stabilization Properties of Soil Using Waste Polypropylene Plastic Fibre", International Journal of Engineering Technology Science and Research, 2017
- Shish Pal1,Vinod Kumar Sonthwal2, Jasvir S Rattan3 "Soil Stabilisation Using Polypropylene as Waste Fibre Material" International Journal of Innovative Research in Science, Engineering and Technology 2015
- Prof.S.Ayyappan, Ms.K.Hemalatha and Prof.M.Sundaram "Investigation of Engineering Behavior of Soil, Polypropylene Fibres and Fly Ash -Mixtures for Road Construction" International Journal of Environmental Science and Development, Vol. 1, No. 2, June 2010.
- Teresa Sunny, Annie Joy "Study on the Effects of Clay Stabilized with Banana Fibre" International Journal of Scientific Engineering and Research (IJSER) 2014.
- Wajid Ali Butt ,B. A. Mir , J. N. Jha "Strength Behavior of Clayey Soil Reinforced with Human Hair as a Natural Fibre" Geotechnical and Geological Engineering 2015.
- Jesna Varghese, Remya.U. R , Snigdha.V. K,"The Effect of Polypropylene Fibre on theBehaviour of Soil Mass with Reference to theStrength Parameters"International Journal of Engineering Research and technology 2016.
- Mamta Mishra*, U. K. Maheshwari and N. K. Saxena.; "Improving Strength of Soil using Fibre and Fly ash -A Review" International Research Journal of Engineering and Technology (2016)
- T.Subramani, D.Udayakumar "Experimental Study On Stabilization Of Clay Soil Using Coir Fibre" International Journal of Application or Innovation in Engineering & Management (IJAIEM) (2016).
- C. M. Sathya Priya1, S. Archana2, A. Bichu Albert3, A. D. Deeraj4 "STABILIZATION OF CLAYEY SOIL USING POLYPROPYLENE FIBRE" International Research Journal of Engineering and Technology (IRJET) (2017)
- IS: 2720 Part 5: Methods of test for soils, Determination of liquid and plastic limit of soil.
- IS: 2720 (Part 7) (1974), "Indian Standard Methods of Test for Soils: Determination of Moisture Content-Dry Density Relation using Light Compaction", Bureau of Indian Standards.
- IS: 1498 (1970), "Indian Standard Methods of Test for Soils: Classification and Identification of Soil for General Engineering Purposes", Bureau of Indian Standards.
- IS:2720 Part 16: Methods of test for soils, Laboratory determination of CBR Value of Soil.
- IS: 2720 Part 13: Methods of test for soils, Direct shear test.
- IS: 2720 Part 16: Methods of test for soils, Laboratory determination of CBR Value ofSoil.
- Dragan Cakmak Elmira Saljnikov, Chemical Soil Stabilization. 1965, National Academic of Sciences.
- O G Ingles, JB Metcalf, Soil Stabilization Principles and Practice. 1973, New York, Wiley, M. Budhu, Soil Mechanics and Foundation. 2010.
- P. Purushothama Raj, Soil Machanics And Foundation Engineering. 2008. Dorling Kindersley (India) Pvt. Ltd.
- Dr. K.R. Arora, Soil Mechanics and Foundation Engineering. Seventh Edition 2008, StandardPublishers Distributers.
- Tripti Goyal "Experimental study of clayey soil stabilized with fly ash and recron-3s"International research journal of engineering and technology(IRJET) VOLUME:05 ISSUE:10 OCT 2018