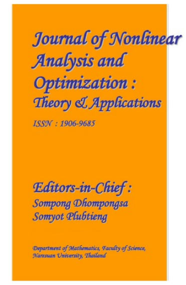
Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.10 : 2024
ISSN :**1906-9685**



GEOTECHNICAL UTILIZATION OF FLY ASH IN SUBGRADES AND EMBANKMENTS

K.Srinivas (Asst Professor) Department of Civil Engineering
Vignan's Institute Of Information Technology (Autonomous)Duvvada,
Visakhapatnam,530049,India srinivas.civil@vignan.edu.in
V.Nishanth, Department of Civil Engineering,Vignan's Institute Of Information Technology (Autonomous)Duvvada,Visakhapatnam, 530049,India. nishanthvydani246@gmail.com
Y.Ashok Department of Civil EngineeringVignan's Institute Of Information Technology (Autonomous)Duvvada,Visakhapatnam,530049,India. yallaashok62@gmail.com
V.Narayan Navtej, Department of Civil Engineering Vignan's Institute Of Information Technology (Autonomous)Duvvada,Visakhapatnam,530049,India. navtejvasipalli@gmail.com
R.Venkata Sai Durga Prasad, Department of Civil Engineering,Vignan's Institute of Information Technology (Autonomous) Duvvada,Visakhapatnam, 530049, India. nanidp7777@gmail.com
S.Samuel babu, Department of Civil Engineering
Vignan's Institute Of Information Technology(Autonomous),Duvvada,Visakhapatnam, 530049,India. settisamuelbabu8838@gmail.com.

ABSTRACT : One waste product that comes from burning coal in a thermal power station is fly ash. (1)It is a significant industrial byproduct of burning coke. India possesses some of the world's greatest coal deposits. Fly ash is utilized in several industries, including the building of roads, embankments, and bricks. Its low cost and wide availability make it worth looking into if it may be used. One of the areas where fly ash is being consumed in large quantities is fly ash embankments. As in India, fly ash is currently only used 6% of the time on roads and embankments. The current investigation compares and determines the geotechnical characteristics of fly ash and soil from the Hinduja National Power Corporation Limited (HNPCL) thermal power plant in Visakhapatnam.
Keywords—Fly ash, physical property.

1.INTRODUCTION

1 Due to its many advantages and potential to completely transform construction methods, fly ash usage has become a crucial topic of research and application in the field of civil engineering(**2**). As students studying civil engineering, the goal of this research was to investigate the advantages of replacing soil in areas lacking strong,(**3**) adequate soil with fly ash.

1.1 WHAT IS FLY ASH

2 A byproduct of burning ground coal, fly ash is typically connected to power plants that generate electricity. Fly ash is a fine-grained dust that is mostly made up of different oxides and alkalies, silica, and alumina.(**4**) It is naturally pozzolanic and can react with hydrated lime to create cement-like substances. The process of changing a soil's characteristics to enhance its engineering capabilities is known as soilstabilization.(**5**) Density, water content, flexibility, and strength are the characteristics that are most frequentlychanged.(**6**)temporary improvement of subgrade stability for the purpose of accelerating construction is known as soil property modification.

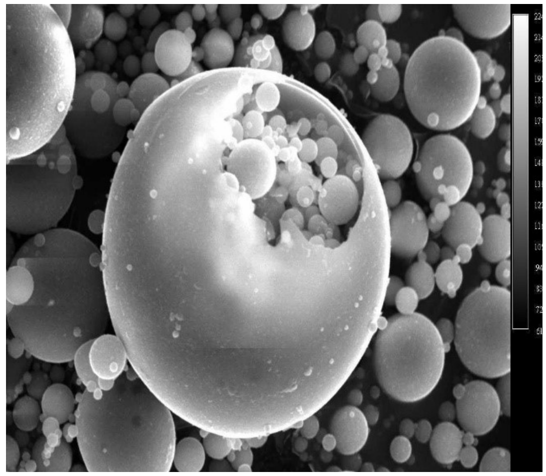


Fig. 1.Scanning Electron microscope of Fly Ash

Soils intended for highway bases can be stabilized with the use of fly ash as a binder.(**7**)On the other hand, not much is known about the repurposing of high carbon off-spec fly ash in the building of road pavements. This is crucial when calcium-rich activators are needed to produce pozzolanicreactions and high carbon fly ash is not cementitious. Thus, it is necessary to assess the base layers stabilized with high carbon fly ash for strength and stiffness.

Fly ash is used for stabilizing embankments to increase slope stability, bases or subgrades, backfill to lessen lateral earth pressures, and slope stability. Numerous projects have effectively used fly ash to enhance the soils' strength properties. (**8**)The normal depth of stabilized soil is between 15 and 46 centimeters, or 6 and 18 inches. Fly ash is primarily utilized in soil stabilization applications to increase the soils' compressive and shearing strengths.

1.2 TYPES OF FLY ASH

. Usually fly ash is two types:

1. Class C
2. Class F

Class C: Class C fly ash hardens and becomes stronger over time when it comes into contact with water. Typically, Class C fly ash has a lime content of greater than 20% (CaO). Self-cementing Class C fly ash doesn't need an activator, in contrast to Class F. Class C fly ashes often contain higher concentrations of alkali and sulfate (SO4). Class C fly ash hardens and becomes stronger over time when wet. Typically, Class C fly ash has a lime content of greater than 20% (CaO). Self-cementing Class C fly ash doesn't need an activator, in contrast to Class F. Class C fly ashes often contain higher concentrations of alkali and sulfate (SO4). Class F: Class F fly ash is usually produced by burning older, harder anthracite and bituminous coal. This fly**1.3 Fly ash uses:** Fly ash has a higher flexural strength than flexible pavement and can be utilized to create semi-rigid or rigid pavement. These requirements have the potential to be implemented as wearing courses for low volume roads and as base courses for corridors with higher traffic density.1.4 Physical (**6**)Properties: Generally speaking, fly ash particles are hollow and spherical or glassy solids.(**9**)The term cenosphere refers to the hollow spherical particles. The size of each individual fly ash particle ranges from I micron to Imm. The fineness of the particles is determined by measuring the fly ash's specific surface area using Blain's specific surface area technique. The greater the surface area, the finer the fly ash. (**10**)The technique employed for **1.4 Physical Characteristics:** The fly ash particles are often spherical in form or glassy solids. The hollow spherical particles are referred to as cenospheres.(**11**) I micron to Imm size is the range of fineness for individual fly ash particles. The specific surface area of fly ash is assessed using Blain's specific surface areatechnique.

The fly ash will be finer the larger the surface area.(**12**)Wet and dry sieving is the process used to measure the fineness of fly ash.

Parameter	**Fly Ash**
Moisture Content	2%
Colour	Grey
Particle Shape	Spherical Irregular
Specific gravity	1.9 - 2.55
Grain Size Distribution	Sandy silt to Silty Sand with clay
Porosity	45 % - 50%
Water Holding Capacity	45% - 65%

Table:1 Physical Properties of Fly Ash(26)

- **1.5 Chemical Characteristics:**

Fly ash mostly consists of SiO, Al2O3, Fe2O3, and CaO. (13)Fly ash also contains trace amounts of unburned carbon, MgO, Na2O, K2O, SO3, and MnO2.

The primary component has a wide range of variance.
• Silica (25–60%)
• Alumina (10–30%)
• 5–25% ferric oxide

(**14**)If the total of these three primary components is 70% or more and the amount of reactive calcium oxide is less than 10%, fly ash is classified as siliceous fly ash, also known as class F fly ash.

(**15**)Fly ash is classified as calcareous fly ash, also known as Class C fly ash, if the total of these three components is equal to or greater than 50% and the amount of reactive calcium oxide is not less than 10%.

(**9**)The active ingredients in calcareous or class C fly ash include tricalcium aluminate, free lime (CaO), anhydrate (CaSO), and, in rare cases, calcium silicate.
The engineering qualities as well as the chemical and physical makeup of fly ash have been determined in a number of research conducted in the lab(**16**).

2. MATERIALS USED

2.1 SOIL :

Fig. 2. Soil

2.2 FLY ASH SAMPLE FROM HINDUJA NATIONAL POWER CORPORATION LIMITED (HNPCL) VISAKHAPATNAM :

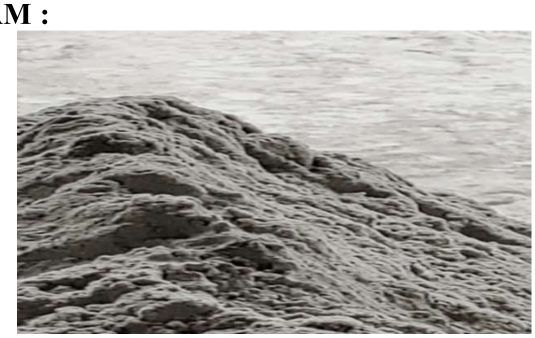


Fig. 3. Fly

3.EXPERIMENTS CONDUCTED

(**17**)Numerous laboratory studies are conducted using the suggested methods. Fly as the index and engineering qualities of materials collected from the field are examined in the lab.(**18**)The sections below provide a detailed explanation of the laboratory investigations.

3.1 SIEVE ANALYSIS (1985 IS 2720-(Part-4)):(**19**)A about 1000 g oven-dried sample of fly ash is placed on a 0.6 mm sieve. Larger opening sieves are positioned above (**20**)smaller opening sieves in a stacking arrangement. Cleanliness of the sieves

The dirt is poured into the stack of sieves from the top after the sieve has been weighted, and the stack is then placed in the sieve shaker with a cover plate on top.**(21**) The sieve's clamps are fastened, and it keeps sieving for ten to fifteen minutes. The mass of each sieve and the dirt that is retained are measured once the sieve shaker is stopped(**22**).

Fig. 4.Sieve analysis equipment.

3.2 SPECIFIC GRAVITY TEST (IS 2720- (Part-3) 1964):

A dry and clean density bottle was used, and it was precisely weighed together with its lid (W1).(**23**) Now, 7 to 10g of cement were moved into the density and weighed once again (W2). The density bottle was now completely filled with kerosene, and the weight of the cement, density bottle, and kerosene was measured (W3). The density bottle was now cleaned, dried, and emptied.(**24**)The density container was now filled solely with kerosene and the lid was weighed (W4). The values listed above are used to determine specific gravity(**25**).

Fig. 5. Density bottle

3.3 PROCTOR CMPACTION TEST (IS 2720-(Part-7) 1980): -

A sample that has been oven dried, weighing about 3 kg, is placed in the pan and well combined with enough water. Weighing the proctor mold is done.(**26**) Using a 4.56 kg rammer, the dirt is compacted in five stages, receiving 25 blows per layer. After removing the collar, the compacted earth is cut and weighed.(**27**) To determine the soil sample's moisture content, a small sample of the soil is taken out of the mold. The preceding process is then repeated for each increment of water supplied. Next, enough water is added to raise the soil sample's moisture content by one or two percentage points. (**28**)The process is kept going until the compacted soil's wet unit weight starts to drop.

Fig. 6. Proctor Compaction Test apparatus

3.4 CALIFORNIA BEARING RATIO TEST
(IS 2720-(Part - 16) 1979): -

At OMC, a representative sample of fly ash is taken, weighing about 5 kg, and properly mixed.(**29**) Using strong compaction, the combined soil is packed into the mold. In order to achieve high compaction, the earth is divided into five equal layers and compressed with a 4.56 kg rammer, giving each layer 56 blows. (**30**)The specimen-containing mold is set on the testing machine's lower plate with the base plate in place and the top face exposed. Before seating the penetration plunger and adding the remaining surcharge weights, a 2.5 kg annular weight is placed on the soil surface to prevent soil from being displaced into the surcharge weight hole(**31,32**).

Fig. 7. CBR Apparatus

4.RESULTS

4.1 SEIVE ANALYSIS OF SOIL:

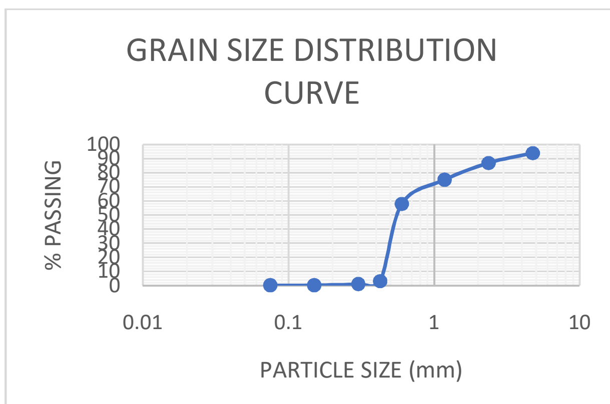


Fig:8 Grain Size Distribution Curve Of Soil

%GRAVAL	**6.11**	**D60**	**0.6**	**CU**	**1.33**
%SAND	**93.68**	**D30**	**0.5**	**CC**	**0.92**
%FINE	**0.21**	**D10**	**0.45**		

Table.2. Sieve analysis values of soil

4.2 PROCTOR TEST RESULTS OF SOIL

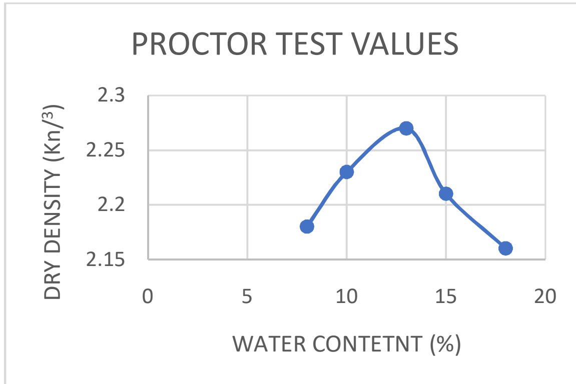


Fig.9. Compaction Curve Of Soil

WATER CONTENT(%)	DRY DENSITY (Kn/m^3)
8	2.18
10	2.23
13	2.27
15	2.21
18	2.16

Table.3. Modified proctor test values of soil

Optimum moisture content (OMC)= 13%
Maximum dry density (MDD)=2.27 (kn/m^3)

4.3 CBR TEST RESULTS OF SOIL

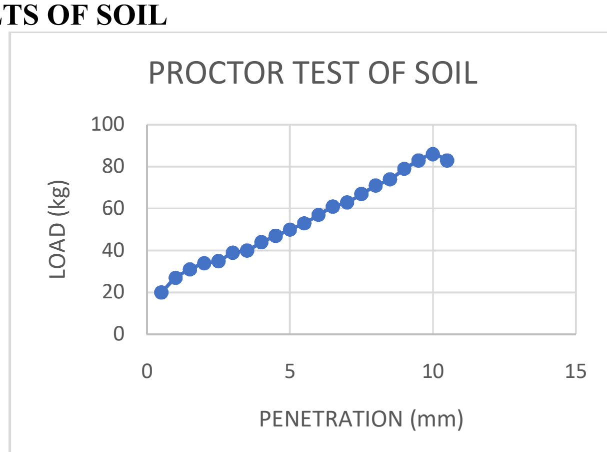


Fig.10. CBR of soil

PENETRATION	LOAD	STANDARD LOAD
@2.5mm	35	1370
@2.5mm	50	2055

Table.4. CBR values of soil

CBR value of fly ash @2.5 mm
(35/1370) *100= 2.5%
CBR value of fly ash @5 mm

(50/2055) *100=2.4%
CBR @2.5 mm is greater than CBR @5 mm, so the CBR value @2.5 mm should be considered

4.4 SIEVE ANALYSIS OF FLY ASH:

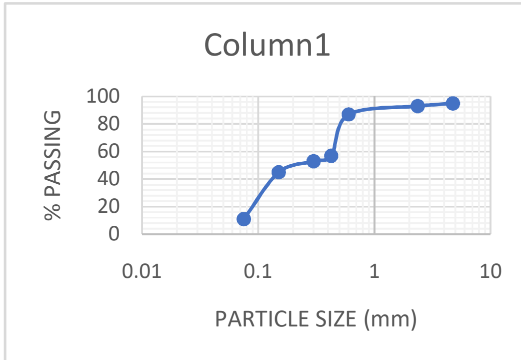


Fig.11. Grain Size Distribution Curve Of Fly Ash

%GRAVEL	0	D60	0.45	CU	6
%SAND	42.6	D30	0.12	CC	0.42
%FINE	57.4	D10	0.075		

Table.5. Sieve analysis values of Fly Ash

4.5 PROCTOR TEST RESULTS OF FLY ASH

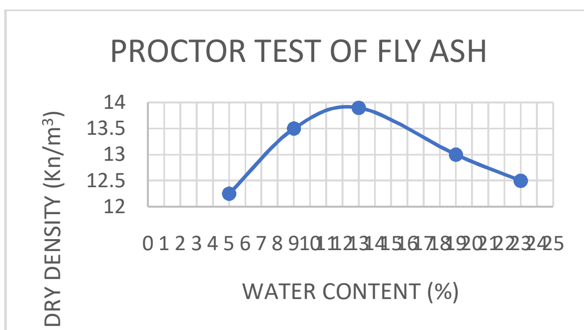


Fig.12. Compaction Curve Of Fly Ash

WATER CONTENT %	DRY DENSITY(Kn/m^3)
5	12.25
9	13.5
13	13.9
19	13
23	12.5

Table:6 Modified proctor test values of Fly ash

Optimum moisture content (OMC) = 13%
Maximum dry density (MDD)=13.9 Kn/m^3

4.6 CBR TEST RESULTS OF FLY ASH:

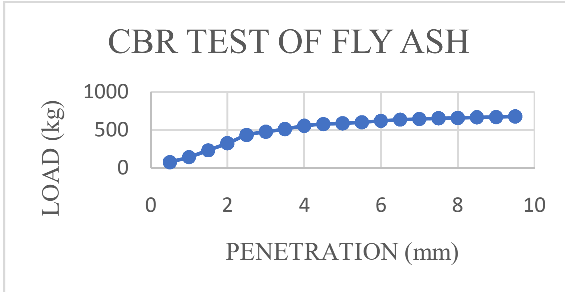


Fig.12. CBR of Fly Ash

PENETRATION	LOAD	STANDARD LOAD
2.5 mm	435	1370
5 mm	587	2055

Table.7. CBR values of Fly Ash

CBR value of fly ash @2.5 mm
(435/1370) *100= 31.75%
CBR value of fly ash @5 mm
(587/2055) *100=28.56%
CBR @2.5 mm is greater than CBR @5 mm, so the CBR value @2.5 mm should be considered

8.7 SPECIFIC GRAVITY:

The specific gravity of soil and fly ash are given below :

SPECIMEN/TYPE OF MATERIAL	SPECIFIC GRAVITY
SOIL	2.5
FLY ASH	2.34

Table:8 Specific gravity of soil & Fly Ash

5.CONCLUSION

The findings of this investigation lead to the following conclusions. Even now, fly ash's potential is still being underutilized. Thus, it is important to efficiently obtain fly ash values while keeping in mind environmental considerations and its necessity as a mineral additive(**33,34,35**). The various physical and chemical specifications outlined in the current fly ash guidelines may not be helpful for geotechnical applications.(**36,37**)A distinct approach of identification and categorization is required in order to facilitate the large-scale use of fly ash as a geo-material.Relevant fly ash index features are identified as a geo-material.(**38**)A straightforward fly ash categorization scheme in relation to the soil classification system is suggested based on these index features(**39**). Since fly is now being used.

6.REFERENCES

1. Arpan Sen, Rishabh Kashyap (2012) soil stabilization wong waste ther materials Department of Civil Engineering, National Institute of Technology Rourkela..

2. BhaskarMajumder "Uses of Industrial Wastes a Focus on Fly Ad, ISBN 7827-172-9, First edition 2007, Volume-8, pp.686-689.

3 DivyaKrishnan K. Janani V.Ravichandran PT. Annadurai and Mand Gunturi (2014), "soil stabilisation using phosphogypsum and flyash International Journal of Engineering Trends and Technology (ETT)
- Volume 9

4 JaxvuSingh Er. Harpreet Singh Maan. Er (July 2017) "soil stabilization using fly ash and rice husk ash International Journal of Innovative Research in Science Engineering and Technology (An ISO 3297 2007 Certified Organization, Vol. 6. Issue 7

5. Joel H. Beeghly (2003) Recent experiences with lime-Fly Ash Stabilization of Pavement Subgrades soils, base and recycled Asphalt". International Ash Utilization Symposium, Center for Applied Energy Research. University of Kentucky, Paper #46

6.Keshav, Vasanth, and Sudhir Vummadisetti. "Non-rectangular plates with irregular initial imperfection subjected to nonlinear static and dynamic loads." *International Journal of Advances in Engineering Sciences and Applied Mathematics* 15, no. 4 (2023): 155-158.

7.Vummadisetti, Sudhir, and S. B. Singh. "The Influence of Cutout Location on the Postbuckling Response of Functionally Graded Hybrid Composite Plates." In *Stability and Failure of High Performance Composite Structures*, pp. 503-516. Singapore: Springer Nature Singapore, 2022.

8.Sathi, Kranthi Vijaya, Sudhir Vummadisetti, and Srinivas Karri. "Effect of high temperatures on the behaviour of RCC columns in compression." *Materials Today: Proceedings* 60 (2022): 481-487.

9.Vummadisetti, Sudhir, and S. B. Singh. "Buckling and postbuckling response of hybrid composite plates under uniaxial compressive loading." *Journal of Building Engineering* 27 (2020): 101002.

10.Vummadisetti, Sudhir, and S. B. Singh. "Postbuckling response of functionally graded hybrid plates with cutouts under in-plane shear load." *Journal of Building Engineering* 33 (2021): 101530.

11.Vummadisetti, S., and S. B. Singh. "Boundary condition effects on postbuckling response of functionally graded hybrid composite plates." *J. Struct. Eng. SERC* 47, no. 4 (2020): 1-17.

12.Singh, Shamsher Bahadur, Sudhir Vummadisetti, and Himanshu Chawla. "Development and characterisation of novel functionally graded hybrid of carbon-glass fibres." *International Journal of Materials Engineering Innovation* 11, no. 3 (2020): 212-243.

13.Vummadisetti, Sudhir, and S. B. Singh. "Buckling and postbuckling response of hybrid composite plates under uniaxial compressive loading." *Journal of Building Engineering* 27 (2020): 101002.

14.Singh, S. B., Himanshu Chawla, and Sudhir Vummadisetti. "Experimental and Analytical Studies of Failure Characteristics of FRP Connections." In *Recent Advances in Structural Engineering, Volume 2: Select Proceedings of SEC 2016*, pp. 755-757. Springer Singapore, 2019.

15.Singh, S. B., Sudhir Vummadisetti, and Himanshu Chawla. "Assessment of interlaminar shear in fiber reinforced composite materials." *Journal of Structural Engineering* 46, no. 2 (2019): 146-153.

16.Singh, S. B., Himanshu Chawla, and Sudhir Vummadisetti. "Experimental and Analytical Studies of Failure Characteristics of FRP Connections." In *Recent Advances in Structural Engineering, Volume 2: Select Proceedings of SEC 2016*, pp. 755-757. Springer Singapore, 2019.
17.Singh, S. B., Sudhir Vummadisetti, and Himanshu Chawla. "Influence of curing on the mechanical performance of FRP laminates." *Journal of Building Engineering* 16 (2018): 1-19.
18.Rakesh, Pydi, Padmakar Maddala, Mudda Leela Priyanka, and Borigarla Barhmaiah. "Strength and behaviour of roller compacted concrete using crushed dust." (2021).
19.Barhmaiah, Borigarla, M. Leela Priyanka, and M. Padmakar. "Strength analysis and validation of recycled aggregate concrete." *Materials Today: Proceedings* 37 (2021): 2312-2317.
20.Padmakar, M., B. Barhmaiah, and M. Leela Priyanka. "Characteristic compressive strength of a geo polymer concrete." *Materials Today: Proceedings* 37 (2021): 2219-2222.
21.Priyanka, Mudda Leela Leela, Maddala Padmakar, and Borigarla Barhmaiah. "Establishing the need for rural road development using QGIS and its estimation." *Materials Today: Proceedings* 37 (2021): 2228-2232.
22.Srinivas, K., M. Padmakar, B. Barhmaiah, and S. K. Vijaya. "Effect of alkaline activators on strength properties of metakaolin and fly ash based geo polymer concrete." *JCR* 7, no. 13 (2020): 2194-2204.

23.Mathew, Rojeena, and M. Padmakar. "Defect development in KDP Crystals produced at severe Supersaturation."
24.Sathi, Kranthi Vijaya, Sudhir Vummadisetti, and Srinivas Karri. "Effect of high temperatures on the behaviour of RCC columns in compression." *Materials Today: Proceedings* 60 (2022): 481-487.
25.Jagadeeswari, Kalla, Shaik Lal Mohiddin, Karri Srinivas, and Sathi Kranthi Vijaya. "Mechanical characterization of alkali activated GGBS based geopolymer concrete." (2021).
26.Srinivas, Karri, Sathi Kranthi Vijaya, Kalla Jagadeeswari, and Shaik Lal Mohiddin. "Assessment of young's modulus of alkali activated ground granulated blast-furnace slag based geopolymer concrete with different mix proportions." (2021).
27.Kalla, Jagadeeswari, Srinivas Karri, and Kranthi Vijaya Sathi. "Experimental analysis on modulus of elasticity of slag based concrete." *Materials Today: Proceedings* 37 (2021): 2114-2120.
28.Srinivas, Karri, Sathi Kranthi Vijaya, and Kalla Jagadeeswari. "Concrete with ceramic and granite waste as coarse aggregate." *Materials Today: Proceedings* 37 (2021): 2089-2092.
29.Vijaya, Sathi Kranthi, Kalla Jagadeeswari, and Karri Srinivas. "Behaviour of M60 grade concrete by partial replacement of cement with fly ash, rice husk ash and silica fume." *Materials Today: Proceedings* 37 (2021): 2104-2108.

30.Mohiddin, Shaik Lal, Karri Srinivas, Sathi Kranthi Vijaya, and Kalla Jagadeeswari. "Seismic behaviour of RCC buildings with and without floating columns." (2020).
31.Kranthi Vijaya, S., K. Jagadeeswari, S. Lal Mohiddin, and K. Srinivas. "Stiffness determination of alkali activated ground granulated blast furnace slag based geo-polymer concrete." *Mater. Today Proc* (2020).
32.Srinivas, K., M. Padmakar, B. Barhmaiah, and S. K. Vijaya. "Effect of alkaline activators on strength properties of metakaolin and fly ash-based geo polymer concrete." *JCR* 7, no. 13 (2020): 2194-2204.

33.Borigarla, Barhmaiah, and S. Moses Santhakumar. "Delay Models for Various Lane Assignments at Signalised Intersections in Heterogeneous Traffic Conditions." *Journal of The Institution of Engineers (India): Series A* 103, no. 4 (2022): 1041-1052.

34.Barhmaiah, Borigarla, A. Chandrasekar, Tanala Ramya, and S. Moses Santhakumar. "Delay models for Signalised Intersections with Vehicle Actuated Controlled system in Heterogeneous Traffic Conditions." In *IOP Conference Series: Earth and Environmental Science*, vol. 1084, no. 1, p. 012038. IOP Publishing, 2022.

35.Borigarla, Barhmaiah, Triveni Buddaha, and Pritam Hait. "Experimental study on replacing sand by M‒ Sand and quarry dust in rigid pavements." *Materials Today: Proceedings* 60 (2022): 658-667.

36.Singh, Sandeep, Borigarla Barhmaiah, Ashith Kodavanji, and Moses Santhakumar. "Analysis of two-wheeler characteristics at signalised intersection under mixed traffic conditions: A case study of Tiruchirappalli city." In *13th Asia Pacific Transportation Development Conference*, pp. 35-43. Reston, VA: American Society of Civil Engineers, 2020.

37.Brahmaiah, B., and A. Devi Prasad. "Study &Analysis Of An Urban Bus And Metro Route Using Vissim Simulated Data." *International Journal of Latest Trends in Engineering and Technology* 8, no. 1 (2017): 406-412.

38.Brahmaiah, B., M. Tech-IITR, A. D. Prasad, and K. Srinivas. "A Performance Analysis Of Modelling Route Choice Behavior On Urban Bus And Multi Mode Transit Route." *Int. J. Adv. Inf. Sci, Technol* (2017): 11.

39.Brahmaiah, B., and A. Devi Prasad. **"PERFORMANCE ANALYSIS OF AN URBAN BUS AND METRO ROUTE USING COMMUTER SURVEY & TRAFFIC DATA."**