ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Characteristics and Utilization of Copper Slag-Fly Ash Mix as Road Construction Material

K.ARUN KUMAR[1],
Ph.D Scholar (Highway Engineering),

DR. A.MAHESH BABU[2],
Professor, Ph.D (Transportation Engineering),

[1,2]Department of Civil Engineering, Tirumala Engineering College, Bogaram(v) Keesara (M), Medchal District Telengana India.

ABSTRACT

In this paper, an effort has been created to check the feasibility of copper dross – ash combine to be used in molding course of the versatile pavements. Variety of cylindrical take a look at specimens (38 millimeter diameter and seventy six millimeter height) was ready with raw materials like copper dross and ash in several proportions.

These samples were cured at a temperature of 300C and wetness ratio of eighty fifth during a humidity controlled chamber for various activity amount of zero, 7, fourteen and twenty eight days. The geotechnical properties of various trial mixes, namely, unconfined compressive strength, soaked CBR and tri axial shear strength were determined. The consequences of ash and content and activity amount on the on top of geotechnical properties were investigated. From this study the half-hour ash +70% copper dross combine was found to be optimum to be used in subbase layers of the versatile pavements. Therefore, construction of road pavements utilizing the optimum combine as stated on top of is feasible. This can facilitate in protective the conventional aggregates used for molding and eliminate problems associated with disposal of commercial waste like copper slag and flash.

Keywords – Copper slag, Fly ash, Unconfined Compressive Strength, CBR, Triaxial Shear Strength.

I. INTRODUCTION

1.1 GENERAL

Copper is one of the basic chemical elements which are a soft and ductile metal, known for its high thermal and electrical conductivity and has a reddish-orange surface in its pure state. It is commonly used in electrical, construction and transportation industries. Pure copper is rarely found in nature, but is usually combined with other chemicals in the form of copper ores.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

The process of extracting copper from copper ore varies according to the type of ore and the desired purity of the final product. Each process consists of several steps in which unwanted materials are physically or chemically removed, and the concentration of copper is progressively increased.

Once the waste materials have been physically removed from the ore, the remaining copper concentrate must undergo several chemical reactions to remove the iron and sulphur. This process is called smelting. The recovery of sulphuric acid from the copper smelting process not only provides a profitable byproduct, but also significantly reduces the air pollution caused by the furnace exhaust. Copper slag (CS) is a waste product which comes out from the smelting process.

Copper slag is a by-product obtained during the copper smelting and refining process. Produced from a copper concentrate containing around 30 - 35% of copper, iron and sulphur each along with around 12% of silica and 5% of calcium. While producing copper the anode, a slag with rich iron and moderate silica content is also generated or copper slag is a by-product created during the copper smelting and refining process.

Copper Slag (CS) is produced as waste from roasting of copper, in which sulphur (as SO 2) is eliminated. CS was used as fine aggregate (up to 30%) in the design of bituminous mixes like Bituminous Macadam, Dense Bituminous Macadam, Bituminous Concrete and Semi-Dense Bituminous Concrete. Mechanical properties of mix such as Marshall Stability, Indirect Tensile Strength was determined. Addition of CS as fine aggregate in various bituminous mixes provides good interlocking and eventually improves volumetric and mechanical properties of bituminous mixes. [5] presented a short overview on widely used microwave and RF applications and the denomination of frequency bands. The chapter start outs with an illustrative case on wave propagation which will introduce fundamental aspects of high frequency technology.

In India, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. The construction of highways and development of several expressways for high-speed corridors exert tremendous pressure on natural resources. Many highway agencies, private organizations, and individuals are in the process of completing a wide variety of studies and research projects concerning the feasibility, environmental suitability, and performance of using waste industrial products in highway construction These studies try to match society's need for safe and economic disposal of waste materials with the highway industry's need for better and more cost-effective construction materials.

Therefore, the naturally occurring materials are fast depleting because of their over exploitation to meet the huge demand for construction of infrastructure projects. In recent years, there has been a growing emphasis all over the world towards promoting the use of marginal materials in road construction in order to affect cost saving, reduce pressure on good quality aggregates and also to protect environment. A huge quantity of industrial by – products

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

such as copper slag, steel slag, blast furnace slag, fly ash etc is generated all over the world and has problems of environmentally safe disposal.

COPPER SLAG

Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which are disposed of as waste or utilized.

Copper slag can be used in concrete production as a partial replacement for sand. Copper slag is used as a building material, formed into blocks. Such use was common in areas where smelting was done, including St Helens and Cornwall in England. In Sweden fumed and settled granulated copper slag from the Boliden copper smelter is used as road-construction material. The granulated slag (<3 mm size fraction) has both insulating and drainage properties which are usable to avoid ground frost in winter which in turn prevents pavement cracks. The usage of this slag reduces the usage of primary materials as well as reduces the construction depth which in turn reduces energy demand in building. Due to the same reasons the granulated slag is usable as a filler and insulating material in house foundations in a cold climate. Numerous houses in the same region are built with a slag insulated foundation.

Fig.1 COPPER SLAG

FLY ASH

Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is a coal combustion product composed of fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as **coal ash**.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

In the past, fly ash was generally released into the atmosphere, but air pollution control standards now require that it be captured prior to release by fitting pollution control equipment. In the US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used as a pozzolana to produce hydraulic cement or hydraulic plaster and a replacement or partial replacement for Portland cement in concrete production. Pozzolana ensures the setting of concrete and plaster and provides concrete with more protection from wet conditions and chemical attack.

Fig 2: FLY ASH

II. LITERATURE REVIEW

M.Maharajan[1] , N.Sakthieswaran[2] , G.Shiny Brintha[3] , O.Ganesh Babu[4] et al. (2013)

The acid attack on cement mortar, the cement mortar is replaced by copper slag and green sand replaced for river sand in equal proportions. The copper slag and green sand replaced by 0%, 10%, 20%, and 30% repectively. The specimen were cured for 28 days from the date of demoulding. The rest specimens were stored in acid solutions (HCl, H2SO4, HNO3) after 28 days of initial curing, and stored at laboratory temperature. Compressive strength tests, mass measurements took place for 24 hours.

Copper slag which is an industrial waste product can be used as replacement for cement and sand and contributes to the increase in various mechanical properties of cement mortar. Copper slag can be used upto 30% but when used beyond 50% results in decrease in strengths. Green sand which is an waste form moulding can be replaced upto 30%, which does not change any properties of cement mortar. If it replaced more than 30%, it will change the strength of the cement mortar. The acid curing is to be done for 10% of dilute acid and kept curing for 24 hours by mixing it with one by third of the water for curing.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

Kacha et al. (2014)

The study concluded that all researchers gave their findings with concrete up to 30- 40% replacement of fine aggregate with foundry sand in which compressive and tensile strength were increased up to 20% whereas not much change occurred in modulus of elasticity. Also workability decreased with the increase of foundry sand content because of very fine particles.

Saraswati et al. (2013)

The study focused on reviewed that compressive strength kept on increasing with an increase on waste foundry sand and the maximum compressive strength had achieved at 60% replacement of fine aggregates. They also reviewed that split tensile strength decreased with increase in percentage of waste foundry

III. EXPERIMENTAL PROGRAMME

A. MATERIALS

In the present investigation, copper slag were collected from Hindalco Industries Ltd. (Unit: Birla Copper) Dahej, Bharuch, Gujarat. Fly ash used in the experimental work was also collected from Hindalco Industries Ltd. (Unit: Birla Copper) Dahej, Bharuch, Gujarat. It was then stored in air airtight container for subsequent use. The physical properties of the raw materials are given in Table I.

B. ATTERBERG LIMITS

Atterberg limit tests were carried out as per IS: 2720 (partV) 1985. The copper slag and fly ash were found to be non plastic in nature. This property is beneficial for use in sub base layer of road pavements.

PHYSICAL PROPERTIES	COPPER SLAG	FLY ASH
Specific gravity	**3.26**	**2.24**
Grain size distribution		
Graval(%)	**0**	0
Coarse sand(%)	20	0
Medium sand(%)	75	5
Fine sand (%)	5	15
Silt +clay	0	80
Co-efficient of uniformity(cu)	2	5
Co-efficient of curvature(cc)	1.75	2.65
IS classification	SP	ML

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

C.UNCONFINED COMPRESSIVE STRENGTH TEST

The loading frame consists of two metal plates. The top plate is stationary and is attached to the load-measuring device. The bottom plate is raised and lowered by means of a crank on the front of the loading frame. After the soil sample has been placed between the plates, the bottom plate is gradually raised; the resistance provided by the stationary top plate applies an axial force to the sample. Although the loading frames in our laboratory are hand operated, electric motor-driven and hydraulic load frames are common. Loads are measured with a calibrated proving ring or an electronic load cell. Vertical deformations are measured with a dial gauge; the dial gauge is attached to the top plate and measures the relative movement between the top and bottom plates. We will be performing a strain-controlled test, in which the load is applied at a constant rate of strain or deformation.

D. CBR TEST

The california bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

This instruction sheet covers the laboratory method for the determination of C.B.R. of undisturbed and re molded /compacted soil specimens, both in soaked as well as un soaked state.

E. TRIAXIAL TEST

A triaxial shear test is a common method to measure the mechanical properties of many deformable solids, especially soil (e.g., sand, clay) and rock, and other granular materialsor powders. There are several variations on the test.

In a triaxial shear test, stress is applied to a sample of the material being tested in a way which results in stresses along one axis being different from the stresses in perpendicular directions. This is typically achieved by placing the sample between two parallel platens which apply stress in one (usually vertical) direction, and applying fluid pressure to the specimen to apply stress in the perpendicular directions. (Testing apparatus which allows application of different levels of stress in each of three orthogonal directions are discussed below, under "True Triaxial test".)

The application of different compressive stresses in the test apparatus causes shear stress to develop in the sample; the loads can be increased and deflections monitored until failure of the sample. During the test, the surrounding fluid is pressurized, and the stress on the platens is increased until the material in the cylinder fails and forms sliding regions within itself, known as shear bands. The geometry of the shearing in a triaxial test typically causes the

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

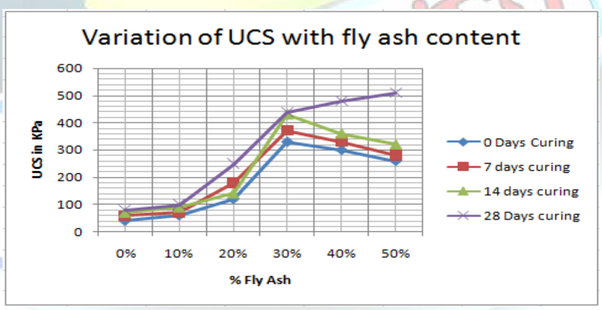
sample to become shorter while bulging out along the sides. The stress on the platen is then reduced and the water pressure pushes the sides back in, causing the sample to grow taller again. This cycle is usually repeated several times while collecting stress and strain data about the sample. During the test the pore pressures of fluids (e.g., water, oil) or gasses in the sample may be measured using Bishop's pore pressure apparatus.

III.RESULTS AND ANALYSIS

1. UNCONFINED COMPRESSIVE STRENTH

Variation of UCS with fly ash content

S.no	%Fly Ash	UCS (KPa)			
		0 days curing	7 days curing	14 days curing	28 Days curing
1	0%	40	60	70	80
2	10%	60	70	90	100
3	20%	120	180	140	250
4	30%	330	370	430	440
5	40%	300	330	360	480
6	50%	260	280	320	510

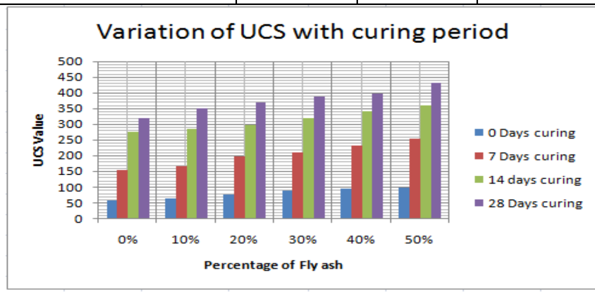


Variation of UCS with curing period

S.NO	% FLY ASH	CURING PERIOD			
		0 days	7 days	14 days	28 days
1	0%	56	152	276	320
2	10%	64	167	284	350
3	20%	74	196	298	370
4	30%	86	210	320	386
5	40%	93	230	342	398

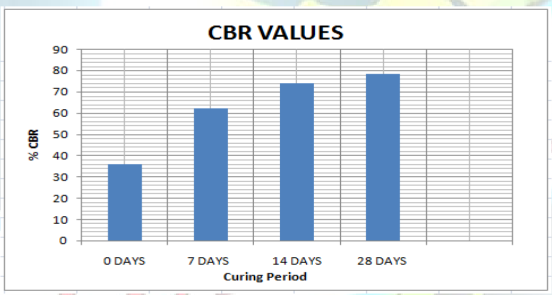
ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

6	50%	98	254	360	430



2. California Bearing Ratio (CBR)

S .NO	CURING PERIOD	CBR VALUES
1	0 DAYS	36
2	7 DAYS	62
3	14 DAYS	74
4	28 DAYS	78

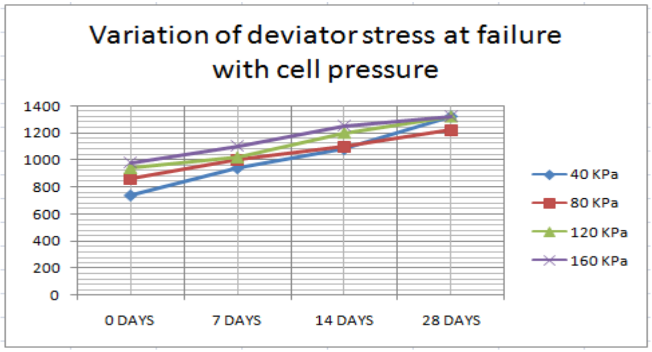


3. Tri axial Shear Strength

Variation of deviator stress at failure with cell pressure

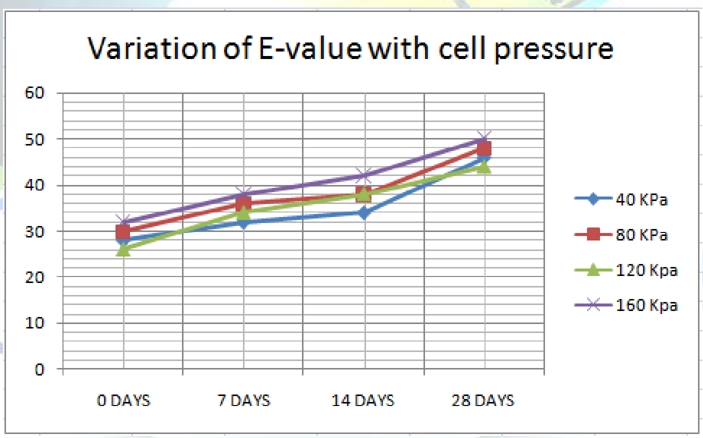
S.NO	CURING PERIOD	DEVIATOR STRESS			
		40	80	120	160
1	0 DAYS	740	940	1080	1320
2	7 DAYS	862	1000	1100	1220
3	14 DAYS	940	1020	1200	1320
4	28 DAYS	980	1100	1250	1320

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017



Variation of E-value with cell pressure

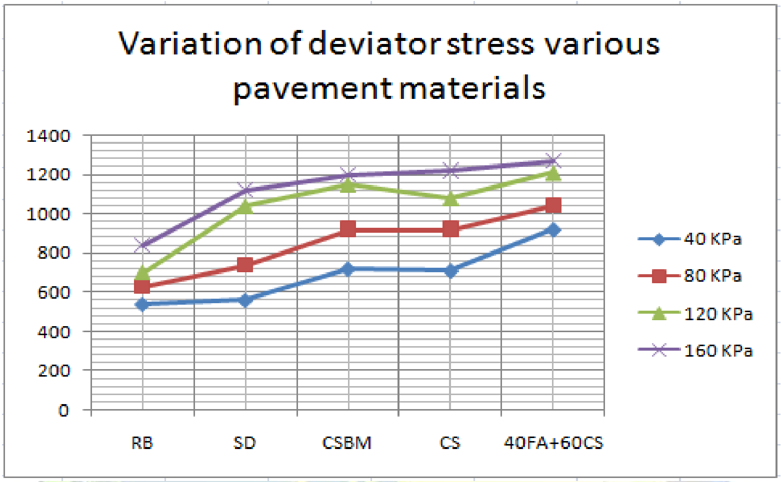
S.NO	CURING PERIOD	DEVIATOR STRESS			
		40	80	120	160
1	0 DAYS	28	32	34	46
2	7 DAYS	30	36	38	48
3	14 DAYS	26	34	38	44
4	28 DAYS	32	38	42	50



Variation of deviator stress various pavement materials

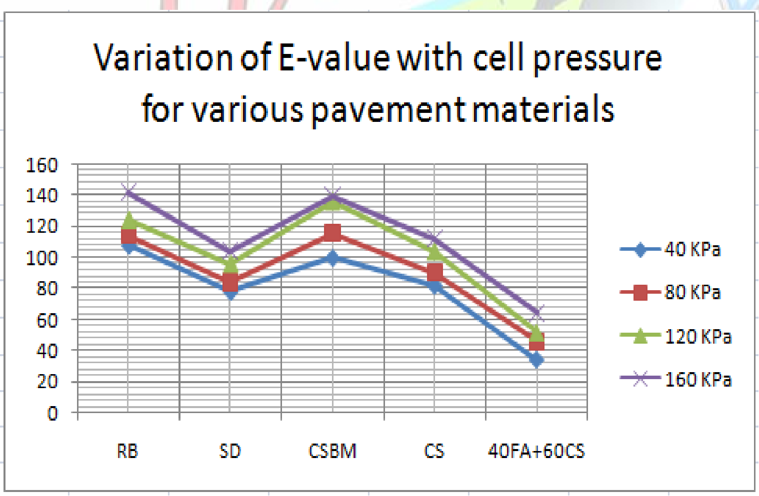
s.no	Cell pressure	Deviator stress				
		RB	SD	CSBM	CS	40FA+60CS
1	40	540	560	720	710	920
2	80	630	740	920	920	1040
3	120	700	1040	1150	1080	1210
4	160	840	1120	1200	1220	1270

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017



Variation of E-value with cell pressure for various pavement materials

s.no	Cell pressure	E value				
		RB	SD	CSBM	CS	40FA+60CS
1	40	108	78	100	82	34
2	80	114	84	115	90	46
3	120	124	96	136	104	52
4	160	142	104	140	112	64



ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

IV CONCLUSIONS

1. Copper slag is a blackish material having specific gravity of 3.26. The high specific gravity is due to the high iron content. Copper slag and fly ash were found to be non plastic in nature.
2. The optimum value of UCS was observed at 30% fly ash content and the UCS values are increases with the increasing the curing time from 0 days to 28 days.
3. The maximum CBR was observed at 28 days of curing. The value of CBR for the mix increases with the curing period. The soaked CBR value of the mix 30% fly ash + 60% copper slag was obtained up to 78 after 28 days of curing. This mix satisfies the minimum criteria for CBR value for use in sub base course as per IRC: 37-2001.
4. The deviator stress at failure and modulus of elasticity (E) increases linearly with the cell pressure for the optimum mix (30%FA+70%C)
5. The failure deviator stress of the optimum mix (30F+70C) is higher whereas the modulus of elasticity is lower as compared to that of coarse sand, stone dust and conventional sub base material.

REFERENCES

[1] Das, B. M., Tarquin, A. J., and Jones, A. D., "Geotechnical properties of copper slag." Transportation Research Record, 941, Washington, D.C., 1983, pp.1-4.

[2] Gorai, B., Jana, R. K., and Premchand, "Characteristics and utilization of copper slag - a review." J. Resources, Conservation and Recycling, Elsevier Publication, 39, 2003, pp.299–313.

[3] Havanagi, V. G., Mathur, S., Prasad, P. S., and Kamraj. C., "Feasibility of copper slag-fly ash-soil mix as a road construction material." J. Transportation Research Board, Washington, D.C., No.1989, Vol. 2, 2007, pp.13-20.

[4] Havanagi, V. G., Sinha, A. K., Mathur, S., and Prasad, P., "Experimental study on the use of copper slag wastes in embankment and pavement construction." Proc., Symposium on Engineering of Ground and Environmental Geotechnics, Hyderabad, 2008, pp.259-264.

[5] Christo Ananth, [Account ID: AORZMT9EL3DL0],"A Detailed Analysis Of Two Port RF Networks - Circuit Representation [RF & Microwave Engineering Book 1]", Kindle Edition, USA, ASIN: B06XQY4MVL, ISBN: 978-15-208-752-1-7, Volume 8, March 2017, pp:1-38.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 2, January 2017

[6] Kumar, P., Chandra, S., and Vishal, R., "Comparative study of different subbase materials." J. Materials in Civil Engg., ASCE, Vol. 18, No. 4, 2006, pp.576-580.

[7] Patel, S., Vakharia, P. P., and Raval, S. M., "Use of copper slag and fly ash mix as subgrade and embankment fill material." J. Indian Highways, Vol. 11, 2007, pp.17-22.

[8] Sinha, A. K., "Study on subbase materials for rural roads." Ph.d. dissertation, Department of Civil Engg., IIT, Roorkee, India, 2009.

[9] Thakkar, A. R., "Environmental aspects of fly ash utilization and its regulation." Proc., Utilization of Fly Ash-2011, Surat, 2011.

Biography

Mr. K.ARUN KUMAR, received the Master of Technology degree in HIGHWAY ENGINEERING from the NRI Institute of Technology, Village kothur(v) srisailam Highway, District Rangareddy, Telengana, he received the Bachelor of Engineering degree from Avanthi Institute Of Engineering & Technology. He is currently working as Assistant Professor in CIVIL with Tirumala Engineering College.

Email id: kandukuri116.arun@gmail.com.