International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

RECYCLED AGGREGATE IN FLY ASH CONCRETE: PRACTICALITY AND EFFICIENCY FOR ECO-FRIENDLY CONSTRUCTION

S.Ramesh[1], M.Supraja[2], A.V.V Daneswari[3], M.Venkatesh[4] , G.Indra Kalyan[5], P.Sudheer Kumar[6], P.Deepak Kumar[7]

[1]*Assistant Professor, Guide & HOD of Civil Engineering Department, Nova College of Engineering and Technology(NCET), Affiliated to JNTU-K, Vegavaram,jangareddygudem, W.G.Dt., A.P-534447, India.*

[2,3,4,5,6,7]*UG Scholar, Department of Civil Engineering, Nova College of Engineering and Technology(NCET), Affiliated to JNTU-K, Vegavaram,jangareddygudem, W.G.Dt., A.P-534447, India.*

---***---

Abstract - The need for building materials is rising dramatically due to the world's population growth, particularly in emerging nations. This puts more pressure on civil engineers to provide affordable, environmentally friendly materials that meet human demands. Fly ash is an industrial by-product whose production and usage have multiplied over the last three decades. It can be utilized to create environmentally friendly materials and is highly exploitable. These days, fly ash serves four purposes: it reduces air and water pollution and increases demand for affordable, high-quality building materials. The primary emphasis of research is on fly ash aggregate production techniques. After testing and comparing these fly ash aggregate's characteristics to those of natural aggregate, the research concludes that fly ash aggregate may be used in concrete in lieu of aggregate. Studying the density and strength characteristics of concrete formed with both natural and manufactured fly ash aggregate and gravel, it was determined that although the addition of fly ash aggregate to concrete lowers its compressive strength, it still satisfies the requirements to be utilized as a structural material.

Key Words: *Fly Ash, Fly Ash Aggregate, Compressive Strength, Density of Concrete.*

1.INTRODUCTION

Concern about the depletion of natural sources and the effect on environment has particularly increased research on development and usage of synthetically produced (from waste materials) aggregates as an alternative to naturally occurring materials. In order to achieve alternative as over a natural, the waste products has to be used effectively[1]. The usage of fly ash in a construction industry is a challenging job and will make tremendous change all over world. There are different ways of using fly ash in industry like it waste can be used as partial replacement of cement. However, the building industry's full usage of fly ash as aggregate will provide a significant barrier. Thus, fly ash may be used to create synthetic coarse aggregates that are low in weight. The process of forming these aggregates, known as pelletization, is called fly ash aggregates[2]. These days, fly ash is often utilized as a cement substitute, pavement foundation, blocks, etc. rather than being dumped in landfills. Functions like embankment fill or aggregate replacement material should be taken into consideration when using fly ash in large quantities. The construction business is expanding quickly. The majority of the globe is experiencing several issues with raw material availability for building. In some places, the ongoing use of natural resources for the manufacturing of concrete poses several risks to the surrounding ecosystem. Scholars have conducted a great deal of research in this field in an effort to find new substitute materials for this shortage in the building sector.

1.1 FLY ASH

Fly ash is by-product, obtained from burning pulverised coal and is recovered to prevent pollution of the environment; fly ash consists of mostly of fused ash particles with some unburned granules of coal and is the result of combustion of powdered coal in modern boilers. The disposal problem of fly ash gained favor by the use in concrete industry, the disposal cost is very high, and hence the use of fly ash in concrete industry has gained much importance[4].

1.2 FLY ASH AGRREGATE

Fly ash is utilized in industry in a variety of ways. For example, it may be used to partially replace cement. However, the building industry's full use of fly ash as aggregate will provide a significant obstacle. Thus, fly ash may be used to create synthetic coarse aggregates that are low in weight. The process of forming these aggregates, known as pelletization, is called fly ash aggregates[3]. These aggregates are made of light-weight aggregate, which may be produced with varying amounts of fly ash and cement. Because this form of concrete has less self-weight than concrete with natural aggregate, it is more cost-effective to design and build. One of the characteristics to compare with the weight of fly ash aggregate concrete in conventional concrete is the weight of the concrete itself[5].

1.3 OBJECTIVES OF WORK

- To evaluate properties of fly ash
- To manufacture of fly ash aggregate prepared using 10M and 12M molarities of NaOH solution combined with sodium silicate solution to form alkaline solution.
- To evaluate properties of fly ash aggregate prepared and its comparison with the manufactured fly ash aggregate and natural granite aggregate.
- To replace the natural aggregate with fly ash aggregate and evaluate properties of concrete.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

- To replace the natural aggregate with fly ash aggregate and evaluate properties of concrete.

2.METHODOLOGY

The following constituent materials of geo polymer fly ash aggregate

- Fly ash
- Cement
- Sodium hydroxide Solution
- Sodium silicate Solution

Fig -1: Different types of Fly ash

Fig -2: Fly ash

Fig -3: Cement

2.1 ALKALINE SOLUTION

Alkaline solutions are mixtures of base materials that dissolve in water. A solution's acidity or alkalinity is defined by its hydrogen potential, which is measured on the pH scale. Each number on the scale ranges from zero to fourteen. Midway, 7, is the pH level that is considered neutral. The term "neutral" does not apply to solutions that are acidic or alkaline. Any solution with a pH value below 7 is said to be acidic, whereas any solution with a pH value over 7 is said to be alkaline. The measurement of acidity or alkalinity is multiplied by 10 for every unit change on the pH scale. It is the intensity, not the capacity, that the pH measures. Some examples of alkaline solutions include magnesium hydroxide, calcium carbonate, sodium hydroxide, and potassium hydroxide. In a wide range of industries, each of these solutions has several applications. Products such as detergents, biodiesel fuels, cleaning products, medications, and soaps commonly include alkaline solutions[5]. In addition to their widespread usage in cooking and other specialised applications, alkaline solutions have several industrial uses. When used as a cleaning agent, alkaline solutions may dissolve oils, fats, grease, and proteins.

Fig -4: Sodium Hydroxide

2.2 GENERAL MIX PROPORTIONS

This mixture has a 28-day strength of 40 MPa and was developed in accordance with IS 10262:2009. The proportions of fly aggregate and natural gravel in a standard concrete mix are shown in the table[6]. The majority of the fly ash is consumed by the coarse aggregate, which accounts for 1293 kg/m3.

Table -1: Calculations for development of fly ash aggregate

Adopted Ratio	Cement%	Fly Ash%
Ratio 1	20	80
Ratio 2	17.5	82.5

For ratio 1:
Cement: Fly ash (quantity) = 20:80
Binder ratio= 0.45
Total weight of sample= 5kg
Amount of binder ($NaOH$+Na_2SiO_3) = 0.45*5= 2.25kg
$NaOH/Na_2SiO_3$= 2.5
Amount of Na_2SiO_3= 0.642 kg
Amount of $NaOH$= 0.642*2.5= 1.60 kg

For ratio 2:
Cement: Fly ash (quantity) = 17.5:82.5
Binder ratio= 0.45
Total weight of sample= 5kg
Amount of binder ($NaOH$+Na_2SiO_3) = 0.45*5= 2.25kg
$NaOH/Na_2SiO_3$= 2.5
Amount of Na_2SiO_3= 0.642 kg
Amount of $NaOH$= 0.642*2.5= 1.60 kg.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Fig -5: Concrete Mix Along with Fly Ash Aggregates

Fig -6: Casting of concrete

Fig -7: Flyash Aggregates

Mix design of fly ash aggregate concrete and natural aggregate concrete using IS 10262-2008:

Mix design of fly ash aggregate concrete of M 25 grade:

Target mean strength = fck+ 1.65(S)
= 25+ 1.65(4)
= 31.6 N/mm2
Where
C-Total mass of coarse aggregate
W-Amount of Water contain
V-Absolute volume of fresh concrete
P-Percentage of fines
F.A-Fine Aggregate
C.A-Coarse Aggregate
S.F.A-Specific gravity of Fine Aggregate
S.C.A-Specific gravity of Coarse aggregate
Maximum water content for 10 mm (max size) aggregate= 208
Slump = 50 mm
Adopted Water cement ratio = 0.55
Cement =208/0.55 = 378.19
V= W+C/Sc+(1/P)F.A/S.FA
1= [208+ (378.18/3.15) + (1/0.35)(F.A/2.6)]1/1000
1000 = 208+ 120.05 + 1.09F.A
F.A= 708.21
C.A =(1-p)/p* (F.A)*(S.C.A/S.F.A)
C.A= (1-0.35/0.35)*(708.21)*(1.66/2.6)
C.A= 839.734
Cement: fine aggregate: coarse aggregate: water cement ratio
= 378.18: 708.21: 839.734: 0.55 (1: 1.87: 2.22: 0.55)
Density of concrete = 2000 kg/m3
Mass = density * volume
= 2000 * 0.153
= 6.75 * 0.2 = 1.35
Mass of concrete = 8.1 kg
Cement = 8.1/5.64 =1.43 kg
Fine aggregate = (1.87*8.1)/5.64 =2.68 kg
Coarse aggregate = (2.22*8.1)/5.64 = 3.18 kg
Water = 0.55*1.43 = 0.786 litres

M25 conventional concrete:

Target mean strength = fck+ 1.65(S)

= 25+ 1.65(4)
= 31.6 N/mm2
Maximum water content for 10 mm (max size) aggregate= 208
Slump = 50 mm
Adopted Water cement ratio = 0.55
Cement =208/0.55 = 378.19
V= W+C/Sc+(1/P)F.A/S.FA
1= [208+ (378.18/3.15) + (1/0.35)(F.A/2.6)]1/1000
1000 = 208+ 120.05 + 1.09F.A
F.A= 708.21
C.A = (1-p)/p* (F.A)*(S.C.A/S.F.A)
C.A= (1-0.35/0.35)*(708.21)*(2.8/2.6)
C.A= 1416.42
Cement: fine aggregate: coarse aggregate: water cement ratio
= 378.18: 708.21: 1416.42: 0.55 (1: 1.87: 3.74: 0.55)
Density of concrete = 2400 kg/m3
Mass = density * volume
= 2400 * 0.153
= 8.1 * 0.2 = 1.62
Mass of concrete = 8.1+1.62 kg = 9.72 kg
Cement = 9.72/7.16 =1.35 kg
Fine aggregate = 2.52 kg
Coarse aggregate = 5.04 kg
Water = 0.55*1.35= 0.742 litres

M45 Fly ash aggregate concrete:
Target mean strength = fck+ 1.65(S)
= 45+ 1.65(4)
= 51.6 N/mm2
Maximum water content for 10 mm (max size) aggregate= 208
Slump = 50 mm
Adopted Water cement ratio = 0.45
Cement =208/0.45 = 462.22
V= W+C/Sc+ (1/P)F.A/S.FA
1= [208+ (462.22/3.15) + (1/0.35) (F.A/2.6)]1/1000

1000 = 354.73+ 1.09F.A
F.A= 591.9
C.A= (1-p)/p* (F.A)*(S.C.A/S.F.A)
C.A= (1-0.35/0.35)*(591.9)*(1.66/2.6)
C.A= 701.82
Cement: fine aggregate: coarse aggregate: water cement ratio
= 462.22: 591.9: 701.82: 0.45 (1: 1.28: 1.51: 0.45)
Density of concrete = 2000 kg/m3
Density of concrete = 2000 kg/m3
Mass = density * volume
= 2000 * 0.153
= 6.75 * 0.2 = 1.35
Mass of concrete = 8.1 kg
Cement = 8.1/4.24 =1.91 kg
Fine aggregate = (1.28*8.1)/4.24 =2.44 kg
Coarse aggregate = (1.51*8.1)/4.24 = 2.88 kg
Water = 0.45*1.91 = 0.8595 litres

M45 Natural aggregate concrete:

Target mean strength = fck+ 1.65(S)

= 45+ 1.65(4)
= 51.6 N/mm2
Maximum water content for 10 mm (max size) aggregate= 208
Slump = 50 mm
Adopted Water cement ratio = 0.45
Cement =208/0.45 = 462.22
V= W+C/Sc+ (1/P)F.A/S.F.A
1= [208+ (462.22/3.15) + (1/0.35) (F.A/2.6)]1/1000
1000 = 354.73+ 1.09F.A
F.A= 591.9
C.A= (1-p)/p* (F.A)*(S.C.A/S.F.A)
C.A= (1-0.35/0.35)*(591.9)*(2.88/2.6)
C.A= 1179.24
Cement: fine aggregate: coarse aggregate: water cement ratio
= 462.22: 591.9: 1179.24: 0.45 (1: 1.28: 2.55: 0.45)
Density of concrete = 2400 kg/m3
Mass = density * volume
= 2400 * 0.153
= 8.1 * 0.2 = 1.62
Mass of concrete = 8.1+1.62 kg = 9.72 kg
Cement = 9.72/7.16 =1.35 kg
Fine aggregate = 2.35 kg
Coarse aggregate = 4.69 kg
Water = 0.45*1.84= 0.828 litres

3.EXPERIMENTAL INVESTIGATION

3.1 SPECIFIC GRAVITY TEST

A specific gravity test determines the aggregate's quality or strength, while a water absorption test determines the amount of water that each aggregate type can hold. The specific gravity of an aggregate is defined as the weight of that aggregate in relation to the weight of water in a given volume. The value indicates how strong or high-quality the material is. The strength of an aggregate is proportional to its specific gravity; smaller specific gravities tend to be weaker.

Fig -8: Aggregate Crushing Test

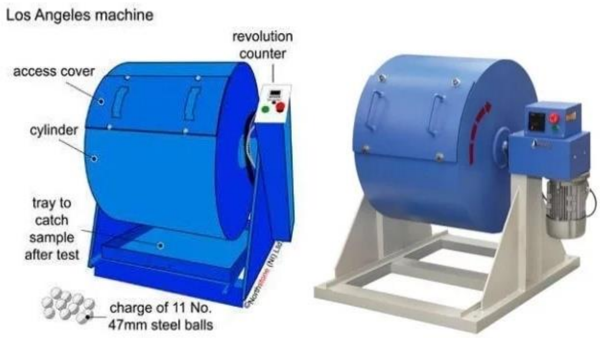

Fig -9: Los Angeles Machine

Breaking down of samples cooled through watering is clearer than that of tests cooled typically[7]. Pulverised fuel ash particles are in full spherical shape, enabling them to flow freely in the mix just like as cement[8]. The essential components of pulverised fuel ash based geo-polymer production are sodium silicate and potassium hydroxide or sodium hydroxide[9]. For example, 8 M of the centralized NaOH solution contained NaOH solids of 8x40= 320 grams per litre of solution, 40 is the molecular weight of NaOH solids[10]. To get the strength at an early stage and decreasing water demand in GPC as well as in concrete mixture at all stages[11]. M is the molar and 12 M concentration NaOH solution is taken, for example, consisted of 12 x 40=480 grams/litre of sodium hydroxide pellets are taken, of which 40 is NaOH molecular mass[12]. Another suggestion is published Indian literature has been to add 12 x 40=480 grams of Sodium Hydroxide solids to (1000-480) = 520 grams of water so that one gets 1 kg of sodium hydroxide having Molarity of 12M[13].

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

4.RESULTS AND DISCUSSION

Table-2: Properties of cement using IS 4031 Part-1(1996)

Properties	Test results	Acceptable limits
Fineness	7	Less than 10%
Specific gravity	2.9	2-3.1
Standard consistency	32	28%-355
Initial setting time	50min	30 min
Final setting time	10 hours	Less than 10 hours

Table-3: Properties of Natural Aggregates IS 2386 Part-3(1963)

Properties	Test
Specific gravity	2.91
bulk density	1.5gm/cc
porosity	46.83%
void ratio	0.88
Aggregate crushing value	12%
Aggregate impact value	24%

Table-4: Properties of Manufactured Fly Ash

Properties	Test results 4-8mm	Test results 8-12mm
Specific gravity	1.95	1.9
Bulk density	0.805	0.88
Porosity	57%	53.63%
Void ratio	1.36	1.15
Aggregate crushing value	10%	10%
Aggregate impact value	29%	29%

Table-5: Comparison of Aggregates

Properties	Natural aggregate	Fly ash aggregate
Specific gravity	2.91	1.9
Bulk density	1.5gm/cc	0.88
Porosity	46.83%	53.63%
Void ratio	0.88	1.15
Aggregate crushing value	12%	10%
Aggregate impact value	24%	29%

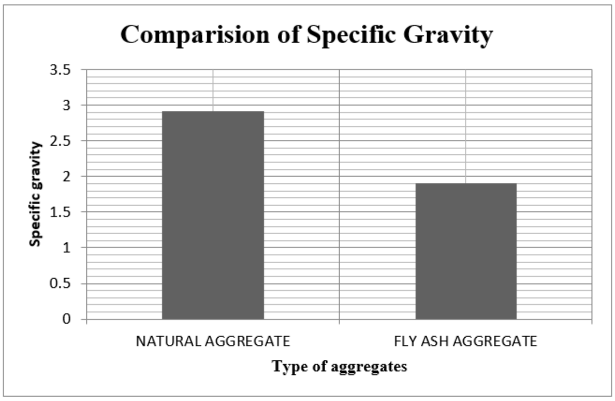

Fig -10: Observed that the value of specific gravity is found to be higher for natural coarse aggregate than fly ash aggregates

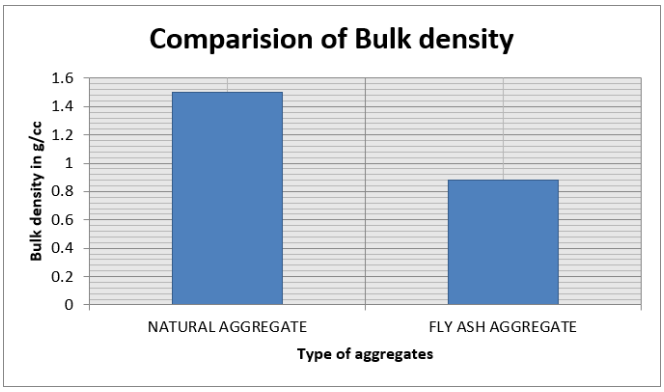

Fig -11: Observed that the value of bulk density is found to be higher for natural coarse aggregate than fly ash aggregates

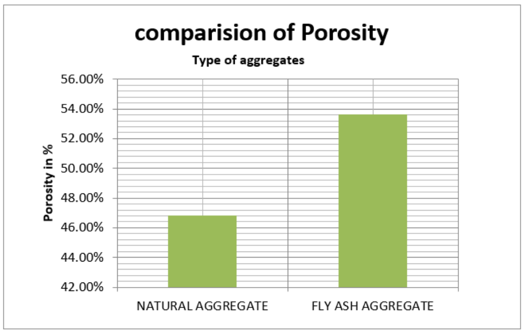

Fig -12: Observed that the value of porosity is found to be higher for natural coarse aggregate than fly ash aggregates

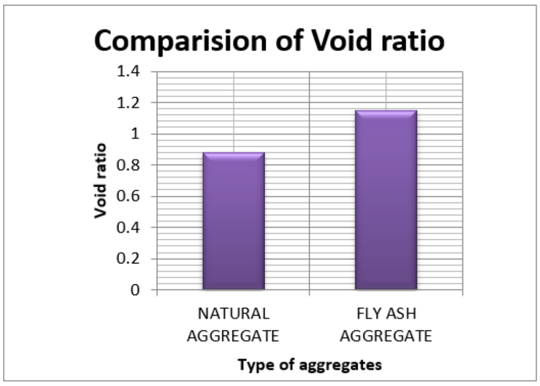

Fig -13: Observed that the value of void ratio is found to be higher for natural coarse aggregate than fly ash aggregates

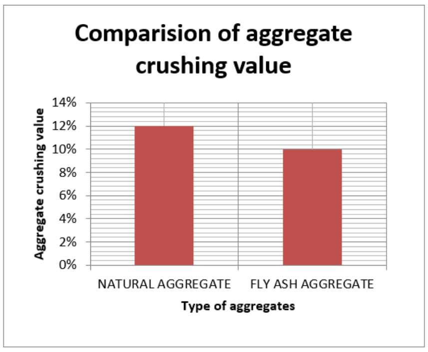

Fig -14: Observed that the value of aggregate crushing value is found to be higher for natural coarse aggregate than fly ash aggregates

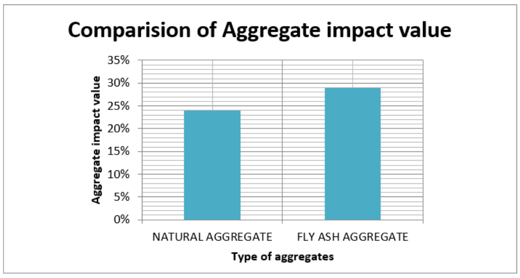

Fig -15: Observed that the value of aggregate impact value is found to be higher for natural coarse aggregate than fly ash aggregates

4.1 EFFECTING PROPERTIES OF FLY ASH AGGREGATE

Several established factors considerably affect the properties of fly ash aggregate. The action accelerator in fly ash based aggregate concrete, which significantly affects mechanical strength, is the curing temperature, followed by the curing duration and the kind of alkaline liquid. Curing at higher temperatures for longer periods of time resulted in a higher compressive strength. The rate of reaction was found to be faster in alkaline solutions containing just hydroxide as opposed to those including soluble silicates.

One component of the experimental programme is testing the compressive strength of cast cubes made of fly ash aggregates and fly ash-based concrete. The cubes were subjected to testing using compressive testing equipment that has a capacity of 200T. The quantities of cement and fly ash in the binder are among the several parameters that are considered in the study. By playing about with different mixes of fly ash and cement (20:80, 17.5:82.5, etc.) and different concentrations of sodium hydroxide and sodium silicate (10M, 12M), and so on.

Table-6: Compressive strength of natural aggregate concrete

Grade of concrete	No. of days of curing	Compressive strength
M_{25}	25 days	43.7N/mm^2
M_{45}	28 days	58.23N/mm^2

Table-7: Compressive strength of flyash aggregate concrete

Grade of concrete	Molarity of NaOH	Binder ratio	No. of days curing	Compressive strength N/mm^2
M_{25}	12M	0.45	28 days	33.5
M_{45}	12M	0.45	28 days	38.3

5.CONCLUSION

1. Although there are a number of treatment options available, such as treating with water glass, etc., the fact that fly ash aggregates absorb nine times more water than natural gravel remains a significant drawback.
2. Fly ash aggregates are easier to deal with than their angular natural counterparts because of their rounded form.
3. We may enhance the water-absorbing properties of the manufactured fly ash aggregates by using compounds that reduce water content.
4. We may enhance the prepared aggregate by employing much finer fly ash because of its low density.
5. More alkaline solution molars resulted in a stronger solution.

REFERENCES

[1] Vinay M[1], Dr. V Ramesh[2],GeenaGeorge[3]etal.,[2015], “Experimental study On Strength Characteristics Of Concrete Using Fly ash Aggregate And Quarry Dust”, International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)Vol. 3, Issue 1, pp: (355-359), Month: April 2015 -September 2015, Available at: www.researchpublish.com.

[2] Nallaiahgari Sivanagi Reddy[1], Ch.Vema Reddy[2], “Study Of Concrete Made Using fly Ash Aggregates” International Journal of Professional Engineering Studies Volume Viii /Issue 4 / Apr 2017.

[3] S. Shanmugasundaram[1], Dr. S. Jayanthi[2], Dr. R. Sundararajan[3] et al.,[2010]”Study on Utilization of Fly Ash Aggregates in Concrete “Modern Applied Science Vol. 4, No. 5; May 2010.

[4] Dr. M.Vijaya Sekhar Reddy[1], Dr. M.C. Nataraja[2], K.Sindhu[3] ,” Performance of Light Weight Concrete using Fly Ash Pellets as Coarse Aggregate Replacement” International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 9, Number 2 (2016), pp. 95-104 © International Research Publication House http://www.irphouse.com..

[5] RavichandraR[1], Dr. J.K. Dattatreya[2], S. M. Maheshwarappa[3], “An Experimental Study on Properties of Fly ash Aggregate Comparing with Natural Aggregate”,

Journal of Civil Engineering and Environmental Technology Print ISSN : 2349-8404; Online ISSN : 2349-879X; Volume 2, Number 11; April –June, 2015 pp 64–68Krishi Sanskriti Publicationshttp://www.krishisanskriti.org/jceet.html

[6] Lakshmi Kumar Minapu,[1] M K M V Ratnam[2], Dr. U Rangaraju[3]," Experimental Study on Light Weight Aggregate Concrete with Pumice Stone, Silica Fume and Fly Ash as a Partial Replacement of Coarse Aggregate" International Journal of Innovative Research in Science, Engineering and Technology*(An ISO 3297: 2007 Certified Organization)* Vol.3 ,Issue12 ,December2014.

[7]. Jonnalagadda, S., Sreedhara, S., Soltani, M. and Ross, B.E., 2021. Foam-void precast concrete double-tee members. PCI Journal, 66.

[8]. Jonnalagadda, S., Ross, B.E. and Khademi, A., 2016. A modelling approach for evaluating the effects of design variables on bridge condition ratings. Journal of Structural Integrity and Maintenance, 1(4), pp.167-176.

[9]. Jonnalagadda, S., Ross, B. E., & Plumblee II, J. M. (2015). A Method for Assessing Capacity Obsolescence of Highway Bridges (No. 15-5316).

[10]. Srimaruthi Jonnalagadda., and Sitaram Vemuri. 2023. "Novel Methods and Materials for Concrete Floor Slab Construction for Small Family Housing Buildings in India." International Research Journal of Engineering and Technology., 10(7),1048-1056.

[11]. Srimaruthi Jonnalagadda., and Sitaram Vemuri. 2023. "Challenges in Traditonal Concrete Slab Construction for Housing Buildings in Developing Countries and Critical Need for Novel Methods." International Journal of Advances in Engineering and Management., 5(5), 176-186.

[12]. Sitaram Vemuri., and Srimaruthi Jonnalagadda. 2023. "Wind Analysis of Tall Buildings Using Codal Provisions, Stochastic Approach and CFD -A Comparative Study." International Journal of Advances in Engineering and Management., 5(7), 58-68.

[13]. ESitaram Vemuri., and Srimaruthi Jonnalagadda. 2023. "A Stochastic Approach to Determine Along-Wind Response of Tall Buildings." International Research Journal of Engineering and Technology., 10(7), 961-969.