Studies On Strength Properties of Expanded Clay Aggregate Concrete Bricks

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***Abstract*— In the present experimental work, is made to study on the strength properties of structural light weight concrete produced replacing coarse aggregate by blending light weight aggregates such as Cinder(class-F) and ECA for M30 grade of concrete. The light weight concrete is prepared by using Cinder and ECA with replacement of cement and coarse aggregate with 40,50,60 % and 100% in concrete . Mix design of the project is 1:1.24:0.63. As per above mix proportion we casting 15 no. of brick specimens of size 0.61x0.20x0.10m and cylindrical moulds of 0.15x0.3m. For the period of 7,14,28 days. Light weight concrete has strength comparable to normal weight concrete, yet is typically 25 % to 35% lighter**

***Keywords:* - Compressive strength, Expanded clay aggregate, Flexural strength, Fly ash, Tensile strength**

I. INTRODUCTION

The light weight concrete helps in decreasing load as the density is reduced substantially from ranges of 2400kg/cubic meter to 1800kg/cubic meter. Light weight concrete is an enhanced version of concrete, with decrease in density of concrete. When structural concerns require a minimum to the dead load, light weight concrete is used. It is light weighted it is easy lifting and carrying which is an important advantage of light weight concrete. It also offers slower temperature transfer rates then standard concrete. The bond between the cement and aggregates is strong in case of light weight concrete when compared to that of normal conventional concrete. There is an increase in demand of light weight concrete due to its low density & improved strength.

Light weight aggregates used for structural light weight concrete are generally expanded clay. The structural engineers to reduce the size of structural members such as columns, foundation and other load bearing structures while contribute and maintain the structural performance. For the most part light weight concrete is not strong as concrete made with typical aggregates. The high self weight of traditional concrete with ordinary aggregates, The past to decrease the self of concrete called light weight concrete. The main objective of this project is to study the different strength parameters like compressive, tensile, flexural strength , comparing density of conventional concrete with light weight concrete for M30 grade of concrete and also study the workability characteristics of concrete.

II. PROCEDURE

Concrete:-

Concrete is a construction material composed of Portland cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite. The cement as water form a paste which hardens by chemical reaction into a strong, stone like mass.

Cement: -

Cement is a binder material which sets and hardens independently, and can bind other materials together. Cement is made up of four main compounds tri calcium silicate (3CaO SiO_2), dicalcium Silicate (2CaO SiO_2), tri calcium acuminate (3CaO Al_2O_3), and tetra-calcium aluminoferrite (4caco Al_2O_3 Fe_2O_3).tetra-calcium aluminoferrite (4CaO Al_2O_3 Fe_2O_3). In an abbreviated notation differing from the normal atomic symbols, these compounds are designated as C3S, C2S, C3A, and C4AF, where C stands for calcium oxide (lime), S for silica and A for alumina, and F for iron oxide Small amounts of uncombined lime and magnesia also are present, along with alkalis and minor amounts of other elements.

Properties of cement

S.NO	Physical property	Test result
1	Compressive Strength(Mpa)	48.35
2	Fineness (%)	6
3	Specific Gravity	3.06

Fly Ash:-

Fly ash is generally finely divided residue ash particle resulting from the combustion of coal in the furnaces which blows along with flue gas of the furnace.

Chemical properties of fly ash

Chemical compound	Low calcium fly ash Class F	High calcium fly ash Class C
Silicon dioxide	54.90	39.90
Aluminium oxide	25.80	16.70
Calcium oxide	8.70	24.30
Magnesium oxide	1.80	4.60
Sulfur trioxide	0.60	3.30
Sodium oxide and potassium oxide	0.60	1.30
Iron oxide	6.90	5.80

Physical properties of fly ash

Properties	……..
Specific gravity	2.3
Moisture content	19.75%
Fineness	0.001-0.6mm
Maximum dry density	1.53
Cohesion	3- 34 Kpa
Compression index	0.15

Aggregates: -

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered.

The size of the aggregate bigger than 4.75 mm is considered as coarse aggregates and aggregate whose size is 4.75 mm and less is considered as fine aggregates.

- Fine aggregates
- Expanded clay aggregates

FINE AGGREGATES: -

Fine aggregates or sand is an accumulation of grains of mineral matter derived from the disintegration of rocks.

Sands that have been stored out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand dunes originally formed by the action of winds.

Physical properties of fine aggregates

S.N0.	Physical property	Test result
1.	Fineness modulus	2.45
2.	Specific Gravity	2.56
3.	Bulk Density(kg/m^3)	1530-1600
4.	Water Absorption (%)	0.80

Expanded Clay Aggregates: -

LIGHT EXPANDED CLAY AGGREGATES. It is the special type of aggregate which are formed by pyroclastic process in rotary kiln at 1,200 °C (2,190 °F) very high temperature. Since it is exposed to high temperature, the organic compounds burn, as a result the pellets expand & form a honeycombed structure. Whereas the outside surface of each granule melts and is sintered. The resulting ceramic pellets are lightweight, porous and have a high crushing resistance. It is environmental friendly, entirely a natural product incorporating same benefits as tile in brick form. LECA is non-destructible, noncombustible & impervious to attack by dry-rot, wet-rot & insects.

Before deciding any material to be used as aggregate it has to possess some standards set by IS: 1343.As we are concerned with the mix design the basic tests were conducted the results were determined.

Expanded Clay Aggregate

Physical properties of ECA

S.NO	Physical property	Test result
1	Maximum Size (mm)	20
2	Fineness modulus	7.25
3	Specific Gravity	2.70
4	Bulk Density(kg/m^3)	1480-1610
5	Water Absorption (%)	0.12
6	Aggregate Crushing Value (%)	16.60
7	Aggregate Impact Value (%)	11.01

Water:-

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete or steel. If the water is drinkable, it is considered to be suitable for concrete making. Hence, potable tap water was used in this study for mixing and curing.

The PH value of water should be in between 6.0 and 8.0 according to IS 456 –2000.

Workability Tests:-

- Compaction Factor Test
- Slump cone Test

Compaction Factor Test: -

Compaction factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test.

Compaction factor values:-

Fly ash%	ECA %	Compaction Factor Values
40	100	0.82
50	100	0.79
60	100	0.8

Slump Cone Test:-

The word ‘ workability’ signifies much wider and deeper meaning than the other terminology “ consistency” often used loosely for workability.

Slump Test Results:-

Fly ash%	ECA %	Slump Values
40	100	132
50	100	129
60	100	127

Compressive Strength Test:-

The compressive strength of any material is defined as the resistance to f0ailure under the action of compressive forces. The compressive strength of a concrete is determined in batching plant in laboratories for every batch in order to maintain desired quality of concrete during casting. Compressive strength is calculated by dividing the failure load with the area of application of load, after 7, 14 and 28 days of curing.

Compression Testing Machine

Compression Test Results:-

Compressive strength is defined as resistance of concrete to axial loading. Cubes are put in the machine and after tighten its wheel start button is pressed as pressure is begin to apply. Reading of meter is note down when cracks are there on cubes.

Compressive strength is calculated by following formula:

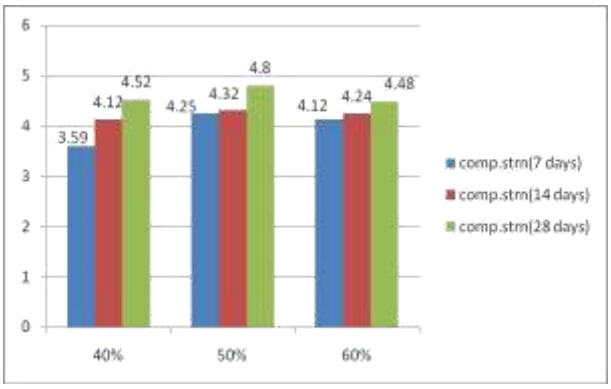
Compressive Strength = P/A

Where P = load

A = area of cube.

Compression strength test values:-

Fly ash%	ECA%	7 days	14days	28days
40	100	3.59	4.12	4.52
50	100	4.25	4.32	4.80
60	100	4.12	4.24	4.48

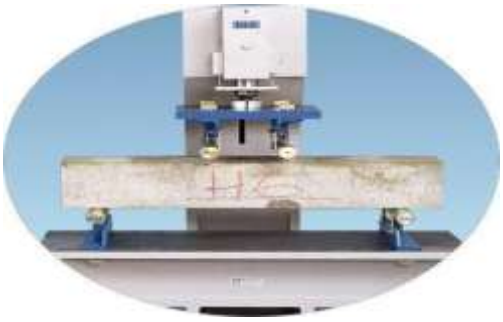


x- Axis: - Fly ash proportions

Y-Axis:- Compressive Strength Values (N/mm^2)

Flexural Strength Test:-

The flexural strength is a stress at failure in bending. It is equal or slightly larger than the failure stress in tension. Concrete as we know is relatively strong in compression weak in tension. The tensile stresses are likely to develop in concrete due to drying shrinkage rusting of steel reinforcement temperature gradient and many other reasons.



Flexural Strength

Test Flexural Strength Values:-

For flexural test beams of 150×150×700 mm3 size were adopted. The load was applied without shock and was increased until the specimen failed, and the maximum load applied which is on the meter to the prism during the test was recorded. The appearances of the fractured faces of concrete failure were noted. Three-point load method was used to measure the flexural strength of Coconut Shell Aggregate Concrete. The flexural strength of the prisms was calculated as per given equation

Modulus of rupture, fb = PL/bd2

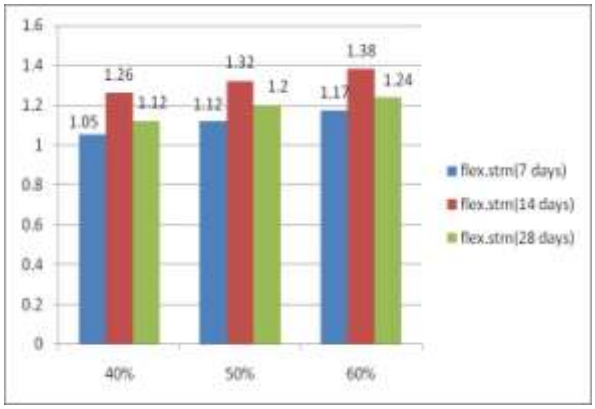
Where P = Maximum load applied, N

L = Supported length of the specimen, mm

b = Measured width of the specimen, mm

Flexural strength values:-

Fly ash%	ECA %	7 days	14days	28days
40	100	1.05	1.26	1.12
50	100	1.12	1.32	1.20
60	100	1.17	1.38	1.24



x- Axis :- Fly ash proportions

Y-Axis :- Flexural Strength Values (N/mm^2)

40% FA and 100% ECA as replacement of cement CA has achieved the normal compressive strength.

50% FA and 100% ECA as replacement of coarse aggregate has achieved the maximum compressive strength.

60% FA and 100 % ECA as replacement of either cement or coarse aggregate has achieved less compressive strength than ordinary concrete after 28 days.

The data show the ECA and FA can be replaced in place of cement. However, percentage ECA and Fly ash replacement has influence on concrete properties. Compressive strength was higher than control concrete for 100 % ECA and 50% FA replacement at 7 and 28 days of curing ages.

III. CONCLUSION

Regardless of the replacement level for all the mixes, inclusion of fly ash and ECA has improved the workability of a concrete due to the fineness and spherical shape of its particles. Having fly ash in a concrete mix as a replacement of cement or fine aggregate increases its compressive strength due to the pozzolanic activity of the ash. The compressive strength of a fly ash and ECA concrete keeps increasing over a long time because the fly ash retards the hydration process of cement, whereas ordinary concrete reaches its maximum compressive strength after around 28 days.

REFERENCES

[1]. Mr. Anil Kumar R Assistant, Dr. P Prakash, 2015 Studies on Structural Light Weight Concrete by Blending Light Weight Aggregates, International Journal of Innovative Research in Engineering & Management (IJIREM) ISSN: 2350-0557, Volume-2, Issue-4, July-2015

[2]. Andro genis. J, M.S.Dinesh kumar, D.Praveen, A.S.Arun Prawin, Anekar Mohammed Uzair,2018 Flexural Behaviour of Light Weight Clay Aggregate Concrete Beam Reinforced With Geogrid, Volume 118 No. 20 2018, 3537-3545 ISSN: 1314-3395 (on-line version) url: http://www.ijpam.eu

[3]. Lenka Bodnarova, Rudolf Hela, Michala Hubertova, Iveta Novakova, 2014 Behaviour of Lightweight Expanded Clay Aggregate Concrete Exposed to High Temperatures, World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering Vol:8, No:12, 2014

[4]. Manu S. Nadesan, P. Dinakar, 2017 Mix design and properties of fly ash waste lightweight aggregates in structural lightweight concrete,Case Studies in Construction Materials 7 (2017) 336–347 journal homepage: www.elsevier.com/locate/cscm

[5]. Obada Kayali, 2005 Flashag – New Light Weight Aggregate For High Strength And Durable Concrete, 2005 World Of Coal Ash (WOCA) April 11-15,2005, Lexington,Kentucky,USA http://www.flyash.info

[6]. R.N. Raj Prakash, A.Krishnamoorthi, 2017 Experimental Study On Light Weight Concrete Using Leca, International Journal of ChemTech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555 Vol.10 No.8, pp 98-109, 2017

[7]. Jos_e Alexandre Bogas*, Jorge de Brito, Jos_e M. Figueiredo, 2015 Mechanical characterization of concrete produced with recycled lightweight expanded clayaggregate concrete , journal homepage:www.elsevier.com/ locate/jclepro

[8]. P.Matysek ,2004 Compressive Tests On Masonary Made Of Expanded Clay Aggregate Concrete Units, 13th International Brick and Block Masonry Conference Amsterdam, July 4-7, 2004

[9]. Etaveni Madhavi, D. Rahul Naik , Koneti Maheshwari, Addagatla Mahesh Kumar, Choehan Jagadeeshmohan , Bollepally Swathi, 2017 Strength Properties Expandable Clay Aggregates Concrete, Imperial Journal of Interdisciplinary Research (IJIR) Vol-3, Issue-5, 2017 SSN: 2454-1362, http://www.onlinejournal.in

[10]. R.Gopi, V.Revathi, R.Ramya, K.Ramesh, 2015 Saturated Light Expanded Clay Aggregate and Fly Ash Aggregate, As Internal Curing Agents In Self Compacting Concrete, Australian Journal of Basic and Applied Sciences, 9(31) September 2015, Pages: 226-233 ISSN:1991-8178

[11]. Vishal Gadgihalli , MeenaY.R , Abrar Khan , Raghavendra Prasad Havanje Dinakar , S. C. Sharma, 2017 Analysis Of Properties Of Concrete Using Expanded Clay Pebbles As Fine Aggregate , [Gadgihalli et. al., Vol.5 (Iss.11): November, 2017] ISSN- 2350-0530(O), ISSN- 2394-3629(P) DOI: 10.5281/zenodo.1117175

[12]. Lena Johansson Westholm, 1998 The use of leca (light expanded clay aggregrates) for the removal of phosphorus from wastewater, Water Science and Technology Volume 35, Issue 5, 1997, Pages 87–93 Wetland Systems for Water Pollution Control 1996

[13]. Girts Bumanis, Diana Bajare, Aleksandrs Korjakins, 2013 Mechanical and Thermal Properties of Lightweight Concrete Made from Expanded Glass,*Corresponding author: girts.bumanis@rtu.lv http://dx.doi.org/10.5755/j01.sace.2.3.2790

[14]. Michal Hora a, Radek Štefan a, Jaroslav Procházka,2013 TEMPERATURE ANALYSIS OF LIGHTWEIGHT AGGREGATE CONCRETE SLAB MEMBERS AT ELEVATED TEMPERATURES FOR PREDICTING FIRE RESISTANCE, Application of Structural Fire Engineering, 19-20 April 2013, Prague, Czech Republic

[15]. Diana Bajare, Janis Kazjonovs*, Aleksandrs Korjakins,2013 Lightweight Concrete with Aggregates Made by Using Industrial Waste, *Corresponding author :janis.kazjonovs@rtu.lv http://dx.doi.org/10.5755/j01.sace.4.5.4188*

[16]. R. Vijayalakshmi and S. Ramanagopal,2018 Structural Concrete using Expanded Clay Aggregate: A Review, Indian Journal of Science and Technology, Vol 11(16), DOI:10.17485/ijst/2018/v11i16/121888 , April 2018

[17]. Michala Hubertova, Rudolf Hela, 2013 Durability of Light Weight Expanded Clay Aggregate Concrete, Available online at www.sciencedirect.com

[18]. M.shankar, 2016 EXPERIMENTAL INVESTIGATION ON SELF COMPACTING CONCRETE USING LIGHT WEIGHT AGGREGATES, International Journal of Advanced Science and Engineering Research www.ijaser.in Volume: 1, Issue: 1, June 2016 ISSN: 2455-9288

[19]. Serkan Subasi,2009 The effects of using fly ash on high strength lightweight concrete produced with expanded clay aggregate, Scientific Research and Essay Vol. 4 (4) pp. 275-288, April, 2009 Available online at http://www.academicjournals.org/SRE ISSN 1992-2248 © 2009 Academic Journals

[20]. T. W. Bremner, J. P. Ries, W. H. Wolfe, Achieving Sustainability with Lightweight Aggregates, http://www.claisse.info/specialabstracts.htm

[21]. Mohammad Noori Sepehr, Hossein Kazemian, Esmail Ghahramani, Abdeltif Amrane, V.Sivasankar, Mansur Zarrabi,2014 Defluoridation of water via Light Weight Expanded Clay Aggregate (LECA): Adsorbent characterization, competing ions, chemical regeneration, equilibrium and kinetic modeling, HAL Idhal-00967968 https://hal.archives-ouvertes.fr/hal-00967968 Submitted on 1 Jul 2014

[22]. Sachin Paul, Ganesh Babu,2014 Mechanical Properties of Light Weight Aggregate Geopolymer Concrete Using Light Weight Expanded Clay Aggregate, Transactions on Engineering and Sciences ISSN: 2347-1964(Online) 2347-1875 (Print) Vol.2, Issue 10, October 2014

[23]. Deividas Rumsys, Darius Bacinskas, Edmundas Spudulis, Adas Meskenas,2017 Comparison of material properties of lightweight concrete with recycled polyethylene and expanded clay aggregates, Available online at www.sciencedirect.com, Modern Building Materials, Structures and Techniques, MBMST 2016, Procedia Engineering 172 (2017) 937 – 944

[24]. Md. Sagirul Islam, Nahid Sharmin, Md. Moniruzzaman, Dr. Umme Sarmeen Akhtar, 2016 Effect of Soda lime Silica Glass waste on the basic properties of Clay Aggregate, International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 149 ISSN 2229-5518

[25]. Bernhardt M,Justnes H,Tellesbo H,Wiik K, 2014 The effect of additives on the properties of lightweight aggregates produced from clay, http://brage.bibsys.no/sintef https://doi.org/10.1016/j.cemconcomp.2014.07.005

[26]. Priyanga.R ,Rajeshwari L.B,Vijaya Baskar S,2017 EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF LIGHTWEIGHT CONCRETE USING LECA AND STEEL SCRAPS, SSRG International Journal of Civil Engineering- (ICRTCETM-2017) - Special Issue - April 2017

[27]. HANAMANTH SHEBANNAVAR, MANEETH P. D,BRIJBHUSHAN S, 2015 " COMPARATIVE STUDY OF LECA AS A COMPLETE REPLACEMENT OF COARSE AGGREGATE BY ACI METHOD WITH EQUIVALENT LIKENESS OF STRENGTH OF IS METHOD", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 08 | Nov-2015 www.irjet.net p-ISSN: 2395-0072

[28]. Jolanta Latosinska, Maria Zygadlo,2009 EFFECT OF SEWAGE SLUDGE ADDITION ON POROSITY OF LIGHTWEIGHT EXPANDED CLAY AGGREGATE (LECA) AND LEVEL OF HEAVY METALS LEACHING FROM CERAMIC MATRIX, Vol. 35 2009 No. 2

[29]. Khaled Heiza,FatmaEidandTahaMasoud, 2017 Lightweight self-compacting concrete with light expanded clay aggregate (LECA),

MATEC Web of Conferences 162, 02031 (2018) https://doi.org/10.1051/matecconf/201816202031 BCEE3-2017

[30]. Marian Asantewah Nkansah , Alfred A. Christy , Tanja Barth, George William Francis, The use of Lightweight Expanded Clay Aggregate (LECA) as Sorbent for PAHs Removal 1 from Water, Corresponding author: Tel.: 0047-96843489. Email: maan4gr@yahoo.co.uk

[31]. Omnia S. Ismail, Omar A. El- Nawawy, Khaled S. Ragab, Mohamed Kohail, 2018 Performance of the lightweight concrete with available nano-silica in case fully replacement of coarse aggregate, International Journal of Scientific & Engineering Research Volume 9, Issue 1, January-2018 223 ISSN 2229-5518

[32]. Vijayalakshmi Ramalingam ,2018 Structural concrete using expanded clay aggregate: a review, See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/324233721 , Article in Indian Journal of Science and Technology • April 2018 DOI: 10.17485/ijst/2018/v11i16/121888

[33]. Samer Kareem Turki Khafaji, Elham Abed Al-Majed, 2016 Synthesis of Light expanded clay aggregates from Iraqi raw materials, International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 690 ISSN 2229-5518

[34]. Andrey MISHUTN, Sergii KROVIAKOV, Oleg PISHEV, Božo SOLDO, 2017 MODIFIED EXPANDED CLAY LIGHTWEIGHT CONCRETES FOR THIN-WALLED REINFORCED CONCRETE FLOATING STRUCTURES, ISSN 1846-6168 (Print), ISSN 1848-5588 (Online) Original scientific paper ID: TG-20170816140212

[35]. Dharani.R ,Sivalingam.A ,Thirumarimurugan.M, 2016 Utilization of Light Weight Expanded Clay Aggregate in Waste Water Treatment –A Review, International Journal of Emerging Technologies in Engineering Research (IJETER) Volume 4, Issue 4, April (2016) www.ijeter.everscience.org

[36]. Rubina Bilqees, Pirzada Naeem, Tazeem Khan, M. Muhammad Junaid, 2011 Engineering tests of aggregate from Lightweight Expanded Slate of Manki Formation, Journal of Himalayan Earth Sciences 44(2) (2011) 53-60

[37]. Vladimir Hamouz , Jardar Lohne , Jaran R. Wood, Tone M. Muthanna, 2018 Hydrological Performance of LECA-Based Roofs in Cold Climates,Correspondence: vladimir.hamouz@ntnu.no; Tel.:+47-410-70-318