Lightweight Concrete Using Fly Ash Aggregates - Review

Hasan Mohamed Aadhil N[1], Dr. D. Shoba Rajkumar[2]

[1]PG Student, Government College of Engineering, Tamil Nadu, India
[2]Professor and Head, Department of Civil Engineering, Government College of Engineering, Tamil Nadu, India

---

Abstract - *This paper presents a review of literature regarding the suitability of flyash aggregates in concrete. The flyash aggregates manufactured by various methods possess different physical properties based on the manufacturing method and the properties of raw flyash used. The influence of flyash on the fresh properties of concrete (density, workability), hardened properties of concrete (like strength, density) and durability properties of concrete (like freeze thaw resistance, water penetration, depth of carbonation) when used with varying gradation, and moisture content were studied.*

***Key Words*: Lytag, Sintered flyash aggregate, lightweight aggregate concrete, sand light weight aggregate concrete, lightweight concrete.**

1. INTRODUCTION

Flyash is a waste material from thermal power plants, which is being produced in larger quantities. Fly ash is used as a mineral admixture in concrete and is also used in Geo-polymer concrete. The use of fly ash as coarse aggregates in concrete has many advantages. As the aggregates occupies major volume in concrete, the use of artificially manufactured fly ash aggregates can help in reducing the consumption of natural aggregates. The main advantages of using the fly ash aggregate in concrete are reduction in dead load and reuse of waste material. Artificial flyash aggregates can be manufactured from flyash through various processes like sintering, hydrothermal treatment and cold bonding. Lytag, Pollytag are some of the commercially available light weight flyash aggregates around the world. The main objective of this paper is to present a review on the previous works carried out by using flyash aggregates in concrete.

2. LITERATURE REVIEW

Lucyna Domagała (2020) experimented on the durability of lightweight concrete containing sintered flyash aggregates. Twelve different concrete mixes were made with different water cement ratio (0.55 or 0.37), coarse aggregate gradation (4/8 mm or 6/12 mm) and initial moisture condition of coarse aggregates (oven dried, moistened or water saturated). The density of all the concrete mixes were within 1470 kg/m3 and 1920 kg/m3. The use of 4/8 mm aggregate fraction enabled the concrete to achieve higher strength in comparison with concrete containing 6/12 mm aggregate fraction. This was due to higher crushing resistance of 4/8 mm aggregate. The water absorption of the concrete was indicated by their densities as it represents the porosity of aggregate and cement matrix. More the density of concrete, lesser was the water absorption of the concrete. The concrete produced with pre saturated aggregates were less durable when compared with the concrete containing dried or moistened aggregates. The water absorption of such pre saturated aggregate concrete was also very high. Due to these reasons, pre saturated aggregate concrete was less resistant to freezing and thawing.

A. Arokiaprakash and **V. Thenarasan** (2018) experimented on the strength properties of the concrete, when the coarse aggregates are partially replaced by sintagg aggregates. Mix design for M25 grade concrete was made using IS 10262:2009. The test specimens were prepared with partial replacement of 10%, 20%, 30%, 40% and 50% of coarse aggregates by sintagg aggregates. The specimens were tested for compression, tension and flexural strengths at 3, 7, 14 and 28th days of curing. Materials used were OPC 53 cement confirming to IS 8112:1989, river sand confirming to zone III of IS 383:1970, Coarse aggregates of maximum size 12mm confirming to IS 2386:1993 and Sintagg flyash aggregates. The properties of sintagg flyash aggregates used are tabulated in table 1. The mix ratio obtained for M25 grade concrete using IS 10262:2009 was 1:2.6:2.5. As the proportion of sintagg increases, the unit weight of concrete decreases. The unit weigth of all the sintagg aggregate concrete was less than conventional concrete. The concrete with 50% sintagg replaced concrete possessed least unit weight compared to other concrete mixes. Cube compressive strength test were carried on 100 x 100 x 100 mm cube. As the proportion of replacement of sintagg aggregates increases from 10% to 30%, the compressive strength of concrete decreases. The compressive strength of concrete with 40% replaced concrete was more than the other concrete proportions. Similar variation was observed in 3, 14 and 28 days of curing. Cylindrical specimens of diameter 100 mm and length 200 mm were tested for 7, 14 and 28 days. Conventional concrete and 40% sintagg replaced coarse aggregate concrete cylinders were subjected to split tensile strength. There was a decrease in strength of sintagg replaced concrete but the percentage of reduction in strength was less than 1%. Prism specimens of size 100 x 100 x 500 mm, were tested for flexural strength on 7, 14 and 28 days of curing. 4 point load test were performed. Conventional concrete was compared with 40% sintagg replaced concrete. It was observed that there was a reduction in the flexural strength of sintagg replaced concrete when compared with conventional concrete. The optimum compressive strength of lightweight concrete is achieved when the sintagg aggregate is partially replaced at 40% and the incresed rate of compressive strength is 1.39%. The split tensile and flexural test results shows there is a slight decrease in the strength properties and this can be studied further with adding fibers in the concrete.

J.Bright Brabin Winsley, **M.Muthukannan** (2018) experimented on two concrete mixes with conventional coarse aggregate and expanded flyash clay aggregate in different concrete mix. Reduction of compressive strength of flyash clay aggregate by 14% was observed. The concrete with flyash clay aggregate possessed lesser tensile strength. The use of flyash clay aggregate in concrete reduced the chloride penetration thus providing better protection to the reinforcements in concrete.

Nallaiahgari Sivanagi Reddy, **CH.Vema Reddy** (2017) studied the influence of mechanical properties of the concrete when flyash aggregates are used as coarse aggregates. Mix design for M40 concrete was obtained using IS 10262:2009. The properties of conventional concrete were compared with the properties of flyash aggregate concrete. The workability of flyash aggregate concrete was better than conventional concrete. The better workability was due to the rounded shape of flyash aggregates. Thus, the superplasticizer dosage can be reduced incase of flyash aggregate concrete. The use of flyash as coarse aggregates resulted in the reduction of density of concrete by 15% when compared with conventional concrete. This reduction in density was due to the light weight of flyash aggregates. The compressive strength of conventional concrete was 68% more than flyash concrete after 1 day of curing. But, after 28 days of curing, the compressive strength of conventional concrete was 48% more than the flyash concrete. This shows that the early strength gain of flyash concrete was lesser and also the strength of flyash concrete increases upon curing.

M.S. Nadesan, P. Dinakar (2017) reviewed the properties of fly ash aggregates suitable to be used as coarse aggregates. Based on their review, following conclusions were made. The physical properties of flyash aggregates depends mainly on the fineness of the fly ash. Flyash aggregates were spherical in shape with specific gravity ranging between 1.33 and 2.35. Fly ash aggregates possessed lesser permeability and chloride penetration than conventional aggregates. The corrosion resistance of fly ash aggregate concrete was more than conventional concrete.

S. Viveka, R. Renuka (2016) experimented on the concrete with replacement of coarse and fine aggregates by flyash aggregates. The materials used for study were OPC 53 grade cement, Flyash, river sand, flyash fine aggregate, hard broken granite stone, flyash coarse aggregates. The experiments were carried out on concrete containing 100% flyash as fine aggregate and the percentage of replacement of coarse aggregate by flyash was varied from 0 to 100% with 10% increment in each successive trails. The flyash aggregates were formed by mixing the cement and flyash in the ratio 25:75 with water-cement ratio of 0.3. These constituents were mixed in a concrete drum mixer until pellets were formed and the pellets were dried for 7 days. The dried pellets were cured in water for 7 days. Mix design for M25 concrete obtained was 1:1.36:2.41 with water cement ratio of 0.45. It was observed that 30% replacement of coarse aggregates by flyash aggregates resulted in increased compressive strength than the remaining mixes. Also, upto replacement of 60% the concrete possessed minimum target strength of 25 MPa, after which the strength of concrete was less than target strength. For 30% replacement of coarse aggregates by flyash aggregates, the split tensile strength was nearly equal to that of the split tensile strength of conventional concrete. The split tensile strength of concrete with other replacement proportions exhibited lesser split tensile strength.

Priyadharshini.P, Mohan Ganesh.G, Santhi.A.S (2011) utilised OPC 53 cement, 12.5 mm crushed coarse gravel as coarse aggregates and river sand as fine aggregates. Flyash aggregates were made by mixing flyash and cement in pelletizer followed by the addition of water mixed with calcium hydroxide. The fresh pellets were kept at room temperature for 24 hours followed by water curing for the next 28 days. Mix design for M40 concrete was done using IS 10262:2009. The flyash aggregates were round. The properties of flyash aggregates are mentioned in table. A comparison of study between conventional concrete and flyash concrete was carried out. The rounded flyash aggregates provided better workability to concrete when compared with angular crushed aggregates. It was found out that there was a reduction of 15% in the density of flyash concrete when compared with conventional concrete. The compressive strength of flyash concrete was 48% lesser than conventional concrete but it satisfies the minimum criteria for the concrete to be used as structural lightweight concrete.

Kayali O (2008) experimented on the properties of with different coarse aggregates. The coarse aggregates used in the study were granite, dacite, commercially available pelletised flyash aggregates (SP) and artificially manufactured flyash aggregates made using flyash (FAA). Four different concrete mixes were made using above specified coarse aggregates. The concrete with commercial fly ash pellets was designated as SP concrete and the concrete with artificial fly ash aggregates was designated as FAA concrete. The workability test was performed on all the four concrete mixes using slump cone. The slump of SP and FAA concrete was comparatively higher than the slump of concrete containing granite and dacite aggregates. The use of flyash aggregates reduced the density of concrete. Hence, both SP and FAA concrete were less dense when compared with the conventional concrete. The compressive strength of SP concrete was less than the compressive strength of concrete containing granite. But, the compressive strength of FAA concrete was more than the compressive strength of conventional concrete. The increased compressive strength was due to the low crushing value of FAA when compared with SP. The indirect tensile strength was more for both SP and FAA concrete. Also, the modulus of elasticity of SP concrete was much lesser when compared with conventional concrete and SP concrete. The modulus of elasticity of concrete depends on the modulus of elasticity of aggregates. As FAA aggregates were stiffer than SP concrete, the modulus of elasticity of SP concrete was lesser than the modulus of elasticity of FAA concrete.

M.N. Haque, H. Al-Khaiat, O. Kayali (2004) experimented on two sand lightweight concrete made up of lytag aggregates of compressive strength 35 N/mm2 and 50 N/mm2 and are designated as SLWC35 and SLWC50 respectively. Also studies were carried out by replacing the sand in SLWC35 and SLWC50 using fine lytag, designated as LWC35 and LWC50 respectively. The densities of SLWC35 and SLWC50 were 1775 and 1800 kg/m3 respectively, which was lesser when compared with the density of conventional concrete. It was observed that under similar curing conditions, the strength attained by LWC and SLWC were nearly similar until 270 days of curing. The modulus of elasticity of SLWC50 was 12% higher than the modulus of elasticity of SLWC35. Water penetration and depth of carbonation were less for concrete containing sand as fine aggregate.

Table -1: Properties of fly ash aggregates

S No	Authors	Type of aggregate	Specific Gravity	Bulk Density (kg/m^3)	Water absorption (%)
1	A.Arokiaprakash, V.Thenarasan	CA	1.72	917	13
2	Priyadharshini.P, Mohan Ganesh.G, Santhi.AS	CA	2.12	1247	13.23
3	S.Viveka, R.Renuka	CA	1.727	924.8	11.84
		FA	1.74	1067	9.54
4	Kayali.O	CA	1.72	831 (dry)	8.5
		CA	1.69	848 (dry)	3.4
5	MN.Haque, H.Al-Khaiat, O.Kayali	CA	1.42	820	13.6
6	Lucyna Domagała	CA (4/8 mm)	1.32	730	19.3
		CA (6/12 mm)	1.34	720	18.8

*CA – Coarse Aggregate, FA – Fine Aggregate

3. CONCLUSIONS

As a result of reviewing the literature, following observations were identified:

- The density of fly ash aggregate concrete was lesser than the density of conventional concrete.
- The workability of the concrete was unaffected when fly ash coarse aggregates was used.
- The use of fly ash aggregates resulted in considerable loss of strength of concrete.
- The concrete made up of fly ash aggregates possessed lower modulus of elasticity when compared with conventional concrete.
- The moisture content of fly ash aggregates affect the durability of the concrete. The concrete made up of dry fly ash aggregate was more durable than the concrete made up of pre saturated fly ash aggregates.
- The use of fine aggregates of fly ash must be avoided as it increased the water penetration and depth of carbonation in concrete.
- The use of fly ash aggregate in concrete would be an effective way to preserve natural resources that are being used as the ingredients of concrete.

REFERENCES

[1] A. Arokiaprakash and V. Thenarasan, "Experimental Study of Properties of Light Weight Concrete as a Partial Replacement of Sintagg Aggregate to Coarse Aggregate", International Journal of Civil Engineering and Technology (IJCIET), Volume 9, Issue 3, March 2018, pp. 656–662, Article ID: IJCIET_09_03_067

[2] Priyadharshini.P, Mohan Ganesh.G, Santhi.A.S , "Experimental study on Cold Bonded Fly Ash Aggregates", International Journal Of Civil And Structural Engineering, Volume 2, No 2, 2011, doi:10.6088/ijcser.00202010129.

[3] Nallaiahgari Sivanagi Reddy, CH.Vema Reddy , "Study Of Concrete Made Using Fly Ash Aggregates", International Journal Of Professional Engineering Studies, Volume VIII /Issue 4 / APR 2017.

[4] S. Viveka, R. Renuka, "Study of Strength Characteristics of Fly Ash Aggregates in Light Weight Concrete", International Journal of Innovations in Engineering and Technology, Vol 6, Issue 3, Feb 2016.
[5] O. Kayali, "Fly ash lightweight aggregates in high performance concrete", Construction and Building Materials 22 (2008) 2393–2399, doi:10.1016/j.conbuildmat.2007.09.001
[6] Rishab Meena, Sumit Sharma, Anuj Sharma, Mukesh Kumar, "Study on Lightweight Concrete- Review", International Journal of Engineering Research & Technology (IJERT), Vol. 9 Issue 07, July-2020.
[7] M.N. Haque, H. Al-Khaiat, O. Kayali, "Strength and durability of lightweight concrete", Cement & Concrete Composites 26 (2004) 307–314.
[8] Al-Khaiat H, Haque MN, "Strength and durability of lightweight and normal weight concrete", ASCE Mater J 1999;11(3): 231–5.
[9] Lucyna Domagała, "Durability of Structural Lightweight Concrete with Sintered Fly Ash Aggregate", Materials 2020, 13, 4565; doi:10.3390/ma13204565
[10] Manu S. Nadesan, P. Dinakar, "Structural concrete using sintered flyash lightweight aggregate: A review", Construction and Building Materials 154 (2017) 928–944.
[11] J.Bright Brabin Winsley, M.Muthukannan, "Expanded Fly Ash Clay Aggregate a Sustainable Alternative Coarse Aggregate for Concrete", Journal Of Materials and Engineering Structures 5 (2018) 347–353.