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Research Paper

A Review on Lightweight Aggregate Concrete

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ABSTRACT: *In the recent times due to tremendous benefits in terms of low density, high thermal conductivity, design flexibility and less cost, the use of light weight aggregate concrete for structural applications has gained a lot of interest. Light weight aggregate concrete is obtained by mixing cement with light weight aggregates having lesser densities. In the current study comprehensive investigation on the properties of light weight concrete obtained with wood chippings, wood powder, granite, low-quality crushed brick aggregate, oil palm shell, expanded clay aggregate, pumice, rice husk and steel cinders have been reviewed from the existing literature. This literature also attempts to provide a thorough understanding of the current applications of various light weight aggregates in the construction sector.*
KEYWORDS: *Light Weight Aggregates, Density, Compressive Strength*

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I. INTRODUCTION

Light weight concrete is an amazing human invention which is used in several fields of construction in the recent times due to its lesser densities and thermal conductivities. The strength of LWC is 25 to 35 % lesser as compared to conventional concrete. Light weight concrete is a blend of light weight coarse aggregate such as shale, clay (or) slate giving it low density which range from 1440 -1840kg/m³. The main advantage of LWC is its low density, reduction of dead load, faster building rates and handling costs. Since eighteenth century, the Romans have used lightweight concrete. In Europe priority of utilization of LWAC happened around a long time back when the Roman constructed the pantheon and water systems in Rome. In light weight aggregate they are two types one is natural light weight aggregate and other one is artificial light weight aggregate. Natural lightweight aggregate includes pumice, diatomite, expanded clay aggregate and rice husk. Day by day the industrial usage is increasing and waste generated will be obtained in more quantities from the industries. To usage the industrial waste they are using cinders, palm oil shells, and fly ash. Usage of this natural and artificial light weight aggregates in making concrete results is achieving lesser densities and high thermal conductivities. Cinder absorbs water at a rate of about 1.5%. This discrepancy is assumed to be the primary cause of the decreased strength and durability of cinder-based concrete. Due to their high porosity and porous structure, pumice aggregates may be used as an alternative to aggregate in porous concrete to increase porosity without significantly lowering concrete strength. Expanded clay aggregate is one of the materials among light weight aggregate which gives the highest compressive strength.

II. TYPES OF LIGHT WEIGHT AGGREGATES

2.1 Wood chippings and wood powder

Sawdust is produced during milling, drilling, and cutting processes of wood when it is cut from a log or while assembling finished goods. The pieces of side-cuts from a wood log are cut into rectangular shape and are called as wood chippings. Each year, hundreds of tonnes of furniture and other wood products are made using wood dust, which is usually collected in filter bags or dust collectors. By using these wood chips and sawdust severe environmental problems can be avoided. Wood's network of capillaries, which allows sap to circulate, is what gives it its hydrophilic properties when combined with cement. This also shows an effective and workable answer to the issue of economic design and the substitution of wood fibre waste which would benefit the environment.

Figure 1: wood chipping and wood powder

2.2 Granite

Nowadays, there is a significant increase in the quantity of granite powder due to the increased use of granite stone products, which has negative social and environmental effects. A type of igneous rock called granite is created when magma beneath the earth's crust crystallises. When granite stoneware is cut and polished in quarry industries, which total between 250 million and 400 million tonnes annually, granite fine powder is produced as a by-product. The granite sludge/waste (GS) used was obtained from filter pressing machines of the granite processing plants. This granite is obtained from the process of transforming raw blocks into slabs, up to 80 % of the granite rock is being wasted, according to Brazilian Association of companies Brazil was the third largest exporter of granite in the world (2017). In order to reduce the pollution and promote economic standards we can use this granite fine powder (GFP) as a replacement of fine aggregate in lightweight aggregate concrete and this residue improves workability, granite residue has greater water absorption unlike sand due to its microstructure Additionally, replacing granite residues with natural aggregates results in a decrease the percentage of air added to the mixture.

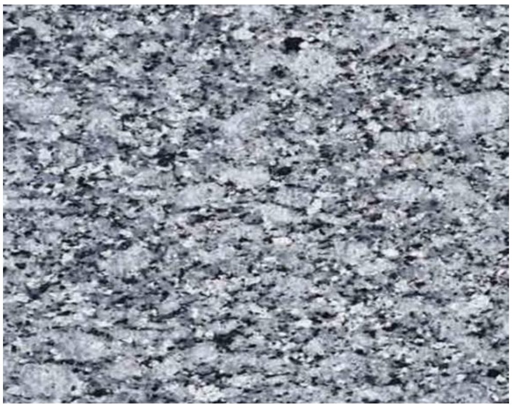

Figure 2: Granite

2.3 Low-quality Crushed Brick aggregate:

Millions of tonnes of construction waste have been created over the past few decades in most developed nations as a result of the demolition of numerous out-dated structures; the compressive strength of these demolished brick varies from 3-7 N/mm^2. Construction trash annually amounted to 12 million tonnes in the UK and 7 million tonnes in Finland, respectively. More than 1 million tonnes of construction and demolition debris are produced annually in large cities Tehran, the capital of Iran, this amount might exceed 10 million tonnes, and 50% of demolition garbage is typically recyclable clay brick. The environmental impact of demolition trash in urban areas is now significant, poses a risk to the quality of subsurface water, and impairs aesthetics. We can use the crushed brick debris as a replacement for fine and coarse aggregate in concrete to solve the major social and environmental issues caused by the disposal of this enormous amount of construction and demolition trash. These aggregates have low durability when compared with conventional aggregates, recycled brick aggregates are seen to be coarser and stiffer.

Figure 3: Low – quality crushed brick aggregate

2.4 Oil palm shell

OPS found in Africa, China. The second-largest producer of palm oil is Malaysia. Oil palm shell (OPS) is the most typical agricultural waste in the palm oil industry. The specific gravity and water absorption over 24 hours of oil palm shell are 1.2 and 20.5% respectively. The OPS aggregate weighs between 500 and 600 kg/m^3

Figure 4: oil palm shell

2.5 Expanded Clay aggregate

LECA is a natural product that is free of any dangerous ingredients. In a rotary kiln, clay is heated to roughly 1200°C to make light expanded clay aggregate or LECA. Due to the circular movement of kiln, it has somewhat a rounded shape. The clay is expanded by hundreds of tiny bubbles that emerge during heating as a result of the releasing gases, creating a honeycomb structure. It is non-combustible, non-biodegradable, with a neutral PH value, is resistant to chemicals, will not break down in water, and has excellent acoustic and thermal insulation properties. The self-weight and the impacts of freezing and thawing on pavements can be reduced by using LECA.

Figure 5: Expanded clay aggregate

2.6 Pumice

In several nations across the world, pumice, a naturally occurring substance of volcanic origin created by the expulsion of gases during the solidification of lava, has been utilised as the aggregate in the creation of lightweight concrete. Pumice has only recently been used in certain areas where it is readily accessible locally or can be imported around 3 to 4 million tonnes annually, and the turkey and Italy produces large amount of pumice. Pumice aggregates have specific gravities of 1.68, 1.18, 0.98, and 0.92 for sizes 0-2, 2-4, 4-8, and 8-16, respectively. To ensure that the qualities of the pumice aggregate do not alter before production stages, it should be kept in closed storage rooms; the water absorption rate of pumice (lightweight aggregates) is quite high.

Figure 6: Pumice

2.7 Rubber

Rubber type aggregate in concrete can improve thermal insulation and have strong mechanical strength. Rubber tyres were physically chopped into sizes less than 25mm and sieved for 19mm.waste tires are difficult to decompose; using waste rubber in conjunction with Portland cement has many advantages, the density of rubber isomer is less than the light weight aggregate.

Figure 7: Rubber

2.8 Plastic

Plastic is utilized as coarse aggregate in concrete mixes, discarded plastic waste showed enhanced compressive strength and workability. PET bottles were shred and crushed at a plastic recycling factory to a small fraction and then washed to get rid of unwanted objects and the oily texture. PET bottles were collected from a disposal place. PET aggregate have specific gravity 2.5, coarse aggregate size is 19 mm.

Figure 8: Plastic

2.9 Rice husk

Rice husk is naturally available material it can be collected from rice mills and industries in Kirinyaga country, where rice husks were purchased. Due to their poor nutritional value, rice husks are an agricultural and industrial by-product of the hulling process. Rice husks are resistant to a natural degradation that can result in significant environmental load due to their siliceous nature. This creates a sizable market for environmentally friendly concrete and concrete goods. Rice husk is found to have a specific gravity of 2.5. More rice husk is utilised while creating bricks, which results in more porous bricks that provide higher thermal insulation. Rice husk is used to make high-quality steel because of its excellent insulating qualities, which include low thermal conductivity, a high melting point, a low bulk density, and high porosity. Additionally, it is used to coat the molten metal in castings and tundishes, which operate as excellent insulators and prevent the metal from cooling quickly.

Figure 9: Rice Husk

2.10 Steel Cinder

Steel cinders from steel companies have been used in place of coarse aggregates in some areas. These steel cinders are less in weight, the research uses steel cinder as a replacement for coarse material to fulfil the required grading in manufacturing concrete. Steel cinder passing through a 30 mm sieve and is retained on a 20 mm I.S sieve. Due of the mineral structure, the surface of the steel cinders is usually rough and porous and are physically viewed as angular materials that can be used in substitute of coarse aggregate in some applications. The steel cinder aggregates would be lighter and having a specific gravity of 2.05.

Figure 10: Steel Cinders

III. LITERATURE REVIEW

Azevedo et al [3] A number of social and environmental problems are being caused by the rising production of granite fine powder. The authors concluded that the use of granite residue in mortar is technically possible after conducting physical-mechanical experiments such as water absorption, compressive strength, and durability tests. Sand and granite residues had specific gravities of 2.62 and 1.87, respectively. It has been noted that the penetration rate of mortars is gradually decreased by the addition of granite, and a replacement is only 40–60% practical when taking mortar workability into account. 3.33 MPa and 700 kg/m^3 are found as the compressive strength and density, respectively.

Vidyapriya et al [8] Pumice aggregate is replaced with coarse aggregate at various amount of replacements (50%,80%,100%) which is having a density of 0.25kg/m^3. They have done several tests on the specimen(100mm*100mm*100mm) of size. The tests are destructive test and non- destructive tests like compressive strength, flexural strength, split tensile strength, ultrasonic pulse velocity and rebound hammer. Due to the more porous and uneven surface structure of pumice, the shear stress of concrete may be reduced.

Destructive tests are conducted by the UTM (Universal Testing Machine). The results show that 50% of pumice aggregate achieved the optimum results compared to other replacements and it shows that increasing percentages of pumice aggregate decreases the strength of concrete. This type of concrete can be used in lintels, sunshades and partition walls. The compressive strength is 12.2 N/mm^2, flexural strength is 3.636N/mm^2, split tensile strength is1.79N/mm^2, Ultrasonic pulse velocity is 5057 m/s, rebound hammer test is 31.94.

Aslam et al. [4] Oil palm boiler clinker (The burned waste of oil palm shell) and Oil palm shell were used in place of coarse aggregates, and local mining sand is used in place of fine aggregate (max 4.75mm). Ordinary Portland cement used as binder, superplasticizer is used to improve bond strength and density. The specific gravity for OPS is 1.19 and OPBC (Oil Palm Binder Clinker) is 1.69. The rate of strength gain was higher in the OPBC. The compressive strength for 28 days is 33Mpa. The water absorption for OPS and OPBC are 20.5 and 7.0. The density is 610 Kg/m^3. In Malaysia, a small footbridge with a span of roughly 2 metres and a cheap dwelling with a footprint of 59^2 metres are built utilising OPS concrete.

Pavithra et al.[5] Clay aggregates were used in place of the natural coarse aggregates. Light weight expanded clay aggregate is obtained by thermal treatment of argillaceous materials. Expanded clay is defined as clay that has produced a mass full of gas bubbles when it is heated. It has the maximum compressive strength. The LECA was put through many tests, including those for compressive strength, split tensile strength, flexural strength, and fast chloride permeability for durability. LECA can be utilised in order to minimise the self-weight and also freezing and thawing effects in the pavements can be reduced, pavement testing such as dynamic cone penetrometer test can be done. The density of concrete is 540-600kg/m^3. LECA has a moisture content of 12–30%, has a strength range of 34–69 MPa. The void ratios of LECA concrete of minimum and maximum are 1.628 and 1.894 respectively. In order to promote ground stability, LECA is used in structural backfill around bridge abutments, retaining walls, and foundations.

S.G. Uma et al. [7] Steel cinders are replaced as coarse aggregates in concrete to reduce the cost of construction and also dead load of the structure and to design heavy structures. The coarse aggregate is partially replaced with steel cinders in various percentages (20%,40%,60%,80%,100%). Mix proportions of 1:2.22:3.66 mix of water cement ratio 0.55 was adopted in this experiment and the cube size is 150mm*150mm*150mm was casted. The 60% replacement of cinder in production of cinder concrete achieve the target mean strength as normal concrete. The workability of the cinder concrete will be good when compared to conventional concrete. The specific gravity of steel cinder is 2.05, Steel cinders can be used in construction to avoid the industrial waste. As a result of the cinder concrete's reduced weight compared to conventional concrete, the Construction costs and the structure's dead load are factors that aid in the design of heavy structures. The compressive strength and flexural strengths are 25.2MPa and 17.1 MPa respectively.

Atif et al [9] The tyre and shattered glass are used as coarse aggregates, the utilization of these recycled aggregates in concrete gain more strength. It is suggested that for the glass concrete specimens, the trend of the increased compressive strength with the increase of glass percentage. The compressive strength is 11.03MPa, the density is 1440 Kg/m^3. Therefore, the concrete containing crushed glass as a partial replacement of natural gravel could achieve a comparable strength with the normal specimens.

Gopinath et al. [11] At weight replacement rates of 0%, 5%, 10%, 15%, 20%, and 25%, OPC was substituted with RHA (Rice Husk Ash). The reference was set to 0% replacement. Fresh concrete was tested for compacting factor. Fresh concrete underwent a compacting factor test, while 150mm concrete cubes that had undergone 7, 14, and 28 days of water curing underwent a compression strength test and density is observed as 495 Kg/m^3. According to the findings, the Compacting factor dropped when more OPC was replaced with RHA. Multiple benefits of rice husk and rice husk ash can be achieved by future critical research efforts to provide new impetus for local and regional sustainable development, the maximum replacement of rice husk should not exceed 20%.

waing et al [12] Coarse aggregate is replaced with rubber particles, if we increase rubber particles replacement then it's setting time increases. It provides resistance to External impact of CLSRC (Controlled Low Strength Rubber Lightweight Aggregate Concrete). The compressive strength will be reduced if we increase rubber replacement. (If 20 % is replaced then the compressive strength results as 0.7 Mpa). 20% replacement of rubber is suggested for concern of the construction and safety.

Bazaz et al. [2] Concrete manufactured from crushed clay bricks has a substantially lower compressive strength than conventional concrete. The coarse aggregate is replaced with crushed brick aggregate here, Los Angles abrasion value is less when compared with natural aggregates. The observed values for soundness, freezing and thawing, and Los Angeles abrasion are 10.9%, 2.3%, and 49.6%, respectively, and observed that it is having high freezing and thawing resistance (weight remains same after 120 times of freezing and thawing). Concrete made from crushed brick has a compressive strength of about 21.5 N/m^3, which is sufficient for non-structural uses, and its body density ranged from 19.4 to 19.85 KN/m^3. The environmental cost must be taken into account, and broken brick must be used as concrete aggregate even when it is not economically feasible. The water cement ratio used here is 0.45-0.7, and as the water cement ratio rises, the voids in the dried concrete, making this type of concrete as semi-lightweight concrete.

Coatanlem et al [1] As a result of their fungicide content wood shavings are not used as fuels and this waste is replaced with fine and coarse aggregates in concrete, wood shavings (0–10 mm), coarse dust (0–8 mm), and fine sawdust (0–2 mm) with respective sizes having specific gravities of 0.64, 0.68, and 0.69 respectively. Due to the shape of the wood aggregates (pyramids) there will be a good water absorption (18% the micro porous wood aggregates reduced the capillary absorption inside the material) but also provide good workability, it obtains appropriate workability (slump value 5.2), good thermal conductivity (0.954) along with low density. To develop strength qualities and strengthen the binding between cement and wood waste, chippings were subjected to a 100 g/l sodium silicate solution for 24 hours. The ideal replacement percentage for wood waste was around 20%, resulting in good mechanical and physical qualities, with a compressive strength after 28 days of curing of 25 Mpa, after adding water reducing admixtures and obtained a density of 510 kg/m^3 and a flexural strength of 10.15 Mpa approximately, Wood chippings could potentially affect the water cement ratio (0.75), which could limit the amount of water available for hydration due to the migration of water into wood particles. Therefore, it is proposed to saturate the wood chippings with water and carried out an estimation of the kinetic of water absorption. The chippings are completely saturated with water after 24 hours. As a silicate additive is added to wood chips in this concrete, it increases resistance to insect and fungus assault and is categorised as class 3 light weight concrete for insulating purposes, in many parts of the world use of sawdust, cement and sand in the manufacturing floor walls and panels which have become common.

Table 1: Summary of Properties of Different Light Weight Aggregate Materials

Material	Density (Kg/m^3)	Specific Gravity	Compressive Strength (Mpa)	Flexural strength (Mpa)	Water Absorption	Author
Granite powder	700	1.87	3.33	-	0.43-0.53	Azevedo [3]
Wood powder, chippings	510	0.69	9.10	10.15	-	Coatanlem [1]
Steel cinder	-	2.05	25.2	17.1	-	S.G. Uma [7]
Rubberized aggregate concrete	1440	1.18	16.33	4.2	4.2	Atif [9]
Recycled crushed brick aggregate	1700-1800	1.9-2.0	21.5	-	0.28	Bazaz [2]
Plastic	1440	2.5	16.33	4.2	4.2	Atif [9]
Glass powder	1440	1.0	16.33	4.2	4.2	Atif [9]
Pumice	1500-1800	1.05	12.2	3.636	-	Vidyapriya [11]
Light weight expanded clay aggregate	540-600	2.68	36.90	4.28	2.8	Pavithra[5]
Oil palm shell	610	1.19	20.43	-	20.5	Aslam [4]
Rice husk	-	2.5	19.68	-	-	Gopinath [12]
cold bonded fly ash	1950-2170	1.78	20.8-47.3	-	-	Mehmet

IV. CONCLUSIONS

Based on the above literature and numerous experiments conducted by several authors with a variety of objectives to generate lightweight concrete with similar physical and mechanical qualities as that of conventional concrete it is concluded that when replaced with fine or coarse particles, the workability of the concrete had varied trends depending on which aggregates were used. The type, form, and shape of the aggregates followed by replacement type and dosages, were found to have the greatest influence on workability. The densities of the concrete obtained with different aggregates varies according to the specific gravities of the aggregates, and compressive strength varies due to water absorption and additives or superplasticizers. Compressive strength of light weight expanded clay gives more strength when compared to all other aggregates. Concrete obtained by using pumice, plastic, rubber and glass powder yields higher densities when compared to other materials.

REFERENCES

[1]. Pascale Coatanlem a, Raoul Jauberthie, Frank Rendell. “Lightweight wood chipping concrete durability construction building materials”. Construction and Building Materials 20 (2006) 776–781

[2]. Jafar Bolouri Bazaz1 and Mahmood Khayati2. “Properties and Performance of concrete made with recycled low quality crushed brick”. American Society of Civil Engineers.

[3]. Afonso Rangel Garcez de Azevedo , Markssuel Teixeira Marvila , Laimara da Silva Barroso , Euzébio Bernabé Zanelato , Jonas Alexandre , Gustavo de Castro Xavier and Sergio Neves Monteiro 3“Effect of Granite Residue incorporation on the behavior of

mortars". Department of Agricultural Engineering and Environment, Federal Fluminense University—UFF, Rua Passo da Pátria, 156, São Domingo, Niteroi, Rio de Janeiro 24210-240, Brazil.

[4]. Muhammad Aslam, Payam Shafigh, and Mohd Zamin Jumaat. "Structural Lightweight Aggregate Concrete by Incorporating Solid Wastes as Coarse Lightweight Aggregate"2015.

[5]. Pavithra , Jerosia De Rose. " Application of Light Expanded Clay Aggregate as Replacement of Coarse Aggregate in Concrete Pavement".

[6]. Rajeswari S, Dr Sunilaa George ''Experimental Study of Lightweight Concrete by Partial Replacement of Coarse Aggregate using Pumice Aggregate" International Journal of Scientific Engineering and Research, Volume 4, Issue -5, 50 – 53, May 2016.

[7]. S.G. Uma, S. Muthulakshmi "Study on light weight concrete using steel cinders " Materials Today: Proceedings (2020).

[8]. R.B. Karthika, V. Vidyapriya, K.V. Nandhini Sri, K. Merlin Grace Beaula, R. Harini, Mithra Sriram, Experimental study on lightweight concrete using pumice aggregate,2021.

[9]. Khandaker Samin Atif, Md. Asadullah-Al-Galib, Nabil Ahmed, Nayem Hasan, Saurav Baru, A Comparative Study on Compressive Strength of Concrete Mix Containing Plastic, Glass and Rubber Aggregates, 2020.

[10]. Mehmet Gesoglu, Turan turan, Erhan Guneyisi "Shrinkage cracking of lightweight concrete made with cold-bonded fly ash aggregates" 2003.

[11]. R Gopinath, T Ajithkumar, M Nithin, V Sanjay Srikanth, P Sivakumar. "Experimental study on partial replacement of course aggregate by coconut shell and Portland cement by rice husk ash". 2018.

[12]. Her-Yung Wang , Bo-Tsun Chen, Yu-Wu Wu "A study of the fresh properties of controlled low-strength rubber lightweight aggregate concrete (CLSRLC)", 2013.

[13]. Teo D.C.L., Mannan M.A. and Kurian V.J., "Utilisation of Solid Waste Oil Palm Shell (OPS) in Concrete Production", Proceedings of the International Conference on Natural Resources and Environmental Management, Kuching, Sarawak, Malaysia, 135-140,2005.