LIGHTWEIGHT AGGREGATE CONCRETE USING EXPANDED POLYSTYRENE BEADS-A REVIEW

Vishakh T M[1], Dr Vasudev R[2]

[1]M.Tech student, Dept. of Civil Engineering, Toc H Institute of Science & Technology, Arakkunnam, Kerala, India
[2] Asso. Professor, Dept. of Civil Engineering, Toc H Institute of Science & Technology, Arakkunnam, Kerala, India

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Abstract - *With the increase in demand for construction materials, there is a strong need to utilize alternative materials for sustainable development. Several studies are done for replacing coarse aggregates in concrete. Expanded Polystyrene (EPS) beads are used as partial replacement to coarse aggregates. There are many advantages to be gained from the use of EPS in lightweight concrete. These include lighter loads during construction, reduced self-weight in structures, and increased thermal resistance. Lightweight concrete is generally accepted as concrete having a density of about 1800 kg/m3 or less. This review paper is concentrated on studies done in the field of lightweight concrete containing Expanded Polystyrene (EPS) beads.*

Key Words: *Lightweight aggregate, Expanded Polystyrene (EPS) beads, Thermal resistance, Compressive strength, Density*

1. INTRODUCTION

Increase in the developmental activities world over, the demand for construction materials is increasing exponentially. This trend will have certainly greater impact on the economic system of any country. India also is aiming at a high developmental rate compared to other nations in Asia. There is heavy demand for the building materials in the domestic market, which is becoming scarce day by day. At this point researchers and engineers who have the foresight to keep the developmental activities abreast and curtail the cost factor should look out for other alternative building materials. In this work, an attempt is made to address the possibility of utilizing Expanded Polystyrene (EPS), a packing material in the form of beads in concrete, which otherwise is posing a threat to waste disposal as well as for waste management. This material is a cause of concern to environmentalists. In this study, it is attempted to partially replace coarse aggregates by means of EPS beads. A general discussion on EPS, its production and its application along with environmental concerns are being discussed.

The first light weight concrete (LWC) has been used for construction of the Port of Cosa built around 273 BC and natural volcanic materials were used to produce light weight concrete. There are several LEC structures in the Mediterranean region, but most notable structures were built during the early Roman Empire and include Pantheon Dome and the Coliseum. The Pantheon, finished in 27 BC, incorporated concrete varying in densities from the bottom to the top of the dome. Roman engineers had sufficient confidence in LWC to build a dome whose span of 43.3 m was not exceeded for almost two millenniums. The structure is in excellent condition and is still being used to this day for spiritual purposes. The excellent cast surfaces that are visible to the observer slow clearly that these early builders had successfully mastered the art of casting concrete made with light weight aggregates.

Since World War I, the application of light weight concrete for structural applications in rapidly spread. Besides the weight savings, LWC has substantially better fire resistance qualities than normal weight concrete, and significantly lower heat transmission. It has become a greater requirement and need to reduce the weight of structural element than increasing the strength of LWC, particularly in cases of heavy structures such as tall buildings and bridges where the own weight of the structure is one of the main problems that faces the designers.. Monolithic concrete structures are also particularly durable and the fact that no plastering or cladding is required leads to cost saving and makes the structures more sustainable. Today LWC are available in wide range of densities and strength LWC provides many advantages for design, construction and for comfort for living in addition to cost economy, easy to transport and construct. However, inspite of increasing use and demand for LWC, there is still a lack of inadequate explanations to identify durability related parameters.

1.1 LIGHTWEIGHT CONCRETE

Concretes having low density about 1800 to 2000 kg/m3 are termed as lightweight concrete which can be apparently achieved either by using low density aggregates or with the complete elimination of coarser aggregates. Concrete is the most widely used construction material in the world. Normal weight concrete (NWC) is generally used for building construction despite its relatively high unit weight and limited thermal performance with a thermal conductivity ranging between1.4 and 3.6 W/m. K. A reduction in the unit weight of concrete and yet providing adequate strength will create a significant economic positive impact to the construction industry. In this regard, lightweight concrete (LWC) offers considerable advantage in terms of its unit weight over NWC.LWC is a conglomerate of cement and lightweight aggregates. It has a bulk density ranging between 300 and 2000 kg/m3comparedto 2200–2600 kg/m3 of NWC. LWC is broadly divided into the following categories based on its bulk density and compressive strength.

a. Thermo insulating lightweight concrete: This type of LWC is used as filling material or as an insulating coating. Its bulk density is in the range of 300–800 kg/m3 while the compressive strength is in the range of 0.5–7 MPa.

b. Low strength lightweight concrete: This type of LWC is used in structures where the strength of concrete is not important; at the same time, it guarantees an acceptable level of thermal comfort. The bulk density is in the range of 800–1400 kg/m3 while the compressive strength is in the range of 7–18 MPa.

c. Structural lightweight concrete: This type of concrete is normally prepared with synthetic aggregates. The reduced bulk density of this type of LWC is due to the addition of a void

1.2 EXPANDED POLYSTYRENE

Polystyrene (PS) is a synthetic aromatic hydrocarbon polymer made from the monomer styrene .Polystyrene can be solid or foamed. General-purpose polystyrene is clear, hard, and rather brittle. It is an inexpensive resin per unit weight. It is a rather poor barrier to oxygen and water vapour and has a relatively low melting point. Polystyrene is one of the most widely used plastics, the scale of its production being several million tonnes per year. Polystyrene can be naturally transparent, but can be coloured with colourants. As a thermoplastic polymer, polystyrene is in a solid (glassy) state at room temperature but flows if heated above about 100 °C, its glass transition temperature. It becomes rigid again when cooled. This temperature behaviour is exploited for extrusion (as in Styrofoam) and also for molding and vacuum forming, since it can be cast into molds with fine detail.

Fig -1 :EPS beads

2. LITERATURE REVIEW

Cheng et al.(2012) investigated the influence of EPS content on the failure mode, stress-strain relationship and elastic modulus of expanded polystyrene aggregate concrete (EPAC) under uniaxial loading. The density of the investigated concrete was less than 900 kg/m3. It was reported that EPAC exhibited good compressibility and the appearance of apparent oblique crack was noted in the specimens tested under compression

Arpit Sharma, et al. (2017), says The conventional aggregates are replaced by light weight aggregates which makes the concrete lighter than the conventional concrete. Comparison has been made between plain cement concrete and lightweight concrete having different proportions of aggregates, pumice stone and aluminium content by the weight of cement. Using different proportions of pumice stone and light weight aggregates three different light weight mixtures were produced with a satisfied strength. Aggregates size and proportion affects the unit weight and compressive strength of concrete. The results showed that it is possible to produce a floating and a satisfied strength concrete by using pumice stone as aggregate. It was also seen that light weight aggregates in concrete mixture can reduce the dead load but decreases the concrete strength. These light weight concrete does not satisfies the strength requirements for load bearing structural elements so can be used as separation walls.

Bagon.C, et al.(2016), The performance of concrete containing expanded polystyrene beads was studied in the context of marine floating structures. It was found that, for an equal density of about 80 % that of sea water, polystyrene concrete has a compressive strength that is 50 % higher, a modulus of elasticity 100 % higher, and a modulus of rupture 25 % higher than those of perlite concrete. Furthermore, polystyrene concrete is much more resistant to sulphate solutions than perlite concrete even though it is less resistant than normal-weight concrete.

Pascal Collet, et al. (2014),describes the way a large pre-stressed concrete Floating Production Unit (FPU) located offshore Congo on N'KOSSA field has been inspected and assessed in order to meet both Bureau Veritas Class and Floating Units Integrity Management System (FUIMS) requirements. This FPU is the largest existing pre-stressed concrete barge.. A significant part of the methodology is based on close inspection for the concrete structure, a graphic assessment of the defects and an implementation of monitoring. This assessment is done a long time after construction and we had to cope with difficulties relative to the structure size, loss of data, barge in operations off-shore. It gives a good feedback of what we should implement during the design and the construction to keep a clear view of the concrete barge. With appropriate high quality concrete, corrosion control and maintenance, it's anticipated to keep in operation more than 40 years the hull without dry docking. After 18 years of operation on Congo N'Kossa field, the hull looks in very good condition without any need for major maintenance works.

Lakshmi Kumar Minapu, et al. (2014), More environmental and economical benefits can be achieved if waste materials can be used to replace the fine light weight aggregate. The new sources of Structural aggregate which is produced from environmental waste is Natural aggregates, synthetic light weight aggregate The use of structural grade light weight concrete reduces the self weight and helps to construct larger precast units. In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M30 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume. The study is also extended for blending of concrete with different types of mineral admixtures. The test results showed an overall strength & weight reduction in various trails.

Therefore, the light weight concrete is no way inferior for construction purpose.

JianboHua, et al. (2011), presents a floating platform concept for offshore wind turbine. A vertical cylinder on the top of an elliptical sphere forms the principal configuration of the platform. A compact and solid floating platform of concrete for offshore wind turbine is introduced in this paper for long service life. Dynamic performance analysis has been carried out for a floating platform with a 5 MW wind turbine, which shows that the platform has the sufficient ability to secure the safe operation of the onboard wind turbine in up to rough sea state and survivability in extreme sea.

Dr. A.S. Kanagalakshmi, et al. (2016), deals with the development of lightweight concrete. This also shows the importance of water/cement ratio as in first type of concrete it produce lightweight structural concrete with the unit weight varying from 1200 to 2000 kg/m^3.. The isomer of all the phenyl groups on same side called polystyrene. Now a day's number of researches have been done on lightweight concrete but in this research have tried to make a concrete having possible lesser density and higher compressive strength. The Aerated concrete is a much lighter concrete and can float on water. It does not contain coarse aggregates. It is composed of cement, sand, high water cement ratio. Just as we mix the cement-sand slurry with EPS, the expansion in the volume can be observed. Within 5 minutes it expands by 30%. It consists of many pores and thus is not structurally strong. It is a good insulator of heat and sound and thus can be used in place of conventional bricks or at the places which does not bear any load.

Gowthamaprasanth.U, et al.(2016), deals with floating concrete precast slab with addition of vermiculite and pumice. Buoyancy plays major role on floating objects. In order to design a floating concrete slab Light Weight Concrete (LWC) plays a prominent role in reducing the density and to increase the thermal insulation. Light weight concrete (LWC) is formed by Natural aggregate, synthetic light weight aggregate. Vermiculite is a light weight and cheap product because of its thermal resistance has become a valuable insulating material. The density of these concrete varies from 750 Kg/m^3 to 2050 Kg/m^3. Pumice is a natural graded light weight coarse aggregate which has a dry density of 1200 Kg/m^3 to 1450 Kg/m. The light Weight Concrete (LWC) M20 using the light weight coarse aggregate as Pumice stone as a full replacement to 100%, light weight fine aggregate as Vermiculite as a replacement of fine aggregate to 75 %. The Cement (Ordinary Portland cement) is partially replaced by Fly Ash up to 50 % and some other mineral admixture are added which are Steel Fibre and Super plasticizer (SP 430) are added.

Dongqi Jiang, et al. (2018), highlights the design concepts, material behavior, analysis approaches and structural systems for floating prestressed concrete structures deployed in shallow waters. Material and design requirements related to prestressed concrete floating structures in particular are reviewed and potential technical challenges are identified. Prestressed concrete floating structures have been used for over a century with notable success in various parts of the world. However, there still exist issues related to the analysis and design, and the service performance of concrete floating structures. Potential design issues and challenges are identified, and design suggestions and recommendations are summarized. The minimum concrete cover for reinforcing and prestressing steel are recommended to be 50 mm and 70 mm in the concrete floating structures subjected to the seawater environment respectively. When concrete with low-permeability and high chloride penetration resistance is used, a reduction in concrete cover may be allowed.

Tanveer Asif Zardi, et al. (2016), says floating concrete is a non structural concrete. GGBS ground granulated blast furnace slag is an environmentally friendly construction material, hence incorporation of GGBS in floating concrete is carried out. The optimum GGBS replacement as cementation material is characterized by high compressive strength, low heat of hydration, resistance to chemical attack, better workability, good durability and cost-effectiveness. The production of GGBS requires little additional energy compared with the energy required for the production of Portland cement. The replacement of Portland cement with GGBS will lead to a significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace as much as 80% of the Portland cement when used in concrete. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced. Here in this study authors tried to bring the density of concrete below water, pumice is light weight aggregate and aluminium powder as air entraining agent has been used. Using different proportions pumice stone and four lightweight concrete mixtures were produced with a satisfied strength. Hence we have analysed that aggregate size and proportion affects the unit weight and compressive strength of concrete. Moreover, the result showed that it is possible to produce a Floating and satisfied strength concrete by using pumice as aggregate. It was also seen that, using light weight aggregate in the concrete mixture can reduce the dead load but decreases the concrete strength.

Tanveer Asif Zardi, et al. (2012), Here in this study floating concrete with lightweight aggregates (Pumice stone) and Aluminum powder as an air entraining agent is prepared. And also sawdust powder also has been used as partial replacement of fine aggregate. It helps to increase volume of concrete and hence reduce the weight There are many types of lightweight concrete which can be produced either by using lightweight aggregate or by using an air entraining agent. Since this is a unique type of concrete hence authors found that very meager quantum of work is carried out in this regard hence authors have taken up this study under consideration, out of motivation. In this study we have worked on combination of above mentioned types. This concrete is a non-structural concrete. In this study, comparison has be made between plain cement concrete and lightweight concrete having different proportion of Aggregate size and fix quantity of Aluminum content (i.e. 2%) by the weight of cement has been taken into account. And also sawdust powder also has been used as partial replacement of fine aggregate. It helps to increase volume of concrete and hence reduce the weight. Different iterations in the form of samples were carried out and results were discussed. From cost analysis it is proved that the cost of our project is less than that of brick masonry. The study showed that using pumice aggregate as a common mixture enable to produce different strength grade lightweight concrete with different unit weight. These concrete does not satisfies the strength requirements for load bearing structural elements.

Yuvraj Chavda, et al. (2015), deals with the study of vermiculite as a replacement of conventional aggregate and its use as a light weight concrete. The tests were conducted as per Bureau of Indian Standards (BIS) specification codes to evaluate the suitability of the vermiculite for structural and non-structural application by partial replacement of up to 25% of cement. The cement-vermiculite samples failed to meet the required strength for structural applications. The strength and other properties met the Bureau of Indian Standards for non-structural materials such as flooring tiles, solid and pavement blocks, and bricks. The experimental results indicate that in general there is an increase in strength with decreasing in cement content and increasing lime content. In the present experimental programs, the maximum percentage lime content was 60% of the total binders. This indicates that the vermiculite is more suitable for lime as a binder as compare to that of cement.

Mohammad Hasan Ramesh, et al. (2013), presents A Case Study on Corrosion in Concrete Floating Docks in Qeshm Port. Floating concrete docks, due to their unique features compared to their other kinds, opened their way to the Persian Gulf and has been welcomed. The advantages of these structures compared to their similar types, could be the usage of concrete in their original structures. Concrete is known as a material resistant to the invasive marine conditions which does not include the restrictions of steel structures, such as rapid and extensive corrosion, the need for care and maintenance, early repairs and periodic visits. Design principles were observed accurately in the construction of floating concrete docks. Also known effective methods to increase durability and reduce the permeability of concrete were used in the marine environment.

Campos A, et.al(2016), The irruption of the floating wind energy in the offshore engineering is changing the paradigm of the structural analysis for those new structures, which are significantly smaller and more slender than those previously existing from the O&G industry and in which the most important load is applied around 100m above the mean sea level. Those characteristics require the structural analysis to include the dynamic effects over the deformation of the structure, integrating the instantaneous deformation of the structure into the nonlinear dynamic finite element analysis (FEA) computation. The model computes a dynamic time domain nonlinear FEA for FOWT's, integrating all the effects of the external forces and the structural stiffness to obtain the displacements at each point of the structure at each time step. With this approach, the dynamic interaction between the wind turbine and the structure, as well as the effects on the internal forces are implicitly considered in the formulation. A comparison of the structure motions and internal forces for a concrete spar concept is presented assuming a nonlinear rigid body approach and a nonlinear dynamic time-domain FEA.

3. CONCLUSION

Polystyrene is chemically very inert, being resistant to acids and bases but is easily dissolved by many chlorinated solvents, and many aromatic hydrocarbon solvents. The Expanded Polystyrene is a stable, low density Foam. It has closed structure and cannot absorb water. It has good impact resistance. Polystyrene is packaging material in medical industry and a non-biodegradable material, so it creates disposal problems. Utilizing crushed polystyrene in concrete is good waste disposal method. The polystyrene beads can be easily merged into mortar or concrete to produce lightweight concrete with a wide range of density. An application of polystyrene concrete includes walls, cladding panels, tilt up panels and composite flooring .From the literature survey, it is understood that there is scope for future studies in this field.

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