STUDY ON STRUCTURAL BEHAVIOUR OF REINFORCED CONCRETE BEAMS WITH PARTIAL REPLACEMENT OF COARSE AGGREGATE BY EXPANDED PERLITE

N.Sarathkumar M.Tech structural
Srm university-chennai
Saratkumar07@gmail.com

Abstract – This paper explains the comparative studies on partial replacement of expanded perlite as coarse aggregate. Perlite is basically the mineral obsidian. It is naturally occurring siliceous volcanic rock. Utilization of natural resources of environment is essence of any development in concrete. Perlite gives excellent insulating properties at temperature varying from very low and very high. Using expanded perlite aggregate in concrete the total amount of cement content 70% and fly ash 30% replacement of cement. The combination reducing the effect of thermal conductivity in light weight concrete. In light weight concrete addition of perlite is reduced the density of concrete. The flexural and compressive response of concrete to be determined and 0% to 30% replacement of fine aggregate using expanded perlite. Optimum percentage of partial replacement of aggregates were obtained by conducting various strength tests such as compression and flexural strength on the casted specimens such as cubes, cylinders, prisms and beams.

1. Introduction

There is a variety of concretes is also being used, some tailored for their intended use and many with improved properties. Perlite is an amorphous volcanic glass and having high amount of water content. The perlite occurs naturally and has the property of greatly expanding when heated. Besides the compressive strength, these indices indicate the perlite powder has a high pozzolanic effect and is an active mineral admixture for concrete. The expanded perlite is used as the partial replacement of coarse aggregate. The various percentages of expanded perlite were partially replaced with coarse aggregates and the optimum percentage of replacement is determined

The objectives of this paper are as follows:

- Reduce the thermal conductivity of concrete and the addition of perlite is reduce density of concrete
- Study the mechanical properties of concrete and partial replacement coarse aggregate by using expanded perlite.
- Determine the optimum percentage of partial replacement of expanded perlite in coarse aggregate.

2. Literature Review

Bindiganavile et.al 2010 Investigates on effect of density in cementitious mortar on its mechanical properties Reduction in density is achieved through addition of expanded Perlite. Volume ratio maintained between 0 – 8.This yielded a range of densities between 1000 and 2000 kg/m^3. The mechanical properties of plain lightweight mortars containing expanded perlite aggregate scale with the density of the mix. This was expressed in terms of density of the composite relative to that of cement paste. While the compressive strength and elastic

modulus vary with cube of the relative density, the fracture toughness was linearly proportional to this parameter [1].Demirboga et.al 2002 Thermal conductivity coefficients of concretes made up of mixtures of expanded perlite and pumice aggregates were measured and compared with cement replaced partially with silica fumes or fly ash. Thermal conductivity is found to be as low as 0.1472W/mK. In expanded perlite aggregate and 70% cement and 30% fly ash combination. The thermal conductivity and dry unit weight of LWAC decreased the maximum reduction SF and FA content .SF(10%,20% and 30%replacement by weight of PC),FA(10%,20% and 30%replacement by weight of PC), and EPA (20%,40%,60%,80% and 100%replacement by weight of PA),were effective core decreasing the thermal conductivity of LWAC up to 43.5%, mainly due to the relatively low conductivity of admixtures and EPA and the consequent low density of the LWAC[2]. Lee et.al 2002 The pozzolanic effect of perlite powder added to the concrete can be determined quantitatively with strength indices: the specific strength ratio(R), index of specific strength(K), and contribution percentage of pozzolanic effect to strength(P).Besides compressive strength, these indices mention that perlite powder has a high pozzolanic effect and is an active mineral admixture for concrete. The pozzolanic effect of the mineral admixture perlite in concrete was quantitatively discussed through specific strength indices like specific strength ratio(R), index of specific strength(K), and contribution the percentage of pozzolanic effect to strength(P). The compressive strength of concrete containing other active mineral admixture like natural zeolite power, condensed silica fume, fly ash ,blast-furnace slag ,rice husk ash, and volcanic rick can be described through these indices [3].Khonsari et. al 2011 Investigation on effects of using Expanded Perlite(CP) as an aggregate in light weight concrete (LWC).Compressive strength and Splitting tensile strength after 7 and 28 days in 2 different curing conditions, water sorptivity and sulfate attack are determined. Expanded perlite aggregate was used by various percentage(of weight), 10%, 20%, 30% and 40% to replace fine aggregates. The compressive and tensile strengths of Perlite concrete decreases with increase of perlite content. The perlite concrete specimens are subjected to ‘wet sack’ curing condition increased their compressive strength. Vijayashankar et.al 2011 High rice building, the density of concrete causes major problem in increasing the dead weight of the structures. In the experimental program, mixtures were prepared by fully replacing the expanded perlite and as a result, the unit weight of fresh state mortar varied between 900 and 1169kg/m^3 for ratios 1:3,1:2,1:1,2:1 and 3:1. The water absorption has been increasing with increasing in addition of expanded perlite to mortar. The compressive strength obtained were 49% less than the conventional mortar of 1:3.The optimum amount can be obtained was 29.32N/mm^2 with the density less than water for the mix ratio 1:2[5].Mahmood et. al 2013 The properties of perlite was calcium carbonate (CaCO3), the wear of carbon fabric reinforced epoxy composites under dry sliding conditions has been investigated. The effect of variants in volume fraction, applied load, time and sliding distance of the wear behaviour of polymer composites is studied by measuring the weight changes. Physical and mechanical properties of perlite particles. Granite filler added to carbon-epoxy composite show better wear resistance than perlite and CaCO3 particles. The highest wear resistance is that of the composite with 15% carbon fiber +5% granite particles, which is 83.4 % higher than that of the matrix material[6].Wenming et. al 2012 The mechanical properties of the perlite air-entrained concrete (PAC) material were discussed using DIC method. The project results show that the elastic modulus and Poisson’s ratio could be exactly measured by DIC method. The fields show the non-uniformity characteristics of deformation and the failure modes caused by the sandwich layered material[7].Erdem et .al 2007 This study focuses on the use of natural perlites in blended cement production. Sixteen types of blended

cements having 320m^2/kg or 370m^2/kg Blaine finesse were produced by using 20% or 30% of perlite additions. Production of the blended cements were accomplished either by intergrinding or separate grinding. The results showed that the perlites possess sufficient pozzolanic characteristics to be used in production of blended cements. The use of perlites in blended cements will be beneficial since the improvements in the grinding efficiency and the availability of them will help reduce the PC consumption[8].

3. Methodology

This experimental methodology was followed in this paper. First the materials were collected and the preliminary tests are conducted on materials. The preliminary tests concrete mix was designed and particular grade of the concrete and the specimens were casted, tested and the results were discussed. The methodology for this study was as shown in Figure 1.

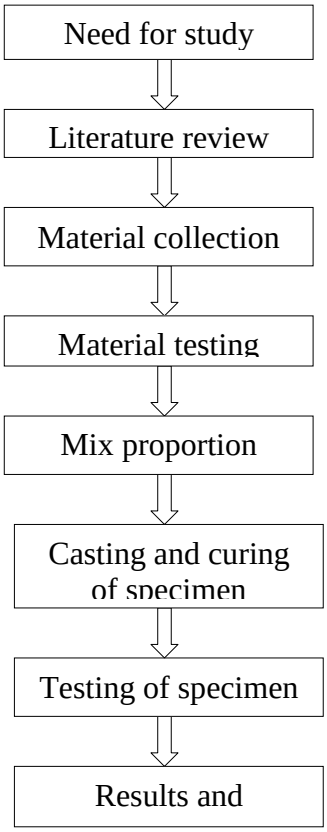

Fig 1 experimental methodology

4. EXPERIMENTAL PROGRAME

(A) Materials used in this project:

Cement: Ordinary Portland cement of grade 53 was used.

Fine aggregate: River sand was free from impurities and size less than 2.6mm was used. The specific gravity and the fineness modulus was 2.71 and 4.13.

Coarse aggregate: The aggregate size of 20mm were used, the expanded angular shaped aggregates are used and free from dust. The fineness modulus and the specific gravity is 2.67 and 7.14. The impact value is 6.15%.

Perlite: Perlite is basically the mineral obsidian. It is naturally occurring siliceous volcanic rock. The specific gravity of the perlite was 2.24.

The physical and the chemical properties of the expanded perlite were discussed in Table1 and Table2 respectively.

Table 1 physical properties of perlite

Color	White
Refractive Index	1.5
Free Moisture, Maximum	0.5%
pH (of water slurry)	6.5 - 8.0
Specific Gravity	2.2 - 2.4
Bulk Density (Raw)	Around 1100 kg/m^3
Mesh Size Available	As desired, 4-8 mesh and finer
Softening Point	1600-2000°F (871-1093°C)
Fusion Point	2300-2450°F (1260-1343°C)
Specific Heat	0.2 Btu/lb·°F (387 J/kg·K)
Thermal Conductivity at 75°F (24°C)	.27-.41 Btu·in/h·ft^2·°F(.04-.06 W/m·K)

Table 2 chemical properties of perlite

Silicon Dioxide(SiO_2)	70–75%
Aluminium Oxide: Al_2O_3	12–15%
Sodium Oxide: Na_2O	3–4%
Potassium Oxide: K_2O	3–5%
Iron Oxide: Fe_2O_3	0.5-2%
Magnesium Oxide: MgO	0.2–0.7%
Calcium Oxide: CaO	0.5–1.5%

(B) Mix design

M_{20} grade of concrete and the water cement ratio of 0.45. The concrete mix proportion was designed as per IS 10262 – 2009 and IS 456 – 2000. The mix ratio of M_{20} is 1:1.55:2.91.

(C) Casting and curing:

Totally six sets of specimens were casted. One set of specimen consists conventional concrete and three sets of specimens partially replaced with expanded perlite as fine aggregate in percentage of 10%,20% and 30% respectively. And two sets of reinforced concrete beams with replacement percentage of 10%, 20% and 30% respectively. Each set consists of three cubes and three cylinders. After casting of specimens were curing done for 7 days and the respective tests will be conducted on the specimens. The dimension of the cube was (150x150x150) mm^3 and the dimension of the cylinder is (300x150dia) mm^2.

The total casting and the quantity of materials details are shown in Table3.

Content	0%	10%	20%	30%
Cubes	3	3	3	3
Cylinders	3	3	3	3
Beams	2	2	2	2
Cement in kg	33.6	33.6	33.6	33.6
Fine aggregate in kg	47.43	42.68	37.94	33.29
Coarse aggregate in kg	89.31	89.31	89.31	89.31
Expanded perlite in kg	–	4.7	9.48	14.15
Slump value	97	93	98	89

5. Results and discussion:

The flexural strength test were conducted on reinforced concrete beams after 7 days and 28 days of curing .The flexural strength values are discussed in Table4 and Table 5.

Table 4 Flexural strength of reinforced concrete after 7 days of curing

S. No	Sample details	Ultimate load in kN	Deflection in mm
1	Sample 1(0% 0f perlite)	46.20	2.56
2	Sample 2(10% 0f perlite)	46.70	2.87
3	Sample 3(20% 0f perlite)	47.40	2.32
4	Sample 4(30% 0f perlite)	45.80	3.85

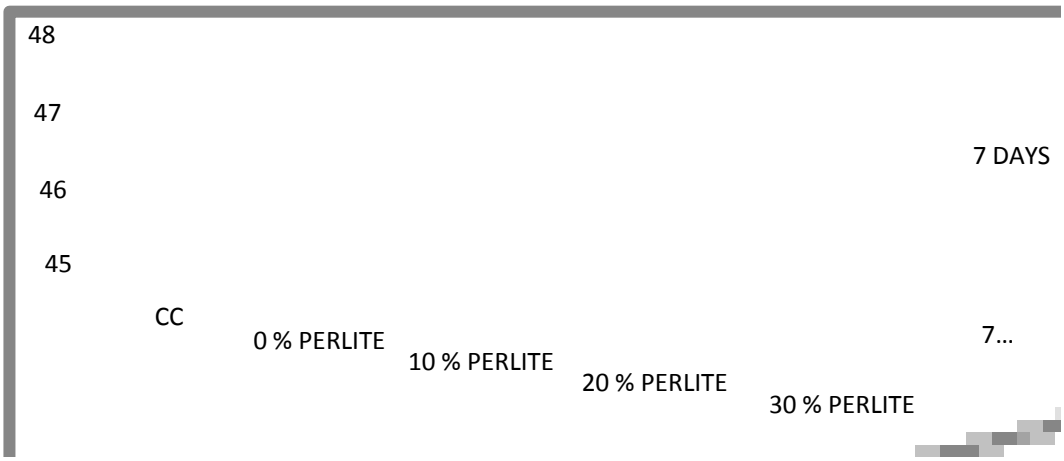

Fig 2 graph shown flexural test on beam for 7 days

Table 5 Flexural strength of reinforced concrete after 28 days of curing

S. No	Sample details	Ultimate load in kN	Deflection in mm
1	Sample 1(0% 0f perlite)	67.60	1.10
2	Sample 2(10% 0f perlite)	68	1.20
3	Sample 3(20% 0f perlite)	68.20	1.09
4	Sample 4(30% 0f perlite)	67.10	1.75

Summary and conclusion

The following conclusions are based on results.

- The maximum flexural strength for partial replacement of fine aggregate with expanded perlite be achieved by 20% is found to be 3.86% greater than the conventional concrete.
- And the minimum deflection for partial replacement of coarse aggregate by expanded perlite be achieved by 20% of replacement.
- Therefore 20% replacement of expanded perlite as coarse aggregate achieves good strength.

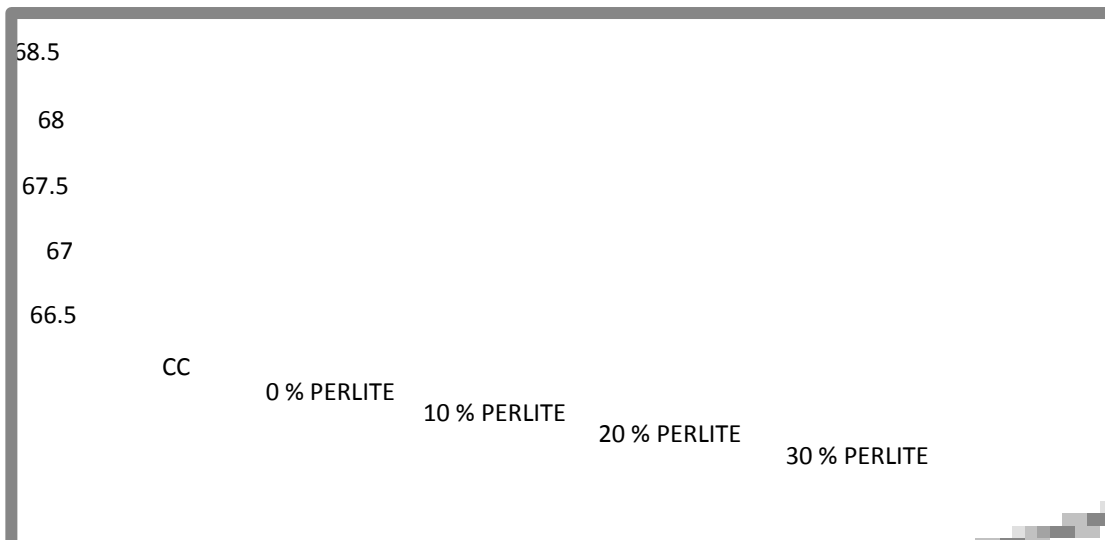

Fig 3 graph shown flexural test on beam for 28 days

References

[1] kramar, D.,"Mechanical properties and size effects in light weight mortars containing expanded perlite aggregate" materials and structures ,2011.

[2] Demirboga, R.,"the effects of expanded perlite aggregate, silica fume and fly ash on the thermal conductivity of the light weight concrete" cement and concrete research ,2003.

[3] Azizi, S.,"Effect of expanded perlite on the mechanical properties and thermal conductivity of lightweight concrete", Energy and Buildings , pp.671–676,2011.

[4] Vijayashankar., "Experimental study of light weight mortar with Expanded perlite as fine aggregate",concrete and research .2015.

[5] Mahmood, "Effects on different types of fillers on dry wear characteristics of carbon-epoxy composite", al-khwarizmi engineering journal, Vol. 9, No. 2, P.P. 85 -93 ,2013.

[6] Wenming, W"experimental study on mechanical behavior of perlite air-entrained concrete by using DIC method", International conference on mechanical engineering and material science (mems 2012).

[7] Khonsari, "Effects of expanded perlite aggregate(epa) on the mechanical behavior of light weight concrete", materials and structures ,2011.