Effect of EPS Beads & Air Entraining Agents on Concrete

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Abstract: Areated concrete can be produced by introducing air entraining agent, gas forming chemicals and foaming agents. Soft ground arresting system (SGAS) consists of cellular aerated concrete blocks arranged in the form of arresting bed having 15 meter width and 30 meter long. SGAS can be used in case of emergency landing of aircraft on all runways and also can be used on runways which do not have required space for emergency landing due to high costs and space limitation. The objective of this paper is to present the required and measured properties of aerated concrete and whether it can be implemented as an SGAS. Tests like compressive strength, transient high temperature test and plate load test were conducted whether it has ability to withstand support vehicle loadings, while failing underneath loading from an overrunning aircraft. In this Trail Mix design has been developed for concrete with varying dosage of 0.5%, 0.1%, 1.5% in case of synthetic based air entraining agent and 2%, 3%, 4% in case of protein based air entraining agent. The dosage is taken by weight of cement respectively. Expanded poly sterene (EPS) beads less than or equal to 2mm are used in case of coarse aggregate in-order to reduce the density of concrete. The density of concrete was kept below 1600 kg/m³. As per the results obtained it was observed that the density and strength of concrete reduces with increase in percentage of air entraining agent. On the basis of results obtained the synthetic based air entraining agent gave good results by using less percentage of air entraining agent by increasing the strength up to permissible dosage and decreasing the density of concrete. The areated concrete when heated at 105°C, leads to increase in the strength of concrete due to rate of hydration. The same Concrete when heated at temperature 170 °C showed decrease in strength of concrete. Plate load test also indicates that Synthetic based air entraining agent is more optimum in comparison of protein based air entraining agent.

Keywords: Areated concrete, Compressive Strength, Plate load test, Transient high temperature test, SGAS.

I. INTRODUCTION

Conventional Concrete is made with natural aggregate originating from hard rock and has high density in the range between 2200 to 2600 kg/m³ and represents a large proportion of dead load in a structure. Light weight concrete can be classified as gaseous or foamed concrete that uses specially prepared chemicals; it can be a no fines concrete with ordinary gravel or crushed stone used, a normal – weight aggregate concrete with excessive amount of entrained air, or a concrete which is made from lightweight aggregates. Light weight areated concrete is characterized by its low compressive strength and high insulation against heat and sound. Light weight aerated concrete offer many benefits and advantages like saving cost, fast completion, and easy application coMPared to other materials such as timber and steel. Application of light weight aerated concrete in civil engineering works is very broad as it can be used in almost every parts of building right from superstructure right down to the substructure including wall panels and roofing. SGAS consists of cellular aerated concrete blocks arranged in the form of arresting bed having 15 meter width and 30 meter long. When an aircraft enters SGAS grade transition occurs from the paved ramp into a cellular aerated concrete arresting bed. Due to the weight of aircraft it may lead to crushing of blocks and creation of a resistive load or drag force that quickly decelerates and ultimately stops the aircraft.

II. Literature survey:

The compressive strength and other functional properties of lightweight areated concrete are greatly influenced by the amount of air content introduced by foaming agents. It is worth noting that the use of lightweight concrete is popular in other countries such Europe, Japan and United Kingdom, United States of America.

Wynand Jvdm Styen et.al (2016) carried out experimental investigation on concrete to present the outcome of an investigation into selected properties of foamed concrete and the possibility of it being implemented as an soft ground arresting system. In this compressive test, stiffness test, density test, plate load test has been done. In this 4 mixes of concrete cubes of densities 600, 800, 1000, 1200 kg/m³ are casted for 7, 28 days each.

Wail N. Al – Rifale et.al (2014) carried out an investigation to develop an ultra-light weight low strength concrete mix that is reliable and economical and can be used as soft ground arresting material. In this 5 mixes of concrete cubes are casted for 7, 28 days. In this density test, compressive test has been done. First mix contains a foaming agent 1% of cement weight, second mix contains foaming agent 2% of cement weight, the third mix contains foaming agent 3% of cement weight, fourth mix contains foaming agent 4% of cement weight, fifth mix contains foaming agent 5% of cement weight.

Ravi Shankar S et.al (2015) carried out test on foamed concrete to study the effect of quarry dust in terms of compressive test by using protein and synthetic based foaming agent. In this compressive test, density test has been done. In this 3 mixes of concrete cubes for densities 800, 1000, 1400 kg/cubic meter are casted for 7, 14, 28 days.

Xianjun Tan et. al (2014) they studied the influence of different mixing amounts of fly ash, fly ash activator, w/c ratio, foaming agent on strength of foamed concrete. In this compressive test, density test has been done. In this 5 mixes of concrete cubes are casted for 28 days.

Funso Falde (2013) carried out experiment onstructural properties of foamed aerated concrete with and without pulverized bone. In this compressive test, flexural test, split tensile test, plastic density test has been done. In this 5 mixes of concrete cubes of 1600 kg/m³ are casted for 28, 60, 90 days. First mix is of conventional foam concrete, second mix is of 5% of cement replaced by pulverized bone, third mix is of 10% of cement replaced by pulverized bone, fourth mix is of 15% of cement replaced by pulverized bone, fifth mix is of 20% of cement replaced by pulverized bone.

A. A. Hilal et.al (2014) carried out experimental investigation to enhance foamed concrete by utilizing 2 types of additives silica fumes and fly ash together with water reducer agent and mechanical foaming agent. In this compressive test, flexural test, split tensile test, thermal conductivity test, water absorption test, density test has been done. In this 5 mixes of concrete cubes of 1300, 1600, 1900 kg/m³ are casted for 28 days. First mix is of conventional foamed concrete, second mix is of 10% of cement replaced by silica fumes with 1.5 % of super plasticizer, third mix is of 10% of sand replaced by fly ash, fourth mix is of 10% of sand replaced by fly ash with 1.5% of super plasticizer and fifth mix is of 10% of sand replaced by fly ash and 10% of cement replaced by silica fumes with 1.5% of super plasticizer

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Md Azree Othuman et.al (2011) carried out experimental investigation on thermal properties of foamed concrete at elevated temperature. In this compressive test, thermal conductivity test, water absorption test, density test has been done. In this concrete cubes of 650, 1000, 1850 kg/m³ are casted for 28 days and then are heated at 20, 60, 90, 105, 150, 170, 180, 200, 220 degree Celsius.

Alonge O. Richard et.al (2013) carried out experimental investigation to produce sustainable foamed concrete by replacing cement by fly ash. In this compressive test, dry shrinkage test, split tensile test, water absorption test, density test has been done. In this 4 mixes of concrete cubes of 1600 kg/m³ density are casted for 7, 14, 28 days. First mix is of conventional foamed concrete with 10% of cement replaced by fly ash, second mix is of 20% of cement replaced by fly ash, third mix is of 30% of cement replaced by fly ash, fourth mix is of 50% of cement replaced by fly ash.

Giridhar. V et.al (2013) they studied the effect of air entraining agents on concrete in varying proportion of 0.5%, 1% and 1.5 % of cement weight in M20 grade of concrete. In this compressive, split tensile test, workability test has been done. In this 3 different air entraining agents used are olive oil, oleic acid and hydrogen peroxide. Cubes are casted for 28 days for each air entraining agent in 0.5%, 1% and 1.5 %.

Sonia Math et.al (2015) they studied the effect of air entraining agents on concrete in varying proportion of 0.1%, 0.2%, 0.3%, 0.5% of cement weight in M35 and M40 grade of concrete. In this compressive, workability test has been done. In this 2 different air entraining agents used are Fosroc, Basf. Cubes are casted for 7 & 28 days for each air entraining agent in 0.1%, 0.2%, 0.3%, and 0.5% for M35 and M40.

Indu Susan Raj et.al (2014) they studied the effect of aluminum powder as air entraining agent on concrete in varying proportion of 0.1%, 0.2%, 0.5%, 1%, 2%, 5% of cement weight in concrete. In this compressive, workability test has been done. Cubes are casted for 3, 7 & 28 days.

Akinkurolere Olufunke Olanike et.al (2013) they studied the effect of air entraining agents on concrete in varying proportion of 2.5%, 3.5%, 4.5% of cement weight is added in concrete. In this three water cement ratio of 0.45, 0.50 and 0.55 is considered. For each water cement ratio coarse aggregate was substituted with 0%, 50%, 100% by recycled aggregate and cement was substituted with 0%, 20%, 30% by fly ash and 2.5%, 3.5%, 4.5% weight of cement was added. In this compressive, workability, flexural test has been done. Cubes are casted for 7 & 28 days.

B. A. Herki et al. (2013) carried out experimental investigation to study the effects of eps beads and fly ash in concrete. In this 9 mixes are prepared for 28 days in which first three mixes contains 0 % replacement of cement by fly ash and eps beads replaced by 0%, 60%, 100% with fine aggregate respectively , in second three mixes 20 % replacement of cement by fly ash and eps beads replaced by 0%, 60%, 100% with fine aggregate respectively, in third three mixes 40 % replacement of cement by fly ash and eps beads replaced by 0%, 60%, 100% with fine aggregate respectively. In this compressive, workability, density test is done.

Abhijit Mandlik et al. (2013) carried out experimental investigation of eps beads on compressive strength, tensile strength and workability of concrete. In this 6 mixes were prepared for 28 days in which first three mixes cement content of 540 kg/m^3 was taken and cement was replaced by 10, 20, 30 % by eps beads and in second three mixes cement content of 410 kg/m^3 was taken and cement was replaced by 10, 20, 30 % by eps beads.

Suhad Mabd et al. (2016) carried out experimental investigation with effective replacement of fine aggregate by eps beads in concrete. In this 3 mixes were prepared for 7, 28 days. In first mix 5% of fine aggregate was replaced by eps beads, in second mix 15% of fine aggregate was replaced by eps beads, in third mix 20% of fine aggregate was replaced by eps beads. In this compressive and workability test is done.

Hind M. Ewadh et al. (2012) carried out experimental investigation on concrete to determine maximum usage of eps beads. In this 4 mixes were prepared for 28 days. In first mix 25% of fine aggregate was replaced by eps beads, in second mix 50% of fine aggregate was replaced by eps beads, in third mix 75% of fine aggregate was replaced by eps beads, in fourth mix 100% of fine aggregate was replaced by eps beads. In this workability, water absorption test is done.

A. Setiawan et al. (2013) carried out experimental investigation on the properties of concrete by replacing fine aggregate by eps beads. In this 8 mixes were prepared for 7, 14, 28 days. In first mix 5% of fine aggregate was replaced by eps beads, in second mix 10% of fine aggregate was replaced by eps beads, in third mix 15% of fine aggregate was replaced by eps beads, in fourth mix 20% of fine aggregate was replaced by eps beads, in fifth mix 25% of fine aggregate was replaced by eps beads, in sixth mix 30% of fine aggregate was replaced by eps beads, in seventh mix 35% of fine aggregate was replaced by eps beads, in eighth mix 40% of fine aggregate was replaced by eps beads. In this compressive, ultrasonic pulse velocity, water absorption test is done.

III. Materials:

Cement

Cement acts as a binder to join the aggregate into a solid mass. It is one of the most important constituent of concrete. Pozzolanic Portland cement of 53 grade is used in concrete.

Crushed sand

When boulders are broken into small pieces crushed sand is formed. It is grey in color and it is like fine aggregate.

Physical properties

The physical properties of crushed sand is listed in the table below

Table 1

Property	Crushed sand
Specific gravity	2.62
Bulk density (kg/m3)	1726
Absorption (%)	1.5
Moisture content (%)	Nil

Expanded Poly sterene (Eps beads)

The EPS or expanded polystyrene is a rigid cellular plastic material. It is used in packaging solutions since 1958. It is 98% air but the rest is made from tiny, spherical EPS beads - themselves made only of carbon and hydrogen.

Admixture

Two types of air entraining admixture are used

1. Synthetic based air entraining admixture= Chemsonite Airex.
2. Protein based based air entraining admixture = Ataous.

Physical properties

The physical properties of Chemsonite Airex and Ataous air entraining admixture is listed in the table below

Table 2

Property	Chemsonite Airex	Ataous
Specific gravity	1.05	1.1
Chloride content	_	<0.10
Color	Brown	Light yellow transparent liquid
PH	7.5	8.5

Water

Water is an important ingredient of concrete and it initiates chemical reaction with cement. Ordinary potable water is used.

IV. METHODOLOGY

Test on materials:

Compressive Test

Compression test is the most common test conducted on hardened concrete. The different mix of concrete gives various strength, according to the IS-10262: 2009 gives the characteristic and design strength values for various grades of concrete. The strength attained by the mix, must be tested by compressive strength of the samples which are made in the standard mould of size 150mm X 150mm X 150mm and then, the cubes are kept for curing and compressive strength was done for 7, 28, 56 days. When curing time is completed, the cubes are tested for compressive test in the compressive testing machine shown in Figure 1.

Figure 1

Transient High Temperature Test

The basic transient high temperature test consists principally of a hot plate and a cold plate. In this test, the specimen is placed on a flat plate heater assembly consisting of an electrically heated inner plate (main heater) surrounded by a guard heater. The guard heater is carefully controlled to maintain the same temperature on both sides of the gap separating the main and the guard heaters. This prevents lateral heat flow from the main heater and ensures that heat from the electric heater flows in the direction of the specimen. On the opposite side of the specimen are additional flat plate heaters (cold plate) that are controlled at a fixed temperature selected by the operator. For a given heat input to the main heater, the hot plate assembly rises in temperature until the system reaches equilibrium. In this cubes are being heated at 105, 170 degree Celsius . The figure2 below in which cubes are heated .

Figure 2

Figure 3

Plate Load Test

Concrete was cast into shutter boxes of 260 × 320 ×150 mm and plate tests were carried out on the concrete samples after 7, 28 days of curing, using plate size of 150 mm diameter as shown in Figure 3. The load-versus-displacement relationship for plate was converted to stress versus displacement.

V. RESULT

COMPRESSIVE TEST

The compressive test results for 7, 28, 56 days are in MPa and are shown in table 3 Ataous for and table 4 for Chemsonite Airex. The strength of concrete for both the air entraining agents is shown figure 4 for Ataous and figure 5 for Chemsonite Airex.

Table 3

Mix	Dosage	7 days	28 days	56 days
1	0.5 %	2	4.6	6.7
2	1 %	1.6	2.9	3.7
3	1.5 %	1.4	1.8	3.3

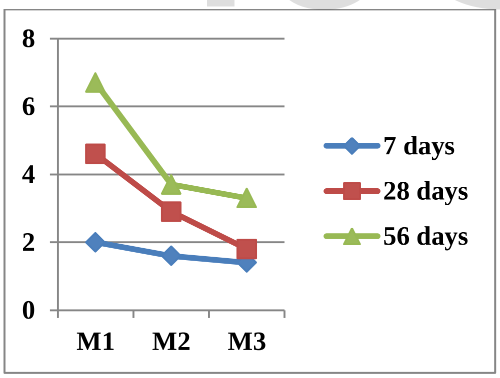

Figure 3

Table 4

Mix	Dosage	7 days	28 days	56 days
1	2 %	6.4	8.3	9
2	3 %	5.7	7.8	7.9
3	4 %	5.1	7	7.5

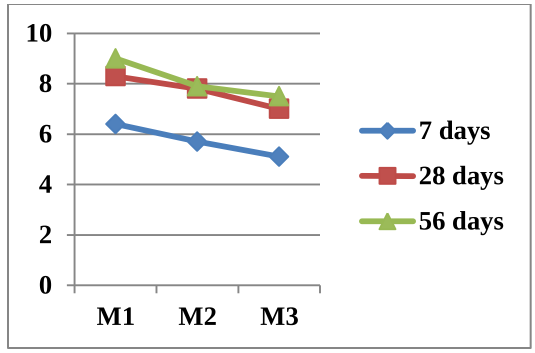

Figure 4

TRANSIENT HIGH TEMPERATURE

The transient high temperature results for 28 days is shown in figure 5 for synthetic air entraining agent and table 6 for protein based air entraining agent and for 56 days for both air entraining agents it is shown in figure 7. One set of cubes with synthetic air entraining agent were heated at 105° Celsius and second set with synthetic air entraining were heated at 170° Celsius after 28 days of curing as shown in figure 5. One set of cubes with protein based air entraining agent were heated at 105° Celsius and second set with protein based air entraining agent were heated at 170° Celsius after 28 days of curing as shown in figure 6 The cubes after 56 days curing were heated at 105° Celsius for both air entraining agents the compressive strength values are shown in figure 7.

Table 5

Mix	105° Celsius	170° Celsius
1	6	4.2
2	2.4	2.2
3	2.1	1.7

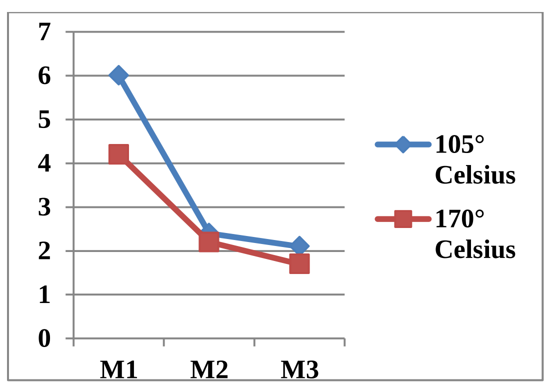

Figure 5

Table 6

Mix	105° Celsius	170° Celsius
1	8.4	7.4
2	7.7	6.4
3	6.4	5.5

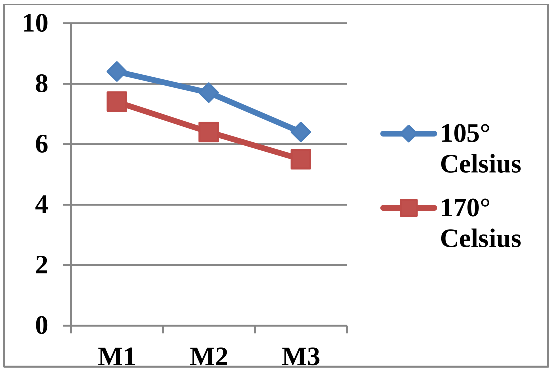

Figure 6

Table 7

Mix	Chemsonite Airex	Ataous
1	7.1	9.4
2	2.8	8.3
3	2.6	6.8

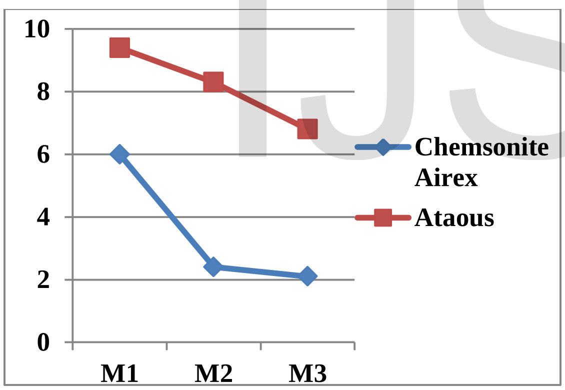

Figure 7

PLATE LOAD TEST

The results for 7 and 28 days are shown in figure 8 for both air entraining agent. In figure M1 and M2 indicates mix for protein based air entraining agent and M3 and M4 indicates for synthetic air entraining agent.

Table 6

Mix	7 days		28 days	
	Deformation	Load(KN)	Deformation	Load(KN)
1	6	79	4.2	100.1
2	2.4	58	2.2	78
3	2.3	85	2	116.5
4	2.1	65	1.95	77

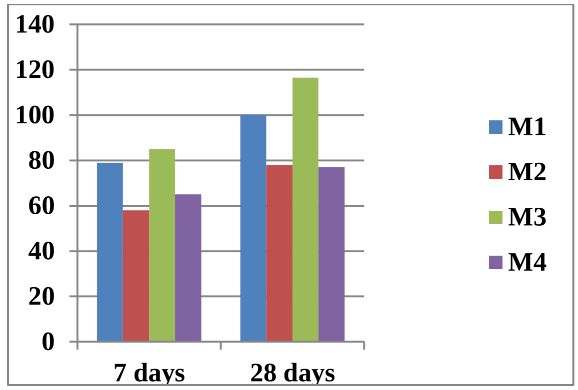

Figure 6

CONCLUSION

The Density and Strength of concrete reduces with increase in percentage of air entraining agent. On the basis of results obtained the synthetic based air entraining agent gave good results by using less percentage of air entraining agent and the strength decreases after 0.5 % of usage of synthetic air entraining agent.

On the basis of results obtained the synthetic based air entraining agent gave good results by using less percentage of air entraining agent and the strength and density decreases after 0.5 % of usage of synthetic air entraining agent. On the basis of results obtained the protein based based air entraining agent gave results by using more percentage of air entraining agent and the strength and density decreases after 2 % of usage of Protein based air entraining agent. The maximum compressive strength obtained for concrete for 28 days is 8.3 MPa when 0.5 % of synthetic air entraining agent is used and 4.6 MPa when 2% of protein based air entraining agent is used.

The concrete cubes when heated at 105°C, after 28 days of curing leads to increase in the strength of concrete due to rate of hydration. The maximum Compressive strength is 9 MPa when 0.5 % of synthetic air entraining agent is used and 6.7 MPa when 2% of protein based air entraining agent is used.

The concrete cubes when heated at 170°C, after 28 days of curing leads to decrease in the strength of concrete due to excessive rate of hydration. The maximum Compressive strength is 7.4 MPa when 0.5 % of synthetic air entraining agent is used and 4.2 MPa when 2% of protein based air entraining agent is used.

Plate load test also indicates that Synthetic based air entraining agent is more optimum in comparison with protein based air entraining agent as synthetic based air entraining agent requires little more load as compared to protein based air entraining agent. The deformation for synthetic air entraining agent is more than that of protein based air entraining agent.

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