# Comparative analysis on aac, clc and flyash concrete blocks

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***Abstract:*** **The main objective of this paper is to comparing the different types of light weight concrete according to their physical properties. Light weight concrete are widely used in all over the world, these types of concrete having densities ranges 450-1800 kg/m3 and are more sustainable than burnt brick clay or ordinary types of concrete. In this paper a deep discussion are carried out between the properties of AAC, CLC and fly ash. AAC(Autoclaved aerated concrete ) is a light weight concrete material that was developed in many years ago, the main constituents used in making of this type of concrete is cement grade53 , gypsum, class C lime (hydrated lime), aluminum powder(.05-.25% by wt of cement) , fine aggregate or fly ash (class F) combining with definite proportions. CLC (Cellular light weight concrete) is another light weight concrete material which are widely used in making infrastructure and high rise building, the main ingredients of making CLC is cement(OPC grade 53), Fly ash (class F),sand (passing 2mm sieve) , foaming agent(either protein based or synthetic based). Fly ash is also taken in this paper as a light weight concrete because it replaces partially fine aggregate and fully coarse aggregate the raw materials of this type of concrete is cement (grade53/grade43), Fly ash (class F),sand (passing 2mm sieve). On keeping density as a constant parameter their load carrying capacity in compression, thermal insulation and water absorption are to be tabulated and then conclusions are made by their best performance.**

**Keyword: light weight concrete, foam concrete, autoclaved aerated concrete, fly ash concrete, comparative study, case study, compressive strength, thermal insulation**

## I. Introduction

Light weight concrete plays an extreme importance in the field of construction projects. Today most of the researches focus on the high performance concrete and very eco-friendly with the environment. A cost-effective material is also an important factor without scarifying their quality. It is lighter than the conventional concrete. The main specialty of this concrete is it's having LWC can significantly reduce the dead load of structural elements, which makes it especially attractive in multi-storey buildings. Yet, most studies on LWC concern semi-lightweight concrete, i.e. concrete made with lightweight coarse aggregate and natural sand. Although commercially available lightweight fine aggregate has been used in investigation in place of natural sand to manufacturer the "total light weight concrete"(S. Chandra and Berntsson 2002,Berre,M. and Ferrara G 1990), more environmental and economic benefits can be achieved if waste materials can be used to replace the fine light weight aggregate. The use of natural aggregate can be reduce in the making of light weight concrete , there will lot of consumption of non renewable sources in the form of natural aggregate can be saved. the LWC is not made to bearing the heavy loads of infrastructure because of its light weight it has comparatively low bearing capacity, now a day's columns, beams and slab are made to take care of the all types of load including earthquake and wind load. The main purpose of light weight concrete block is to act like wall and support the structure of building.

## II. Types of LWC

**2.1. Autoclaved aerated concrete: -** It is a LWC which is made up of cement, sand, lime, gypsum, water and small quantity Al powder. It's also known as aircrete because it entrains air into it. It contains nearly about 50-60% of air voids. It is a porous material and containing uniform air pockets which make it light in weight therefore it is termed as aerated concrete. In the manufacturing of AAC, the raw materials are thoroughly mixed with water in definite proportion as per the required density and after that expansion agent like Al powder is added to the mixture so that volume is increased about 2-5 times of its original volume. This Al powder reacts with calcium hydroxide which is the product of cement-water reaction. The reaction between Al powder and calcium hydroxide generates uniform micro air bubbles which results in increasing concrete volume.

$$\text{Cement + water} \rightarrow \text{C-S-H gel} + 3Ca(OH)_2$$

$$2Al + 3Ca(OH)_2 + 6H_2O \rightarrow 3\,CaO.Al_2O_3 + 3H_2$$

Aluminum powder + Calcium hydroxide → Tricalcium hydrated + Hydrogen

The target density of AAC achieving ranges between 451-1000 kg/m$^3$ and codal provision IS 2185.3.1984

**Fig.1 AAC block**

**2.2. Cellular lightweight concrete: -** Foam concrete is a mixture of cement, fly ash, sand, water and foaming agent. When the foaming agent is diluted with water and air, further it is mixed into the cement slurry. The water-cement slurry sets around the foam bubbles and this paste have sufficient strength to maintain its shape around the foam bubbles, it entrains 30-35% of air by volume into the concrete, as results the low density Foam Concrete is obtained. It can be categorized as cellular material because it contains higher amount of pores. Further quality of foam concrete is depending upon the quality and type of foam is used. As mostly no coarse aggregate is used in the production of the foam concrete or cellular concrete, the correct terms would be called mortar instead of concrete. The density of foam concrete generally varies from400kg/$m^3$ to 600kg/$m^3$ and codal provision IS.2185.4.2008. There are two types of Foaming agent used as a construction material.

- Protein-based foaming agents come from animal proteins (horn, blood, bones of cows, pigs & other remainders of animal carcasses). These surfactants might therefore be best suited to the production of foamed concrete of relatively high density &high strength.
- Synthetic foaming agents are such chemicals which reduce the surface tension of liquid and commonly used globally to make blocks, bricks, CLC concrete etc where the high density is needed and it requires less energy for formation as compared to other foaming agents

**Fig.2 CLC block**

**2.3. Fly ash concrete: -** Fly ash brick or concrete have great economical and environmental advantages and it may also makes a concrete sustainable. Fly ash is coal combustion product which is finely divided residue left into the boiler, blast furnace or

any other type of thermal power station. It consists about 15-25% of cementitious material. There are three types of fly ash used as a construction material are

- Class C Fly ash having high lime
- Class C and F Fly ash having intermediate lime
- Class F Fly ash having low lime

Use of fly ash according to IS.3812.1.2003. The specific gravity of fly ash is ranging between 2.1 to 3. Fly ash concrete block are lighter in weight because of partial replacement of fine aggregate and fully replacement coarse aggregate. It is very cost effective and having greater density to compression strength ratio. The raw ingredients of fly ash concrete is cement , sand , fly ash and water are mixed in well definite proportion and cast into different sizes of mould according to the requirement. The curing processes of concrete block are done under guidance IS.456.2000.

**Fig.3 Flyash block**

## III. MATERIAL USED

**3.1. Cement: –** Cement is a binding material used in construction projects that sets and hardened to other materials when reacts with water. If cement is used with only fine aggregate then it known as mortar and if cement, fine aggregate and coarse aggregate used together then it is known as concrete. Ordinary Portland cement type grade53 is commonly used. Physical properties of the cement is

- Color-white
- Specific gravity-3.15
- Specific surface area-2250cm$^2$/kg
- Compressive strength-53MPa
- Codal provision- IS.269.1989 and IS.383.1970
- Chemical composition of cement

| Compound | Composition (%) |
|---|---|
| $SiO_2$ | 20.33 |
| $Al_2O_3$ | 3.40 |
| $Fe_2O_3$ | 4.68 |
| CaO | 57.84 |
| MgO | 1.51 |
| MnO | 0.10 |
| $TiO_2$ | 0.09 |
| $K_2O$ | 0.72 |
| $Na_2O$ | 0.51 |
| $SO_3$ | 7.26 |
| Loss on ignition | 3.42 |
| Insoluble residue | 1.23 |

**3.2. Fly ash: -** Fly ash is poorly graded particles, generally spherical in shape and range in size from 0.5µm to 300µm. It contains nearly about 15-25% cementitious material. It provides great workability and consistency to the concrete and lowers the heat of hydration. Fly ash increases setting of concrete. It also provides higher strength at later stages in concrete. Physical properties of concrete used are

- Type- Class C Fly ash
- Specific gravity-2.5
- Color- white
- Specific surface area-4000$cm^2/g$
- Codal provision- IS.3812.1.2003
- Chemical composition of fly ash

| Chemical component | Typical Fly ash | |
|---|---|---|
| | Class C | Class F |
| Silica ($Si O_2$) | 40 | 55 |
| Alumina ($Al_2O_3$) | 16 | 26 |
| Ferric oxide ($Fe_2O_3$) | 6 | 7 |
| Calcium oxide (CaO) | 24 | 9 |
| Magnesium oxide ( MgO) | 2 | 2 |
| Sulfate oxide ($SO_3$) | 3 | 1 |
| Loss of ignition (LOI) | 6 | 6 |

**3.3. Sand: -** Sand is generally obtained from marine environment. Sand is a naturally occurring granular material which composed of finely divided rock and mineral particles. It is defined by size being finer than gravel and coarser than the silt. Amount of sand is used to ensure less quantity of cement and less water, which are further increased strength, durability but lowers the shrinkage of concrete. Sand is also used as fine aggregate because of its size ranges between 0.0625mm to 2mm. the specific gravity of sand used in this experiments is 2.6 and having fineness modulus 2.63. Coda provision used IS.383.1970.

**3.4. Gypsum: -** Gypsum is a type of mineral and a hydrated calcium sulfate in chemical form. It plays a vital role in compensating the rate of hardening of the cement. It is used to control the setting time of cement but if it is in excess it may unsound the cement concrete because of sulfate. Physical properties of gypsum are

- Color- white grey
- Specific gravity-2.3
- Specific surface area-3800$cm^2/g$
- Size- less than 1mm
- Chemical formula-$Ca(OH)_2.2H_2O$

**3.5. Lime: -** Lime is used in making AAC and reduces the amount of water into the concrete block. It prevents the AAC from drying out too quickly and also from dry shrinkage. Hydrated lime, fat lime and quick lime are the main types of lime in which hydrated lime are widely used in making construction. Physical properties of hydrated lime are as follows

- Color-white
- Type- Hydrated lime
- Specific gravity-2.81
- Specific surface area-4300$cm^2/g$
- Codal provision- IS.3115.1992
- Chemical formula- CaO

**3.6. Aluminum powder: -** Al powder is a finely grinded powder, such that it reacts with calcium hydroxide a byproduct of cement-water reaction and then after reaction between Al powder and calcium hydroxide generates uniform micro air bubbles which results in increasing concrete volume making it very light weight concrete.

Cement + water → C-S-H gel +3Ca(OH)$_2$

$$2Al + 3Ca(OH)_2 + 6H_2O \rightarrow 3\ CaO.Al_2O_3 + 3H_2$$

Aluminum powder + Calcium hydroxide → Tricalcium hydrated + Hydrogen

Physical properties of Al powder

- Color-Grey
- Melting moint-660ºC
- Specific surface area-7000cm$^2$/g
- Specific gravity-0.22
- Particle size- 45µm

**3.7. Foaming Agent: -** It is a material that facilitates formation of foam such as surfactants. When foaming agent is added into the water in foam generator with proportion 1:30 to 1:40(1 part foaming agent and 30to40 part water), a foam is generated which is light in weight and brown/white color. The foam is after used in mix slurry to make foam concrete(CLC).The physical properties of Foaming Agent used in making CLC are

- Color-brown
- State-liquid
- Specific gravity-1.15
- Ph at 20ºC-6.5 to 7.5

## IV. Result and Discussion

**4.1. Autoclaved Aerated Concrete: -** Durable and workable properties of AAC block of having sizes 15cm cube. In fire resistance and sound insulation test the thickness of AAC block considered 100mm.

**Table.1 AAC classification**

| Oven dreid Density (kg/m$^3$) | Compressive Strength (N/mm$^2$) | Water absorption (in %) | Thermal conductivity (W/m.K) | Fire resistance (hr) | Sound Insulation (dB) |
|---|---|---|---|---|---|
| 500 | 2 | 45 | 0.21 | 4 | 39 |
| 600 | 4 | 35 | 0.24 | 4 | 40 |
| 700 | 5 | 40 | 0.30 | 4 | 40 |
| 800 | 6 | 38 | 0.37 | 4 | 41 |
| 1000 | 7 | 30 | 0.42 | 4 | 42 |

**4.2. Cellular Lightweight Concrete: -** Durable and workable properties of CLC block of having sizes 15cm cube. In fire resistance and sound insulation test, thickness of the block considered 100mm.

**Table.2 CLC classification**

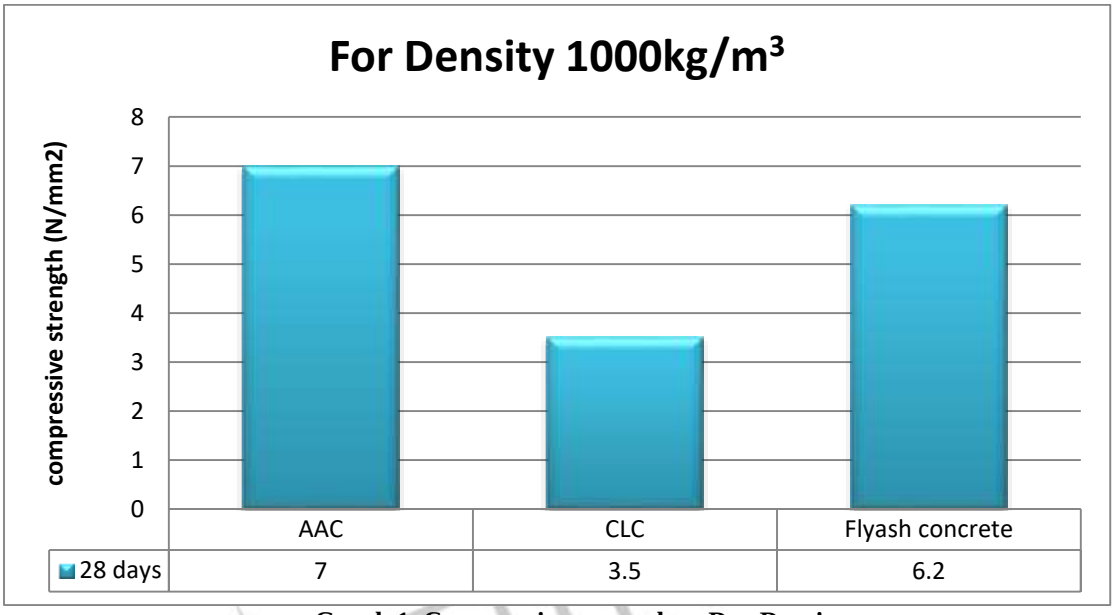
| Oven dried Density (kg/m$^3$) | Compressive strength (N/mm$^2$) | Water absorption (in %) | Thermal conductivity (W/m.K) | Fire resistance (hr) | Sound insulation (dB) |
|---|---|---|---|---|---|
| 800 | 2.5 | 12.5 | 0.37 | 4 | 40 |
| 1000 | 3.5 | 12.5 | 0.41 | 4 | 40 |
| 1200 | 6.5 | 10 | 0.44 | 4 | 41 |
| 1400 | 12 | 10 | 0.49 | 4 | 41 |
| 1600 | 17 | 7.5 | 0.53 | 4 | 42 |
| 1800 | 25 | 7.5 | 0.57 | 4 | 42 |

**4.3. Fly ash based Concrete: -** Durable and workable properties of Fly ash concrete block of having sizes 15cm cube. In fire resistance and sound insulation test, thickness of Fly ash concrete block considered 100mm.

**Table.3 Flyash classification**

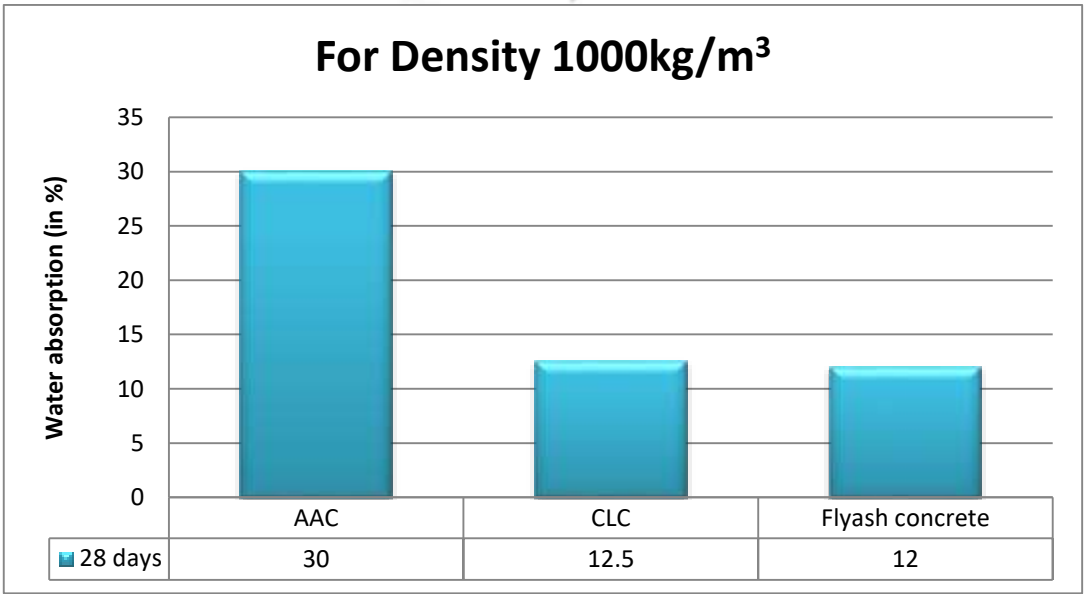
| Oven dreid Density ($kg/m^3$) | Compressive strength ($N/mm^2$) | Water absorption (in %) | Thermal conductivity (W/m.K) | Sound insulation (dB) |
|---|---|---|---|---|
| 1000 | 6.2 | 12 | 0.77 | 36 |
| 1160 | 9.2 | 12 | 0.76 | 36 |
| 1260 | 12.8 | 13 | 0.77 | 37 |
| 1300 | 15.5 | 14 | 0.78 | 37 |
| 1350 | 16.7 | 11 | 0.78 | 37 |

**4.4**. Comparing all types of light weight concrete on the basis of compressive strength with respect to their dry density keeping constant.



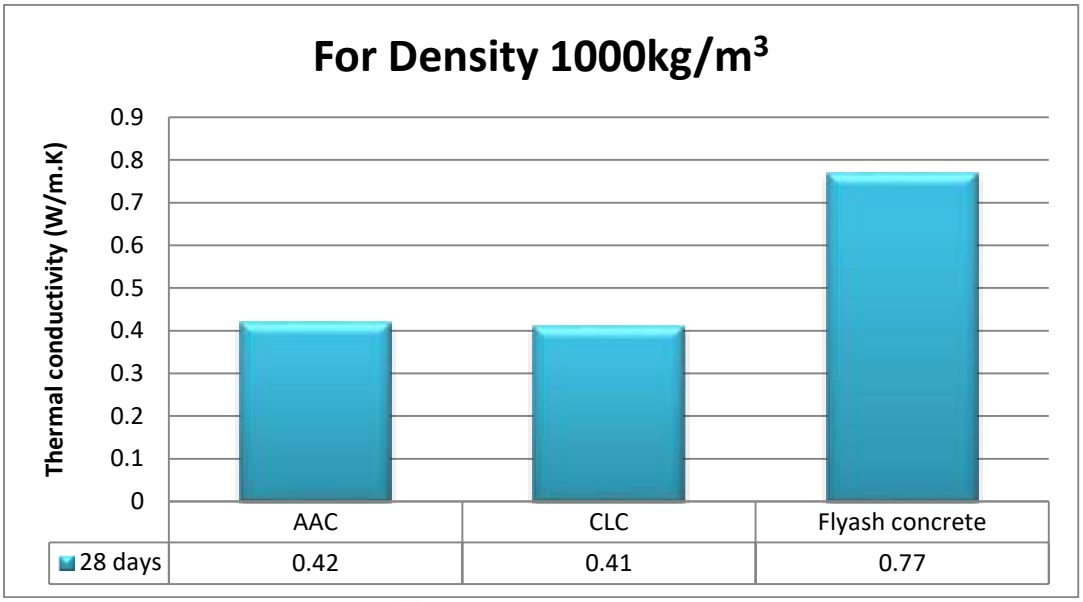

**Graph.1. Compressive strength vs Dry Density**

**4.5.** Comparing all types of light weight concrete on the basis of water absorption with respect to their dry density keeping constant.



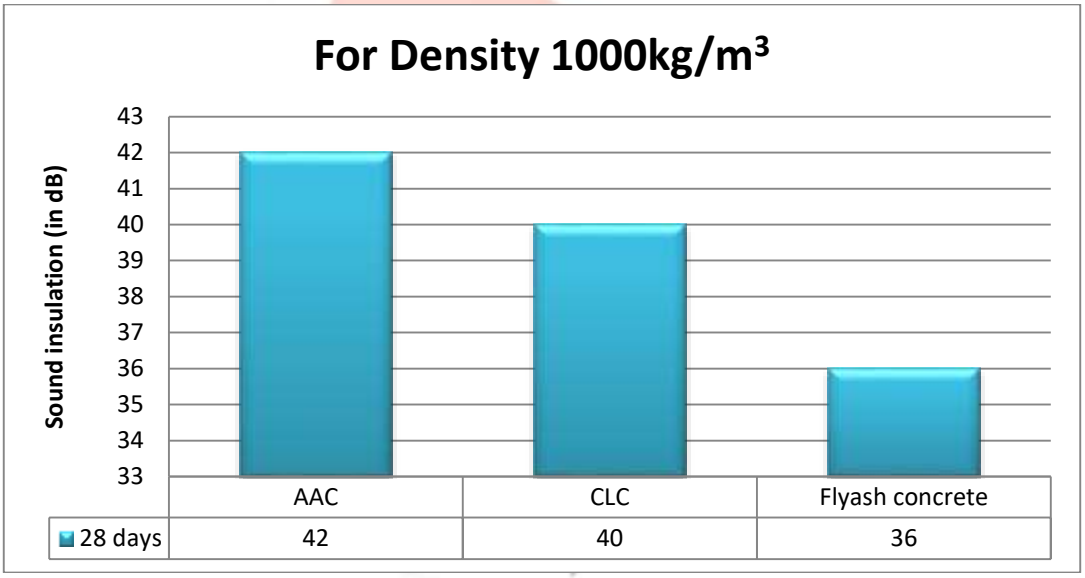
**Graph.2. Water absorption vs Dry Density**

**4.6.** Comparing all types of light weight concrete on the basis of thermal conductivity with respect to their dry density keeping constant.




**Graph.3. Thermal conductivity vs Dry Density**

**4.7.** Comparing all types of light weight concrete on the basis of sound insulation with respect to their dry density keeping constant.




**Graph.4. Sound insulation vs Dry Density**

## V. Conclusion

In results and discussion part, the durable and bearable properties of all type of concrete is shown above graphs and tables, each type of concrete have their own comfort specialty. Therefore the comparison should be done on the basis of density keeping constant. On the above graphs the compressive strength, thermal conductivity, water absorption etc. are to be compared with their density 1000kg/m$^3$. The comparison between three of them are as follows.

1) In Graph.1, the compressive strength of AAC block are better than the other two concrete blocks (CLC, Fly ash based concrete).
2) In Graph.2, the water absorption of Fly ash based concrete are quite good w.r.t. the other concretes.
3) In Graph.3, thermal conductivity of AAC and CLC are quite similar and both of them are better than Fly ash concrete.
4) In Graph.4, sound resisting capacity of AAC is better than the CLC and Fly ash concrete.

Based on the above tests and analysis made, we came to conclusion as follows AAC block are most preferable than the any other because of its compressive strength and of its less dead load.

## VI. Reference

**[1]** http://brickwell.in.
**[2]** https://en.wikipedia.org.

**[3]** IS:2185(Part 3):1984, Specification for concrete masonry units, Autoclaved Cellular (Aerated) Concrete Blocks, First revision, Ch-4, page7.
**[4]** IS:2185(Part 4):2008, Concrete masonry units specification, Preformed Foam Cellular Concrete Blocks, Ch-5, page2.
**[5]** IS:383:1970, Specification for coarse and fine aggregate from natural sources for concrete, second revision.
**[6]** IS:3812(Part 1):2003, Pulverized fuel ash-specification, for use as pozzolana in cement, cement mortar and concrete, second revision.
**[7]** M.S. Shetty, Concrete Technology, 1982, S. Chand & Company Ltd, New Delhi, Edition 2005, Ch 12, page 504-607.
**[8]** Ahsan Habib1, Hosane Ara Begum2, Rubiya Hafiz3, Study on production of Aerated Concrete block in Bangladesh, International Journal of Innovative Science Engineering & Technology, vol.2, 3 March 2015.
**[9]** Shweta O. Rathi1, P.V. Khandve2, AAC Block-A new Eco-friendly Material for Construction, International Journal of Advance Engineering and Research Development, Vol 2, 4 April 2015.
**[10]** http://infinityc4x.com/indexMenu.htm?menulink=prop.
**[11]** http://ecovision.in/index.php/services/flyash/clc/.
**[12]** K. Mahendran1, T. Sivaram2, Dr. M. Shahulhamedd3, R. Logaraja, A Comparative Study on Various Building Blocks as an Alternative to Conventional Bricks, International Conference on Emerging Trends in Engineering and Management Research, 16, 23 March2016.
**[13]** Serkan Subai1, The effects of using Fly ash on high strength lightweight concrete produced with expanded clay aggregate, Scientific Research and Essay, Vol.4(4), pp.275288, April 2009.