International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

IJIEMR Transactions, online available on 18 Jun 2022. Link :http://www.ijiemr.org/downloads.php?vol=Volume-11&issue=ISSUE-06

DOI: 10.48047/IJIEMR/V11/I06/98

Title **An Experimental Study of Light Weight Concrete with Partial Replacement of Coarse Aggregate by Pumice and Cement by Fly ash**

Volume 11, Issue 06, Pages: 1620-1625

Paper Authors
Srilakshmi Vadavelli, Ch. Bhavannarayana

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

An Experimental Study of Light Weight Concrete with Partial Replacement of Coarse Aggregate by Pumice and Cement by Fly ash

*Srilakshmi Vadavelli** Ch. Bhavannarayana

*PG Scholar, Kakinada Institute of Engineering and Technology - II, Korangi, Kakinada

** Professor & HOD, Kakinada Institute of Engineering and Technology - II, Korangi, Kakinada

ABSTRACT: Concrete is widely acknowledged as one of the most expensive components in the construction industry. Many studies on concrete mixes have encouraged the development of materials containing pumice stone, thermocol beads, and saw dust as partial replacements for natural aggregate. Natural aggregate, which is produced from environmental waste and helps in the construction of larger precast units, is a new source for the construction of structures. It reduces self-weight and helps in the construction of larger precast units. Light weight concrete plays an important role in reducing the density of concrete structures, where self-weight reduction is an important factor that may increase thermal insulation through structural response and serviceability. When used as aggregates, light weight aggregate is mostly volcanic tuff, which acts as active pozzolonas. The strength and durability properties of M40 concrete will be investigated in this study by partially replacing coarse aggregate with natural light weight aggregate pumice stone. The properties of traditional M40 concrete are compared to the properties of concrete with light weight aggregate, which is made by replacing coarse aggregate with pumice stone by 0%, 10%, 20%, 30%, 40%, and 50%. Natural aggregate's physical and mechanical properties are assessed. After that, 10% of the cement was replaced with fly ash, and up to 50% of the pumice stone was replaced with natural aggregate, and the mechanical properties were assessed. Based on structural light weight concrete M40, an optimum control mix is developed using light weight aggregate pumice stone as a partial replacement for coarse aggregate. In order to do this, 12 sets were put together. Each set has 6 cubes, 6 cylinders, and 6 beams. The compressive strength of cubes (150mm x 150mm x 150mm), the split tensile strength of cylinders (150mm diameter x 300mm height), and the flexural strength of beams (500mm x 100mm x 100mm) will be tested to find out how strong concrete is at 7 and 28 days after it has hardened.

Keywords: Lightweight concrete, Pumice, Fly ash, Compressive strength, Splitting tensile strength, Flexural strength.

1. INTRODUCTION

In construction with concrete, the weight of the concrete is a very large part of the total load on the structure, and it is clear that reducing its density would have many benefits. Lightweight aggregate concrete is one way to cut down on the weight of a building. A type of concrete called "lightweight concrete" is one that has a "expanding agent" added to it. This agent increases the volume of the mixture and gives it other properties, like making it less heavy. It weighs less than regular concrete. Lightweight concrete has been used a lot in places like the United States, the United Kingdom, and Sweden. The best things about lightweight concrete are how light it is and how well it moves heat. Its benefits include less dead weight, faster building rates, and lower costs for transporting and handling. When it is put on a wall, lightweight concrete keeps its big holes and doesn't form cement layers or films. This study looked at how well-aerated lightweight concrete worked. But the water-cement ratio must be right for the cement and water to stick together well. If there isn't enough water, the particles won't stick together, and the concrete will lose strength. In the same way, too much water can cause cement to run off the aggregate and form weak layers called laitance. So, this fundamental research report is being made to show what has been done and how things are going with lightweight concrete. The performance of aerated lightweight concrete was looked at through tests like compressive strength, water absorption, and density, as well as through additional tests and comparisons with other types of lightweight concrete. You can make lightweight concrete by adding air to it or by leaving out the smaller sizes of aggregate or even by replacing them with an aggregate that is hollow, cellular, or porous. Particularly, lightweight concrete can be categorized into three groups:

i) No-fines concrete
ii) Lightweight aggregate concrete
iii) Aerated/Foamed concrete

1.2 No-Fines Concrete

Cement and fine aggregate make up no-fines concrete, which is lighter than traditional concrete but still strong. Their entire mass becomes riddled with holes that are scattered at random. The fundamental feature of this lightweight concrete is that it does not develop laitance layers of cement film when applied to a wall, thus the huge spaces it has when it is mixed remain when it is poured. One type of No-fines concrete.

No-fines Concrete is commonly used for external load-bearing and non-load-bearing walls and partitions. As the cement concentration of no-fines concrete grows, so does its strength. It is, nevertheless, sensitive to the makeup of the water. Inadequate water can result in a lack of cohesiveness between the particles and, as a result, a loss of concrete strength. Similarly, excessive water can cause cement film to run off the aggregate and produce laitance layers, leaving the majority of the concrete deficient in cement and so decreasing the strength.

1.3 Lightweight Aggregate Concrete

In place of regular concrete, this lightweight concrete is made with an aggregate that is both porous and lightweight and has a low specific gravity. Natural lightweight aggregates include pumice, scoria, and everything else of volcanic origin. Artificial lightweight aggregates include expanded blast-furnace slag, vermiculite, and clinker aggregate. Both natural and artificial lightweight aggregates can be used. The high porosity of this lightweight aggregate, which contributes to the material's low specific gravity, is the primary distinguishing feature of the material. According to the purpose for which it will be used, lightweight aggregate concrete can be separated into two distinct categories. The first variety is known as partially compacted lightweight aggregate concrete, while the second variety is known as structural lightweight aggregate concrete. The partially compacted lightweight aggregate concrete serves primarily two objectives, the first of which is for the production of precast concrete blocks or panels, and the second is for the construction of cast-in-place roofs and walls. The primary need for this kind of concrete is that it must have sufficient strength in addition to a low density in order to achieve the highest possible level of thermal insulation. Additionally, it must have a low drying shrinkage in order to prevent cracking. Concrete made of structurally lightweight aggregate is fully compacted in a manner that is analogous to that of conventionally reinforced concrete made of dense aggregate. It is possible to utilise it in conjunction with steel reinforcement in order to achieve a strong bond between the concrete and the steel. It is expected that the concrete will offer sufficient protection against the steel's corrosive effects. It is common for concrete mixtures to be on the harsh side because of the form and texture of the aggregate particles as well as the coarse nature of the fine aggregate. When it comes to lightweight aggregate, only the more compact varieties are appropriate for use in structural concrete. The characteristic of lightweight aggregate concrete is depicted.

1.4 Aerated Concrete

Since it lacks coarse aggregate, aerated concrete can be thought of as an aerated mortar. The conventional method of producing aerated concrete involves mixing fine sand, cement slurry, and air or another gas. In industrial applications, powdered fuel ash or another siliceous material may be substituted for sand, and lime may be used in place of cement. The aerated concrete can be made in one of two ways. The first strategy entails introducing the gas into the mixture while it is still in a plastic state, produced by a chemical reaction. In the second procedure, an air-entraining agent is whipped into the mixture or mixed into a stable foam to introduce the air. The first approach is typically utilised in precast concrete plants, where the resulting autoclaved precast units are employed to create concrete with relatively high strength and low drying shrinkage. The latter is typically employed when in-situ concrete is required, such as for insulating roof screeds or lagging pipes.

1.5 Pumice

Pumice stone is a textured material created when gas bubbles are trapped in fast cooling viscous molten rock, creating a foamy whipped glass. Pumice comes from the Latin word pumeu, which means froth. It can also be created when lava erupts from a vent deep beneath, creating gases that leave behind a frothy structure. Pumice is an amorphous rock created from converted magma. Depending on the direction and strength of the wind, pumice can take on a number of different forms, including pyroclastic flows, piled drifts, piles, and river bank deposits. Floating pumice masses or pumice found near the shoreline are the most reliable sources of pure pumice because of the wind's effect on the material as it sinks and becomes saturated. Although pumice is a common amorphous rock found across the country, not all of it is suitable for industrial usage due to its low silica content. The ancient Greeks and Romans used pumice in concrete, which was a novel technology at the time. Pumice stone was used extensively in the construction of ancient constructions. Having different qualities in different areas indicates that it is not a product made specifically for a single region. Pumice's high demand stems from the material's impressive Mohs hardness, purity, and witness, as well as the expertise of the company that mines and processes it.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

The celluar structure of the matrix determines the physical qualities of the pumice stone, which is an exceptionally lightweight rock that may float on the surface of water for an extended period of time. These cells are completely separate from one another, and the levels of both sound and heat generated by hydration are quite modest. The chemical characteristics of pumice stone, which is predominantly composed of silicon dioxide, aluminium oxide, and trace amounts of other oxides, vary from location to location. Pumice stone is also known as sandstone. On the Mohs scale, pumice has a hardness of between 5.5 and 6. It is tiny in size, has a pourness nature, and is chemically inert. It includes 75% silicon oxide and 85% pumice grain volume and has a pourness nature. The ratio of SIO2 that creates forms a chemical structure that endows rocks with an abrasive quality. The composition of AL2O3 provides a great resistance to heat and fire. Minerals that display reactive properties in tentive industries include sodium oxide and potassium oxide..

1.6 Fly ash:

With a rapidly expanding economy, India's need on electricity has increased, and thermal power plants now provide the majority of the country's electricity. Air pollution from particulate emission, water pollution, and a lack of space for fly ash disposal are among concerns brought on by these facilities. In addition, the disposal issue is made worse by the high ash concentration of low-quality Indian coal. Fly ash can be utilised as a cement substitute, rather than being dumped in landfills. The building business is expanding at a breakneck pace currently. It is a worldwide issue that construction raw materials are in short supply. In some areas, the ecology is put at risk due to the constant use of natural resources used in the manufacturing of concrete. Researchers have done a lot of study in this field, and they're still looking for a good replacement material to use in construction. To address this issue, the present investigation focused on using synthetic fly ash aggregates in place of natural coarse aggregates. Coarse aggregates made from waste products like fly ash can be utilised in concrete if a suitable binder is used. Environmental issues are being caused by fly ash released by thermal power plants. Using environmentally friendly building materials, such as industrial waste products like fly ash, is a must for a green structure to meet its environmental standards. Advantages to both the economy and the environment can be expected from making use of fly ash byproducts simultaneously..

2.MATERIALS & PROPERTIES

Table-1 Properties of cement

S.NO	Properties	Test results	IS: 169-1989
1.	Normal consistency	0.45	
2.	Initial setting time	29min	Minimum of 30min
3.	Final setting time	598min	Maximum of 600min
4.	Specific gravity	3.18	

Table 2: Properties of Fine Aggregate

S. No	Description Test	Result
1	Sand zone	Zone- II
2	Specific gravity	2.63
3	Free Moisture	0.01
4	Fineness modulus	3.19

Table 3: Properties of Coarse Aggregate

S. No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.77
3	Fineness modulus	7.22
4	Water absorption	0.15%

Table4: Pumice Stone

S. No	Property	Value
1	Specific gravity	0.92
2	Fineness modulus	7.12
3	Impact value	33%
4	Nominal maximum size	20 mm

3. MIX DESIGN FOR M40 GRADECONCRETE:

[According to investigations done on FA, CA, cement]

DESIGN STIPULATIONS DATA:

Gradedesignation : M40
Typeof cement : OPC 53 grade
Maximum nominal sizeofaggregate : 20 mm
Maximumwater-cementratio :0.45
Degreeof supervision : Good
Typeofaggregate :Crushed angular
Exposurecondition :moderate
Workability :100mm(slump)

TEST DATA FORMATERIALS:

1. Typeof cement : OPC 53 grade conforming to IS:
2. Specific gravityofcement: 3.1

3. Specific gravity of

a) Fineaggregates : 2.71

b) Coarseaggregates : 2.78

4. Water absorption of

a) Fineaggregates : 0.34%

b) Coarseaggregates : 0.6%

TARGET MEANSTRENGTH:

[According to IS 10262-2019, clause 4.2]

$f^{l}ck=fck+1.65(S.D)$ $f^{l}ck=35+1.65(5)$

[here S.D is standard deviation from table 2, clause 4.2.1.3]

$f^{l}ck= 48.25N/mm$

Standard Deviation S=5N/mm

SELECTION OF WATER CEMENTRATIO:

[According to IS 456-2000, table 5] (i) W/C=0.45

(ii) W/C=0.45(from fig 1, IS 10262-2019)

W/C=0.45

SELECTION OF WATERCONTENT:

[According to IS 10262-2019, table 2]

From table 2 of IS 10262:2009, Maximum water = 197.16lit(for 100mm slump) for 20mm aggregate.

Required water content = 197 liters

CALCULATION OF CEMENT CONTENT:

We have, W/C=0.45

Cement content=197.6/0.45

=438.13 kg/m^3

From table5 of IS 456-2000, the minimum cement content. For moderate exposure condition =280kg/m^3 450kg/m^3> 320kg/m^3

Hence ok.

ESTIMATION OF COARSE AGGREGATEPROPORTION:

[According to IS 10262-2009, table 3]

Vol. of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (Zone -2) For water cement ratio 0.50=0.62, But our water content is 0.40 Volume of coarse aggregate is required to be increased to decrease the fine aggregate content, as w/c is lower by 0.10, the proportions of volume of coarse aggregate increased by 0.02.

Volume of coarse aggregate for the water cement ratio=0.64

Volume offineaggregate=0.62-0.01

=0.61

MIXCALCULATIONS:

The mix calculations for unit volume of concrete shall be as follows

Total volume = 1m^3

vol of cement = (mass of cement/ specific gravity of cement)×(1/1000)

= (438.13/3.18) × (1/1000)

= 0.137 m^3

vol. of water = (mass of water/ specific gravity of water) ×(1/1000)

= (197.16/1) × (1/1000)

=0.197 m^3

Volume of add mixtures = Nill

vol. of all in aggregates = [(a-b)-(c+d)]

= [(1-0.01)-(0.137+0.197)]

=0.656m

mass of CA = 0.656 × (vol. of CA) × (specific gravity of CA) ×1000

= 0.656 × 0.61 × 2.78 × 1000

=1130.24 kg

mass of FA = 0.656 × (vol of FA) × (specific gravity of FA) ×1000

= 0.656 × 0.39 × 2.71 × 1000

= 693.32 kg

Mix proportions fortrail(1m)

Cement = 438.13kg/m Water=197.16lit

Fine aggregate = 693.32kg Coarse aggregate =1130.24kg Water cement ratio = 0.45

Mix proportions byweight:Design mix of M30

C	:	FA	:	CA	:	W
438.13	:	693.32	:	1130.24	:	197.16
1	:	1.58	:	2.54	:	0.45

4. EXPERIMENTAL DETAILS

Mix ID	Cement	Flyash	Fine aggregate	Coarse aggregate	Pumice	water
C0P0	437.7	-	774.54	983.07	-	197
C0 P10	437.7	-	774.54	884.76	98.31	197
C0 P20	437.7	-	774.54	786.46	196.61	197
C0 P30	437.7	-	774.54	688.15	294.92	197
C0 P40	437.7	-	774.54	589.84	393.84	197
C0 P50	437.7	-	774.54	491.54	491.54	197
C10P0	393.93	43.77	774.54	983.07	-	197
C10 P10	393.93	43.77	774.54	884.76	98.31	197
C10 P20	393.93	43.77	774.54	786.46	196.61	197
C10 P30	393.93	43.77	774.54	688.15	294.92	197
C10 P40	393.93	43.77	774.54	589.84	393.84	197
C10 P50	393.93	43.77	774.54	491.54	491.54	197

TESTS TO BE CONDUCTED:

1.Compressive strength

2.Split tensile strength

3.Flexural strength.

5. RESULTS & DISCUSSION

Compressivestrength:

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

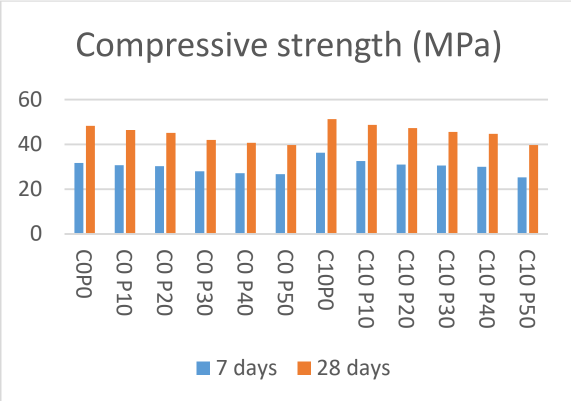


Figure 1: Graph of Compressive Strength comparison at 7days and 28 days for M40 lightweight concrete

Split tensile strength

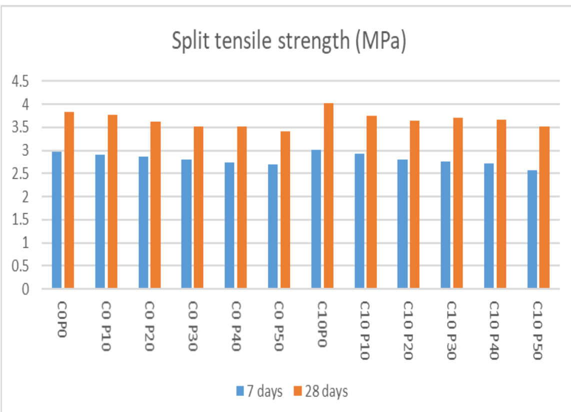


Figure 2: Graph of Split tensile Strength comparison at 7, 14 and 28 days for M40 lightweight concrete

Flexural strength

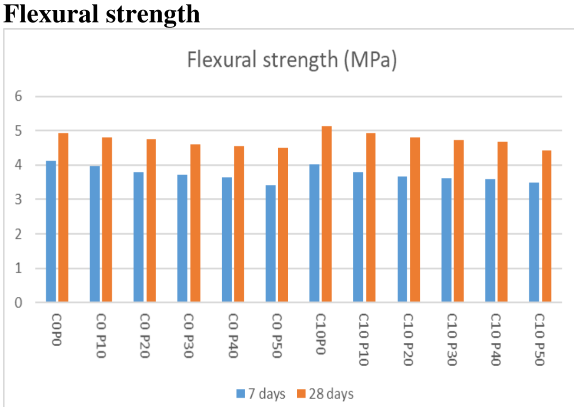
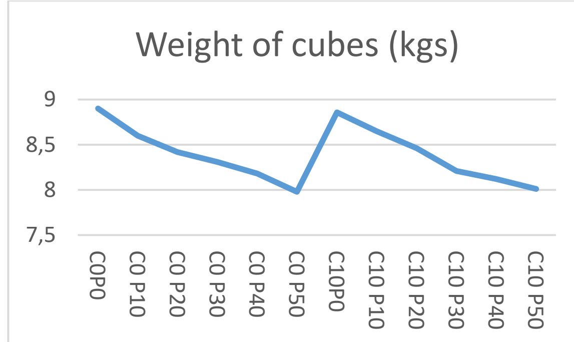


Figure 13: Flexural Strength comparison at 7days and 28 days for M40 lightweight concrete

Weight of cubes



6. CONCLUSION

- For lighter concrete, pumice aggregate can be used in place of natural aggregate.
- The compressive strength, split tensile strength and flexural strength values are decreased with increases of Pumice light weight aggregate with 0-50% replacement.
- With addition of 10% flyash in control mix, compressive strength value is 6.24% higher than control mix.
- With addition of 10% flyash in control mix, split tensile strength value is 5.22% higher than control mix.
- With addition of 10% flyash in control mix, flexural strength value is 4.06 % higher than control mix.
- 50% replacement of pumice with natural coarse aggregate is 10.34% decreases.
- Replacement of coarse aggregate with pumice aggregate and 10% of flyash replaced with cement gave better results.

References

[1] A. Arokiaprakash and V. Thenarasan, “ExperimentalStudy of Properties of Light Weight Concrete as a Partial Replacement of Sintagg Aggregate to Coarse Aggregate”, International Journal of Civil Engineering and Technology (IJCIET), Volume 9, Issue 3, March 2018, pp. 656–662, Article ID: IJCIET_09_03_067.

[2] Priyadharshini.P, Mohan Ganesh.G, Santhi.A.S , “Experimental study on Cold Bonded Fly Ash Aggregates”, International Journal Of Civil And Structural Engineering, Volume 2, No 2, 2011,doi:10.6088/ijcser.00202010129.

[3] Nallaiahgari Sivanagi Reddy, CH.Vema Reddy , “Study Of Concrete Made Using Fly Ash Aggregates”, International Journal Of Professional Engineering Studies, Volume VIII /Issue 4 / APR 2017.

[4] S. Viveka, R. Renuka, “Study of Strength Characteristics of Fly Ash Aggregates in Light Weight Concrete”, International Journal of Innovations in Engineering and Technology, Vol 6,

Issue 3, Feb 2016.
[5] O. Kayali, "Fly ash lightweight aggregates in high performance concrete", Construction and Building Materials 22 (2008) 2393–2399, doi:10.1016/j.conbuildmat.2007.09.001
[6] Rishab Meena, Sumit Sharma, Anuj Sharma, Mukesh Kumar, "Study on Lightweight Concrete-Review", International Journal of Engineering Research & Technology (IJERT), Vol. 9 Issue 07, July-2020.
[7] M.N. Haque, H. Al-Khaiat, O. Kayali, "Strength and durability of lightweight concrete", Cement & Concrete Composites 26 (2004) 307–314.
[8] Al-Khaiat H, Haque MN, "Strength and durability of lightweight and normal weight concrete", ASCE Mater J 1999;11(3): 231–5.
[9] Lucyna Domagała, "Durability of Structural Lightweight Concrete with Sintered Fly Ash Aggregate", Materials 2020, 13, 4565; doi:10.3390/ma13204565.
[10] Manu S. Nadesan, P. Dinakar, "Structural concrete using sintered flyash lightweight aggregate: A review", Construction and Building Materials 154 (2017) 928– 944.
[11] J.Bright Brabin Winsley, M.Muthukannan, "Expanded Fly Ash Clay Aggregate a Sustainable Alternative Coarse Aggregate for Concrete", Journal Of Materials and Engineering Structures 5 (2018) 347–353.
[12] Lina Chica, Albert Alzate, "Cellular concrete review: New trends for application in construction"Construction and Building Materials Vol. 200, 2019, pp 637–647.
[13] Siveji J S, Dr. Elson John , "Aerated concrete incorporating quarry dust", International Research Journal of Engineering and Technology (IRJET), Volume: 05 Issue: 04 | Apr-2018.
[14] Indu Susan Raj, Dr. Elson John, "Evaluation of properties of aerated Concrete partially replaced by cement with fly ash"International Journal of Advanced Research in Engineering and Technology (IJARET) Volume 10, Issue 1, January- February 2019, pp. 223-229.
[15] Indu Susan Raj, Dr. Elson John, "A Study on the Properties of Air-Entrained Concrete for Masonry Block", International Journal of Scientific Engineering and Technology (ISSN : 2277-1581) Volume No.3 Issue No.11, pp : 1367-1370 01 Nov. 2014.
[16] Sarika.R, Indu Susan Raj, Dr. Elson John, "Effect on the properties of aerated concrete developed by partially replacing cement with fly ash and fine aggregate with rubber powder",GRD Journels,Vol 2,Issue 12,November 2017.
[17] K. Naveen Kumar, D.S. Vijayan,R. Divahar, R. Abirami, C. Nivetha,"An experimental investigation on light-weight concrete blocks using vermiculite", Materials Today: Proceedings, 2019.
[18] Merin K Abraham, Elson John, Bybin Paul,"A Study on the Influence of Mineral Admixtures in Cementitious System Containing Chemical Admixtures", International Journal of Engineering Research and Development Volume 10, Issue 3 (March 2014), PP.76-82.
[19] Sarika R, Prof.Sarah Anil, "Study on the Properties of Aerated Concrete Incorporating Fly Ash & Rubber Powder", IJSTE International Journal of Science Technology & Engineering | Volume 3 | Issue 11 | May 2017.
[20] S. Geetha, K. Ramamurthy, "Properties of sintered low calcium bottom ash aggregate with clay binders" Construction,Vol.25,2011,2002–2013.
[21] Le Anh-tuan Bui, "Manufacture and performance of cold bonded lightweight aggregate using alkaline activators for high performance concrete", Construction and Building Materials Vol.35, 2012, pp 1056–1062