AUTOCLAVED AERATED CONCRETE INCORPORATING BAUXITE MUD AND ALUMINIUM DROSS

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

Under the supervision
of

Dr. Amardeep
Assistant Professor (Senior Grade)
Mr. Abhilash Shukla
Assistant Professor (Grade II)

by

Harjot Singh (161627)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

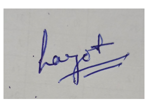
WAKNAGHAT, SOLAN-173234

HIMACHAL PRADESH, INDIA

JUNE,2020

STUDENT'S DECLARATION

I hereby declare that the work in the Project report entitled **"Autoclaved aerated concrete incorporating Bauxite mud and Aluminum dross"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Amardeep.** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.



Signature of student

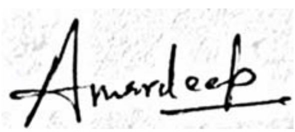
Harjot Singh
161627
Department of Civil Engineering
Jaypee University of Information Technology, Wakhnaghat, India
2 June 2020

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Autoclaved aerated concrete incorporating Bauxite mud and Aluminum dross"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil engineering, **Jaypee University of Information Technology, Wakhnaghat** is an authentic record of work carried out by **Harjot Singh (161627**) during a period from August,2019 to May,2020 under the supervision of **Dr. Amardeep.** Department of Civil Engineering, Jaypee University of Information Technology, Wakhnaghat.

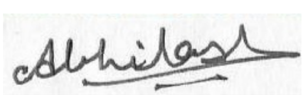
The above statement made is correct to the best of our knowledge

Date: 2 June 2020



Signature of Supervisor
Dr. Amardeep
Assistant Professor (Senior Grade)
Department of civil engineering
JUIT, Waknaghat

Signature of HOD
Prof.Dr. Ashok Kumar Gupta
Professor and Head
Department of Civil Engineering
JUIT, Waknaghat



Signature of C0- Supervisor
Mr. Abhilash Shukla
Assistant Professor (Grade II)
Department of Civil Engineering
JUIT, Waknaghat

ACKNOWLEDGMENT

I take this opportunity to acknowledge all who has been great sense of support and inspiration throughout the project work. There are lots of people who inspired me and helped, worked for me in every possible way to provide the detail about various related topics, thus making of report work success. My first gratitude goes to our head of department **Dr. Ashok Kumar Gupta** for his guidance, encouragement and support.

I am very grateful to **Dr. Amardeep Boora** (Asst. Professor), for all his diligence, guidance, and encouragement and helped throughout the project work. I also thank him for the time that he spared for me, from his extreme busy schedule. His insight and creative ideas are always the inspiration for me during the dissertation work

Harjot Singh

161627

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS & ABBREVIATIONS

AAC	Autoclaved aerated concrete
RM	Red mud
XRD	X-Ray diffraction
XRF	X- Ray Fluorescence
GGBFS	Ground granulated blast furnace slag
MSWI	Municipal solid waste
BM	Bauxite mud
BA	Bagasse ash
BRHA	Rice husk ash
WAAC	Waste autoclaved aerated concrete
SEM	Scanning electron microscope
MK	Metakolin
REE	Rare earth metal
GW	Granite waste
MW	Marble waste
MPC	Magnesium phosphate cement
PCE	Polycarboxylate super plasticizer

CHAPTER 1

INTRODUCTION

1.1 General

The economy of country usually depend upon good infra structure road, building, airport etc. AAC blocks are light weight masonary unit, basically used as partition walls. For every tonne of alumina produced globally approximately 1.5 - 2 tonnes of bauxite mud is produced. Aluminum dross is a byproduct of the aluminium smelting process, small amount of dross can be recycled. Autoclaved aerated concrete (AAC) block are mainly composed of sand, gypsum, lime, cement, aluminum powder. Calcining lime and clay are important components of Cement. Cement is used as a binding material which is mixed with fine aggregates, water and coarse aggregates for construction purpose. The cement consumption increasing at a rate of 6% per year.

1.2 Introduction

Autoclaved aerated concrete (AAC) were first developed in sweden in 1924. Autoclaved aerated blocks are also known as cellular concrete, thermalite, Aircrete, Hebel block. It is used in construction widely having low density, high fire resistance,eco-friendly, low shrinkage which can be used for construction of floors, trench fills, roof insulation and masonary units as partition walls.The cement paste having uniform cellular structure of distributed air voids is the reason for low density of Autoclaved aerated concrete. Finely divided aluminium powder is used for inclusion of gas in Autoclaved aerated concrete. Aluminium powder reacts with water to generate small bubbles of hydrogen in presence of soluble alkalis. the aluminum powder is having 98%, iron 0.1%, manganese 0.02%, titanium 0.03%, nitrogen 0.001%, silicon 0.1%, copper 0.02%. while , lime is to be added as a calcium source. Small amount of cement is used to reduce cost. Addition of gypsum increases the strength of AAC paste after pre curing. There is no toxic gases or other toxic substances in autoclaved aerated concrete. They are needed to be handled more carefully than clay bricks to avoid breakage (Brittle nature), because of the brittle nature of the AAC blocks longer, thinner screws are used for wall hangings.

Aluminum was discovered in 1825 by a physicist Hans christian orsted, for some time soon after discovery of this metal, this metal was having a price more than gold. Later reduced after first ever industrial production by Henri Etienne Sainte-claire Divelle.Globally the demand of aluminium is projected to expand 5.8 percent per year. In 2017 63.2 million tonnes of aluminium was produced worldwide. There are generally two types of aluminium dross, white dross and black dross. These two types are categorized depending on the content. White dross has higher aluminium content (15-70%) & black dross having 12-18% aluminium metal. Aluminium dust is a hazardous waste & needs to be treated before landfill because when aluminium dust comes in contact with water it generates hydrogen gas (alkaline environment), leading to an explosion. Different methods are there to treat the aluminium dust. For example, aqueous dissolution of aluminium dust at 60°C for 48h can be done to reduce its reactivity. It has also been shown that gypsum can also be used stabilize aluminium dust. Aluminum recycling is different from Aluminum dross recycling.Additional cost is therefore associated with disposal of aluminium dust. So, we are using aluminum dross to replace costly aluminum powder as expansion agent.

Red mud(RM) is an industrial waste produced as a by-product in the bayer process of alumina production. The first process to produce Alumina from Bauxite is Deville process. The process was invented in 1849 also known as Deville-Pechiney process, in this process extraction is don with sodium carbonate. Deville process was later replaced by bayer process. Carl Josef Bayer is the one who invented Bayer process in Russia. The bayer process replaced the Le Chatelier process in industrial process.Bayer's process uses sodium hydroxide to dissolve the aluminium silicate and to collect RM. Gibbste, bohmite are the different forms of Aluminum compounds in Bauxite. Aluminum oxides are both acidic and basic. In bayer process bauxite ore is heated with caustic soda in a pressure vessel at a temprature of 150 to 200°C. One tonne of Aliminum oxide is produced using 1.9-3.6 tons of bauxite. Around 1.5-2 metric tonnes of bauxite residue for each tonne of alumina produced. The Ajka Alumina plant in hungary city on 4 October,2010 had a incident in which the reservoir containing red mud collapsed. The red mud was having a pH of 12. The mud was released in the river and flooded some parts of the city. 10 deaths were reported in the incident and more than hundred cases of injuries where reported and also contamination in lakes and rivers where also reported.

RM has a considerable effect on the environment due to its chemical composition and alkali nature. Disposal of RM is a huge problem for the alumina production industry. RM having PH(10.5-12.5) are strongly alkali and need vast landfill, high cost for disposal. PH of wet rud slurry is about 12. Proper disposal of RM should be exercised as improper disposal can lead to soil infertility, groundwater resource depletion. RM mainly contains six main oxides Sio2, Fe2o3, Al2o3, Tio2, Na2o these may vary depending upon the bauxite source. RM can be used as construction material as it provides pozzolanic properties. RM is compatible with steel reinforcement when used in mortars, concrete and cement because of its high PH.

FIG 1 AAC block

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

Lixiong cai et. al. (2016) [1] conducted a study in which he used OPC, Carbide slag, iron tailing, quartz tailing, Phospho gypsum, to analyse the performance of AAC and also to study the effect of mix grinding process. XRD and XRF tests of all the samples were done. Conventional grinding and mix grinding process where done at different time intervals to know there effects and efficiency. The particle characterization was done by specific surface area, sieve residue (80um). Results showed Grinding of particles with mix grinding process showed greater efficiency than the conventional grinding process. The proportion carbide slag 33%, iron tailing 28%, phosphogypsum 3%, quartz tailing 28%, when autoclaved at 1.4Mpa steam pressure for 8hr, showed that compressive strength can be improved by 8-13% by finer carbide slag and iron tailing. Hence, study showed that (high content solid waste) HCS- AAC reduces cost of production and conserves environment.

Yiquan liu et. Al.(2019)[2] conducted a study using Portland cement, micro silica , lime, gypsum, aluminum dust. Instead of doing landfill disposal of aluminum dross, the dross was used as a foaming agent replacing the costly aluminum powder. During smelting process of aluminum waste/ unburnt aluminum is aluminum dross. Study showed us that two types of aluminum drossare there black and white dross. White dross having aluminum content than black dross. The raw material used were micro silica sand, lime, gypsum, Aluminum dust, type 1 portland cement. Samples were prepared with different aluminum and aluminum dross dosages. Rapid stiffening was observed in fresh paste incoporating aluminum dust. Denisty remains almost unchanged in Aluminum dross samples and has similar voids. Very low density AAC can't be achieved in Aluminum dross samples. Results showed that 15.6g Al dust generates same amount of gas 1g of Al powder, compressive strength obtained was 2.5Mpa. Therefore dross can be considered as alternative foaming agent.

B. Yuan et. Al. (2017)[3] conducted a study using cement, GGBFS, CaO as replacement to cement for AAC. To complete the replacements certain stages were formed, solution was formed (Alkali activator) after 20 min Stage 1 material were added like Quartz, $Ca(OH)_2$. After 2 min stage 2 material were added CaO, Slag, $CaSO_4$. Then after 3min Foaming agent was added (Al). In stage 3 casting was done followed by green body development & after this autoclaving at 187°C was done. The samples were demoulded on the same day after 12hours. Certain tests like SEM for AS AAC were done done to study the microstructure using different sodium carbonate quantity. Hardened state analysis were done for raw density and compressive strength values. A higher value of Al in the chain of tobermorite was observed in AS AAC sample than ref sample. ASSAC sample shows good thermal properties, Cost reduction, reduced environmental impact & poor strength than the ref. sample. Results showed that compressive strength decreased by 25%, thermal conductivity increased by 18%, drying shrinkage increased by 5%.

Xianggio li et. al. (2018)[4] conducted a test using cement, quicklime and municipal solid waste as a partial replacement to quartz sand.Bottom ash was imported from china. Ferrous and non-ferrous were separated out. The BA received was irregular in shape mainly 18mm. cement and quicklime as calcareous materials were used. Different samples were prepared with different quantity of BA. XRF analysis of BA was done, results showed that mainly SiO2 was present. Tests for thermal conductivity showed that samples having BA were having low density which resulted in lower thermal conductivity. XRD was also done on AAC based BA to find out the microstructure changes, which showed that tobermorite insenity increased, mainly because of the difference in the reactivity of BA and SiO2. Results showed that substituting BA in place of quartz sand shortened gas foaming time and also increasing gas foaming value which mainly depends on fineness of BA. The addition of BA in AAC resulted in decrease in density and compressive strength, thermal conductivity. This replacemement hand a high effect on foaming tobermorite and the MSWI samples showed no harm to the environment.

Huiwen Wan et. al. (2018) [5] conducted a test using river sand, stone sawing mud, cement, desulfurization gypsum. Considerable amount of sodium feldspar and potassium feldspar are present in stone sawing mud. This waste in mainly produced in industry where stone processing is done. River sand was having density of 2.63g/cm3. Seiving was done in above 80um seive with 12% residue was considered. XRD analysis of river sand and mud was done, mainly having quartz, mica and no sodium feldspar. Desulfurization gypsum was used to delay slaking of lime. River sand was replaced with 0%, 25%, 50%, 75% and 100% of sawing mud. Tests like XRF and particle size analyser were also used in the study. Results showed that presence of K2O and Na2O can improve compressive strength, fine particle size can also help in improving compressive stength. 73.3% and 74.6% were the porosity of AAC sample produced by adding stone sawing mud and river sand, all the samples were having a good thermal conductivity of 0.14 W/(m.k).

Kittipong kunchariyakun et. al. (2018)[6] conducted a test using OPC, lime, rice husk ash (BRHA), Al powder, Baggase ash (BA) to enhance the properties of AAC. BA & BRHA are used partial sand replacement, these are residue from sugar plants and rice plants. Both the samples were dried for 24hr at 105°C, later sieved to retain on Seive no.325 below 34%. Chemical composition of samples were determined using XRF and XRD, which showed that BRHA had more SiO2. The residues used were classified as class F pozzolons. Samples for both BA & BRHA were prepared, separate and collective samples. AAC having BA showed greater compressive strength than BRHA samples. SEM reported that there is a overlapping of CSH and calcite. Results showed that replacment are successful and showed better results. High fineness of samples resulted in higher compressive strength. Low specific gravity of both samples are benifical in dry density of AAC. Increased temperature had no effect on dry denisty but has a effect on microstructure & compressive strength.

Ling qin et. al.(2019) [7] conducted a test using recycled aggregate in AAC(W AAC). The W AAC blocks were taken from a province in china. The blocks were crushed to powdered form. The blocks consisted of tobermorite, gypsum, quartz & calcite, which were determined using XRD. Laser analyzer were used to identify the particle sizes, having size of 22.86um and 18.73um. A super plasticizer was also used as water reducing agent. River sand was used with a fineness modulus of 2.65. cubic samples of 20 mm were prepared for compressive strength. Chloride ion penetration measurements was done with Cylinder samples of height 50mm and diameter 100mm. Carbonated samples were tested after 4hr carbonation curing, later for 3, 7, 28 days. Six cubic samples were created for each mix design. Results showed that carbonation curing increased the compressive strength,205 weak can be successfully recycled to replace PC. More pores were seen after induction of W AAC. Results show Compressive strength of W

AAC samples increases with acclerated carbonation curing. Acclerated carbonation curing improves chloride penetration resistance. Results showed that without compromising compressive strength 20% W AAC is recycled to replace PC.

Zuhtu onur Pehlivanli et. al.(2017)[8] conducted a test using Polypropylene fiber(10mm), basalt fiber(8mm), glass fiber(24mm), carbon fiber(8mm). The changes in the compressive strength, flexural strength, conductivity value of AAC using the above mentioned fibres were studied. There were two type of fibre used G3 and G4, also a non fiber sample was prepared. The feautres of the fibres which were known are fiber density, thermal conductivity, melting point, tensile strength. Thermal conductivity of AAC samples were measured by heat flow meter method.SEM was used for microstructural analysis of AAC. Samples were steam cured for 4h at 60°C, partial hardening of AAC cake was observed. Then at 11 bar pressure, autoclaving was done for 7hr at 180°C. Results showed carbon fiber were having the highest thermal conducitvity, carbon fiber were having the highest compressive strength, basalt fiber reduced thermal conductivity while other fibre increased the thermal conductivity. Hence, best properties are in AAC samples were shown by carbon fibre.

Hamdyel-didamony et.al. (2019) [9] conducted a test using OPC, silica, sand, gypsum, lime, GBFS, Al powder, rise husk ash, recycled aggregate to study the fabrication and properties of AAC. Using jaw crusher GBFS was crushed into finer particles, later passed through 71um sieve. Cement is to be replaced by GBFS and rice husk ash and silica fume replaced silica sand. Recycled- AAC waste were placed for 24hr in electric oven at 105°C. Different samples were prepared with different proportions of materials and the standard procedure of AAC was followed. XRD, XRF and SEM were carried out after the AAC samples were prepared. The increase of GBFS and MK results in increment of bulk density because there is a formation of excessive amount of CSH. The increase in the MK dosage showed decrement in compressive strength. Samples containing silica fume were having higher bulk density. Calcium silicate hydrate transforming into tobermorite was seen by SEM and XRD which happened due to silicate sources.

Chenna Rao Borra et. al.(2015) [10] conducted a test using bauxite residue to now the leaching of rare earth metals. Bauxite residue waas taken from Greece. It was received from a refinery of alumina and then after dewatering by filter presses was done. Drying of sample was done for 12h at 105°C. Reagents like nitric acid, hydrochloric acid, sulphuric acid, citric acid and methane sulfonic acid was used. XRF and XRD anlaysis of RM was done. Scanning electron microscopy(SEM) was performed to know the particle morphology. Laser particle analyser was used to know the particle size. Thermo gravimetric analysis was carried out at room temperature to almost 1000°C. leaching with different organic acids was done to study the leaching of elements and pH effect, a decrease in pH was observed when acid concentration increased. Tests with both high and low concentartion acids were performed. In high concentration acid when L/S ratio increased the extraction of elements also increased. Results showed that 0.1wt% REE were present in residue. REE extraction was highest with HCl compared to other. Scandium in the residue is closely associated with iron.

Mansour Ghalenovi et.al. (2019) [11] conducted a test using red mud(RM), granite, marble, super plasticizer, limestone powder to study effect on self compacting concrete. RM production exceeds 117 million tonnes worldwide, having six major oxides. RM has high alkanity which is harmful to the environment, dumping of RM is also economically inefficient. RM is compatible with steel reinforcement and cement because of high pH, containing mineral compunds like goosecrekite, gidmondine, epistibite. It has been studied that adding GW produced ground micro filler effect which enhanced the concrete production. The voids between the sand grains are filled up by MW. Due to the low pozzolonic effect, MW and GW are more favourable in concrete mixed than sand. Sampling was done according to ASTM C311(2018a). Different samples were prepared with replacement of 2.5%, 5%, 7.5%, 10% of cement by RM. Slump flow and T500 time tests were performed as per ASTM C1611(2018), these tests observed a reduction of workability with increase in RM dosage. Which was due to high surface area and porosity(RM). Tweleve samples each were prepared and tested for tensile strength, compressive strength, electrical resistivity, water absorption, ultrasound pulse velocity. Results showed that compressive strength reduced due to increase in RM dosage. Using MW increased absorption of water. Hence, replacing cement with increasing RM reduced the durability of concrete.

M.A. khairul et.al. (2018) [12] conducted various methods to get the efficient method to treat RM which is produced during bayer's process and due to high alkanity RM needs to be disposed off as it can cause harm to the environment. Efficient recycling needs to be done to get the crucial metals seprated from the waste. Surface area of RM is 10 to 30m2/g. The major method used dry stacking, safe disposal is done by this method. Many other suitable methods are explained by the author to tackle the waste red mud which include both chemical and industrial ways. These methods are to be updated and introduction of new methods should be there because as per study due to low level of land fill available, industries dump there waste in sea which pollute the environment. Hence, effective and new methods should be practiced.

Shuqiong Luo et. al. (2019)[13] conducted a analysis of waste(RM) from alumina industry using various test like XRD, SEM, thermogravimetric analysis (TG) and DTG. Chinese standard were used – GB-175-2007. XRF was used to know the chemical composition of both RM and portland cement. TG was used to phases of decompostion of RM..400 to 4000cm-1` was the range of FTIR. Partlice size analyser was used for size identification RM. 40mm cubes were casted, which were tested at 3, 7, 28 days interval. Results showed that calcined RM at 1000°C increases the strength of PC. At 28 days pure cement paste is comparable in terms of compressive strength of paste containing 30% calcined RM. Cancrinite and brinessite decompose to form gehlenite and nepheline during calcination of RM (900 and 1000°C), that means change in morphology takes place and particle size of RM increases.

Yuantao liu et.al. (2019) [14] conducted a test using Ammonium dihydrogen sulphate, red mud, magnesia powder, sodium trisulphate to know the effect of RM on properties of magnesium phosphate cement. Dead burned magnesia powder was imported, calcined at 1600°C for 5hr. Magnesia powder was having a specific surface area of 399.26m2/kg, having diameter of 28.70 um. Properties of fresh mortar were checked like setting time, temperature evaluation, flowing table test all under chinese standards. Strength measurement and water resistance were examined at room temperature of 20°C. after the flexural strength test the same samples wgere used for compressive strength. Tests such as XRD, LF-NMR , SEM were done to analyze the behaviour of MPC. Results showed that MPC showed higher working properties, 272.5 was the increment in the fluidity value with a reduction in exothermic reaction intensity. Increase in water resisitance was observed by addition of RM from 10% to 40%. The microstrcutre analyses represented that a amount of RM can make the structure more denser by simply resucing the porosity along with smaller pores.

B. yuan et. al.(2017) [15] conducted a test using cement, GGBFS, aluminum powder, $CaSO_4$, CaO, SiO_2, Na_2CO_3. Full replacemennt of cement was done by sodium carbonate activated slag.

To complete the replacements certain stages were formed, solution was formed (Alkali activator) after 20 min Stage 1 material were added like Quartz, $Ca(OH)_2$. After 2 min stage 2 material were added CaO, Slag, $CaSO_4$. Then after 3min Foaming agent was added (Al). In stage 3 casting was done followed by green body development & after this autoclaving at 187°C was done. The samples were demoulded on the same day after 12hours. Certain tests like SEM for AS AAC were done done to study the microstructure using different sodium carbonate quantity. Hardened state analysis were done for raw density and compressive strength values. A higher value of Al in the chain of tobermorite was observed in AS AAC sample than ref sample. ASSAC sample shows good thermal properties, Cost reduction, reduced environmental impact & poor strength than the ref. sample. Results showed that compressive strength decreased by 25%, thermal conductivity increased by 18%, drying shrinkage increased by 5%.

I.M. Nikbin et.al. (2017) [16] conducted a analysis of environmental impacts of bauxite residue in red mud. RM was having a specific gravity of 2.65, natural river sand was used with fineness modulus of 2.85, PPC type 2 cement was used, 19mm is the maximum size of coarse aggregate having specific gravity of 2.6. The code used were of ASTM. Samples were made of 100mm cubic in shape. Samples of 150°300mm cylinderical shape were made for checking split tensile strength and elasticity test. An ultrasonic device (PUNDIT) was used to measure the ultrasonic waves having an accuracy of 0.1us, operated as per ASTM. Results showed that as the dosage of RM increased the compressive strength decrease, low pozzolanic property is the reason. Good filling capacity was observed in RM due to smaller size. The same nature was observed in tensile strength because of the low pozzolonaic property. On adding RM modulus of elasticity also decreased. Flexural strength also decreases with increase in RM. Dry density was observed between 1685-1780 (kg/m3). While increment in RM was done it was seen that water abosrption also increased, because to the porosity. When RM dosage was increased it was seen that the velocity of ultrasonic waves decreased.

H. Beltagui et.al. (2017) [17] conducted a test to study the impact on microstucture of AAC by mix design and materials. Materials used are pulverised fuel ash , two type of sands both of high silica composition(92%), while PFA showed lower silica content(52%) than the sands, cement, silt, Al powder, lime. Three mix designs were prepared of different C/S ratio. Different size of moulds were prepared with autoclaving at 180°C upto 12hr at 12.6 bar. Compressive strength and density of all the mix designs were determined, and the mineralogical analysis using XRD was done. Though the two type of sands were having same silica content but the sand 2 showed a reduction of compressive strength, SEM showed that the sand 1 particles were porous and round whereas sand 2 particles were less porous and angular. Results showed that the silica sources which are to be used in AAC should not be considered only on silica content but the type of silica present should be analysed.

Zewu Fu et.al.(2012) [18] conducted a test using cement, lime, Al powder, river sand, and admixtures to study basic property of AAC and effect of mix ratio test. Basic tests for cement like specific surface area, intial and final setting, compressive and flexural strength as per china standards. Block strength and drying shrinkage were also tested according to china standards. the strength of the block will decrease if porosity increases. Results showed that amplitude and water permeable depth rise due to strong capability of water absorbing of AAC blocks and the volumetric water absorption was at high rate in the beginning but later dropped at a rapid rate.

Amit raj et.al.(2019) [19] conducted a study to examine the bond strength of AAC. In the study the author conducted the basic tests of AAC blocks under indian standards. Three types of sand-cement mortar were prepared, characterised on the bases of strength that is strong, medium and weak mortar, polymer modified mortar(PMM) was also used to study the binding strength. To study the tensile bond and shear bond strength of the masonary triplet and couplet masonary were used. In masonary triplet of Ordinary Sand-cement mortar was having a very low shear strength, 0.02-.0.43 Mpa was the shear bond strength range of all the mortars. In cross-couplet samples tensile bond strength was between 0.01-0.28Mpa. Results showed that PMM was having more shear bond strength. Samples with leanest cement content showed lower shear bond strength. Highest tensile bond strength was showed by PMM sample. Hence, mortars with ultra high bonding strength are not prefferable as the same results can be achieved with ordinary mortar along with cement slurry coating.

Zhan Li et.al.(2017) [20] conducted a test using AAC masonary walls under vented gas explosions. As we know that the AAC blocks offer high fire resistence, low thermal conductivity etc and are used as both load bearing walls and non-load bearing walls, these blocks can be used in many industry's to reduce the probability of failure of structure under explosions or natural calamity the tests were carried to make the AAC structure's safe. A testing setup was formed using concentration analyzer, fuel cylinder, high voltage power source, explosion proof fan, and water tank. Three wassc specimens were created, to achieve the desired explosions different gas concentrations and vent cover were used. Methane was the gas used for the explosion directly piped into RC chamber, various sensors like pressure sensor, displacement tranducer were also used. Results showed that boundary conditions and masonary wall thickness effect the wall responses. AAC walls should be used with caution under response to the gas explosion loads.

Pawel Walczak et.al.(2015) [21] conducted a test using fly ash in density 350kg/m3 in AAC as environmentally friendly material. PGS process technology is used to add fly ash to the AAC mixer. Fly ash is used as it is a major waste material and can help in reducing the U-value of the buildings. Material used were quick lime, gypsum, surfactant, Al powder and fly ash, XRD and XRF of the mentioned materials were done. Results showed that fly ash in density 350kg/m3 can be ysed in the production of autoclaved aerated concrete. AAC incoporating sand lower

thermal density than the AAC having fly ash of the same density. Product of hydration Sand based AAC is more crystalline than the fly ash AAC. AAC in lower density increases transportation , reduction in environment degradation and causes reduction in thickness of external walls.

Jan Koci et.al.(2017) [22] coducted a test for identifying moisture diffusivity of AAC in smooth two- variable function. Here the two variable function are moisture content and temperature. Inverse analysis were carried on all samples after the series of labrotary experiments. AAC of two type were studied, having different compressive strength and bulk density. The basic parameters were identified such as bulk density, open porosity, specific heat capacity, thermal conductivity in water saturated state, thermal conductivity in dry state, matrix density. Computational analysis where done to identify the two variables. Results showed a good relationship between simulated data and experimental data. Moisture diffusivity can be easily connected into current computational models. Hence, this can help to improve the accuracy of simulated hygrothermal performance of the various building materials.

Zdislawa Owsiak et.al. (2015) [23] conducted a test to study the properties of AAC with halloysite under various industrial conditions. AAC with slow-setting silicate was used, to examine the effect of halloysite powder. Halloysite powder is used as admixture to fabricate the AAC. Standard process of manufacturing of AAC was followed, with tests like XRF, XRD, SEM. Different dosages of halloysite were added to study the effect. Results showed that cement when replaced by halloysite by 5.5% increases strength by 5.8% having same bulk density of

AAC. Addition of halloysite did not reduce the thermal insulation parameter and bulk density also did not increase. During autoclaving tobermorite and quartz residual appeared as primary phase in the study. Under hydrothermal conditionds needle like crytals of tobermorite were found.

Antanas Laukaitis et.al.(2011) [24] conducted a test on AAC using mechanically treated carbon fibre additives. The material used were mild lime, quartz sand, cement, aluminium paste as gas foaming agent. Sample were prepared by using ball mill, laser analyser was used later to determine the size. 0.53Mpa was the flexural strength of AAC without carbon fibre(CF), addition of CF increased the flexural strength. In AAC samples volume density increased by 3-8%, volume density is main parameter of AAC blocks. 2.52Mpa was the compressive strength of AAC without CF. 6% to 22% of compressive strength is incresed due to addition of any type of CF. XRD analyses of sample were done which showed that during hardening tobermorite and calcined were formed and some of the sand particles remained unreacted. Results showed by XRD analysis were confirmed by DSC analyses. Samples with CF additive experience thermal decrease in the thermal deformation. Results showed that crushing degree of CF also had an positive effect on the crystallinity on AAC material.

Watchapong Wongkeo et.al.(2011)[25] conducted a study using bottom ash as a replacement of cement in AAC to determine compressive strength, flexural strength and thermal conductivity. With standard AAC material, calcium hydroxide was also used. Mix proportions of binder/sand/calcium hydroxide which was used is 55:40:5%, BA was used as partial replacement to cement. XRD and DTG analysis were done of all the material and AAC samples. Small peaks of C3S and C2S were shown in XRD along with $Ca(OH)_2$ phases. Cement content were replaced by BA at different proportions and for different proportions compressive strength, flexural strength and thermal conductivity were determined. Flexural strength incresed with BA contents. Increase in density of LWC resulted in increase of thermal conductivity. Compressive strength also increased with increased dosage of BA.

Rostislav Drchytka et. al. (2015) [26] conducted a test using fly ash to study the microstructure of AAC and physical and mechaincal tests on samples containing fly ash. One fluidized combustion ash (FBC) along with two high temperatures fly ashes, flyash here is contributing for silicate. Desulphurizatin gypsum(flue gas) was used as in auxillary material with lime as binder. Samples of 100mm cubic in shape were prepared to find bulk density, compressive strength, coefficient of thermal conductivity(hot wire method). Results showed that in samples containing 13% FBC admixute had a decrement in bulk density. XRD and SEM of the samples were performed after 2 years of storage, calcium-aluminate-silicate-hydrates and considerable ettringite were formed during 2 years storage. SEM results were also positive which showed crystal structures. Hence, results showed that FBC had an negative effect on formation of mineral. Increase in compressive strength and bulk density was observed in samples which were under storage for 2 years.

Rana Shabbar et.al. (2011) [27] conducted a test to study the effect of temperature and various curing method on AAC. Raw materials whivh were used cement, sand, Aluminum powder, super-plasticizer. Nine different mixes of100mm cubic shape were prepared and were cured at 100-140°C at 0-2.6 bar pressure for 12 hr. Compressive strength and density tests were performed after 7 days. Results showed that by increasing the curing temperature the dry density and compressive strength of AAC increased. Curing of samples by water curing decreased the compressive strength, high steam curing showed greater strength. Autoclaving till 120°C increased the compressive strength and bulk density.

Rongsheng Xu et.al. (2019) [28] conducted a test on AAC using wood fiber produced with wood waste. The wood fiber preparing process starts with collecting waste pine scraps then poaching them into softened pine scraps, later shredding of original wood fiber is done followed by alkali or coupling treatment to get the wood fiber. Different samples were prepared incoporating varying dosages of wood fiber and polyester fiber. Results showed that fluidity and swollen heights decreased with addition of wood fibre and polyester fiber in range from 0.1%- 0.5%. thermal conducitivity of both polyester fibre and wood fibre samples increased while the porosity decreased for both. Mechanical strength of wood fiber increased at specific dosage of 0.4%.

Rendi Wu et.al.(2019) [29] conducted a test using fludized bed combustion ash in AAC with effect of superplasticizer, mainly to solve the problem of high water abosrption. Chemical composition of the raw material was determined using XRF. Glycerol alcohol method was used to determine free calcium oxide content. Chinese standard were used for fluidity measurements. Compressive strength and bulk density were also measured using the chinese standards. microstructure of the samples was analysed by XRD from 5° to 70°, which showed samples containing PCE had no harmful effects on the hydration products. Results showed that rheology of the slurry were affected by water reducing agent and changes in water consumption. Addition of water reducer had a great change in the porosity of AAC samples, mainly macroscopic pore structure. Hence, the problem of high water absorption in preparing AAC can be solved by using PCE.

Muhammad Saeed Zafar et.al.(2020) [30] conducted a test using waste granite dust replacing sand in AAC. Raw materials which were used are cement, high quartz sand, quick lime, Al powder, all were prepared as per ASTM. In mix designs lime and cement content are kept constants. Samples of different composition of WGD were prepared upto 20%. Tests like XRD, XRF, SEM, TGA and acid attack. Results showed that WGD incoporation in AAC reduced environment degradtion by using the granite waste. XRD of samples showed that particles of WGD were rough, angular and flaky, particle size was 1.06um which was resulted in higher pozzolanic reactivity. Incorporation of WGD reduced the porosity and water absorption, increased the hardened density and compressive strength of AAC. Physio-mechanical properties were increased by the densified microstructure due to tobermorite. Samples containing WGD improved the AAC samples against acid attack by 54%.

M.Kalpana et.al.(2019) [31] wrote a review on autoclaved areated concrete. The author stated the adavantages and disadvantages of AAC over conventional concrete. Author also studied various other production methods and there effects on porosity, compressive strength and thermal conductivity. Author concluded that AAC are highly resistant to earthquake. Better balance of AAC blocks was studied due to mild weight.

Baris Binici et.al, (2019) [32] conducted a test on AAC infill walls. Infill walls elements which provide heat, sound insulation and fire resistance. Comined action of in plane and out-of- plane seismic demand were studied. Six samples of AAC infill RC(reinforce concrete) were prepared to test the presense of the gap between the frame and infill wall. The details of samples which were shown are wall frame interface, infill overlay, loading, concrete strength, compressive strength of AAC blocks, compressive strength of plaster, tensile strength of fibre mesh. Results showed that AAC infill walls were prone to cracking at low deformation in the absence of plaster layer. Addition of fibre mesh plaster reduced the drift capacity and eleminated the visible cracking. Infill performance was not afftected by the gap between the AAC infill layer and beam. Hence, during design of AAC walls the out-of plane and in plane demand should be taken into consideration.

Ghasem Pachideh et.al.(2019) [33] conducted a test on AAC, studying the effects of pozzolonaic materials and water absorption. Silica fume, zeolite and granulated blast furnace slag were used at percentage of 7%, 14% and 1% by cement, AAC blocks of 100mm cubic in shape were considered. Tests like water absorption test, compressive strength, tensile strength test, were performed according to ASTM. Results showed that compressive strength can be improved by 84,72 and 200% by the addition of silica fume, granulated blast furnace slag. Water absorption was reduced due to addition of silica fume by 45, 50 and 37%. Water absorption was reduced due to addition of zeolite by 37, 45 and 24%. GGBFS also decreased the water absorption by 13, 24 and 35%. Hence, overall silica fume showed better results in all departments than the zeolite and GGBFS.

Tingshu He et.al.(2018) [34] conducted a test on sand AAC using carbonation modeling analysis to study the effect of carbonation. Steam curing is the method used for manufacturing of cellular sand autoclaved aerated concrete(S AAC). Calcium based phases and carbon dioxide are responsible for reaction of carbonation. There are different kind of carbonation models empirical models, numerical models, simulation models, statistical models. 500kg/m3 was the apparent density of S AAC. The maximum carbonation depth was 100mm with a porosity of 75.22%. XRD, SEM and compressive strength tests were done. Results showed that the value of carbonation rate of ordinary cement were less than S AAC. With a increment in carbonation depth there was a decrease in compressive strength of samples. XRD showed that with increment in calcite and quartz, the tobermorite content decreased.

Rongsheng Xu et.al.(2019) [35] conducted a test using zinc silicate and potassium silicate coating on steel bar used in AAC. A self curing water borne coating was prepared using zinc silicate powder added to potassium silicate solution. Water borne silicate coating as compared to solvent based organic coating has a very less VOC emission. The main film forming material are litium silicate, potassium silicate and sodium silicate. The reagents used were 3-Glycidyloxypropy1-trimethoxysilina(coupling agent), hydroxypropyl-methyl-cellulos(thickening agent), dibutyl phosphate (defoamer). Mechanical properties were calculated using powerful electromechanical testing machine. XRD, elctrochemical impedance spectroscopy(EIS), potentiodynamic polarization(PDP) tests were also done. Results showed that bonding strength and impact resistance decrease with a inncrement in the zinc silicate from 40wt% to 60wt%.

Bonding between AAC matrix and coated steel bar increased with the formation of calcium silicate hydrate.

Lixiong Cai et.al.(2019) [36] conducted a test using thermal oven and microwave pre curing process on carbide slag AAC. In the study carbide slag replaced the role of quicklime. Rough body strength, foaming course and mechanical properties were analysed. Thermo-technical analysis and XRF tests were performed on samples. The bulk density, compressive strength fluctuate irregularly with increase in thermal oven temperature. Using microwave technology in pre curing the increasing temperature from 40°C to 60°C decreased the bulk density, specific strength and compressive strength varied. Both the pre-curing process barely showed difference in the physic- mechanical properties. In the gasification stage the microwave pre-curing process showed excellent product performance through the formation of porous structure in the AAC samples. Microwave heating technology is economical and energy saving in manufacturing AAC only in long term.

Shuai-Qi Tian et.al. (2019) [37] conducted a test using paraffin in AAC for improving thermal storage performance and effective thermal conductivity by fractal modeling. Three type of AAC with different porosities were impregnated with RT28 paraffin. AAC samples used were having bulk density of 300kg/m3, 400kg/m3 and 600kg/m3, these samples were soaked into liquid phase changing materials(PCM). Results showed with increasing paraffin content the thermal conductivity increased, while decreasing the porosity. The study concluded that the fractal model showed good results for thermal conductivity and the corresponding porosity. The study showed that a paraffin dosage of two thirds of saturation level is sufficient for optimal overall performance.

CHAPTER 3

METHODOLOGY

3.1 Materials

Portland pozzolana cement (PPC), Lime , Gypsum, Aluminium powder, Aluminium dross, Rm and sand are used in this study. RM was obtained from Gujarat, Nangal enterprise. Aluminium dross was obtained from Mumbai, Kiran metal works. Lime and gypsum were transported from chandigarh, manufactured in Rajasthan. Aluminium dross will be used as pore forming agent replacing costly Aluminium powder. White dross is used because it is having high alimuina content than the black dross. Two samples of alumina were transported from mumbai one was having high alumina and a rough surface with large particle size and the other one having fine particle size. RM and aluminum dross are used to replace partial amount of cement and aluminum powder in AAC at different dosages. The X-ray diffraction(XRD) pattern of aluminium dross and RM are shown . The chemical composition(XRF) of Aluminium dross, cement, RM are shown . The raw materials used conformed the requirements of AAC as per Indian standards.

3.2 Tests

XRD was done to know the mineralogical phase analysis of Aluminium dross and RM using Panalytical's X'Pert Pro. X-ray fluorescence(XRF) was done to know the chemical composition of Aluminium dust, cement & RM using wavelength dispersive X-ray Fluorescence-S8 Tiger from buker, germany. Above mentioned tests were done at SAIF Panjab university,chandigarh. Various tests for cement were also done like specific gravity, intial and final setting time, fineness test, consistency test, soundness test and the corresponding values are shown in Table 1. Fineness of the cement was determined using 90 micron sieve and the criteria is that the detained cement on sieve shall not be more than 10%of the taken weight of cement initially.

Soundness was test by Le Chatelier method, the expansion should be less than 10mm as per IS 4031(Part3) 1988. Soundness can be affected by addition impurities like sulphates and quick lime. The setting time of PPC using vicat apparatus as per IS 4031(Part5) 1988, 30min(Minimum) for intial setting and for final setting time 600min(Maximum). After the production of AAC blocks the following tests will also be performed : Block density, compressive strength, Thermal conductivity, Drying shrinkage. For block density the specimen should be weighted before drying(W1), after oven drying the specimen at 105°C the specimen should again be weighted until constant weight is obtained within 4 hours (W). therefore, block density and moisture content can we known as per IS:6441(Part1)-1972. The wet density is determined by first taking the dry weight of AAC blocks and then putting them in water bath for 24hr. After 24 hr the AAC blocks are again weighted and absorption rate is determined and also the wet density is calculated. The compressive strength can be determined using compression testing machine as per IS:6441(Part5)-1972. Thermal conductivity of the specimen can be determined from IS:3346-1980. For testing nine samples were prepared with dimensions 650mm×150mm×200mm, three samples for every test were considered.

3.3 Sample preparation

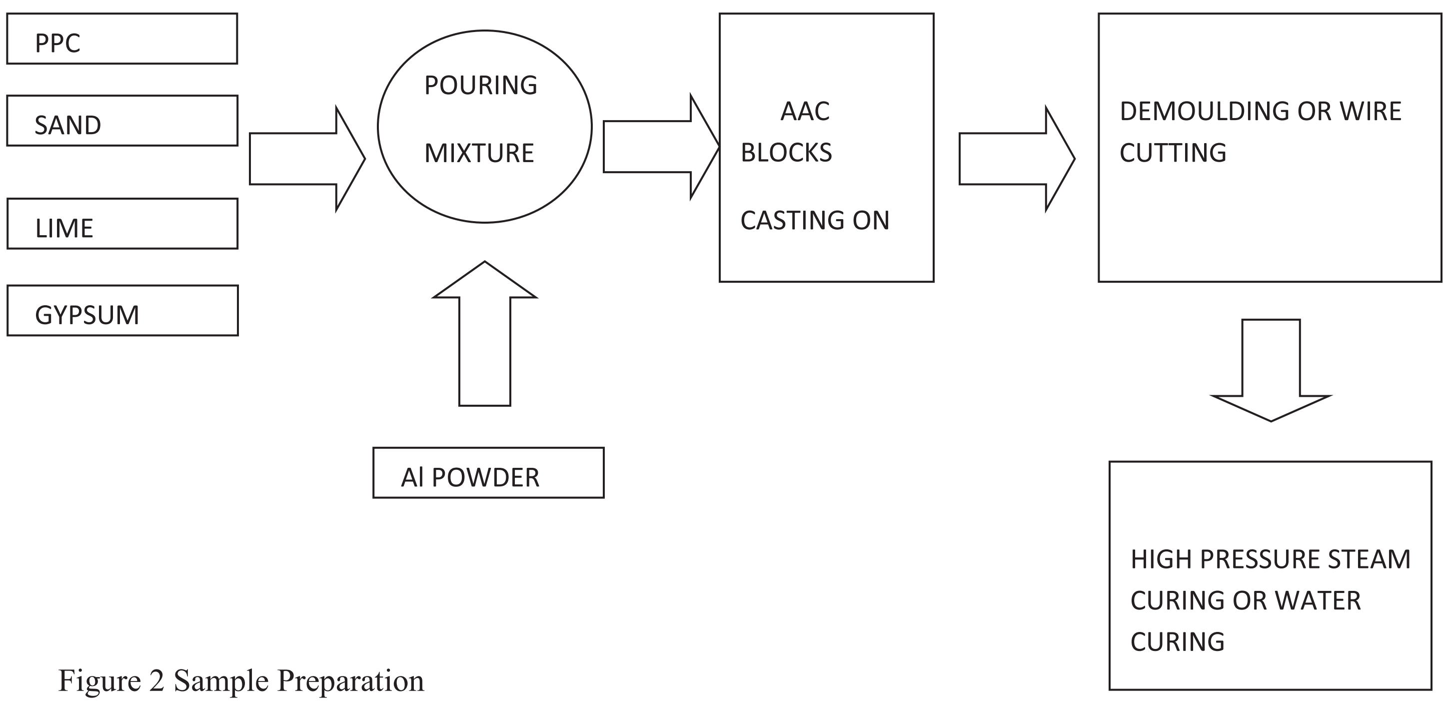


Figure 2 Sample Preparation

Step1- Raw material preparation

List of required materials and specifications are mentioned below:

- CEMENT- Portland pozzolanic cement will be used for the manufacturing of AAC
    - blocks.
- ALUMINUM POWDER- Aluminum powder (98%) was imported from Bangalore, BFC lab..

- LIMESTONE POWDER- Lime powder required for the production is imported from Rajasthan.

- GYPSUM- Readily available in the market(POP).

- RED MUD- A waste material produced during Bayer's process from Bauxite ore.

- ALUMINIUM DROSS- A waste material produced during aluminum smelting.

Step 2- Dosing and mixing

The mixing of all the materials did not be exceed 5-6min. A mixing unit is to be used for the mixing of cement, lime, gypsum, RM, aluminum dross and water, continue mixing for 2-3 min after slurry formation takes place feed aluminum powder into the mixing container. After the mixing is properly done the product is poured into the moulds. The moulds should be greased or oiled before pouring the slurry. The material should be poured as soon as possible into material to avoid hardening of cement in the mixing container. The RM and aluminum dross were also added after the testing of standard sample.

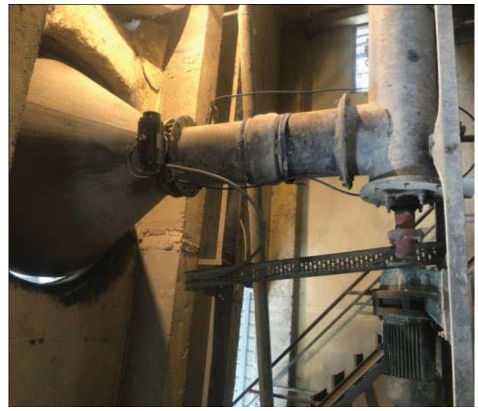


FIG 3- Container for mixing raw materials FIG 4- Separate container for mixing aluminum powder

Step 3- Casting, Rising & curing

After mixing the raw material, it is poured into moulds. Different moulds can be prepared depending upon the producer. Nominal dimensions as per IS:2185 (Part3)-1984 are Length-400mm,500mm,600mm , Height-200mm, 250mm, 300mm, Width-100mm, 150mm, 200mm, 250mm. Maximum variation in the length should not be more or less than 5mm and there variations in width or height should not be more or less than 3mm. The moulds should be well greased before casting. Aluminum powder reacts with calcium hydroxide and water which leads to formation of hydrogen gas and expansion of slurry mix. Formation of bubbles takes place which is the reason for light weight of AAC blocks. Rising takes around 2-3 hours. The rising completely depends on the pore formation, which depends on the amount of aluminum powder dosage. AAC is cured in autoclave, under large pressure vessel. Dimensions of the autoclave are 3m diameter and 45 meter in length. Pressure inside the autoclave ranges from 800kPa-1200kPa and temperature 220°C. Water curing is also to be performed to see the differnce in the mechanical properties of AAC blocks.

FIG 5- Casted AAC in mould.

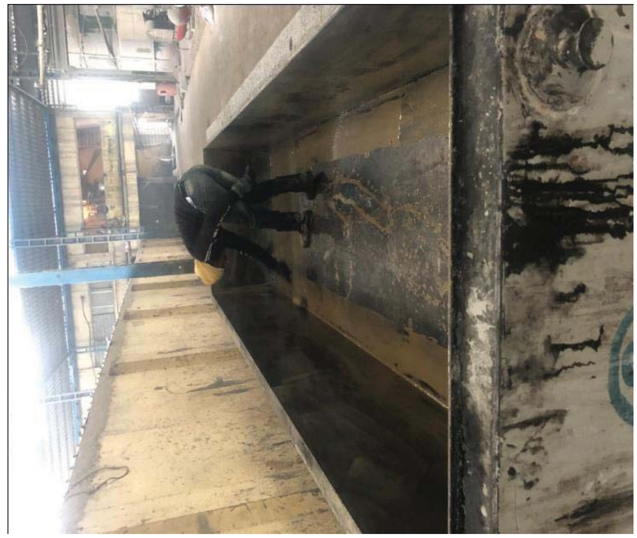


FIG 6- Greasing of mould.

Step 4- Demoulding or cutting

Wire cutting is done during large scale manufacturing of AAC blocks. The size on the AAC blocks can adjusted through these wire cutting method.-When the green cake reaches certain strength to be autoclaved, it is demoulded and cut into desired dimensions. After demoulding the AAC block samples can be cured either by water curing or by autoclaving at high temperature and pressure. The one which we performed is autoclaving and decided to test for water curing also.

FIG 7- Autoclaving euipment

FIG 8- AAC blocks after cutting into desired dimensions ready to be autoclaved.

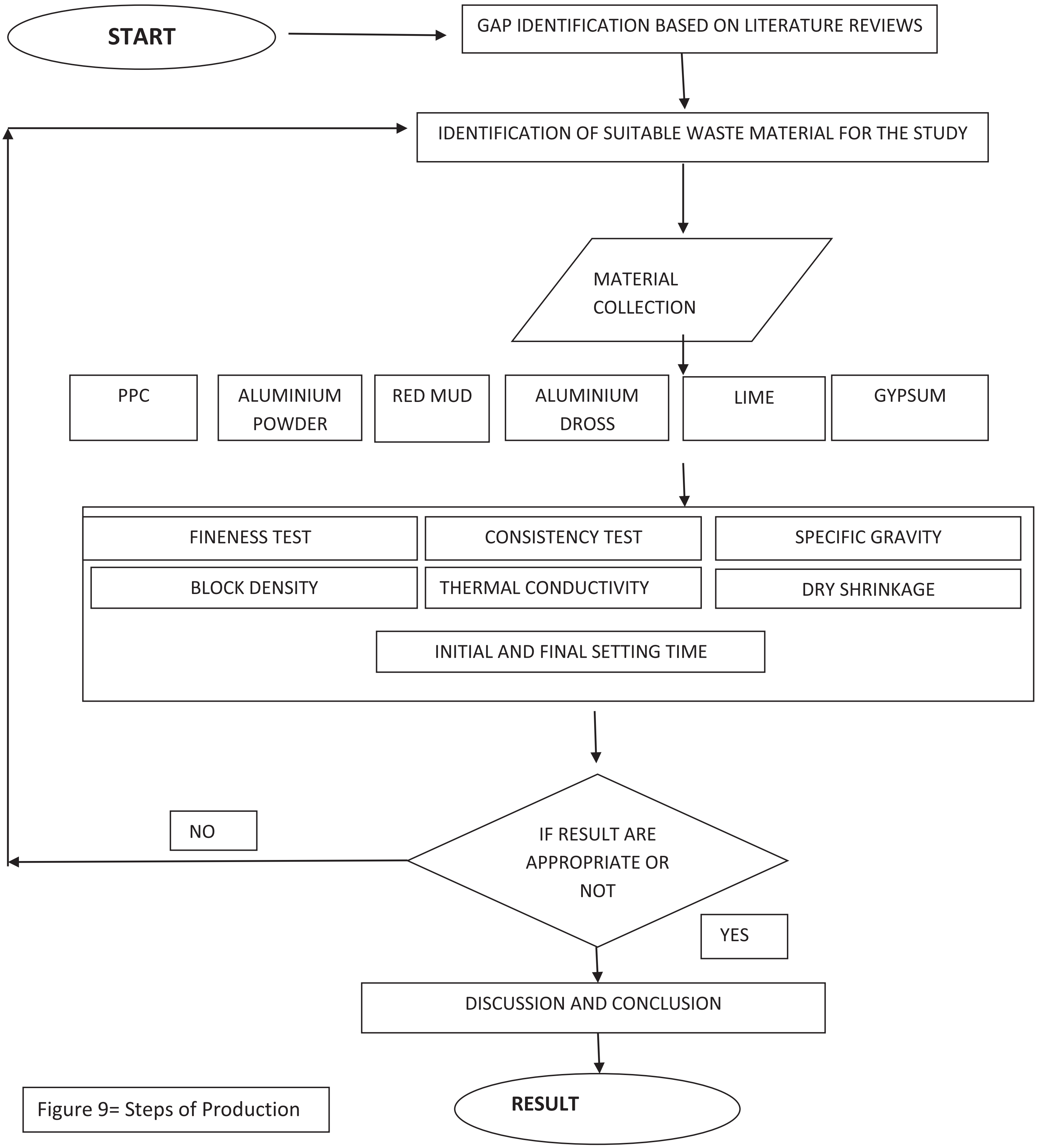


Figure 9= Steps of Production

CHAPTER 4

RESULTS

General

In the study we tested 9 samples of AAC block, 3c sample for each test is used. The tests which were performed were compressive strength test, density test & water absorption test. Table 5 shows the value of compressive strength & density as per Indian standard and following results are obtained.

Table 1 CEMENT PROPERTIES

CEMENT TESTS	VALUES
Specific gravity	2.489
Consistency test	34%
Fineness test	0.1%
Intial and final setting time	Initial=130min & Final= 7hr 30min
Soundness test	expansion= 1mm

The specific gravity of Portland- pozzolona cement is around 2.60 as per IS: 2720 (Part 3). There are two methods to find the Specific Gravity of Cement, Le Chatelier's flask method and Specific Gravity Bottle. Specific Gravity Bottle was used to determine the Specific Gravity of cement which is close to the prescribed value. Fineness of the cement was determined using 90 micron seive as per IS: 4031(Part2)-1988. The criteria is that the detained cement on sieve shall not be more than 10% of the taken cement quantity. Soundness test can be done by two methods Le-Chatelier method and Autoclave method. The apparatus for conducting Le-Chatelier test shall conform IS:5514-1969.The expansion should be less than 10mm as per IS 4031(Part3)-1988 and our value is satisfying the Indian standards. The setting time of PPC was determined using Vicat apparatus, 30min(Minimum) for initial setting and 600min(Maximum) for final setting. The apparatus used for consistency test should conform IS:5513 -1976 and the plunger used should penetrate 5mm-7mm only

XRF TEST

XRF (X-ray fluorescence) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when is excited by a primary X-ray source. Each of the elements present in a sample produces a set of characteristic fluroscent X-ray that is unique for that specific element. The rays which are used in the test are gamma rays. XRD test is to performed after the samples has been found to study the change in the elemental composition of AAC blocks.

Table 2 XRF tests

	Aluminum Dross%	**Bauxite Mud%**	**Cement%**
Al2O3	78.59	32.75	14.30
SiO2	10.04	37.76	30.88
Na2O	3.19	0.08	0.30
Cl	2.47	0.05	0.02
MgO	1.65	0.14	2.16
Fe2O3	1.12	25.17	3.73
CaO	1.06	0.31	41.90
TiO2	0.42	3.16	0.98
K2O	0.30	0.18	1.53
SO3	0.26	0.03	3.69
CuO	0.21	0.01	75PPM
NiO	0.02	83PPM	83PPM

XRD TEST

This test determines the molecular and atomic structure of crystal. In the test the beam of X- rays diffract into many specific directions after coming into contact with crystalline structures. The crystallographer produces a three dimensional picture by measuring angles and intensities of diffracted beams, which shows the density of electrons in the crystal of the specific material. The intensity of rays were increased from 0 to 3500(a.u.) and the angle was taken from 0° to 70°. The chemical bonds, crystallographic disorder, positions of atoms and various other information can be determined from the electron density. The peak in the results shows the extent of the crystallinity of the material in particular plane. The graph has a shifted peak because of varying material content in the sample.

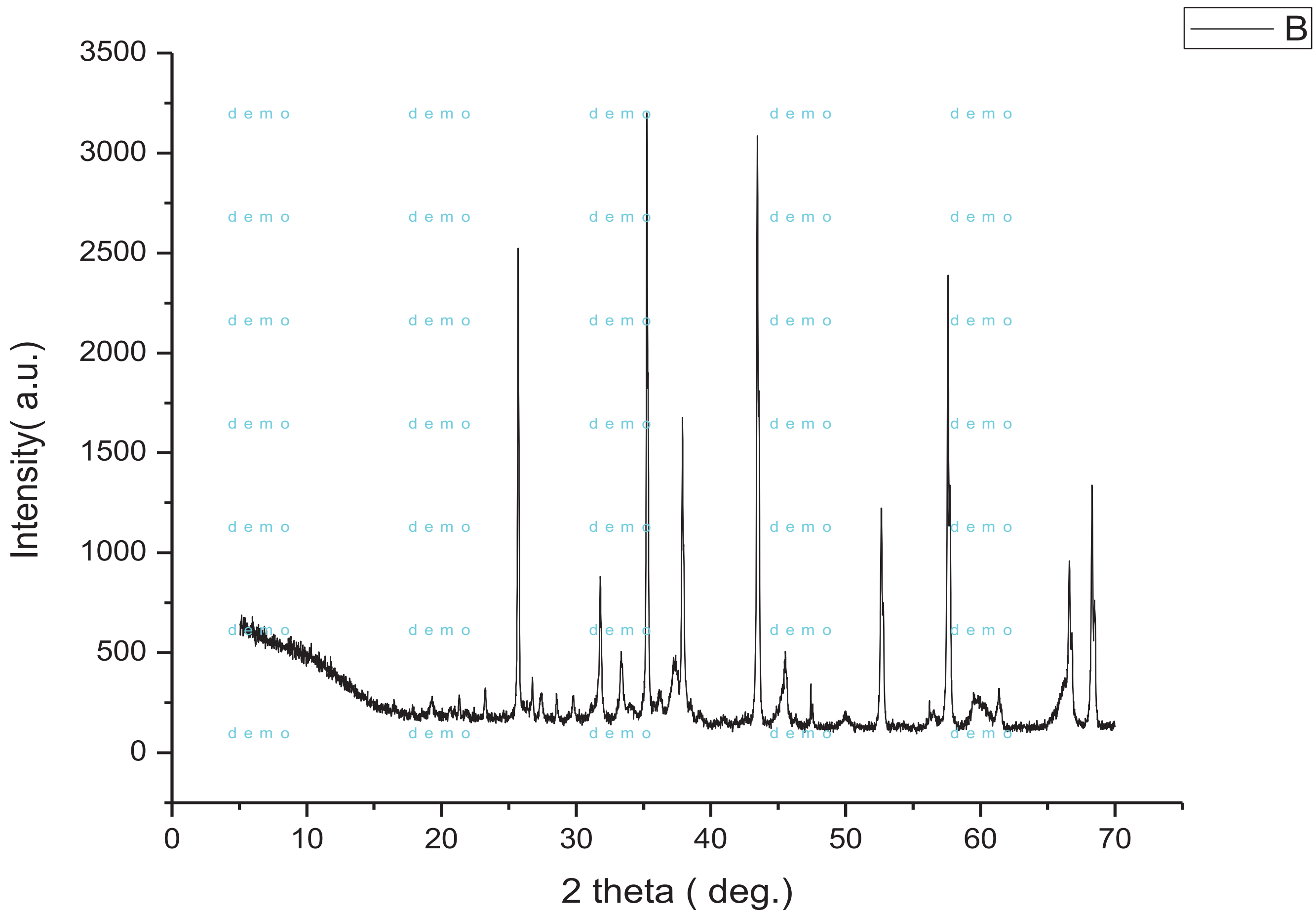


Table 3 Density Test of AAC Blocks:

DIMENSION	VOLUME	WEIGHT	DENSITY=volume/weight
650mm×150mm×200mm	19500cm3	13450 gm	680kg/m3
650mm×150mm×200mm	19500cm3	13450 gm	680kg/m3
650mm×150mm×200mm	19500cm3	13450gm	680kg/m3

Table 4 Compressive Strength Test of AAC Blocks:

DIMENSION	AREA	APPLIED LOAD (KN)	COMPRESSIVE STRENGTH= Applied load/area
650mm×150mm×200mm	30000mm2	120	4N/mm2
650mm×150mm×200mm	30000mm2	120	4N/mm2
650mm×150mm×200mm	30000mm2	120	4N/mm2

FIG 10- AAC block for submerged in water. FIG 11: AAC block tested under UTM.

FIG 12- Specific Gravity Bottle.

FIG 13: AAC block Failure Pattern

FIG14- AAC block having high alumina content

FIG15-AAC block having low alumina content

Table 5 Indian Standards for AAC Block:

DRY DENSITY (kg/m3)	COMPRESSIVE STRENGTH (GRADE1) N/mm2	COMPRESSIVE STRENGTH(GRADE2) N/mm2
451 -550	2	1.5
551-650	4	3
651-750	5	4
751-850	6	5
851-1000	7	6

CHAPTER 5

CONCLUSION

Results showed the AAC blocks were of GRADE 2 as per Indian standards and is can used as replacement to ordinary Brick. Due to light weight they were easy to transport and helps in reducing the Dead load of the structure. These are also available in different dimensions , can fit individual requirement. The aluminum powder and aluminum dross play a major role in compressive strength as the content of aluminum powder or dross in AAC blocks can increase or decrease the porosity of the AAC. The FIG 11 is having high dosage of aluminum which lead to breaking from corners even on holding the sample, whereas FIG 2 is having slighlty lower dosage of aluminum which lead to good strength. The content of alumina also showed a change in the colour of AAC blocks.

REFERENCE

1. Luo, S., Liu, M., Yang, L., Chang, J., Yang, W., Yan, X., … Shen, Y. (2019). Utilization of waste from alumina industry to produce sustainable cement-based materials. Construction and Building Materials, 229, 116795.
2. Laukaitis, A., Kerienė, J., Kligys, M., Mikulskis, D., &Lekūnaitė, L. (2012). Influence of mechanically treated carbon fibre additives on structure formation and properties of autoclaved aerated concrete. Construction and Building Materials, 26(1), 362–371.
3. Li, X. G., Liu, Z. L., Lv, Y., Cai, L. X., Jiang, D. B., Jiang, W. G., & Jian, S. (2018). Utilization of municipal solid waste incineration bottom ash in autoclaved aerated concrete. Construction and Building Materials, 178, 175–182.
4. Cai, L., Li, X., Liu, W., Ma, B., &Lv, Y. (2019). The slurry and physical-mechanical performance of autoclaved aerated concrete with high content solid wastes: Effect of grinding process. Construction and Building Materials, 218, 28–39.
5. El-Didamony, H., Amer, A. A., Mohammed, M. S., & El-Hakim, M. A. (2019). Fabrication and properties of autoclaved aerated concrete containing agriculture and industrial solid wastes. Journal of Building Engineering, 22, 528–538.
6. Huang, X. Y., Ni, W., Cui, W. H., Wang, Z. J., & Zhu, L. P. (2012). Preparation of autoclaved aerated concrete using copper tailings and blast furnace slag. Construction and Building Materials, 27(1), 1–5.
7. Ghalehnovi, M., Roshan, N., Hakak, E., Shamsabadi, E. A., & de Brito, J. (2019). Effect of red mud (bauxite residue) as cement replacement on the properties of self-compacting concrete incorporating various fillers. Journal of Cleaner Production, 240, 118213.
8. Qin, L., & Gao, X. (2019). Recycling of waste autoclaved aerated concrete powder in Portland cement by accelerated carbonation. Waste Management, 89, 254–264.
9. on the structure and properties of autoclaved aerated concrete produced with the stone-sawing mud. Construction and Building Materials, 184, 20–26.
10. Liu, Y., Qin, Z., & Chen, B. (2020). Experimental research on magnesium phosphate cements modified by red mud. Construction and Building Materials, 231, 117131.
11. Liu, Y., Leong, B. S., Hu, Z. T., & Yang, E. H. (2017). Autoclaved aerated concrete incorporating waste aluminum dust as foaming agent. Construction and Building Materials, 148, 140–147.

12. Kunchariyakun, K., Asavapisit, S., &Sinyoung, S. (2018). Influence of partial sand replacement by black rice husk ash and bagasse ash on properties of autoclaved aerated concrete under different temperatures and times. Construction and Building Materials, 173, 220–227.
13. Khairul, M. A., Zanganeh, J., &Moghtaderi, B. (2019). The composition, recycling and utilisation of Bayer red mud. Resources, Conservation and Recycling, 141(September 2018), 483–498.
14. Li, Z., Chen, L., Fang, Q., Hao, H., Zhang, Y., Chen, W., … Bao, Q. (2017). Study of autoclaved aerated concrete masonry walls under vented gas explosions. Engineering Structures, 141, 444–460.
15. Pehlivanli, Z. O., Uzun, I., Yücel, Z. P., & Demir, I. (2016). The effect of different fiber reinforcement on the thermal and mechanical properties of autoclaved aerated concrete. Construction and Building Materials, 112, 325–330.
16. Drochytka, R., &Helanová, E. (2015). Development of microstructure of the fly ash aerated concrete in time. Procedia Engineering, 108, 624–631.
17. Owsiak, Z., Sołtys, A., Sztąboroski, P., & Mazur, M. (2015). Properties of autoclaved aerated concrete with halloysite under industrial conditions. Procedia Engineering, 108, 214–219.
18. Wongkeo, W., Thongsanitgarn, P., Pimraksa, K., &Chaipanich, A. (2012). Compressive strength, flexural strength and thermal conductivity of autoclaved concrete block made using bottom ash as cement replacement materials. Materials and Design, 35, 434–439.
19. Nikbin, I. M., Aliaghazadeh, M., ShCharkhtab, &Fathollahpour, A. (2016). Environmental impacts and mechanical properties of lightweight concrete containing bauxite residue (red mud). Journal of Cleaner Production, 172, 2683–2694.
20. Borra, C. R., Pontikes, Y., Binnemans, K., & Van Gerven, T. (2015). Leaching of rare earths from bauxite residue (red mud). Minerals Engineering, 76, 20–27.
21. Walczak, P., Szymański, P., &Rózycka, A. (2015). Autoclaved Aerated Concrete based on Fly Ash in Density 350kg/m3 as an Environmentally Friendly Material for Energy - Efficient Constructions. Procedia Engineering, 122(Orsdce), 39–46.
22. Kočí, J., Korecký, T., &Černý, R. (2017). Identification of Moisture Diffusivity of Autoclaved Aerated Concrete in the Form of Smooth Two-Variable Function. Energy Procedia, 132, 219–224.
23. Andrei, R., Iernutan, A., & Babota, F. (2019). ScienceDirect Numerical simulations for autoclaved aerated concrete (AAC) masonry modules reinforced with columns of disperse reinforced concrete Costing models for capacity optimization in Industry between used capacity and operational efficiency. 0–7.

24. Binici, B., Canbay, E., Aldemir, A., Ozan, I., & Uzgan, U. (2019). Seismic behavior and improvement of autoclaved aerated concrete in fi ll walls. 193(April), 68–81.
25. Cai, L., Tang, T., Liu, M., & Xie, D. (2020). Comparative study of carbide slag autoclaved aerated concrete (AAC) manufactured under thermal oven and microwave pre-curing process : Foaming course , rough body strength and physic-mechanical properties. 236, 1–11.
26. Chen, Y., Chang, J., Lai, Y., & Chou, M. M. (2017). A comprehensive study on the production of autoclaved aerated concrete : Effects of silica-lime-cement composition and autoclaving conditions. 153, 622–629.
27. El-didamony, H., Amer, A. A., Mohammed, M. S., & El-hakim, M. A. (2019). Fabrication and properties of autoclaved aerated concrete containing agriculture and industrial solid wastes. 22(January), 528–538.
28. He, T., Xu, R., Chen, C., Yang, L., Yang, R., & Da, Y. (2018). Carbonation modeling analysis on carbonation behavior of sand autoclaved aerated concrete. 189, 102–108.
29. He, T., Xu, R., Da, Y., Yang, R., Chen, C., & Liu, Y. (2019). Experimental study of high-performance autoclaved aerated concrete produced with recycled wood fi bre and rubber powder. 234, 559–567.
30. He, X., Zheng, Z., Yang, J., Su, Y., Wang, T., Zheng, Z., … Wang, T. (2019). Journal Pre-proof.
31. Kalpana, M., & Mohith, S. (2019). Materials Today : Proceedings Study on autoclaved aerated concrete : Review. (xxxx), 10–12.
32. Kočí, J., Korecký, T., & Černý, R. (2017). ScienceDirect ScienceDirect Identification of Moisture Diffusivity of Autoclaved Aerated Concrete in the Form of Smooth Two-Variable Function Assessing the feasibility of using the heat demand-outdoor temperature function for a district heat demand forecast.
33. Pachideh, G., & Gholhaki, M. (2019). E ff ect of pozzolanic materials on mechanical properties and water absorption of autoclaved aerated concrete. 26(February).
34. Pietras, D., & Sadowski, T. (2019). A numerical model for description of mechanical behaviour of a Functionally Graded Autoclaved Aerated Concrete created on the basis of experimental results for homogenous Autoclaved Aerated Concretes with different porosities. 204, 839–848.

35. Qin, L., & Gao, X. (2019). Recycling of waste autoclaved aerated concrete powder in Portland cement by accelerated carbonation. 89, 254–264.
36. Saeed, M., Javed, U., Arsalan, R., Nawaz, A., & Zafar, T. (2020). Sustainable incorporation of waste granite dust as partial replacement of sand in autoclave aerated concrete. 250.
37. Stasiak, M., Bochenek, M., & Musielak, G. (2018). International Journal of Heat and Mass Transfer Assessment of a new method for determining the relationship between effective diffusivity and moisture concentration – Exemplified by autoclaved aerated concrete of four density classes. 124, 288–297.
38. Tian, S., Yu, S., Wang, X., Fan, L., Yu, Z., Xu, X., & Ge, J. (2019). Experimental determination and fractal modeling of the e ff ective thermal conductivity of autoclave aerated concrete (AAC) impregnated with para ffi n for improved thermal storage performance. 163(January).
39. Wan, H., Hu, Y., Liu, G., & Qu, Y. (2018). Study on the structure and properties of autoclaved aerated concrete produced with the stone-sawing mud. 184, 20–26.
40. Wu, R., Dai, S., Jian, S., Huang, J., Lv, Y., & Li, B. (2020). Utilization of the circulating fluidized bed combustion ash in autoclaved aerated concrete : Effect of superplasticizer. 237.
41. Xu, R., He, T., Da, Y., Liu, Y., Li, J., & Chen, C. (2019). Utilizing wood fiber produced with wood waste to reinforce autoclaved aerated concrete. 208, 242–249.
42. Xu, R., He, T., Yang, R., Da, Y., & Chen, C. (2020). Application zinc silicate-potassium silicate coating for anticorrosion of steel bar in autoclaved aerated concrete. 237.

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

PLAGIARISM VERIFICATION REPORT

Date: ...30/05/2020...........

Type of Document (Tick): PhD Thesis | M.Tech Dissertation/ Report | B.Tech Project Report ✓ | Paper

Name: Harjot Singh **Department:** Civil Engineering **Enrolment No** 161627

Contact No. +91-7006548998 **E-mail.** harjotsingh603143@gmail.com

Name of the Supervisor: Dr.Amardeep Boora

Title of the Thesis/Dissertation/Project Report/Paper (In Capital letters):

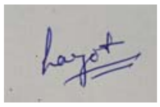
AUTOCLAVED AERATED CONCRETE INCORPORATING BAUXITE MUD AND ALUMINIUM DROSS

UNDERTAKING

I undertake that I am aware of the plagiarism related norms/ regulations, if I found guilty of any plagiarism and copyright violations in the above thesis/report even after award of degree, the University reserves the rights to withdraw/revoke my degree/report. Kindly allow me to avail Plagiarism verification report for the document mentioned above.

Complete Thesis/Report Pages Detail:

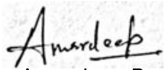
- Total No. of Pages = 42
- Total No. of Preliminary pages = 8
- Total No. of pages accommodate bibliography/references = 4



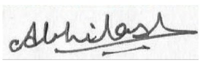
(Signature of Student)

FOR DEPARTMENT USE

We have checked the thesis/report as per norms and found **Similarity Index** at ....13.........(%). Therefore, we are forwarding the complete thesis/report for final plagiarism check. The plagiarism verification report may be handed over to the candidate.



Dr. Amardeep Boora



Mr. Abhilash Shukla

(Signature of Guide/Supervisor)

Prof. Dr. Ashok Kumar Gupta

Signature of HOD

FOR LRC USE

The above document was scanned for plagiarism check. The outcome of the same is reported below:

Copy Received on	Excluded	Similarity Index (%)	Generated Plagiarism Report Details (Title, Abstract & Chapters)	
28-May-2020	• All Preliminary Pages • Bibliography/Images/Quotes • 14 Words String	13 %	Word Counts	10696
Report Generated on			Character Counts	56373
28-May-2020		**Submission ID**	Total Pages Scanned	42
		1333226644	File Size	2.02 Mb

Checked by
Name & Signature **Librarian**

....

Please send your complete thesis/report in (PDF) with Title Page, Abstract and Chapters in (Word File) through the supervisor at **plagcheck.juit@gmail.com**