THE EFFECTS OF DIFFERENT PROPERTIES OF LIMESTONE ON THE MECHANICAL PROPERTIES OF ADOBE

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ABSTRACT

Soil is the oldest and largest source of structures on since long time, Statistics show that about nearly 30% of the Earths still inhabitants live in mud buildings, particularly in rural areas and cities located in the ancient archaeological plains and valleys surrounded by vast plains, 50% represents a civilized nation. Earth climatic economic environment-friendly is used in a broad and large-scale construction around the world, especially in those countries that not possess large plant life on its territory. The use of the soil before ten thousand years as a major source for the building, along with stones and still some of the remnant of those buildings found until now. In this study, adobe with different proportions of Limestone. Meanwhile, the control is pure adobe which does not have limestone. In addition, different proportions of Limestone are 10%,20% and 30%. There are two types of tests conducted, cubes were subjected to compressive strength test and beams were subjected to flexural strength test. All the specimens were 7 days in air then 7 days in Ventilated Oven with T= 40 C.

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LIST OF ABBRREVIATIONS

BS	British Standard
ASTM	American Standard Test Method
POC	Ordinary Portland Cement
RAC	Recycled Aggregate Concrete
RC	Reinforced Concrete

LIST OF SYMBOLS

N/mm2	Newton per millimeter square
KN	Kilonewton
N	Newton
mm	Millimeter
m	Meter
MPa	Megapascal
Kg	Kilogram

CHATER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Soil is the oldest and largest source of structures on since long time, Statistics show that about nearly 30% of the Earth's still inhabitants live in mud buildings, particularly in rural areas and cities located in the ancient archaeological plains and valleys surrounded by vast plains, 50% represents a civilized nations. Earth climatic economic environment-friendly is used in a broad and large-scale construction around the world, especially in those countries that not possess large plant life on its territory. The use of the soil before ten thousand years as a major source for the building, along with stones and still some of the remnant of those buildings found until now, as in Shibam Hadramout which was considered the largest city skyscrapers in the world with a height of up some of those buildings about 30 meters, Was founded in the third century, also old Sana'a, which was founded in the fifth century BC, and the city of global Akhri in South Africa and other many. In Portugal the use of building materials mud commonplace in the mid-twentieth century between 1950s-1970s. This method has been replaced gradually by reinforcement concrete structural, used as a more powerful and longer combined with ceramic brick walls. (Dora Silveira, 2011)

Furthermore, adobe is the Arabic word originally, was used more widely in the Spanish language means building materials made of earth or clay mixed with some organic materials. It is manufactured from materials easy access to it, a water and soil are often in the vast land of the globe that’s makes Adobe is a cheap cost , materials are available and often mated by local’s communities. Ground bricks were used in the center of Mexico sometime before the culture of Latin America and to build one of the largest pyramids in the world known as Agran (The big pyramid) done build this magnificent structure to eight consecutive stages each stage is greater

than before. And most likely are making Adobe bricks into small units and weighing 100 grams, is small enough not to exceed in order to be a dry process quick and easy, without cracking and collected at a later date (Fulvio Parisi D. A., 2014).

However, it was the beginning of starting a study in modern when it was discovered the remains of the walls of Roman well saved Adobe origin and belonging. The have been discovered in the archaeological site of the Italian city of Antioch in 2004. This consists of brick walls - the raw land tied together stacked rectangular shape is completely dry, with a thin layer of clay and mud between each other, the dimension of bricks $0.31 \times 0.46 \times 0.13\ m^3$. Romanian knew very well that they cannot brick-making from the soil only, strongly great pressure due to the excessive speed of contraction that cause cracks making it invalid bricks to the construction process, so the Romans added to the mixture some of materials such as sand and wood at a low rate. Adobe components actually reinforced concrete components are similar in terms of structure and additions. Moreover, Roma added vegetable fiber, straw and dry leaves that reduces shrink, and most of the piece its ability to release water slowly.

In addition, Adobe material available, easy to make, readily available materials, it also has the characteristics of Thermography as a natural conditioning, its do not lose heat and don't quickly gained high to make them maintain a temperature average daily fluctuations in light air. This characteristic of Adobe contributed to the survival Pearls now, despite the scientific revolution and technological materials that allowed much more powerful pressure (Juliana A. Calabria, 2009).

Bricks made from adobe are often done through a mixture of mud and then pressed and placed in wooden intended for these purpose templates. In Yemen, the brick is typically about 25 cm width and 36 cm length in terms of size. After drying for several hours is converted to the edge to finish drying so that it is slow drying to reduce cracking. The same mixture without adding straw used to industry plaster and put it on the walls of the home and abroad to protect Damage of rain, this way is work in some cultures, including Yemen. It can have to add some of the material that may be working to increase the compressive strength and the Mod, wood, fiber, small sand and cement. Studies and past experience has demonstrated that the addition of these materials enhances the compressive strength at Adobe. Depending on the template you are pressed, Adobe that can include any shape or size, provided the complete drying to ensure that no cracking.

In spite of the benefits that's given by built-up brick buildings Adobe, the building of Adobe, which are not reinforced properly when built, this type of construction can respond minor and devastating in the event of some earthquakes due to the properties of Adobe, Mass great, limited tensile strength, the fragile behavior, and loss of strength when saturated with water. Can such structures suffer from damage to large and it may lead to collapse, causing the huge number of casualties.

In 2001, a major earthquake occurred at a rate of 8.4, the areas affected by Peru's Arequipa, Moquegua and Tacna, causing the collapse of the house of 36000, 25,000 of them built of adobe bricks, causing the deaths of nearly 81 people. In the same year, two earthquakes occurred in both of El Salvador, with 7.7 to 6.6 MW, causing landslides in gross rivers where nearly 200,000 homes house of adobe and the loss of 1,100 people. In 2007, another earthquake along the coast of Peru happened 0.169 km north of the capital, southeast of Lima.

The weakness of these structures, especially in seismic zones most at risk, spared us to side with non-exhibition states seismic risk, all of this justifies the work of the investigation and audit, development and attempt to raise the efficiency of mud structures commensurate with the

1.2 PROBLEM STATEMENT

Nowadays, the use of adobe reduced utilization in the building because of the weakness of adobe structures and availability of construction materials manufactured. There are some recommendations and technic are really popular actual marketing and building lobbies. In 2010, ASTM stipulates the first recommendations guide that may be offers more legal future to adobe constructions. In some countries, such as Argentina it prevents construction with Adobe because of the seriousness of this type of construction in seismic places. Two earthquakes have occurred in this country in 1861 in the city of Mendoza, and also in 1945 in the city of San Juan’s. Yet still this kind of construction is common in rural areas for financial reasons. (Dominique Daudon, 2014).

Largest cities are built of adobe had been destroyed in the past and also the present time where was the fort of Bam in eastern Iran, the largest city built of adobe, it destroy before in 2003 after a devastating earthquake. Has been built fortified city on the Silk Road from Adobe in the first century before was inhabited until 2003 earthquake and this carry Adobe for centuries it appears. However, this feature does not apply to seismic zones. This is due to the weakness that

had not been strengthen the construction by adding some reinforcements inside the walls, and also inside the adobe and walls have not Compaction so as to ensure its resistance to earthquakes. This is to avoid this weakness by adding some vegetable fiber, and also add some sand. (Dominique Daudon, 2014).

Despite the many advantages and brilliant Adobe however, this type of construction is losing steam and ability in cohesion and tensile if not properly enhances and strong. It loses this type of construction and its ability to respond badly in cases of earthquakes due to the characteristics of adobe building in terms of the mass and limited big tensile behavior and fragile, and also to the loss of its strength when saturated with water. This kind of weaknesses in the construction Adobe can we observe in some cases when an earthquake anywhere there is construction of adobe. Leaving many of the victims, and also to humanitarian material losses. (Varum, 2012).

Also, there is another problem facing this type of construction used Adobe, problem of saturation by water. This type of construction is facing a big problem in terms of saturation with water; especially in areas has a lot of raining. We know that the climate of the earth continuously variable, in my country, for example Yemen, there are two essential elements for building is Adobe, and also stones. In a time of construction popularized with Adobe because of the ease of comparing construction of stones, in that period was little rainfall rate and seasonal, and sometimes it was a rare occurrence, which encouraged in a lot of adobe construction. now it is differed circumstances climatic where rainfall is increasingly periods long rate increased, causing the collapse of some buildings mud in some areas, making residents are rushing to develop some solutions to immediate and necessary to limit the erosion of the structures and crack through the construction by coating the walls of adobe by concrete. To ensure the cohesion of the cement layer coating is put nails on the walls in abundance and left half Distance those nails far back in history, in the sense long screws inside the walls of adobe and leave the other half showed so as to ensure coherence between the coated layer of cement and adobe walls. (Vandna Sharma B. M., 2016).

What happens for construction when an earthquake occurs? Because of the weakness of tensile strength when the soil leads to the walls spacing from each other in corners of the construction. Beginning from top of the building, the walls become independence from each other’s. They become separate elements with no lateral stability. The failure occurs in terms of

shear. If the joint of walls has been controlled it will impossible to separate each other's. In adobe walls, the better horizontal pressure on the surface with vertical that could stop failure of shear and turn the appearance of diagonal cracks. Finally, the failure due overturning. Once the walls become independence by bending failures or once they start to cracks and break, they behave as independence rigid structures and the weight walls sponsor the occurrence of collapse.

Adobe load-bearing walls, that is, they carry the load instead of any other structure cannot carrying their place as the buildings of concrete reinforcement, because the piece has to be for Adobe to possess enough pressure to be able to withstand the load. In most building codes must be a minimum of compressive strength of at least 300lbf/in2 (2.07 newton/mm2) for Adobe bricks. Adobe construction should design the structural walls in order to avoid some of the side loads, and those side loads earthquakes, storms, powerful, and also to the nearby explosions that would create a large compression strength side.

To improve the mechanical strength to build Adobe by adds some natural fibers. The use of natural fibers and local product, especially in developing countries is more beneficial to the abundance of this type of natural product, also to the limited capacity of the economic and physical disease These people. The production of this nature fiber is low cost, easy production and familiar to the environment. All of these factors contributed to reconsider to revive the use of adobe construction, try to add these materials to increase the power and the ability to Adobe structures. It has been observed in previous experiments that there is evolution and improvement to build Adobe When you add fiber and also coconut, wheat straw, bamboo and cane. Has been studying the effects of synthetic fibers in the construction of adobe it has been compared with the impact of natural fibers for Adobe. When you add vegetable fiber to mixture of Adobe will helps to delay contraction when drying, which prevents cracking and increases strength and tensile strength. This is what I want to achieve to have a better in the draft to improve this kind of adobe structures. (Younoussa Millogo J.-C. , 2013).

1.3 OBJECTIVES:

The main objectives for this research are:

i. To investigate the effects of different limestone proportion on compressive strength of adobe.

ii. To investigate the effects of different limestone proportion on flexural strength of Adobe.

1.4 Scope of research

In this research, this project focused on the effects of different proportions of limestone on the Flexural and compressive strengths of adobe cubes and beams.

Samples	Type of test	Mix percentage 100%	NO. Of Samples	Curing
Control Cube Samples	Compression strength test	Adobe 100%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Cube samples with limestone of 10%	Compression strength test	Adobe 90% limestone 10%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Cube samples with limestone of 20%	Compression strength test	Adobe 80% limestone 20%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Cube samples with limestone of 30%	Compression strength test	Adobe 70% limestone 30%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Control beam Samples	Flexural strength test	Adobe 100%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C

Beam samples with limestone of 10%	Flexural strength test	Adobe 90% limestone 10%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Beam samples with limestone of 20%	Flexural strength test	Adobe 80% limestone 20%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Beam samples with limestone of 30%	Flexural strength test	Adobe 70% limestone 30%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C

The water quantity will be 20% of mixture weight.

CHAPTER 2

LITERATURE REVIEW

2.1 THEORETICAL BACKGROUND

Adobe buildings are located in many countries of the world and often are promote brick by adding straw and vegetable fiber to enhance the strength and durability. Often Adobe consists of water, soil, sand, fibers or natural fibers. Many trials of fiber and straw additive have been conducted for Adobe to know influence and change in the strength of Adobe. Mostly, the manufacture of Adobe manually without the need for industrial tools. Conducted a lot of experiments to determine the effect of adding fiber to Adobe. It was found that the impact on Adobe in increased strength and tensile including increases the effectiveness of adobe construction. It was the work of several tests in terms of pressure, flexibility and tension. Adobe has added fiber was marked by an increase in strength and flexibility and tensile factor. (Fulvio Parisi D. A., 2014).

However, there are experiments began far beyond the increase the power of Adobe added fiber. Some experiments worked to learn the capabilities of Adobe neutralize radiation of Adobe in preventing the transmission of sound in the room. Add feature Adobe friendship in the environment when produced. And also to study Adobe advantage in the natural air-conditioning in the countries hot and cold on the end either. And some studies have worked on the study of fiber types and the biggest impact on the increase the strength of Adobe. Lignin lineage in vegetable fiber works increase impermeability. Lignin in vegetable fiber added to Adobe works to differential shrinkage when drying prevents from cracks in the soil matrix. Works to reduce the

speed of drying leads to reduce the speed of contraction prevents cracks. The study added feature of vegetable fiber on the level close without studying for a long stability for several decades. (Younoussa Millogo J.-C. , 2014).

More than that, there are some studies and experiments went out how to rehabilitate and strengthen the historical cities that have been built of adobe. Such buildings weak reinforcement and consolidation may respond poorly and weak with earthquakes, severe storms and wind speed, which may occurs to collapse with the collapse of ancient history. To rehabilitate such adobe construction must know mechanical behavior to build of mud. Studies of the effect of mechanical characterization tests have been conducted for Adobe. Some strength tests were conducted on the square and cylindrical molds for tests passion, cylindrical samples to test division. (Dora Silverira, 2013)

Finally, adobe has been built with Historical Background old and vegetable fiber were added early on that time started the use of adobe construction. Not for the first time is added to vegetable fiber, straw barley but were added, of the Covenant Roman But recent studies is working to increase strength and stiffness Adobe in order to face the threats to its risks in some countries as earthquakes, saturation rains and the risk of explosions from nearby buildings, and also to hurricanes. Due to the weakness of the construction of adobe construction comparing to concrete. It had to be the work of research to enhance strength and durability of adobe building to fit the situation in which we live and the poor class fits that rely on this type of construction.

2.2 METHODOLOGY

(Sukru Yetgin, 2006) Reported that Adobe has been kneading in a large, broad and deep basin so as to ensure uniformity. He later was left to dry and then harden even upside volatility following the evaporation of water in order to ensure all-round at the same rate. And also, when increasing contagious fiber had increased the amount of water a little bit. Adobe mixture formed in the shape of prismatic samples in special in these form templates. And it removed samples of the templates after three days and then left to dry until it became fixed weights. Varied drying period of 14-28 days depending on the content of the water. The work of the two types of samples with Limestone and others without adding Limestone where the dimensions of prism samples

(150 x 150 x 150mm^3) for cubes and (500 x 100 x 100mm^3) for beams. These samples prismatic worked to test the compressive strength and flexural strength of adobe and to understand the importance Additional Limestone or not and to know the difference between them.

(Fulvio Parisi A. P., 2015) Investigated that the effect of straw in the adobe where the volumes straw added between 100 200 400 mm^3 and weight equal to 16.80 kN /m^3 with the difference in coefficient (COV)) equal to 2%. Adobe has been producing through some traditional manufacturers that are still operating in this field in the area of Sardinia, Italy. Where electrical mechanisms used for mixing clay with straw mechanical helicopter that run on straw chopping randomly less than 100 mm length. According to the traditional construction process in the Italian City of Sardinia, in first Phase mixing clay with water and straw by machine confused electrical and then adds straw randomly. After the completion of the process of confusion including to add straw Adobe is formed in makeshift wooden molds prismatic shape. Where the mixture is placed in the wooden molds and then pressing the mixture by hand to ensure the effectiveness of compaction, but without a measurable degree of compaction spectrum. In the last stage of the manufacturing it is left in the sun to ensure the drying of water. The manufacturing process is a process similar to those by traditional manufacturing operations in developing countries in Africa and the Middle East. It has been tested in a tensile prismatic moldings manufactured in the process.

(Vandna Sharma B. M., 2015) Presented two types of samples are two types of geometric shapes, namely: a cylindrical and cubical. The cylindrical shape with dimensions of 38 mm diameter and 76 mm height and cubical shape with dimensions of (190 mm x 190 mm x 190mm). It was the work of a mixture of moist soil with moist soil + cement and moist soil + cement + fiber all the samples 360 (cubical 180: cylindrical, 180). According to the criteria established by the Indian it has been work with these kinds of samples. After the mixing process for all samples were covered with burlap bags in place is not up to them to the sun for one week in custom templates according to the forms previously. During the development of the mixture into the molds has handmade process pressure on the mixture in the form of three stages when filling templates to ensure consistency between the classes in every effort. After briefly samples were removed from the molds and then left to dry in a more.

(Younoussa Millogo K. G.) Used that the selection of quality red soil, which lies in the valley of Desire (France). This quality of the soil containing 45% on the amount of sand 0.30% silt 0.25% of clay. Sieved the soil has been appointed for particles less than 5 mm in size. The soil mixing powder with plant fiber type Hibiscus cannabinus fiber length ranges from 30 mm to 60 mm, up to 0.8% of the weight of the soil. The soil mixing with water by 20% of the soil weight with fibers for 15 minutes until it became homogeneous paste. The difference dough introduced in parallel templates and presses the dough by about 2 MPa to ensure the homogeneity of the mixture. She was drying the mixture in a laboratory at room temperature (average $22C^o$) with humidity of 60% without exposure to the sun until it became a fixed mass of an average three weeks.

(Humphrey Danso D. M., 2015) Soil was used for local City Snini in Ghana to produce Adobe. In this experiment was the use of agricultural waste (coconut husk, and bagasse fibers and oil palm fruit). Soil that has been used with few Leone, where the plasticity index of 13.9 reached, liquid 13.3% and a maximum dry density limit (MDD) 1.78 mg/m^3. Soil used were neutral between alkaline and acidic, reaching pH value of 7.33, this explains what I talked previously about fair. Obtained fibers agricultural waste as coconut husk of the coconut fruit in the sales catalog centers, and also sugar cane fiber and oil palm fruit. Some fibers were overwhelmed by water where it was dried for 48 hours at least so as to be usable. It was used hundred of fiber (of all kinds) randomly selected. Was determined using measurements of some modern instruments, for example, has been using a diameter measuring microscope (LEITZ HM-LUX3) where the body grows by 25 times greater than the naked eye, it has been identified lengths Ba use solid panels where they were taking the average lengths. When the process was confusing to use fiber 1% of the weight of the mixture and the largest and others recommended by the owners of previous experiences in this area ratio. The use of different lengths of fibers 25, 50, 75, 100 and 125 cm. The basic elements used in the mixture (soil and water) also fiber that had been prepared before. Soil was published first, and then deployed fiber from above the soil was then the heart of the soil over and over again until he was getting on a combination of the two equal. After the process of mixing soil with fiber was sprayed water on the piece mixture and mixing it with water again time to get the mixture full process Adobe. It was used machines pressure (hydraulic machines) in the process of forming the mold strongly 100 bars. Drying process in the air outside the open under the sun at a temperature 27 degrees C, relative humidity of 72% for 21 days.

(Subramaniaprasad, 2014) Used a new type of fiber, a fiber average of waste plastic,

where the use of two types of fiber, one made of polyethylene terephthalate (PET) bottles, and the other kind of tote bags (pick up bags). Fiber is manufactured by chopping of waste plastic into small along with almost the same minimum width of 1.2 mm. The longest fiber used in the process 1 and 2 cm. Used fiber waste cut by 0.1 and 0.2% of the dry weight of the soil used. Beside the soil was used cement Ordinary Portland Cement (OPC) ($43C^{o}$) at different rates as a stabilizing factor for the mixture. The use of an additional pressure factor through a digital, at a pressure of 1000 kN and not less applied force through pressure on the mixture for 100 Newton. Before the initiation of a process the mixture has been initiated elements used in the mixture. Initially dry the soil through air-drying, and then cracking the big molecules in the soil after drying, and then sifting the soil is still big objects that exceed 4.75 mm to achieve unity of the mixture. After filtering and drying process is add the amount of cement appropriate amount of soil dried in a tray and mixed several times to get the amount equal Cement in all the mixture. It was chosen the same water (OMC) by up to 14% by weight of the raw soil. And used the same amount of water for all the samples that have been produced. Fiber has been added during the mixing by hand to ensure homogeneity between the cement and the fiber. Mixing continued even get a homogeneous mixture and a fair distribution of fibers in all the mixture. Cylindrical samples have been prepared by filling the mixture into cylindrical form templates with an internal diameter of 101.5 mm and a height of 117 mm and height of 50 mm at the top. The mixture was added to the templates in stages carefully before using the compression pressure autism and durability test machine. After filling the mold with the mixture is still excess layer headlights excess to make level mixture equal to the height of the upper mold. To ensure the stability of the cement samples were placed and linked in jute bags for 28 days prior to the configuration of the test. The samples were dried in the inside laboratory without exposing it to the sun.

(Ghavami, 2004) Used of natural soil from an area near the French city of Lyon famous for a multitude of mud buildings. Featuring soil characteristics of this city with the level of gravel between 2-10 mm, and the content of the sand between 0.06- 2.0 mm, the silt content from 0.002 to 0.06 mm, and the content of the soft clay (Clay) 0.002 mm. The use of key elements of the mixture of gravel by 3%, and 43% sand, silts 42%, and also the soft clay (Clay) by 12%. Sisal fibers were added to the mixture and originating Sisal plants to the bloc's cactuses more linked cohesion. Featuring this type of fiber for strength and flexibility where they are used in the production of conventional ropes and blankets. He have been using this type of fiber in previous experiments have shown strong success factor linking to Adobe. Sisal fibers used in previous experiments with an average length of 20 to 50 mm and an average width 0.1042 mm. Sisal fiber

was added to mixture in the rate of 0.5% of the soil dry weight. Sisal fiber was added by naked hand slowly when mixing process to ensure a uniform distribution of fibers in all the mixture.

(Rakshith P. C., 2016) The use of soil quality available in the Phoenix area multiple sizes and materials damaged. The use of sand particles in this experiment were separated from other sizes by sifting soil through NO.4 No.200 sieves. Where the stones remain in the sieve No. 4 and the remaining sand to sieve No. 200 and for fines pass through a sieve No. 200. Only fines and sand granules were retained and disposed of stones. It was then fines mixing soil with sand granules to obtain a homogeneous mixture was the work of different samples so that they are varying ratios for the granules of sand with fines. Used samples and ratios varying for the production of samples in the first sample (90% sand and 10% of the fines) and sample the second (70% sand and 30% of fines) the third sample (50% sand and 50% of the fines). Portland cement was used for the mixture, taking into account that the sulfur-containing soil consciousness does not affect the hydration of cement. Use the new carbon fiber different from previous experiments, a comminuted sugar cane bagasse passing sieve No. 100.

Cement was added to three samples of 3% and 5% and 7% of the weight of the samples in the respectively, and the ratio of fiber 0.25%, 0.5%, 1% and 2%, respectively. The mixing soil with cement before the former was spraying water on the mixture to ensure the allocation of a block of cement in the soil evenly. And then add fiber to the dry mixture and mix it well. After the process of mixing cement and fiber with the soil is add the amount of water specified in advance and then mixing by hand for three minutes until they get the desired pattern. After the process of mixing the previous been put wet mixture into molds ores in three phases where the soil is stuffing nicely using an iron bar to remove the blanks aerobic within the templates. And then put the templates in the family strongly static pressure, including approximately 10. And then decoding the present of the pressure quickly after the completion of the pressure and put it at a temperature of laboratory 22 ± $2C^o$) to prevent loss of moisture quickly. It was a damp cloth in place to ensure the interaction of cement properly for 28 days before the testing process.

(Bachir Taallah, 2014) Used sandy soil from an area in southern Algeria Biskra east. A soil with Steel erection contains a large amount of gypsum and calcite quart and on the proportion of relatively few of kaolin. It has been added to the ordinary Portland cement to the soil mixture given the importance of sulfates in the soil for added durability. In addition to the soil and cement are added crushed sand with specifications {sand grain size distribution: 3.25% (0.01 to 0.08 mm), 52.83% (0.08 to 1.25 mm) and 43.92% (1.25 to 5 mm)}. Fiber also been added to the

mixture which fibers are extracted from the trunks of palm almost rectangular forms and proportions as follows (300–500mm length and 200–300 mm width). The use of ordinary drinking water that contains a small percentage of sulfur with degree temperature 20 ± 2C^o. Before you start mixing the dry soil and sand in the oven for 24 hours at a temperature of 60C^o. After completion of the drying of the soil and sand for a full day he was mixing the soil with sand and crushed in Mixing Machine for 2 minutes, then add cement to the mixture and crushed for 5 minutes at speeds of 139 rev / min, and then add water and continue mixing for all for 2 minutes. In the final stage of fiber is added to the mixture so that it is confused by hand, and then put the mixture into molds and pressed immediately. Press the mixture into the mold strongly fixed through hydraulic pressure. Templates used sizes (100 200 mm). After the completion of the process of pressure to take samples manually and carefully been keeping the samples at a temperature of the laboratory between 20 ± 2 ° C for 28 days before you start the test

2.3 PREVIOUS FINDING

(Nambiar, 2015) Founded that the results of the experiment that the addition of cement to the mixture leads to a marginal increase in tensile strength. But it's completely different when you add fiber to the mixture which produces Noticeable increase in tensile strength. The addition of fiber in the presence of a small percentage of cement works to a marked increase in tensile strength. The fiber kit showed better performance compared to bottle fibers, an increase of 4.5 times. There are positive and the other to add fiber, an increase in the flexibility of the samples. Add fiber to the raw soil mixture works to a marked increase in tensile strength compared to other samples of raw soil mixture without adding fiber. Add cement works to increase only in the tensile strength and hardness layer headlights for specimens, if not added fiber. When you add cement to a mixture of raw ground, and works to increase the fiber in the process of linkage between crude fiber and soil, which works to increase significantly in tensile strength. The high proportion of cement in the mixture in the presence of fiber works to raise the level of tensile strength.

This improvement and the increase in tensile strength when you add both fiber and cement with some due to the stability of cement over the stability of the mechanical samples, and realized in the low proportion of cement with the addition of fiber. It was found that samples containing 10% of the cement more tensile strength compared with samples that contain 15% of

the cement. This means that the addition of fiber in the presence of a small percentage of cement works to increase the tensile strength and the provision of cement. Experience has shown that the length of the fiber increase works to increase the tensile strength. And experience has shown that bottle fibers give a more robust comparison of samples with fiber kit. The decrease in the number of fiber tensile strength compared with bottle fiber to lower its strength and rigidity. During the test samples showed crude fiber without fail fast and without warning compared with samples fortified with fiber division into two halves. Unlike fortified with fiber samples showed a tensile strength.

(Ghavami, 2004) Founded that experience has shown that the use of fibers from Sisal agent's types 20 and 50 mm increases the tensile strength and relenting, but it turns out that the greater the fiber length increases the level of stress in the sample. When an operation added sampling Sisal fibers reached by between 0.10 and 0.12 MP before reaching the breakage. The test results were less than expected due to problems in mixing the additive when confused. But it remains that adding Sisal fibers to samples is working to increase the tensile strength and flexibility than with samples of fiber is added.

(Humphrey Danso J. W.) Reported that results experience has shown that the addition of coconut fiber to the mixture worked to increase the tensile strength of a sample has reached 61%, 24% and 20% respectively of the coconut, bagasse and oil palm fiber. It was noted that even after the removal of samples from the machine of the test after it divides into two halves are still in a good healthier except for some cracks. This demonstrates that addition of fiber to the samples increases the tensile strength and flexibility. And it indicates that the samples added to the fiber will fail slowly instead of sudden failure. It was concluded that increasing the proportion of fiber in the mixture works to increase in strength and tensile strength and flexibility. A lot of agricultural waste that can be used as fibers in Adobe, which in turn operates in an increase in tensile strength and flexibility. But it must take into account that it is not worth all the contaminated waste increase in the ratio in order to work to increase the tensile strength and flexibility, not originally condition.

(Younoussa Millogo K. G., 2014) Reported that experience has shown that the addition of the results of fibers (Hibiscus cannabinus) a percentage from 0.2 to 0.8% of the raw soil with lengths of 30 mm and weight of 60 it did not increase the tensile strength and flexibility as

expected but improved soil properties. It found that the addition of this quality of fiber has a negative impact on the strength of the pressure but there was a positive sign in terms of tensile strength and that was weak and inadequate. It emerged positive add this quality of fiber in the resistance of the friction and heat conductivity.

(Bachir Taallah ،2014) Founded that it is well known that the addition of natural fibers into the soil mixture works to reduce cracking and increase the tensile strength, but it is unclear in the case of compressed earth blocks. The test showed that the tensile strength less than 700% of the compressive strength. This is pretty much easier than cracking process when applying tensile test. Test results showed that the tensile strength decreases with the high proportion of fiber used in the mixture. In this study, it has been found less tensile strength at 2% of the fiber. Results showed that where the tensile strength rises with the high proportion of cement in the presence of the fiber while taking into consideration the Influence of the high proportion of fiber tensile strength. This is because the negative impact is an increase of palm fibers to the mixture Pearls impairment in the adhesion between the fiber and the matrix, which is caused by the pressure of the mass. Pressure on the block causing the sliding fiber in the Mass, which works on low adhesion between the fiber and the rest of the mixture. While clicking on the block works on a sliding fiber, which in turn collects in, places convergent unequally compared to the rest mass.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Structures throughout the ages and ages predecessor periods may be from the Pharaonic era in Egypt or much before, they knew the soil in terms of plasticity, dislocation, and the movement and the development of the surrounding environment greatly affect and wide on the pressure and hardening properties during construction. That the earth from ancient times to present day and is still a safe haven for all modes of life. Known to man from time immemorial importance of land and how to use them in the architectural field. Since more than five thousand years of man developed his methods of how to build using the soil. Rights machinery has been under construction for several decades starting from the Pharaonic era, flashlight Roman Covenant to this day.

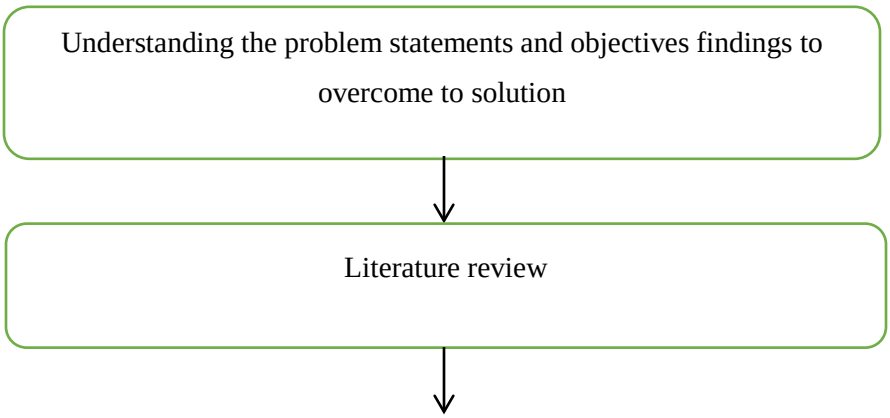
More than that, Romans knew that they couldn't use the soil in the production of Adobe in terms of singular without adding any other materials. So, the process of ancestral methods and ways to improve the user's building from the soil. The Romans had to add some materials as sand soil and agricultural fiber in order to work to visit the tensile strength and pressure in Adobe made from the soil. The Romans knew that they could not be the constructed building of adobe using only the soil to the speed of contraction of the soil, at dry which would lead to cracking and

fragmentation. In order to develop the Romans building strength user of the soil, they worked on the development of methods and techniques used.

Time period's forgotten people this kind of adobe structural, especially in the stages of the discovery of new building materials as cement, the extent of the difference in the compressive strength and tensile strength and flexibility, make the world is heading for new and more powerful types. However, during the fifteen years with Adobe recent renewed interest in the construction of several reasons, including antiquities and ancient mud also the environment and other things. In recent years, fifteen scientists and scholars began to study building more mud and deeper, the researchers seemed to develop and raise the compressive strength and tensile strength and also the flexibility of Adobe. Researchers relied on several ways to add natural fibers including industrial and sometimes add cement with fiber. A lot of research had been successful in the pressure increase the strength and tensile strength and flexibility as well.

The research methodology is an important procedure to securing that the project is proceed smoothly and well while ensuring that the aims that have been proposed are accomplished with satisfactory. Systematic work planning is also very important to assure that this work will be carried out with an organized and successful. The procedure adopted by this research is in progress to illustrate the overall process achieving the objective targets involved in such project.

In the beginning of the study, a flow chart plays an important role to ensure the study progressing according to plan and to avoid any distraction during period preparation. It's too important to arrange the thing that we want to do according to the order. Therefore, the flow chart will make the studies more systematic. Below is a chart flow of the research methodology.



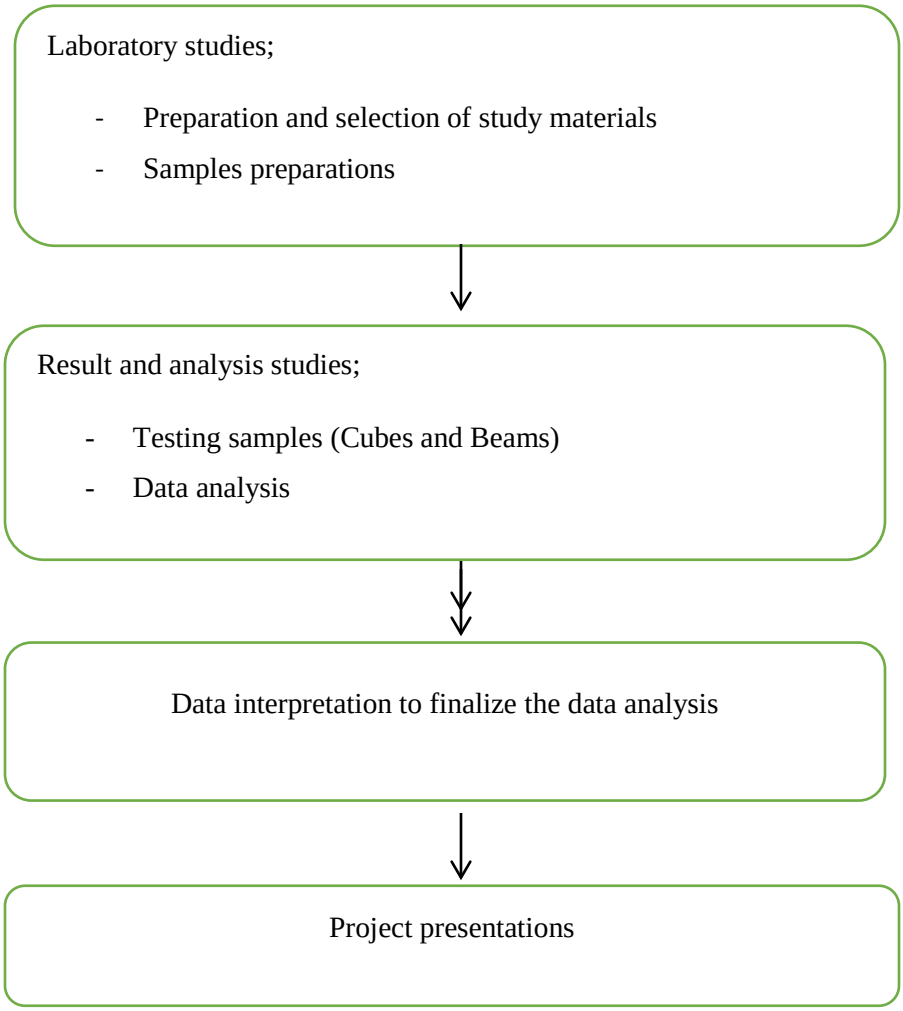


Figure 3. 1: The flow chart of the research methodology

Finally, it can be said that there is still a lot of material that did not work out and perhaps add to the adobe building strength and durability. Perhaps the previous research is adequate and cutter are not such as to develop these types of construction. In order to determine either there are other materials can increase strength of Adobe or not, we have to continue like this kind of research. The research methodology is very important process to insure that the process will go smoothly and the aim that I plan to be achieved and satisfaction

3.3.1 THE MATERILAS USED IN ADOBE MIXING

3.3.1.1 SOIL

Malaysia has limited types of soil originating in the mountainous highlands. Those from the soil of the highlands known as highly weathered. Highlands soil are classified as Oksysls, this type of soil is dominated in its composition kaolinite and hematite, Jbsat and Jaotheit. This type of soil who prevails upon kaolin tends mainly to acidity. In the experiment, which will be carried out by regular soil used in Malaysia as shown in figure 3.2. Where the type of soil in Malaysia are often red soil. Red soil formed in the warm areas of heavy rain and wet air and dense forests. The source of this type of red soil is crystalline rocks. Often these soils are poor and growing, with low dietary difficult content material for the cultivation and humus. It is difficult to transplant to the low water-holding capacity. This type of soil is shifting from sand to mud, where the majority of component mud. This type of soil characteristic of a fragile, vulnerable, poor content of lime and low in dissolved salts. Contain non-soluble materials a percentage of 90.47%, 1.01% and organic materials.

Figure 3. 2: Soil

3.3.1.2 WATER

In the experiment, which I will do will use water drinking non-contaminated, and also water-free from any additions of any Material to drinking water. I will use water that free from any harmful chemicals and only consider the clean water to be used which is the normal water from the tap as shown in figure 3.3.

Figure 3. 3: Water

3.3.1.3 LIMESTONE

Limestone is usually an organic sedimentary rock that forms from the accumulation of shell, coral, algal, and fecal debris. It can also be a chemical sedimentary rock formed by the precipitation of calcium carbonate from lake or ocean water. There are many different names used for limestone. These names are based upon how the rock formed, its appearance or its composition, and other factors. Here are some of the more commonly used varieties such as chalk which is a soft limestone with a very fine texture that is usually white or light gray in color as shown in figure 3.5. It was ordered by the laboratory engineering from a material company.

Figure 3. 5: Limestone

3.3.4 MIXING PROCEDURES

The preparation mixing process had be conducted once all materials needed for mixing are prepared. Firstly, In the process of mixing, will initially work on the mixing Adobe and Limestone. The mixing process of adobe can be done using a concrete mixer machine at FKKSA laboratory. After confirm the specific percentages of the mixing then start to mix the mixture several times to make sure that the mixture contains all the ingredients evenly. After making sure that the mixture has all the ingredients evenly distributed in all over the place, add the water to the mixture and left it briefly in order to penetrate the water in the blanks in the mixture and then start racing mixing until I make sure that the workability of the mixture is ready and I will work to add water to the mixture by approximately 20% of the volume of the mixture. Soil mixing with water for at least 15 minutes until the paste becomes homogeneous.

3.3.5 COMPACTING PROCESS

The process of sample preparation is made after the mixing process properly and evenly. After making sure of the process of mixing water is added by approximately 0.3 m3 per trail mix of each material is used in the preparation of adobe. After the addition of water then waiting for a short period until they are allowing the water Spill into pores and voids soil mixture, and then start mixing for at least 10 minutes until the paste becomes homogeneous. This process can be done when the adobe mixed is ready, the next stage is to prepare the mold that has been set up in the laboratory either for beams or cubs and pour the earth mixing into the mold. After confirm the homogeneity of the mixture, the next stage put dough in custom templates for the formation of the mold according to the shape and dimensions to be out for each of the two types of testing. Dough is placed in the cubes and beams.

3.3.6 CURING THE SPECIMEN

This process is taken into mind as the last steps involved in adobe production. Its advantage is to make sure that hydration process is taken place in a proper way to prevent adobe from being affected by humidity. The curing process was outside door for 7 days and then 7 days at oven in temperature of 40℃. After process of preparation is finished then will take the specimens outside door and waiting period of time before takeoff the moldings to make sure that

the specimens is already drying little bit. It could not take the moldings from the specimens until I make sure that, the workability of the mixture already reduced. After the workability of specimens is already poor, then will take off the moldings. The specimens will protect from the raining by using transparent plastic that the light of sun can enter through. As a result, adobe blocks are to be air-dried for 7 days in the open area then 7 days on oven in temperature of 40℃.

3.3.6 PREPARATION OF SAMPLES

The samples are therefore composing of cubes and beams required for adobe mix. The soil itself is the main component used in this project with different percentages in its compositions. The material compositions are discussed in the beginning of this chapter as shown above in sub-topic 3.3.1. There are about 30 of samples of cylinders with the same percentages in compositions as shown in table 3.2.

In this study, 20 samples can be treated with limestone as partial adobe replacement for both tests while other 10 samples can be considered as a plain samples without using limestone. After the samples were prepared, then some tests can be applied. The main tests used are Compression strength test and Flexural strength test. For both of tests will performed cube and beam shapes. As a result, obtained from both tests, the perfect samples are then used for further discussion to achieve the main objectives of this project.

Table 3. 1: Table of Samples Testing

Samples	Type of test	Mix percentage 100%	NO. Of Samples	Curing
Control Cube Samples	Compression strength test	Adobe 100%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Cube samples with limestone of 10%	Compression strength test	Adobe 90% limestone 10%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C

Cube samples with limestone of 20%	Compression strength test	Adobe 80% limestone 20%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Cube samples with limestone of 30%	Compression strength test	Adobe 70% limestone 30%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Control beam Samples	Flexural strength test	Adobe 100%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Beam samples with limestone of 10%	Flexural strength test	Adobe 90% limestone 10%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Beam samples with limestone of 20%	Flexural strength test	Adobe 80% limestone 20%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C
Beam samples with limestone of 30%	Flexural strength test	Adobe 70% limestone 30%	3 Samples	7 days in air then 7 days in Ventilated Oven with T= 40 C

The water quantity will be 20% of mixture weight.

3.4 COMPRESSIVE STRENGTH TEST

The quality of good Adobe will be identified through this test. Also the value result of this test will be provided the overview of the Compression strength and Flexural strength. In Figure 3, shows a machine utilized in compressive strength test. The test is accordance to BS EN 12390-3:2002. The cube size 150 mm x 150 mm x 150 mm^3 and beam size is 500 mm x 100 mm x 100mm^3.

It is important to make sure that the surface of cube sample is smooth before the test is conducted .the reading value shows in the digital meter are recorded and it will give the value of the maximum load can be sustained by the sample cube concrete before it fails. The compressive strength is expressed in MPa $\left(\frac{N}{mm^2}\right)$ and the load value is recorded and the compressive strength can be calculated by the following formula:

Compressive strength $=\frac{maximum\ load(N)}{surface\ areao\ fcube(mm^2)}$ Equation (1)

3.5 FLEXURAL STRENGTH TEST

Flexural strength is known as modulus of rupture. The modulus of rupture of beam is identified the fails to occur in the tension part. Moreover, it measures the Flexural strength of Adobe and measure of beam to resist failure in bending. it is measured by loading adobe beams with a span length at least 3 times of depth. This test also includes the use of beams sample size 500 mm x 100 mm x 100mm.this test, the four points loading method are utilized and it is determined by British standard(1881:part118:1983). the formula for the flexural strength is: modulus of rupture, $F = \frac{FL}{bd^2}$ Equation (2)

Where

F= maximum applied load

L= beam length (500mm)

b=beam width (100mm)

d=beam depth (100mm)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter show the result gained from all the testing conducted in order to achieve the objectives of this study. All the data and results from the testing have been recorded and analyses in form of graph and table. The samples were prepared into four categories for each test, namely, one category without limestone and other categories with limestone. The samples were labeled and cured using Ventilated oven. The samples are then tasted to gain their compressive strength and flexural strength. A total of 20 cubes and 20 beams were casted and cured in same times. This chapter presents the result obtained from the current study and discusses the result by comparing the samples have limestone with samples without limestone.

4.2 COMPRESSIVE STRENGTH OF ADOBE WITH LIMESTONE

Table 4.1 and Figure 4.1 show the results on compressive strength of adobe soil cube size 150 x 150 x 150mm3. In this section, the compressive strength tests conducted on the samples are presented. The average reading from the Compressive strength test results of five samples of each category. The control samples contain 0% limestone and other samples contain 10%, 20%, and 30% limestone of adobe weight respectively. Samples were casted and labeled then placed through 7 days in air and then 7 days in

oven before being tested. All the specimens were tested using the compression machine in accordance to the ASTM Specification C 579.91. The effect of using different percentage of limestone to compressive strength of Adobe is discussed in this chapter.

4.2.1 COMPRESSIVE STRENGTH OF ADOBE WITH 0% LIMESTONE

Table 4.1 and Figure 4.1 displayed that the average maximum load and average maximum compressive strength of adobe. From the experimental result, the strength developments of compressive strength of adobe without limestone were analyzed.

Table 4.1 Compressive strength and load of adobe with 0% limestone

No. OF sample	Max load KN	Compressive Strength (N/mm2)
1	5.01	0.2227
2	4.74	0.2107
3	4.97	0.2209
4	5.01	0.2226
5	4.85	0.2157
Average	4.93	0.2193

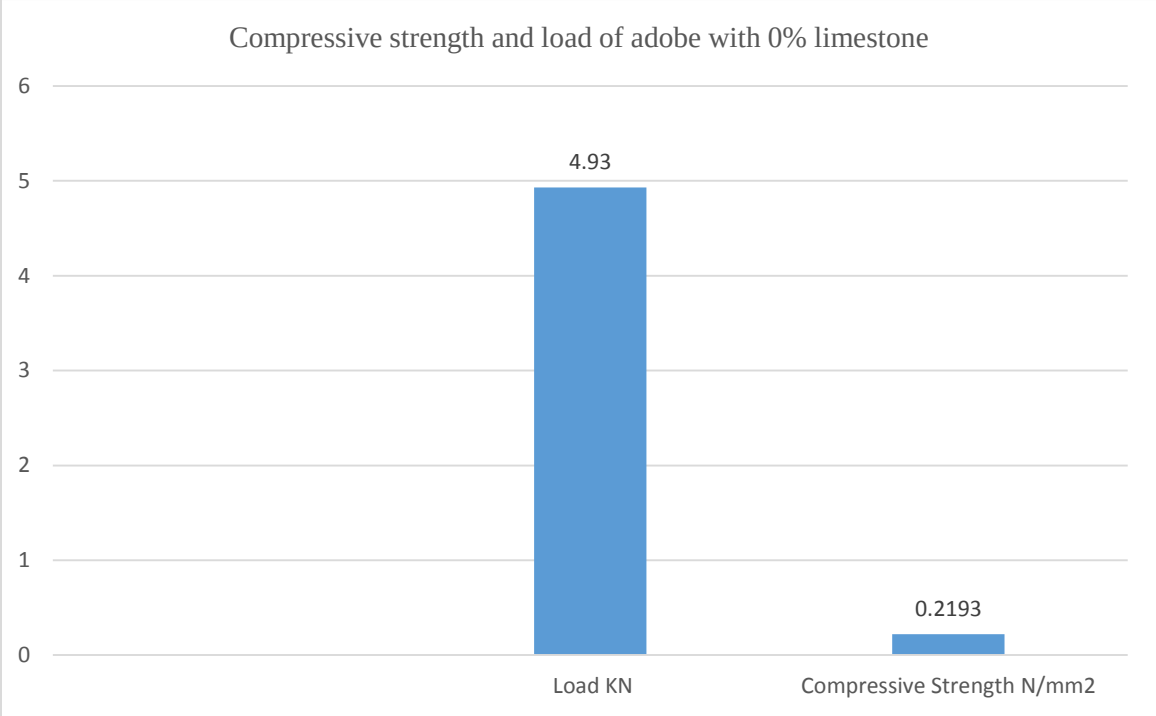


Figure 4.1 Compressive strength and load of adobe with 0% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 4.93 KN with highest value of average maximum strength 0.2193 MPa.

4.2.2 COMPRESSIVE STRENGTH OF ADOBE WITH 10% LIMESTONE

Table 4.2 and Figure 4.2 displayed that the average maximum load and average maximum compressive strength of adobe. From the experimental result, the strength developments of compressive strength of adobe with 10% limestone were analyzed.

Table 4.2 Compressive strength and load of adobe with 10% limestone

No. OF sample	Max load KN	Compressive Strength (N/mm2)
1	4.88	0.2165
2	5.21	0.2323
3	5.28	0.2342
4	4.48	0.1985
5	5.14	0.2281
Average	4.99	0.2219

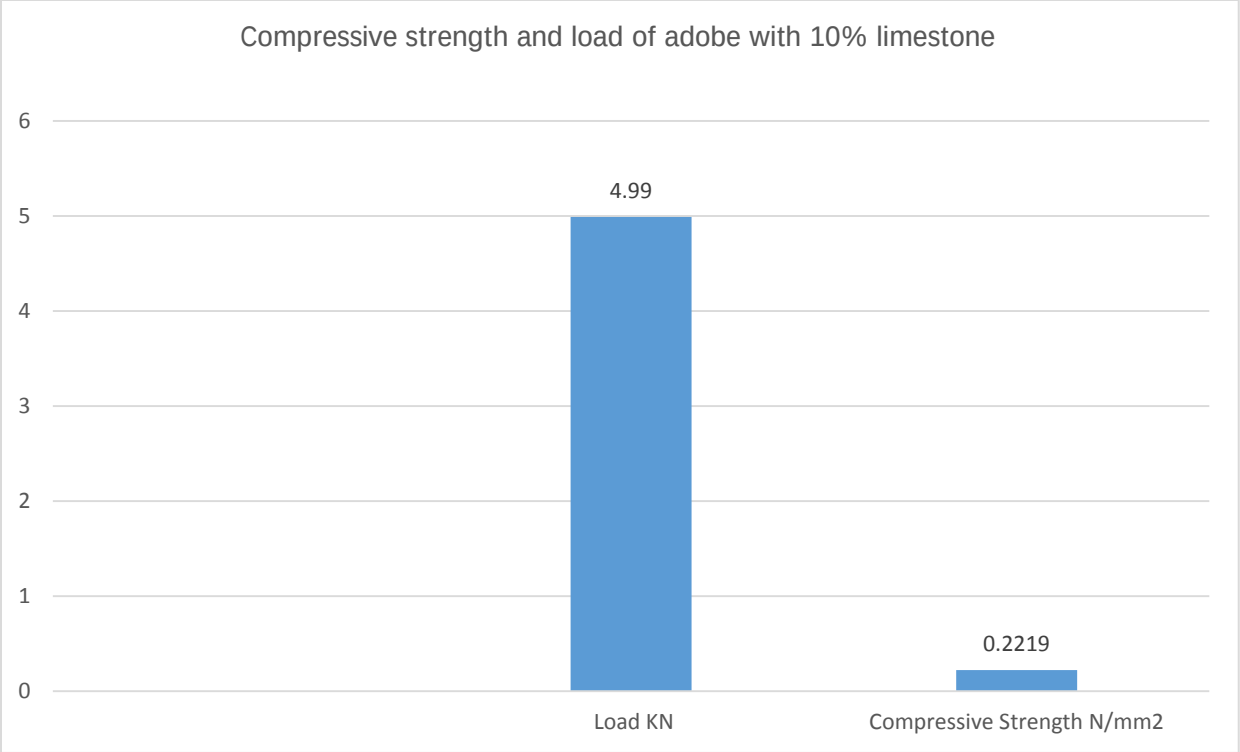


Figure 4.2 Compressive strength and load of adobe with 10% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 4.99 KN with highest value of average maximum strength 0.2219 MPa.

4.2.3 COMPRESSIVE STRENGTH OF ADOBE WITH 20% LIMESTONE

Table 4.3 and Figure 4.3 displayed that the average maximum load and average maximum compressive strength of adobe. From the experimental result, the strength developments of compressive strength of adobe with 20% limestone were analyzed.

Table 4.3 Compressive strength and load of adobe with 20% limestone

No. OF sample	Max load KN	Compressive Strength (N/mm2)
1	5.32	0.2362
2	4.92	0.2185
3	5.27	0.2341
4	4.85	0.2154
5	5.51	0.2447
Average	5.17	0.2296

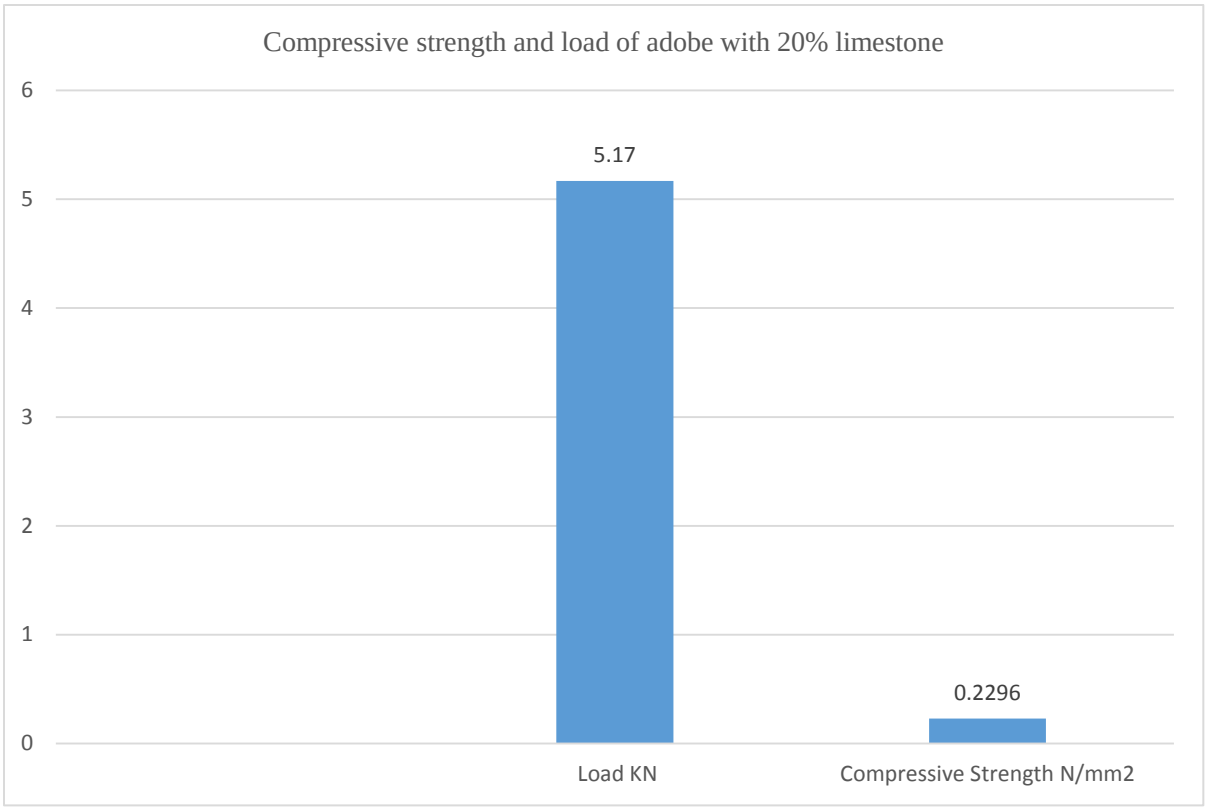


Figure 4.3 Compressive strength and load of adobe with 20% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, it can be seen

that the highest value of average maximum load is 5.17 kN with highest value of average maximum strength 0.2296 MPa.

4.2.4 COMPRESSIVE STRENGTH OF ADOBE WITH 30% LIMESTONE

Table 4.4 and Figure 4.4 displayed that the average maximum load and average maximum compressive strength of adobe. From the experimental result, the strength developments of compressive strength of adobe with 30% limestone were analyzed.

Table 4.4 Compressive strength and load of adobe with 30% limestone

No. OF sample	Max load KN	Compressive Strength (N/mm2)
1	5.45	0.2867
2	6.12	0.2720
3	6.34	0.2818
4	6.37	0.2831
5	5.62	0.2498
Average	5.98	0.2747

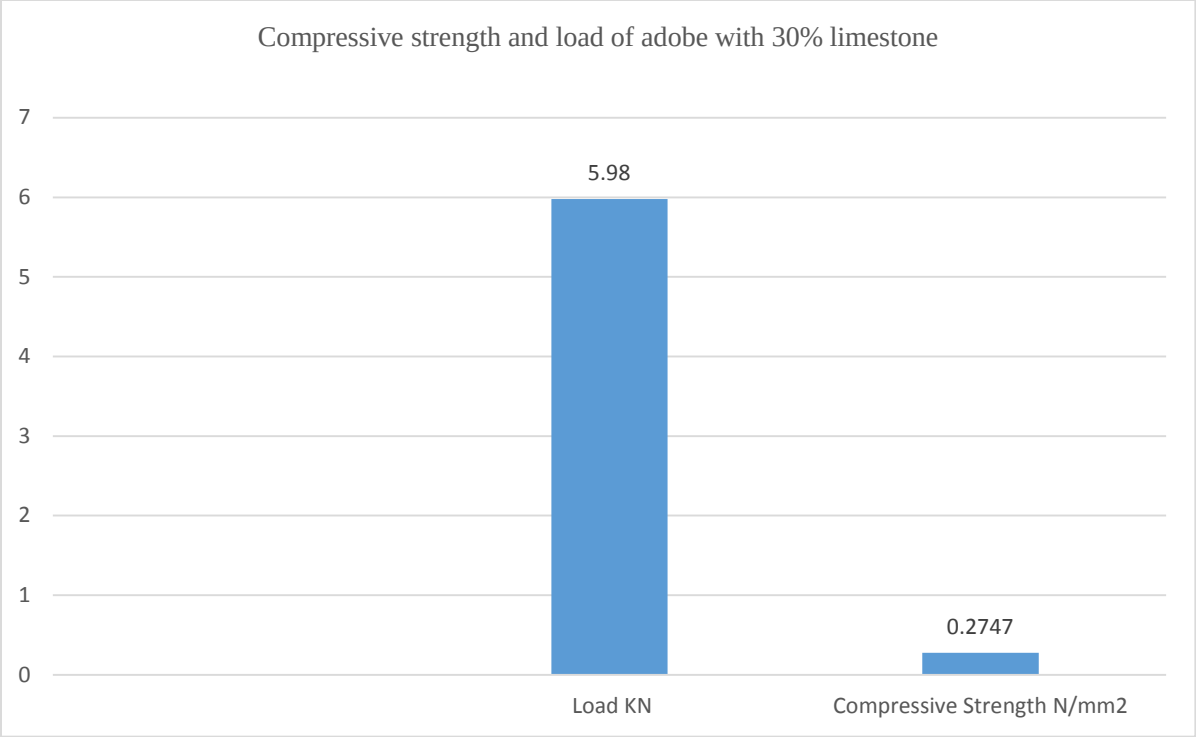


Figure 4.4 Compressive strength and load of adobe with 30% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 5.98 KN with highest value of average maximum strength 0.2747 MPa.

4.2.5 COMPARISON OF COMPRESSIVE STRENGTH BETWEEN ADOBE WITH DIFFERENT PERCENTAGE OF LIMESTONE 0%,10%, 20% AND 30%

Adobe has been reported in literature not as a very strong material. There is no a high variation reported in the mechanical properties of adobe. The present research focused on the effects of limestone on the mechanical properties of adobe as shown in figure 4.5.

Table 4.4 Comparison of Compressive Strength between adobe with different Percentage of limestone 0%,10%, 20% and 30%

Type of mix	Compressive Strength N/mm2
0% Limestone(control)	0.2193
10% Limestone	0.2219
20% Limestone	0.2296
30% Limestone	0.2314

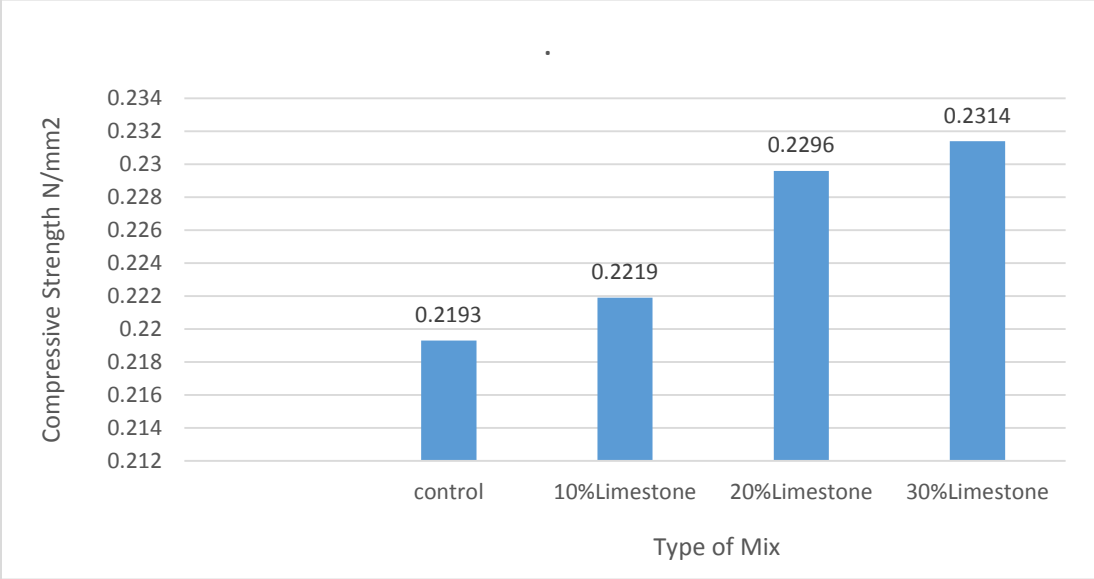


Figure 4.5 Compressive strength of adobe with different Percentage of limestone 0%,10%, 20% and 30%

While the compressive strength of all the samples considerably are not different from each other and there is no significant improvement was noted when the adobe samples added with limestone. On average, the total load taken by the samples without limestone was about 4.93 KN resulting in a compressive strength of 0.2193 MPa. Using 30% limestone of total weight of adobe achieved highest strength of 0.2314 MPa which increased by 5.22% compared to 0%limestone. Furthermore, the compressive strength for adobe was increased with increasing percentage of limestone. The compressive strength of 10% and 20% limestone was in range of 1.17% to 4.49 % compared to use 0% limestone.

This strength is on the lower side compared to the values reported in literature. This is due the process of mixing did not initially work on the separation of the components of soil from each other by using a sieve. Sieve works to categorize the separation of the three components of soil (sand, mud and silt). The components that should be used in the mix are sand with size of 2 mm and mud smaller than the size of 0.002 mm. In addition, silt with size between 0.002 mm- 0.06 mm. Each component should be used with a specific percentage of total weight of adobe. Therefore, the percentage separation should be as 50% sand, 25% mud and 25% silt.

4.3 FLEXURAL STRENGTH OF ADOBE WITH LIMESTONE

Table 4.5 and Figure 4.5 show the results on flexural strength of Adobe soil beam size 500 x 100 x 100mm3. In this section, the flexural strength tests conducted on the samples are presented. The average reading from the flexural strength test results of five samples of each category. The control samples contain 0% limestone and other samples contain 10%, 20%, and 30% limestone of adobe weight respectively. Samples were casted and labeled then placed through 7 days in air and then 7 days in oven before being tested. All the specimens were tested using the flexural machine. The effect of using different percentage of limestone to flexural strength of Adobe is discussed in this chapter.

4.3.1 FLEXURAL STRENGTH OF ADOBE WITH 0% LIMESTONE

Table 4.6 and Figure 4.6 displayed that the average maximum load and average maximum flexural strength of adobe. From the experimental result, the strength developments of flexural strength of adobe without limestone were analyzed.

Table 4.6 Flexural strength and load of adobe with 0% limestone

No. OF sample	Max load KN	Flexural Strength (N/mm2)
1	0.65	0.0291
2	0.61	0.0272
3	0.71	0.0314
4	0.75	0.0335
5	0.50	0.0224
Average	0.64	0.02850

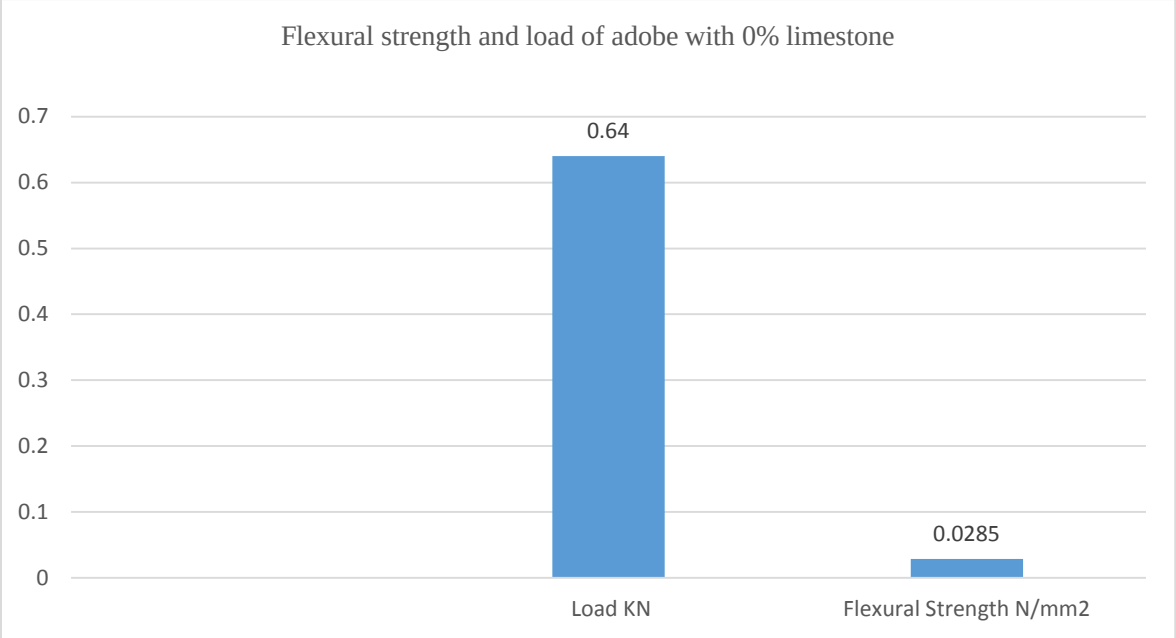


Figure 4.6 Flexural strength and load of adobe with 0% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 0.64 kN with highest value of average maximum strength 0.0285 MPa.

4.3.2 FLEXURAL STRENGTH OF ADOBE WITH 10% LIMESTONE

Table 4.7 and Figure 4.7 displayed that the average maximum load and average maximum flexural strength of adobe. From the experimental result, the strength developments of flexural strength of adobe with 10% limestone were analyzed.

Table 4.7 Flexural strength and load of adobe with 10% limestone

No. OF sample	Max load KN	Flexural Strength (N/mm2)
1	0.07	0.0331
2	0.05	0.0227
3	0.08	0.0395
4	0.08	0.0401
5	0.06	0.0317
Average	0.07	0.0333

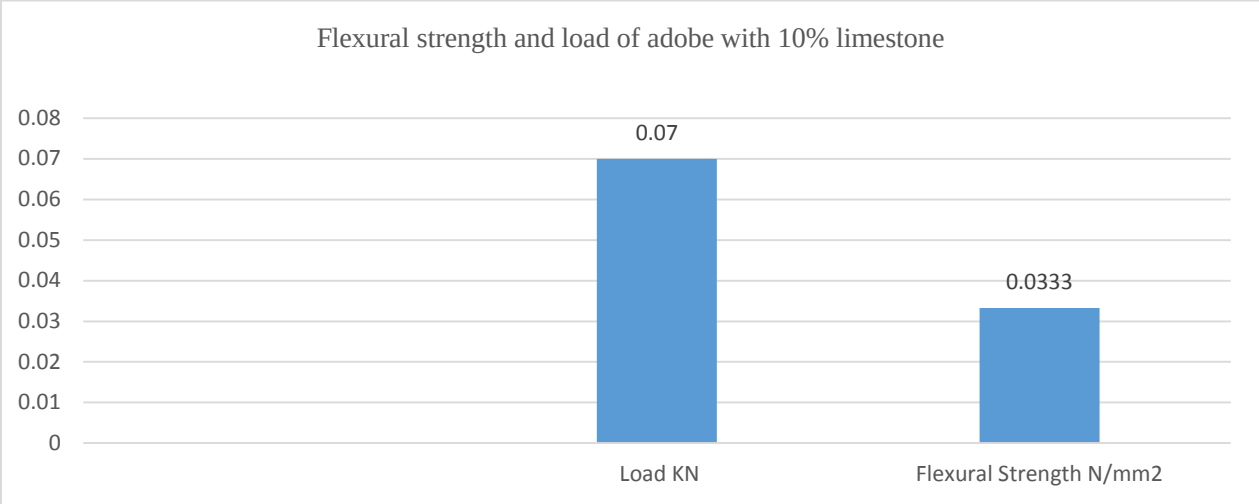


Figure 4.7 Flexural strength and load of adobe with 10% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 0.07 KN with highest value of average maximum strength 0.0333 MPa.

4.3.3 FLEXURAL STRENGTH OF ADOBE WITH 20% LIMESTONE

Table 4.8 and Figure 4.8 displayed that the average maximum load and average maximum flexural strength of adobe. From the experimental result, the strength developments of flexural strength of adobe with 20% limestone were analyzed.

Table 4.8 Flexural strength and load of adobe with 20% limestone

No. OF sample	Max load KN	Flexural Strength (N/mm2)
1	0.09	0.0431
2	0.07	0.0351
3	0.08	0.0384
4	0.10	0.0510
5	0.06	0.0311
Average	0.08	0.0390

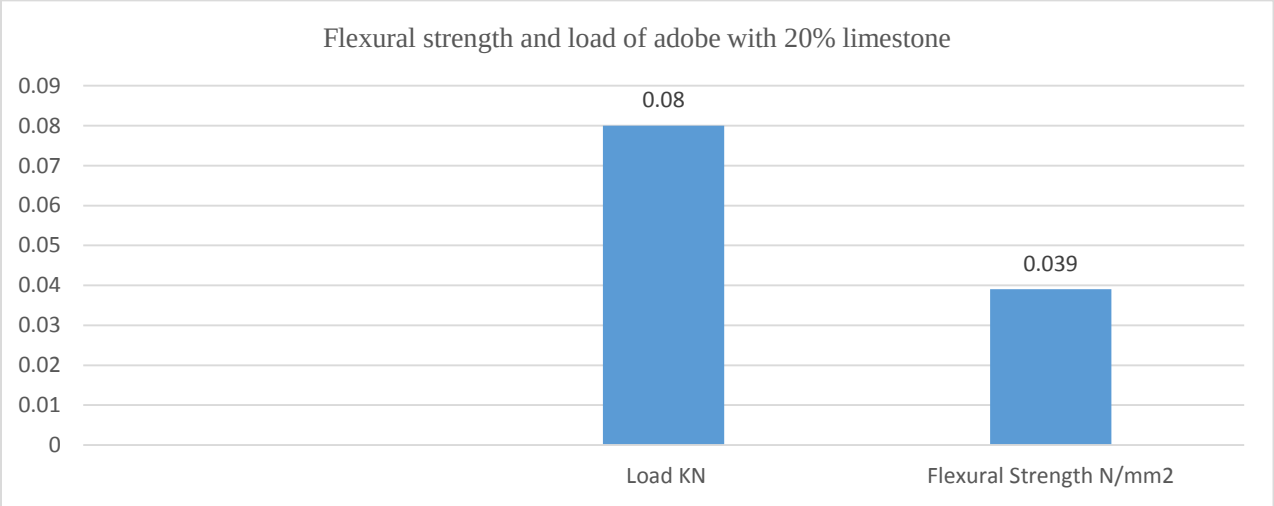


Figure 4.8 Flexural strength and load of adobe with 20% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 0.08 KN with highest value of average maximum strength 0.0390 MPa.

4.3.4 FLEXURAL STRENGTH OF ADOBE WITH 30% LIMESTONE

Table 4.9 and Figure 4.9 displayed that the average maximum load and average maximum flexural strength of adobe. From the experimental result, the strength developments of flexural strength of adobe with 30% limestone were analyzed.

Table 4.9 Flexural strength and load of adobe with 30% limestone

No. OF sample	Max load KN	Flexural Strength (N/mm2)
1	0.10	0.0480
2	0.09	0.0471
3	0.10	0.0503
4	0.07	0.0327
5	0.09	0.0468
Average	0.54	0.0450

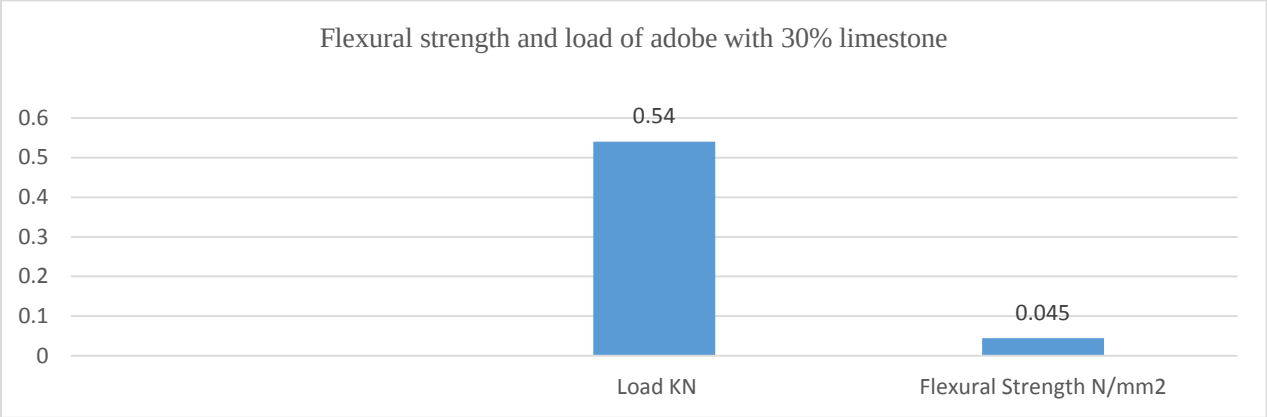


Figure 4.9 Flexural strength and load of adobe with 30% limestone

According to the result, it was illustrated that the average maximum load and average maximum strength for the cubes tasted after 14 days in which the blue histograms represent the maximum load and the maximum strength. From the graph, we can say that the highest value of average maximum load is 0.54 KN with highest value of average maximum strength 0.0450 MPa.

4.2.5 COMPARISON OF FLEXURAL STRENGTH BETWEEN ADOBE WITH DIFFERENT PERCENTAGE OF LIMESTONE 0%,10%, 20% AND 30%

Adobe has been reported in literature not as a very strong material. There is no a high variation reported in the mechanical properties of adobe. The present research focused on the effects of limestone on the mechanical properties of adobe. While the flexural strength of all the samples considerably are not different from each other and there is no significant improvement was noted when the adobe samples added with limestone. On average, the total load taken by the samples without limestone was about 0.64 KN resulting in a compressive strength of 0.0285 MPa. Using 30% limestone of total weight of adobe achieved highest strength of 0.0450 MPa which increased by 36.67% compared to 0%limestone. Furthermore, the compressive strength for adobe was increased with increasing percentage of limestone. The compressive strength of 10% and 20% limestone was in range of 14.41% to 26.92 % compared to use 0%limestone.

Table 4.10 Comparison of Flexural Strength between adobe with different Percentage of limestone 0%,10%, 20% and 30%

Type of mix	Compressive Strength N/mm2
0% Limestone (control)	0.0285
10% Limestone	0.0333
20% Limestone	0.0390
30% Limestone	0.0450

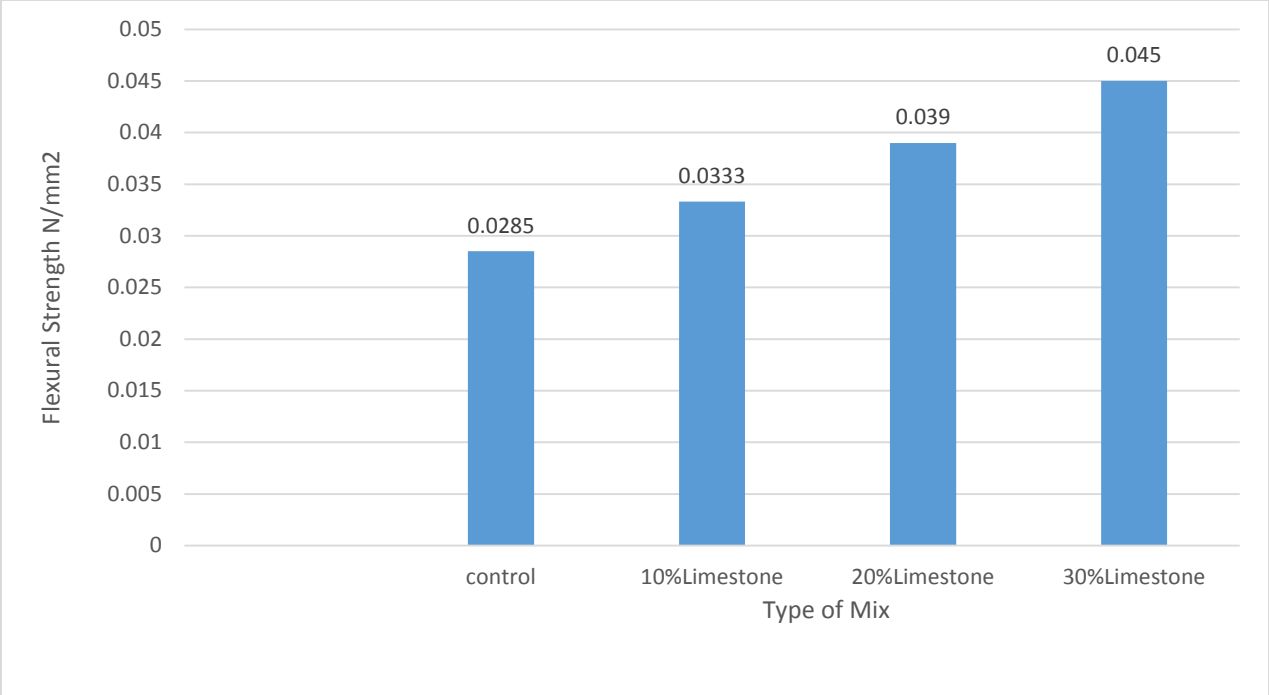


Figure 4.10 Comparison of Flexural Strength between adobe with different Percentage of limestone 0%,10%, 20% and 30%

This strength is on the lower side compared to the values reported in literature. This is due the process of mixing did not initially work on the separation of the components of soil from each other by using a sieve. Sieve works to categorize the separation of the three components of soil sand, mud and silt. The components that should be used in the mix are sand with size of 2 mm and mud smaller than the size of 0.002 mm. In addition, silt with size between 0.002 mm- 0.06 mm. Each component should be used with a specific percentage of total weight of adobe. Therefore, the percentage separation should be as 50% sand,25% mud and 25% silt.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUTION

In this chapter, the conclusion has been done to take out the objectives and outcomes for this study. Some recommendations were also included to further the study for the effect of limestone as adobe partial replacement on the mechanical properties of adobe.

5.2 CONCLUSION

The objectives of the study were to investigate the effect of limestone on mechanical properties of adobe structures. The samples were subjected to same curing periods tested and undergo compressive strength and flexural strength tests.

i. Adobe cubes and beams contain limestone recorded the highest compressive and flexural strengths.
ii. The following conclusions can be drawn from the results obtained. It shown that, the physical characteristics of limestone itself is suitable for used as adobe partial replacement. However, the strength for adobe is not high compared to concrete strength.

iii. According to the compressive test, the strength increased with replacement of 10%, 20% and 30% by total weight of adobe with limestone. It showed that adobe with 0% limestone achieved the lowest compressive strength.

iv. According to the flexural test, the strength increased with replacement of 10%, 20% and 30% by total weight of adobe with limestone. It showed that adobe with 0% limestone achieved the lowest flexural strength.

5.3 RECOMMENDATIONS

The recommendations for this study are: -

1) The research should focus to increase the soil strength which is by add some a natural fiber such as kenaf.

2) The curing process should complete at least 70% before cake off the mold to reduce the cracking damage.

3) Further study on limestone is recommended to increase the percentage.

4) Increase the percentage of limestone at least 50% with increase of sand percentage at least 60%.

REFERENCES

a) Dominique Daudon, Y. S. (2014). Adobe construction modeling by discrete element method: first methodological steps. Grenoble Alpes, france: Elsevier.

b) Dominique Daudon, Y. S. (2014). Adobe construction modeling by discrete element method: first methodology steps. Grenoble Alpes, frence.

c) Varum, A. F. (2012). Seismic retrofitting solution of an adobe masonry wall. (O.ARTICLE, Trans.) Aveiro, Portugal.

d) Vandna Sharma, B. M. (2016). Enhancing durability of adobe by natural reinforcement for propagating sustainable mud housing. Hamirpur, India: ELSEVIER.

e) Younoussa Millogo, J.-C. (2013). Experimental analysis of Pressed Adobe Blocks reinforced with Hibiscus cannabinus fibers. Janeiro, Brazil: ELSEVIER.

f) Fulvio Parisi, D. A. (2014). Experimental Characterization of Italian composite adobe bricks reinforced with straw fibers. Cagliari, Italy : ELSEVIER.

g) Younoussa Millogo, J.-C. (2014). Experiental analysis of pressed Adobe Blocks reinforced with Hibiscus Cannabinus fibers. Janeiro, Brazil: ELSEVIER.

h) Dora Silverira, H. V. (2013). Influence of the testing procedures in the mechanical characterization of adobe bricks. Aveiro, Portugal: ELSEVIER.

i) Sukru Yetgin, A. C. (2006). The effects of the fiber contents on the mechanic properties of the adobes. (ELSEVIER, Ed.) Gumushane, Turkey.

j) Fulvio Parisi, A. P. (2015). Experimental characterization of Italian composite adobe bricks reinforced with straw fibers. (ELSEVIER, Ed.) Naples, Italy.

k) Vandna Sharma, B. M. (2015). Enhancing Sustainability of rural adobe houses of hills by addition of vernacular fiber reinforcement (Vol. ELSEVIER). Pradesh , India.

l) Younoussa Millogo, K. G. Experimental analysis of pressed Adobe Blocksreinforeced with Hibiscus Cannabinus fibers. Janeiro, Brazil: ELSEVIER.

m) Humphrey Danso, D. M. (2015). Effect of fibe aspect ratio on mechanical properties of soil building blocks. Kumasi, Ghana: ELSEVIER.

n) Subramaniaprasad, C. A. (2014). Influence of Embedded Waste-Plastic Fibers on the Improvement of theTensile strength of Stabilized Mud Masonry Blocks. Kerala, India: American Society of Civil Engineers.

o) C. K. Subramaniaprasad, E. K. (2014). Influence of Embedded Waste-Plastic Fibers on the Improvement of the Tensile strength of Stabilized Mud Masonry Blocks. Kerala , India: American Society of Civil Engineers.

p) Ghavami, A. M. (2004). Development of a Direct Tensile Test for Compacted Earth Blocks Reinforced with Natural Fibers. Lyon, France : American Society of civil Engineers.

q) Rakshith P. C. Gowda and Ph.D., M. (2016). Effect of Bagasse Fiber on the Properties of Compressed Cement Stabilized Earth Blocks. carolina, united state : American Society of Civil Engineers.

r) Nambiar, C. K. (2015). Influence of Embedded Waste-Plastic Fibers on the Improvement of the Tensile strength of Stabilized Mud Masonry Blocks. Kerala , India: American Society of Civil Engineers.

s) Ghavami, A. M. (2004). Development of a Direct Tensile Test for Compacted Earth Blocks Reinforced with Natural Fibers. Lyon, France : American Society in Civil Engineers.

t) Younoussa Millogo, K. G. (2014). Experimental analysis of pressed Adobe Blocks reinforced with Hibiscus cannabinus fibers. Janeriro , Brazil: ELSEVIER.

u) Bachir Taallah, A. K. (2014). Mechanical properties and Hygroscopicity behavior of compressed earth block filled by date palm fibers. Biskra, algeria: Elsevier.

v) Dora Silveira, H. V. (2011, October 1). Mechanical properties of adobe bricks in ancient constructions . ELSEVIER , 36–44 .

w) https://www.twpinc.com/wire-mesh-material/stainless-steel. (n.d.). TWP. (S. S. Mesh, Producer) Retrieved from CHOOSE YOUR Mesh by Material.

x) Humphrey Danso, J. W. Effect of fiber aspect ratio on mechanical properties of soil building blocks. Portland, United kingdom: ELSEVIER.

y) Juliana A. Calabria, W. L. (2009). Microstructure and chemical degradation of adobe clay bricks. ScienceDirect , 665-671.