Feasibility Studies and Analysis to turn Raw Sand Dust into Construction Material with The Addition of Calcium Carbonate as a Melting Catalyst

By

Nur Syafiqah Binti Azan

13625

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical)

May 2014

Universiti Teknologi PETRONAS
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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

____
(AP Ir Dr Masri Baharom)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
May 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or doe by unspecified sources or persons.

NUR SYAFIQAH BINTI AZAN

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ABSTRACT

This project is an experimental project which involves investigation in developing new construction material. Sand is the main ingredient in construction as well in glass making process. In this project, sand dust with smaller grain size is used to imitate the desert sand. This project proposed to use only two (2) of the ingredients which are sand and calcium carbonate. The materials used in this project are similar with the materials of making simple glass. However, simple glass needed three (3) main ingredients which are sand, sodium bicarbonate and calcium carbonate. Glass powder is added to the mixture as an option to test the hardness of samples.

These two (2) ingredients is mixed and melt together under proposed temperature and time. Calcium carbonate will act as melting catalyst to the sand. Normal sand starts to melts at $1723^{o}C$, therefore calcium carbonate with melting point at $825^{o}C$ is used to help in lowering the melting temperature of the sand. Besides that, calcium carbonate is used to increase the hardness and durability of the mixture and providing insolubility of the produced sample. Glass powder acts as a flux as well as to increase the strength of the samples.

Five (5) samples were prepared for this project at three (3) different proposed temperatures. Each sample with different composition between the sand and the calcium carbonate and also glass powder; may heated at different temperatures and duration.

After the samples were ready, they were tested under hardness testing to identify the strength of the new construction material. After that, the material compositions of the samples also were identified.

ACKNOWLEDGEMENT

Firstly, I thank Almighty for giving me the opportunity in conducting my Final Year Project (FYP) and also giving me a good health in completing this project and to complete this report.

I would like to express my sincere gratitude to my Ir Dr. Masri Baharom for the continuous support of my Final Year zproject and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this dissertation. I could not have imagined having a better advisor and mentor for my FYP course.

I'm also grateful to my examiner Dr. Zainal Ambri for his cordial support, valuable information and guidance and has offered much advised and insight throughout my work.

Getting through my dissertation required more than academic support, and I have many, many people to thank for listening to and, at times, having to tolerate me over the past five years. I cannot begin to express my gratitude and appreciation for their friendship. Syazwani binti Abdullah, Azlan bin Azahar, Muhammad Shukor bin Sahroni and Intan Sazliyana binti Abd Rahim have been unwavering in their personal and professional support during the time I spent at the University. For many memorable evenings out and in, I must thank everyone above.

Most importantly, none of this could have happened without my family, who give continuous support mentally and physically during my last semester period and also in completing this report until the end.

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LIST OF ABBREVIATIONS

AIV	Aggregate Impact Value
$CaCO_3$	Calcium Carbonate
EDXA	Energy dispersive X-ray analysis
GPa	Giga Pascals
HV	Hardness Vickers
Kgf/cm2	kilo gram of force per square of centimeter
MPa	Mega Pascal
MPa	Mega Pascals
SEM	Scanning Electron Microscope

CHAPTER 1

INTRODUCTION

1.1. Background

Sand is the critical material mostly used in construction and glass making process. Sand is differed and categorized based on it sizes. Different experts define sand contrarily, as for engineers, they define sand as anything that has measurement between 0.074 and 2 millimeter and in general sand is classified with anything that is large enough to feel between the fingers and smaller than a match head. In this project, studies and analysis is conducted to test or to turn raw sand dust into construction material. Raw sand dust is tested together with calcium carbonate acting as melting catalyst. Sand dust differs from normal sand due to its grain size. This project might be useful to the Middle East country, since there is a lot of available sand can be found there. The characteristics and properties of sand in Malaysia would be different than the desert sand in Middle East. Desert sand normally has smaller diameter size, lightweight and also in round shape compared to normal sand in Malaysia that has bigger size, more weight and irregular shape. However, to make the characteristics of the normal sand the same with the desert sand, the normal sand would be crushed into very fine sand and called it as sand dust due to the small diameter grain size.

In order for the sand dust to melt at lower temperature calcium carbonate is chosen as melting catalyst to help in melting the sand dust. Calcium carbonate is mostly used in construction world in making the cement and mortar, it is also very useful in making simple glass such as soda lime glass and has melting point of 825^{o}C. Therefore, calcium carbonate plays an important role in melting the sand dust. Due to the fine particle and small grain size, it is assumed that the sand dust can be easily melted with the help from calcium carbonate. However, glass powder is also added to the mixture as an option to test the hardness of the samples when melt with and without the glass powder.

There are two (2) batches of samples. First batch will be the sample without adding glass powder and the second batch is the sample with the addition of the glass powder. Those both mixtures will be compressed first and then be put into high temperature furnace at proposed temperature. The sample obtained from the process would be put under several tests to testify the mechanical properties [1].

1.2. Problem Statement

It is announced inside an article early 2014 that Malaysia is struggling with shortage of construction material. This news gives a huge impact to the government as well to the citizen. Due to this reason, some consequences can arise such as increasing price of houses and raw material. The increment for the housing price could be a burden to the citizen. Therefore, new alternative is needed to help this problem and also to help the country [2].

The availability of abandon sand is very huge. This abandon sand can be very useful in many ways to improve the development of our country and to save a lot of money for future purpose. An effort must be taken to convert this abandon sand into useful construction material either for building sector or for agriculture usage [3]. Apart from that, sand is mostly related in making of glass product. Common glass making product is very expensive and also complicated. Thus, this project is design to find an alternative way in making glass or ceramic products at inexpensive way and less complicated. Percentage of waste glass in Malaysia is very high and around 6-7 tonnes of glass is collected every month [4]. This waste glass can be recycle and turn into useful products. By recycling this glass, less energy is used than manufacturing glass from sand, lime and soda [5].

The melting temperature for sand is very high. For sand to start melting without any assistance from other materials, normally requires temperature of more than $1800^{o}C$. Not all furnaces could handle this high temperature. Another alternative is to decrease the melting temperature is by adding more than two additives such as soda ash or calcium carbonate. However, this project is designed to use only one additive to lower the melting temperature of sand [6]

Besides that, India also facing enormous shortage of the preferred material, river sand which is used for plastering building interiors and exteriors. The river sand is replaced by sand dust or crushed sand for construction purpose [7].

1.3. Objectives

The main objective of this project is to turn raw sand dust into construction material with calcium carbonate as melting catalyst. The strength of samples with the addition of glass will also be investigated. Besides that, other objective is to study the best methodology and operating parameters required to turn sand dust into construction material.

1.4. Scopes of study

This experimental project focused on three (3) scopes which are:

- Preparation of samples using:

  Three (3) main materials are used in this project which are sand, calcium carbonate and glass powder. Before the sand can be use, it need to be crushed into sand dust to have a sand with small grain size.
- Laboratory testing for samples.

  The test is used to testing the samples to identify the mechanical properties of the new construction material. The results obtained wil be compared with the existing glass product.
- Determine of product properties.

  The samples obtain will be put into scanning electron microscope (SEM) to obtain the energy dispersive X-ray analysis (EDXA).

CHAPTER 2

LITERATURE REVIEW

2.1 Ceramic Die Pressing Process

Die pressing process is one of the techniques used in forming the ceramic powder. Generally, it is the method of compaction of the ceramic powder that involvies uniaxial pressure applied in a die between two rigid punches.

The process started by filling the die cavity with ceramic powder. After that, the upper weight moves down and presses the powder with the selected pressure. Usually the pressure would vary between 10,000 psi to 120,000 psi. When the ceramic powder is compressed, the lower part will eject the compressed powder out from the die cavity. There are two (2) types of die pressing which are cold pressing and hot pressing. Cold pressing is conducted at the room temperature, while hot pressing is conducted at increased temperature [8].

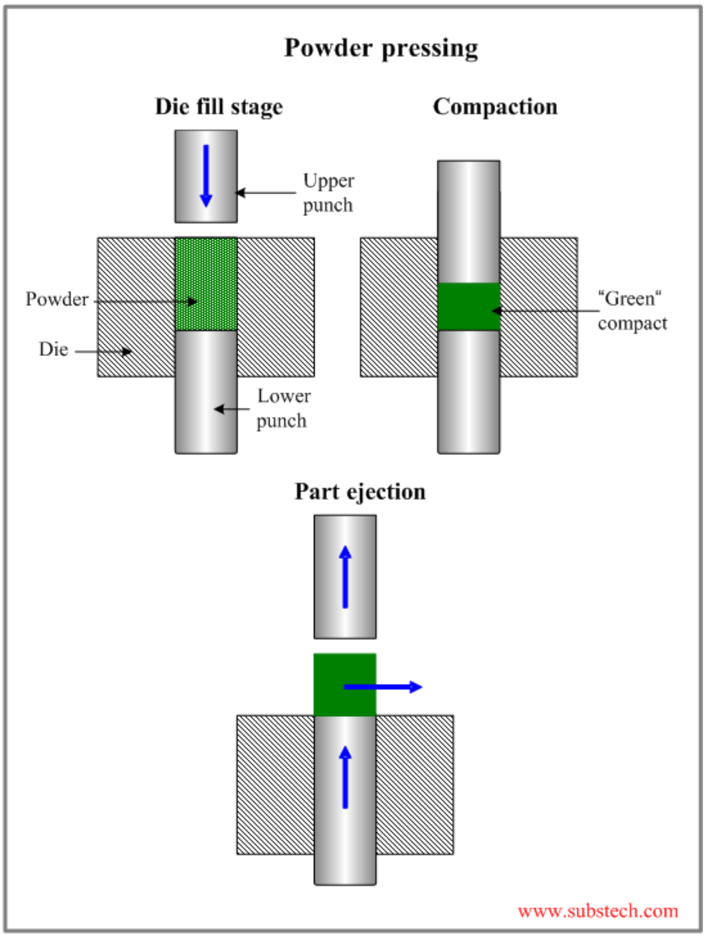

Figure 2.1: Ceramic die pressing process

2.2 Shortage of Construction Material

In Malaysia, it was reported that shortage of construction materials have become a serious matter. The shortage of materials could possibly lead to price instability, increase the project cost, burden builders and eventually citizen will suffer [2].

The increasing demands for construction nowadays cause the shortage of construction materials and also the increase of materials cost. In India, shortage of construction material has become an issue for the government. The country mainly used river sand in building construction and due to the enormous shortage of the material, the state public works department (PWD) has provided a solution by replacing river sand with crushed sand or sand dust that has fine grain size. The PWD has launched an experimental project to construct a building using crushed sand instead of river sand and reply back to the department after three months to report on the efficiency of the material used. The crushed sand may mainly used for plastering building interiors and exteriors. The destruction of the river by extensive sand mining causes protest from villagers. The sand mining also can lead to the dried riverbeds and lead difficulty to the villagers especially during summer [7].

2.3 Calcium Carbonate

Calcium carbonate is a type of mineral that mainly can be found in a sedimentary rock of all parts of the world and is the main components in marine organism. Calcium carbonate is very useful in many aspects, it can be used for health purposes, environmental applications and also for the industrial development. The main use of the calcium carbonate is in the construction industry. Figure 2.2 shows the sample of calcium carbonate powder.

Figure 2.2: Calcium carbonate in powder form

Figure 2.3: Limestone

Limestone is mainly made up of calcium carbonate substances. Over thousands of years, limestone has been used as main materials in construction of buildings and roads. Besides that, it has also been used for making glass. Figure 2.3 is a picture of common limestone found.

There is no doubt on the availability of calcium carbonate in Malaysia. Based on research limestone covered 15% of Malaysia bedrocks formation. In 2007, Malaysia was able to produce 20.948 Million tonnes of calcium carbonate [9].

2.4 Availability of Desert

Desert is defined as a desolate land which receives only little rainfall. Desert formation is very complex but importantly it was formed due to the accumulation of windblown sand. However, there are three basic conditions in the formation of the desert. First is the existence of a plentiful resource of loose sand in region usually barren of plant life. Second is the sufficient source of wind energy to blow or to move the loose sand and the third is the structure of a place that allowed the sand to settle down and to pile up to form a desert [3]. Deserts cover about one fifth or 20 percent of the earth’s land area. In Middle East only, 89% to 93% is covered by the desert as shown in Figure 2.1. Sand is defined and categorize based on its grain size and the shape. Loose sand that forms the desert has much smaller diameter compared to normal sand which diameter ranges between 0.02 mm to 1.0 mm and based on research it shows that the loose sand has round shape, light in weight than normal sand that has irregular shape and heavy weight [10].

Figure 2.4: Deserts in Middle East

Middle East is one of the countries that are rich with petroleum. Based on research it says that, more than 62% of oil reserves can be found in Middle East [11]. Petroleum is non-renewable sources; therefore the world should expect that petroleum will run out in future. When this phenomenon happens, the desert will be left with unwanted sand dust and some effort should be put to make the sand dust into useful sources.

2.5 Regular Sand vs Silica Sand

Regular sand is the normal sand that can be obtained anywhere such as construction sand, beach sand, stone sand and many more. Even though it is called sand but it has different composition among every type of sand. This regular sand is widely available and not very expensive and some of it can be obtain free. However, the use of the regular sand in this project could affect the outcome since it contains a lot of impurities and other minerals composition. Common regular sand has composition of eroded limestone, dust or may contain coral or shell fragments, worn down rock, silica or quartz and other materials [12]. To compare with silica sand that is mostly used in industry of glass and ceramic making it is can bring good outcome to this project. Silica sand or industrial sand has very high quality and it is also expensive because of the clean composition and very hard to obtain. Sand that contains 100% silica is very expensive but very reliable in making glass and ceramic. This silica sand composition solely contains of silicon and oxygen. Silica is classified as hard, act as a flux that can give the strength of bonds between the atoms, it also has high melting point and chemically inert. Due to fewer impurities in silica sand, this sand is widely used in the glass and ceramic industry for good quality. Besides that, silica sand is very famous in construction world in making specialty cement, flooring compounds and many more [13].

2.6 Glass Powder

Glass powder is a waste glass that crushed into finer particles. Glass powder is very useful nowadays because it act as replacement in construction material. The most popular application is the used of glass powder and fly ash in concrete mixture. The use of glass powder is to help increase the strength of the mixture since glass powder contains high percentage of silica mineral. Therefore, it can act as replacement to the silica sand and at the same time can cut the cost of not buying expensive silica sand [14]. Table 2.1 below shows the composition content in the glass powder.

Contents	Cement	Silica fume	Recycled glass powder
SiO_2	21.0	85–96	71.4
Al_2O_3	5.9	—	1.4
Fe_2O_3	3.4	—	0.2
CaO	64.7	—	10.6
MgO	0.9	—	2.5
Na_2O	—	—	12.7
K_2O	—	—	0.5
TiO_2	—	—	—
SO_3	2.6	0.3–0.7	0.1
Loss on ignition (%)	1.2	3.5	0.4

Table 2.1: Chemical composition of cement, recycled glass powder, and silica fume.

CHAPTER 3
METHODOLOGY

3.1 Flow Chart of the Project

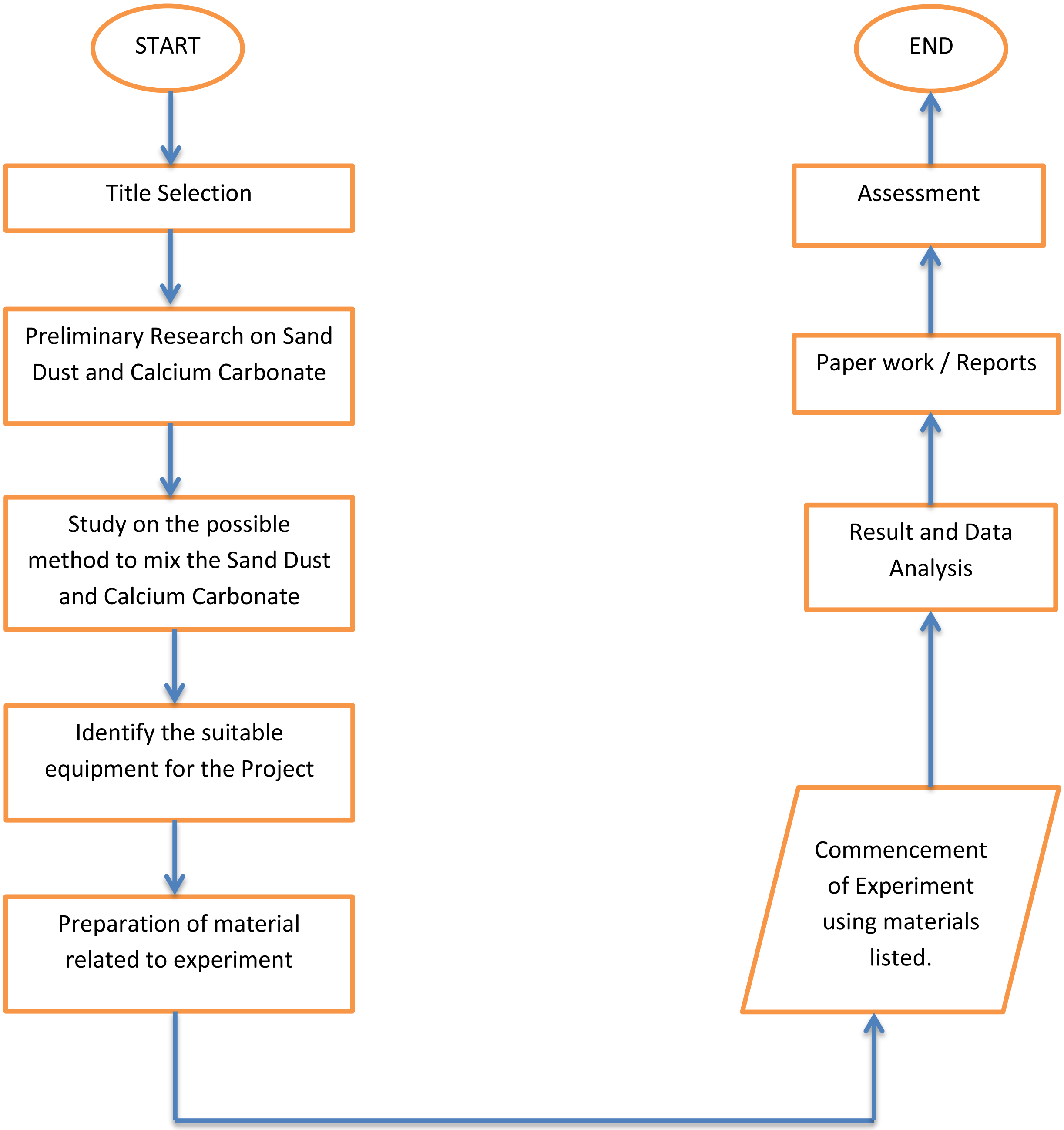

Figure 3.1: Flow Diagram

3.2 Project Gantt Chart

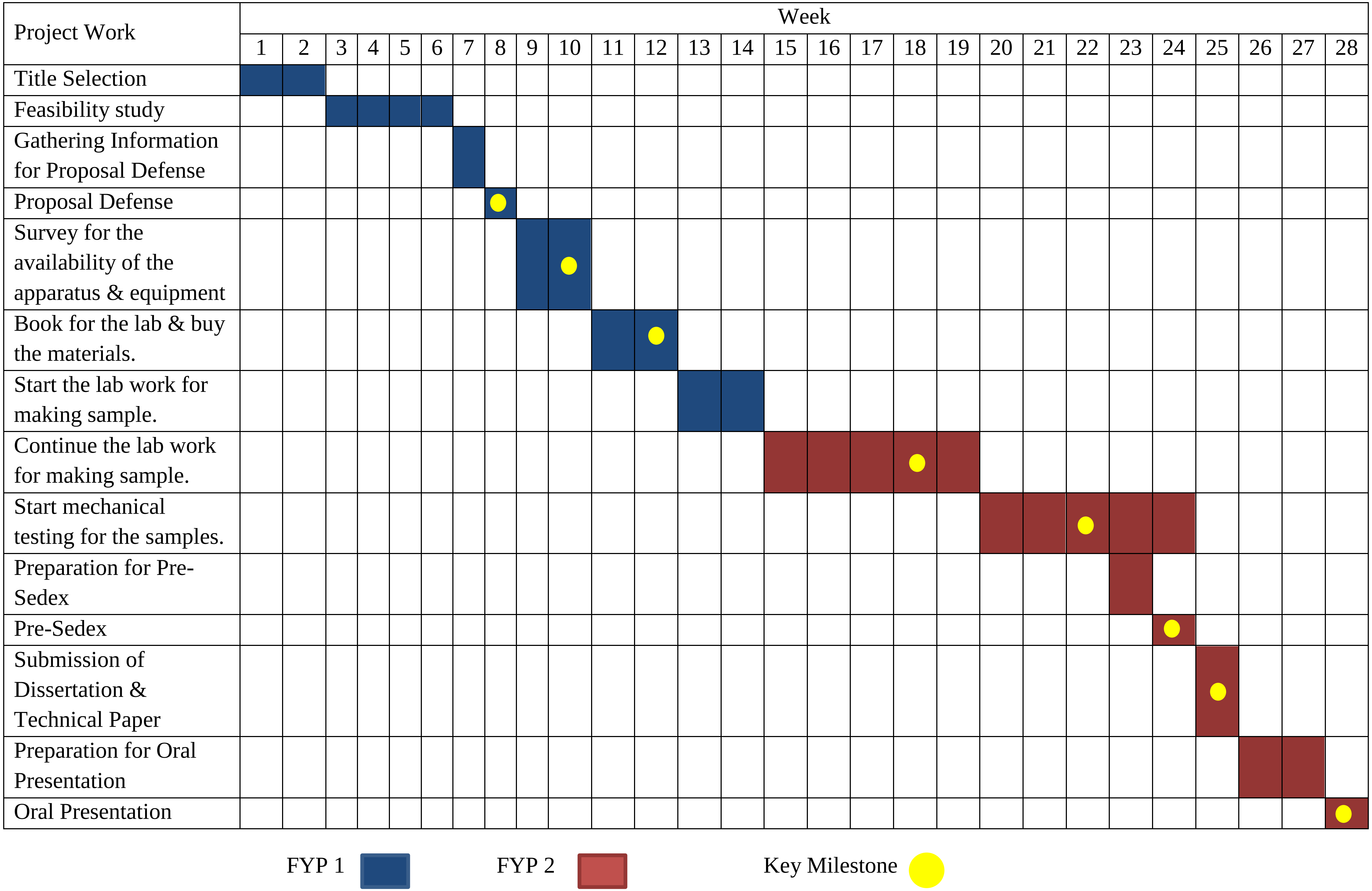

Table 3.1: Project Gantt Chart.

3.3 Experimental Methodology

3.3.1 Apparatus for Sample Making

The experimental work for this project will be divided into two parts. The first part of the work is to prepare the sample and the apparatus are:

- AIV (Aggregate Impact Value) as shown in Figure 3.1
- Crucible mold/heat resistant container
- Ceramic mortar and pestle as shown in Figure 3.2
- Vibrating sieve shaker as shown in Figure 3.3
- Compressor as shown in Figure 3.4
- High temperature oven as shown in Figure 3.5

Figure 3.2: AIV in Block 13 UTP

Figure 3.3: Ceramic mortar and pestle

Figure 3.4: Vibrating sieve shaker

Figure 3.5: Compressor used to compress the samples

Figure 3.6: High temperature oven

3.3.2 Apparatus for Sample Testing

The second part is to test the sample and the apparatus will be used are:

- Hardness test machine as shown in Figure 3.6
- Scanning Electron Microscope (SEM).

Figure 3.7: Hardness Test Machine (Vickers)

Figure 3.8: Scanning Electron Microscope (SEM)

3.3.3 Materials

The materials needed for the experiment are:

- Mining sand or beach sand
- Calcium carbonate powder.
- Glass powder

3.4 Procedure

3.4.1 Sample Making Procedure without Glass Powder

The first part of the experimental work is to prepare the sample. There are two (2) batches of samples. The first batch of samples contains crushed sand and calcium carbonate only. The second batches of samples were added with additional material which was glass powder. There were five (5) samples that need to be prepared. Each sample has different percentage of sand dust and calcium carbonate contents as shown in Figure 3.7. It is assumed that the total volume of the sample is 100%. Therefore, the five samples with different percentage contents are:

Sample No.	Sand Dust, %	Calcium Carbonate, %
A	80	20
B	75	25
C	70	30
D	65	35
E	60	40

Table 3.2:Materials Composition in Percentage.

Figure 3.9: Different percentage contain of sand dust and calcium carbonate in a ceramic bowl

The procedures to prepare the samples are:

1. The raw sand is put into AIV to turn it into sand dust. The size of sand should be in between 3-600 microns to be considered as sand dust.
2. The sand dust is sieved inside vibrating sieve shaker to remove any sand that has bigger size than sand dust.
3. The sand dust is mixed with the calcium carbonate powder inside a ceramic mortar and it is then placed into compressor to compress the sample before putting it inside an oven as shown in Figure 3.8 and Figure 3.9.
4. After the sample is compressed as in Figure 3.5, the sample is placed inside an oven at the selected temperature. The oven will be left for 24 hours to ensure the mixture melt completely.
5. The temperature and the time taken for the mixture were recorded.
6. Step 1 until 5 is repeated with different materials of difference percentage contents.
7. For the Second Batch, any glass can be used to turn into glass powder. For this project, window glass is used.
8. Take the normal window glass; cover the glass with thick cloth. Use hammer to crush the glass into fine size until it becomes powder.
9. The glass powder then will be mix together with other materials for the second batch and step 3 until 5 is repeated.
10. After heating, the sample is cooled down with surrounding temperature.

Figure 3.10: Mixture of sand dust and calcium carbonate in a ceramic mortar

Figure 3.11: Compressed samples before heating inside an oven

3.4.2 Sample Making Procedure with Glass Powder

This second batch of sample contains three materials which are sand dust, calcium carbonate and glass powder. The additional of the third material has changed the composition of the samples. The new composition contains:

Sample No.	Sand Dust, %	Calcium Carbonate, %	Glass Powder, %
A	85	5	10
B	80	10	10
C	75	15	10
D	70	20	10
E	65	25	10

Table 3.3:Materials Composition in Percentage.

The procedures to prepare the samples are the same with the previous batch but additional the glass powder is mixed together inside the ceramic mortar. Figure 3.10 is the waste glass before crushing it into finer particle and Figure 3.11 is the glass powder after the glass is crushed.

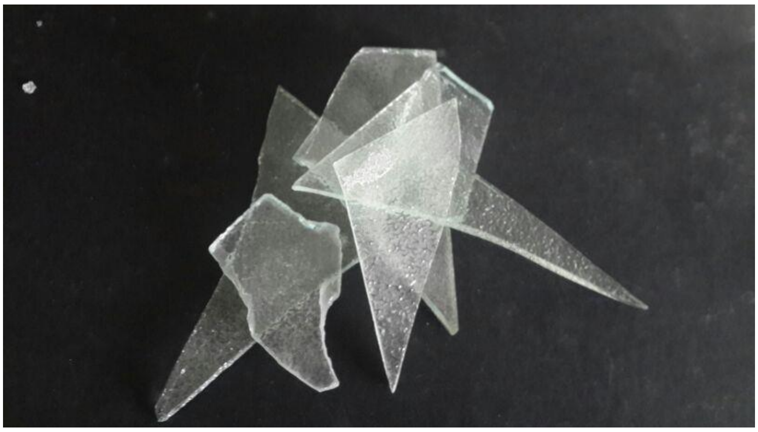

Figure 3.12: Waste glass original shape

Figure 3.13: Glass powder

3.4.3 Testing Procedure

After five (5) samples were cooled, it was analyzed under two different tests which are:

- Hardness test
- Energy dispersive X-ray analysis (EDXA)

The result of the tests was compared with the existing construction product.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Results for Samples Making

Table 4.1 below shows the result for the temperature and time taken for the mixture of sand dust and calcium carbonate to start melting.
The completed samples is shown in Figure 4.1

- Table 4.1 shows the sample without glass powder.

	Composition, %			
Sample No.	**CaCo3**	**Sand Dust**	**Temp. (^oC)**	**Time taken (hrs)**
A	20	80	1300	48
B	25	75	1300	48
C	30	70	1300	48
D	35	65	1300	48
E	40	60	1300	48

Table 4.1: Samples without glass powder

- Table 4.2 shows the sample with glass powder.

	Composition, %				
Sample No.	**Glass Powder**	**CaCo3**	**Sand Dust**	**Temp. (^{o}C)**	**Time taken (hrs)**
A	10	5	85	1250	24
B	10	10	80	1250	24
C	10	15	75	1250	24
D	10	20	70	1250	24
E	10	25	65	1250	24

Table 4.2: Samples with glass powder

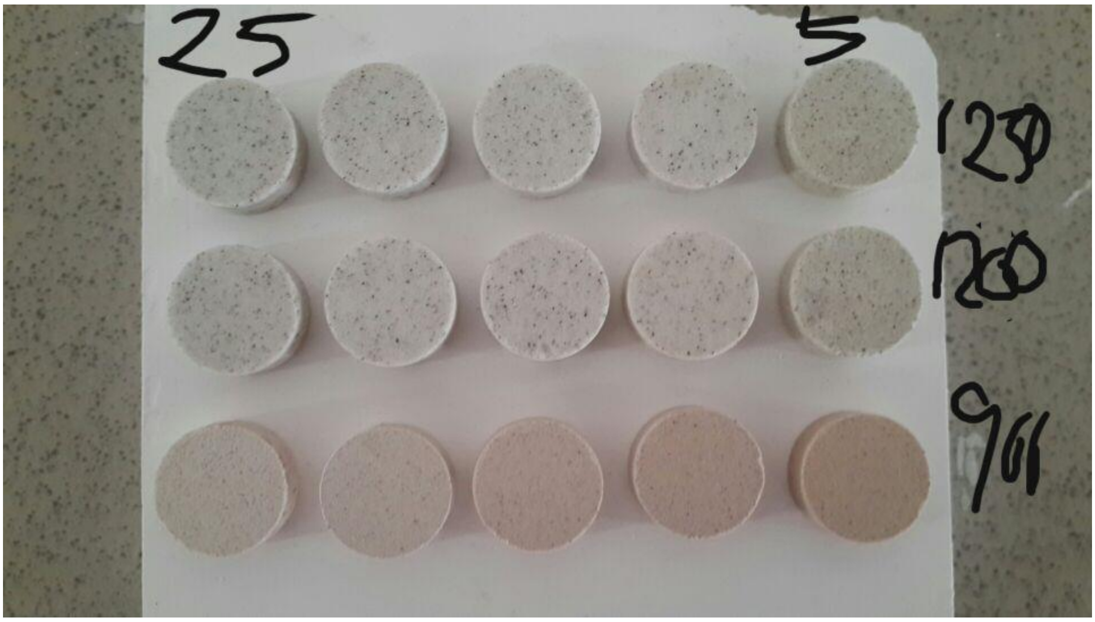

Figure 4.1: Completed samples at different percentage contents and melting temperature

4.1.2 Results for Samples Testing

4.1.2.1 Hardness Testing

Two (2) samples from each batch are put under hardness test. Since these samples can be classified under ceramic properties, therefore hardness Vickers test machine was used. Hardness Vickers uses a diamond shape indenter to indent the samples. After the samples are indented, the diagonal length of the shape was measured and the hardness of the samples was calculated using the following formula.

$$HV = \frac{F}{A} = 1.854\frac{F}{d^2}$$

- Sample without Glass Powder
  - Sample C

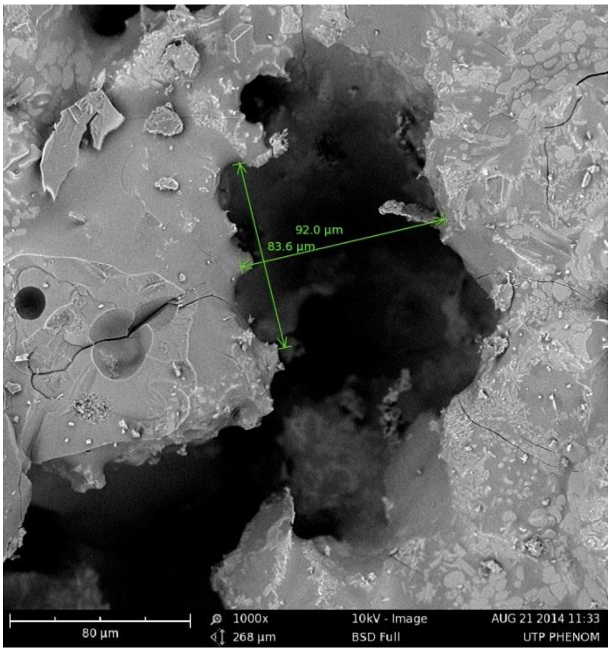

Figure 4.2: Measurement taken by SEM (Sample C).

$$d = \frac{d_1 + d_2}{2} = \frac{92\mu m + 83.6\mu m}{2} = 87.8\mu m$$

$$HV = \frac{F}{A} = 1.854\frac{F}{d^2} = 240.50 kgf/mm^2$$

To convert HV in MPa the value need to multiply by 9.807.

$$HV = \frac{240.50kgf}{mm^2} \times 9.807 = 2358.58MPa$$

- Sample D

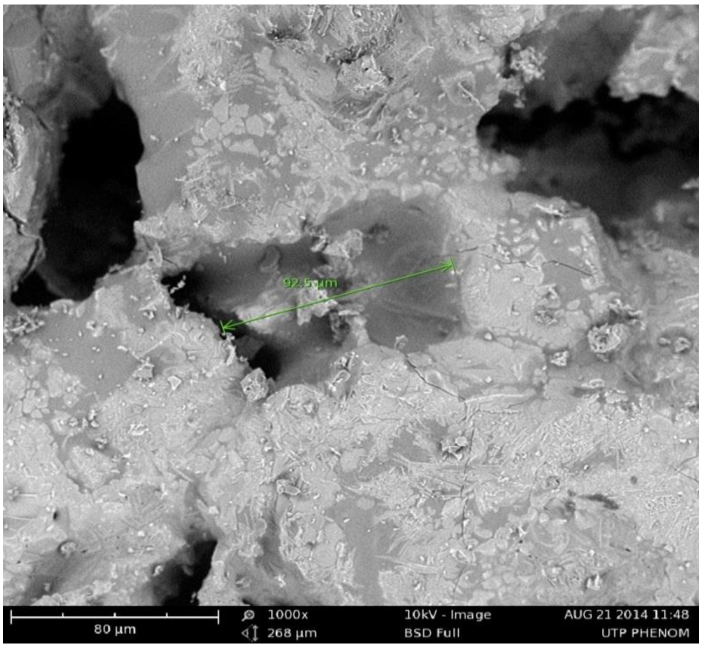

Figure 4.3: Measurement taken by SEM (Sample D).

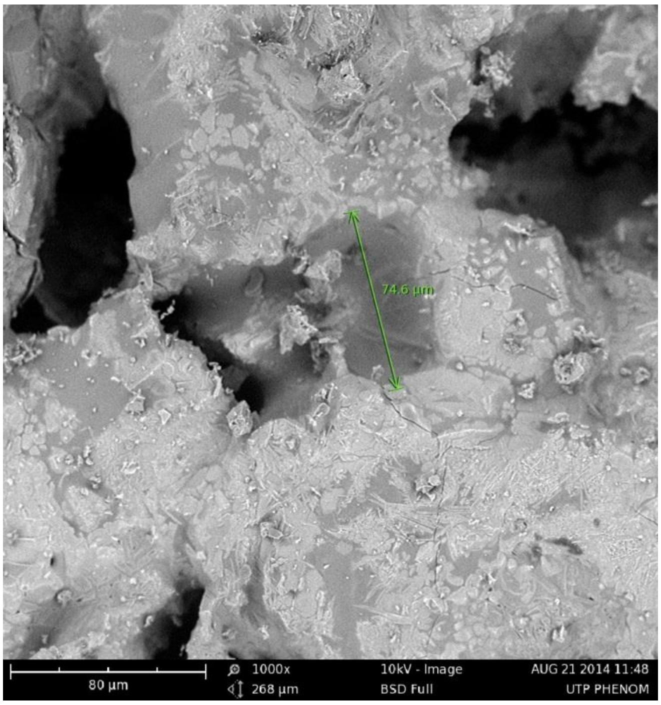

Figure 4.4: Measurement taken by SEM (Sample D).

$$d = \frac{d_1 + d_2}{2} = \frac{92.5\mu m + 74.6\mu m}{2} = 83.55\mu m$$

$$HV = \frac{F}{A} = 1.854\frac{F}{d^2} = 265.91kgf/mm^2$$

To convert HV in MPa the value need to multiply by 9.807.

$$HV = \frac{265.91kgf}{mm^2} \times 9.807 = 2607.78MPa$$

CaCO3 Composition, %	Hardness Value in MPa
20	**1837.18**
25	**2096.3**
30	**2358.58**
35	**2607.7**
40	**2934.82**

Table 4.3: Hardness Value for Samples of First Batch

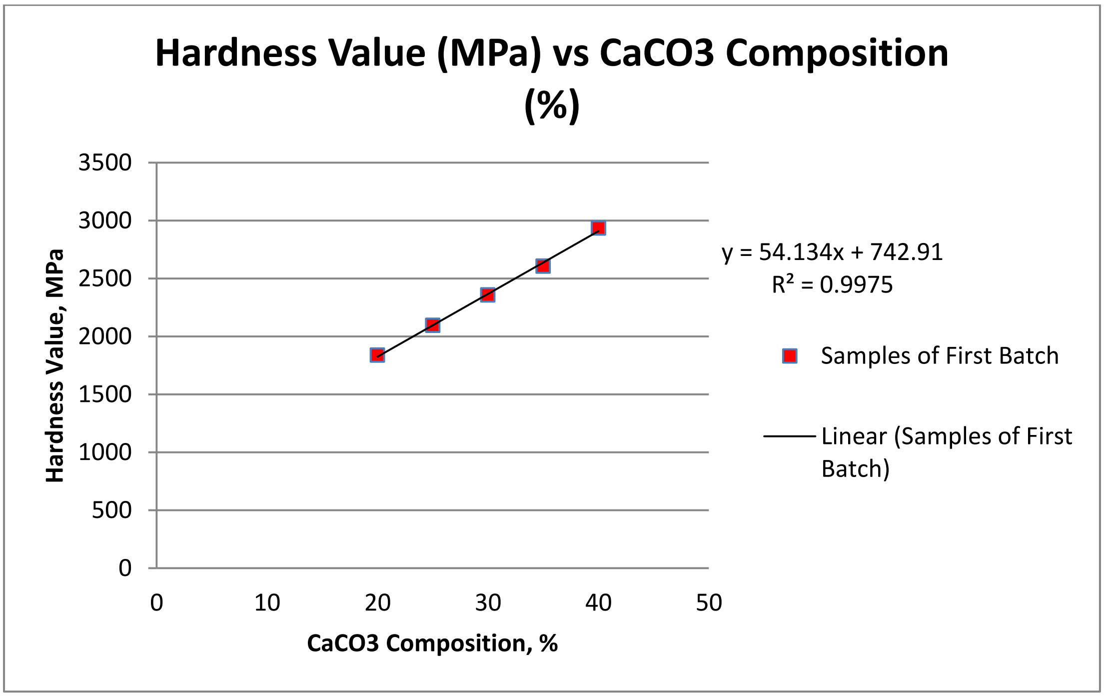

Figure 4.5: Graph Hardness Value (MPa) vs CaCO3 Composition (%) for First Batch.

- Samples with Glass Powder
    - Sample A

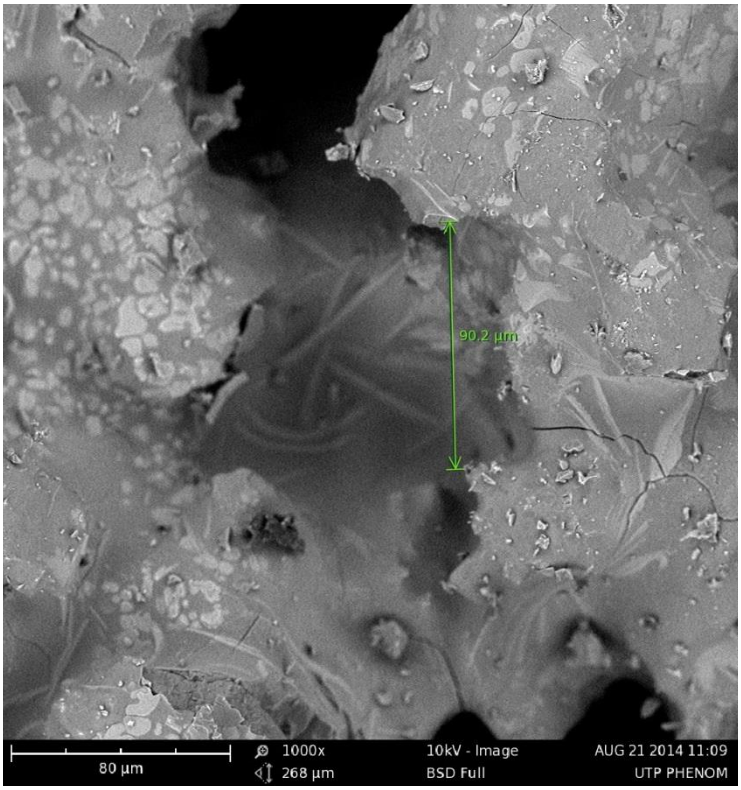

Figure 4.6: Measurement taken by SEM (Sample A).

Figure 4.7: Measurement taken by SEM (Sample A).

$$d = \frac{d_1 + d_2}{2} = \frac{90.2\mu m + 92.5\mu m}{2} = 91.35\mu m$$

$$HV = \frac{F}{A} = 1.854\frac{F}{d^2} = 222.417kgf/mm^2$$

To convert HV in MPa the value need to multiply by 9.807.

$$HV = \frac{222.417kgf}{mm^2} \times 9.807 = 2181.24MPa$$

- Sample E

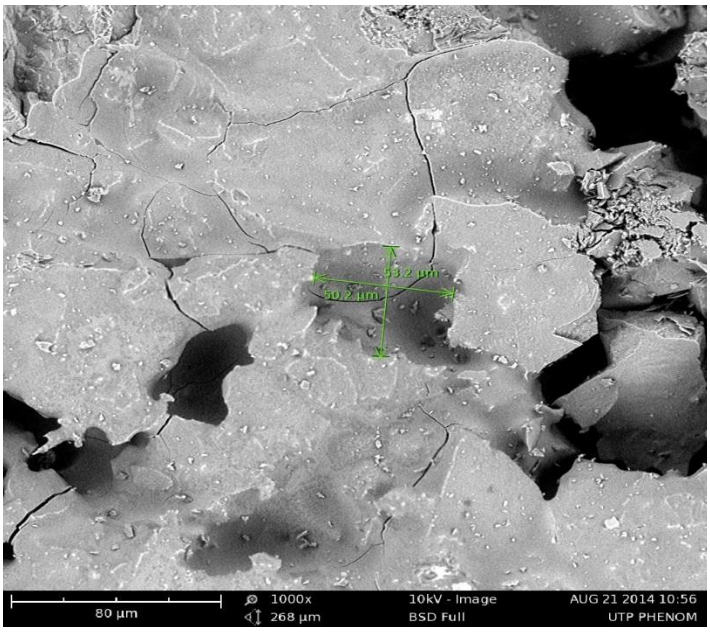

Figure 4.8: Measurement taken by SEM (Sample E).

$$d = \frac{d_1 + d_2}{2} = \frac{50.2\mu m + 53.2\mu m}{2} = 51.7\mu m$$

$$HV = \frac{F}{A} = 1.854\frac{F}{d^2} = 693.63kgf/mm^2$$

To convert HV in MPa the value need to multiply by 9.807.

$$HV = \frac{693.63kgf}{mm^2} \times 9.807 = 6802.43MPa$$

CaCO3 Composition, % + 10% Glass Powder	Hardness Value in MPa
15	**2181.24**
20	**3336.46**
25	**4591.68**
30	**5738.88**
35	**6802.43**

Table 4.4: Hardness Value for Samples of Second Batch

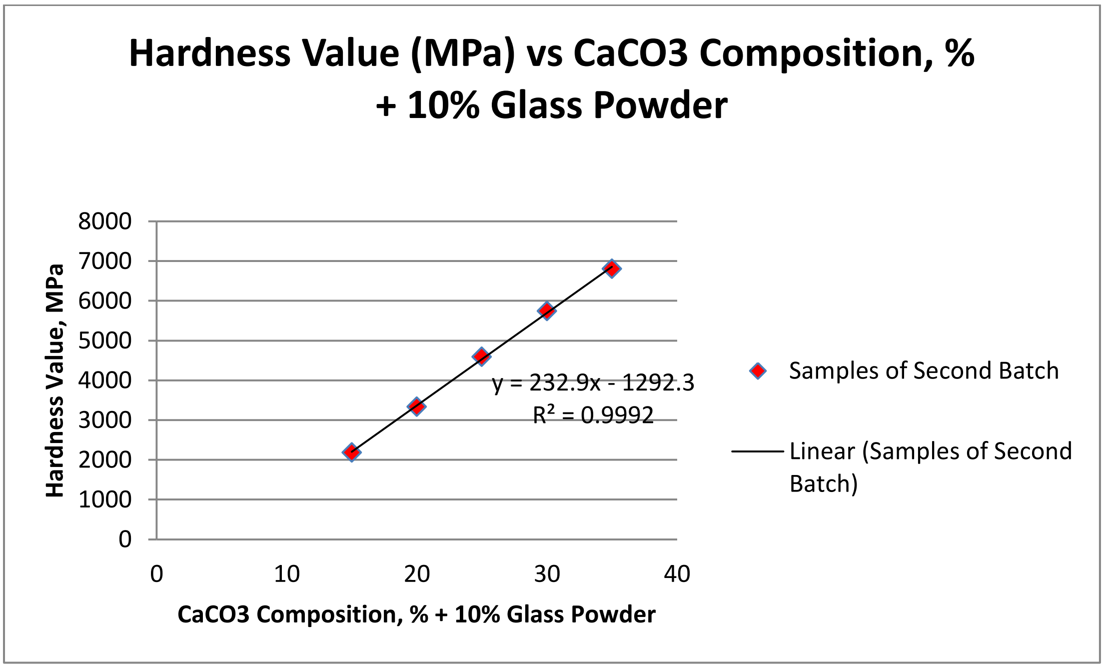

Figure 4.9: Graph Hardness Value (MPa) vs CaCO3 Composition (%) for Second Batch

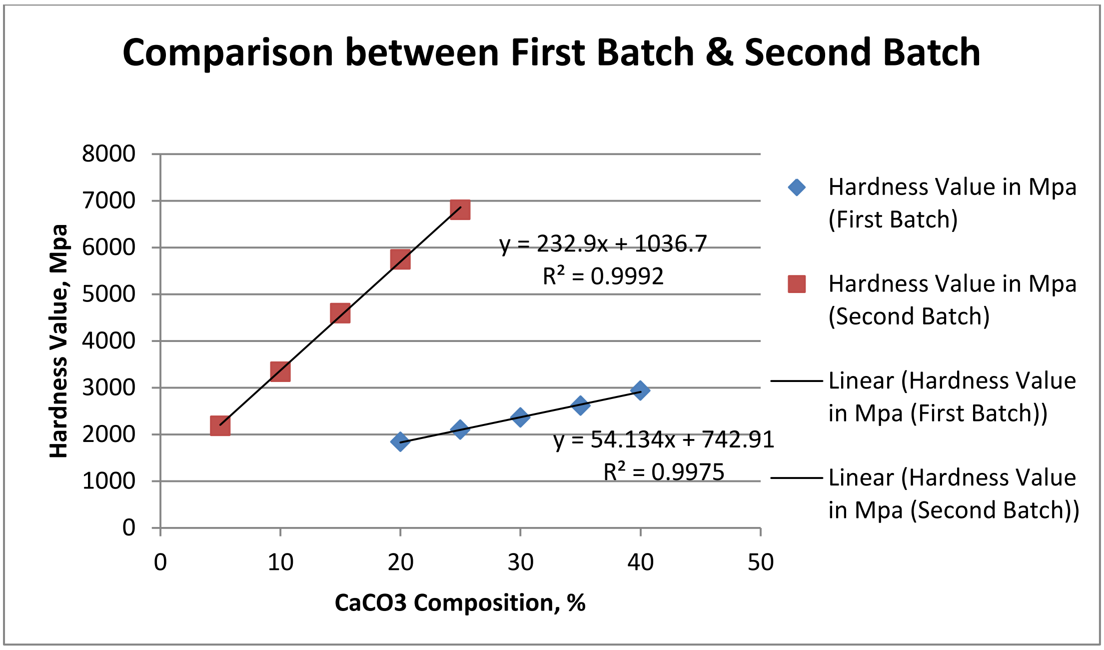

Figure 4.10: Graph Comparison between First Batch Hardness Values with Second Batch Hardness Values.

4.1.2.1 Energy Dispersive X-Ray Analysis (EDXA)

- This test is an analysis used to analyze the elements contain inside the samples produced. The listed elements obtain will be compared with ceramic chemical composition.
- Sample without Glass Powder
  - Sample C

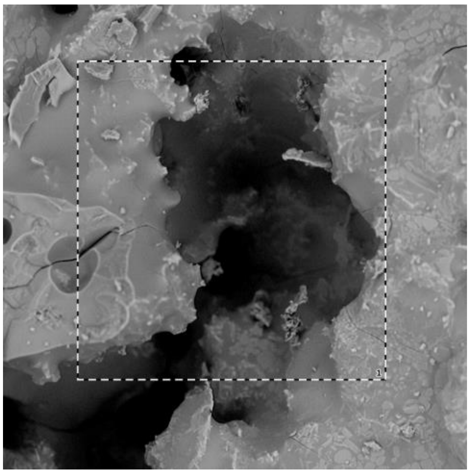

Figure 4.11: Cut out Map (Sample C)

Element Number	Element Symbol	Element Name	Confidence	Concentration	Error
8	O	Oxygen	100.0	66.4	0.8
14	Si	Silicon	100.0	24.9	0.6
13	Al	Aluminium	100.0	4.9	1.8
11	Na	Sodium	100.0	3.7	4.3

Table 4.5: List of elements found in Sample C

- Sample D

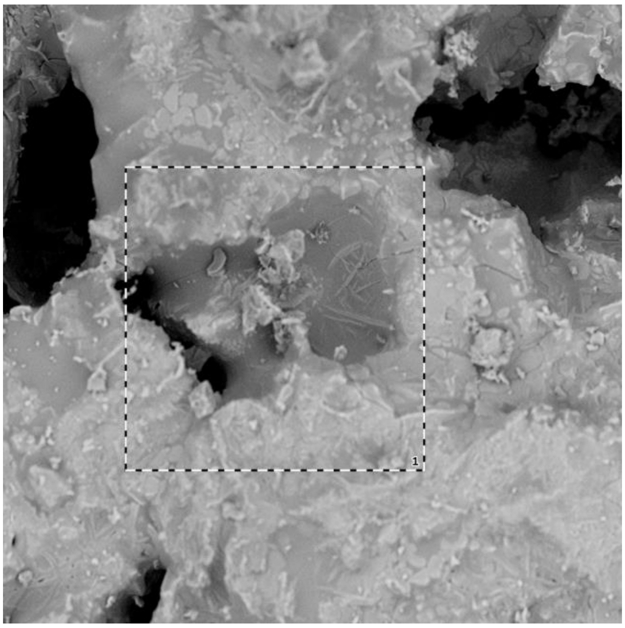

Figure 4.12: Cut out Map (Sample D)

Element Number	Element Symbol	Element Name	Confidence	Concentration	Error
14	Si	Silicon	100.0	19.6	0.5
8	O	Oxygen	100.0	65.7	0.8
20	Ca	Calcium	100.0	11.4	0.8
13	Al	Aluminium	100.0	2.3	2.4
6	C	Carbon	100.0	1.0	3.8

Table 4.6: List of elements found in Sample D.

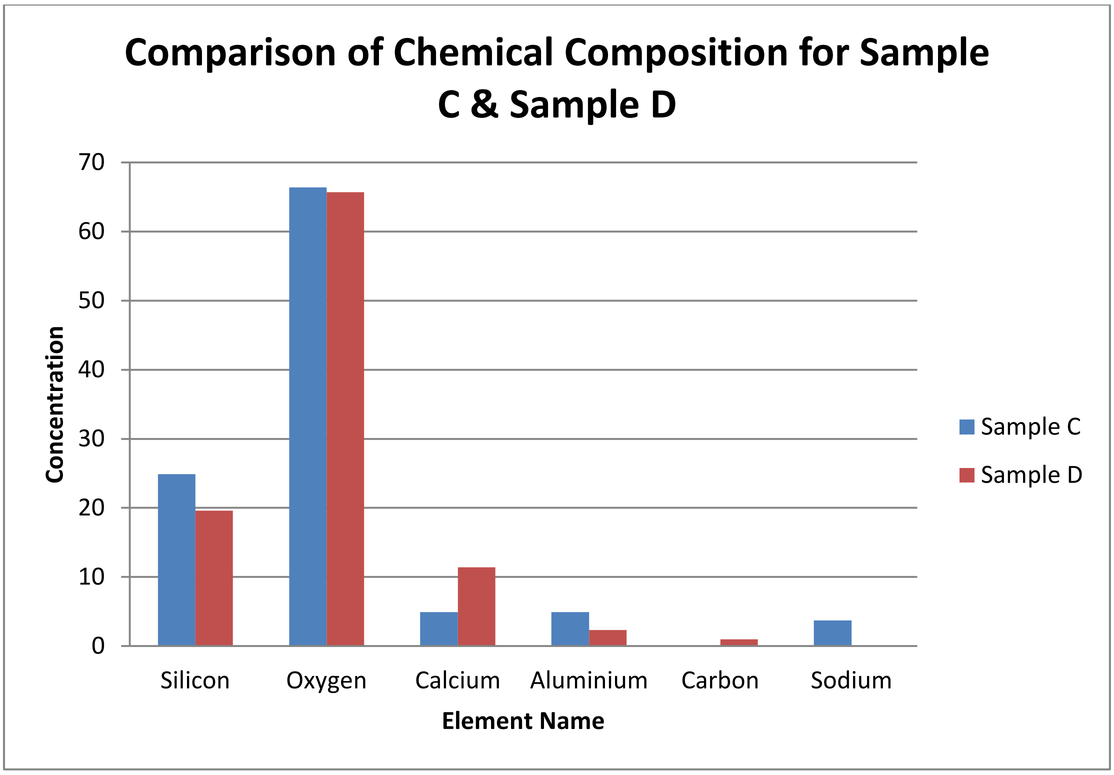

Figure 4.13: Graph of Comparison between Sample C & Sample D (First Batch)

- Sample with Glass Powder
    - Sample A

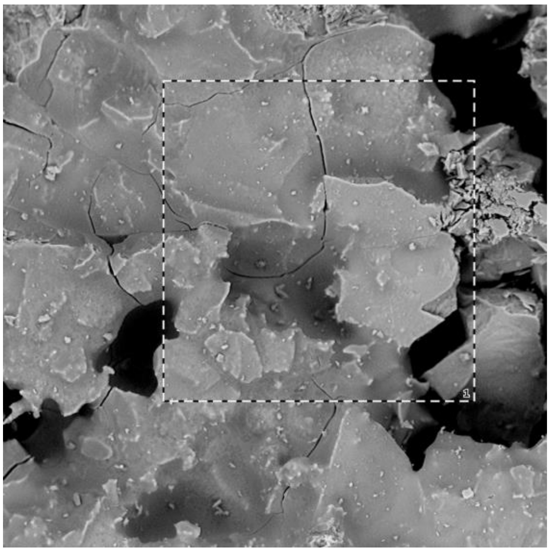

Figure 4.14: Cut out Map (Sample A)

Element Number	Element Symbol	Element Name	Confidence	Concentration	Error
14	Si	Silicon	100.0	25.6	0.4
8	O	Oxygen	100.0	65.4	0.5
13	Al	Aluminium	100.0	3.4	1.4
11	Na	Sodium	100.0	3.6	2.6
7	N	Nitrogen	100.0	2.0	3.7

Table 4.7: List of elements found in Sample A.

- Sample E

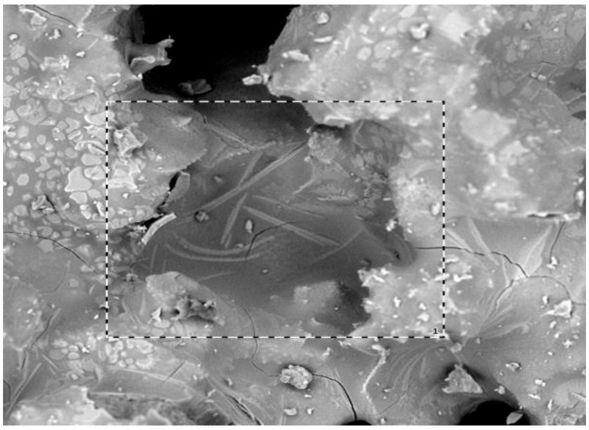

Figure 4.15: Cut out Map (Sample E)

Element Number	Element Symbol	Element Name	Confidence	Concentration	Error
14	Si	Silicon	100.0	22.9	0.7
8	O	Oxygen	100.0	65.9	1.0
6	C	Carbon	100.0	1.9	3.8
13	Al	Aluminium	100.0	2.1	3.5
11	Na	Sodium	100.0	4.9	4.1
7	N	Nitrogen	100.0	2.4	6.6

Table 4.8: List of elements found in Sample E.

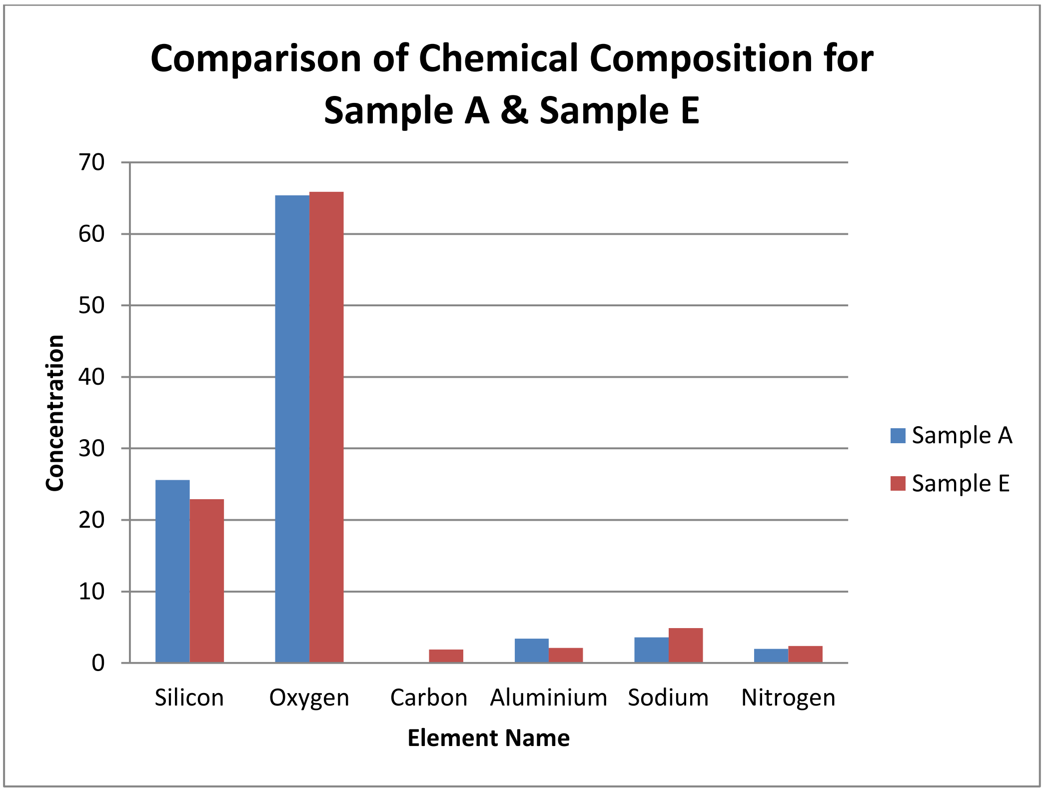

Figure 4.16: Graph of Comparison between Sample A & Sample E (Second Batch)

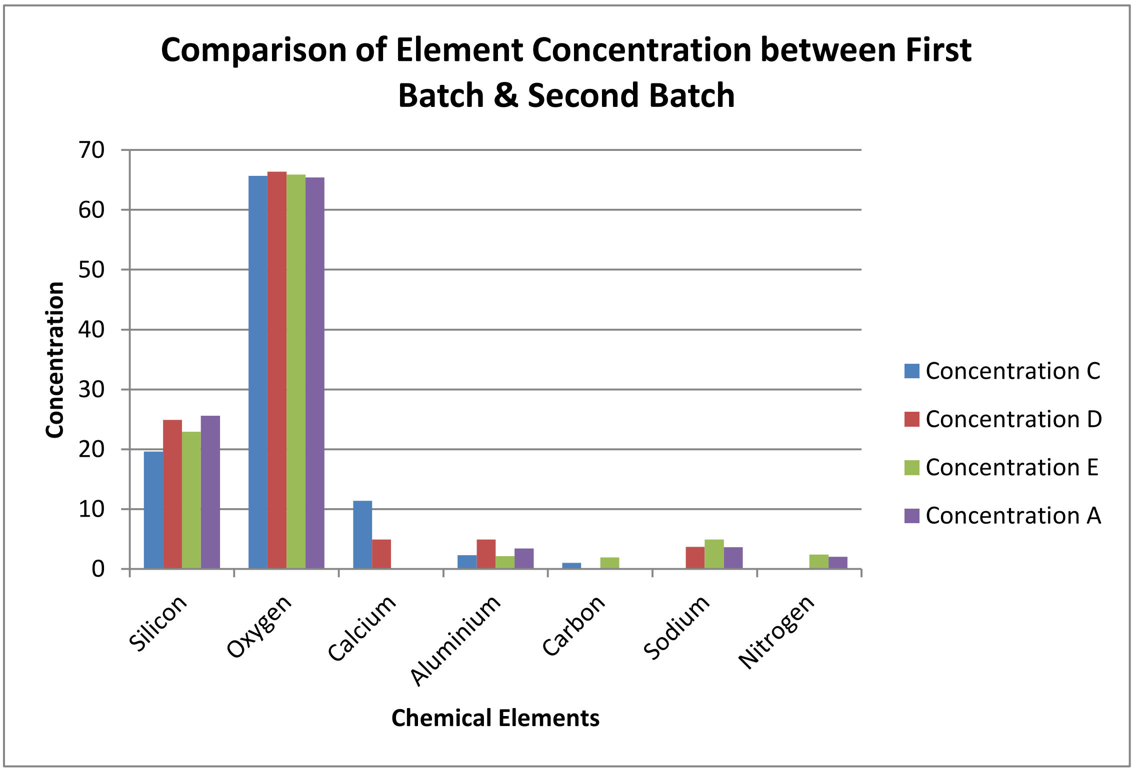

Figure 4.17: Graph of Comparison between First Batch & Second Batch

4.2 Discussion

The hardness value calculated from the samples is compared with the existing ceramic products. Figure 4.12 below shows the hardness value for various ceramic products and common metal used in industry.

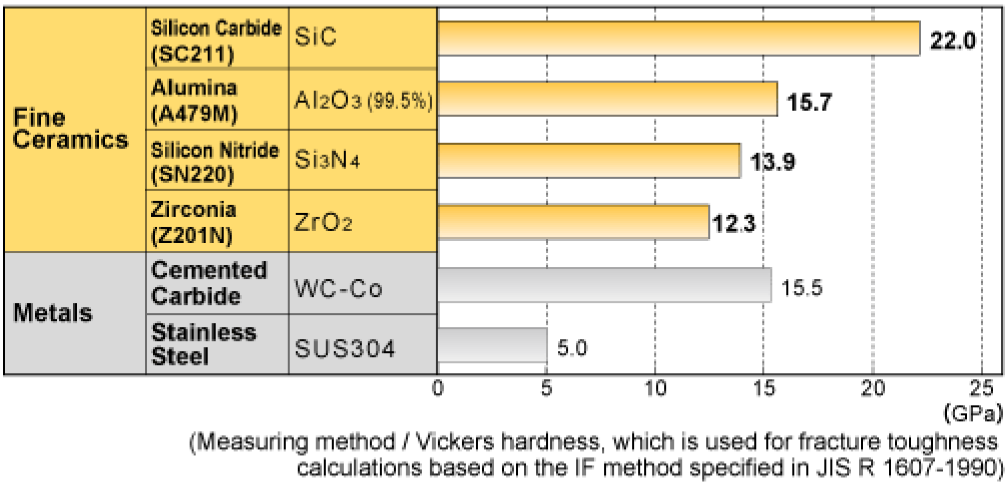

Figure 4.18: Hardness Value for various ceramic products and metal in GPa.

Based on the figure above, the hardness value obtain from the samples is almost similar with the existing ceramic products. By using simple materials and methods, useful products is produced with similar strength with the ceramic products.

From EDXA result, there are five (5) common elements which can be found in each sample. The elements are Silicon, Oxygen, Aluminium, Sodium and Nitrogen. These elements also can be found in the common ceramic products sold in market. For high quality ceramic products, the elements must have Silicon dioxide.

The hardness values from the samples were also being compared with the concrete surface hardness testing in kgf/cm2 [15]. Figure shows the hardness value for concrete.

Item	Concrete compressive strength (kgf/cm^2)	Regression formula estimates (kgf/cm^2)	Absolute error value	Absolute error percentage
1	279	270.3	(−) 8.7	3%
2	356	355.5	(−) 0.5	0%
3	437	402.5	(−) 34.5	8%
4	202	217.2	(+) 15.2	8%
5	225	284.2	(+) 59.2	26%
6	189	219.3	(+) 30.3	16%
7	352	357.1	(+) 5.1	1%
8	345	344.1	(−) 0.9	0%
9	325	314.5	(−) 10.5	3%
10	331	340.2	(+) 9.2	3%
11	150	148.9	(−) 1.1	1%
12	281	285.7	(+) 4.7	2%
13	168	148.9	(−) 19.1	11%
14	251	219.3	(−) 31.7	13%
15	161	160	(−) 1	1%
16	150	160	(+) 10	7%
17	285	295.9	(+) 10.9	4%
18	345	342.6	(−) 2.4	1%
19	320	314.5	(−) 5.5	2%
20	314	314.4	(+) 0.4	0%
Mean value			13.045	5.43%

Figure 4.19: Hardness Value for concrete in kgf/cm2.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This experimental project contains two main objectives. First, is to turn raw sand dust into glass construction material with calcium carbonate as melting catalyst. Second objective is to study the best methodology and operating parameters required. This experimental work could benefit mostly to the semiarid country.

The result obtained for the hardness testing of first batch shows that the samples produced is quite strong and hard as the hardness values varies from 1837.18 MPa to 2934.82 MPa. These values are very high compared to the hardness values of common concrete.

The result obtained from this project shows that both of the objectives stated are achieved. Therefore, this project can be classified as successful. However, lots of improvement can be done to obtain more good results and the application for this project can be used. Besides that, the second batch is experimented to increase the strength of the samples by adding glass powder. The result obtained from the hardness testing are varies from 2181.24 MPa to 6802.43 MPa with increasing amount of calcium carbonate contains. The hardness values for second batch is triple the value from the first batch. From the result obtained, it shows that with additional material the hardness value of sample will be increased and also the strength of the samples.

The chemical composition for two (2) batches shows that the element contains is very similar. Major elements inside the samples of batches are silicon and oxygen. Based on the research, good quality of ceramic products would have the elements of silicon and oxygen. Therefore, the samples produced for this project do possessed the characteristics of clay and ceramic.

5.2 Recommendation

Many problems are encountered during the making of the samples. Many solutions are proposed in order to overcome the problems. First recommendation is to use very small diameter of the sand dust particle. The existing sand dust is put under AIV to crush it smaller, after that the crush sand dust is put inside vibrating sieve shaker to remove any impurities and big size of sand dust.

Second recommendation is to change the percentage contents of the sand dust and calcium carbonate in each samples. The first sample contains 70% of sand dust and 30% calcium carbonate. Next recommendation is by adding new material in the mixture to help calcium carbonate act as melting catalyst and also to bind the melting sand together Increase the percentage of glass powder contain in each sample. For example increase to 20% of glass powder. Glass powder can be obtained from any existing glass product by crashing into finer particle until it becomes powder.

Other recommendation is to improve the making of the samples by using the real sand dust from Middle East. This is because the sand dust from there has different properties from the artificial sand dust in terms of impurities contains, mineral properties and size.

Besides that, to have the samples' properties the same with the ceramic properties the normal sand dust can be change by using silica sand. Silica sand is normally used in glass making because it have lower melting temperature than normal sand. However, silica sand is hard to find and also the price is quite expensive compare normal sand that can obtain anywhere.

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