PARAMETRIC STUDY OF WATER RATIO ON COMPRESSIVE STRENGTH OF MIRHA MORTAR

(Supervisor: Kalaikumar a/l Vallyutham)

by

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Dissertation submitted in partial fulfilment of

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved by,

(Kalaikumar a/l Vallyutham)

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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 done by unspecified sources or persons.

MUHAMMAD FAIZ BIN MOHD YUSOF

ABSTRACT

In this feasibility study, experimental works with varied water ratio on varied Microwave Incinerator Rice Husk Ash (MIRHA) content as partial cement replacement were investigated. Binder sand ratio of 1:3 and 1:4, and replacement of MIRHA content: 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40% and 45% were studied. Only two water ratios of 0.5 and 0.55 were used respectively. Several tests were conducted namely compressive strength at 7, 28, and 60 days, water absorption, Intial Rate of Suction (IRS). The compressive strength ranged from 10 MPa to 45 MPa from 7 to 60 days. In general, water absorption and IRS were found to be proportionally inversed with the strength. Highest compressive strength was obtained from binder sand ratio of 1:3 at water ratio of 0.5 for 15% MIRHA replacement at 60 days. Whilst, lowest compressive strength of 12MPa was obtained from binder sand ratio of 1:4 at water ratio of 0.55 for 45% MIRHA replacement at 60 days.

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CHAPTER 1

INTRODUCTION

1.1 Background

The demand for new and better material in the construction world has increased dramatically and this promote inventers particularly engineer to find alternative in building and material technology. Mortar is generally used in the building and pavement which consists of water, sand, and cement. Mortar is typically low cost, durable, and has high compressive strength to withstand the weight. Mortar is usually rectangular shape.

Rice milling generates a by product known as husk. This surrounds the paddy grain. Rice Husk Ash (RHA) produced from the burning process of paddy husk is a pozzolanic material that contains substantial amount of silica. During milling of paddy about 78% of weight is received as rice, broken rice and bran. The remaining 22 % of the weight of paddy is received as husk. This husk contains about 75% organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). Latest research found that by replacing 10% of RHA in cement, it can increase the compressive strength by 30% (Ou, E., 2007)

Microwave Incinerated Rice Husk Ash (MIRHA) is RHA that is burnt at a different temperature by using microwave incinerator. In order to produce MIRHA of good quality with high reactive silica content, controlled combustion of rice husk at specify temperature are vital. The microwave incinerator used for the burning process had temperatures set at 800°C, 700°C and 600°C to produce good quality MIRHA (Kamal N.L.M, 2008).

1.2 Problem Statement

In Malaysia, huge amount of rice husks is being produced annually in Malaysia almost reaching 2.231 million tons (Nuruddin, 2009). This waste product from the rice industry when burnt, about 20% of the rice husk would become rice husk ash (RHA) (Chao LH, 1997). This means 0.1 million tons of Rice Hush is produced annually in Malaysia. Globally, in 2007, about 650 tons of paddy rice was produced, a quantity which is without doubt growing in the future due to the increase population. Hence, it is estimated that about 26 million tons of Rice Husk as renewable sources of siliceous material can be worldwide available. (Nuruddin, 2009).

Rice Husk is considered as raw material in construction and building technology due to their pozzolanic effect behaviour. This pozzolanic behaviour is well suited for the use in the Portland cement replacement which leads to the advantages of this material.

In this research, the production of Microwave Incinerated Rice Husk Ash (MIRHA) will be the product of the burning of Rice Husk using microwave incinerater. MIRHA will be burnt at a specify temperature to produce a high quality MIRHA, contain high silica content. Thus, this study needs to be implement to find the paramount water ratio of MIRHA and optimum percentage of MIRHA to cement.

1.3 Objective And Scope Of Study

The main objectives of this research are:-

- To determine the most suitable composition of water ratio in mortar.
- To find out the optimum percentage of MIRHA to cement in order to produce the best quality of mortar.

The scope study of this project consist of water ratio of 0.5 and 0.55 is use, the proportion of cement to aggregate are varies which is 1:3 and 1:4, inclusion of MIRHA as cement replacement in mortar at 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40% and 45%, and conducting of compressive test of mortar sample every 7, 28 and 60 days. Other tests such as water absorption, Initial Rate of Suction (IRS) and hydrometer test are also been conducted.

CHAPTER 2

LITERATURE REVIEW

2.1 Properties of Hardened Mortar

The role of mortar when hardened in the finished structure is to transfer the compressive, tensile and shear stresses between the units and it must be sufficiently durable to continue to do so over the life of the structure. The strength and durability requirements of a mortar depend upon the type of service the masonry is required to perform. Some of the important properties of hardened mortar are; 1) bond, 2) compressive strength, 3) durability, 4) flexural strength, 5) appearance.

2.1.1 Bond

The interface of the masonry unit and the mortar is usually the most vulnerable part of the masonry construction to the ingress of rain. Bond strength is required to withstand tensile forces due to wind, structural and other applied forces, movement of the masonry units and temperature changes. It should also be emphasised that workmanship is a key factor in affecting bond. The time lapse between spreading mortar and placing must be kept to a minimum. Once the masonry unit is in place and aligned it must not be subsequently moved.

2.1.2 Compressive Strength

Examination of many specifications gives the impression that compressive strength is the most important property of mortar. Some of the important factors affecting compressive strength are cement content, sand grading, entrained air content and water content. The compressive strength of mortar has a relatively minor influence on the strength of masonry construction when compared to the strength of the units. Stronger mortars with higher cement contents tend to have higher shrinkage. This may result in an increased risk of rain penetration due to the greater potential incidence of fine crack formation.

2.1.3 Durability

Durability of mortar may be defined as its ability to endure aggressive conditions during its design life. A number of potentially destructive influences may interact with the mortar: these include water, frost, soluble salts and temperature change. There is often a requirement to test mortar for durability, but satisfactory tests are difficult to develop in practice and most suggested regimes are either too lengthy and complicated or do not relate sufficiently well to site practice.

2.1.4 Flexural Strength

Traditional masonry construction tended to be massive relative to modern structures, typically with very thick walls. This meant that the mass or bulk generally resisted the various forces applied to it. The development of modern masonry units and advances in mortar technology has led to more slender structures which are more vulnerable to lateral forces e.g. wind loads.

2.1.5 Appearances

The colour and shade of the mortar joints greatly affects the overall appearance of a masonry structure. It should be remembered that some 15- 25 % of the visual surface may be comprised of mortar. Careful measurement of mortar materials and thorough mixing are important to maintain uniformity from batch to batch and from day to day.

2.2 Rice Husk Ash (RHA) as Cement Replacement in Mortar

Studies of mortar made with Ordinary Portland Cement (OPC) of 10%, 15%, 20%, 25% and 30% of OPC replaced by RHA (Habeeb, 2009). The mechanical properties investigated were the compressive strength. The obtained results show that the strength of mortar incorporating RHA is better, up to 20% of cement replacement level.

At 3 days result it was observed that all the samples containing RHA, shown lower than the controlled one and for the 7 days result it is also true except 10RHA sample. Strength at 28 days of mortar, containing 25% and 30% RHA is slightly lower than that of OPC mortar. The addition of RHA reduce the early strength of mortar, but the strength at ages of 28 and 90 days of the RHA mortars are slightly higher than that of the controlled one. This indicates that RHA is pozzolanic materials and the early pozzolanic reaction rate is slow. The pozzalanic reaction can be seen at the age of 28 days onwards resulting in the higher strength of mortar incorporating RHA in comparison to that of OPC.

Table 2.1: Compressive Strength of Mortar. (Rashid M.H, 2010)

Mix ID	Symbol	Compressive streath (psi)			
		3 days	7 days	28 days	90 days
1	OPC	3481 -100.00	4006-100.00	5291-100.00	5531-100.00
2	10RHA	3218 -92.40	4083-102.00	5511-104.20	5744-103.90
3	15RHA	3172-91.10	3964-99.00	5498-103.90	6102-110.30
4	20RHA	3185-91.50	3827-95.50	5408-102.20	5946-107.50
5	25RHA	3017-86.70	3860-96.40	5173-97.80	5687-102.80
6	30RHA	2868-82.40	3779-94.30	4968-94.20	5638-101.90

2.3 Development of Mechanical Properties of Self Compacting Concrete Contain Rice Husk Ash With Different Water Ratio

In this research, the characteristic of self compacting concrete that contain RHA will give different result with varies of water ratio (Ahmadi, M.A., 2007). Two replacement percentages of cement by RHA, 10% and 20% with mix have no RHA and two different water/cementicious material ratios (0.4 and 0.35), were used for both of self compacting and ordinary concrete specimens. The mixture proportions and result according to water/binder ratio adopted and are reported in Table 2.2 and 2.3 and Figure 2.1 and 2.2.

Table 2.2: Mix design with water ratio of 0.35. (Ahmadi, M.A., 2007)

Mix	Gravel	Sand	Water	Cement	RHA	W/B
SCC(0%RHA)	770	1000	161	460	0	0.35
SCC(10%RHA)	770	1000	161	414	46	0.35
CC(20%RHA)	770	1000	161	368	92	0.35
OC(0%RHA)	1043	750	161	460	0	0.35
OC(10%RHA)	1043	750	161	414	46	0.35
OC(20%RHA)	1043	750	161	368	92	0.35

Table 2.3: Mix design with water ratio of 0.40. (Ahmadi, M.A., 2007)

Mix	Gravel	Sand	Water	Cement	RHA	W/B
SCC(0%RHA)	770	970	184	460	0	0.4
SCC(10%RHA)	770	970	184	414	46	0.4
SCC(20%RHA)	770	970	184	368	92	0.4
OC(0%RHA)	1043	700	184	460	0	0.4
OC(10%RHA)	1043	700	184	414	46	0.4
OC(20%RHA)	1043	700	184	368	92	0.4

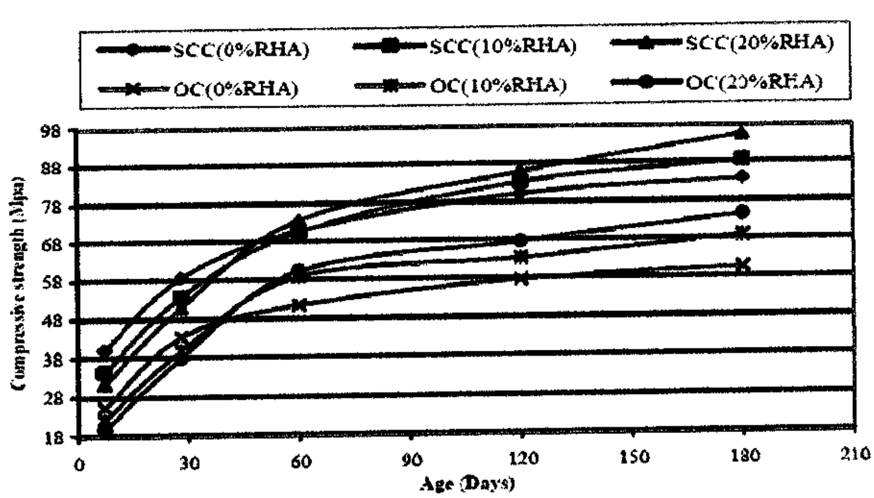

Figure 2.1: Compressive strength (water/binder=0.40). (Ahmadi, M.A., 2007)

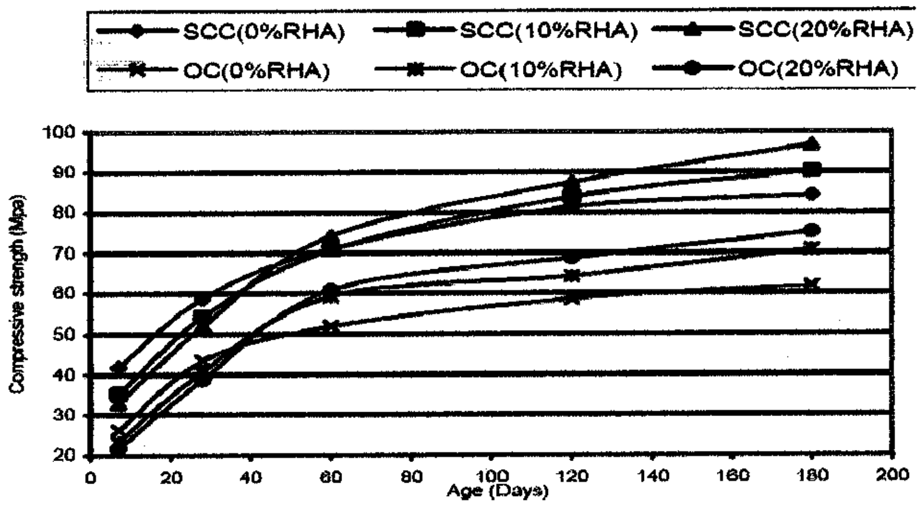

Figure 2.2: Compressive strength (water/binder=0.35) (Ahmadi, M.A., 2007)

From the result, it can be concluded that mix design with the water ratio of 0.35 give a better compressive strength compare to water ratio of 0.40.

2.4 MIRHA (Microwave Incinerated Rice Husk Ash) As Cement Replacement Material

Study on MIRHA as a cement replacement material is very limited due to its new inventing material. Few studies had been conducted on it such effect of microwave incinerated Rice Husk Ash (MIRHA) on the compressive strength of concrete (Kamal N.L.M., 2008). In this study, experiments were conducted to test the performance of concrete by compressive test at age 3, 7, and 28 days. Four series of concretes with water/cement ratios (w/c) of 0.45 were made. The absolute volume method was used in calculating the mixture proportions. MIRHA was used to replace 5%, 10%, 15% and 20% of cement content in concrete. The control concrete was designated NC (normal concrete) without any addition of MIRHA as a comparison. Superplasticizer was used in concrete containing MIRHA to increase its workability.

Table 2.4: Mixture Proportion of Concrete. (Kamal N.L.M., 2008)

Mix Code	Percentage of Rha (kg/m^3)	Percentage of Sp	Cement (kg/m^3)
NC	0.00	0	475.00
MIRHA5	23.75	0.4	451.25
MIRHA10	47.50	0.8	427.50
MIRHA15	71.25	1.5	403.75
MIRHA20	95.00	2.0	380.00

From the experiment, the result obtain found that MIRHA concrete samples have gained strength faster and 5% additions of MIRHA has the highest level of compressive strength among MIRHA at 800°C concrete samples. After 28 days, the 5% MIRHA concrete achieved compressive strength performance 33.33% higher than control concrete, 23.33% higher than 15% MIRHA concrete, and 13.33% higher than 10% MIRHA concrete. There is no significant different of compressive strength between 5% and 20% MIRHA concrete at 28 days.

2.5 Effect Of Water Absorption On Mortar

An experimental to study the effect of water absorption on durability of fly ash based geopolymer mortar specimens in sulphuric acid solution. Low calcium Class F fly ash was activated by a mixture of NaOH and Na_2SiO_3 containing 5% to 8% Na_2O with water to fly ash ratio of 0.33. (Thokchom, 2009)

In conclusion, residual compressive strength of specimens decreases with increase in water absorption. Variation of residual compressive strength with water absorption is shown in Figure 2.3. The specimen which recorded a residual strength of 29.4% corresponds to maximum water absorption (11.79%) among the three series. In contrast, the other specimen with 6.42% water absorption retained maximum residual compressive strength of 54.8%.

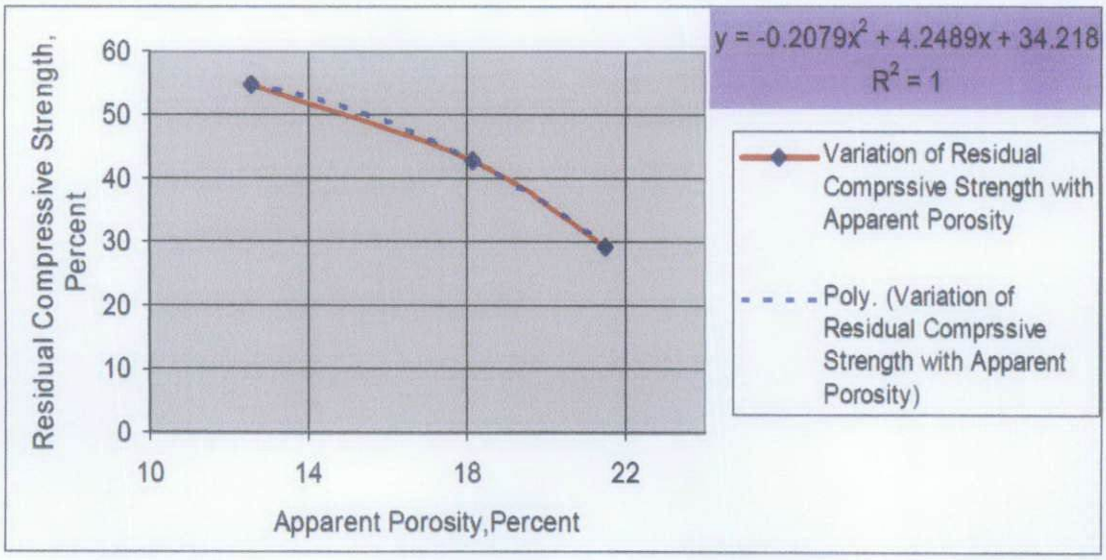

Figure 2.3: Relationship between residual compressive strength and porosity. (Thokchom, 2009)

2.6 Initial Rate of Suction (IRS)

Initial rate of suction (IRS) is used to determine the rate of absorption (sorptivity) of water by hydraulic cement concrete by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water. The exposed surface of the specimen is immersed in water and water ingress of unsaturated concrete dominated by capillary suction during initial contact with water.

The absorption, *I*, is the change in mass divided by the product of the cross-sectional area of the test specimen and the density of water. For the purpose of this test, the temperature dependence of the density of water is neglected and a value of 0.001 g/mm3 is used. The units of *I* are mm. (ASTM C 1585 – 04)

$$I = m_t/a/d$$

Where;

I = the absorption,
M_t = the change in specimen mass in grams, at the time t,
a = the exposed area of the specimen, in mm2, and
d = the density of the water in g/mm3.

CHAPTER 3

METHODOLOGY

3.1 Preparations

To make the experiment work in good flow, preparations woi : on the project need to be planned. Make sure the materials and the machineries that will be use are available. The process itself should follow the specification and the procedure that been implement.

3.2 Materials

The materials that will be used in this research are; cement, sand, water and M IRHA.

3.2.1 Sand

Sand is use in the mortar mix design as aggregates. It is also known as fine aggregates. Based on the research that had been done, size of the sand used in this experiment is 2.36mm. The sand obtained should be dried under the sun. After been dried up, keep in the container for the brick mixture.

3.2.2 Water

Water use in this experiment will be ordinary water. A tap water will just do it. In this research, water ratio are varied from 0.5and 0.55. Different water ratio is to find the suitable result from the test.

3.2.3 Cement

Cement used for this research is Ordinary Portland Cement (OPC) type 1 according to BS EN 197-1 2000. OPC type 1 is preferred because it is frequently used in construction industry and can be done in normal hydration process (Kusbiantoro, A., 2008)

.2.4 Microwave Incinerator Rice Husk Ash (MIRHA)

In order to obtain the optimum MIRHA, the Rice Husk is burnt at temperature of 400 °C using UTP Microwave Incinerator in Highway laboratory. Rice Husk burnt with high temperature to increase it silica content (Kamal N.L.M., 2008) and it has appearance colour of grey.

After the burning process, MIRHA was then ground in the Los Angeles to increase its fineness. MIRHA need ground for 3000 times to obtain the optimum fineness particles and it takes roughly about 1 hour and 30 minutes. Then, the obtained MIRHA put inside the container and close the lid tightly to avoid any others particles contaminated the MIRHA.

3.3 Microwave Incinerator

The UTP Microwave Incinerator (UTPMI) used in the research adopted the Air Cooled Magnetron system with an overall dimension of 2.3(H) x4.0 (W) x4.0 (L) with a chamber capacity of 1 m^3. Ceramic filter is used in the emission and ash control system with PLC (Programmable Logic Controller) mode of operation. Flue Gas Filter equipped with the microwave incinerator provides significant positive effect to the environment. It distils all the dust and ashes that are resulted from rice husk incineration, hence the air pollution from burning process can be reduced. The temperature range is up to 1600°C with operating temperature of 800°C. Rice husks were dried under direct sunlight to reduce their moisture content that result in large amount of smoke.

3.4 Mix Design Proportion

Overall, there are total of 40 different mixes that will be prepared throughout this research. The mixes are prepared with different quantity of cement-sand ratio, different water ratio, and different amount of percentage MIRHA. Control brick will be used as the control samples. The cement-sand ratio used is 1:3 and 1:4. Percentage of MIRHA used in this study are 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40% and 45% of the cement quantity. Water ratio used in this experiment is 0.5 and 0.55. In the end of the experiment, the best of the combination of the mixture will be monitored in the compressive strength test.

Table below show the mix proportion for one mortar sample with **water ratio of 0.5**

Table 3.1: Mix proportion for one mortar (cement/aggregate ratio, 1:3)

% MIRHA	MIRHA (kg)	Cement (kg)	Sand (kg)	Water (kg)	Total Mass (kg)
0	0	0.067	0.200	0.033	0.3
5	0.003	0.063	0.200	0.033	0.3
10	0.007	0.060	0.200	0.033	0.3
15	0.010	0.057	0.200	0.033	0.3
20	0.013	0.053	0.200	0.033	0.3
25	0.017	0.050	0.200	0.033	0.3
30	0.020	0.047	0.200	0.033	0.3
35	0.023	0.043	0.200	0.033	0.3
40	0.027	0.040	0.200	0.033	0.3
45	0.030	0.037	0.200	0.033	0.3

Table 3.2: Mix proportion for one mortar (cement/aggregate ratio, 1:4)

% MIRHA	MIRHA (kg)	Cement (kg)	Sand (kg)	Water (kg)	Total Mass (kg)
0	0	0.055	0.218	0.028	0.3
5	0.003	0.052	0.218	0.028	0.3
10	0.005	0.049	0.218	0.028	0.3
15	0.008	0.046	0.218	0.028	0.3
20	0.011	0.044	0.218	0.028	0.3
25	0.014	0.041	0.218	0.028	0.3
30	0.016	0.038	0.218	0.028	0.3
35	0.019	0.035	0.218	0.028	0.3
40	0.022	0.033	0.218	0.028	0.3
45	0.025	0.030	0.218	0.028	0.3

Table below show the mix proportion for one mortar sample with **water ratio of 0.55**

Table 3.3: Mix proportion for one mortar (cement/aggregate ratio, 1:3)

% MIRHA	MIRHA (kg)	Cement (kg)	Sand (kg)	Water (kg)	Total Mass (kg)
0	0	0.066	0.198	0.036	0.3
5	0.003	0.063	0.198	0.036	0.3
10	0.007	0.060	0.198	0.036	0.3
15	0.010	0.057	0.198	0.036	0.3
20	0.013	0.053	0.198	0.036	0.3
25	0.017	0.050	0.198	0.036	0.3
30	0.020	0.047	0.198	0.036	0.3
35	0.023	0.043	0.198	0.036	0.3
40	0.027	0.040	0.198	0.036	0.3
45	0.030	0.037	0.198	0.036	0.3

Table 3.4: Mix proportion for one mortar (cement/aggregate ratio, 1:4)

% MIRHA	MIRHA (kg)	Cement (kg)	Sand (kg)	Water (kg)	Total Mass (kg)
0	0	0.054	0.216	0.030	0.3
5	0.003	0.051	0.216	0.030	0.3
10	0.005	0.049	0.216	0.030	0.3
15	0.008	0.046	0.216	0.030	0.3
20	0.011	0.043	0.216	0.030	0.3
25	0.014	0.041	0.216	0.030	0.3
30	0.016	0.038	0.216	0.030	0.3
35	0.019	0.035	0.216	0.030	0.3
40	0.022	0.032	0.216	0.030	0.3
45	0.024	0.030	0.216	0.030	0.3

3.5 Mixing Procedures

The mixing process of this experiment is done by using the mortar mixer. First of all, material is prepared first before mixing. The power supply is switch on. Put sand and cement into the mixer. Water then is poured inside. Adjust the speed of the mixer to the suitable level. Turn on the power supply and mix it follow to the design proportion. Lastly, do the hand mixing to ensure the homogeneity.

3.6 Casting and Curing

The fresh mixture of brick then is cast into the steel mould, 50mm x 50mm x 50mm in size which are prepared earlier. The mould need to coat with gris before the fresh mixture is cast inside it. After finish casting, left the mould in the room temperate for 24 hours covered with sacks. The mould is open after 24 hours and is cured in the water at 25 °C. This curing process is to avoid shrinkage cracking due to temperature fluctuation and enable the brick samples to gain its maximum strength.

3.7 Compressive Test For Mortar

After the brick had been set into mould, the compressive test will be applied upon it. Compressive test are performed to measure the compressive strength of the brick at every 7, 28 and 60 days. The equipment used to do the test is Digital Compressive Testing Machine.

3.8 Water Absorption Test

The determination of water absorption in mortar is following the standard set by ASTM C67-90a. The testing needed the wet mass and the dry mass in order to find the water absorption of the sample. The testing method been used in this experiment are using the immersion test where the sample will be put in the water bath for 24h and then is put inside the oven for another 24h.

3.9 Initial Rate of Suction (IRS) Test

The determination of IRS is following the standard of ASTM C1585. The mortar is dried in the oven as in absorption test. The dry weight is recorded. The dry mortar is immersed in water at a depth of 3 ± 1mm for the time that been set by the standard and recorded the weight for each time. After all the recorded been done, graph of time (sec $^{1/2}$) will be plotted against I (mm) and the slope is the IRS of the sample.

3.10 Sieve Analysis and Hydrometer Test

Hydrometer test is performed to determine the percentage of different grain sizes of the sample. Sieve analysis is performed to determine the distribution of the courser, larger-sized particle, and hydrometer method is used to determine the distribution of the finer particles. The test procedure follows the standard of ASTM D-422.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Compression Test Result for 7 days

Result of the 7 days of compressive strength was obtained after the date the sample been cast. For each of the mixes, average results were calculated to gain the best possible result. The results and discussion are as below.

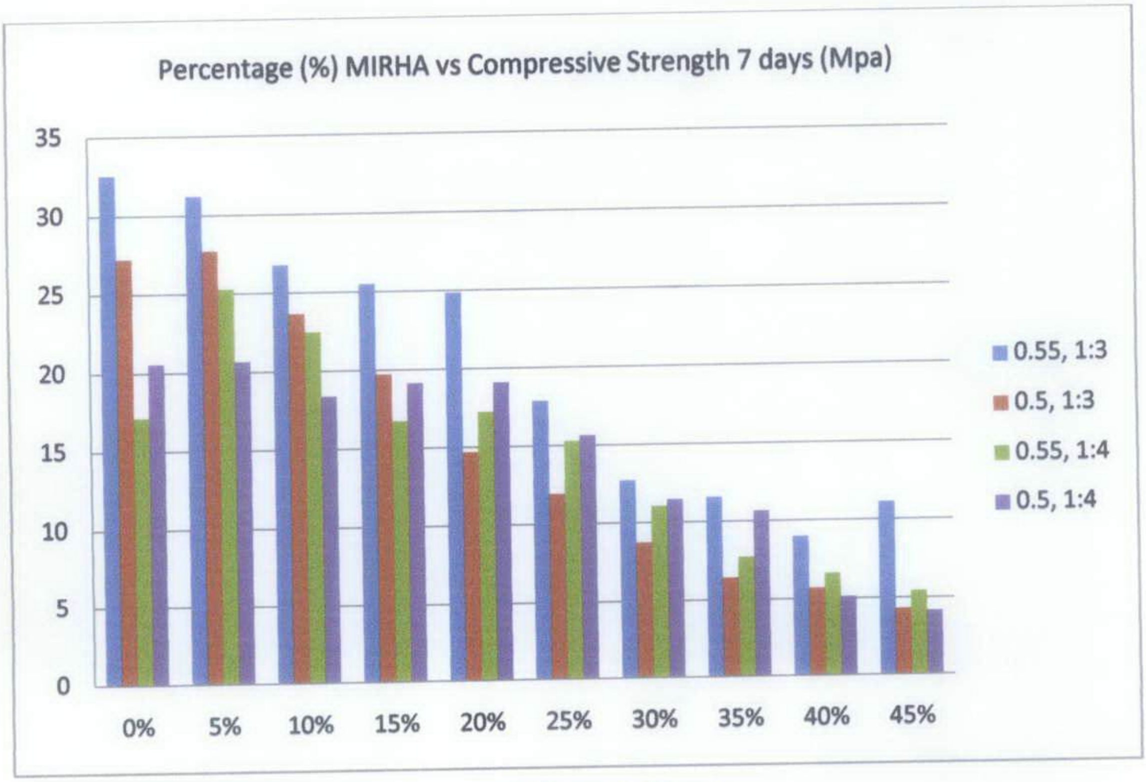

Figure 4.1: Result of compressive strength test (7 days)

From the figure 4.1, the compressive strength of 7 days testing was obtained. Strength of the mortar seems to decrease as the content of MIRHA increases. Water ratio of 0.55 have a higher strength compare to the 0.5 water ratio. Cement to aggregate with ratio of 1:3 also has higher strength compare to 1:4. Control mortar at

0% seems to have achieved early high strength. 5% of MIRHA at water ratio of 0.55 and 1:4 have higher value than 0% of MIRHA. Other than that, there is no significant difference between MIRHA percentage and the control mortar. The detail of the result can be seen at appendices A1.

4.2 Compression Test Result for 28 days

Result of the 28 days of compressive strength was obtained. Basically the strength of the mortar will increase compare to the previous date of 7 days testing. Results and discussion are as below.

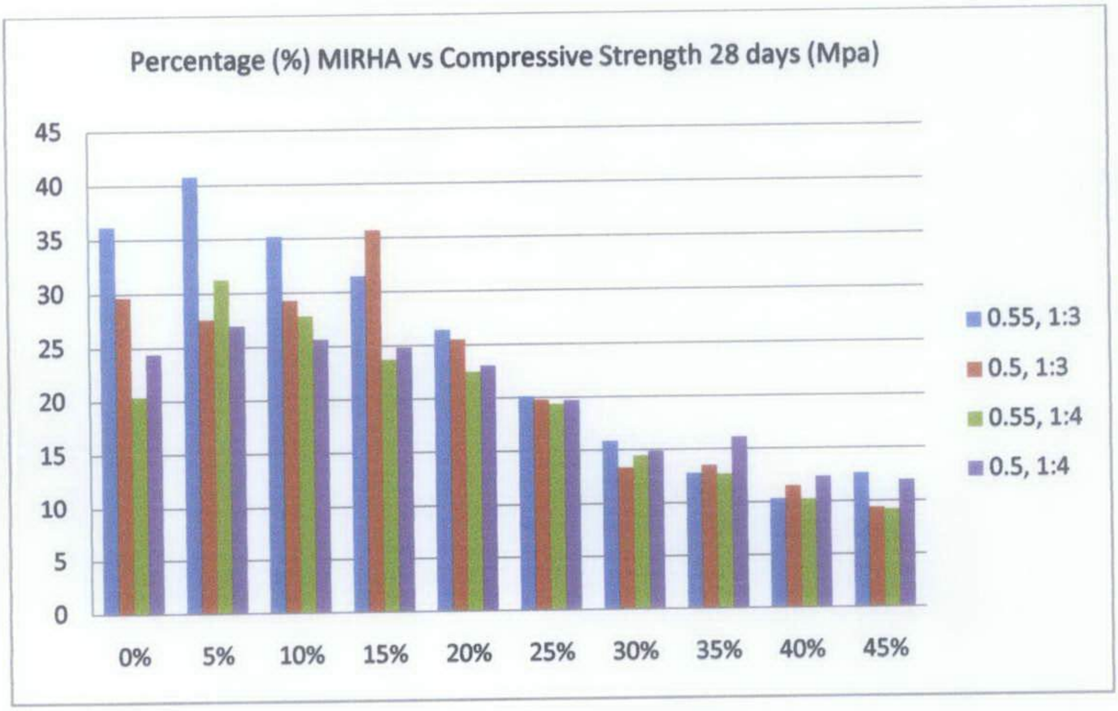

Figure 4.2: Result of compressive strength test (28 days)

From the figure 4.2, the compressive strength of 28 days testing was obtained. The strength of MIRHA mortar keeps increase until 5 to 15%. At water ratio of 0.5 and 1:3, it is obtained that the strength of MIRHA mortar peak at 35.71 MPa, 15% of MIRHA. Water ratio of 0.55 consistently have a higher strength compare to the 0.5

water ratio. Cement to aggregate with ratio of 1:3 also has higher strength compare to 1:4. The detail of the result is attached in Appendix A1.

4.3 Compression Test Result for 60 days

Result of the 60 days of compressive strength was obtained. The result obtained should not have lower strength value than the previous days. Results and discussion are as below.

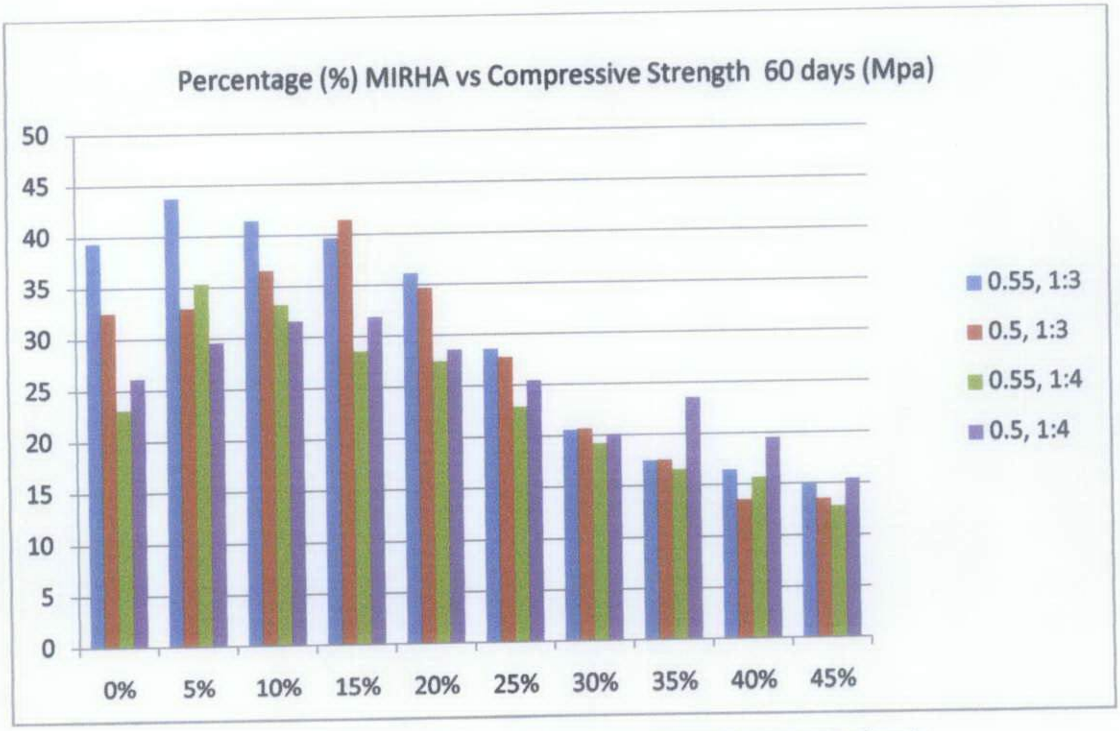

Figure 4.3: Result of compressive strength test (60 days)

From the figure 4.3, the compressive strength of 60 days testing was obtained. The strength of MIRHA mortar increases up to 15% of MIRHA. At water ratio of 0.5 and 1:3, it is obtained that the strength of MIRHA mortar peak at 41.45 MPa at a 15% of MIRHA. Cement to aggregate with ratio of 1:3 also has higher strength compare to 1:4. The detail of the result can be refer at appendices A1.

4.4 Density Result

The density results of the mortar are based on the 28 days age. The density was obtained by the weight of the sample and divided the volume of it. Results and discussion of density are as below.

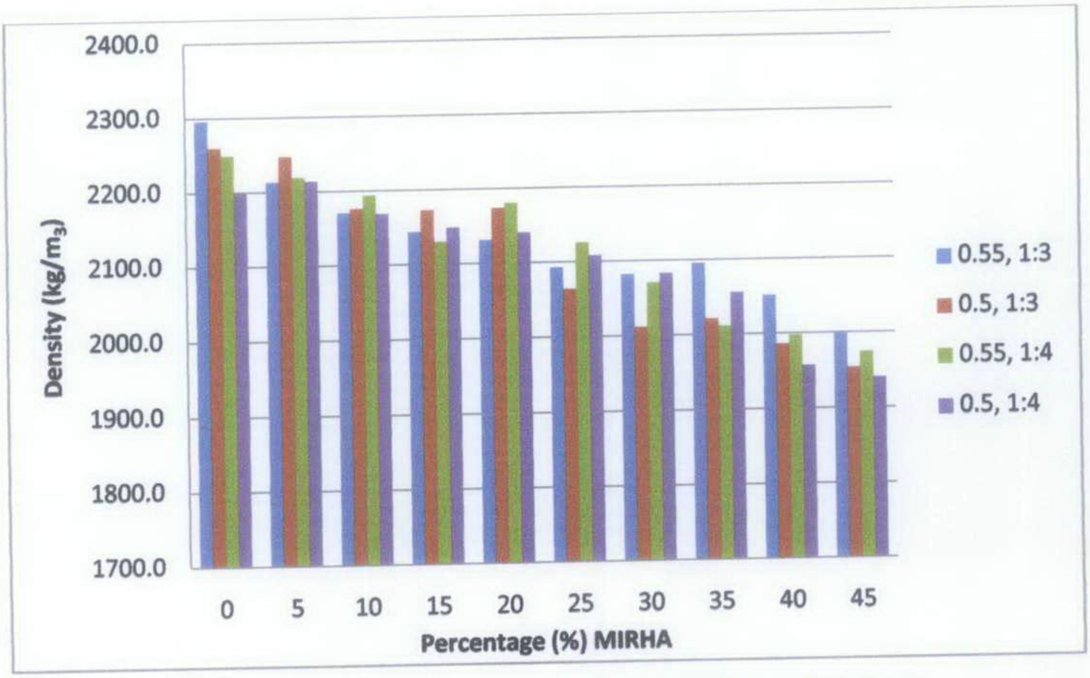

Figure 4.4: Result of compressive strength test (28 days)

The figure 4.4 shows the density of the mortar obtained at 28 days. The density also has the same characteristic with mortar in terms of the strength where as the percentage of MIRHA increase, the density decreases. The density also may play a part in relation to the strength of the mortar because both results show the declination with respect to the increases of MIRHA content in the mortar. The detail of the result can be refer at appendices A2.

4.5 Water Absorption Result

Water absorption test were carried out to find out the ability of the MIRHA sample to absorb water. Below are the results and discussion of the test.

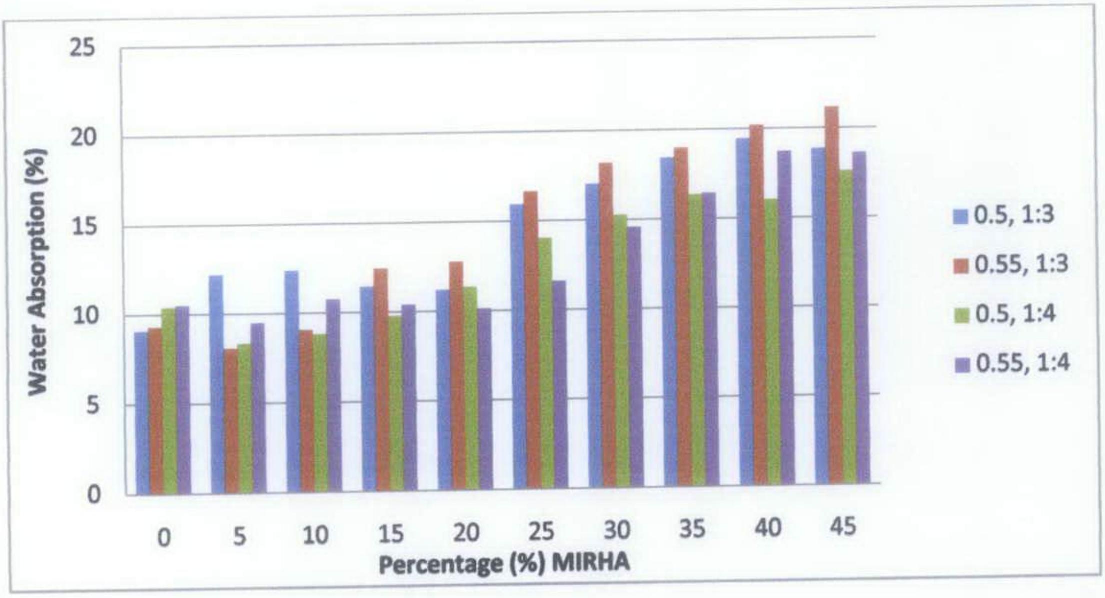

Figure 4.5: Result of water absorption

The figure 4.5 shows the result obtained from the water absorption test. Water absorption increases as the content of MIRHA increases. It may due to MIRHA ability to absorb water more compare to cement. Ranges of water absorption that achieve are varies from 8% to 21%. Water are absorb even higher in 0.55 ratio compare to 0.5 maybe because of the high amount of water content inside of the sample. This result shows that residual compressive strength of specimens decreases with the increase in water absorption which akin to the result from the study (Thokchom, 2009). The detail of the result can be refer at appendices A3.

4.6 IRS (Initial Rate of Suction) Result

Initial Rate of Suction Test or also known as IRS, is the test of the sample mortar to absorb water after been dry with respect to time. It is to find the rate how much the sample mortar can absorb water with differ MIRHA content.

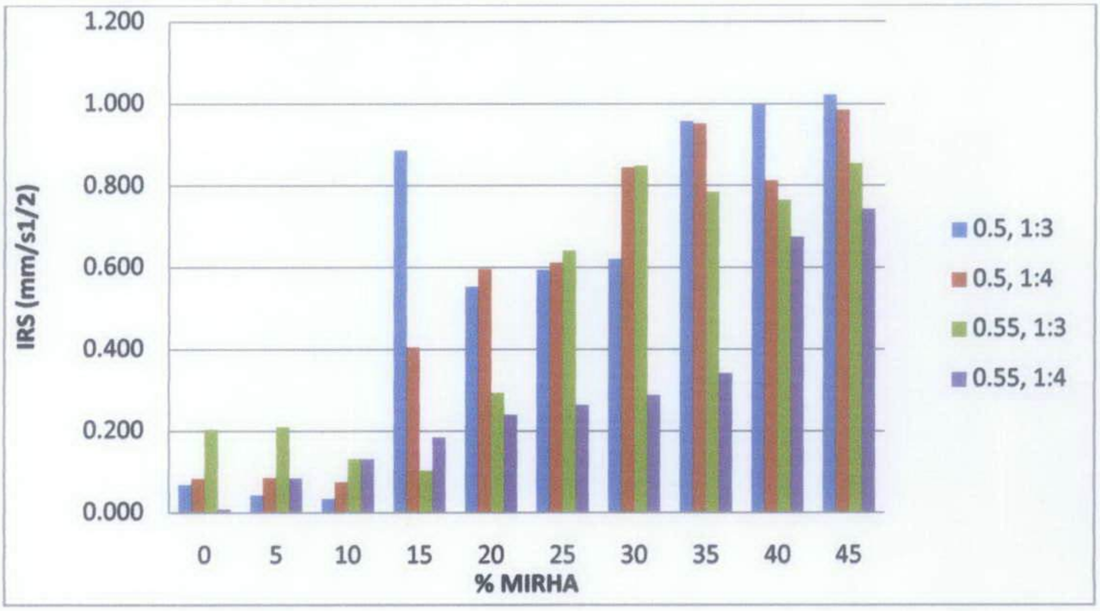

Figure 4.6: Result of IRS

The figure 4.6 shows the result obtained from the IRS test. Percentage of MIRHA affects the IRS rate because the higher amount of MIRHA, the higher the value of IRS. It may be one of the characteristic of MIRHA to absorb water faster in early minutes. The characteristic of MIRHA to absorb water at high rate after been put in the water may be the cause of the decreasing strength of mortar. IRS of water ratio of 0.5 and 1:3 at 15% increase suddenly may contribute to the strength that it achieves.

4.7 Sieving Analysis Test Result

Sieving analysis test were carried out to find the size of the particle of sand, cement and MIRHA. Results and discussion of test are as below.

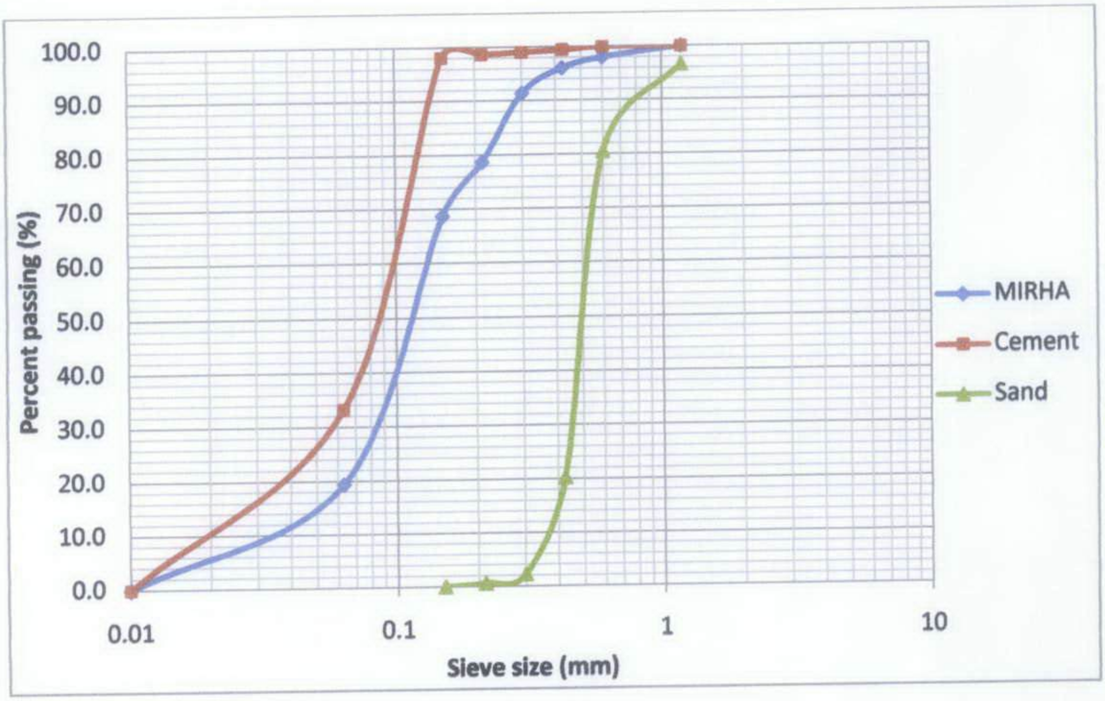

Figure 4.7: Result of sieving analysis

Figure 4.7 above shows the result obtained from the sieving testing with sample form sand, cement and MIRHA. Sand has a larger particle compare to MIRHA and cement while cement has the smallest particle size. The sizes of pan been uses are ranges from 1.18mm, 0.6mm, 0.425mm, 0.3mm, 0.212mm, 0.12mm, 0.063 and lastly a close pan. At the bottom of each pan, the weight retained for MIRHA after passing the 0.063mm is 29 g, weight retained for cement 49.4 g, and sand has no particle that pass through the 0.063mm. The large sizes of the sand contribute to the factor of it not passing through.

For the fine particle of cement and MIRHA, hydrometer test can be conducted because they pass the 0.063mm pan. From the table 4.1 and table 4.2 below, it is found that cement and MIRHA has a same diameter after the final minutes of testing which is 0.0027mm. Detail result can be seen at appendices A5.

Table 4.1: Hydrometer result for MIRHA

Elapsed Time, t min	Reading, R_h'	Particle Diameter, D mm
0.0	20.0	-
0.5	19.0	0.1171
1.0	18.5	0.0834
2.0	17.5	0.0598
4.0	16.0	0.0432
8.0	13.5	0.0315
30.0	8.0	0.0174
120.0	4.5	0.0090
480.0	3.0	0.0046
1440.0	2.5	0.0027

Table 4.2: Hydrometer result for Cement

Elapsed Time, t min	Reading, R_h'	Particle Diameter, D mm
0.0	30.0	-
0.5	27.0	0.1024
1.0	25.0	0.0751
2.0	24.5	0.0536
4.0	24.3	0.0380
8.0	21.5	0.0282
30.0	7.3	0.0175
120.0	3.5	0.0091
480.0	2.3	0.0046
1440.0	2.0	0.0027

4.8 Comparison between Compressive Strength and Water Absorption

Relation between the compressive strength and water absorption are somehow related to each other. The compressive strength is based on the 28 days. As for that, comparison between these two tests is done below.

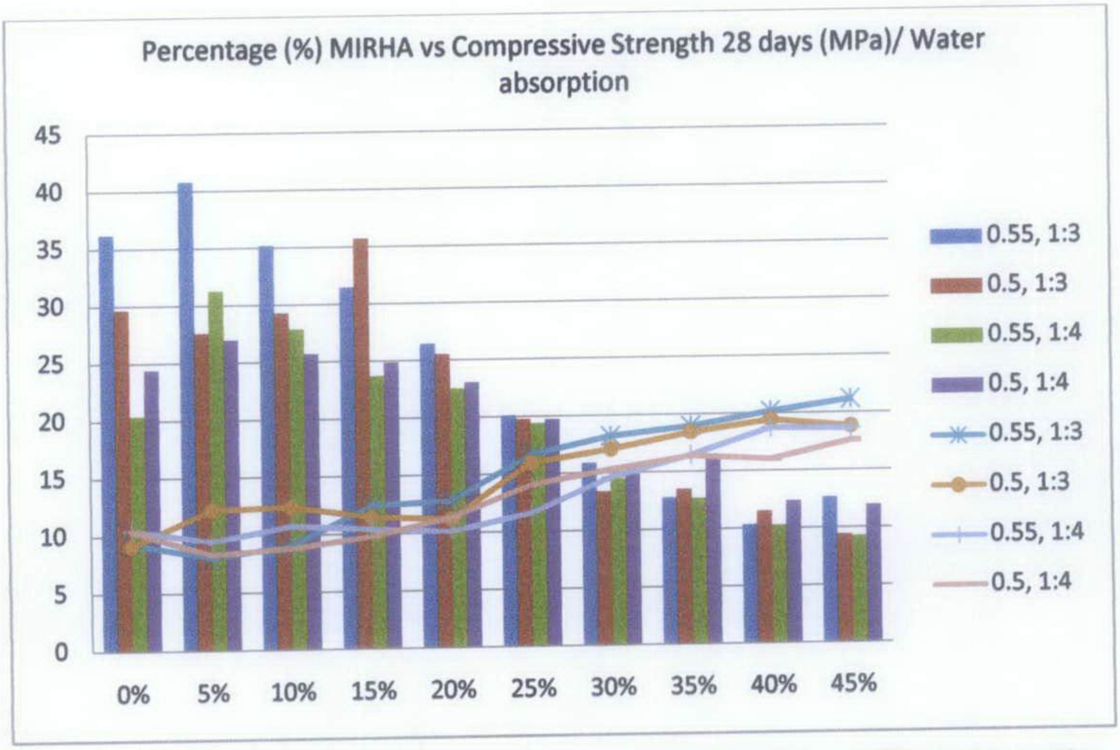

Figure 4.8: Result Comparison between Compressive Strength and Water Absorption

From the figure 4.8, the result between the compressive strength and water absorption is compared. The column shape is the compressive strength while the line is the water absorption indicator. Based from the figure, it is found that with the increases of MIRHA content, the strength of mortar decreases but the water absorption increase. It may be due to the MIRHA ability to absorb more water that affected the strength of MIRHA mortar.

4.9 Result of Sand Moisture Content

Table 4.3: Result of sand moisture content and calculation of moisture content

No.	Description	Sample No. 1
1	Weight of Empty Container, W_1 (g)	20.68
2	Weight of Container + Wet Soil, W_2 (g)	59.80
3	Weight of Container + Dry Soil, W_3 (g)	59.60

CALCULATION

1	Weight of Water (g) = W_2 - W_3	0.20
2	Weight of Dry Soil (g) = W_3 - W_1	38.92
3	Water content, w = (W2 - W3)/(W3 - W1) * 100%	0.51

Sand of Sample 1 was kept in the laboratory at approximately 27° C for five days. The sample are put inside the container that been provided inside the concrete lab.

4.10 Economical Benefit

In Malaysia, huge amount of rice husks is being produced every year and almost reaching to 2.231 million tons (Nuruddin, 2009). This shows that Malaysia has huge amount of rice husks available due to it is one of this country producing. Rather than let this rice husks been wasted, why not we use it. Using this RHA/MIRHA material, it can reduce the need for new construction material because RHA/MIRHA is a waste material. With this new invented MIRHA, it will reduce the need of cement which is expensive in the current prices and may increase in the future due to high demand. This reduction for new construction resource will also save the environment in a long term.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project presented the result of the compressive strength of MIRHA mortar. Based from the result:-

- Cement to aggregate ratio of 1:3 consistently has higher strength than the ratio of 1:4.At water ratio of 0.5 and cement to aggregate of 1:3, the optimum strength was achieved at 15% of MIRHA.
- At 7 days, the strength of mortar has no significant difference with increases of the MIRHA content. At 28 days of testing, the strength of mortar keeps on increases up to 5%, 10%, and 15% then decline with respect to MIRHA percentage. At 60 days, water ratio of 0.5 and 1:3, it is obtained that the strength of MIRHA mortar peak at 41.45 MPa at a 15% of MIRHA.
- For the cement to aggregate of 1:3, the strength of mortar with water ratio of 0.55 has higher strength compare to 0.5 while for the cement to aggregate of 1:4, it is vice verse.
- MIRHA mortar has lower strength when the percentages of MIRHA increase. This may be due to the MIHA ability to absorb water more than cement.

5.2 Recommendation

- Higher water ratio than 0.55 should be use in determining the strength but at certain degree because too many water will affect the mortar strength.
- In order for this research can obtain the accurate results, all the material that use in experiment must be ensuring in excellent condition. Also, to improve the progress of experiment, the materials must be ready earlier to avoid any delay.

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Table A1-1:

Result of Compressive Strength at water ratio of 0.55 and aggregate of 1:3

%MIRHA	7 days strength (MPa)	28 days strength (MPa)	60 days strength (MPa)
0%	32.57	36.21	39.41
5%	31.22	40.8	43.76
10%	26.79	35.21	41.51
15%	25.51	31.47	39.68
20%	24.86	26.45	36.12
25%	17.9	20.11	28.56
30%	12.7	15.86	20.56
35%	11.55	12.75	17.47
40%	9	10.31	16.46
45%	11.11	12.64	14.97

Table A1-2:

Result of Compressive Strength at water ratio of 0.5 and aggregate of 1:3

%MIRHA	7 days strength (MPa)	28 days strength (MPa)	60 days strength (MPa)
0%	27.24	29.66	32.54
5%	27.73	27.59	32.96
10%	23.65	29.29	36.57
15%	19.75	35.71	41.745
20%	14.68	25.53	34.68
25%	11.91	19.78	27.78
30%	8.74	13.35	20.68
35%	6.43	13.49	17.54
40%	5.7	11.49	13.53
45%	4.3	9.41	13.54

Table A2-3:

Result of Density at water ratio of 0.55 and aggregate of 1:4

%MIRHA	Density (kg/m^3)
0	2249.3
5	2219.0
10	2193.7
15	2130.2
20	2180.7
25	2126.1
30	2070.5
35	2010.7
40	1997.0
45	1974.4

Table A2-4:

Result of Density at water ratio of 0.5 and aggregate of 1:4

%MIRHA	Density (kg/m^3)
0	2199.3
5	2214.0
10	2169.3
15	2149.1
20	2141.0
25	2108.5
30	2082.9
35	2055.8
40	1956.7
45	1940.1

Table A1-3:

Result of Compressive Strength at water ratio of 0.55 and aggregate of 1:4

%MIRHA	7 days strength (MPa)	28 days strength (MPa)	60 days strength (MPa)
0%	17.14	20.39	23.1
5%	25.3	31.26	35.34
10%	22.47	27.86	33.21
15%	16.74	23.71	28.54
20%	17.24	22.49	27.46
25%	15.29	19.4	22.9
30%	11.06	14.44	19.24
35%	7.73	12.67	16.57
40%	6.62	10.26	15.69
45%	5.44	9.24	12.79

Table A1-4:

Result of Compressive Strength at water ratio of 0.5 and aggregate of 1:4

%MIRHA	7 days strength (MPa)	28 days strength (MPa)	60 days strength (MPa)
0%	20.56	24.42	26.15
5%	20.67	26.98	29.57
10%	18.41	25.68	31.57
15%	19.16	24.85	31.9
20%	19.12	23.06	28.57
25%	15.66	19.73	25.46
30%	11.48	14.87	20.09
35%	10.66	16.13	23.56
40%	5.12	12.36	19.55
45%	4.16	11.96	15.45

Table A2-1:

Result of Density at water ratio of 0.55 and aggregate of 1:3

%MIRHA	Density (kg/m^3)
0	2296.0
5	2213.2
10	2171.0
15	2144.0
20	2131.5
25	2093.0
30	2082.1
35	2095.7
40	2051.0
45	1999.0

Table A2-2:

Result of Density at water ratio of 0.5 and aggregate of 1:3

%MIRHA	Density (kg/m^3)
0	2260.0
5	2247.4
10	2176.3
15	2173.3
20	2174.7
25	2064.0
30	2011.1
35	2021.2
40	1986.0
45	1953.4

A3

Results of the Water Absorption of the Mortar

Table A3-1:

Result of Water Absorption at water ratio of 0.5 and aggregate of 1:3

MIRHA (%)	Wet mass (g)	Dry mass (g)	Water absorption (%)
0	281	258	9.1
5	276	246	12.2
10	272	242	12.4
15	273	245	11.4
20	268	241	11.2
25	269	232	15.9
30	261	223	17.0
35	257	217	18.4
40	252	211	19.4
45	246	207	18.8

Table A3-2:

Result of Water Absorption at water ratio of 0.55 and aggregate of 1:3

MIRHA (%)	Wet mass (g)	Dry mass (g)	Water absorption (%)
0	287	263	9.3
5	281	260	8.1
10	277	254	9.1
15	271	241	12.4
20	265	235	12.8
25	266	228	16.7
30	260	220	18.2
35	257	216	19.0
40	256	213	20.2
45	252	208	21.2

Table A3-3:

Result of Water Absorption at water ratio of 0.5 and aggregate of 1:4

MIRHA (%)	Wet mass (g)	Dry mass (g)	Water absorption (%)
0	298	271	10.4
5	286	264	8.3
10	284	261	8.8
15	281	256	9.8
20	275	247	11.3
25	268	235	14.0
30	264	229	15.3
35	263	226	16.4
40	246	212	16.0
45	254	216	17.6

Table A3-4:

Result of Water Absorption at water ratio of 0.55 and aggregate of 1:4

MIRHA (%)	Wet mass (g)	Dry mass (g)	Water absorption (%)
0	282	256	10.5
5	277	253	9.5
10	278	251	10.8
15	276	250	10.4
20	272	247	10.1
25	269	241	11.6
30	267	233	14.6
35	262	225	16.4
40	260	219	18.7
45	255	215	18.6

A4

Results of the Initial Rate of Suction (IRS) of the Mortar

Table A4-1:

Result of Water Absorption at water ratio of 0.5 and aggregate of 1:3

%MIRHA	Mass, M (g) at Time, t (min)					
	0	60	120	300	600	1200
0	258.33	259.07	259.12	259.33	259.46	259.76
5	246.43	246.54	246.64	246.79	246.94	247.23
10	242.74	243.21	243.96	243.43	243.76	243.53
15	245.13	249.41	252.46	256.16	259.65	261.45
20	241.12	242.51	245.56	247.14	249.67	251.57
25	232.32	235.86	238.51	240.13	242.96	244.12
30	223.51	225.41	228.51	229.58	232.46	234.41
35	217.75	220.58	224.49	228.68	231.54	233.51
40	211.52	219.41	223.51	228.64	231.54	234.87
45	207.62	213.41	216.87	218.78	220.68	222.90

Table A4-2:

Result of Water Absorption at water ratio of 0.5 and aggregate of 1:4

%MIRHA	Mass, M (g) at Time, t (min)					
	0	60	120	300	600	1200
0	271.41	272.01	272.53	272.98	273.2	273.31
5	264.05	264.76	264.91	265.05	265.23	265.38
10	261.58	262.76	263.21	262.76	263.12	263.38
15	256.17	258.86	259.51	259.95	261.57	261.96
20	247.2	249.58	251.69	253.54	254.54	255.65
25	235.43	238.46	240.69	242.65	243.68	244.37
30	229.01	233.56	237.67	239.57	241.88	243.56
35	226.49	233.67	237.57	240.74	243.08	245.24
40	212.67	217.56	221.67	224.05	226.12	227.46
45	216.96	223.66	226.47	230.86	233.66	235.58

Table A4-3:

Result of Water Absorption at water ratio of 0.55 and aggregate of 1:3

%MIRHA	Mass, M (g) at Time, t (min)					
	0	60	120	300	600	1200
0	263.57	264.25	264.47	264.80	264.99	265.65
5	260.68	261.46	261.78	261.97	262.25	262.78
10	254.87	255.12	255.47	255.90	256.41	256.75
15	241.12	242.04	242.21	242.29	242.40	242.59
20	235.76	236.67	237.54	237.58	238.51	238.95
25	228.05	230.51	233.57	235.12	237.58	238.63
30	220.56	225.57	227.51	230.59	233.51	234.57
35	216.46	219.57	222.41	224.67	227.12	229.57
40	213.67	216.39	219.59	222.12	224.05	226.45
45	208.51	213.41	216.68	219.56	221.02	223.23

Table A4-4:

Result of Water Absorption at water ratio of 0.55 and aggregate of 1:4

%MIRHA	Mass, M (g) at Time, t (min)					
	0	60	120	300	600	1200
0	256.62	264.15	264.22	264.24	264.25	264.25
5	253.63	253.86	253.97	254.42	254.69	254.85
10	251.74	251.96	252.21	252.57	252.86	253.21
15	250.63	250.76	250.89	251.21	252.38	252.59
20	247.12	247.95	248.68	249.58	250.14	250.96
25	241.69	242.67	243.79	244.12	244.97	245.96
30	233.96	234.44	234.76	234.99	235.51	236.75
35	225.57	227.47	228.63	229.65	230.51	231.14
40	219.69	223.52	225.67	227.68	228.56	230.51
45	215.05	218.67	219.96	222.58	225.68	226.96

A5

Results of the Sieving Analysis

And Hydrometer Test of the Mortar

Table A5-1:

Sieve result of the MIRHA

Pan size (mm)	Weight retained (g)	Cumulative passing	Percentage passing (%)
1.180	0	0	100.0
0.600	3	3	98.0
0.425	3	6	96.0
0.300	7	13	91.3
0.212	19	32	78.7
0.150	15	47	68.7
0.063	74	121	19.3
0	29	150	0.0

Table A5-2:

Sieve result of the Cement

Pan size (mm)	Weight retained (g)	Cumulative passing	Percentage passing (%)
1.180	0	0	100.0
0.600	0.05	0.05	99.97
0.425	0.78	0.83	99.44
0.300	0.62	1.45	99.03
0.212	0.52	1.97	98.68
0.150	0.83	2.8	98.12
0.063	96.78	99.58	33.16
0	49.4	148.98	0.00

Table A5-3:

Sieve result of the Sand

Pan size (mm)	Weight retained (g)	Cumulative passing	Percentage passing (%)
1.180	17	17	96.6
0.600	80	97	80.5
0.425	300	397	20.3
0.300	90	487	2.2
0.212	8	495	0.6
0.150	3	498	0.0
0.063	0	498	0.0
0	0	498	0.0

Table A5-4:

Hydrometer Result for MIRHA

Elapsed Time, t min	Temperature, °C	Water Viscosity, η mPa.s	Relative Density	Reading, R_h'	$R_h' + C_m = R_h$	Effective Depth, Hr mm	Particle Diameter, D mm
0.0	27	0.8538	1.0200	20.0	20.5	128.8	-
0.5	27	0.8538	1.0190	19.0	19.5	132.7	0.1171
1.0	27	0.8538	1.0185	18.5	19.0	134.7	0.0834
2.0	27	0.8538	1.0175	17.5	18.0	138.5	0.0598
4.0	27	0.8538	1.0160	16.0	16.5	144.4	0.0432
8.0	27	0.8538	1.0135	13.5	14.0	154.1	0.0315
30.0	27	0.8538	1.0080	8.0	8.5	175.5	0.0174
120.0	27	0.8538	1.0045	4.5	5.0	189.1	0.0090
480.0	27	0.8538	1.0030	3.0	3.5	194.9	0.0046
1440.0	27	0.8538	1.0025	2.5	3.0	196.8	0.0027

Table A5-5:

Hydrometer Result for Cement

Elapsed Time, t min	Temperature, °C	Water Viscosity, η mPa.s	Relative Density	Reading, R_h'	$R_h' + C_m = R_h$	Effective Depth, Hr mm	Particle Diameter, D mm
0.0	27	0.8538	1.0300	30.0	30.5	90.0	-
0.5	27	0.8538	1.0270	27.0	27.5	101.6	0.1024
1.0	27	0.8538	1.0250	25.0	25.5	109.4	0.0751
2.0	27	0.8538	1.0245	24.5	25.0	111.3	0.0536
4.0	27	0.8538	1.0243	24.3	24.8	112.1	0.0380
8.0	27	0.8538	1.0215	21.5	22.0	123.0	0.0282
30.0	27	0.8538	1.0073	7.3	7.8	178.2	0.0175
120.0	27	0.8538	1.0035	3.5	4.0	192.9	0.0091
480.0	27	0.8538	1.0023	2.3	2.8	197.6	0.0046
1440.0	27	0.8538	1.0020	2.0	2.5	198.8	0.0027

Gant Chart for FYP 1

Table A6-1: FYP 1 Progress

Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Selection of Project Topic	■	■																	
Data Gathering		■	■	■	■	■													
Progress Report							■												
Experimental Works											■	■	■						
Brick Mixing											■	■	■						
Grinding MIRHA																			■
Cube Test: 7 days												■	■						
Cube Test: 28 days															■	■			
Study Weeks															■				
Final Exam																■	■		
Interim Report											■	■	■	■					
Submission of Interim Report														■					
Final Presentation															■				