Pull Out Tension Capacity of Self Compacting Concrete Containing Rice Husk Ash

by

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CERTIFICATION OF APPROVAL

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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.

MOHD AFFENDI BIN RAMLAN

ABSTRACT

Self-compacting concrete (SCC) is a relatively new kind of high performance concrete product that sees the addition of superplasticiser and a stabilizer to the concrete mix to significantly increase the ease and rate of flow. By its very nature, self-compacting concrete (SCC) does not require vibration. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate. For normal high strength concrete, bonding between concrete and rebar can be considered relatively high due to vibration process. The study related to the shear bond properties of self-compacting concrete and rebar. In additional, the self-compacting-concrete added with admixture namely rice husk ash (RHA). Incidentally, this study focused on the performance of self-compacting-concrete with rice husk ash (RHA) in different three water-to-cement ratio for finding the optimum value of the ratio. Since this study involves rebar and concrete, the performance measured with pull-out-test. The pullout technique measures quantitatively the in-situ strength of the self-compacting concrete when proper correlations have been made. At the end of this investigation, it is identified the optimum water-to-cement ratio and super plasticizers in self-compacting concrete (SCC) for maximum bonding stress between concrete and rebar. It is also to identify the effect of rice husk ash (RHA) as filler in self-compacting concrete (SCC).

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CHAPTER 1

INTRODUCTION

1.0 Background

Self-compacting concrete (SCC) is a relatively new kind of high performance concrete product that sees the addition of superplasticiser and a stabilizer to the concrete mix to significantly increase the ease and rate of flow. By its very nature, SCC does not require vibration. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate. SCC being used given health and safety benefits and offers faster construction times, increased workability and ease of flow around heavy reinforcement. Having no need for vibrating equipment spares workers from exposure to vibration. No vibration equipment also means quieter construction sites.

SCC is a generic term for mix designs that differ from traditional concretes at the molecular interface between the cement compounds and the admixture polymers. The fluidity of SCC ensures a high level of workability and durability whilst the rapid rate of placement provides an enhanced surface finish. SCC is certainly the way forward for both insitu and precast concrete construction. The health and safety benefits and the improved construction and performance results make it a very attractive solution.

1.1 Problem Statement

Since structural concrete is, in the vast majority of cases, used with steel reinforcement, the strength of bond between the two materials is of considerable importance with respect to structural behavior, including cracking due to shrinkage and early thermal effects. Bond arises primarily from friction and adhesion between concrete and steel.

Therefore, this project will aim to recognize the bonding stress between concrete and steel. This project also aims to find the optimum water-to-cement ratio and super plasticizers in self-compacting concrete (SCC) and the behavior and effect of rice husk ash (RHA) as filler in self-compacting concrete (SCC).

1.3 Objective

This study was undertaken to achieve the following objectives:

- To determine the bond characteristics of self compacting concrete containing rice husk ash as a filler materials.
- To compare the bond characteristics of SCC with the conventionally designed normal concrete.

1.4 Scope of Study

The scope of work for this study will be related to the shear bond properties of self-compacting concrete and rebar. The self-compacting-concrete will be added with admixture namely rice husk ash (RHA). The admixture is added in order to study the performance of self-compacting-concrete with RHA in different water-to-cement ratio.

Since this study involves rebar and concrete, the performance will be measured with pull-out-test. All mixtures and materials preparations will take into place inside the concrete laboratory only except for the rice husk ash (RHA) material preparation. The RHA was taken from BERNAS Factory at Sungai Renggam, and the grinding process prepared by using the Los Angeles Abrasion Testing machine at old building (Block J). The pull out test was done inside the concrete laboratory. Consequently, results were employed from laboratory results lonely.

To carry out the investigation, 10 sets of mixture being prepared and each set consist of 9 samples of cylinder (Table 1) and 3 samples of cubes. The steel bar was put together inside the cylinder sample mould for pullout test purpose, which gave the relationship between load and elongation of the sample. The source of information chiefly taken from related journals and textbooks. Samples of cubes 150mm x 150mm were prepared in order to get the compressive stress of the concretes.

Table 1: Preparation of Self-Compacting Concrete Samples for Pull out Test

No	Water/Cement ratio	Super plasticizers (%)	Test (days)	Steel bar sizes (mm)	No. of Sample
1	0.39	2	28	10	3
				12	3
				16	3
		4	28	10	3
				12	3
				16	3
		6	28	10	3
				12	3
				16	3
Total Samples					27

Table above represented for 1 set of water-cement ratio which is 0.39. There will be another two sets of different water-cement ratio i.e., (0.44 and 0.50) which give a total of 81 samples.

Table 2: Preparation of Control Samples for Pull out Test

Water/Cement ratio	Test (days)	Steel bar sizes (mm)	No. of Sample
0.4	28	10	3
		12	3
		16	3
Total Samples			12

One set of conventionally design concrete mixture without Rice Husk Ash (RHA) and superplastisizers will be prepared for control purposes.

Table 3: Preparation of Self-Compacting Concrete Samples for Compressive Strength Test

No	**Water/Cement ratio**	**Super plasticizers (%)**	**Test (days)**	**No. of Sample**
1	0.39	2	28	3
		4	28	3
		6	28	3
2	0.44	2	28	3
		4	28	3
		6	28	3
3	0.5	2	28	3
		4	28	3
		6	28	3
Total Samples				27

Table 4: Preparation of Control Samples for Compressive Strength Test

Water/Cement ratio	**Test (days)**	**No. of Sample**
0.4	28	3
Total Samples		3

One set of conventionally design concrete mixture without Rice Hush Ash (RHA) and superplastisizers will be prepared for control purposes.

CHAPTER 2

LITERATURE REVIEW

2.0 Self Compacting Concrete (SCC)

Self-compacting concrete (SCC) is defined so that no additional inner or outer vibration is necessary for the compaction (Frank, et. al 2000). SCC is compacting itself alone due to its self-weight. It was first developed in Japan about 20 years ago in order to reach durable concrete structures. SCC composition is of the same with normal concrete (NC) but high amount of superplasticizer for reduction of the liquid limit and for better workability, the high powder contents as "lubricant" for the coarse aggregate, as well as the use of viscosity-agents to increase the viscosity of the concrete have to be taken into account (Frank, et. al 2000). Thus, in principle, the properties of the fresh and hardened SCC, which depend on the mix-design, should not be different from NC. One exemption is only the consistency where SCC should have a slump flow s_f of approximately $s_f > 65$ cm after pulling the flow cone.

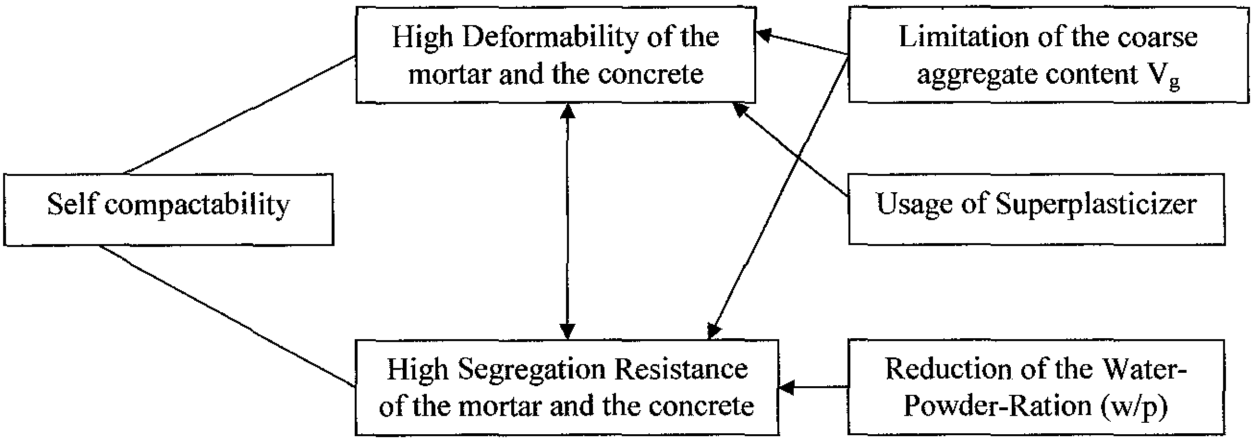


Figure 1: Basic Principles for the production of Self-Compacting Concrete (Frank, et.al, 2000)

At present, the procedure for the production of SCC is mainly empirical. The experience from Japan, Netherlands, France and Sweden is employed for mix design. The SCC mix design should be performed so that the predefined properties of the fresh and hardened concrete are reached for sure. The components shall be coordinated one by one so that segregation, bleeding and sedimentation are prevented.

Frank, Klaus and Dirk (2000) have investigated on the bond behavior between the rebars and the SCC considering the time development of the bond strength. They have studied the bond behavior of rebar in normal concrete and has found out that main parameters which have an influence on the bond behavior are the surface of the rebars, the number of load cycles, the mix design, the direction of concreting, as well as the geometry of the test specimen (pull out test).

The investigation is focused on determining and evaluating the bond behavior of the SCC under monotonic/static loading. A powder-type SCC was chosen for the study and below mix design is used:

Table 5 : Mix Design for the used SCC (Frank, et.al, 2000)

Cement CEM I 45.5 R	1.0
Fly ash	0.67
Quartz powder (0.1 – 0.4 mm)	0.21
Sand (0 – 2 mm)	2.43
Gravel (2 – 8 mm)	0.41
Gravel (8 – 16 mm)	2.09
Superplasticizer (Polycarboxylatether)	0.01
w/b – ratio	0.41

The bond behavior for monotonic loading is tested with pull-out specimens using electro mechanic testing machine. The specimen size is 10 cm diameter and 10 cm length. The used bar is in 10 mm diameter for the whole test series. To avoid an unplanned force transfer between the reinforcing bar and the concrete in the unbonded area, the rebars were encased with a plastic tube and sealed with a highly elastic silicone material. The rebars were placed concentrically and the concrete was cast parallel to the loading direction.

Frank, et. al (2000) has explained how the specimen is tested. "The tests were carried out in an electro mechanic testing machine where the specimens were loaded path-controlled. The loading rate was 0.0008 mm/sec. The applied force of the machine was measured corresponding to the slip displacement of the reinforcing bar on the non-loaded side. The additional of the slip path was constantly monitored during the whole testing time."

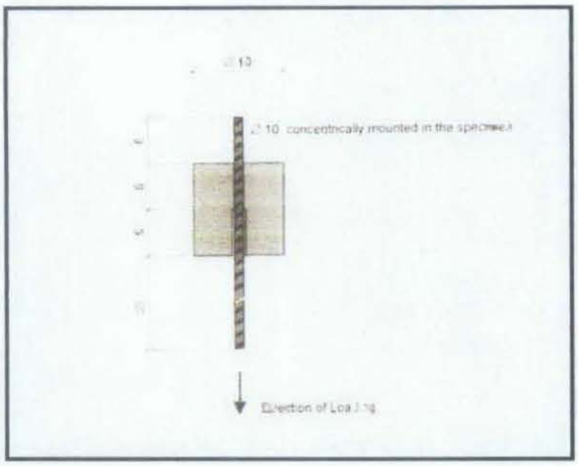


Figure 2: Pull-out specimen

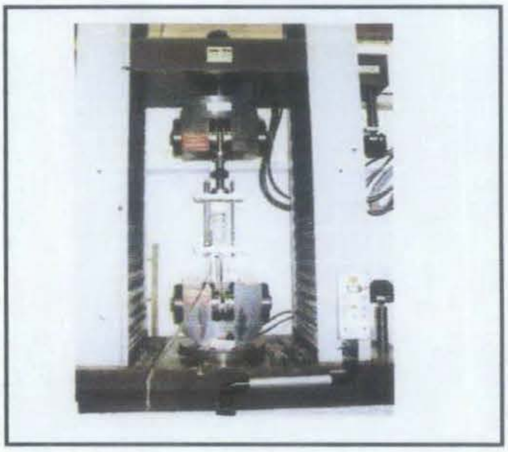


Figure 3 : Electro Mechanic Testing

Test Result

The material properties were evaluated using four standard tests according to CIN 1048:

- Cube compressive strength (cube: 150 x 150 x 150 mm^3)
- Cylinder compressive strength (cylinder: Ø 150/300 mm^3)
- Splitting tensile strength (cylinder: Ø 150/300 mm^3)
- Modulus elasticity (cylinder: Ø 150/300 mm^3)

Frank et. al (2000) has mentioned that, the specimens were cured in water for 28 days to avoid changes in the curing conditions. Table below shows the cube compressive strength and the modulus of elasticity after 28 days of 3 specimens each.

Table 6: Material properties after 28 days

Cube compressive strength	[N/mm2]	56.17	55.25	54.581	55.41
Modulus of elasticity	[N/mm2]	29190	29754	31217	30100

From table above, it can deduce that the concrete could be classified as B 45 according to DIN 1045. In this standard the modulus of elasticity for B 45 is 37000 N/mm^2. For the tested concrete can be seen that the modulus of elasticity for the SCC is lower than the modulus elasticity of conventional concrete; so the SCC is "softer" (Frank et. al , 2000).

Bond Behavior

For this test, the researchers have measured the bond behavior at 1, 3, 7 and 28 days after concreting. They carried 12 tests: three specimens for each concrete age. It was found out that all specimens failed from pulling-out, no visible cracks in the concrete cover were discovered. The results are shown in figure 4.

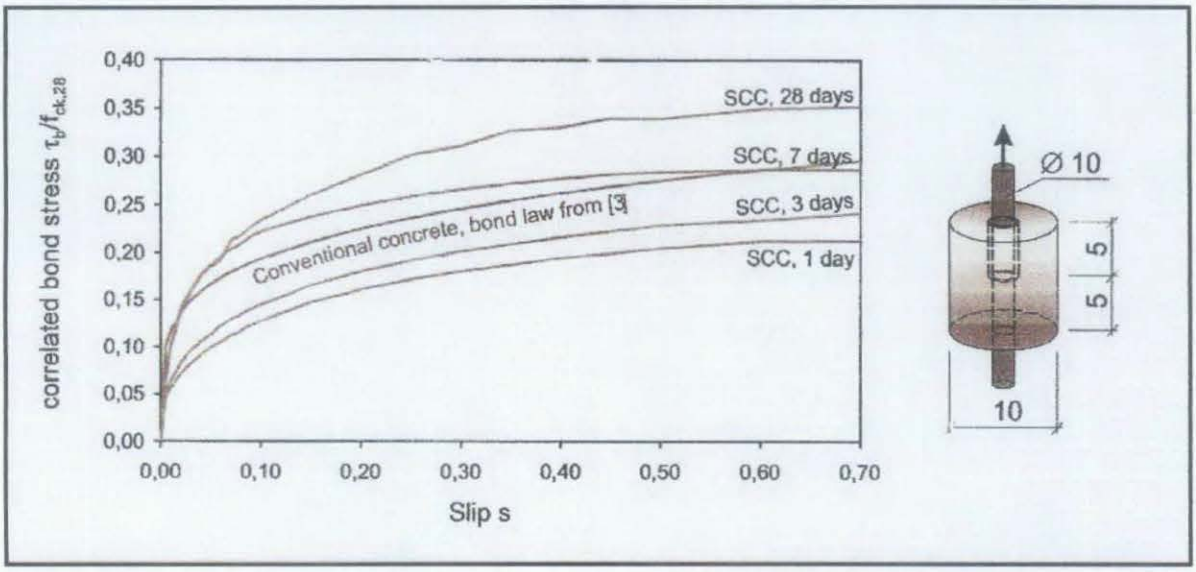


Figure 4 : Time development of the experimental bond stress-slip relationship

The performed tests show, that the bond behavior of self-compacting concrete is better than that of normally vibrated concrete (Frank et. al, 2000).

2.1 Rice Husk Ash (RHA)

Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. This rice husk is mostly used as a fuel in the boilers for processing of paddy. Rice husks ash is by products of rice paddy milling industries.

For rice growing countries, rice husks have attracted more attention due to environmental pollution and an increasing interest in conservation of energy and resources. There are several reasons that draw the attention of concrete researchers.

Rice husk ash is a good super-pozzolan. This super-pozzolan can be used to make special concrete mixes. The use of rice husk ash (RHA) to partially substitute for cement is attractive because of its high reactivity. According to G. Rodriguez de Sensale,(2006), at higher ages (91days), the rice husk ash concrete had higher compressive strength in comparison with that of concrete without rice husk ash, and the highest values of compressive strength were achieved in concrete with 20% of rice husk ash.

G. Rodriguez de Sensale,(2006), have investigated the development of compressive strength up to 91 days of concrete with rice husk ash (RHA). They have considered two sources of ash; a residual RHA from the unique rice paddy milling industry in Uruguay and a homogeneous ash produced by controlled incineration from the United States, for comparison purposes.

They used two different quantity of RHA which are 10% and 20% replacement percentage of cement and three different water/cement ratio; 0.50, 0.40 and 0.32 were used. They compared the results with those of the concrete without RHA, with splitting tensile strength and air permeability.

G. Rodriguez de Sensale,(2006) conclude that residual RHA provides a positive effect on the compressive strength at early ages, but the long term behaviour of the concretes with RHA produced by controlled incineration was more significant. They also conclude that the increase in compressive strength of concretes with residual RHA is better acceptable by the filler effect (physical) than by the pozzolanic effect (chemical/physical). Rising in compressive strength of concretes with RHA formed by controlled incineration is primarily due to the pozzolanic effect.

2.2 Super plasticizers

Super plasticizers or High Range Water Reducers are chemical admixtures that can be added to concrete mixtures to improve workability. Strength of concrete is inversely proportional to the amount of water added or water-cement (w/c) ratio.

In order to produce stronger concrete, less water is added, which makes the concrete mixture very unworkable and difficult to mix, necessitating the use of plasticizers, water reducers, super plasticizers or dispersants.

Super plasticizers are also often used when pozzolanic ash (Rice Husk Ash will be used in this project) is added to concrete to improve strength.

2.3 Bond Strength and Anchorage

S. P. Tastani, MSc, and S. J. Pantazopoulou, in his journal "Bond in Concrete – from research to standards" 2002 stated that the average bond strength values were calculated assuming a uniform distribution along the anchorage length L_b (mm):

Equation 1 : Anchorage Bond Stress

$$\boxed{f_b = P/(\pi \cdot D_b \cdot L_b)}$$

Where:

P (N) = the applied load

D_b (mm) = the diameter of the test steel bar

(Equation 1 also applies to the cubic specimens)

CHAPTER 3

METHODOLOGY

3.0 General

There are three major operations to be conducted throughout the project, which are:

- Preparation of Rice Hush Ash
- Preparation of Normal and Self Compacting Concrete Samples
- Pull out test

3.0.1 Preparation of Rice Hush Ash

Figure 5 : Rice Husk

The preparation of Rice Hush Ash supposed to be prepared at the Incinerator Room (Block J). As we know, rice husk ash is a product from burning process of rice husk (Figure 5).

Approximately, after burning 100kg of rice husk, only 10kg of ash will be produced. In this project, approximately 4.3 kg of rice husk ash will be added together with every mixture of self-compacting concrete mix. Subsequently, total of nine mixtures of self compacting concrete, 38.7 kg of rice husk ash will be needed.

Theoretical, the incinerator machine will do the burning process. The machine need to be in good condition and operable before being used. However, the incinerator machine is not functioning for quite a long period.

In order to prevent from further delay in preparation of Rice Husk Ash, a decision has been made which is to buy the Rice Husk Ash from rice factory rather than waiting for the incinerator to be fixed. There are two locations where the Rice Husk Ash can be obtained which are

1. Kilang Beras Bernas Sungai Ranggam, Kampung Gajah, Perak; and
2. Kilang Beras Bernas Sungai Manik, Teluk Intan, Perak.

About 60kg of Rice Husk Ash has been taken from Kilang Beras Bernas Sungai Ranggam, Kampung Gajah, Perak since it is nearer from UTP. The Rice Husk Ash then grinded by using Los Angeles Abrasion testing machine (Figure 6). Here are the details of grinding process:

Machine : Los Angeles Abrasion testing machine
Number of cycles : 3000

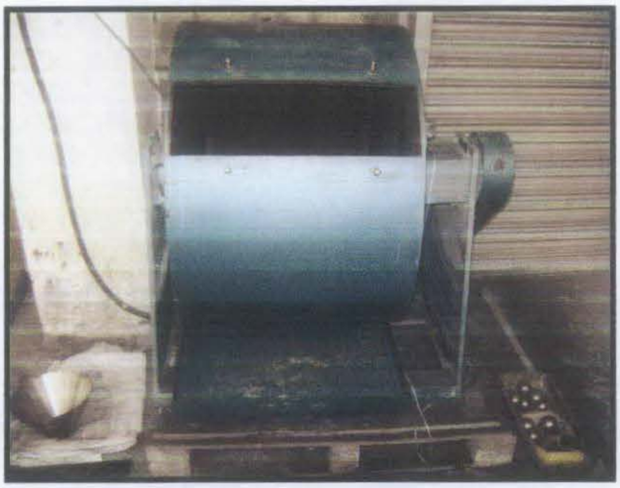
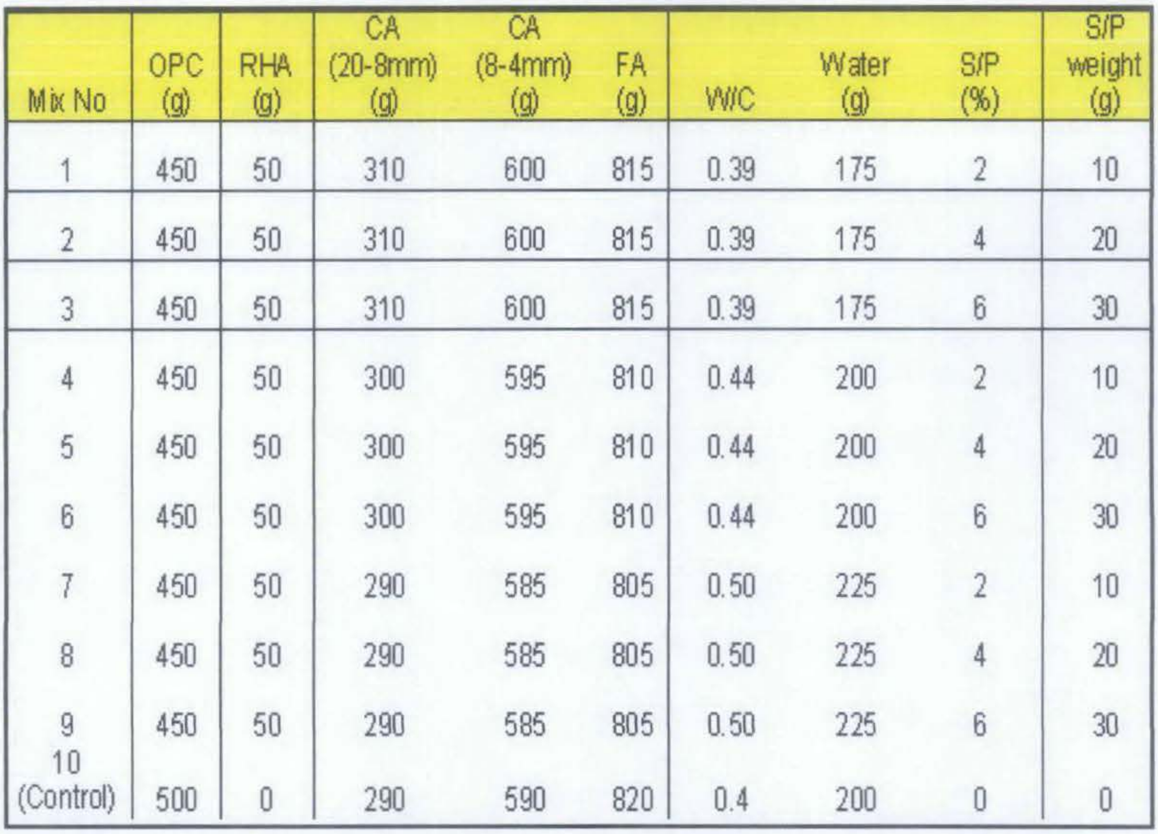


Figure 6 : Los Angeles Abrasion Testing Machine

Approximately, 6 to 7 kg of grounded Rice Husk Ash can be prepared after each 3000 cycles of grinding process.

3.0.2 Preparation of Normal and Self Compacting Concrete Samples

The preparation for both normal and self-compacting concrete sample will be done at concrete laboratory (Academic building- Block 13). The following materials were used in the preparation of the concrete specimens: fine aggregate with maximum aggregate size of 4mm; coarse aggregate with maximum aggregate size of 20mm, Ordinary Portland Cement (OPC); Rice Husk Ash as additive and superplastisizers. Concrete samples prepared according to this design mix:



Mix No	OPC (g)	RHA (g)	CA (20-8mm) (g)	CA (8-4mm) (g)	FA (g)	W/C	Water (g)	S/P (%)	S/P weight (g)
1	450	50	310	600	815	0.39	175	2	10
2	450	50	310	600	815	0.39	175	4	20
3	450	50	310	600	815	0.39	175	6	30
4	450	50	300	595	810	0.44	200	2	10
5	450	50	300	595	810	0.44	200	4	20
6	450	50	300	595	810	0.44	200	6	30
7	450	50	290	585	805	0.50	225	2	10
8	450	50	290	585	805	0.50	225	4	20
9	450	50	290	585	805	0.50	225	6	30
10 (Control)	500	0	290	590	820	0.4	200	0	0

Figure 7 : Mix Design for Self Compacting Concrete

OPC : Ordinary Portland cement

RHA : Rice Husk Ash

CA : Course aggregates

FA : Fine aggregates

W/C : Water to cement ratio

S/P : Super Plasticizers

The preparations of normal concrete have been done on 8th July 2008. The sample have been prepared with usual procedure of preparing concrete sample which mixing cement, water, coarse aggregates and fine aggregates together. Sieve analysis has been done in order to differentiate two groups of coarse aggregates according to their aggregates sizes; (20 – 8 and 8 – 4) mm.

After slump test have been performed, the concrete mixture will then pour into the 3 cube moulds of 150mm by 150mm (figure 7) sizes and 9 cylindrical moulds with proper vibration. After 24 hours, samples were demoulded and being cured in the curing tank.

A 60cm steel rod bar placed in the center of the cylindrical mould (Figure 10) before the concrete mixture is poured inside, the embedded length for the steel bar inside the concrete will be:

15 x diameter of steel bar

Figure 5 shown the preparation of steel bar for concrete sampling.

Figure 8 : Cutting steel bar into smaller pieces

Here are the casting dates for self compacting concrete:

No	**Mix No**	**Casting Date**
1	1 and 10	14th July 2008
2	3	16th July 2008
3	2	23rd July 2008
4	4	30th July 2008
5	7	31st July 2008
6	5	7th August 2008
7	6	20th August 2008
8	8	26th August 2008
9	9	28th August 2008

The sample have been prepared with usual procedure of preparing concrete sample which mixing cement, water, coarse aggregates and fine aggregates together with rice husk ash and superplasticizers according to the SCC design mix (Figure 9). Sieve analysis has been done in order to differentiate two groups of coarse aggregates according to their aggregates sizes; (20 – 8 and 8 – 4) mm

Figure 9 : Self compacting concrete during mixing process

Figure 10 : Placing the steel bar inside the concrete

For self compacting concrete, two tests have been conducted after the mixing processes which are:

1. Slump Flow test

The slump flow is used to evaluate the horizontal free flow (deformability) of SCC in the absence of obstructions. The test method is very similar to the test method for determining the slump of concrete. The difference is that, instead of the loss in height, the diameter of the spread concrete is measured in two perpendicular directions and recorded as slump flow. The higher the slump flow, the greater the concrete's ability to fill formworks. During the slump flow test, the time required for the concrete to reach a diameter of 500 mm is also measured and recorded as t_{500}. This parameter is an indication of the viscosity of concrete and indicates how stable the concrete is. A lower time points to a greater flow ability. (Mustafa Sahmaran, et al, 2005)

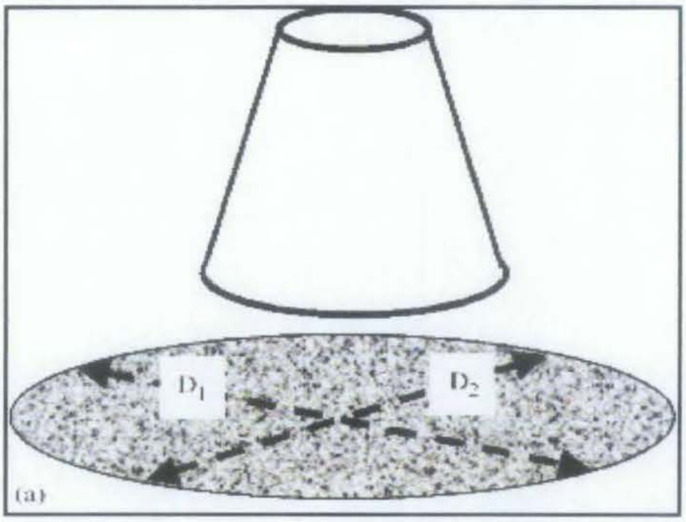


Figure 11: Slump flow

2. L-Box test

L-box had dimensions according to (Figure 13 a). The steel bars that were used in this work are shown in (Figure 13 b). Once the test was completed, the height of concrete in the chimney was recorded as h_1 and the height of concrete at the opposite end of the channel was recorded as h_2. The L-box value (also referred to as the "L-box ratio", "blocking value", or "blocking ratio") is simply h_2/h_1. If the concrete is perfectly levelled at the end of the test, the L-box value is then equal to 1. Conversely, if the concrete is too stiff to reach the end of the channel, the L-box value is equal to 0. The regulations regarding acceptance L-box values in the case with steel bars vary from one country to another in the range of 0.60 to 1 (T.L.H Nguyen et. al, 2006)

Figure 12 : L-Box flow equipment used

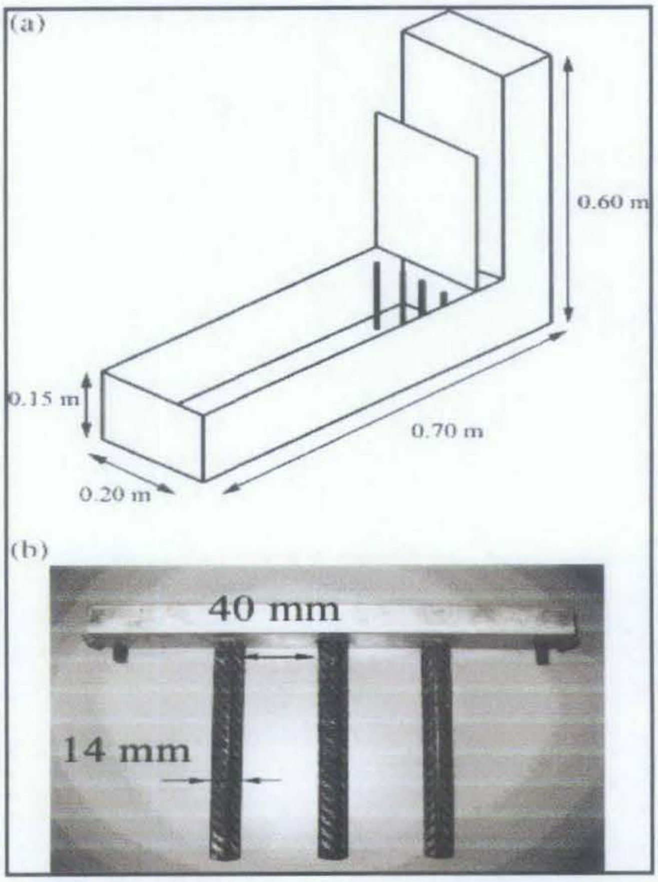


Figure 13 : L-Box flow equipment dimensions

After the tests have been performed, the process will continue exactly as preparation of normal concrete which pouring the mixture inside the mould together with the steel bar. After 24 hours, samples were demoulded and being cured in the curing tank (Figure 14).

Figure 14 : Samples in the curing tank

3.1 Hazard Analysis

Hazards can be biological, chemical, or physical conditions that potentially cause harm to people, property, or the environment. The purposes of hazard analysis are to give precaution from any unwanted injury, which may happen during the laboratory works. For this project, there was no biological and chemical compound involve. Consequently, the hazard analysis will be only focused on the physical conditions.

In order to prevent hazard in the laboratory, it is essential to use and wear the personal protective equipment accordingly, any injury or accidents including all unsafe conditions must be reported to the laboratory technician immediately. Other than that, while in the laboratory, avoid disturbing or distracting others while they are performing laboratory tasks, which may lead to the hazard possibilities.

All machineries involve in this project (i.e., concrete mixer, incinerator machine, universal testing machine and others) have to be in good condition. Basic operating procedures for all equipments have to be read and understand before using them. It is to prevent from any misuse, which can cause unexpected damage to the machineries. The last things to do after completing laboratory works is house keeping, working areas must be keep clean and free from any obstructions.

As a conclusion, hazard analysis is an important thing to be done before starting the project. It is to provide general guideline and basic rules in order to prevent any unwanted incident while performing laboratory works.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 General

After the normal concrete and the self compacting concrete have been prepared, samples will be tested for 2 characteristics which are compressive stress (Mpa) and pullout stress (kN/m).

All the test; compressive strength test and pull-out test will be conducted for normal concrete and self compacting concrete samples according to the date stated in the results' table and will be recorded by time.

4.1 Compressive Strength Test

For compressive strength test, the concrete sample tested on the 28th days after casting date. The compression test done to determine the behavior of concrete samples under compressive loads.

The compressive strength of concrete is measured by breaking the concrete sample in a compression-testing machine (Figure 15). The compressive stress is calculated from the failure load divide by the cross sectional area resisting the load and represent in a unit of Mega Pascal (Mpa).

Figure 15 : Compressive strength test machine

4.2 Results of Compressive Strength

These are the results recorded for compressive strength of concrete samples at 28th day's strength.

Table 7 : Result of compressive strength test

No	Date	Mix No	Sample No	Compressive Strength (MPa)
1	11.08.2008	1	1	54.75
			2	51.86
			3	53.14
2	25.08.2008	2	1	49.12
			2	29.57
			3	30.68
3	18.08.2008	3	1	39.94
			2	46.46
			3	37.15

4	27.08.2008	4	1	49.99
			2	47.32
			3	47.07
5	4.09.2008	5	1	43.95
			2	57.34
			3	50.24
6	17.09.2008	6	1	46.28
			2	48.21
			3	40.75
7	28.08.2008	7	1	33.63
			2	34.43
			3	44.32
8	23.09.2008	8	1	45.68
			2	49.86
			3	43.48
9	25.09.2008	9	1	60.35
			2	51.36
			3	46.63
10	5.08.2008	10 Normal	1	49.50
			2	54.28
			3	45.16

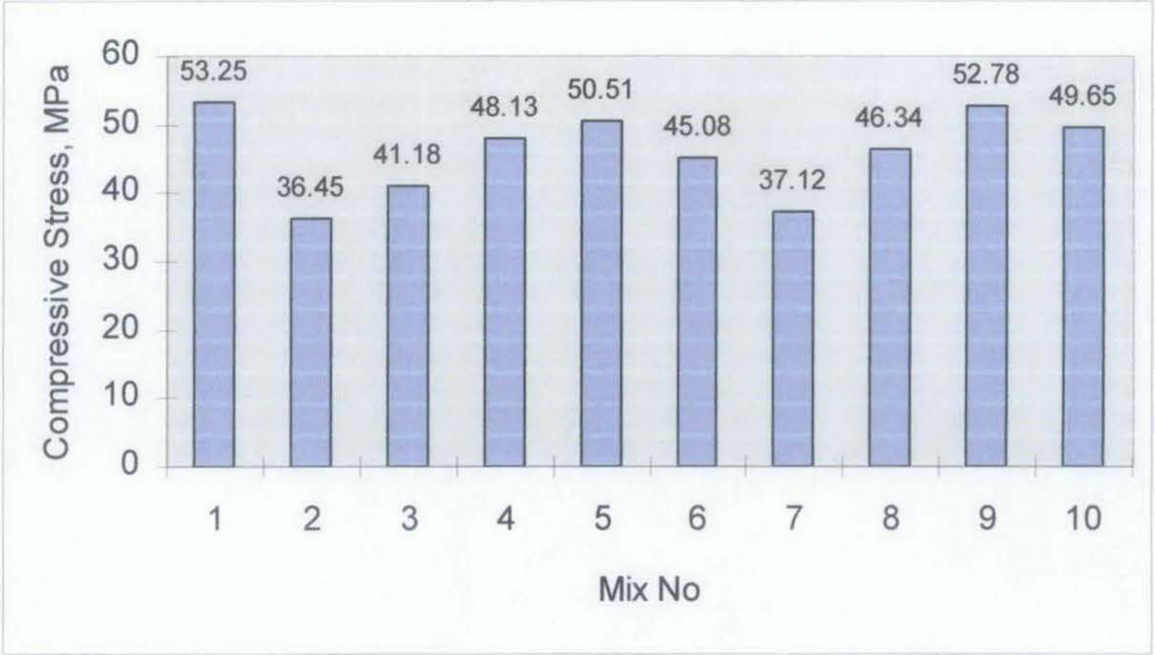


Figure 16 : Graph of compressive stress versus mix no

Based on the graph:

- The effect of Rice Hush Ash (RHA) as filler in Self Compacting Concrete (SCC) did not really provide a positive effect on the compressive strength. Only 3 mixes (Mix no 1, 5 and 9) gave the positive outcome for compressive stress.

- For water-cement ratio 0.5 (Mix no 7, 8 and 9), increasing of superplasticizer content (%), raise the compressive stress of the concrete.

- For superplasticizer content 6 % (Mix 3, 6 and 9), increasing of water-cement ratio increase the compressive stress of the concrete.

4.3 Pull out Test

For pull out test, the concrete samples were also being tested at 28th days after casting date. This test is to measure the bonding stress between concrete and rebar. Three sizes of steel bar were used; 10mm, 12mm and 16mm.

The pull out strength of concrete measured by putting the concrete sample in a pullout-testing machine (Figure 17). The machine gave maximum failure load by pulling out the steel bar with 0.02mm/s rate. Data were collected and recorded for further analysis.

Figure 17 : Universal testing machine 1000kN

Figure 18 : Sample ready to be tested

4.4 Results of Pull out Test

Table 8 : Result of pull out test

No	Mix No	Date	Steel bar (mm)	Sample No	Maximum Pull Out Load (kN)
1	1		10	1	45.21
				2	42.10
			12	1	65.86
				2	67.62
			16	1	81.45
				2	89.49
2	2		10	1	42.06
				2	41.75

			12	1	60.63
				2	56.18
			16	1	108.86
				2	94.69
3	3		10	1	29.90
				2	24.70
			12	1	65.72
				2	66.30
			16	1	133.57
				2	132.60
4	4		10	1	41.73
				2	48.30
			12	1	58.53
				2	56.13
			16	1	101.39
				2	105.67
5	5		10	1	42.38
				2	37.24
			12	1	63.89
				2	65.21
			16	1	80.23
				2	82.69
6	6		10	1	10.03
				2	9.47
			12	1	35.67
				2	32.83
			16	1	110.98
				2	102.18

7	7		10	1	40.02
				2	44.25
			12	1	68.59
				2	66.94
			16	1	63.75
				2	61.44
8	8		10	1	24.49
				2	32.71
			12	1	49.35
				2	63.49
			16	1	95.64
				2	108.36
9	9		10	1	22.65
				2	28.71
			12	1	68.34
				2	63.68
			16	1	85.17
				2	96.55
10	10		10	1	42.19
				2	42.96
			12	1	65.70
				2	64.76
			16	1	118.12
				2	104.09

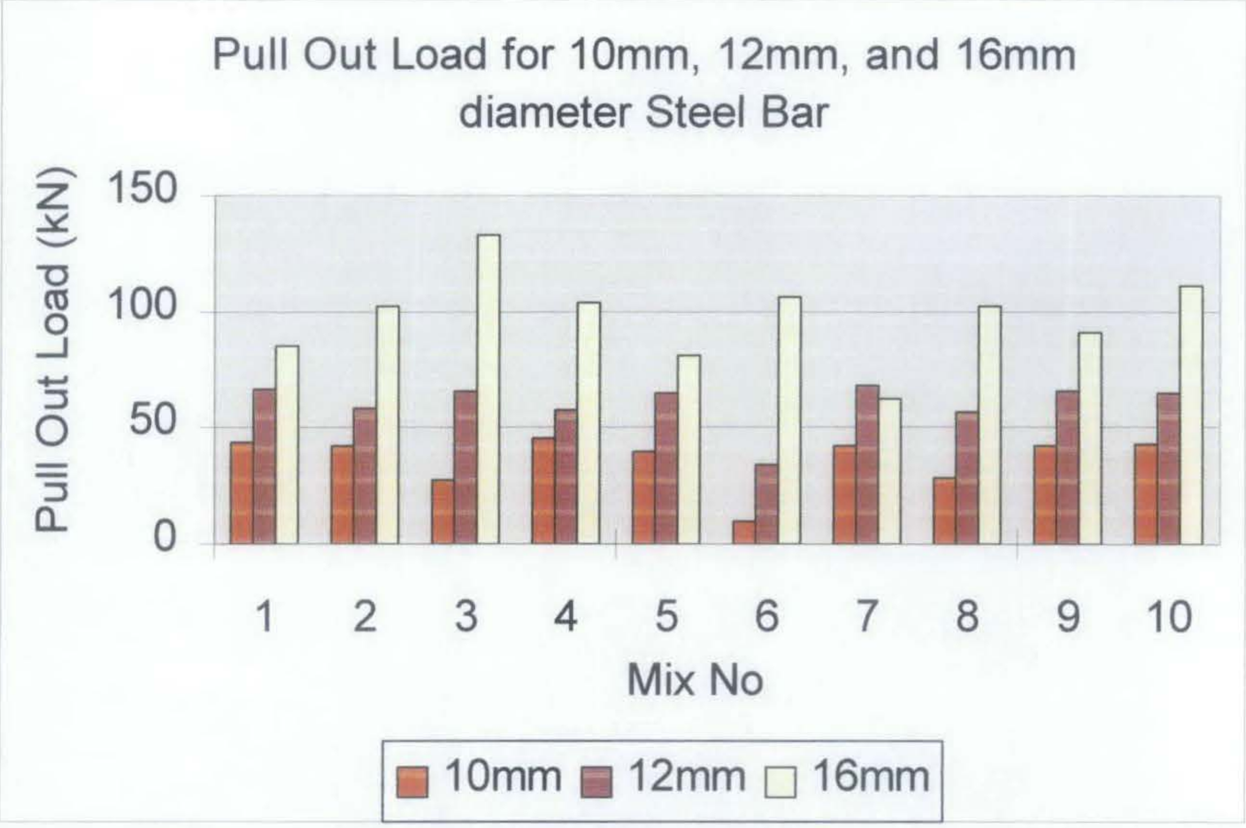


Figure 19 : Graph of pull out load

Based on the pull out load result, the bonding stress, fb between steel bar and concrete were calculated by using Equation 1. Here are the results of calculated bonding stress.

Table 9 : Result of the bonding stress

Mix No	Pull Out Load, Fs (kN)	Steel Bar Diameter, (mm)	Embedded Length (mm)	Compressive Stress, (Mpa)	Superplasticizer (%)	Bond Stress, fb (Mpa)
1	43.655	10	150	53.25	2	9.26
	66.74	12	180	53.25	2	9.84
	85.47	16	240	53.25	2	7.08
2	41.905	10	150	36.45	4	8.89
	58.405	12	180	36.45	4	8.61
	101.775	16	240	36.45	4	8.44

3	27.3	10	150	41.18	6	5.79
	66.01	12	180	41.18	6	9.73
	133.07	16	240	41.18	6	11.03
4	45.015	10	150	48.13	2	9.55
	57.33	12	180	48.13	2	8.45
	103.53	16	240	48.13	2	8.58
5	39.81	10	150	50.51	4	8.45
	64.55	12	180	50.51	4	9.51
	81.46	16	240	50.51	4	6.75
6	9.75	10	150	45.08	6	2.07
	34.25	12	180	45.08	6	5.05
	106.58	16	240	45.08	6	8.83
7	42.135	10	150	37.12	2	8.94
	67.765	12	180	37.12	2	9.99
	62.595	16	240	37.12	2	5.19
8	28.60	10	150	46.34	4	6.07
	56.42	12	180	46.34	4	8.31
	102.00	16	240	46.34	4	8.46
9	25.68	10	150	52.78	6	5.45
	66.01	12	180	52.78	6	9.73
	90.86	16	240	52.78	6	7.53
10	42.575	10	150	49.65	0	9.03
	65.23	12	180	49.65	0	9.61
	111.105	16	240	49.65	0	9.21

Figure 20 : Graph of anchorage bond stress

Based on the graph:

10mm steel bar:

- Increasing of superplasticizer content (%) reduce the anchorage bond stress.

12mm steel bar:

- The anchorage bond stress for 12mm steel bar were higher than 10mm steel bar except for mix no 2 and 4.

16mm steel bar:

- For water to cement ratio 0.39, increasing of superplasticizer content (%) raised the bonding stress between steel bar and concrete.

From the graph also, effect of Rice Hush Ash (RHA) as filler in Self Compacting Concrete (SCC) did not really provides a positive effect on the bonding stress between steel bar and concrete.

CHAPTER 5

CONCLUSION

- Based on this design mix, the maximum compressive stress for SCC achieved for mix no 9 (52.78 Mpa), mix no 1 did not take into account because it is not pass the SCC properties.

- This study presents result of experimental investigation on the pull out tension capacity of self compacting concrete with different water to cement ratio and superplasticizer contents. The bonding capacity of SCC were evaluated by pull out test in the laboratory.

- The optimum water-to-cement ratio for self compacting concrete is 0.39 and the optimum % for superplasticizer is 4% (mix no 2).

- Based on data analysis, it is also concluded that the effect of Rice Hush Ash (RHA) as filler in Self Compacting Concrete (SCC) did not provides a positive effect on the bonding stress between steel bar and concrete. Most of the bonding stresses for the SCC with RHA lower than the control mix stress.

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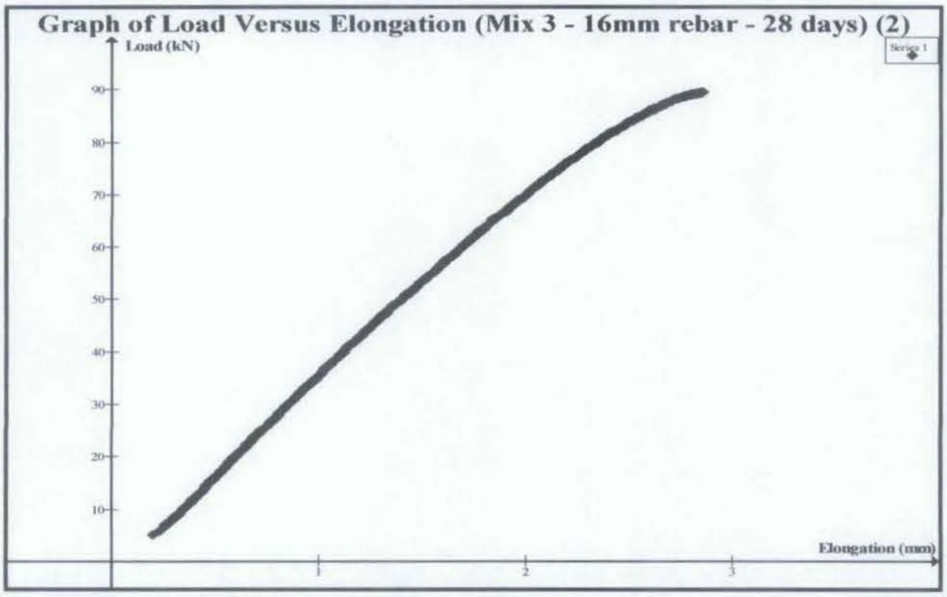
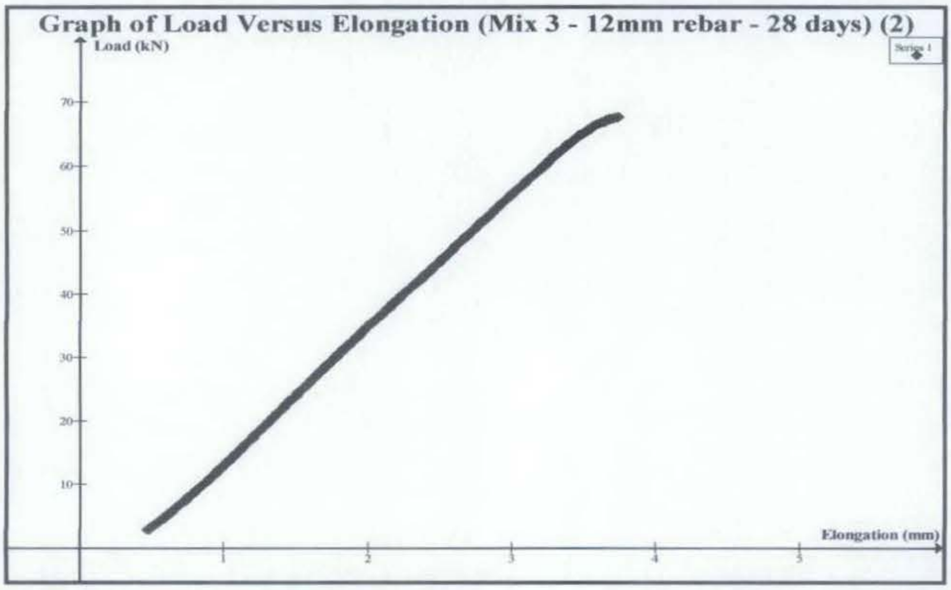
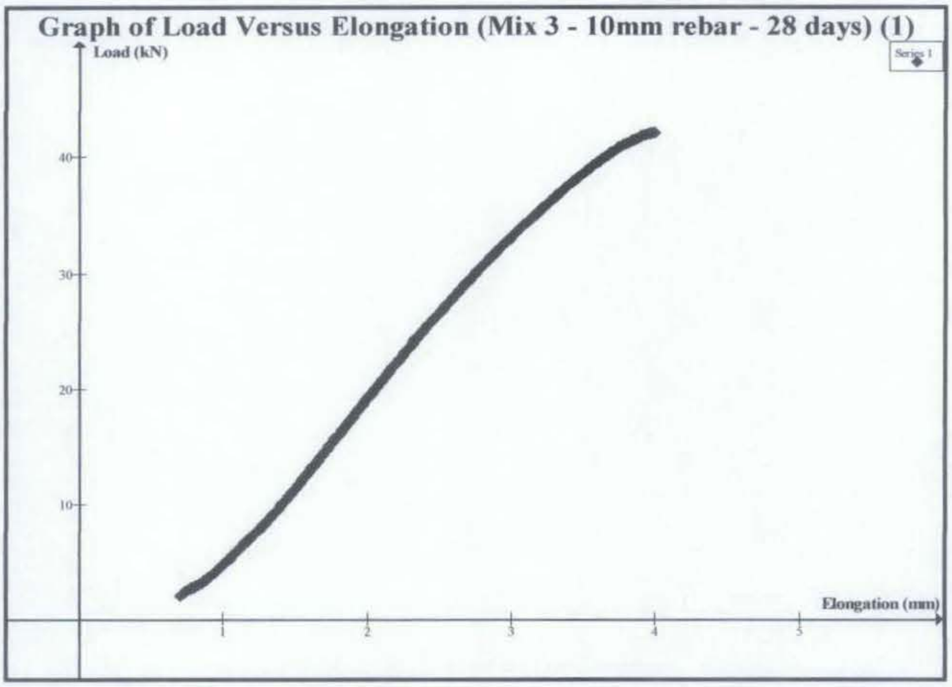
APPENDIX



Appendix 1: Sample graph of pull out load versus elongation for mix 3 (16mm rebar)



Appendix 2: Sample graph of pull out load versus elongation for mix 3 (12mm rebar)



Appendix 3: Sample graph of pull out load versus elongation for mix 3 (10mm rebar)

Appendix 4: Example of sample failed after pull out test (mix 5, 12mm rebar)

Appendix 5: Example of sample failed after pull out test (mix 6, 12mm rebar)

Appendix 6: Example of sample failed after pull out test (mix 9, 16mm rebar)