The Performance of used engine oil on high strength concrete : A Structural Behaviour of Reinforced Concrete Elements Under Static Loading

by

Nasrul Hakim b. Mohd Daud

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
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CERTIFICATION OF APPROVAL

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Approved by,

(Assoc. Prof. Dr. Nasir Shafiq)

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TRONOH, PERAK

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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.

NASRUL HAKIM B. MOHD DAUD

ABSTRACT

There is a current trend all over the world to investigate the utilization of processed and unprocessed industrial by-products and domestic wastes as raw materials in cement and concrete. This has a positive environmental impact due to the ever increasing cost of waste disposal and stricter environmental regulations. Historically, reference books on concrete technology and cement chemistry indicate that the leakage of oil into the cement in older grinding units resulted in concrete with greater resistance to freezing and thawing. This effect is similar by adding an air-entraining chemical admixture to the concrete. Such information is not backed by any research study reported in the literature. The objective of the research reported in this paper was to investigate the effects of used engine oil on High Strength Concrete (HSC). The main variables included the type and dosage of an air-entraining agent (commercial type, used engine oil, super plasticizer), microwave incinerated rice husk ash, silica fume and water-cement ratio of the concrete.

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LIST OF ABBREVIATIONS

Abbreviations	Full Name
HSC	High Strength Concrete
NSC	Normal Strength Concrete
UEO	Used Engine Oil
MIRHA	Microwave Incinerated Rice Husk Ash
SSD	Saturated Surface Dried
OPC	Ordinary Portland Cements

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF PROJECT

Wastes can be defined as not readily avoidable by-products for which there is no value and whereby disposal is required. Basically, wastes can be used as raw materials in cement manufacturing as components of concrete binder, as aggregates, a portion of aggregate, or ingredients in manufactured aggregates. Some wastes also can be used as chemical admixtures and additives which can improve selected properties of fresh and hardened concrete. The successful use of industrial by-products or wastes in concrete depends on the required properties of the end product. Economical factors would be the main factor in determining if potentially beneficial waste could be used as an ingredient in concrete. These factors are generally involved the cost of waste disposal, the cost of transportation of waste to a manufacturing site, and environmental regulations that exist [Bilal and Ahmad, 2002].

Nowadays, the amount of waste generated by society has continuously increased. This is due to the advancement of industrial activity and improvement of living standards of the society. The proper treatment and disposal of wastes should be the main concern to everyone. There are many alternatives and options in treating the wastes that we produced. For instance, there are still many other unused industrial by products that not fully utilized as raw materials in the cement industries. Combustible waste such as used oils, tires, sludge, rubbers and incineration ash from urban refuse could be consider to be utilized as the blending components. Apart from that, the industrial sector is urged to find the best alternative to treat their waste properly and hence make our world a better place to live in.

1.2 Problem statement

Used oil affects both marine and human life. Oil in bodies of water rises to the top and forms a film that blocks sunlight thus stopping the photosynthesis process. Consequently, the process of reproducing the oxygen will be stopped and this will lead to the death of the underwater life. Furthermore, used oil contains some toxic materials that can reach humans body through the food chain. Health hazards that caused by this toxic range from mild symptoms to death. The break down of the additives and the interaction of these substances with others particles found in the stream cause the water to be hazardous. It shows that the proper management of used oil is essential to eliminate or minimize potential environmental impacts [Bilal and Ahmad, 2003].

In 1986, El-Fadel and Khoury suggested three solutions to the problem of used oil waste. According to them, the used oil should be reprocessed into lube oil or into fuel oil. Conducting control destruction of the used oil at high temperature also becomes the main option. In their study, the used engine oil will be the main subject where it will be added on the high strength concrete to increase the concrete's strength and durability [El-Fadel M Khoury R, 2001]. There are a lot of research had been done in producing practical and cost effective high strength concrete. However, until today not much of the research regarding the performance of used engine oil in high strength concrete base on static loading test had been done. Therefore, this project will focus on the statically behavior of high strength concrete with addition of used engine oil as its admixture. Apart from that, the addition of used engine oil to the fresh concrete mix could be similar with adding an air-entraining chemical admixture. This addition is believed will enhance some durability properties of concrete while serving as another technique of disposing the oil waste [Bilal and Ahmad, 2002]. However, experimental data to support this hypothesis appear to be lacking.

1.3 Objectives

The objectives of project is to determine the performance and statically behavior of used engine oil in high strength concrete base on the statically loading test.Through this research:

- the effect of adding used engine oil to concrete on the properties of fresh and hardened concrete will be investigate.
- the hypothesis that adding used engine oil to the fresh concrete mix could be similar to adding an air-entraining chemical admixture, thus enhancing some durability properties of concrete while serving as a technique of disposing the oil waste.
- the performance of concrete by adding used engine oil as an admixture will be determine.

1.4 Scope of study

The scope of study for this project would be on the performance of the high strength concrete containing used engine oil as an additive base on the statically loading test. Four reinforced concrete beam specimens had been prepared. Each beam has different type of mix. The main variables included type of admixtures such as used engine oil, silica fume, super plasticizer and rice husk ash. The effect of the used engine oil on the concrete will be studied and be investigated. The static loading test will be carried out after 28 day of sample age and all the results will be collected and recorded.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Concrete has been one of the most commonly used building materials in the world. The exploring of research and applications on concrete materials seems never to be end. Scientist and researchers are always trying to find the alternative additive material that can be used as the constituent material of the concrete hence improving its durability properties. In these modern days where the world is encountered by rapid development, higher compressive strength concrete is really needed. High strength concrete will produce a very high quality mega structures that can sustain bad weather and natural disasters [A.M Neville, 1995]

In high strength concrete, admixtures and additives are added into the mix. Normally, there are three kinds of admixtures, namely silica fume, fly ash, and blast furnace slag. Several decades ago, concrete with strength of 42MPa was considered to be high strength. However, as the time pass by it is possible to produce concrete with compressive strength of 150 MPa by adding those admixtures.

2.2 High Strength Concrete

A.M Neville defined high strength concrete(HSC) as the concrete with a compressive strength greater than covered by current codes and standards. Until the late 1960s, 35 MPa and 42 MPa were considered as HSC while in the mid 1980s, 55 MPa concrete was considered as HSC. Probably in the future, 150 MPa will be branded as HSC. In different countries the current codes are always diverse. In United Kingdom for instance, 60 MPa concrete or more is considered as high strength concrete as it is not covered in the codes. However in Norway the design code already includes concrete with characteristic cube strengths up to 105 MPa [A.M Neville, 1995].

High-strength concretes (HSC) are characterized by a low porosity and show an internal structure more uniform at the matrix-aggregate interface than normal strength concretes (NSC). This makes HSC is very effective in multistory buildings as it reduces the cross-sectional area of the structural elements [John Newman, 2003].

Muhammad Shoaib in his research in 1995 found that HSC is also effective in pavements because of less abrasion and longer durability [Muhammad Shoaib, 1995]. Apart from that, in the construction of the Akkagawa Bridge in Japan, concrete with design strength of 79 MPa was used and it was produced with autoclave curing. The advantage of using high strength concrete for the bridge's piers was examined. It showed that the cross section of a highway bridge could be reduced by 13 to 30 percents [Shigeyoshi and Etsuo ,1994].

The main towers of Aomori Bay Bridge also in Japan used HSC with a design strength of 59 MPa. This prestressed concrete cable-stayed highway bridge used HSC to achieve a slender structure with a reduced dead load. Besides, it also looks as an aesthetic appearance that can attracts tourist. HSC is also used in the construction of oil drilling rig in Artic Ocean. The usage of HSC will provide greater durability and a lighter dead load. Some special methods were introduced into the production of the concrete for this oil drilling rig in order to enhance its freeze-thaw resistance [Shigeyoshi and Etsuo ,1994].

2.3 Superplasticizer

It is a material containing sodium salt of high molecular weight sulphonic polymer. Its function is to delay the time for the mix to change from the plastic to the hardened state by the range of 90 minutes to 360 minutes. It is specially formulated for production of high quality, high early and ultimate strength water-tight concrete that possesses excellent workability retention. It may also reduce the required mixing water by 15 to 20% while maintaining the required workability. It can also speeds up the early strength development and improves the ultimate strength of the concrete [M.L Gambhir, 2004].

The introduction of this material made it possible to batch the concretes with water/cement ratios of 0.35 or less and batch Silica Fume concrete at low water/cement ratios. By adding superplasticizer the concrete will be able to achieve the super-fluid and hence highly workable concretes will be produced without excessive set extension [M.L Gambhir, 2004].

For the high rise construction in Japan, the strengths of the concretes utilized generally range between 35 MPa to 63 MPa. The chemical additives such as superplasticizer is usually used. This superplasticiser main ingredient is carboxylate polymer with a low rate of slump loss, high water reduction and little retardation. The adding of this admixture eventually produce the high rise building that can sustain the earthquake vibration in Osaka. [Shigeyoshi and Etsuo ,1994]

The typical properties of superplasticizer have been summarized as below:

- Enables the production of high strength concrete by reducing the water-cement ratio.
- Possesses excellent slump retention.
- Improves the concrete workability at given water-cements ratio and therefore aids flow and compaction around reinforcements.
- Enables the production of self-compacting concrete which eases placing in difficult situations and alleviates the need for vibration.
- Facilitates the production of fair-faced concrete.
- Reduces the shrinkage and crazing cracks in mass concrete.

2.4 Silica Fume

Silica fume is a substance that is produced by reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. It contains primarily of amorphous (non crystalline) silicon dioxide. Silica fume is also known as microsilica [David Whiting,1999].

Silica fume contains very fine particles where its properties are hard, shiny and transparent like glass. By measuring with nitrogen absorption techniques, it can be found that its particles are approximately 100 time smaller than the average cement particle. It is a highly effective pozzolanic material due to its extreme fineness and high silica content [David Whiting,1999].

Silica fume is widely used in concrete to improve its properties where it has the ability to improve compressive strength. John Newman in his book published in 2003 explains that the addition of silica fume to a concrete mix will increase the strength of that mix between 30 percent to 100 percent depend on the amount of the silica fume used. It can also reduce the permeability of the concrete and hence helps to protect the reinforcing steel from corrosion [John Newman,2003].

Silica fume used in concrete is available in wet or dry forms. It is normally added during concrete production at a concrete plant. Silica fume has been used as an addition to concrete up to 15 percents by weight of the cement in the concrete. With an addition of 15 percents silica fume, a very strong and brittle concrete could be well produced.

2.5 Used Engine Oil

Used engine oil can be define as any oil that reprocessed from crude oil or synthetic oil that cannot longer be used for its original purpose. On the other hand it may be suitable for the other application. According to Bilal S Hamad and Ahmad A Rteil , used oil includes crankcase oil, compressor oil, cutting oils and synthetic oils [Bilal and Ahmad, 2002].

Mindess and Young in their research in 1981 reported that when the oil leaked into the cement in older grinding units resulted in concrete with greater resistance to freezing and thawing. This means that by adding used engine oil into the fresh concrete mix could be similar in adding an air-entraining chemical admixture, thus enhancing some durability properties of concrete. On the other hand it also merged as another technique of disposing the oil waste [Bilal and Ahmad, 2002].

The study of the effect of used engine oil on properties of concrete has been carried out by Bilal. Mixes was contained with 0.075, 0.15 and 0.30% used engine oil by weight of cement. The result illustrated that used engine oil could successfully act as a chemical plasticizer by improving the fluidity and almost doubling the slump of the concrete mix. They also found that used engine oil could maintain the concrete compressive strength whereas the chemical air-entraining admixture caused a loss of approximately 50% compressive strength at all ages. They also carried out the study for the effect of used engine oil on structural behavior of reinforced concrete elements by using 0.15% used engine oil by weight of cement. The result shows that used engine oil could be used in concrete to improve fluidity and air content without adversely affecting strength properties and structural behavior [Bilal and Ahmad, 2002].

2.6 Water

Fundamentally, using less water produces a higher quality concrete hence provided the concrete to be properly placed, consolidated, and cured. Cement and water form a paste that coats each particle of stone and sand. Through a chemical reaction called hydration, the cement paste hardens and gains strength. The character of the concrete is determined by quality of the paste. The strength of the paste depends on the ratio of water to cement. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. High-quality concrete is produced by lowering the water-cement ratio as much as possible without sacrificing the workability of fresh concrete [M.L. Gambhir, 2004].

Almost any natural water that is potable and has no pronounced taste or odor may be used as mixing water for concrete. Excessive impurities in mixing water not only may affect setting time and concrete strength, but also may cause efflorescence, staining, corrosion of reinforcement, volume instability, and reduced durability. For instance, the sea water may not suit to be used as the mixing water as it has sodium chloride (Na Cl) that can corrode the reinforcement steel and hence effect the concrete properties. Specifications usually set limits on chlorides, sulfates, alkalis, and solids in mixing water unless tests can be performed to determine the effect the impurity has on various properties [M.L. Gambhir, 2004].

All Portland cements are hydraulic cements that set and harden through a chemical reaction with water. During hydration, a node forms on the surface of each cement particle. The node grows and expands until it links up with nodes from other cement particles or adheres to the nearby aggregates. The building up process results in progressive stiffening, hardening, and strength development.

Basically, water is the key elements in the curing process. This process begins after the exposed surfaces of the concrete have hardened sufficiently. Curing ensures the constant hydration of the cement and the strength gain of the concrete. Concrete surfaces are cured by sprinkling with water fog, or by using moisture-retaining fabrics such as burlap or cotton mats. Other curing methods prevent evaporation of the water by sealing the surface with plastic or special sprays. The longer the concrete kept moist, the stronger and more durable it will become. Most of the hydration and strength gain take place within the first month of concrete's life cycle. Hydration is still continues at a slower rate for many years. This shows that concrete continues to get stronger as it gets older [John Newman,2003].

2.7 Rice Husk Ash

Among the different existing residues and by-products, the possibility of using rice-husk ash (RHA) has attracted more attention of cement researchers than other crop residues. Firstly, due to the overabundance of this residue, 100 million tonnes of husk are obtained from an annual world production of 500 million tonnes of rice. This huge quantity of residue can only be consumed by the cement and concrete industries that use a wide range of by-products. Mehta in his study in 1992 stress that, rice-husk is not appropriate as feed for animals due to its few nutritional properties and its irregular abrasive surface where it is resistant to natural degradation, which posses serious accumulation problems [Mehta,1992].

On the other hand, RHA when incinerated will produce a great quantity of ash. On average, each tonne of rice-husks on complete combustion produce 200 kg of RHA. No other crop residue generates a greater quantity of ash when it is burnt according to Bharatkumar. Besides that, the used of RHA as a supplementary cementing material has become the great interest to many developing countries where the rice production is in large quantity [Bharatkumar, 2005].

RHA also has been recognized as pozzolanic additions where it can reduce the porosity of concrete especially at the interfaces between cement paste and aggregates, which are the weakest zones of the material. This improvement can modify the failure mechanism in concrete. Recently, a study on the fracture characteristics of high performance concrete was performed. The study performed by Bharatkumar in 2005 concluded that there is a reduction in the fracture energy due to the addition of fly ash and slag [Bharatkumar, 2005]..

The development and use of rice-husk ash (RHA) is not new. There is a lot of researcher working on it as Mehta in 1992 studied on supplementary cementing material. 5 years later in 1997, Aminul reported on concrete behavior with addition of mineral admixture and RHA. He found that high strength concrete could be produced by adding RHA into the normal strength concrete (NSC). Rice-husk ash is recognized as a mineral admixture for concrete, and much data has been published concerning its influence on the behavior of concrete. Results for concretes with a 10% substitution of Portland cement by RHA indicate excellent performance when compared to control concretes [Mehta, 1992] and [Aminul,1997].

Chapter 3

Methodology

3.1 Material selection

The cementitious material that has been used in this study were Ordinary Portland Cement while the admixtures were Silica Fume, Super Plasticizer and Used Engine Oil. 20mm nominal maximum gravel is used as coarse aggregates and while 3.35mm nominal maximum sand is used as fine aggregates.

3.2 Mix proportion

By considering other admixtures, several mix proportion have been proposed and tested throughout compressive strength test at 28 days. The admixtures that have been used in the design were Rice Husk Ash, Silica Fume, Super Plasticizer and Used Engine Oil. Each mix was designed to be consisted of two different types of admixtures in order to achieve the optimum compressive strength. The detail of mix proportions that tabulated in Table 3-1 below show the measure of the mix that to be used in every $1m^3$:

Table 3-1: Mix proportion for 1 kg/m^3 beam

Mix	Water	MIRHA (kg/m^3)	Silica Fume (kg/m^3)	Super Plasticizer (kg/m^3)	Used Engine Oil (kg/m^3)	Cement (kg/m^3)	Fine Aggre-Gates (kg/m^3)	Coarse Aggre-Gates (kg/m^3)
Control Mix	0.4	-	-	-	-	605	670	1120
Mix 1 (SF + SP)	0.27	-	60	15	-	600	650	1090
Mix 2 (SF + UEO)	0.46	-	50	-	20	500	690	1150
Mix 3 (MIRHA + SP)	0.30	55	-	16.5	-	550	670	1120

The mix proportions have been recalculated to meet the dimension weight ratio of beam as tabulated in Table 3-2 below. The design of beam is 140mm x 260mm x 1800mm.

Table 3-2 : Mix Proportion for 140mm x 260mm x 1800mm beam

Mix	Water (kg)	MIRHA (kg)	Silica Fume (kg)	Super Plasticizer (kg)	Used Engine Oil (kg)	Cement (kg)	Fine Aggre-Gates (kg)	Coarse Aggre-Gates (kg)
Control Mix	15.86	-	-	-	-	39.64	43.90	73.38
Mix 1 (SF + SP)	10.61	-	3.93	0.98	-	39.31	42.59	71.42
Mix 2 (SF + UEO)	15.07	-	3.28	-	1.31	32.76	45.21	75.35
Mix 3 (MIRHA + SP)	10.81	3.60	-	1.08	-	36.04	43.90	73.38

3.3 Material preparation

Before proceeds to the mixing process, all materials should be prepared according to the proper procedure. It is to make sure that the raw materials are ready and the most important thing it must be done days before the mix to avoid error during the mixing.

3.3.1 Formwork

Firstly, the formwork as shown in Figure 3-1 below had been fabricated at laboratory and had been casted with the dimension of 140mm x 260mm x 1800mm. The formwork is made from the plywood. This formwork is an integral part of the project where it will acts as a mould to all the four beams that will be cast later and there is only one formwork that had been fabricated during the research.

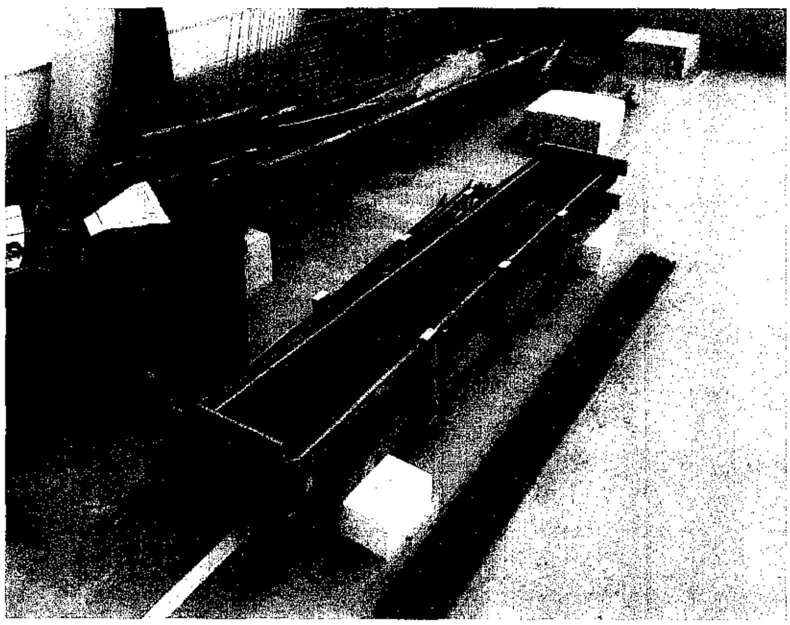

Figure 3-1: Formwork

3.3.2 Rebars

These rebars as shown in Figure 3-2 below is designated to act as a frame to the beam. Its function is to give the support to the beams from any load that imply on the beams. In this research, bars with diameter 12mm were used as the reinforced bars. These rebars is fabricated with the length of 1750 mm. The length 1750 mm is chosen because it will give the beam nominal cover to 25mm. Apart from that,6mm stirrups are used as the link for the rebars.

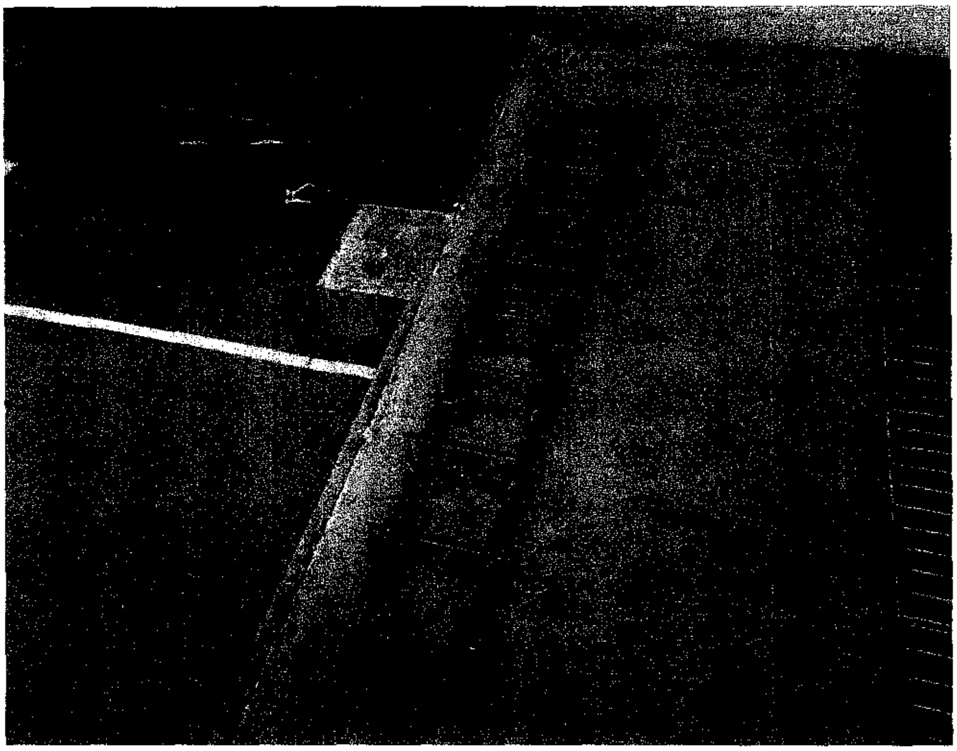

Figure 3-2 : Rebars

3.3.3 Ordinary Portland Cement

Cement is a powder, which by hydraulic reaction forms a solid and cohesive mass. Ordinary Portland Cement (OPC) is the standard, grey cement used for most purposes. It is a complex mixture of components, where it primarily consists of dicalcium (C_2S) and tricalcium silicates (C_3S). Besides that it also contains tetracalcium aluminoferrite. The water/cement ratio, the cement/aggregate ratio and aggregate size distribution are also important to the strength of the concrete. The chemical composition of OPC is shown in the Table 3-3 below [Edward G.Nawy, 2001]

Table 3-3: Chemical compositions of OPC, silica fume and used engine oil

Chemical Composition	Ordinary Portland Cement (%)	Silica Fume (%)	Used Engine Oil (%)
SiO_2	21.98	91.7	-
Al_2O_3	4.65	1	-
Fe_2O_3	2.27	0.9	0.43
CaO	61.55	1.68	15.9
MgO	4.27	1.8	-
SO_3	2.19	0.87	37.0
K_2O	1.04	-	-
Na_2O	0.11	0.1	-
CaO	-	-	15.9
P2O5	-	-	8.95
ZnO	-	-	17.7
Cl-	-	-	15.9

3.3.4 Aggregate preparation

Preparation of the aggregates took 2 days as we need to collect the aggregates, soak it in the water and let it dry for one day at the room temperature. The aggregates are soaked in the water to remove dirt at the surface of the aggregates that might disturb the strength or proportion of the concrete. This is also to ensure the aggregates to be in saturated surface dried (SSD) condition. Then the aggregates must be dried for one day at room temperature. This procedure had to be done to make sure the aggregates will not absorb water during the mixing. If the aggregates are too dry, there could absorb the water content during the mix and this will lead to lack of water in the mix and eventually disturb the flow ability of the concrete.

3.3.5 Preparation of Microwave Incinerator Rice Husk Ash(MIRHA)

Rice husks used in this research were taken from rice milling plant Bernas, Malaysia. Rice husks were dried under direct sunlight to reduce their moisture content so when they were burnt would not produce large amount of smoke. Dried rice husks were then burnt in automatic microwave incinerator as shown in Figure 3-3 to produce amorphous Microwave Incinerated Rice Husk Ash (MIRHA). The controlled combustion of MIRHA was done in two stages since the composition of silica content is very high [S.Beddu, M.F. Nuruddin, N.Shafiq, 2007].

Table 3-4: Burning Procedure for Microwave Incinerator [S.Beddu, M.F. Nuruddin, N.Shafiq, 2008]

Phase	Temperature	Duration	Remarks
Phase I	25° C - 150° C	1.5 hours	To remove the carbon and other volatile materials
Cooling	25° C		To ensure excess heat is not generated that can cause crystalline MIRHA for the next burning stage
Phase II	25° C - 550° C	2.5 hours	To achieve amorphous silica content of MIRHA.

At the first stage, rice husk was burnt in microwave incinerator with temperature was set to a maximum of 150° C. This process objective is to remove the volatile materials from rice husk. The rice husk ash was then cooled until reached ambient temperature. After that it is burned again in the second stage. At this stage, the microwave incinerator temperature was set to a maximum of 550° C. This stage is to achieve MIRHA with quality pozzolanic reactivity [S.Beddu, M.F. Nuruddin, N.Shafiq, 2008].

Figure 3-3 : Microwave Incinerator

3.4 Test procedure

Four beams including control beam will be casted for this study. The reinforcement of the beam depicted in Figure 3-4 and Figure 3-5.The dimension of 140mm x 260mm x 1800mm is chosen because the bigger dimension of the beam the more accurate and precise result will be obtained. Besides that this dimension is suitable with the space area that provided in the laboratory. Most of the machine also capable to handle the beam with less than 2.5 m length only.

The statically load test will be carried out 28days after casting. All beams will be experimented to failure under fatigue failure. All specimens were tested as a simply supported beam with a span length of 1.8m and loaded in one point in the middle of the beam or with a constant moment region of 540 mm at the middle of the beam. The point of flexural tests of reinforced concrete beams were performed on dynamic machine with a maximum load capacity of 500 kN under displacement control mode. During testing, the midspan deflection was measured and the ultimate load of the beams were recorded in the computer. All beams were tested up to failure under four-point bending.

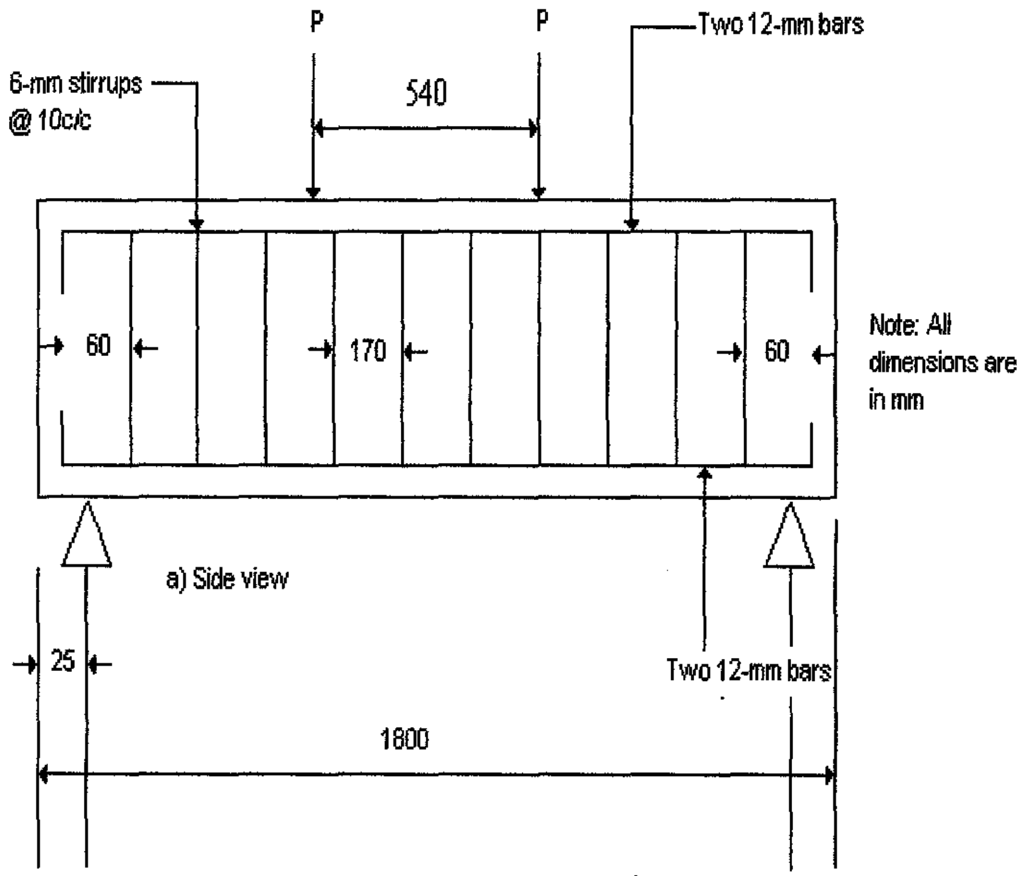

Figure 3-4: Beam layout from side view

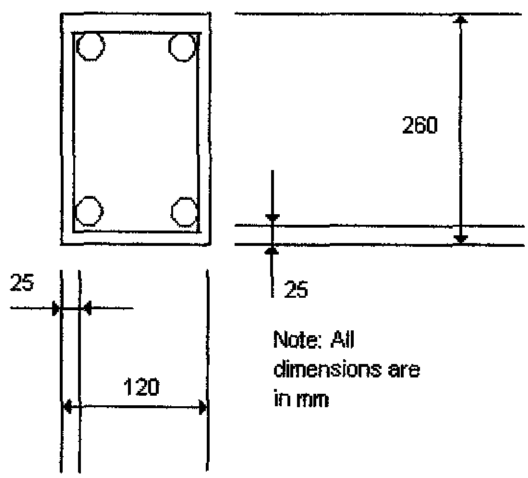

Figure 3-5: Cross section of the beam

3.5 Hazard analysis

3.5.1 Concrete Mixing

Dust of cement, sand, silica fume, smells of superplasticiser and used engine give unwanted odors to our nose. Thus it may cause dizziness to users. Besides that there are no proper tools for lifting sand, aggregates, and cement into the mixer before mixing. Apart from that noise of the turning mixer gives an irritating sound to the surrounding. In order to prevent the hazards during concrete mixing, students are oblige to wear mask and glove during doing the concrete mixing. This his regulation should be followed and obeyed by all the students to protect them from the hazards mentioned above. Students are also suggested to use shovels to lift the mixing up to the mixer. Apart from that, by wearing muff or ear plug during mixing, can protect our ear drums from noise pollution and can prevent from ear damage cause by the mixer machine.

3.5.2 Concrete Casting

When doing concrete casting, the moulds are too heavy to carry from another place to another and when pouring the mix into the mould, bad or improper posturing could lead to backache. To make this activity safe, the using of trolley is highly recommended to move the mould around. On the other hand, during pouring the mix into moulds students must sit down to avoid the backache.

3.5.3 Handling Wet Cements

When cement is mixed with water a highly alkaline solution is produced. The pH quickly exceeds 13 and is highly corrosive to skin. This will lead to injury that looks like a burn to our skin. In order to prevent from this hazard, it is highly recommended that while handling the wet cements, students should wear mask, goggles, long sleeve shirt and mask to avoid wet cement entering our eyes, mouth and nose. This is also to prevent the wet cements from making contact with our skin and thus can cause injury to our skin.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Properties of Fresh Concrete

The Table 4-1 below shows the properties of the concrete that had been designed and mixed. The concrete that been used to cast a beam was also cast into 4 mixes of cube. Each cube was tested with the compressive machine to get its maximum load and compressive strength. This test had been done after 28 days age of concrete.

From the table above, the mix 1 shows the greatest compressive strength with average value of 107.23 Kn. With the addition of the super plasticizer and silica fume the strength of the concrete can be increased. Silica fume produces the higher compressive strength concrete as it will act as a filler and cover all the voids in the concrete. Besides that, the super plasticizer will act as a water reducer hence it will reduce the pore in the concrete and eventually increase the concrete strength.

Table 4-1 : Results for the properties of the concrete

Samples	Slump Test (mm)	Weight (kg)		Maximum Load (kN)		Stress (MPa)	
Control Mix	50	Cube 1	2.36	Cube 1	600.1	Cube 1	60.01
		Cube 2	2.49	Cube 2	578.7	Cube 2	57.87
		Cube 3	2.42	Cube 3	536.8	Cube 3	53.68
Mix 1 (SF + SP)	90	Cube 1	2.46	Cube 1	1084.3	Cube 1	108.43
		Cube 2	2.40	Cube 2	1100.1	Cube 2	110.01
		Cube 3	2.39	Cube 3	1032.4	Cube 3	103.24
Mix 2 (SF + UEO)	90	Cube 1	2.37	Cube 1	544.8	Cube 1	54.48
		Cube 2	2.45	Cube 2	696.6	Cube 2	69.66
		Cube 3	2.43	Cube 3	712.3	Cube 3	71.23
Mix 3 (MIRHA + SP)	100	Cube 1	2.50	Cube 1	1003	Cube 1	100.3
		Cube 2	2.36	Cube 2	507.2	Cube 2	50.72
		Cube 3	2.44	Cube 3	1037	Cube 3	103.7

4.2 Maximum Load and Deflection at failure for each beam

4.1.1 Beam 1 (control mix)

From the table 4-2 below, the maximum load that beam 1 can sustain is 108.2 kN. Its deflection at failure is 7.617 mm. This beam is also shows its elasticity behavior when the load is at 105 kN. This can be observed in figure 4-1 where it shows the graph for maximum load versus deflection at failure for beam 1.

Table 4-2: Load and deflection at failure for beam 1 (control mix)

Load (kN)	Deflection (mm)
1.7	0.066
0.39	0.098
0.99	0.071
2.24	0.14
3.55	0.208
4.87	0.265
6.15	0.249
7.51	0.059
8.86	0.055
10.15	0.009
1015	0.009
12.86	0.099
14.16	0.157
15.48	0.298
16.81	0.494
18.13	0.901
19.45	0.223
20.82	0.595
22.09	1.028
23.4	0.988
24.72	1.071
26.07	1.033
27.4	1.161
28.72	1.312
30.01	1.429
31.33	1.473
32.73	1.38
34.08	1.378
35.41	1.452
36.82	1.595
38.22	1.627
39.48	1.868
40.9	2.176
42.19	2.253
43.52	2.327
44.84	2.399
46.18	2.734
47.48	2.691
48.8	2.676

Load (kN)	Deflection (mm)
56.7	3.243
58.01	3.341
59.33	3.236
60.64	3.6
61.95	3.616
63.26	3.73
64.61	3.797
65.92	3.932
67.26	3.933
68.58	3.961
69.91	3.995
71.2	3.346
72.49	3.656
73.81	4.16
75.14	4.197
76.44	4.335
77.75	4.184
79.07	4.287
80.42	4.272
81.72	4.126
83.03	3.992
84.36	4.251
85.67	3.512
87.07	4.35
88.32	4.345
89.62	4.49
90.95	4.532
92.24	4.532
93.57	5.148
94.85	5.222
96.17	5.492
97.5	5.316
98.79	5.512
100.14	5.209
106.68	5.862
108.06	7.244
108.2	**7.617**
24.37	66.511
5.95	64.171

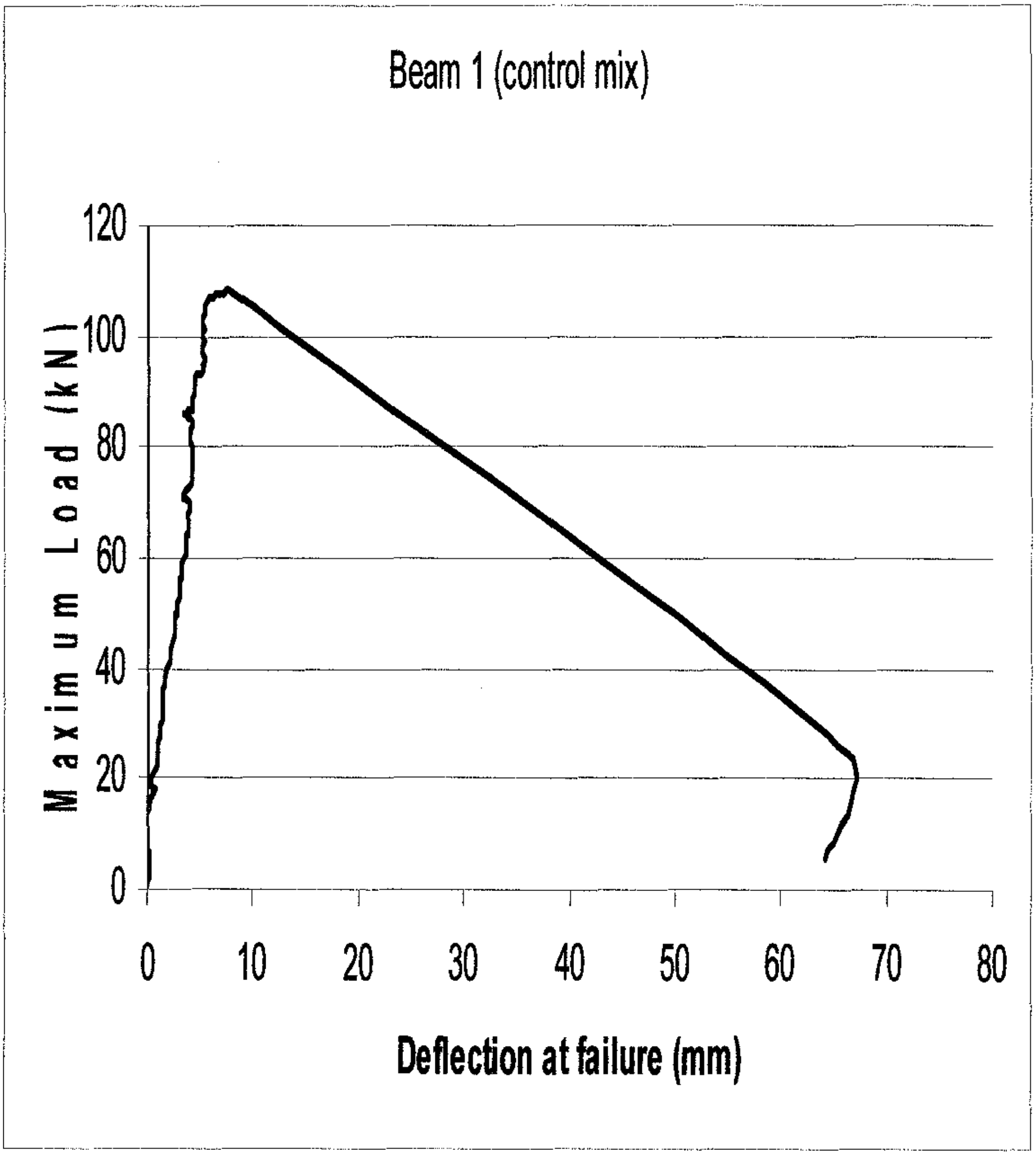

Figure 4-1 : Maximum Load versus Deflection at failure for Beam 1 (control mix)

4.2.2 Beam 2 (mix 1)

From Table 4-3, the maximum loading that can be sustained by beam 2 is 121.88 kN while its deflection at failure is 11.653 mm. This beam also tends to show its elasticity behavior when the load is 118 kN. This can be observed from the figure 4-2.

Table 4-3: Load and deflection at failure for beam 2 (mix 1)

Load (kN)	Deflection (mm)
0.3	0.245
1.78	0.08
3	0.177
4.28	0.173
5.56	0.133
6.89	0.276
8.15	0.254
9.6	0.405
10.81	0.298
12.14	0.341
13.41	0.361
14.73	0.425
16.07	0.61
17.41	0.598
18.69	0.78
19.98	0.788
21.3	0.815
22.61	0.957
23.94	0.983
25.29	1.155
26.6	1.171
27.95	1.237
29.26	1.461
30.7	1.5
31.97	1.612
33.48	1.763
34.63	1.818
35.89	1.878
37.25	1.821
38.52	2.057
39.83	2.077
41.13	2.131
42.49	2.073
43.79	2.073
45.08	2.327
46.38	2.508
47.93	2.833
49.15	2.991
50.39	3.102
51.68	3.171
52.99	3.133
54.29	3.261
55.64	3.393
58.25	3.618
59.59	3.682
60.87	3.69
62.22	3.873
63.55	3.945
64.89	3.975
66.18	4.068
67.49	4.031
68.84	4.204
70.09	1.3
71.57	4.457
72.81	4.593
74.06	4.665
75.39	4.8
76.69	4.865
78.01	4.993
79.35	5.111
80.63	5.296
81.95	5.389
83.26	5.549
84.58	5.61
86.04	5.847
88.66	6.213
89.9	6.219
91.19	6.291
92.55	6.421
93.82	6.425
95.17	6.623
95.17	6.623
97.99	6.893
99.22	6.967
100.43	7.073
101.68	7.287
103.05	7.479
104.33	7.609
105.64	7.719
106.98	7.799
108.26	7.945
109.55	8.218
110.97	8.411
112.21	8.629
113.73	8.841
115.06	9.243
117.57	9.762
121.88	**11.653**
64.04	50.069
39.19	48.643

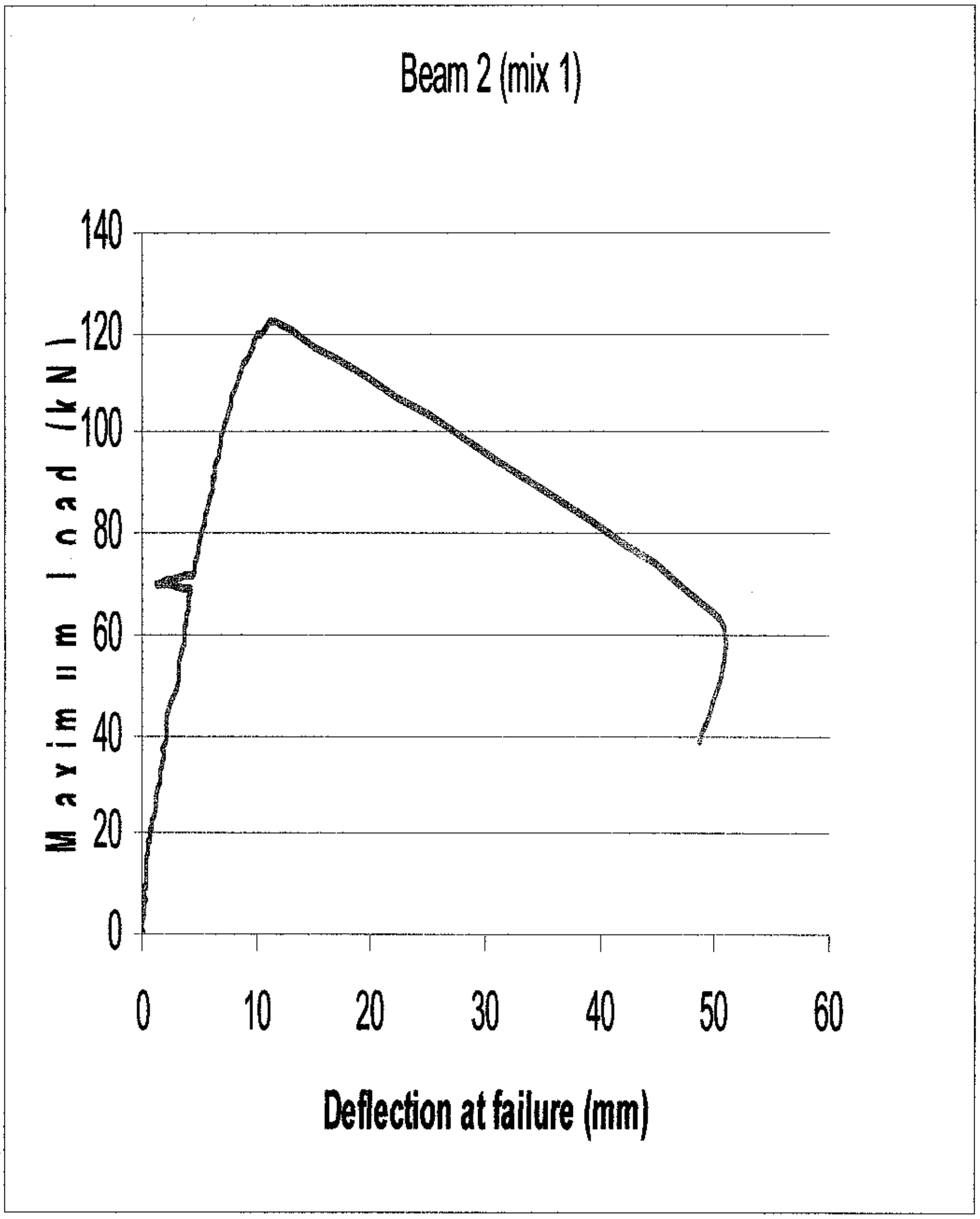

Figure 4-2 : Maximum Load versus Deflection at failure for Beam 2 (mix 1)

4.2.3 Beam 3 (mix 2)

From the table below (table 4-4), the maximum load that beam 3 can sustain is 137.02 kN. Its deflection is 21.995 kN. From the graph in figure 4.3, the beam starts to elastic when the load is at 121 kN. When the load is increased to 137.02 kN it started to crack and fail.

Table 4-4: Load and deflection at failure for beam 3 (mix 2)

Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)
5.59	0.184	63.55	3.871	122.76	11.36
6.87	0.231	64.87	3.97	124.01	12.436
8.22	0.33	66.18	4.069	125.4	13.905
9.52	0.385	67.48	4.168	126.67	15.14
10.77	0.434	68.77	4.276	128.08	16.259
12.1	0.491	70.11	4.392	129.36	17.067
13.45	0.544	71.53	4.522	130.68	18.327
14.74	0.596	72.83	4.631	132.07	19.156
16.05	0.648	74.11	4.718	133.27	19.734
17.36	0.703	75.41	4.809	134.56	20.353
18.67	0.763	76.72	4.897	135.86	21.086
20.01	0.828	78.04	4.987	**137.02**	**21.995**
21.32	0.899	79.34	5.08	136.65	29.647
22.63	0.979	80.68	5.172	128.7	42.057
23.96	1.081	81.98	5.264	118.05	51.337
25.29	10175	83.29	5.355		
26.66	10281	84.57	5.446		
27.95	1.37	85.9	5.543		
29.27	1.464	87.21	5.642		
30.59	1.555	88.52	5.74		
31.9	1.635	89.86	5.832		
33.26	1.723	91.16	5.926		
34.56	1.802	92.46	6.019		
35.89	1.883	93.76	6.108		
37.21	1.964	95.07	6.201		
38.51	2.044	96.39	6.298		
39.89	2.134	97.7	6.392		
41.23	2.252	98.99	6.501		
42.5	2.346	100.48	6.701		
43.78	2.428	101.73	6.833		
45.1	2.513	102.98	6.941		
46.43	2.609	104.26	7.046		
47.74	2.696	105.59	7.168		
49.07	2.798	107.04	7.37		
50.4	2.912	108.26	7.505		
51.72	3.009	109.52	7.618		
53.04	3.098	110.8	7.725		
54.34	3.188	113.45	7.955		
55.67	3.284	114.75	8.07		
56.98	3.38	116.06	8.203		
58.26	3.473	117.45	8.345		
59.59	3.572	118.67	8.487		
60.93	3.668	119.99	8.681		

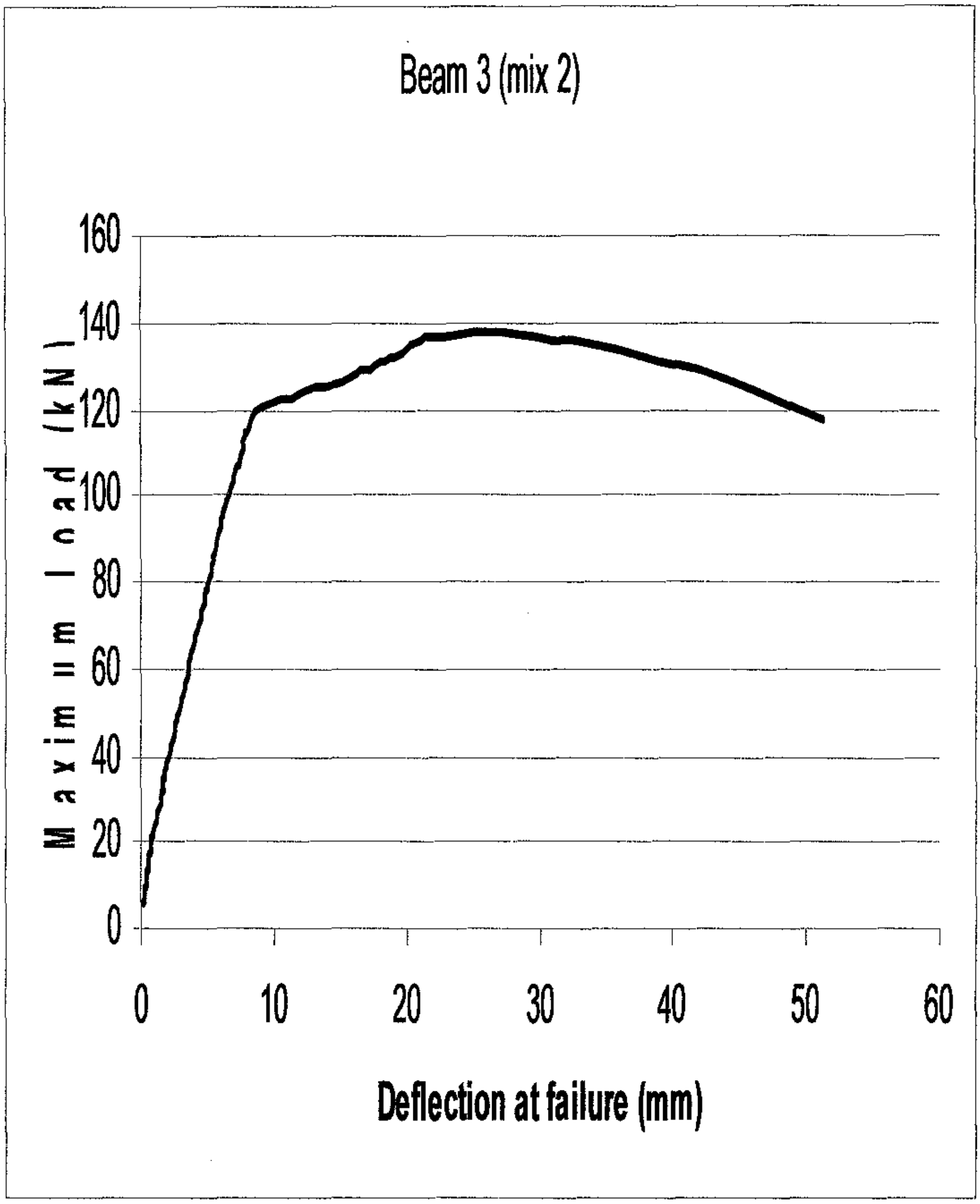

Figure 4-3 : Maximum Load versus Deflection at failure for Beam 3 (mix 2)

4.2.4 Beam 4 (mix 3)

From the table 4.5, the maximum load that the beam 4 can sustain is 117.35 kN while its deflection at failure is 11.253 kN. From the graph in figure 4-4 below, the beam starts to elastic at 102 kN and when the load is at 117.35 kN it starts to crack and fail.

Table 4-5: Load and deflection at failure for beam 4 (mix 3)

Load (kN)	Deflection (mm)
0.17	0.098
1.52	0.042
2.81	0.011
4.13	0.069
5.46	0.131
6.8	0.201
8.14	0.278
9.48	0.349
10.8	0.43
12.08	0.487
13.41	0.551
14.74	0.614
16.03	0.67
17.36	0.729
18.69	0.792
19.99	0.852
21.29	0.908
22.6	0.973
23.91	1.032
25.28	1.099
26.62	1.158
27.93	1.228
29.23	1.297
30.55	1.368
31.86	1.445
33.2	1.534
34.51	1.616
35.8	1.705
37.13	1.793
38.44	1.877
39.71	1.961
41.12	2.082
42.4	2.165
43.72	2.248
45.03	2.336
46.36	2.435
47.68	2.55
49.01	2.66
50.29	2.758
51.6	2.863
52.93	2.953
54.21	3.04
55.54	3.132
58.2	3.31
59.51	3.398
60.84	3.485
62.16	3.579
63.48	3.667
64.81	3.765
66.11	3.859
67.44	3.956
68.69	4.038
70.03	4.132
71.33	4.232
72.75	4.375
74.02	4.474
75.3	4.566
76.62	4.659
77.93	4.759
79.24	4.854
80.56	4.954
81.87	5.063
83.2	5.194
84.51	5.331
85.81	5.443
87.15	5.586
88.46	5.736
89.78	5.867
91.06	5.973
92.38	6.087
93.72	6.208
95.02	6.329
96.34	6.453
97.65	6.577
98.96	6.726
100.26	6.862
101.64	7.069
102.91	7.296
104.36	8.371
105.62	8.63
106.98	9.22
108.27	9.413
109.55	9.601
110.87	9.812
112.17	10.048
113.43	10.279
116.06	10.786
117.35	**11.253**
98.81	36.419
100.63	36.485
98.02	36.359
96.38	36.319
98.97	36.398

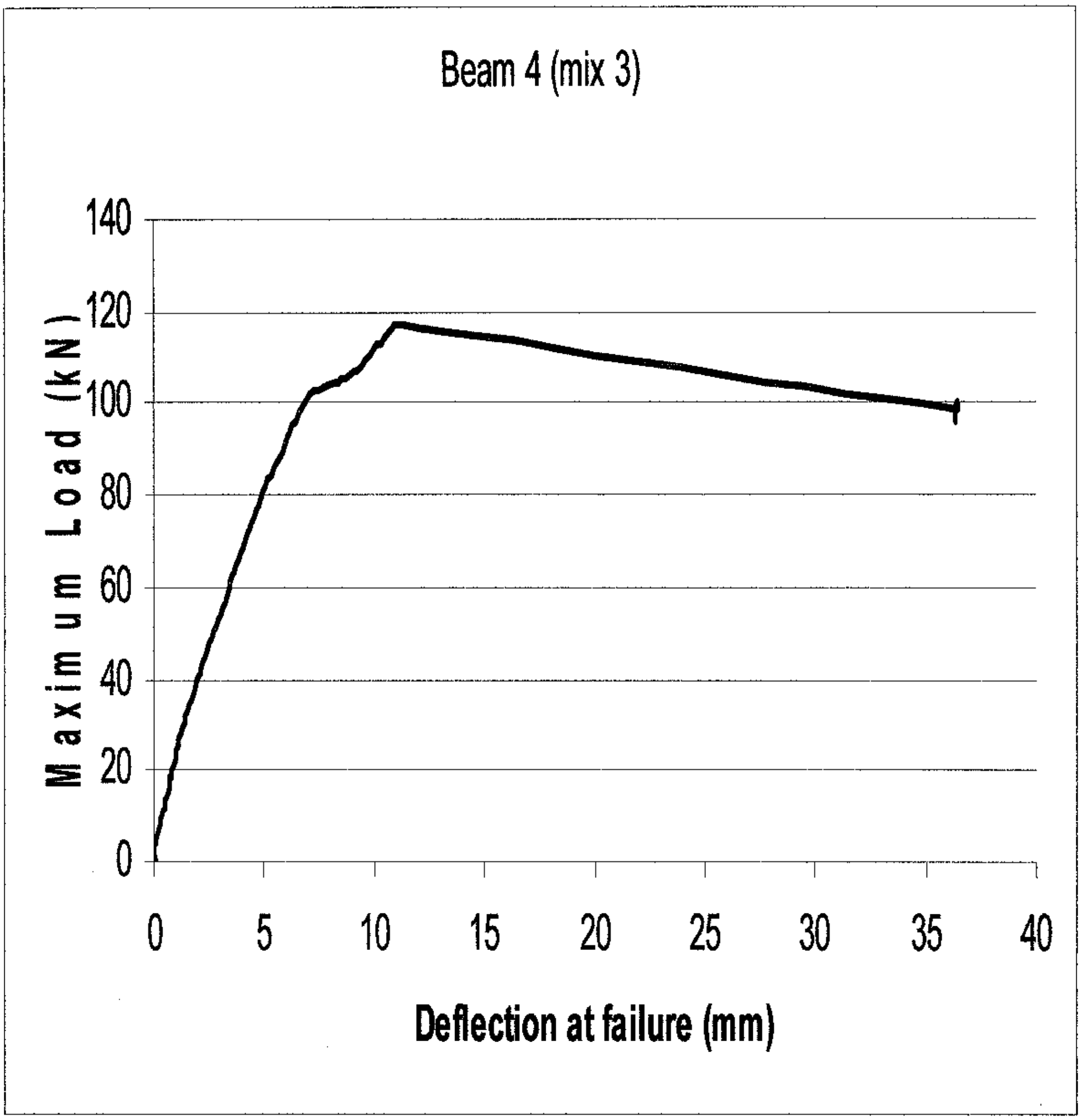

Figure 4-4 : Maximum Load versus Deflection at failure for Beam 4 (mix 3)

4.2.5 Beam 1, 2, 3 and 4

From the graph in figure 4-5, beam 3 (mix 2) has the highest maximum loading 137.02 kN and beam 1 (control mix) has the lowest maximum loading 108.02 kN. From the figure 4-5 also, all the beams are elastic. Beam 3 is the most elastic beams and it is the most plastic beams as well. Besides that, it has the highest fatigue behavior where it took a plenty of time to fail completely. It also found that the beam 3 has the highest ductility ratio. Beam 1 shows the less elastic behavior and less plastic as it shows its brittleness after a while. Eventually, it also experiencing sudden failure after showing a moment of plastic behavior.

The addition of used engine oil and silica fume in the mixture of the beam 3 manages to produce the strongest, the most durable and the most elastic beam. Used engine oil has the capability to increase the surface tension of the concrete. Hence it can avoid water leakage in the concrete and eventually the workability and strength of the concrete can be maintained.

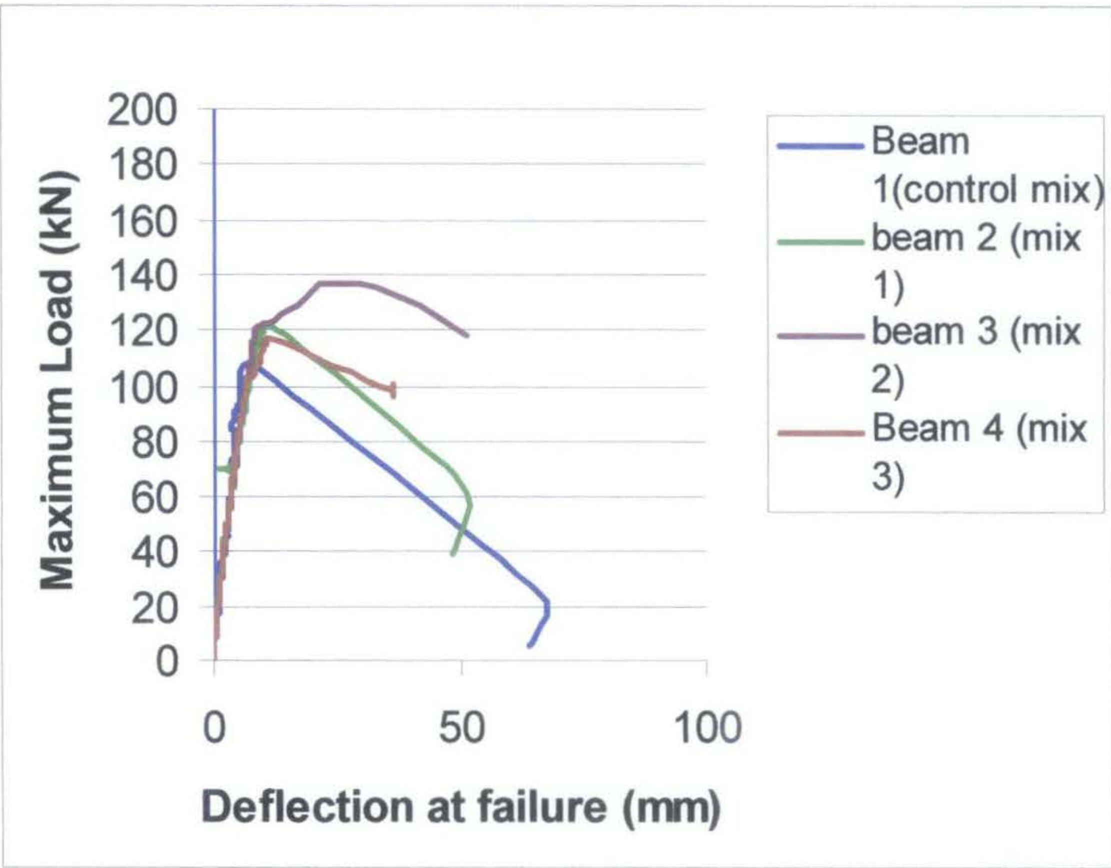

Figure 4-5 : Maximum Load versus Deflection at failure for all Beam 1, 2,3 and 4

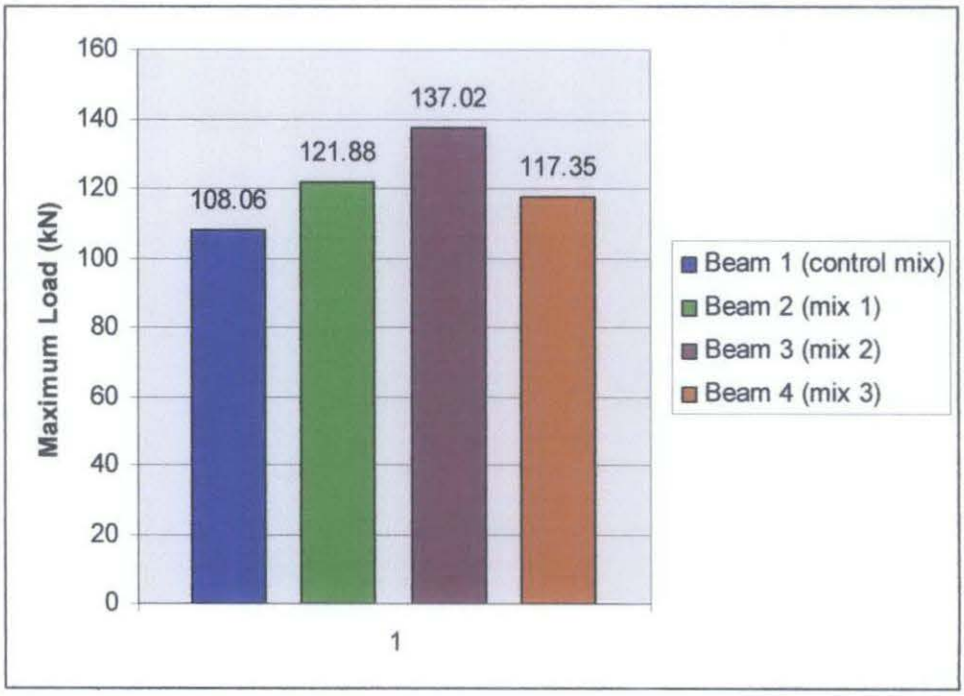

Figure 4-6 : Bar Chart of Maximum Loading for each beam

4.3 Deflection at failure

From the figure 4-7 below, beam 3 has the highest deflection at failure of 21.995 kN while beam 1 has the lowest deflection of 7.244 kN. This shows the beam 3 is the most stiff and hardest beam as it needs to deflect further to crack at failure. Beam 3 is the hardest and most stiff as its mixture contains used engine oil and silica fume.

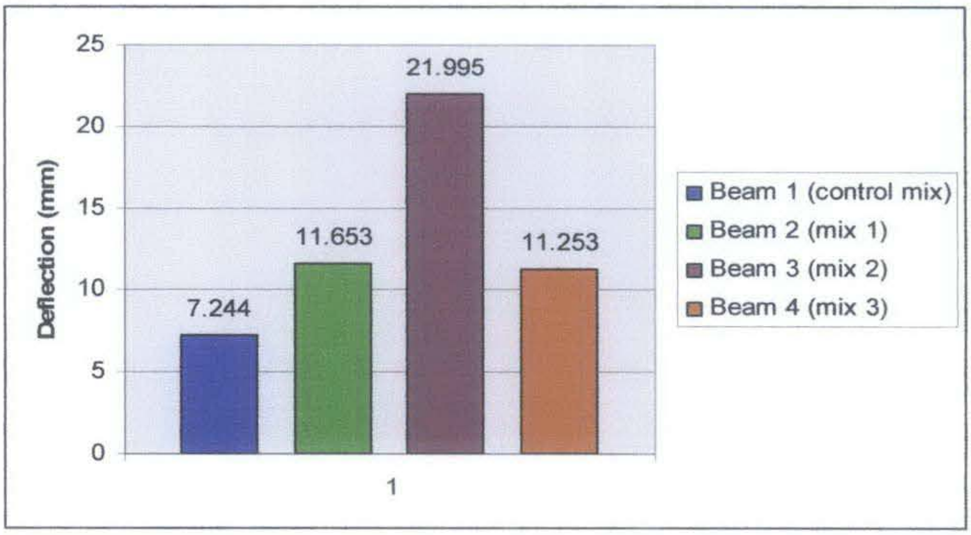

Figure 4-7 : Bar chart of deflection at failure for each beam

4.4 The condition of the beam before and after the testing

Figure 4-8 : Beam 1 before testing was done

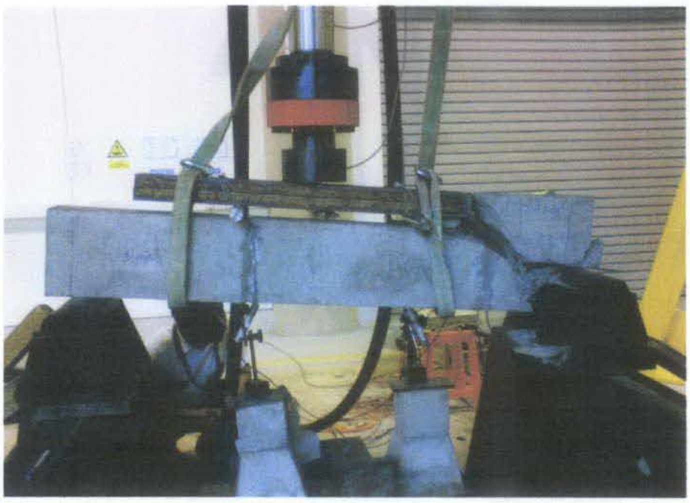

Figure 4-9 : Beam 1 after testing was done

Figure 4-10 : Beam 2 before testing was done

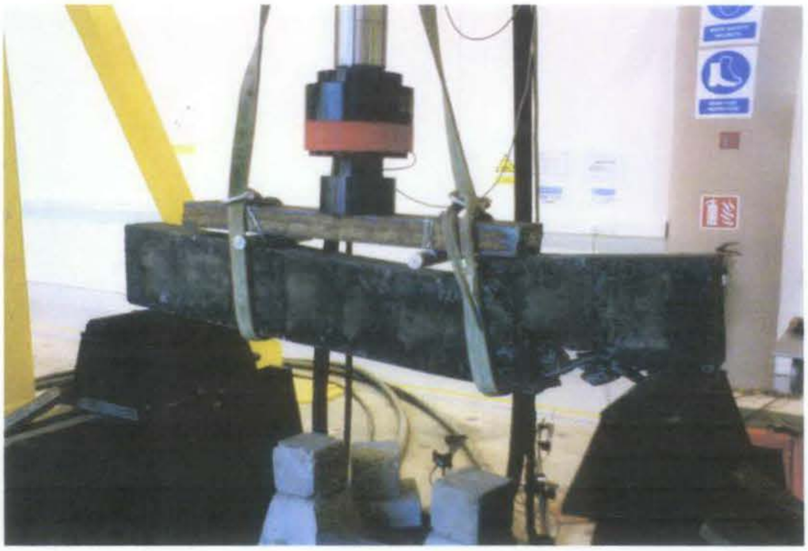

Figure 4-11 : Beam 2 after testing was done

Figure 4-12 : Beam 3 before testing was done

Figure 4-13 : Beam 3 after testing was done

Figure 4-14 : Beam 4 before testing was done

Figure 4-15 : Beam 4 after testing was done

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

In conclusion, this research has achieve its objective. Beam 3 with the addition of used engine oil and silica fume merges as the strongest beams. Used Engine Oil prove to be the best admixture and it can increase the strength and durability of the High Strength Concrete.

The effects of Used Engine Oil on structural behavior of beam 3 under static load are quite pronounced and encouraging as compared to other three beams. The effects are particularly very significant after yielding (post elastic), where it has shown very ductile as compare to other three beams They had failed immediately after yielding.

5.2 RECOMMENDATION

From this research, beam 1, 2 and 4 experienced shear crack at failure. To prevent from this crack, shear link should be provided in the rebars. This is to ensure that the beam get sufficient support from the rebars and hence ensures the beams to experience flexural deflection. Further calculation should be done in the future research.

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LIST OF APPENDIXES

APPENDIX A

GANTT CHART

Week Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**		**8**	**9**	**10**	**11**	**12**	**13**	**14**
Activities/ milestones															
Selection of Project Topic															
Preliminary Research Work															
Brainstorming															
Submission of Preliminary Report															
Survey Materials															
Project Work															
Prepare material															
Conduct Experiment															
Research Work															
Submission of Progress Report															
Research Work															
Project work continues															
Data Gathering															
Submission of Interim Report Final Draft															
Preparation of Oral Presentation															
Oral Presentation															

Figure: Milestone for the first semester of Final Year Project

GANTT CHART

Details/ Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Project Work Continue														
-Practical/Laboratory Work														
Project Work Continue														
-Practical/Laboratory Work														
Submission of Progress Report 1 and 2								x						
Project work continue														
-Practical/Laboratory Work														
Submission of Dissertation Final Draft												x		
Oral Presentation													x	
Submission of Project Dissertation (Hardbound)														x

Figure: Milestone for the second semester of Final Year Project

APPENDIX B

GRAPH RECORDED FROM THE DYNAMIC MACHINE 500 kN

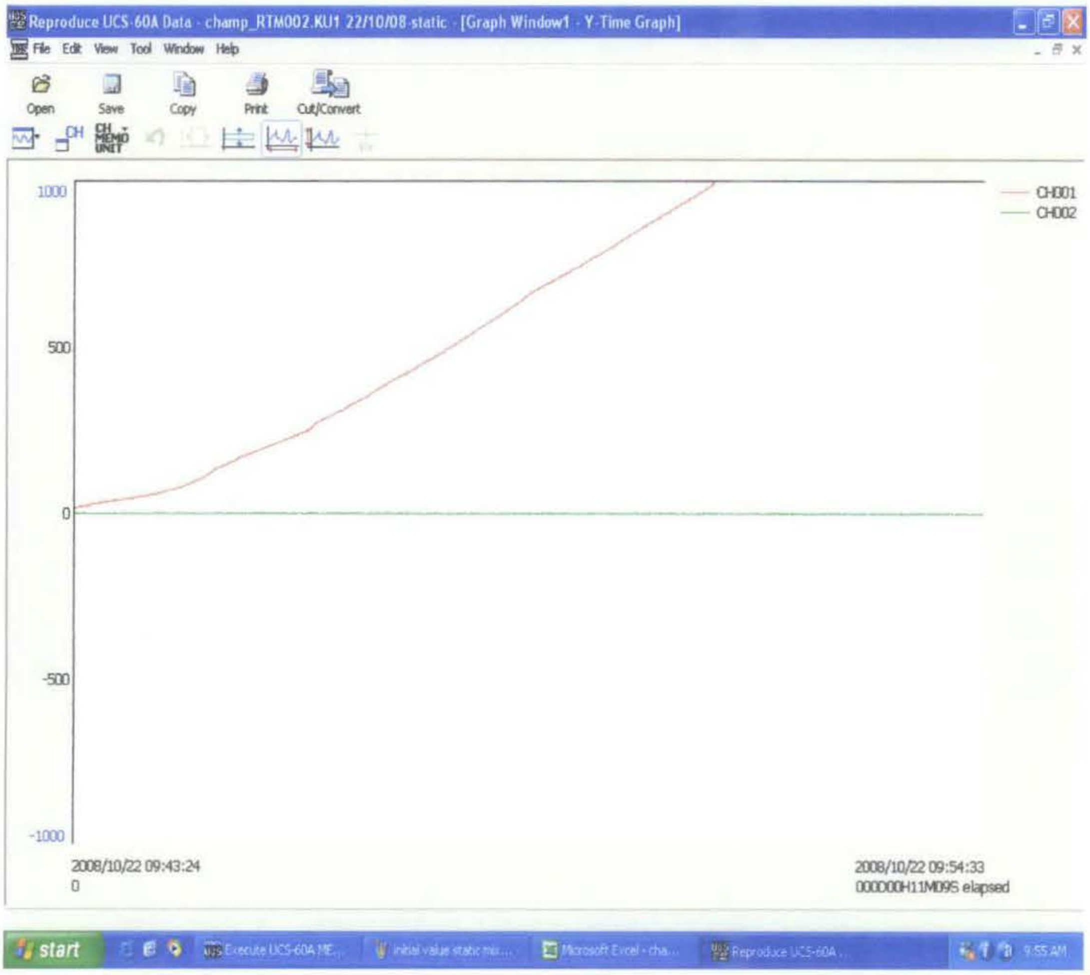

Figure : Maximum Load Graph from dynamic machine

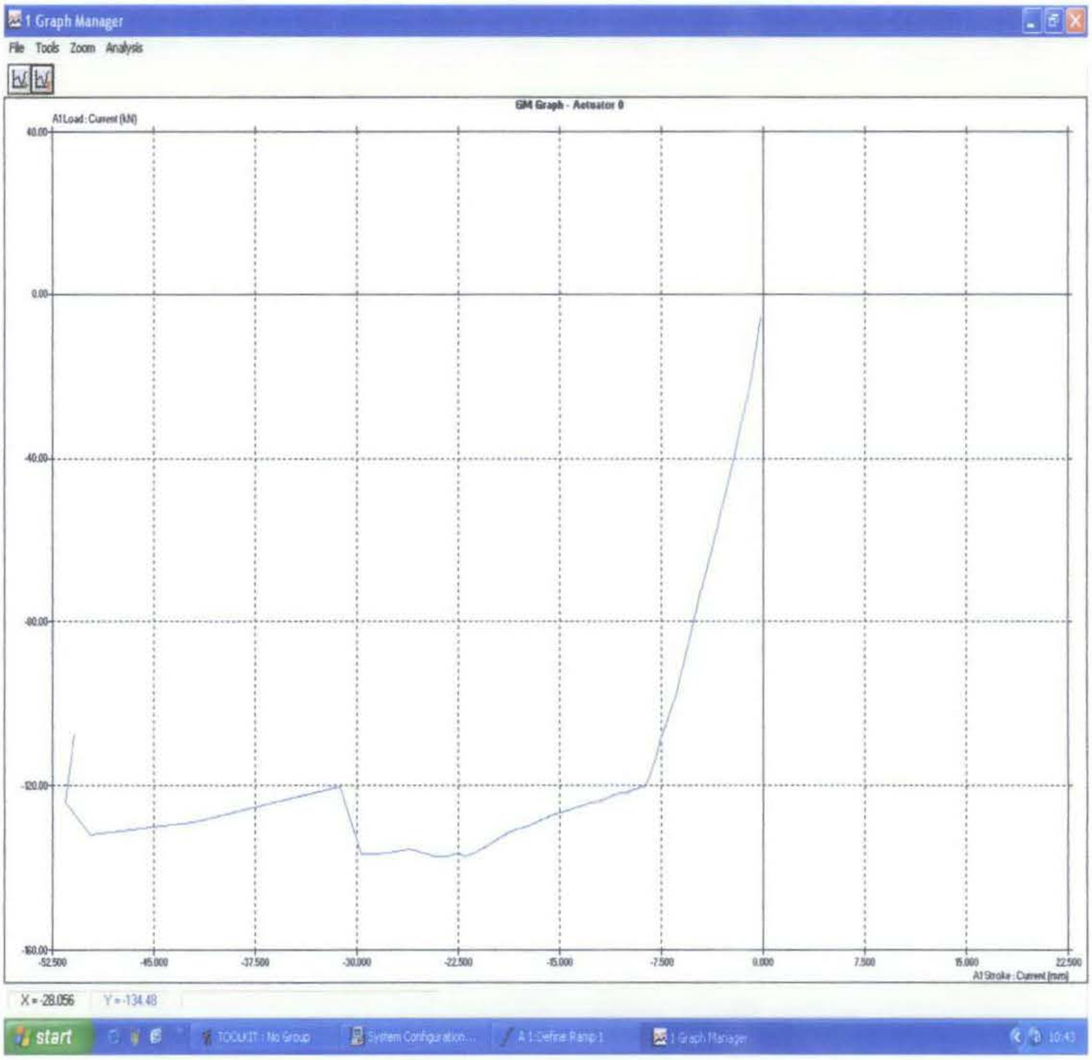

Figure : Deflection graph from dynamic machine