UTILIZATION OF CATALYST WASTE MOLINEX (CWM) IN CONCRETE

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JANUARY 2006

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by

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Dissertation submitted in partial
fulfillment of the requirement for the
Bachelor of Engineering (Hons) Civil

JANUARY 2008

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Civil Engineering)

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January 2008

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 Afiq bin Mhd Khazar

ABSTRACT

Catalyst is being used by various kinds of industries and most of it are in process plant as booster for reaction.. After some time, the catalyst can no longer be used and then reprocessed is needed to make it become useful. Results of the process, another undesired product or catalyst wastes are being produced. These wastes are normally dumps into landfill but the increasing quantities and occupy big areas and poses into danger of nature pollution.

Concrete technology currently focuses on the cement replacement material (CRM) in order to find alternatives for cement usage. Pulverized fly ash (PFA) and silica fume are the most common cement replacement material which being utilized from waste material. The contribution in term of strength, durability and permeability are the ultimate goal of collaborating with CRM besides the economical point of view.

The main objective of this project is to observe the possibility of recycling the catalyst waste which is called 'molinex' into concrete and cement mortar. The research is based on the contribution of waste molinex in mortar in term of compressive strength.The approach used is to determine the oxide content of molinex and cementitious material (silica oxide) are expected from molinex. Scanning electronic microscope is employed to examine this waste. Study on molinex as sand and cement replacement is also conducted. Effects of both replacements on compressive strength are carried out at 3,7,28 days.

In conclusion, it has found that molinex do contribute to the strength development of mortar according to experimental casting of molinex as sand replacement and cement replacement.

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INTRODUCTION

1.1 BACKGROUND

Waste is currently a major problem to our environment. Government has spent a lot of money in order to dispose all kind of waste. There are many types of waste, municipal waste, solid waste, scheduled waste and many more. These kind of waste need to be disposed with different approach of disposal. For Instant, burning and dumping method of disposal are used for solid waste. However, for schedule waste we have to dispose according to 'KUALITI ALAM's' requirement, which is one of the government company that manage this type of waste. Disposal at 'KUALITI ALAM' have to consider the high cost of disposal.

Current practice in the industries is to recycle, reuse and utilize the waste. Recycling practice in the oil and gas industries increasing and company processing used engine oil, used catalyst, used coal and many others. Those companies tend to produce good products that can be used by the industries.

Production of catalyst that is being used in most of the processing plants especially oil and gas currently increasing. For instant, approximately 2000 m^3 catalyst is used by an Operation PETRONAS unit (OPU), per year. After the catalyst have been used for certain plant process, this catalyst which is in waxy waste will be disposed and according to scheduled waste. These require cost around RM1500 per kg according to 'KUALITI ALAM' rate of disposal and there are very limited companies in charge in disposing scheduled waste.

Waste molinex is a type of waste that comes out from this catalyst waste. Besides, there are other types of catalyst waste such as palladium, titanium and so on. Research on the contents of molinex is important in order to determine silica content. This will give some view on how this molinex can contribute to the concrete or mortar. Basically, from existing information, molinex contain some clay mineral such as aluminium and carbon.

Concrete and mortar is basically ingredients of cements, aggregates and sand with some proportions of water. All this material gives impact to the strength of concrete itself. The main point here is to focus on the replacement material on production of concrete. Cement replacement material such as Pulverized fly ash (PFA) rice husk ash (RHA) is the best model that proven it capability as waste to contribute in concrete. Therefore, this project will be carry on to zoom in on how much molinex can be as cement replacement in concrete production.

1.2 PROBLEM STATEMENT

1.2.1 The waste is abundance.

The production of catalyst waste is about 800 barrel/year sent by process plant all around Malaysia. The waste is continuously sent to this enviro company and they pay for the disposal. It is about 3000 barrel stored currently in this recycle company and will be increasing.

1.2.2 The waste is a costly disposal.

The cost of disposal at 'KUALITI ALAM' is RM 900/barrel.

1.2.3 Current practice

Currently molinex have being used to be sell in KOREA for RM 50 /tonne. YTL cement used to buy this waste before for concrete production as clay replacement material. Molinex used to be sell to cement company in INDIA for cement production.

1.3 OBJECTIVE

The objective of this research are :

- To identify the oxide content of catalyst waste molinex
- To identify possible substitution of sand and cement with catalyst waste molinex
- To determine the different in contribution of raw molinex and grinds molinex in mortar.
- To determine the effects of molinex in mortar

1.4 SCOPE OF STUDY

The scope of study of this project covers determination of oxide content of molinex itself. Scanning electronic microscope (SEM) test is used for this purposes. This test objective to determine the existing silica content (SiO_2) and cementitious properties : SiO_2 Al_2O_3 Fe_2O_3 and Ca O. this required > 70% content to prove that it is cementitious material.

First and foremost, normal size of molinex is being used in sand replacement and cement replacement. Sand replacement were conducted at 50% replacement while cement replacement were conducted at 20% replacement and their strength development is being monitored for 3, 7 and 28 days. These will be the basis of the project to observe the contribution of molinex in mortar.

Two types of molinex sizes were considered namely 0.5mm and 0.25mm. Three mix proportion for each size were cast: (10%, 20% and 30 %) cement replacement and their strength development is being monitored at ages 3,7 and 28 days. The water cement ratio for all mixes was fixed at 0.5.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

Concrete is defined in ASTM terminology relating to concrete and concrete aggregates (C125) as a composite material that consist essentially of a binding medium within which are embedded particles or fragments of aggregates: in hydraulic –cement concrete, the binder is formed from a mixture of hydraulic cement and water. Hydraulic cements as cement that sets and hardens by chemical interaction with water and that is capable of doing so under water. Typical hydraulic –cement concretes have volume fractions of aggregate that range approximately from 0.7 to 0.8. the remaining volume is occupied initially by a matrix of fresh cement paste consisting water , cement and admixtures that also enclosed air void. (1)

In this literature review will focus on the studies and theory of the contribution waste molinex in concrete or mortar. Therefore, studies n the relationship of this molinex with sand, clay and cement will be carried out. The objective is to find out the similarity in material content of this molinex and those concrete materials.

2.1 INGREDIENTYS OF CONCRETE

Basically, there are 5 important ingredients that are includes in concrete-making in common. They are: (2)

- 2.1.1 Cement
- 2.1.2 Aggregates
- 2.1.3 Cement replacement material (CRM)
- 2.1.4 Admixtures (mineral)

2.1.1 CEMENT

Portland cement is the most common type of cement in general usage in many parts of the world, as it is a basic ingredient of concrete, mortar, stucco and most non-specialty grout. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a maximum of about 5% gypsum which controls the set time, and up to 5% minor constituents (as allowed by various standards). As defined by the European Standard EN197.1, "Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates ($3CaO.SiO_2$) and $2CaO.SiO_2$), the remainder consisting of aluminium- and iron-containing clinker phases and other compounds. The ratio of CaO to SiO_2 shall not be less than 2.0. The magnesium content (MgO) shall not exceed 5.0% by mass." (The last two requirements were already set out in the German Standard, issued in 1909). (3). The raw material used in manafacture cement consist mainly of lime, silica, alumina and iron oxide. Main compound of cement :

Name of compound	Oxide composition	Abbreviation
Tricalcium slicate	$3CaO.SiO_2$	C_3S
Dicalcium silicate	$2CaO.SiO_2$	C_2S
Tricalcium aluminate	$3CaOAl_2O_3$	C_3A
Tetracalcium aluminoferrite	$4CaO.Al_2O_3Fe_20$	C_4AF

TABLE 2.1

Hydration of cement

The reaction by virtue of which cement becomes a bonding agent take place in a water-cement paste. In other words, in the presence of water, the silicates and aluminates form products of hydration which in time produce a firm and hard mass- the hydrated cement paste. There are two ways in which compounds of the types present in cement can react with water. In the first, a direct addition of some molecules of water takes place, this being a true reaction of hydration. The second type of reaction with water is hydrolysis. It is convenient and usual.

Process

Portland cement clinker is made by heating, in a kiln, a homogeneous mixture of raw materials to a sintering temperature, which is about 1450 °C for modern cements. The aluminium oxide and iron oxide are present as a flux and contribute little to the strength. For special cements, such as Low Heat (LH) and Sulfate Resistant (SR) types, it is necessary to limit the amount of tricalcium aluminate ($3CaO.Al_2O_3$) formed. The major raw material for the clinker-making is usually limestone ($CaCO_3$). Normally, an impure limestone which contains SiO_2 is used - the $CaCO_3$ content can be as low as 80%. Secondary raw materials (materials in the rawmix other than limestone) depend on the purity of the limestone. Some of the secondary raw materials used are: clay, shale, sand, iron ore, bauxite, fly ash and slag. When a cement kiln is fired by coal, the ash of the coal acts as a secondary raw material. (4)

Process of cement production :

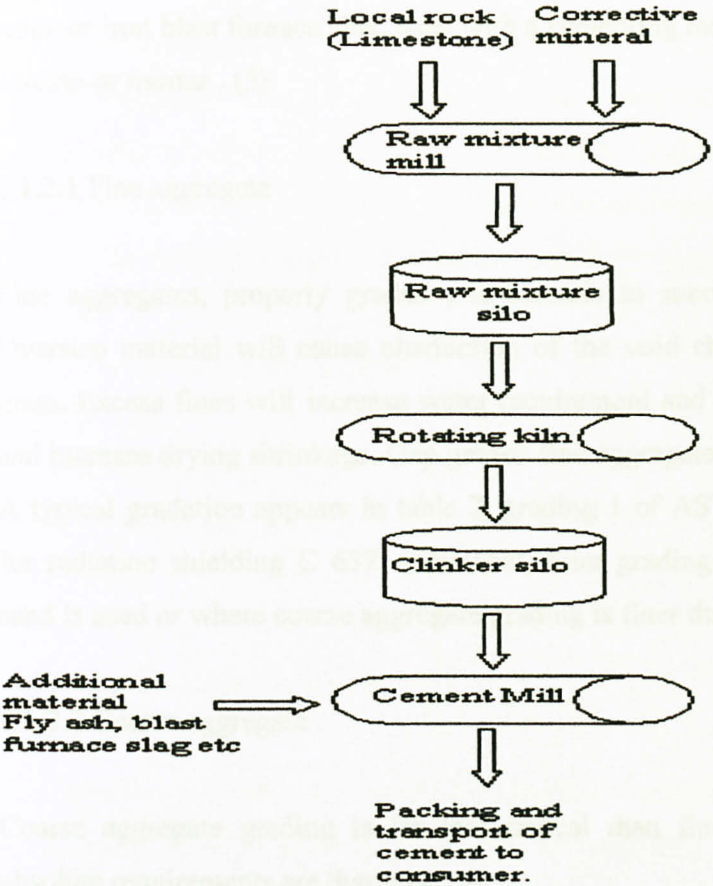


FIGURE 2.1

2.1.2 AGGREGATES

Aggregates is defined in ASTM C125 as granular material , such as sand , gravel crushed stone or iron blast furnace slag, used with a cementing medium to form hydraulic cement concrte or mortar . (5)

2.1.2.1 Fine aggregate

Fine aggregates, properly graded , is essentia to successful execution of the work.. Oversize material will cause obsrtuction of the void channel in the coarse aggregates mass. Excess fines will increase water requirement and so reduce compressive strength and increase drying shrinkage. Gap graded fine aggregates may cause excessive bleeding. A typical gradation appears in table 2, grading 1 of ASTM specification for aggregates for radiation shielding C 637. somewhat, finer grading is required where high-density sand is used or where coarse aggregate grading is finer than normal.

2.1.2.2 Coarse aggregate

Coarse aggregate grading is far less critical than fine aggregate grading. The only absolute requirements are that it be :

a) free of surface dust that would prevent bond of grout to the aggregates particle

b) Sufficiently saturated that it will not absorb water from the rout and so cause premature thickening

Normal aggregate gradin limts for most structural applications is Shown in table 2, grading 1 ASTM C637. aggregate graded within these limits will exhibit a void content in the range 43-48 %. In the absence of very closely spaced reinforcing or resrticted from configuration , it is common practice to scalp coarse aggregate on a 20mm wash screen.(6)

2.1.2.3 Clay

Clay is a term used to describe a group of hydrous aluminium phyllosilicate (phyllosilicates being a subgroup of silicate minerals) minerals (see clay minerals), that are typically less than 2 µm (micrometres) in diameter. Clay consists of a variety of phyllosilicate minerals rich in silicon and aluminium oxides and hydroxides which include variable amounts of structural water. For conclusion, these are the contents of clay:

1) Aluminium phyllosilicate
2) Silicon
3) Aluminium oxides
4) Hydroxides
5) Water

2.1.2.3.1 Formation of clay:

Clays are generally formed by the chemical weathering of silicate-bearing rocks by carbonic acid but some are formed by hydrothermal activity. Clays are distinguished from other small particles present in soils such as silt by their small size, flake or layered shape, affinity for water and tendency toward high plasticity.

Grouping of clay

Depending upon academic source, there are three or four main groups of clays: kaolinite, montmorillonite-smectite, illite, and chlorite (the latter group is not always considered a part of the clays and is sometimes classified as a separate group within the phyllosilicates). There are about thirty different types of "pure" clays in these categories but most "natural" clays are mixtures of these different types, along with other weathered minerals.main group of clay :

1) Kaolinite

2) Montmorillonite-smectite

3) Llite

4) Chlorite

2.1.2.3.2 Varieties

Montmorillonite, with a chemical formula of $(Na,Ca)_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$, is typically formed as a weathering product of low silica rocks. Montmorillonite is a member of the smectite group and a major component of bentonite. This is also commonly called as nanoclay, and is an important product group in the emerging nanomaterials market.

Varve (or *varved clay*) is clay with visible annual layers, formed by seasonal differences in erosion and organic content. This type of deposit is common in former glacial lakes left over from an ice age.

Quick clay is a unique type of marine clay, indigenous to the glaciated terrains of Norway, Canada, and Sweden. It is a highly sensitive clay, prone to liquefaction which has been involved in several deadly landslides

2.1.3 CEMENT REPLACEMENT MATERIAL (CRM)

1) Fly ash

Fly ash (one of several coal combustion products, or CCPs) is the finely divided mineral residue resulting from the combustion of coal in electric generating plants. Fly ash consists of inorganic, incombustible matter present in the coal that has been fused during combustion into a glassy, amorphous structure (7)

Fly ash is used as a partial cement replacement in concrete, the fly ash content of the final concrete product is between 2 and 3 percent (assuming a 15-25 percent cement replacement rate and an 8 to 1 ratio of aggregate and water to cementitious material

2) Silica fume

Silica fume, also known as microsilica, is a byproduct of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica Fume is also collected as a byproduct in the production of other silicon alloys such as ferrochromium, ferromanganese, ferromagnesium, and calcium silicon (ACI Comm. 226 1987b).

Specifications

The first national standard for use of Silica Fume ("microsilica") in concrete was adopted by AASHTO in 1990 (AASHTO Designation M 307-90). The AASHTO and ASTM C 1240 covers microsilica for use as a mineral admixture in PCC and mortar to fill small voids and in cases in which pozzolanic action is desired. It provides the chemical and physical requirements, specific acceptance tests, and packaging and package marking

Mix Design

Silica Fume has been used as an addition to concrete up to 15 percent by weight of cement, although the normal proportion is 7 to 10 percent. With an addition of 15 percent, the potential exists for very strong, brittle concrete. It increases the water demand in a concrete mix; however, dosage rates of less than 5 percent will not typically require a water reducer. High replacement rates will require the use of a high range water reducer

2.1.4 ADMIXTURE

Admixtures are materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties, such as workability, curing temperature range, set time or color. Some admixtures have been in use for a very long time, such as calcium chloride to provide a cold-weather setting concrete. Others are more recent and represent an area of expanding possibilities for increased performance. Not all admixtures are economical to employ on a particular project. Also, some characteristics of concrete, such as low absorption, can be achieved simply by consistently adhering to high quality concreting practices.

The chemistry of concrete admixtures is a complex topic requiring in-depth knowledge and experience. A general understanding of the options available for concrete admixtures is necessary for acquiring the right product for the job, based on climatic conditions and job requirements. Based on their functions, admixtures can be classified into the following five major categories:

- Retarding admixtures
- Accelerating admixtures
- Super plasticizers
- Water reducing admixtures
- Air-entraining admixtures

.2.2 POSSIBLE WASTE MATERIAL IN CONCRETE

2.2.1 Slag

The term slag defined in ASTM specification for ground granulated blast furnace slag (GGBS) C 989 is meant to include each of the modifier. According to ASTM , it is glassy , granular material formed when molten blast-furnace slag produced as a by product in the making of iron is rapidly chilled as by immersion in water.

The slag is the nonmetallic product consisting essentially of silicates and auminosillicates of calcium and other bases , that is developed in the molten conditon simultaneously with iron in a blast furnace.

The granulated material is then ground to cement fineness. The slag specified in ASTM C 989 may be used for blending with portland cement to produce a cement that meets the requirement of ASTM specificaition for Blended Hydraulic Cements (C 595) or it may be added as a separate ingredients in concrete or mortatrs. (8)

Advantages using slag

a) higher ultimate strengths with a tendency towards early strength
b) higher ratio of flexural to compressive strength.
c) Improved refractory properties
d) Lower coefficients of variation in strength
e) Decreased porosity and chloride penetration
f) Ower temperature rise due to lower heat of hydration
g) Equivalent durability in freezing and thawing
h) Better finish and ligther colour

2.3 CATALYST WASTE MOLINEX

2.3.1 Introduction

Molinex waste is basically a catalyst waste, which is obtained from palm oil, refinery and oil factory. Catalyst is used in reactor which runs process of reaction for hydrocarbon for example. Platinum catalyst etc.. this catalyst enhances the process of burning hydro- carbons. once the burning process is done platinum catalyst has to be reuse leaving behind this type of waste, such molecular sieve (molinex). palladium and zinc alloys.

Molinex waste has number of sizes as well as color, this is due to different stages of hydro carbons burning. Mainly, there are white and black in color of molinex that contains different composition.

For this project, we are focusing on the two type of the molinex:

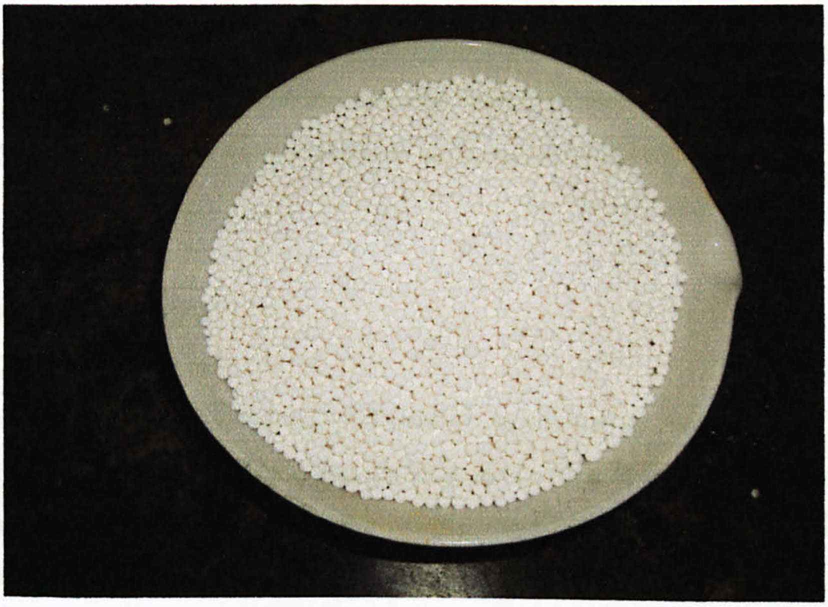


FIGURE 2.2 – WHITE MOLINEX

FIGURE 2.3 – BLACK MOLINEX

Molinex is the one which used by several companies in concrete production. From the early info, both molinex contribute as clay replacement in concrete production. Therefore, further research is conducted to find the inside contents of the molinex.

2.3.3 Fineness of MOLINEX

In this research, fineness MOLINEX as cement replacement material (CRM) will be applied in mortar. Hydration starts at the surface of the MOLINEX particles, it is the total surface area of cement that represents the material available for hydration. Thus, the rate of hydration depends on the fineness of the MOLINEX particles, and for rapid development of strength. High fineness is necessary. (11)

FIGURE 2.4 – 0.5mm MOLINEX

FIGURE 2.5 – 0.25mm MOLINEX

2.3.2 Abundance of Molinex

Information from the host company stated that there is approximately 2000 tan stored in the hanger; means that they will receive molinex depends on the various company that send this waste throughout the year. Basically, they will receive molinex twice a year with about 1000-1800 kg per batch.

Therefore, we can reduce the cost of material by adapting this molinex into the production of mortat or concrete perhaps and making some money from it.

CHAPTER 3

METHODOLOGY

PHASE 1

In phase one, as stated in chapter 1, research will be conducted on the molinex itself. To have better view on the molinex :

1) Conduct , scanning electronic microscope (SEM) on molnex

3.1 Scanning electronic microscope (SEM)

3.1.1 SEM is conducted to determine the inside content of waste molinex. Inside content is important to determine whether there are silica content (Si). If there are Silica, it can be the cement replacement material.

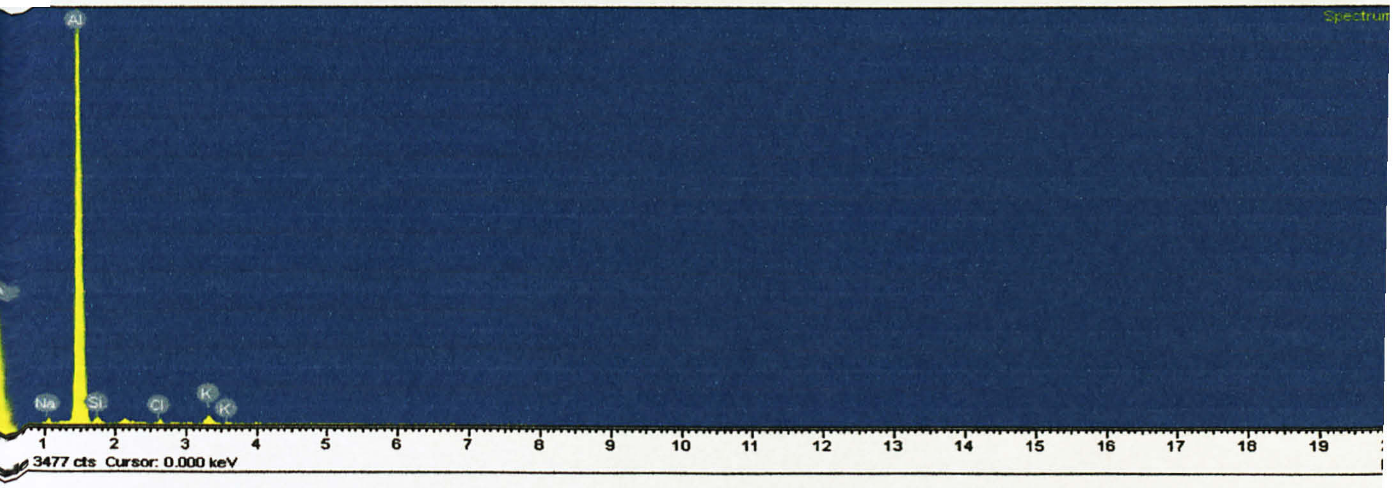
3.1.2 In this test, I had conduct two sample:

1.2.1 White molinex
1.2.2 Black molinex

3.1.3 The results as shown below :

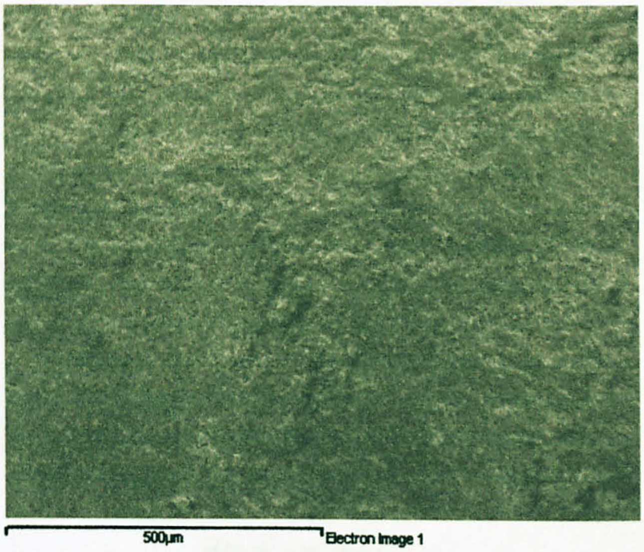
3.1.3.1 White molinex :

Spectrum processing :
Peak possibly omitted : 2.131 keV



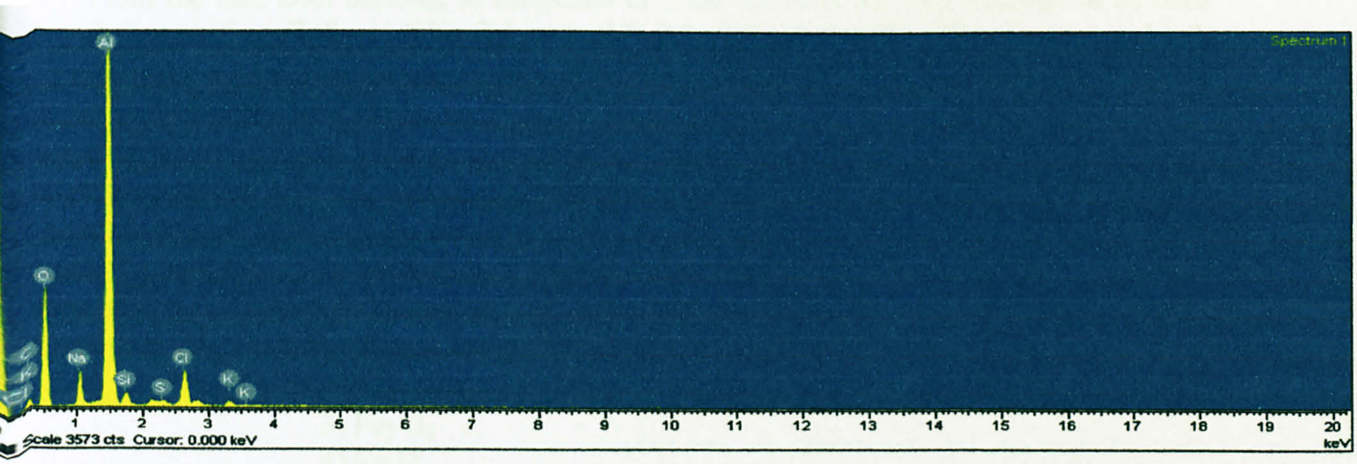
Element	Weight%	Atomic%
C	5.39	8.49
O	52.66	62.31
Na	0.93	0.77
Si	1.15	0.77
Cl	0.59	0.31
K	1.03	0.50

TABLE 3.1



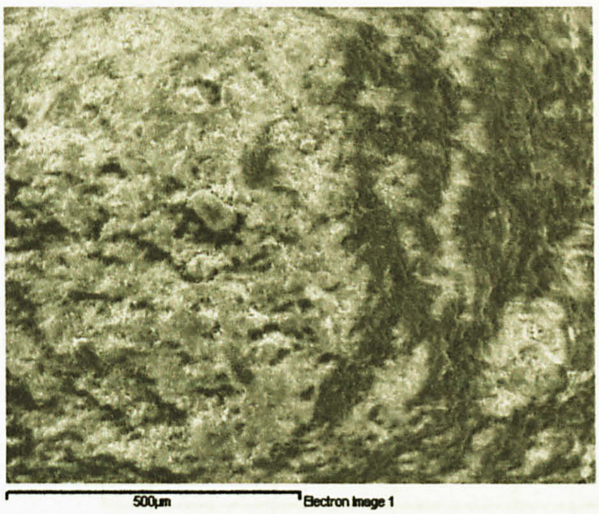
White molinex

3.1.3.2 Black molinex



Elements	Weight	Atomic%
C	10.71	16.49
O	47.72	55.17
Na	5.12	4.12
Cl	3.60	1.88
Si	1.45	0.96
K	1.03	0.50

Table 3.2



Black molinex

From the test, both molinex is compared in order to focus the best molinex to be used during casting. Refer to table 3.1 and table 3.2, defined that the silica content in black molinex is more then the white one. This will conclude that black molinex will be using for research in this project.

1) Besides inside content in SEM test, SEM test also conducted to determine the cementitious material above. The content of all this that >70 % will defined as cementitious material :

1) $Si\ O_2$
2) $Al_2\ O_3$
3) $Fe_2\ O_3$
4) $Ca\ O$

PHASE 2

3.2 TESTING PROCEDURE

3.2.1 Compressive test

A compression test determines behavior of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. Compressive stress and strain are calculated and plotted as a stress-strain diagram which is used to determine elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength. (9)

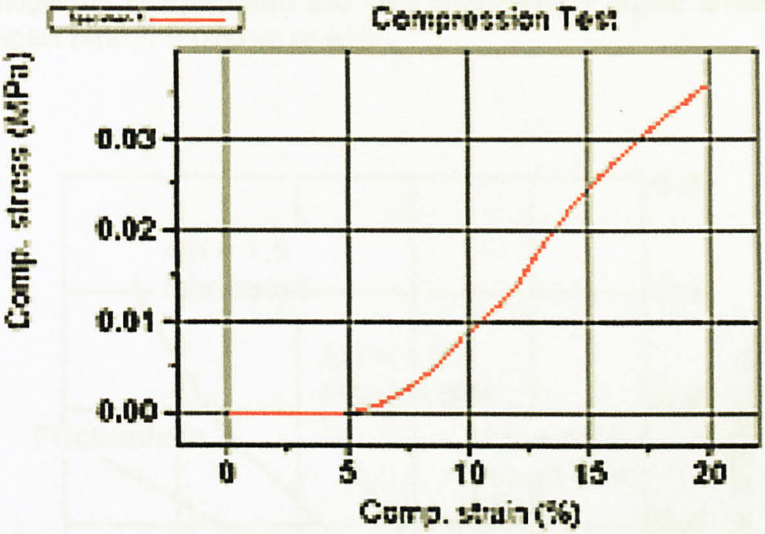


FIGURE 3.1

.2.2 Objective

The ASM Handbook, Volume 8, Mechanical Testing and Evaluation states: "Axial compression testing is a useful procedure for measuring the plastic flow behavior and ductile fracture limits of a material. Measuring the plastic flow behavior requires frictionless (homogenous compression) test conditions, while measuring ductile fracture limits takes advantage of the barrel formation and controlled stress and strain conditions at the equator of the barreled surface when compression is carried out with friction. Axial compression testing is also useful for measurement of elastic and compressive fracture properties of brittle materials or low-ductility materials. In this case, the use of specimens having large *L/D* ratios should be avoided to prevent buckling and shearing modes of deformation[1]."

The image at right shows variation of the strains during a compression test without friction (homogenous compression) and with progressively higher levels of friction and decreasing aspect ratio *L/D* (shown as *h/d*)[1].

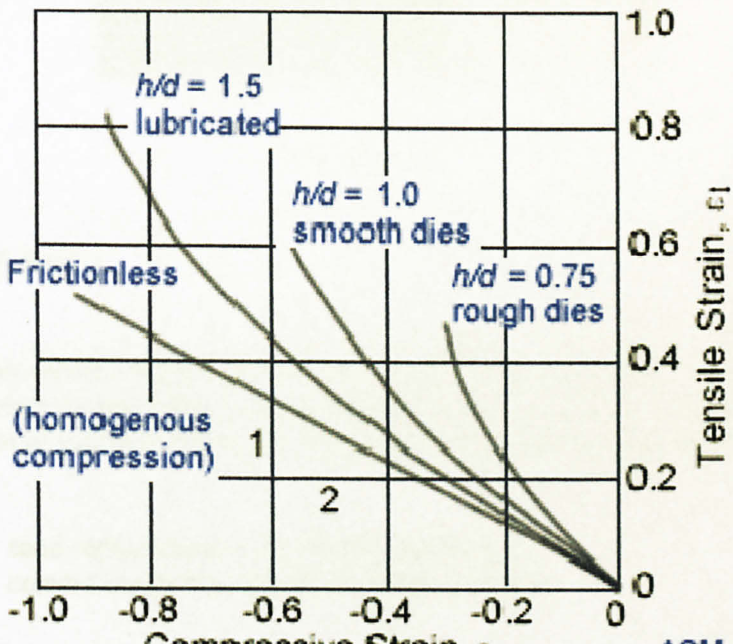


FIGURE 3.2

3.2.3 Compression machine

FIGURE 3.3

3.3 PROJECT BASIS

In phase 2, after determination of the inside content of the molinex, I continue the project to decide on what we are going to do with this waste. Basically we are going to focus on the contribution of molinex in mortar. Therefore, I had starting casting on two mixes:

1. sand replacement with 50:50 proportions
2. cement replacement with 20:80 proportions

3.3.1 Sand replacement

For casting mortar, 1:1 proportion is being used, which 1 cement to 1 sand. Two mixes had been cast for this sand replacement;

1. Normal (control)
2. 50 % molinex : 50% sand

The normal is for control purposes where it will compare the result of compression test for both cubes in order to observe the contribution of molinex. The results for sand replacement are as follow:

COMPRESSION TEST

Proportion/days	3days (N/mm^2)	Avg	7days (N/mm^2)	Avg	28days (N/mm^2)	Avg
Normal	14.33	14.43	18.32	19.97	27.11	28.63
	14.54		21.62		30.15	
50% molinex	15.65	15.77	20.28	21.01	29.54	29.89
	15.89		21.74		30.23	

TABLE 3.3

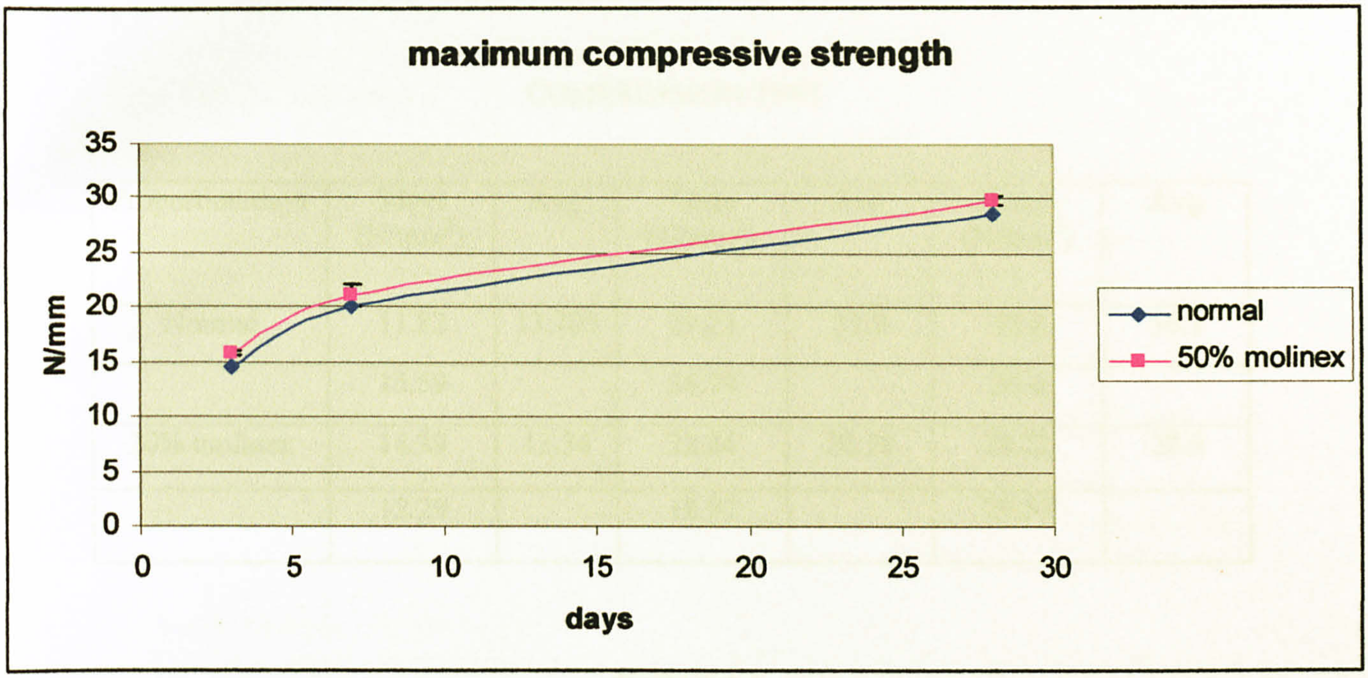


FIGURE 3.4

3.3.2 Cement replacement

For casting mortar, we used proportion 1:1, which 1 cement to 1 sand. Two mixes had been cast for this cement replacement;

1. Normal (control)
2. 20 % molinex : 80% cement

The normal is to control purposes where we will compare the result of compression test for both cubes in order to observe contribution of molinex. The result for sand replacement are as follow :

COMPRESSION TEST

Proportion/days	3days (N/mm²)	Avg	7days (N/mm²)	Avg	28days (N/mm²)	Avg
Normal	11.82	13.705	29.23	31.9	35.6	36.1
	15.59		34.74		36.6	
20% molinex	14.39	13.34	22.24	20.58	28.22	28.9
	12.29		18.92		29.57	

TABLE 3.4

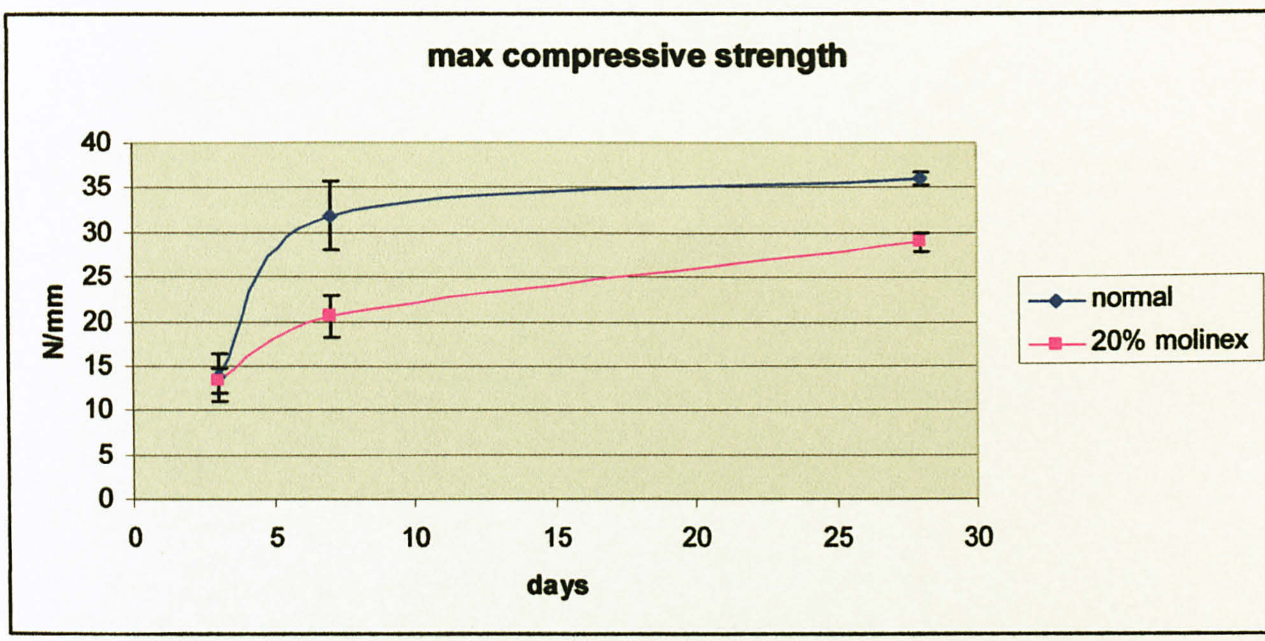


FIGURE 3.5

3.4 FINENESS MOLINEX IN MORTAR

3.4.1 Cement replacement

In this next method, molinex will be consider as CRM in mortar. However, the fineness of molinex will be take into consideration. This is because, base on previous results, molinex do contribute in mortar with some extend. Moreover, the raw molinex is used which 2-3mm sizes. Now, method of grinds the molinex will be used to observe the contribution.

3.4.2 Mx proportion

In the mix proportion, ratio of 1 : 1 will be used which 1 sand to 1 cement. The proportion of cement will be replaced as follow:

1) 30% molinex : 70 % cement
2) 20% molinex : 80% cement
3) 10% molinex : 90% cement

CHAPTER 4

RESULT AND DISCUSSION

4.1 FINENESS MOLINEX IN MORTAR

4.1.1 Goal

After conducting experiment on the cement replacement and sand replacement in mortar, now the fineness of molinex will be taken into consideration. The goal is to observe the contribution of fine molinex as CRM in mortar.

From theoretical point of view, the fineness will be impact on the durability of mortar/concrete. It will also parallel to the duration of curing process. Durability will increase parallel to time of curing.

Comparison between normal molinex size and fine molinex size will be observed based on the compression test result. The research also will compare the result between normal proportion (control), fine 0.25mm and fine 0.5mm of molinex.

4.1.2 Mix proportion

In the mix proportion, ratio of 1: 1 will be used which 1 sand to 1 cement. The proportion of cement will be replaced as follow:

4.1.2.1 Fineness of 0.5mm molinex :

30% molinex : 70% cement
20% molinex : 80% cement
10% molinex : 90% cement

4.1.2.2 Fineness of 0.25mm molinex :

30% molinex : 70% cement
20% molinex : 80% cement
10% molinex : 90% cement

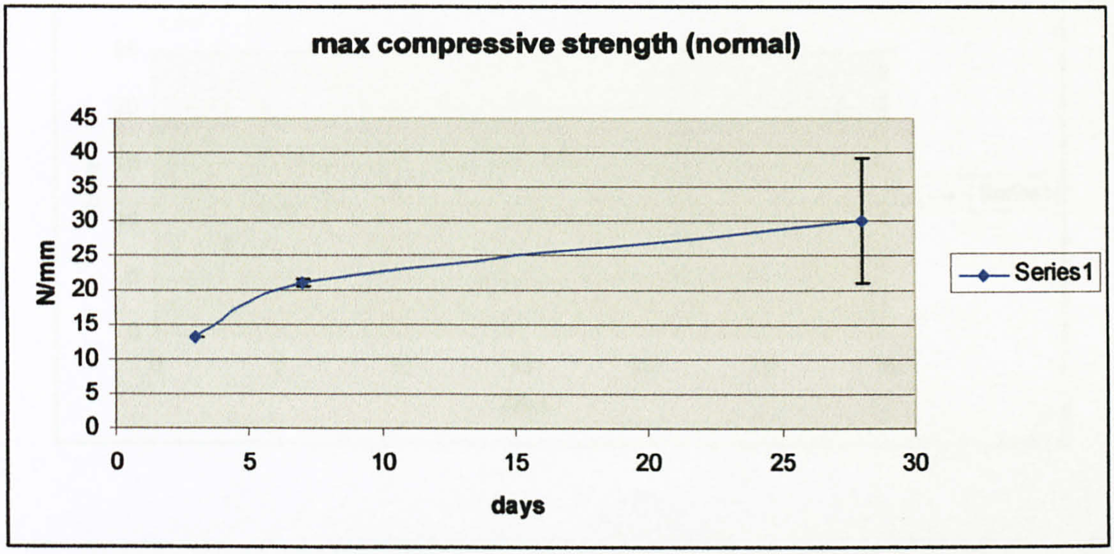
4.1.2.2 Water cement ratio

Water cement ratio used in this casting is 0.5 of cement content

4.2 RESULTS OF COMPRESSIVE STRENGTH

4.2.1 Normal (control)

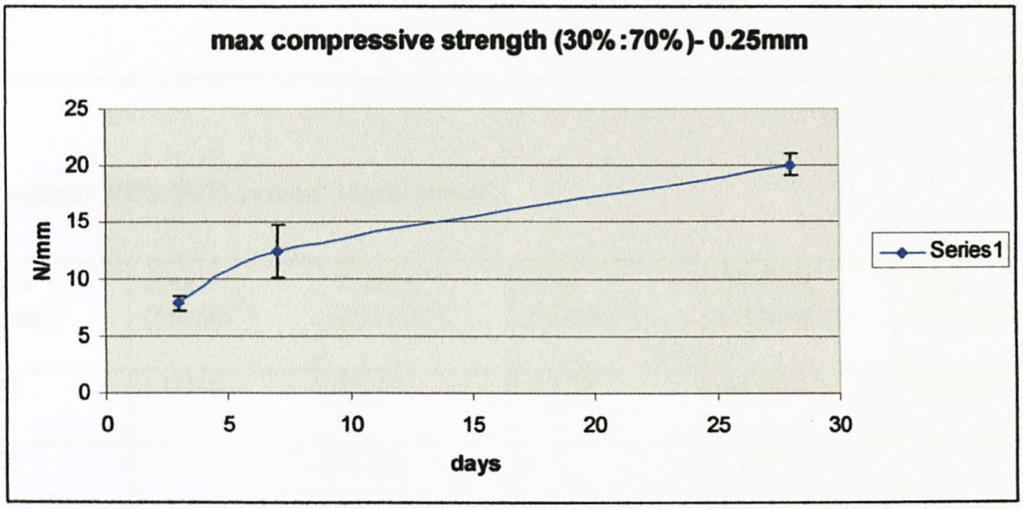
3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
13.11	13.16	20.62	20.975	36.44	30.105
13.25		21.33		23.7	



4.2.2 0.25mm molinex

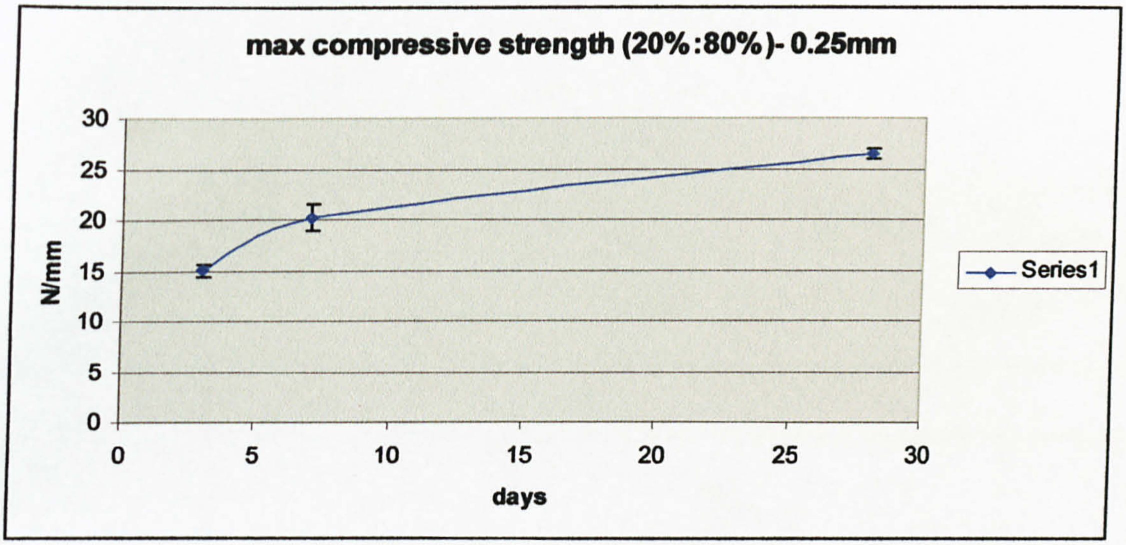
Proportion: 30%: 70% cement replacement

3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
7.39	7.845	14.09	12.445	21.35	20.075
8.30		10.8		20,06	



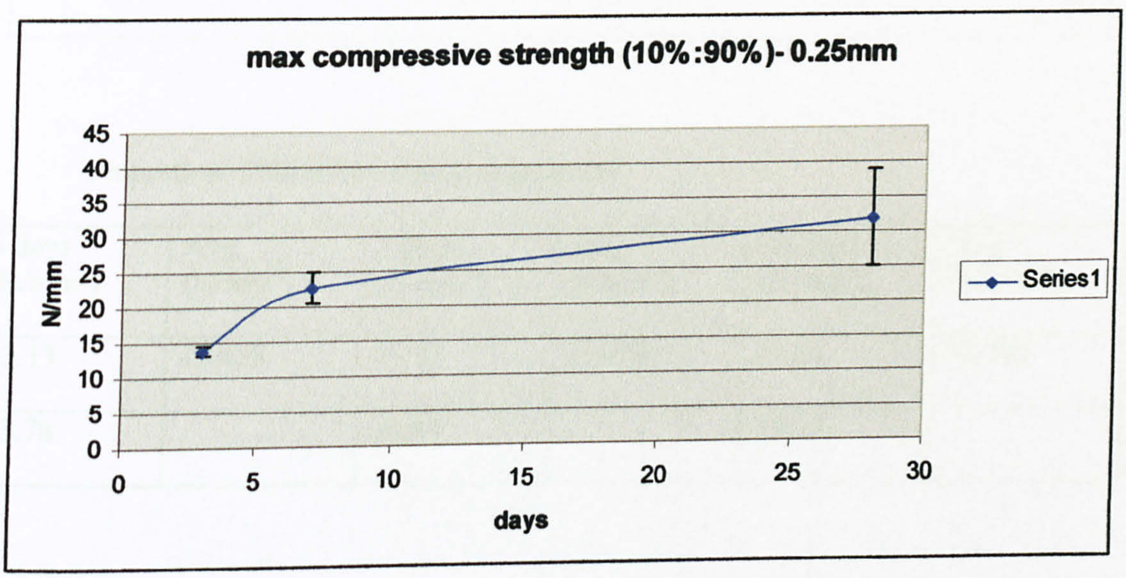
Proportion: 20%:80% cement replacement

3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
15.46	15.035	21.14	20.215	26.9	26.5
14.61		19.29		26.10	



Proportion: 10%: 90% cement replacement

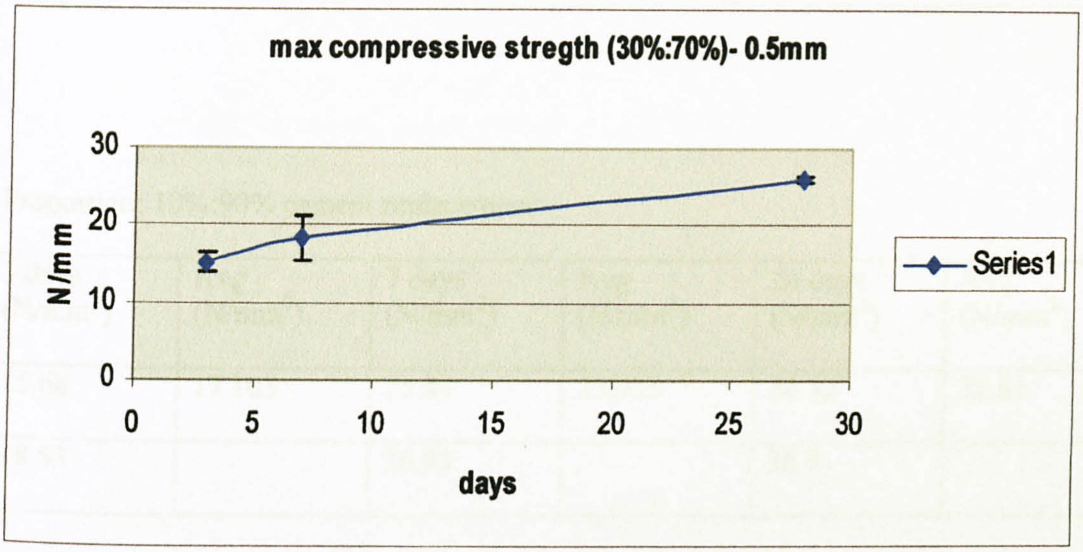
3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
14.23	13.795	21.15	22.73	36.84	31.955
13.36		24.31		27.07	



4.2.3 0.5mm molinex

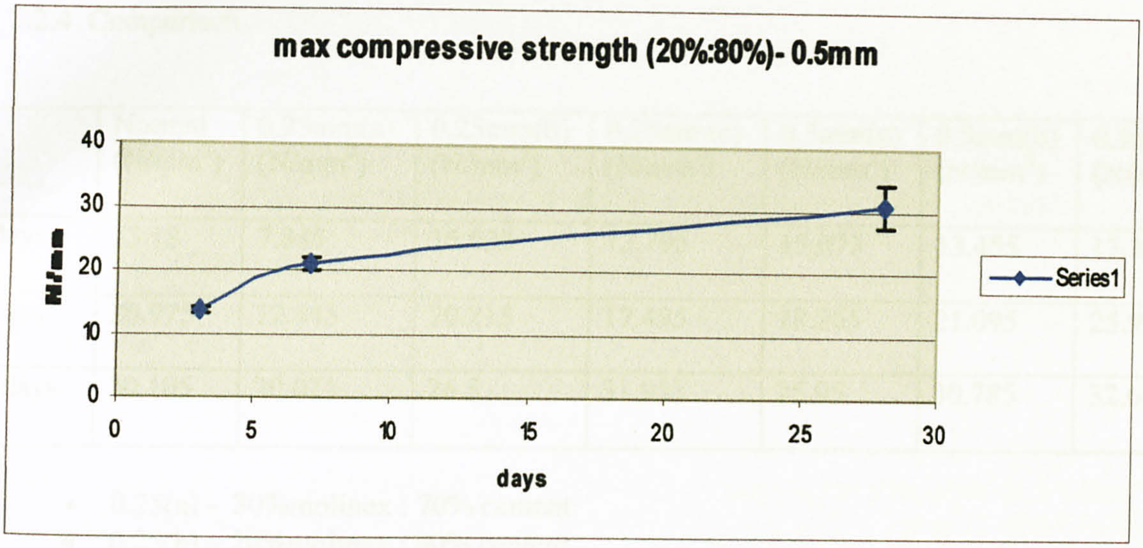
Proportion: 30%:70% cement replacement

3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
14.78	15.075	20.41	18.265	25.75	25.95
16.63		16.12		26.15	



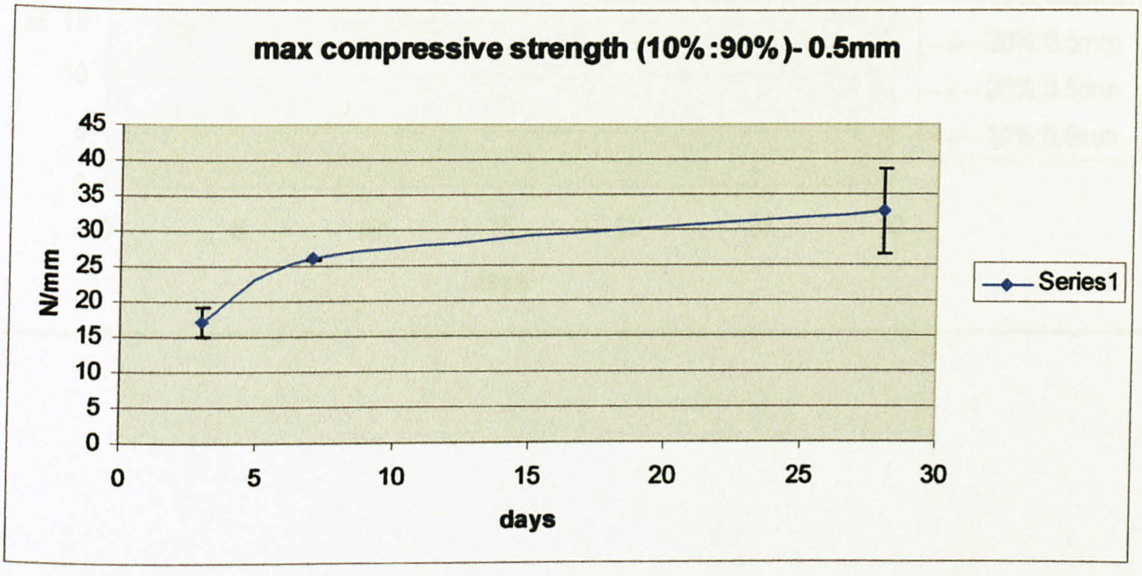
Proportion: 20%:80% cement replacement

3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
13.13	13.455	21.75	21.095	33.21	30.785
13.78		20.44		28.36	



Proportion: 10%:90% cement replacement

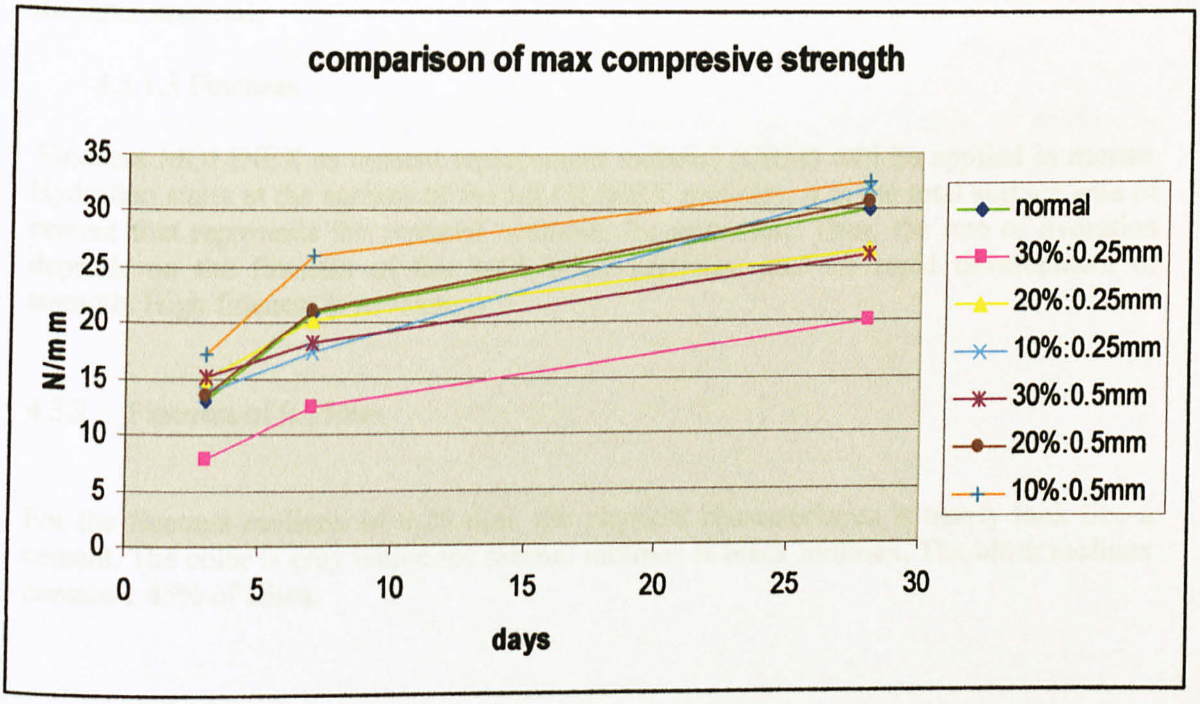
3 days (N/mm^2)	Avg (N/mm^2)	7 days (N/mm^2)	Avg (N/mm^2)	28 days (N/mm^2)	Avg (N/mm^2)
15.68	17.105	25.84	25.935	28.32	32.61
18.53		26.03		36.9	



.2.4 Comparison

	Normal (N/mm^2)	0.25mm(a) (N/mm^2)	0,25mm(b) (N/mm^2)	0,25mm(c) (N/mm^2)	0.5mm(a) (N/mm^2)	0.5mm(b) (N/mm^2)	0.5mm(c) (N/mm^2)
3 days	13.18	7.845	15.035	13.795	15.075	13.455	17.105
7 days	20.975	12.445	20.215	17.495	18.265	21.095	25.935
28 days	30.105	20.075	26.5	31.955	25.95	30.785	32.61

- 0.25(a) - 30%molinex : 70% cement
- 0.25(b) – 20%molinex : 80% cement
- 0.25(c) – 10%molinex : 90% cement
- 0.5 (a) - 30%molinex : 70% cement
- 0.5 (b) - 20%molinex : 80% cement
- 0.5 (c) - 10%molinex : 90% cement



4.3 DISCUSSION

4.3.1 Contribution of MOLINEX

From the compressive strength result, the discussion can be base on the proportion of molinex and the fineness of molinex. From the proportion, the best proportion is 10%:90% of molinex partial replacement. In term of fineness, the best size is 0.5mm. the focus of the discussion are focusing on how do molinex contribute in mortar. The possibilities are:

4.3.1.1 Hydration process

The reaction by virtue of which molinex becomes a bonding agent take place in a water-cement paste. In the other words, in the presence of water and silicates (1.45%) form products of hydration which in time produce a firm and hard mass- the hydrated cement paste. The products of reaction closely resemble C-S-H produced by hydration process.

4.3.1.2 Pozzolanic reaction

Pozzolanic reaction between silica content in molinex and calcium hydroxide produced by the hydration of Portland cement. Molinex contributes to the progress of hydration of the latter material.

4.3.1.3 Fineness

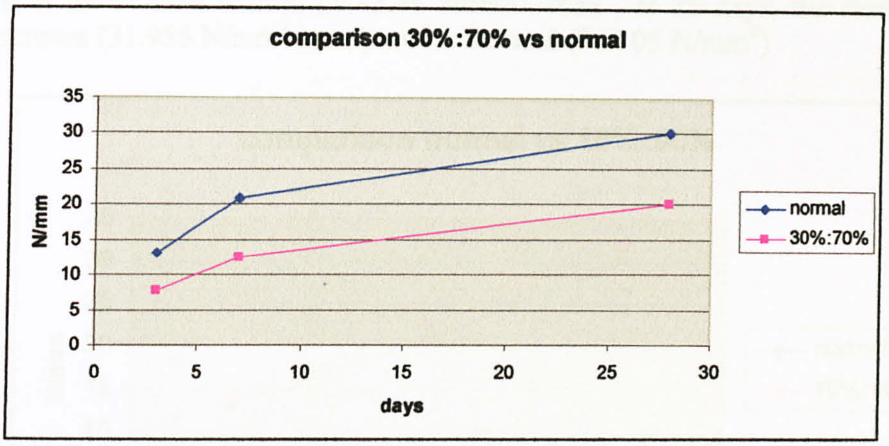
Fineness MOLINEX as cement replacement material (CRM) will be applied in mortar. Hydration starts at the surface of the MLOLINEX particles, it is the total surface area of cement that represents the material available for hydration. Thus, the rate of hydration depends on the fineness of the MOLINEX particles, and for rapid development of strength. High fineness is necessary.

4.3.2 Fineness of 0.25mm

For the fineness molinex of 0.25 mm, the physical characteristics is nearly look like a cement. The color is grey which the normal molinex is black molinex. The black molinex contain 1.45% of silica.

4.3.2.1 30% molinex : 70% cement

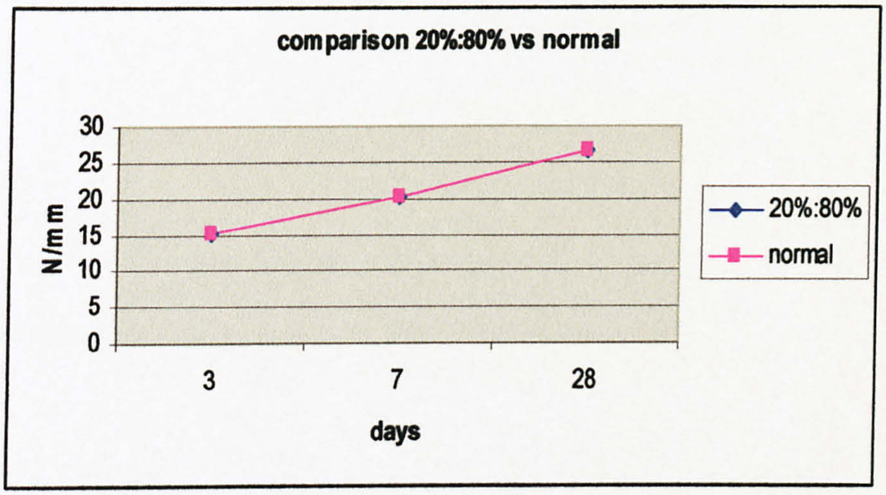
For this proportion, from the observation of 3 days , 7 days and 28 days show that the increasing of maximum compressive strength proportionate to days of curing. This means the result is acceptable according to theoretical aspect. The graph indicated that normal propotion is much higher than molinex. This situation nearly shown molinex cannot contribute better in higher amount. The strength development will decrease as more molinex involve



4.3.2.2 20% molinex : 80% cement

For this proportion, from the observation of 3 days , 7 days and 28 days show that the increasing of maximum compressive strength proportionate to days of curing. This means the result is acceptable according to theoretical aspect.

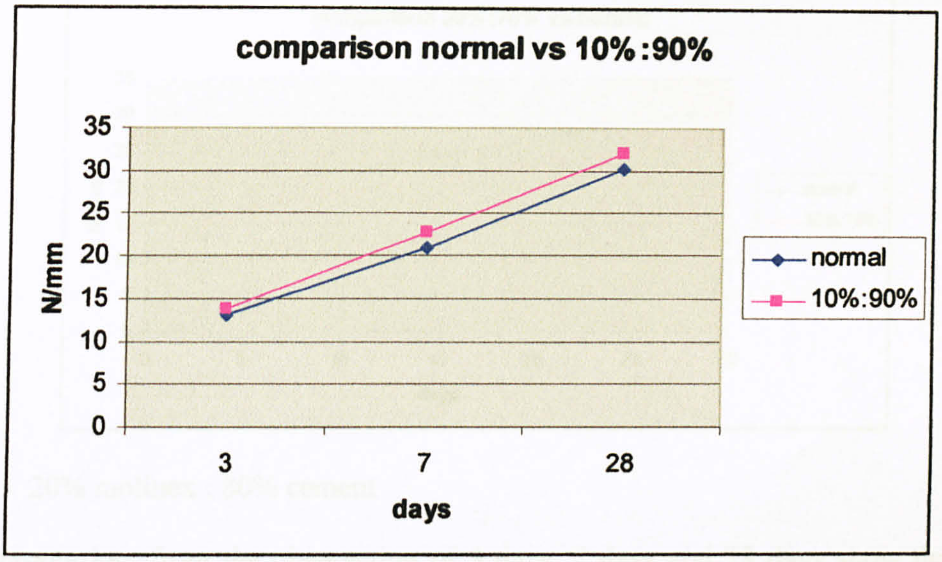
When compared this result to normal (control) , it shows instability which the results is greater (15.035N/mm^2) compared to the control (13.18 N/mm^2). However, for 7 days and 28days, it shown a terrible decreasing compared to normal proportion. The 28 days result (26.5N/mm^2) is unpredictable. this is because usually, at 28 days , the results is aove 30N/mm^2 base on the other proportion results on 28 days.



4.3.2.3 10% molinex : 90% cement

For this propotion, from the observation of 3 days , 7 days and 28 days show that the increasing of maximum compressive strength proportionate to days of curing. This means the result is acceptable according to theoretical aspect.

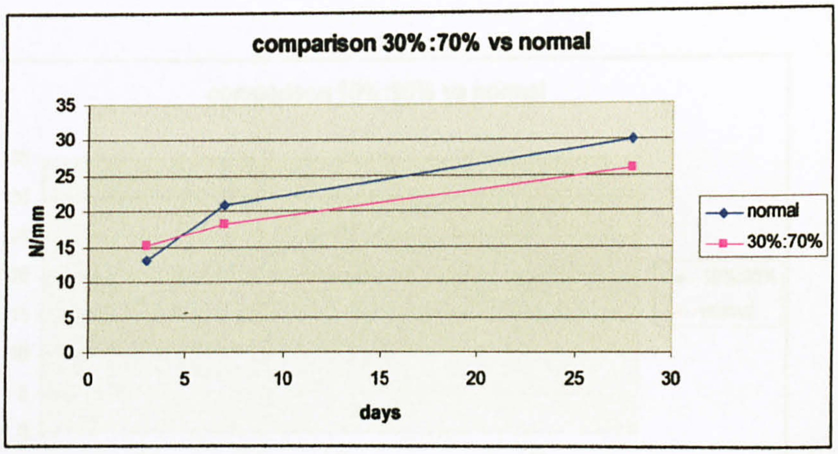
The result for this proportion is fluctuating compared to the normal proportion. The result is greater on the 3 days (13.795 N/mm^2) compared to normal (13.18 N/mm^2). However, at 7 days, it lower than normal by -3.48 N/mm^2. then , at 28 days, the results shows greater increase (31.955 N/mm^2.)compared to normal (30.105 N/mm^2)



4.3.3 Fineness of 0.5mm

4.3.3.1 30% molnex : 70% molinex

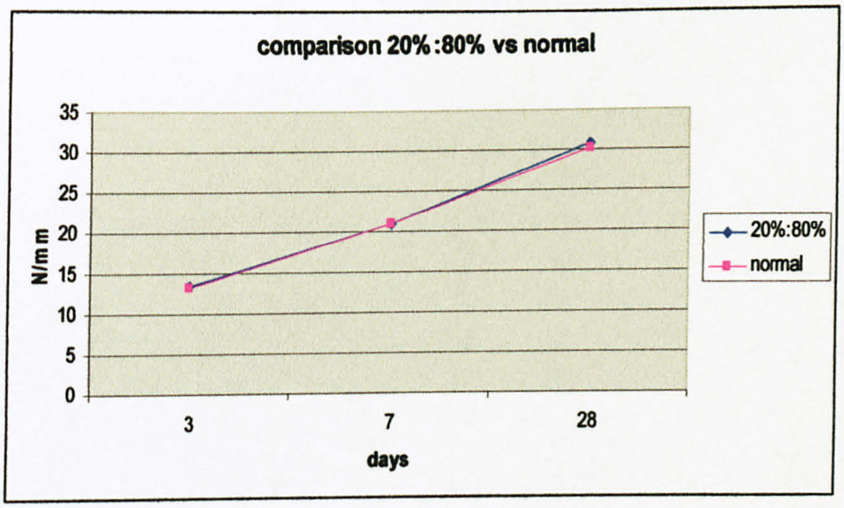
For this proportion, from the observation of 3 days, 7 days and 28 days show that the increasing of maximum compressive strength proportionate to days of curing. This means the result is acceptable according to theoretical aspect. The result from 0.25mm and this 0.5mm indicated that there is decreasing of strength development in mortar. The main factor of decreasing is the amount of molinex (30%) is quite much and molinex cannot replace cement activities at this stage.



4.3.3.2 20% molinex : 80% cement

For this proportion, from the observation of 3 days, 7 days and 28 days show that the increasing of maximum compressive strength proportionate to days of curing. This means the result is acceptable according to theoretical aspect.

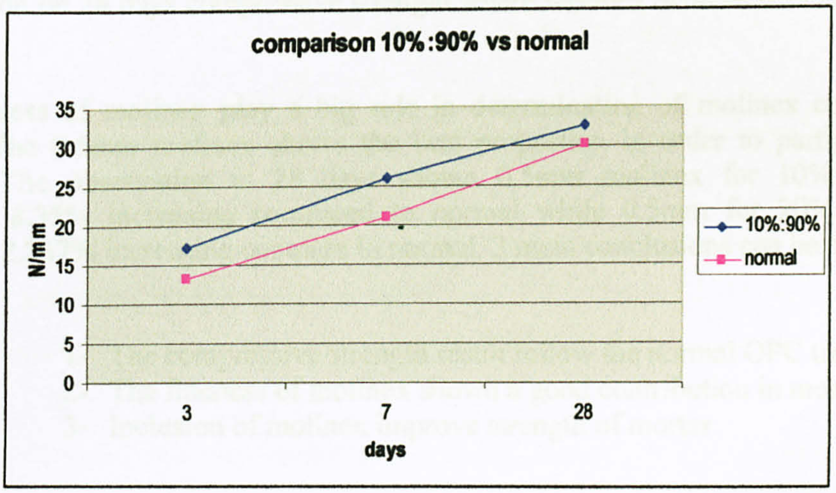
Comparison all the results for this proportion shows a good sign. The result for 3,7 and 28 days shows greater then the normal. For 3 days (13.455N/mm^2.) compared to normal (13.18 N/mm^2) , 7 days (21.095 N/mm^2) compared to normal (20.975 N/mm^2) , 28 days (30.785 N/mm^2) compared to normal (30.105 N/mm^2).



4.3.3.3 10% molinex : 90% cement

For this propotion, from the observation of 3 days , 7 days and 28 days show that the increasing of maximum compressive strength proportionate to days of curing. This means the result is acceptable according to theoretical aspect.

This is the best proportion shown when compared to normal proportion. Looking at 3,7 and 28 days results, it shown the increasing of strength and above expectation.



CHAPTER 5

CONCLUSION

From the results and discussion it can be conclude that molinex can be utilized to replace either sand or cement in improving the strength development of mortar. The result in sand replacement show very good contribution of molinex. This was justified by the observation on 28 days compressive strength where molinex achieve 6.17% compared to normal.

The fineness of molinex play a big role in determination of molinex contribution in mortar. The 0.5mm molinex shows the best proportion in order to partly replace the cement. The observation at 28 days shown 0.5mm molinex for 10% replacement achieved 8.35% increasing compared to normal while 0.5mm for 20% replacement achieved 2.267% increasing compare to normal. 3 main conclusions can be made:

1- The compressive strength result follow the normal OPC trend
2- The fineness of molinex shown a good contribution in mortar
3- Inclusion of molinex improve strength of mortar

Recommendations for this research are: there should be continuous research on the chemical reaction of molinex, the permeability and porosity of molinex and also mixture of molinex with other admixture such as super plasticizer to observe the contribution. Finally, molinex can be use as materials that contribute in term of strength of mortar.

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