REUSING OF TREATED WASTE WATER IN CONCRETE PRODUCTION

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This study is especially dedicated to my beloved Mother and Father,
Brothers and Sisters,
Beloved *Dear*,
for everlasting love, care, and supports…..

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ABSTRACT

This Project was conducted to study the possibility of usage of treated waste water in concrete production, so that the shortage and cost using potable water can be greatly reduced and the waste water can be suitably disposed for safe guarding the environment at the concrete batching plant. Grade 30 and Grade 35 concrete mix design were prepared using Ordinary Portland Cement using potable water and treated waste water produce from paper recycling factory (which is treated in a facultative pond) were tested to determine the mechanical properties of concrete. Among the test conducted are slump test, slump retention, compressive strength and setting time for laboratory mix concrete and plant batching mix concrete. The concrete mix designs were mixed at the laboratory using a drum mixer and also batched at concrete batching plant further ascertain the various in laboratory and plant mix concrete. The research shows that treated waste water from the paper recycling factory which had been treated in the facultative pond qualifies and can be used in making concrete.

ABSTRAK

Projek ini dijalankan untuk mengkaji kesesuaian menggunakan air sisa yang telah dirawat dalam bancuhan konkrit di sebuah kilang bancuhan konkrit, dimana masalah kekurangan air and kos menggunakan air paip boleh dikurangkan serta pembuangan air sisa dapat membawa manfaat dalam isu menjaga alam sekitaran. Spesifikasi bancuhan konkrit gred 30 dan gred 35 dibancuh menggunakan simen 'Ordinary Portland' dengan air sumber paip and air sisa yang telah dirawat dari kilang kitar semula kertas (rawatan air sisa dalam kolam fakultatif) yang diuji sifat – sifat mekanikal konkrit. Diantara ujian yang dilakukan adalah ujian penurunan konkrit, ujian masa penurunan konkrit, ujian tekanan ricih konkrit and ujian penusukan konkrit untuk konkrit bancuhan dalam drum untuk kuantiti kecil konkrit manakala di kilang bancuhan bagi kuantiti yang lebih besar. Spesifikasi konkrit yang direka dibancuh di makmal konkrit dan juga di kilang bancuhan untuk menentukan perbezaan variasinya. Daripada kajian yang dijalankan ini, didapati air sisa dari kilang kitar semula kertas yang telah dirawat sesuai untuk bancuhan konkrit.

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TW	-	Treated Waste Water
PW	-	Potable Water

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the era of new developments and an age in increasing human population coupled with the need to curb expenditure in various sectors of the government budget, attention has been brought to the re-use of resources whenever possible. Practice of reuse involves processing used materials into as an reuse able products in order to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from land filling) by reducing the need for "conventional" waste disposal. Reuse is one of key component of modern waste management and is an effective method to be in cooperated towards wastewater reuse in both the agricultural and industrial fields.

A popular criterion as to the suitability of water for mixing concrete is the expression that if water is fit to drink it is suitable for making concrete. Other criteria attempting to ensure the suitability of water for batching fresh concrete require that the water be clean and free from deleterious materials. However these specifications may not be the best basis for evaluation of the suitability of water as mixing water. Some waters which do not meet these criteria have been found to produce concretes of satisfactory quality.

Currently there are no special tests developed to determine the suitability of mixing water except comparative tests. Generally, comparative tests require that, if the quality of water is not known, the strength of the concrete made with water in question should be compared with the strength of concrete made with water of known suitability. Both concretes should be made with cement proposed to be used in the construction works.

1.2 Research Background

Undoubtedly, concrete is an ideal material for construction industry which can provide desired strength and durability in the condition that everything is done properly from the early stage of concrete mix design, materials selection, mixing process, concrete placement to the stage of curing the concrete. In short, the performance of concrete is directly related to the design, workmanship and environment of the concrete. However, in actual construction, not all these stages can be done perfectly especially in the aspect of workmanship.

From the study of Ooi Soon Lee (2001), the result showed that the concrete strength produced using the reusing treated effluent in concrete technology increases the compressive strength concrete compare to potable water With proper water quality control, this treated effluent can also be considered as a potential water resource for specific applications. Two tests were carried out namely compressive strength test and setting time to determine the feasibility of using treated effluent for concrete mixing. The results were compared against the tests conducted on control specimens which used potable water. The results showed also that treated effluent increases the setting time when compared with potable water.

Another study by V Sivakumar (2008), using the waste water from the textile industry cubes, cylinders and beams were casted and tested for its mechanical properties (compressive strength, tensile strength, flexural strength etc) and the result was found to be satisfactory. Hence the experiment conducted in this study was continued on for durability studies where the corrosion attack was also studied. The results of other durability studies were found to be satisfactory. In this experimental study the results of specimen's casted using treated and untreated textile water were compared with the specimens casted with potable water. Since there was some corrosion, admixtures were added to counter act the same and the results were found to be satisfactory.

Now, the questions are *"What is the significance of using the treated waste water in actual concrete production?", "What are the effects on strength concrete?"*, *"Is laboratory scale and actual production scale of batching concrete using treated waste water have a lot variance?"* and *"How will the outcome of the actual production of concrete using a treated waste water whether is favorable or not?"*. These are to be answered and become the main interests of this study.

This has brought the interest to conduct a research on reusing treated water waste produce from a paper recycling factory in a concrete production. The research is carried out at a concrete batching plant situated in Jalan Kuchai Lama. Their concrete are supplied throughout the Klang Valley construction projects. The concrete batching plant consists of two type of mixer in the batching plant consist of wet mix plant and dry mix plant. The production rate for the batching plant perday is about $1000m^3$ of concrete in a day with high water usage consumption. The purpose of the study conducted is also to reduce the high water usage consumption.

Figure 1.1 shows a satellite view the location of concrete batching plant and the location facultative pond which the source of treated waste water. The plant operation runs twenty four hours with a monthly production supply of $35{,}000m^3$ concrete. The plant operates with 50 numbers of concrete mix trucks with capacity of $6\text{-}9m^3$ per truck batching concrete capacity. The concrete production is in massive quantity which suits for the research to take place.

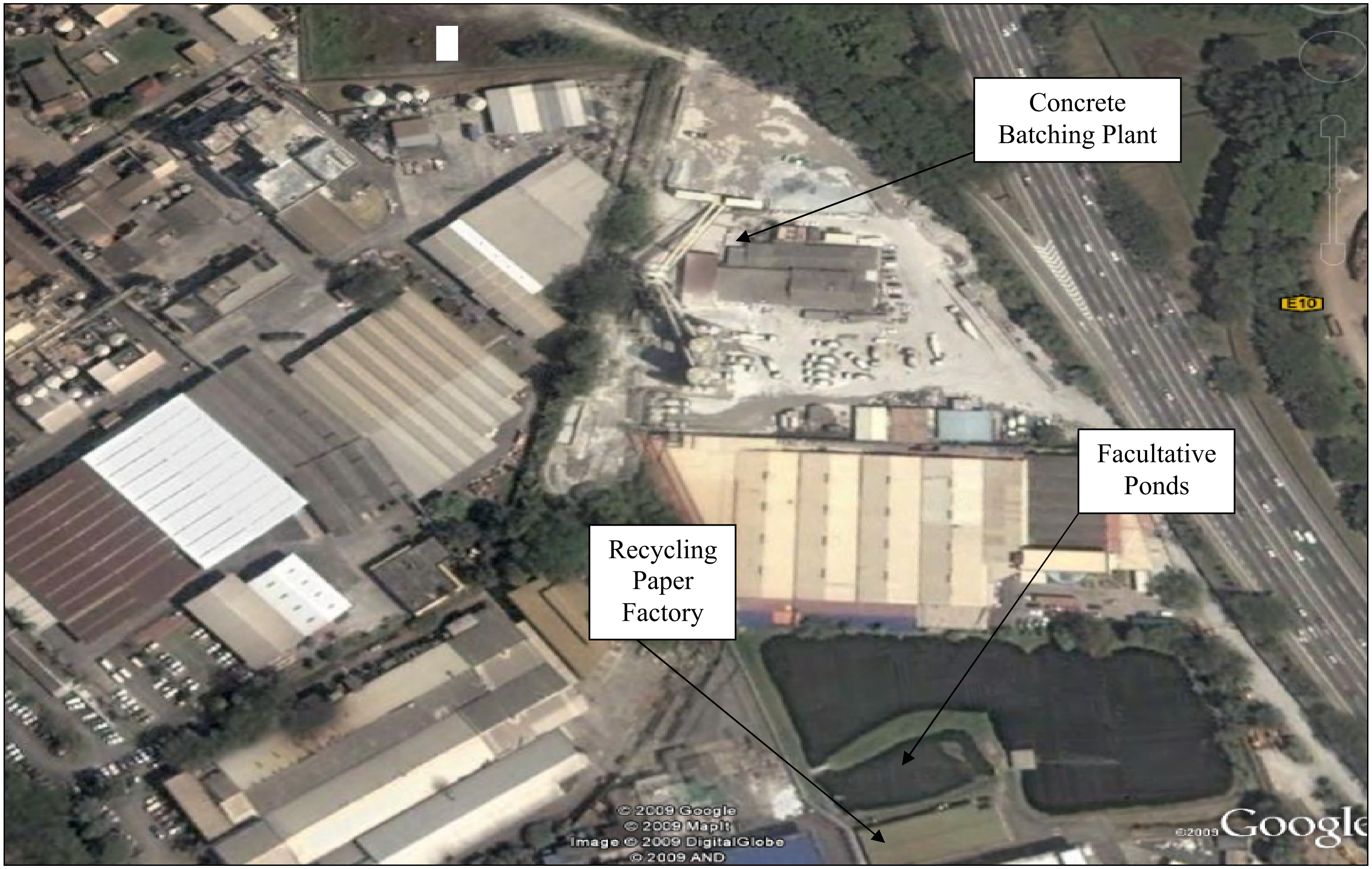


Figure 1.1: Satellite view of research study area

Figure 1.2 shows below the condition of the concrete batching plant on daily basis massive operation and supply of concrete to site.

Figure 1.2 : Concrete batching plant

The source treated waste water is produce from the activity of paper recycling factory (Figure 1.3) which is situated beside the concrete batching plant. The is also some water runoff from the cement truck washing bay which run to the facultative pond. This also contributes of some substances of carbon in the treated waste water.

Figure 1.3 : Paper recycling factory

Figure 1.4 : Facultative pond located beside the concrete batching plant

Figure 1.4 is the condition of the facultative pond, which is an alternative source of treated waste water (TW) and reduces the cost of using potable water (PW) for the batching plant concrete production. The treated waste water (TW) is proposed to be used in mixing concrete and also currently the batching plant is using the treated waste water as concrete slurry wash water.

1.3 Research Objectives

The objective of the research is to conduct a feasibility study of using treated waste water (TW) in concrete production.

i) The source of waste water is from paper recycling factory which is treated in a facultative pond

ii) The treated water is used in concrete mixing in a laboratory scale as experiment and actual concrete production scale at concrete batching plant.

iii) The comparison of chemical properties of the concrete produce is tested using portable water (PW) and treated water (TW).

1.4 Scope of Research

The scope of research shall be in line with the usage of treated waste water in the production of concrete in the effect on concrete compression strength, water demand, slump loss, slump retention, setting time and workability of the concrete. The research attempt to reduce the high cost potable water usage in concrete production, the use of treated waste water had been considered for this purpose. Finally, all the interpreted and analyzed of water sample and test conducted will be tabulated in a table form, showing comparison using portable water (PW) and treated waste water (TW). Data of concrete compressive strength tested at 1, 2, 3, 7 and 28 days, slump test, slump retention, setting time, water demand and workability of concrete is retrieve for the research analysis study.

In addition, it is hoped that the information from this study can be useful as a preliminary reference to reusing waste water in concrete production executing any concreting construction works in the future prospect of the Malaysian construction industry.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, facts and information of some research subjects that will support the research question and hypothesis are defined and explained. The first subject to be defined is the concrete. The constituents of concrete, the properties of fresh and hardened concrete and their respective tests are explained to provide an overview of the fundamental material used in this study. The last subject is the previous studies and research that had been carried on treated waste water which within the scope of this study are detailed.

At the end of this chapter, a hypothesis will be made based on the literature reviews of these subjects.

2.2 Concrete

2.2.1 Introduction

Concrete, as quoted by A. M. Neville, in the broadest sense, is any product or mass made by the use of a cementing medium. In general, the cementing medium is the product of reaction between hydraulic cement and water. As mentioned early, ever since the introduction of concrete until today, it remains as the most frequently used material in the construction industry due to its lower cost and better overall performance. Therefore, a thorough understanding of concrete is essential for all the people involving in the world of construction.

2.2.2 The Constituents of Concrete

2.2.2.1 Cement

In general, cement is an adhesive and cohesive bonding material and its chemical composition mainly consists of 54.1% tricalcium silicate (C_3S), 16.6% dicalcium silicate (C_2S), 10.8% tricalcium aluminate (C_3A) and 9.1% tetracalcium aluminoferrite (C_4AF).

Both C_3S and C_2S are responsible for the development of strength that C_3S contributes most of the early strength and C_2S influences the later gain of strength. The presence of C_3A in cement is not desirable due to its reaction with sulfates to form expansive calcium sulphoaluminate (ettringite) which may cause disruption. C_4AF may accelerate the hydration of the silicates.

The chemical composition of cement can be modified to produce different cement with various desired properties. Modification can also be done by mixing other materials during the production of cement. The modification of cement is to ensure good durability of concrete under a variety of the construction conditions. Below are the general types of cement and their applications in different conditions and environments of construction.

i) *Ordinary Portland Cement (Type I)* for normal construction where there is no extreme exposure to aggressive agents
ii) *Modified Cement (Type II)* for the type of construction which moderately low generation of heat is desirable or where moderate sulfate attack may occur
iii) *Rapid-hardening Portland Cement (Type III)* for construction which requires

early development of strength so that formwork can be removed early for reuse or further construction is required quickly

iv) *Low-heat Portland Cement (Type IV)* for mass construction to limit the release of heat of hydration to minimize expansion of concrete and cracking

v) *Sulfate-resisting Cement (Type V)* for type of construction where sulfate attack is severe

vi) *Portland Blast Furnace Cement (Type IS)* which is also known as slag cement, exhibits properties of better resistance to sulfate attack, lower heat of hydration and better performance in marine construction

vii) *Portland Pozzolanic Cement (Type IP, P and I(PM))* which contain pozzolanic materials, exhibits properties of lower early strength, lower heat of hydration but higher later strength

Other than the types of cement mentioned above, there are also some types of cement less commonly used such as *high alumina cement* and *white and colored cement*. In addition, there are also some special types of cement such as *antibacterial cemen*t, *hydrophobic cement*, *masonry cement*, *expansive cement*, *oil-well cement* and *natural cement*.

2.2.2.2 Water

The quantity and quality of water as part of the mixing material in producing concrete are of vital consideration and they must be controlled properly.

The quantity of water influences the strength of concrete. In general, with higher water/cement ratio, the strength becomes lower. The quality of water affects the durability of concrete. Water containing excessive sulfates, chlorides, clay, silt and undesirable substances and aggressive chemical ions should not be used as the mixing water.

No standards explicitly prescribing the quality of mixing water are available but in many project specifications, the quality of water is covered by a clause saying that water should be fit for drinking.

2.2.2.3 Water / Cement Ratio (*w/c*) and Curing

Concrete should be mixed with lowest possible *w/c* ratio and should have undergone full compaction as mentioned previously in order to get a more durable and less permeable concrete. Concrete has a tendency to be permeable due to the presence of capillary voids in the cement paste matrix. In order to obtain workable mixes it is usually necessary to use more water than is actually for hydration of the cement. This excess water occupies space and when later the concrete dries out capillary voids are left behind.

On the other hand, if the concrete has been fully compacted and properly cured, these voids will be extremely small and their number and size decrease as the *w/c* ratio is reduced. At high w/c ratio the particles of cement along with their hydration products will tend to be spaced widely apart as shown in Figure 2.4 and the capillaries will be greater compared with a mix at a lower *w/c* ratio as shown in Figure 2.1 and Figure 2.2 [11]. The more open the structure of the paste the more easily it will permit the ingress of air and moisture and will be very sensitive to the drying regime, both at early ages and in the more matured hardened state.

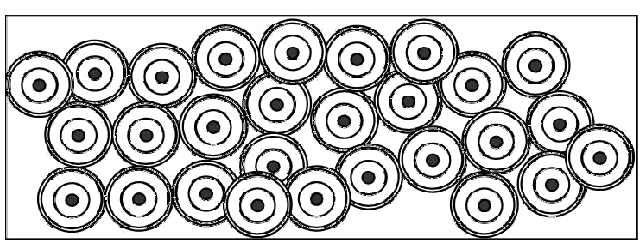


Figure 2.1: Water / cement ratio 0.3

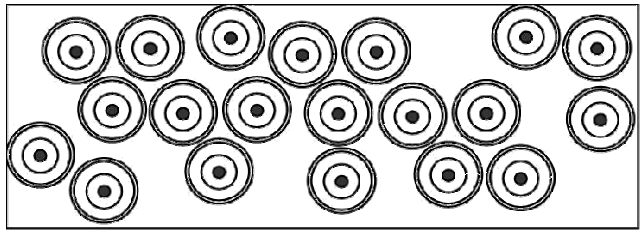


Figure 2.2: Water / cement ratio 0.5

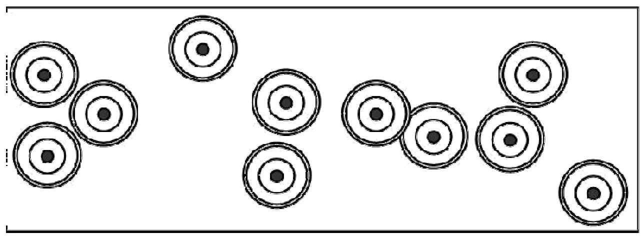


Figure 2.3: Water / cement ratio 0.8

The distribution and size of the capillary voids do not depend only with the *w/c* ratio but also on the duration of moist-curing. It is therefore obvious that as the level of exposure conditions increase in severity the w/c ratio must be reduced accordingly. The importance of curing in relation to durability is seldom fully appreciated. It is essential that proper curing techniques have to be used to reduce the permeability of concrete by ensuring the continued hydration of the cement, particularly in the area of concrete cover. The hydration process, and the formation of reaction products which fill up the capillary voids, cease when the concrete dries to below 80% relative humidity.

Therefore, adequate curing is essential to ensure that the concrete is durable and impermeable. The areas most affected by poor curing are the surface zones, and these are critical with respect to durability. In particular, the protection of reinforcement against corrosion depends on the concrete quality in the top few millimetres of cover to reinforcement. Methods of curing can conveniently be considered in two groups:

i) Those which keep water or moisture in close contact with the surface of the concrete, such as ponding, spraying/sprinkling, damp sand, and damp Hessian.
ii) Those which prevent the loss of moisture from the concrete, such as plastic sheeting, gunny sack, building paper, leaving the formwork in place, and sprayed-on curing membranes.

2.2.2.4 Aggregate

The use of aggregate may limit the strength and affect the durability of concrete because almost three quarters of the volume of concrete are occupied by aggregate.

Among the important properties of aggregate which are of main concerns are its shape, texture, mechanical properties (bond, strength, toughness and hardness), physical properties (specific gravity, bulk density, porosity, absorption, moisture content, bulking of sand and soundness) and thermal properties. In general, a strong concrete requires aggregates which are angular and rough to increase the bonding with cement and interlocking among aggregates.

The cost of aggregate is cheaper than cement and therefore it is economical to put as much as of the former into a concrete mix and as little of the latter as possible. In addition, higher percentage of aggregate in concrete increases the volume stability and durability of concrete.

2.2.2.5 Types of Aggregate

Aggregates generally occupy about 70 to 80% of the total volume of concrete, thus it has important influence to overall behaviour of concrete. Clearly, it is important that the chosen aggregate should contain no constituent that might adversely affect the hardening of the cement or the durability of the hardened mass. Aggregate shape and texture also affect the workability of fresh concrete through their influence on cement paste requirement. Sufficient paste is required to coat the aggregates and to provide lubrication to decrease interactions between aggregate particles during mixing. In order to be able to promote suitable concrete mixes, certain properties must be known such as shape and texture, size gradation, moisture content, specific gravity and bulk unit weight. These properties influence the paste requirements for workable fresh concrete.

The essential requirement of an aggregate for concrete is that it remains stable within the concrete and in the particular environment throughout the design life of the concrete [9]. The overall stability of concrete aggregates may be defined as the ability of individual particles to retain their integrity and not to suffer physical, mechanical or chemical changes to an extent which could adversely affect the properties or performance in either engineering or aesthetic aspects. When abrasion resistance is required, a dense hardwearing aggregate should be selected and this is specified by BS 882 of not be less than 50kN (for coarse aggregate) in ordinary concrete. In addition, aggregate for concrete wearing surface 10% fines value should not less than 100kN [11].

Field investigations and research findings over many years have demonstrated that various forms of reaction can occur in concrete between certain aggregates and alkali hydroxides derived from the concrete mix [10]. The principal effects of alkali-aggregate reactivity are that affected concrete suffers expansion and cracking. The expansion causes misalignment of structures and can threaten structural integrity. Cracking can lead to reinforcement corrosion and other durability problems because it provides access to aggressive agents penetrating into the concrete.

2.2.3 Degree of Compaction and Air Content

After concrete has been mixed, transported and placed, it contains entrapped air in the form of large voids. The purpose of compaction is to get rid of the entrapped air as much as possible. Before compaction, concrete with a 75mm slump may contain 5% entrapped air, while concrete with a 25mm slump may contain as much as 20% [11]. If this entrapped air is not removed by proper compaction, the presence of large voids will result in:

i) Reduce the strength of the concrete – more than 5% loss of strength for every 1% air;
ii) Increase permeability and hence reduces the durability and the protection to the reinforcement;
iii) Reduce the bond between the concrete and reinforcement;
iv) Result in visual blemishes such as excessive blowholes and honeycombing on formed surfaces. Fully compacted concrete will be dense, strong, impermeable and durable otherwise, durability will be drastically reduced due to air voids in the concrete. The optimum air content recommended by BS 8110 for a mix with 20mm maximum-sized aggregate is 5%; for 40mm and 10mm maximum-sized aggregate, the optimum amounts are 4% and 7%, respectively [12].

2.2.4 Properties of Fresh Concrete

2.2.4.1 Workability

The ACI defines workability as “that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished”. There is one term which is always confused with and taken as interchangeable with workability is consistency. ACI defines consistency as “the relative mobility or ability of freshly mixed concrete or mortar to flow”. In other word, consistency is more to the degree of wetness. Wet concretes are more workable than dry concretes but concretes of the same consistency may vary in workability.

The primary importance of workability is its influence on the compaction and density of the concrete. A workable concrete facilitates the compaction to achieve a denser and less permeable concrete. The strength of concrete increases with higher density and its durability better with lower permeability.

Workability of concrete is greatly affected by water content. Other additional factors are the aggregate type and grading, aggregate/cement ratio, presence of admixtures and fineness of cement.

2.2.4.2 Setting Time

The setting time of concrete can be determined by a penetration test using Proctor probe. The *initial set of concrete* occurs when it is able to sustain a penetration of 3.5 MPa and by then, the concrete has become too stiff to be made mobile by vibration. On the other hand, the *final set of concrete* is indicated when the concrete is able to support penetration of 27.6 MPa.

It is important to understand that the setting time of concrete is distinct from the setting time of cement. Setting time gives an indication of the degree of stiffening of concrete.

2.2.4.3 Segregation

Segregation can be defined as separation of the constituents of a heterogeneous mixture so that their distribution is no longer uniform. In the case of concrete, it is the differences in the size of particles that are the primary cause of segregation. The strength of segregated concrete is no longer uniform. However, segregation can be controlled by the choice of suitable grading and by care in handling.

2.2.4.3 Bleeding

Bleeding is also known as water gain or emergence of water on the surface caused by separation of the concrete. It is another form of segregation in which some of the water in the mix tends to rise to the surface of fresh concrete. Bleeding often occurs as a result of defects in fines in the aggregate and in low cement or high water containing mixes.

2.3 Suitability of Waste Water

2.3.1 Criteria for Evaluation

A popular criterion as to the suitability of water for mixing concrete is the expression that if water is fit to drink it is suitable for making concrete. Other criteria attempting to ensure the suitability of water for batching fresh concrete require that the water be clean and free from deleterious materials. However these specifications may not be the best basis for evaluation of the suitability of water as mixing water. Some waters which do not meet these criteria have been found to produce concretes of satisfactory quality [14].

Currently there are no special tests developed to determine the suitability of mixing water except comparative tests [15]. Generally, comparative tests require that, if the quality of water is not known, the strength of the concrete made with water in question should be compared with the strength of concrete made with water of known suitability. Both concretes should be made with cement proposed to be used in the construction works. The American Standard ASTM C 94 requires that age of 28 days mortar strengths made with test water to be a minimum of 90% of the strength of cubes made with distilled water and the time of setting in the test mortar should not be more than 1 hour quicker nor more than 1½ hour later than the time of setting when distilled water is used.

Given the scenario described above, two criteria should be considered in evaluating the suitability of RMC waste water for producing fresh concrete. One is whether the impurities in the waste water will affect the properties and quality of concrete, and the other is the degree of impurity which can be tolerated. Both of these criteria have been studied to some extent.

2.3.2 Permitted Levels of Impurities

The ASTM specification for Ready Mixed Concrete permits the use of waste water from mixer washout operations for making fresh concrete. The levels of impurities permitted in the wash water should be below the maximum concentration criteria as in Table 2.1 below

Table 2.1 : Level of Impurities

	ppm
Chloride as Cl	500
Sulfate as SO^4	3000
Alkalies as Na^20	600
Total Solids	50000

Source : ASTM C

Portland Cement Association (PCA) [13] also permits the use of wash water for mixing concrete with a tolerance of up to 50,000 ppm of total solids.

2.4 Treated waste water in Concrete Mixing

The " conventional wisdom " in the concrete technology literature has been that the water used for mixing and curing concrete would be satisfactory if it is potable and fit for human consumption (Neville 1981, Mindess & Young 1981, Metha 1986, Raina 1988, Waddell & Dobrowski 1993). The reason for this is that municipal drinking containing organic material (humid acids) may retard by hydration of cement. Many organic compounds that are also available in untreated industrial wastes may affect the hydration of cement or entrain excessive amounts of air [10].

Seawater which contains about 35,000 mg/l dissolved salts or more, has not been found to be harmful to the strength of plain concrete. However, with reinforced and pre-stressed concrete, the risk of corrosion in increased. Therefore the use of seawater as mixing water should be avoided under these circumstances. Although research performed on the use of the raw and treated domestic wastewater in concrete mixing and curing is sparse, some information is available (Tay & Yip 1987 , Tay 1989, Cebeci & Saatci 1989) and researchers have concluded some important information on this possibility.

Tay and Yip (1987) investigated the use of various quantities of reclaimed wastewater. The water was reclaimed by coagulation – flocculation, sedimentation, filtration, aeration and chlorination. The reclamation operations followed activated sludge treatment. The treated water was used in various proportions (0%, 25%, 50% and 100%) to cast 100 mm cubes using a 1:2:4 (cement: sand: course aggregate) mix with a water cement ration of 0.6. Both short and long term effects were studied.

Results from Tay and Yip (1987) showed increase in early (3-28day) compressive strength with increasing amounts of treated wastewater used in the concrete mixes. For ages of 3 months and higher, compressive strengths of cubes made with 100% treated wastewater, and those made with potable water, were similar. The use of treated wastewater in concrete mixing did not have an adverse effect on the concrete.

They also studied the effect of curing concrete cubes in treated waste water. This was performed by casting concrete cubes with potable water, and then curing them in 100% treated waste water. The results were compared to cubes that were both cast and cured in potable water. The results showed that the compressive strength of the cubes cured with treated waste water was greater than that of cured using potable water. The 28 day strength cubes cured in treated waste water was 1.5% higher than those cured in potable water. The gain of strength for ages three month and beyond was insignificant.

In addition to the use of tertiary treated wastewater in concrete, Cebecci and Saatci (1989) reported on use of both treated and raw wastewater in concrete mixing. Again, treated wastewater did not show an adverse effect on concrete. However, raw sewage reduced the 3 and 28 day compressive strength by 9%. Thus, average raw domestic sewage was shown to increase the initial setting time, entrain and reduce the strength of mortar and concrete. Cebecci and Saatci (1989) were only authors to point out the fact that the use of treated in concrete did not pose a health hazard, since the pathogenic activity of the microorganisms was reduced substantially after pH exceeded 12, due to the rapid saturation with calcium hydroxide formed by cement hydration.

Nevertheless, the use of untreated sewage in concrete mixing was not advocated. Additional research on the subject by Tay (1989) also demonstrated that the use of treated wastewater as mixing water for concrete did not affect properties other than strength (segregation, shrinkage, water absorption, bulk density and setting time)

2.5 Corrosion on Concrete using Treated and Untreated Textile Effluent

The term corrosion is defined as an act or process of gradual wearing away of a metal due to chemical or electrochemical reaction by its surroundings such that the metal is converted into an oxide, salt or some other compound. It indicates the deterioration and loss of material due to chemical attack [7].

Comparison was made between specimens (cylinder) casted using treated textile effluent, untreated textile effluent and potable water. There was deterioration due to corrosion attack and to counteract the corrosion attack concare and calcium nitrate was added on trial and error basis and it was found that 2.5% concare and 2.0% calcium nitrate was found to be suitable. In addition cempatch-R coating was done on the reinforcement bar and the effect was also studied. The experimental study was conducted for three grades of concrete i.e. 20 and 25, but only for 20 and 30 grade of concrete the corrosion studies were analyzed. The results of other two grades 25 and 30 were also same as M20grade of concrete. The specimens were tested after 28 days, 180 days, 1 year, 2 year and 2.5 years of curing.

Treated and untreated textile water can be used for construction purpose after adding concare and calcium nitrate admixture. It will be a boon for the environment if the industrial water is used for construction purpose. The problem of disposal of the waste water will be greatly reduced.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, intended methods in gathering and collection of reliable information and then be interpreted and analyzed will be discussed and streamlined. Methodology discussed in this chapter should be taken as a holistic approach in fulfilling the paramount objectives of this study.

Since the type of this research is a basis on experiment analysis and actual result obtain from the production of concrete from the batching plant and the laboratory data as guide of measures. Basically there were two main methods adopted that helped in the accomplishment of the objectives of the study namely as follows:

(i) Experiment analysis conducted in laboratory

Two grades of mix design in volume of $0.04m^3$ is mixed at laboratory drum mixer and the fresh concrete were cast in 100mm cube mould using potable water (PW) and treated waste water (TW). By conducting the laboratory mix, an analytical data were obtained without any influent of variance example as different in material quality.

(ii) Actual production of concrete at the batching plant

The same two grades mix design as per the laboratory mix is batched at concrete batching plant in a volume of $6.0m^3$ in concrete truck mixer. The potable water (PW) is used at Plant 1 and Plant 2 which is a wet concrete plant mixer as shown in Figure 3.1 and Figure 3.2.

Figure 3.1 : Wet concrete mixer

Figure 3.2: Plant 1 and Plant 2 (Wet mix)

The potable water is mix with the concrete composition during the batching process into the concrete truck mixer drum as per shown in Figure

3.3 follows at the batching plant 1 and plant 2

Figure 3.3 : Potable water mixed in the concrete truck mixer drum

Meanwhile for treated waste water (TW), the concrete is batched at Plant 3 which is a dry concrete mixer plant ans as shown in Figure 3.4 the treated waste water is added at the slump bay area by the truck driver or the slumper..

Figure 3.4 : Treated waste water is mixing in the concrete truck mix drum.

In Figure 3.5, at the slump bay, where the slumper a technician whom is skilled as an a visual slump checker before the slump test is done.

Figure 3.5 : Slump bay

At the slump bay, the treated waste water is used in concrete mixing and also to wash the truck before the truck leave the batching plant heading to the designated construction site. The treated waste water is pumped from the facultative pond to the slump bay area and is channeled into three pipelines as shown in Figure 3.5 and Figure 3.6.

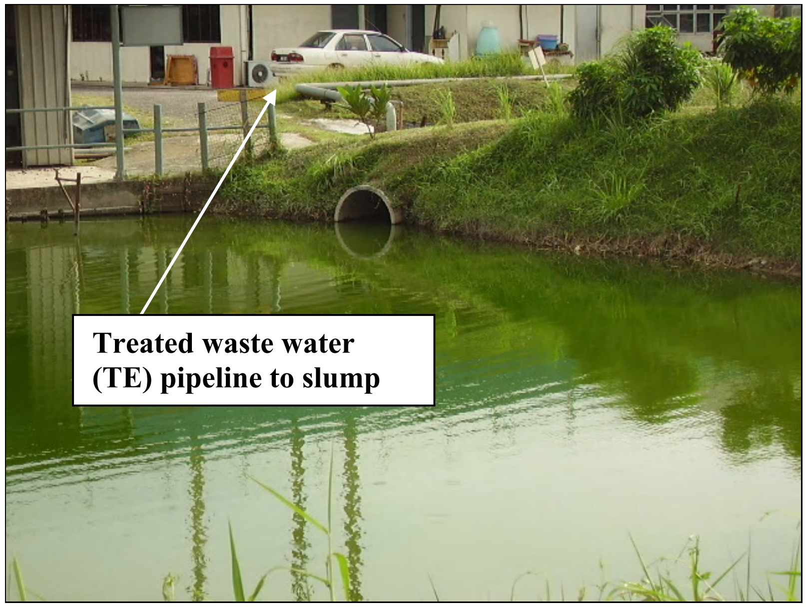


Figure 3.6 : Treated waste water (TE) pump from the facultative pond

The concrete is batched in laboratory mix and batching plant using portable water and treated waste water were tested for slump test, slump retention, setting time and compressive strength.

3.2 Material of the Specimens

Material for the specimens of concrete consists of raw material such as cement, water , fine aggregate, coarse aggregate, is from the same sources for both laboratory drum mix and batching concrete at plant.

3.2.1 Potable Water and Treated Water

A sample of potable water and treated water was retained for physical and chemical analysis. The characteristic of treated effluent and potable water were analyzed according to the methods described in the Standard Methods.

Table 3.1 : Characteristic of treated waste water (TW) and potable water (PW)

Parameter	Unit	Concentration		Tolerable Limits
		TE	PW	
pH	-	7.5	7.3	6.0 – 8.0
Total solid	mg/l	75.8	-	2000
Total suspended solid	mg/l	13.9	-	2000
Total alkalinity	mg/l as $CaCO_3$	42	20	1000
Sulfate, SO_4^{2-}	mg/l	9.5	10.8	1000
Chloride, Cl^-	mg/l	12.7	7.0	500
Lead, Pb	mg/l	N.D	N.D	
Copper, Cu	mg/l	0.0765	0.0645	500
Manganese, Mn	mg/l	0.135	0.034	
Zinc, Zn	mg/l	0.045	0.025	
Calcium, Ca	mg/l	32	0.15	2000
Magnesium, Mg	mg/l	5.7	2.1	(include
Sodium, Na	mg/l	25.022	1.317	sulfate
Ferum, Fe	mg/l	0.35	0.141	and
Nitrate, NO_3^{2-}	mg/l	2.3	2.7	Chloride)

Source : MS IS0 14000 Report Buildcon Concrete Sdn Bhd (Testing at independent lab BS EN Lab)

3.2.2 Cement

Pahang 's Ordinary Portland Cement (OPC) which complied to MS 522 : Part 1, was used as a reference in preparing the concrete mix. The chemical analysis and physical properties of the cement is given in Table 3.2.

Table 3.2 : Chemical analysis and physical analysis properties of OPC Pahang

Chemical analysis		**Percentage (%)**
Calcium oxide (CaO)		62.81
Silicon dioxide(SiO_2)		16.42
Aluminium oxide (Al_2O_3)		4.17
Ferric oxide (Fe_2O_3)		3.19
Magnesium oxide(MgO)		0.60
Sulphur trioxide (SO_3)		2.47
Pottasium oxide (K_2O)		0.63
Sodium oxide (Na_2O)		0.04
Loss on ignition (LOI)		9.4
Physical properties		
Surface area (m^2/kg)		370
Residue (%)	+ 45µm	13.6
	+ 89µm	0.26
Setting time (min)	Intial	150
	Final	210
Expansion (mm)		1.0

Source : Pahang Cement Sdn Bhd (A YTL Company)

The concrete compressive strength using Pahang Cement in a laboratory test conducted by the manufacture is given in Table 3.3. The compressive strength will be guide and reference to conduct the test on the actual data obtained.

Table 3.3 : Compressive strength of Pahang Cement (OPC)

Testing Days	**Compressive Strength (N/mm^2)**
1	15.3
3	25.2
7	36.5
28	46.7

Source : Pahang Cement Sdn Bhd (A YTL Company)

3.3 Concrete Mix Designs

The concrete mix design was proposed for the research study is Grade 30 and Grade 35 concrete as per Table 3.4.

Table 3.4 : Mix Design

Mix Design	Grade	Composition				
		Cement (kg)	**Fine Aggregate (kg)**	**Coarse Aggregate (kg)**	**Water (kg)**	**Admixture (ml)**
N304	30	336	840	1000	185	1344
N354	35	355	780	1020	195	1420

Source : Mix Design Buildon Concrete Sdn Bhd

The concrete mix design proposed with usage of admixture is to give the fresh concrete about 10% or workability and also act as a water reducer agent.

3.4 Testing Slump and Slump Retention

Workability of the concrete mixed with portable water (PW) and treated waste water are measured by conducting slump test and slump retention of the mix design.

"Workability" means the behavior of the fresh concrete during mixing, handling, delivery and placement at the point of placing and then during compaction and finishing of the surface. It is a measure of the deformability of the fresh concrete. It is defined by measurable numbers.

The fresh concrete is placed in a hollow cone – shaped form and compacted. When the form is raised, the slump gives a measure of the concrete consistence. The slump is the difference in mm between the height of the form and the height of the fresh concrete cone out of the form.

Slump test is conducted as shown in Figure 3.7 for concrete mix design batched at batching plant and also at the laboratory scale drum mixer. Slump retention is conducted on the fresh concrete mix for every half an hour to measure the slump lost and the data is recorded.

Figure 3.7 : Slump Test

3.5 Compressive Strength of Concrete Cube Test

The compressive strength test was performed according to the British Standard (BS 1881: Part 116). The concrete specimens were casted in 100 mm for laboratory scale mix and 150 mm for production mix. The concrete cubes are tested for 1 days, 2 days, 3 days, 7 days, 14 days, 28 days and 56 days. A compression machine was used for the compression testing. A total of 21 concrete cubes were cast for each mix design using portable water and treated water. Average value of three cubes is used in the investigation.

3.6 Setting Time

The setting time test was carried out with freshly mixed concrete according to the ASTM standard C484. The concrete mix design for potable water (PW) and treated waste water (TW) is tested using penetration probe. The initial and final setting time is plotted in graph.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

In this chapter, data of the research study is tabulated and the data is analysis. In order to avoid deviation from the context of the survey, analysis shall be in line with the results as indicated and referred to the both laboratory concrete mix and batching plant concrete mix.

4.2 Slump Test and Slump Retention

Table 4.1 summarize the slump test and slump retention result that had been conducted for laboratory concrete mix and batching plant concrete mix using potable water and treated waste water. The initial slump obtain for all the mix were measured at 100mm to 105 mm and slump retention were done for every 15 minutes to measure the slump loss or slump retention. Initial slump were taken at a certain range to get a data that can be analyzed. The slump lost for treated waste water is higher compare to the potable water. This is caused there are still some substance in the treated waste water such as carbon that is not removed by treatment at the facultative pond. The carbon source are actually from the water runoff caused by washing concrete truck and cement truck at the wash bay, which located beside the facultative pond.

Table 4.1 : Slump Test Result

Type of Water	Grade	Laboratory Concrete Mix		Batching Plant Concrete Mix	
		Initial Slump	Slump Retention	Initial Slump	Slump Retention
Potable water	30	100 mm	15 min – 90mm 30 min – 80mm 45 min – 60mm	100 mm	15 min – 90mm 30 min – 85mm 45 min – 65mm
	35	100 mm	15 min – 90mm 30 min – 85mm 45 min – 65mm	105 mm	15 min – 90mm 30 min – 85mm 45 min – 60mm
Treated waste water	30	100 mm	15 min – 80mm 30 min – 60mm	105 mm	15 min – 80mm 30 min – 55mm
	35	100 mm	15 min – 80mm 30 min – 60mm	100 mm	15 min – 80mm 30 min – 55mm

From the above result, the supply of concrete batched with treated waste water is advised to be casted at construction site in radius distance of 5 km to 10 km from the batching plant to obtain the required slump at site and achieve the required workability.

4.3 Compressive Strength

4.3.1 Laboratory Concrete Mix (Experimental)

Table 4.2 summarize the laboratory concrete mix compressive strength for potable water and treated waste water. The result shows percentage of strength increase higher for treated waste water then potable water. As mention early, the carbon substance found the treated waste water act to increase the strength for the concrete mixture with treated waste water. For grade 30 concrete the 28 days strength had is 42Mpa for treated waste water which 12Mpa higher compare to potable water is only 9Mpa higher. Meanwhile for grade 35 concrete the 28 days strength is 48Mpa for treated waste water and potable water is 45.5Mpa. Figure 4.1 and Figure 4.2 shows the comparison compressive strength between potable water and treated waste water visually.

Table 4.2: Laboratory Mix Compressive Strength

Grade (N/mm^2)	Age of Testing (Day)	Compressive Strength (N/mm^2)		Percentage of Strength increase (%)
		Potable Water (PW)	Treated Waste Water (TW)	
30	1	13.5	14.5	7.40
	2	18.0	19.0	5.50
	3	22.0	23.5	6.80
	7	26.0	28.0	7.77
	14	32.0	34.0	6.25
	28	37.5	39.5	5.33
	56	39.5	42.0	6.33
35	1	17.0	18.5	8.82
	2	23.0	24.5	6.52
	3	25.0	29.5	18.00
	7	32.0	35.0	9.38
	14	36.5	38.5	5.48
	28	42.5	44.0	3.53
	56	45.5	48.0	5.49

Figure 4.1 : Grade 30 Comparison Compressive Strength between Potable Water (PW) and Treated Waste Water (TW)

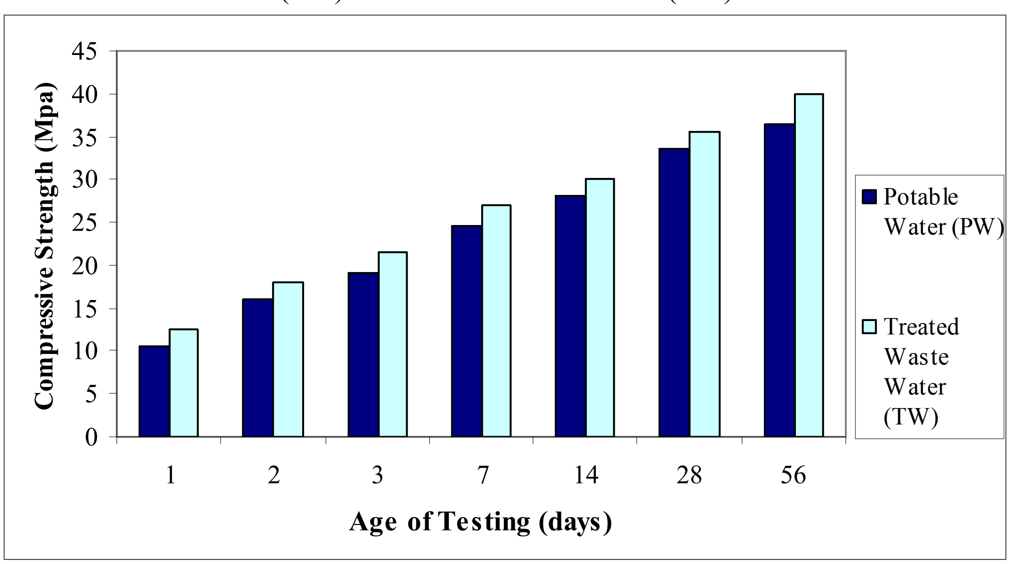
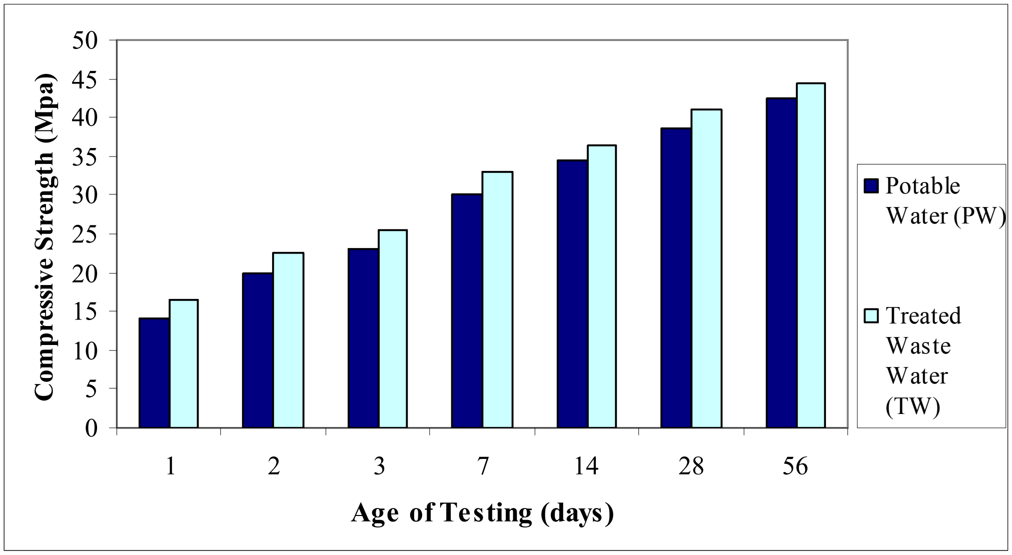


Figure 4.2 : Grade 35 Comparison Compressive Strength between Potable Water (PW) and Treated Waste Water (TW)



4.3.2 Batching Plant Concrete Mix (Actual)

Table 4.3 summarizes the batching plant concrete mix compressive strength for potable water and treated waste water. The result also shows percentage of strength increase higher for treated waste water then potable water for actual production supply.

Figure 4.3 to Figure 4.4 shows the comparison compressive strength between potable water and treated waste water visually.

Table 4.3 : Batching Plant Concrete Mix Compressive Strength

Grade (N/mm^2)	**Age of Testing (Day)**	**Compressive Strength (N/mm^2)**		**Percentage of Strength increase (%)**
		Potable Water (PW)	**Treated Waste Water (TW)**	
30	1	10.5	12.5	19.1
	2	16.0	18.0	12.5
	3	19.0	21.5	13.2
	7	24.5	27.0	10.2
	14	28.0	30.0	7.14
	28	33.5	35.5	6.00

	56	36.5	40.0	9.59
35	1	14.0	16.5	17.86
	2	20.0	22.5	12.5
	3	23.0	25.5	10.9
	7	30.0	33.0	10.0
	14	34.5	36.5	5.80
	28	38.5	41.0	6.49
	56	42.5	44.5	4.71

Figure 4.3 : Grade 30 Comparison Compressive Strength between Potable Water (PW) and Treated Waste Water (TW)

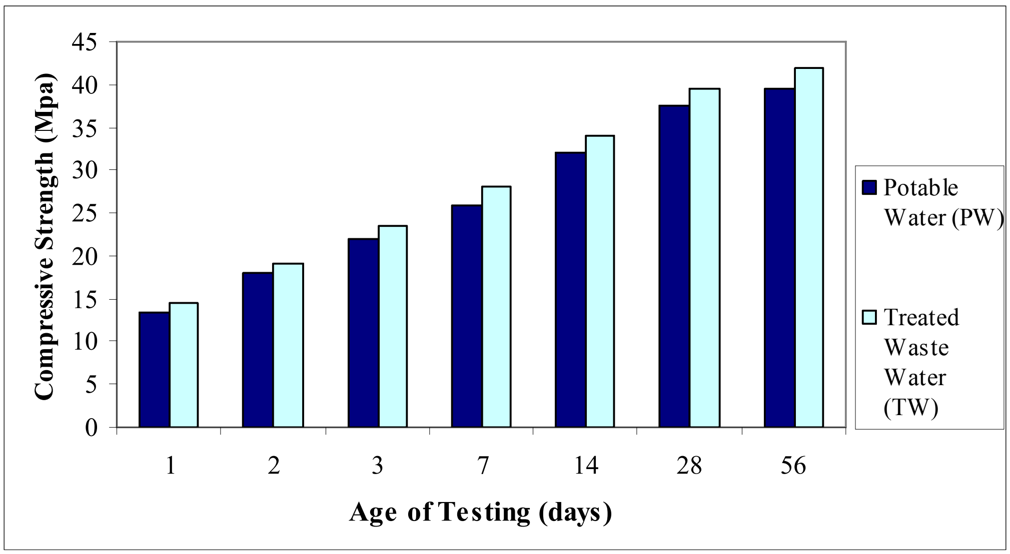


Figure 4.4 : Grade 35 Comparison Compressive Strength between Potable Water (PW) and Treated Waste Water (TW)

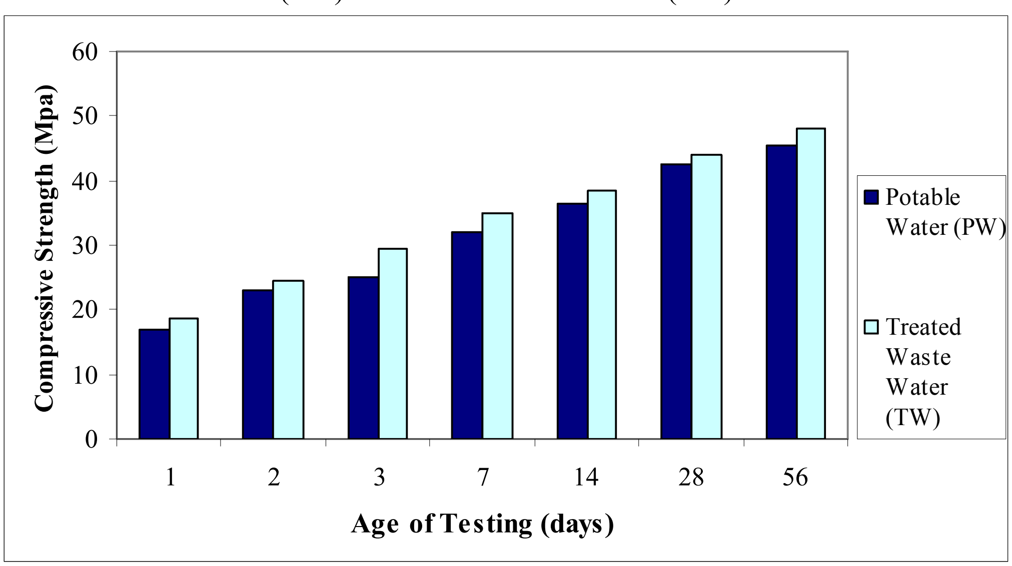


Figure 4.5 : Variation of Grade 30 compressive strength with testing period prepared with potable water (PW) and treated waste water (TE)

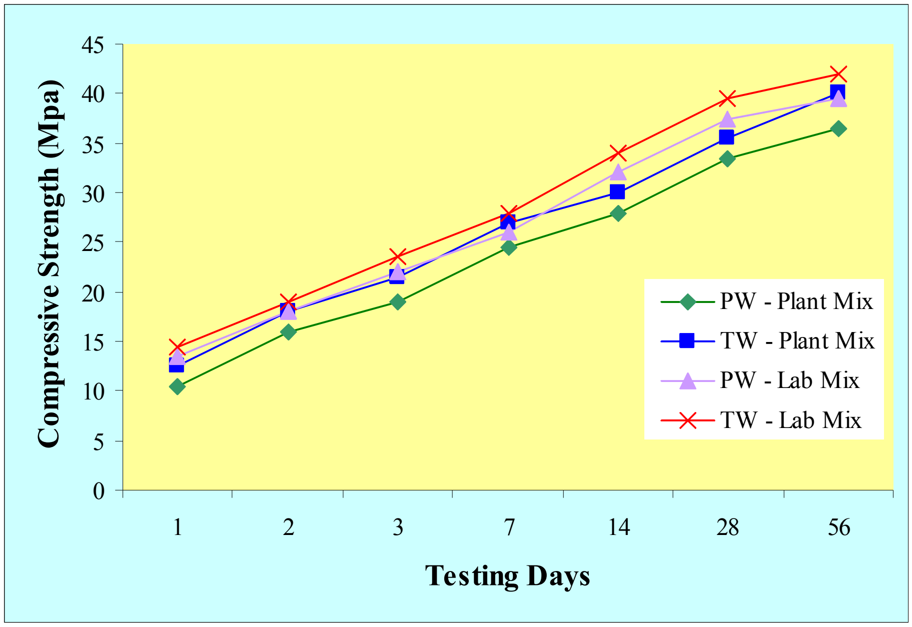


Figure 4.6 : Variation of Grade 35 compressive strength with testing period prepared with potable water (PW) and treated waste water (TE)

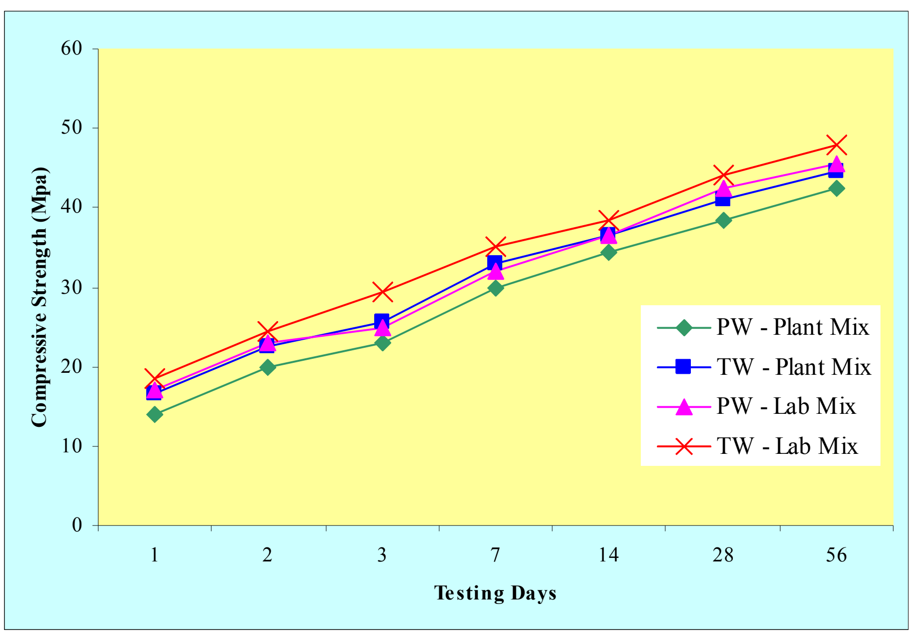


Figure 4.5 and Figure 4.6 shows the variation of compressive strength with testing days. The figure show there is some variation in the laboratory and batching plant mix concrete because of the condition of environmental, machinery calibration and the scale involved.

4.4 Setting Time

The setting time tests were conducted for both laboratory and concrete batching mix. The requirement of BS 3148: 1980 for Ordinary Portland cement stated that the initial setting time should not be less than 75 minutes. The setting time for the mix proportions using portable water and treated waste water are analysed between differential of laboratory concrete mix and concrete plant batching mix.

4.4.1 Laboratory Concrete Mix (Experimental)

Figure 4.7 to Figure 4.22 shows the graph analysis of Grade 30 and Grade 35 concrete mix using potable water and treated waste water. Furthermore, the graph plotted shows the penetration resistance against elapsed time and setting time by regression analysis.

Figure 4.7 : Grade 30 Penetration Resistance vs Elapsed Time for potable water (PW)

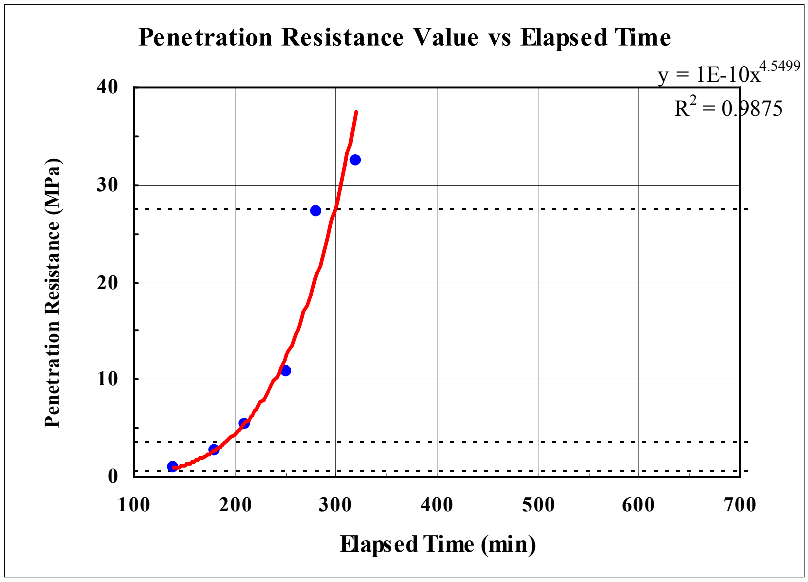


Figure 4.8 : Grade 30 Setting Time by Regression Analysis for potable water (PW)

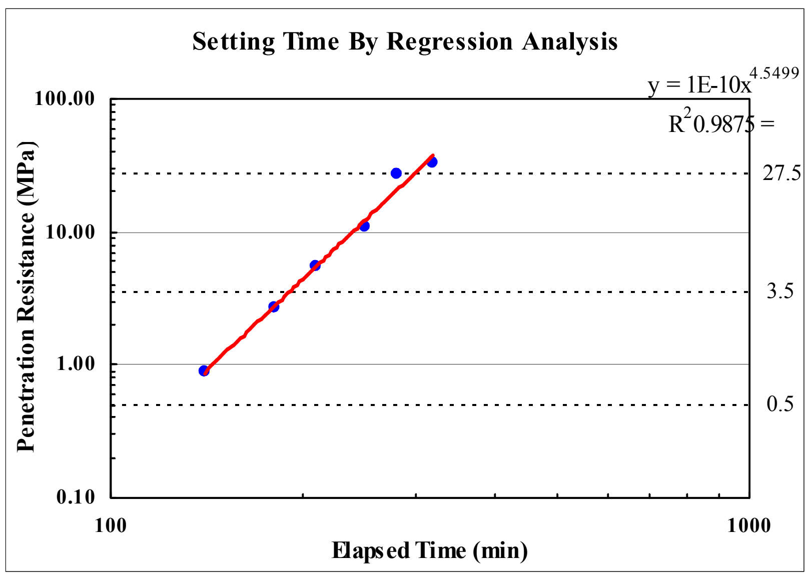


Figure 4.9 : Grade 35 Penetration Resistance vs Elapsed Time for potable water (PW)

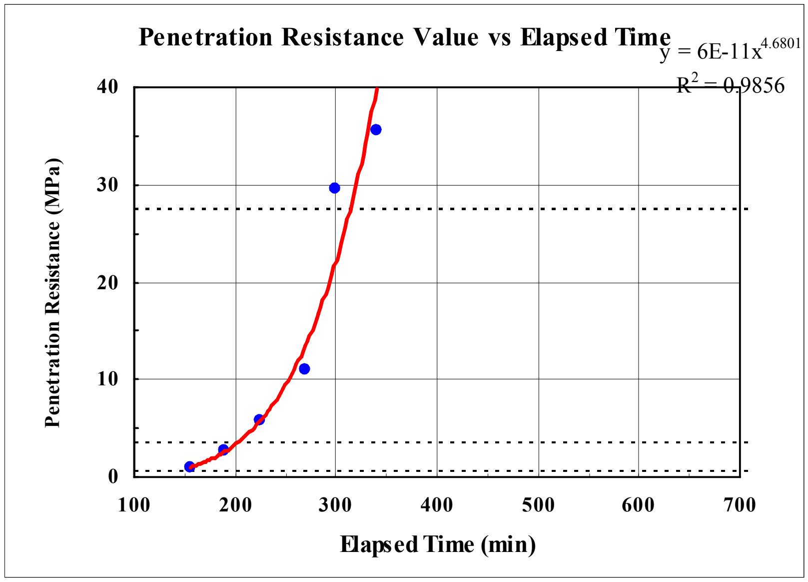


Figure 4.10 : Grade 35 Setting Time by Regression Analysis for potable water (PW)

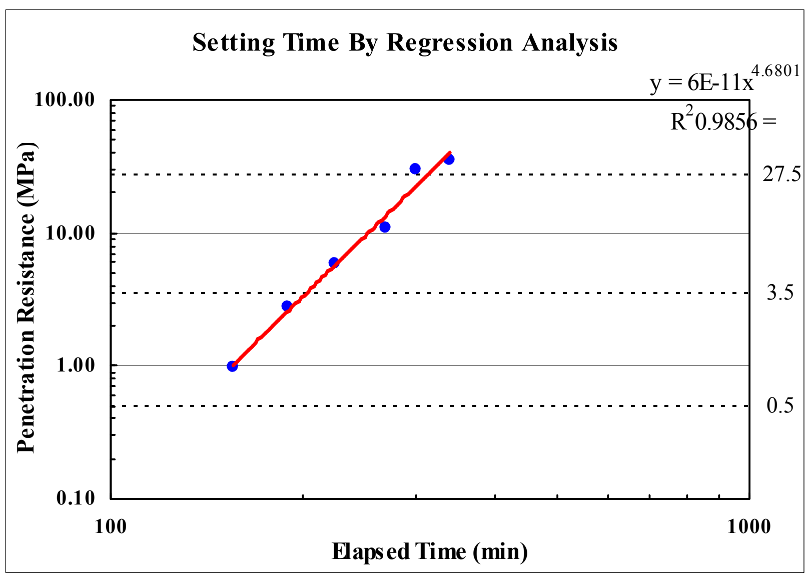


Figure 4.11 : Grade 30 Penetration Resistance vs Elapsed Time for treat waste water (TW)

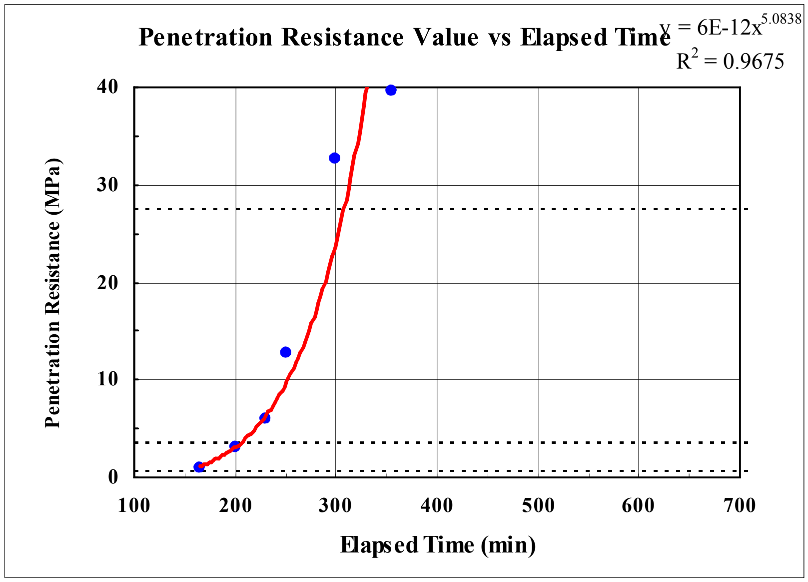


Figure 4.12: Grade 30 Setting Time by Regression Analysis for treat waste water (TW)

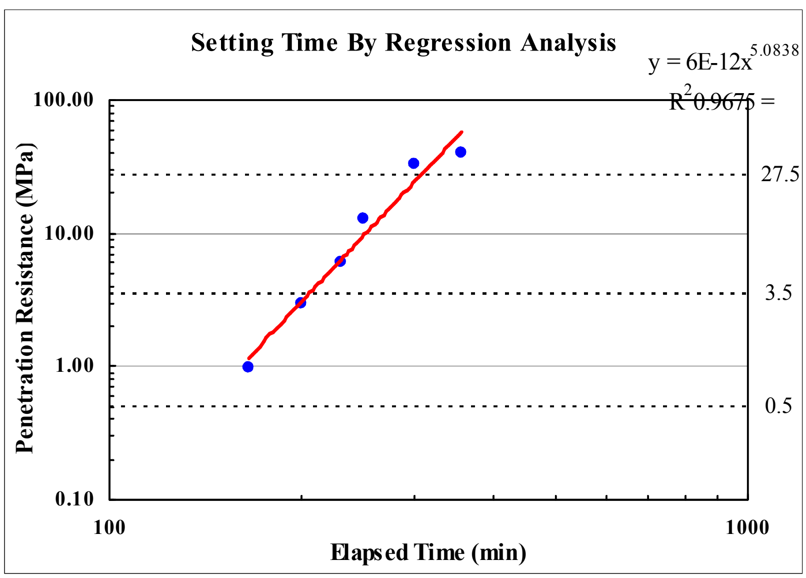


Figure 4.13 : Grade 35 Penetration Resistance vs Elapsed Time for treat waste water (TW)

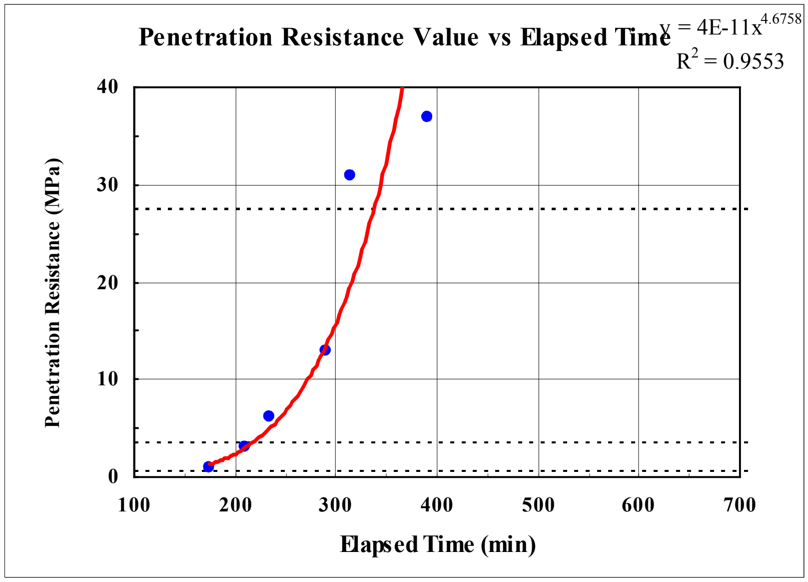
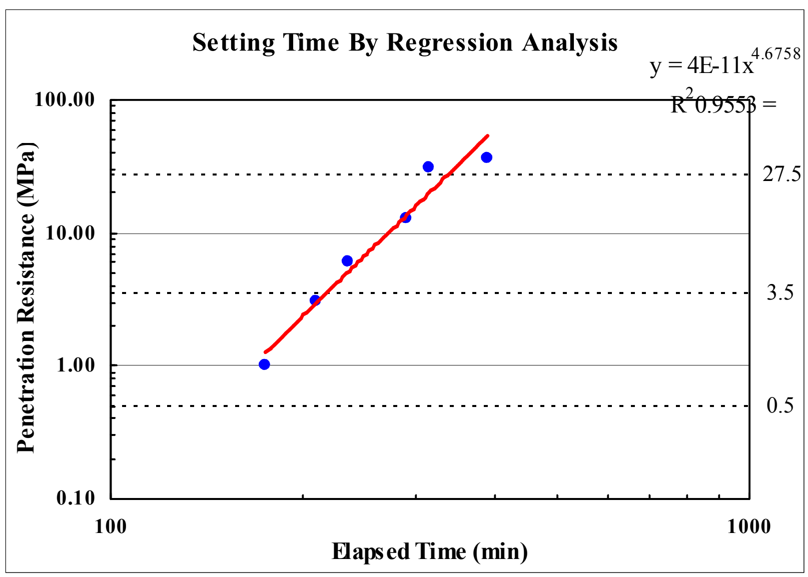


Figure 4.14: Grade 35 Setting Time by Regression Analysis for treat waste water (TW)



4.4.2 Batching Plant Concrete Mix (Actual)

Figure 4.15 : Grade 30 Penetration Resistance vs Elapsed Time for potable water (PW)

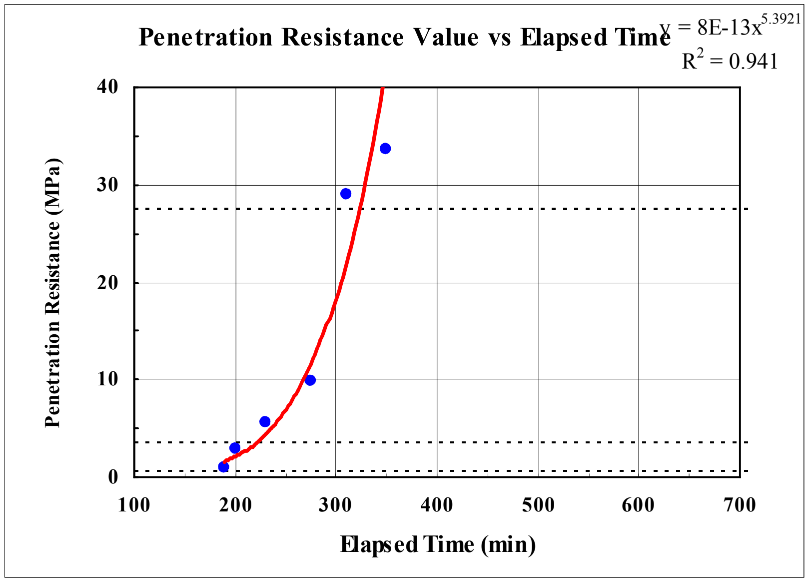


Figure 4.16 : Grade 30 Setting Time by Regression Analysis for potable water (PW)

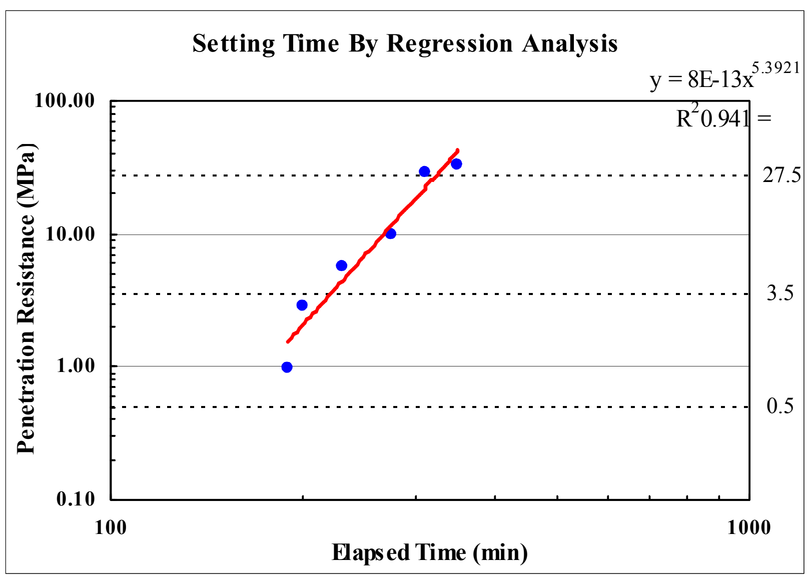


Figure 4.17 : Grade 35 Penetration Resistance vs Elapsed Time for potable water (PW)

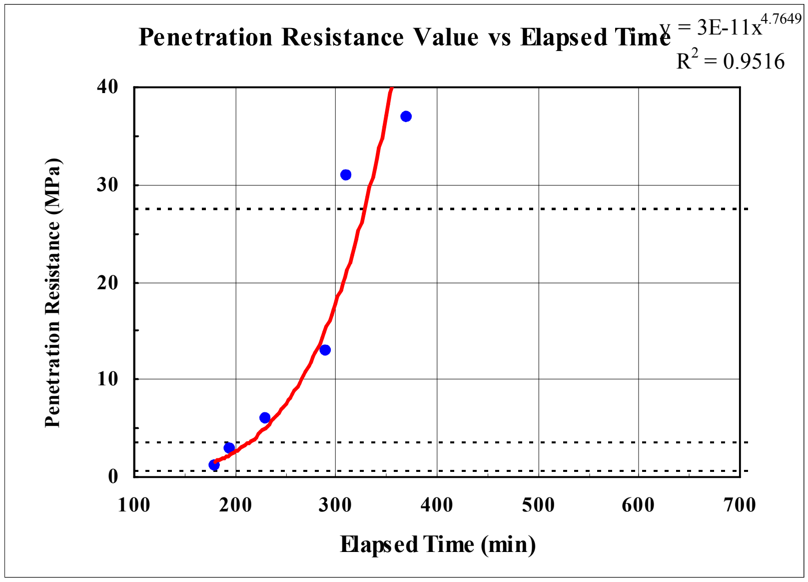


Figure 4.18 : Grade 35 Setting Time by Regression Analysis for potable water (PW)

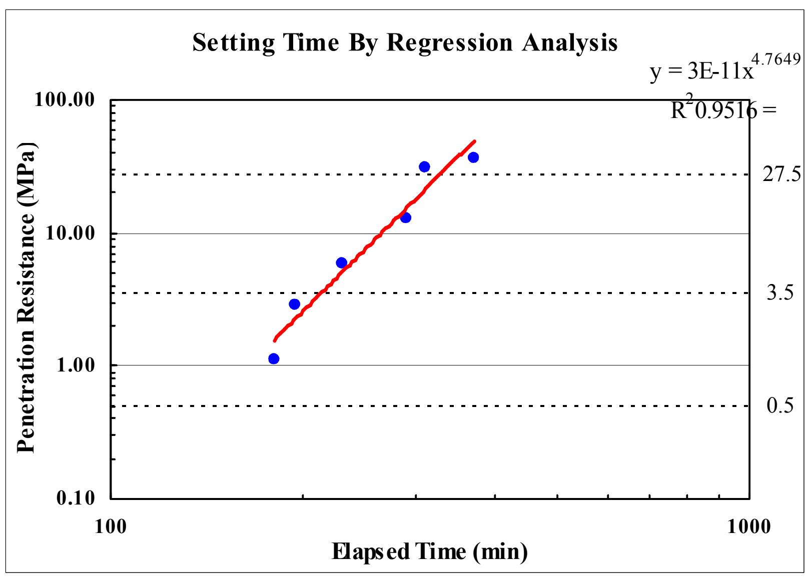


Figure 4.19: Grade 30 Penetration Resistance vs Elapsed Time for treat waste water (TW)

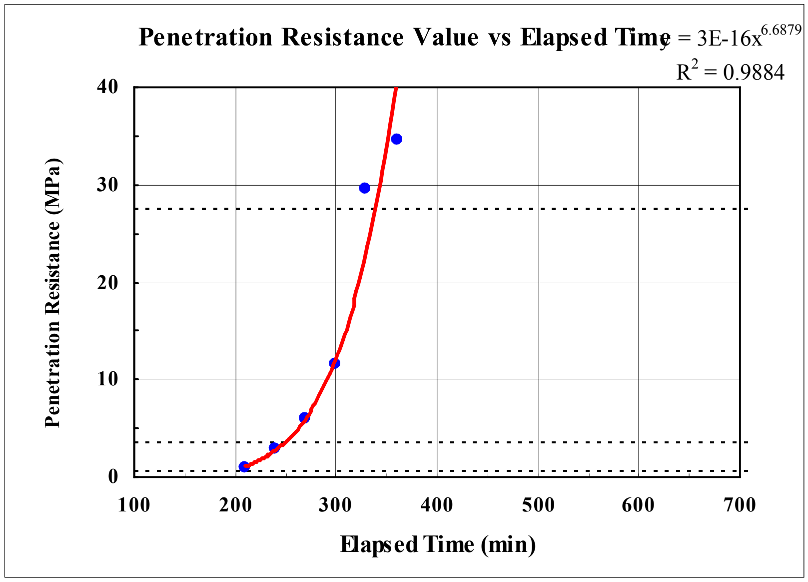


Figure 4.20: Grade 30 Setting Time by Regression Analysis for treat waste water (TW)

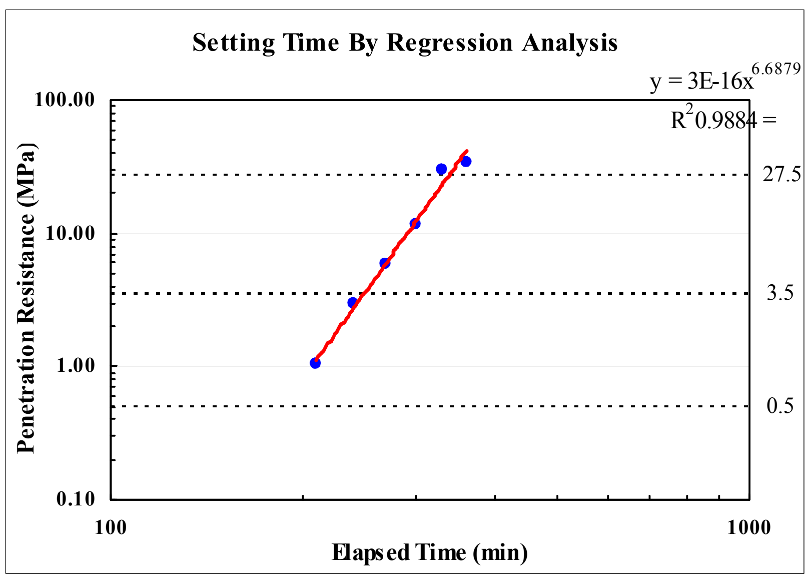


Figure 4.21: Grade 35 Penetration Resistance vs Elapsed Time for treat waste water (TW)

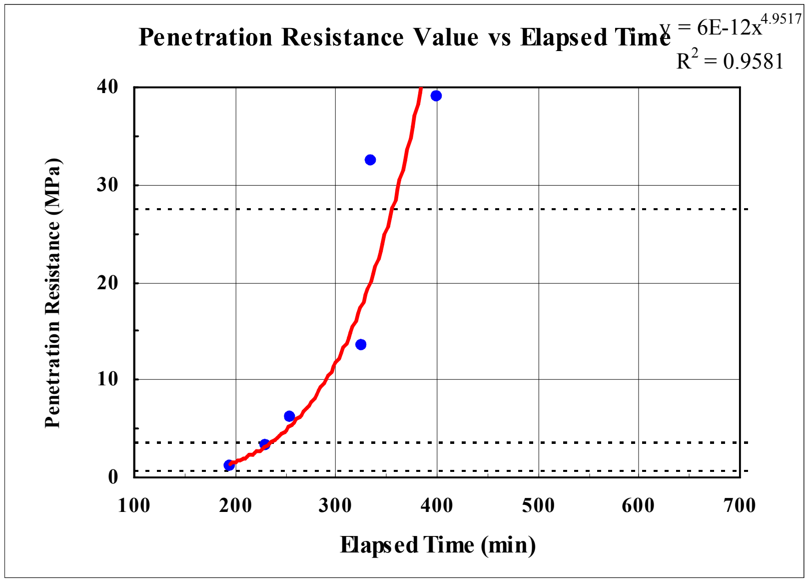


Figure 4.22: Grade 35 Setting Time by Regression Analysis for treat waste water (TW)

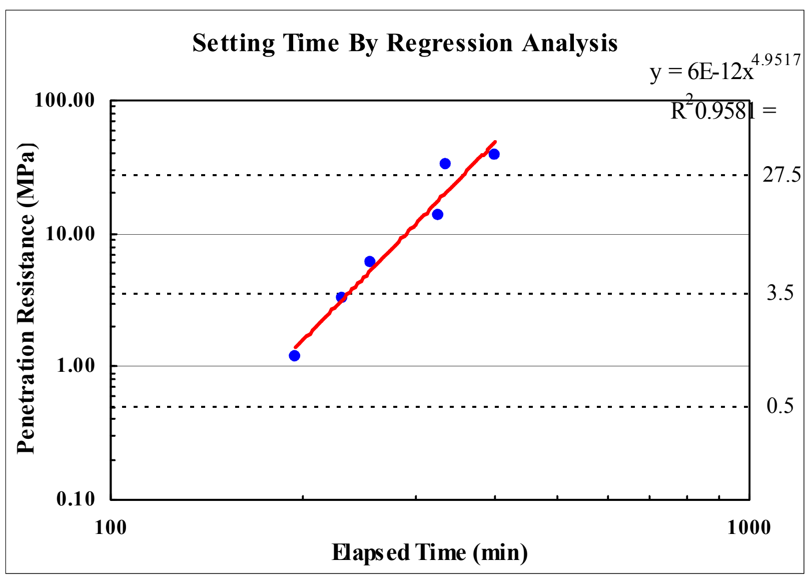


Table 4.4: Setting Time

Type of Water	Grade	Laboratory Concrete Mix		Batching Plant Concrete Mix	
		Setting time			
		Initial	Final	Initial	Final
Potable water	30 35	3 hr 10 min 3 hr 22 min	4 hr 59 min 5 hr 14 min	3 hr 20 min 3 hr 33 min	5 hr 13 min 5 hr 28 min
Treated waste water	30 35	3 hr 25 min 3 hr 37 min	5 hr 08 min 5 hr 38 min	3 hr 35min 3 hr 55min	5 hr 30 min 5 hr 56 min

Table 4.4 summarize the setting time for both concrete mix conducted at laboratory and at batching plant. The initial and final setting time for treated waste water is longer compare potable water which is caused by the slump retention lost higher for treated waste water. The setting time is higher for treated waste water is caused by the additional water that had to add in the concrete mixture to obtain the initial slump at the same range for all the concrete mixture. But additional water in the treated waste water concrete does not affect the compressive strength due to carbon substances found in the treated waste water.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter presents the conclusions including contribution of work to the body of knowledge and lastly, recommendations for future research.

5.2 Conclusions

1. The properties of treated waste water from the paper recycling factory is within the tolerable limits.
2. Concrete slump rentention and slump loss were affected by the type of mixing water that were used in this studies.
3. Slump test achieved according to the proposed mix design, the water demand for treated waste water is higher than potable water for Plant Mix.
4. Higher compressive strength was achieved for treated waste water compared to potable water
   - Laboratary concrete mix have achieved higher strength than Plant concrete mix due to controlled environment and small scale
5. Setting time mix design used with treated waste water ahieved within the standard
   - Intial and final setting time is higher for treated waste water
   - Setting time were found to increase with deteriorating water quality

5.3 Recommendation

In this chapter, intended methods in gathering and collection of reliable information and then be interpreted and a

1. The durability of concrete mixed with treated waste water, where the below test to be conducted
   - Flexural Strength
   - Tensile Splitting Strength
2. Curing with treated waste water
   - Strength development of the concrete is analysis
   - Achieveablity of compressive strength designed

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