International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-02, Issue-02, February 2015

Study on Durability Properties of Concrete Prepared by using Rice Mill Effluent

Pradeep T, Mageshkumar P

***Abstract*— There is a growing concern for environmental conservation and sustainable development across the globe. To achieve long environmental sustainability requires innovative solutions to many problems caused by human to aquatics, atmosphere and land. Environmental problems ranging from noxious aerosols, fumes in the air, heavy metals and hazardous organics into the water to solid wastes that will overcome our landfill.**

The scarcity of water resources, the ever deteriorating in many metropolis, the threat of monitoring volumes of wastes without suitable disposal sites and a long list of other critical innovative must be resolved through innovations of scientists and engineers.

Hence, we focus our attention in developing a method for reuse of waste water for construction purpose. In this work it is to be planned to collect the waste effluent from the rice mill in and around erode and analyze the various basic characteristics of waste effluent, then appropriate technology is to be developed to make it suitable for construction purposes. It is also planned to study the mechanical and durability properties of concrete using rice mill effluent.

***Index Terms*— Rice Mill Effluent, Durability Properties, Mechanical Properties and Accelerated corrosion.**

I. INTRODUCTION

The ground water is depleting in a fast manner. The water available should be used with greatest care to cater the needs of the people. Even, the used water in the industry should be recycled and used for either gardening purpose or for the construction purposes.

India is the second biggest Rice producing country in the world. Large amount of waste water is released from rice industry. The volume of waste water generated from rice mill is approximately 900-1000 liter / ton of paddy. So the effluent available from the rice mill may be used for the construction purposes.

Water scarcity is also a main problem during summer. So, construction industries are facing a lot of struggles in summer. This effluent after checking its properties it may be used for construction purposes. So, an attempt is made to utilize the rice mill effluent for construction purposes.

Manuscript received Feb 10, 2015

Pradeep T, PG Student, Structural Engineering, K S Rangasamy college of Technology, Tiruchengode, Namakkal, Tamil Nadu, India

Mageshkumar P, Assistant professor, Department of Civil Engineering, K S Rangasamy college of Technology, Tiruchengode, Namakkal, Tamil Nadu, India

1.2 SALIENT FEATURES OF THE RESEARCH

The rice mill effluent which joins in the river is only partially treated. The partially treated effluent consist lot of total dissolved solids which affect water so much.

In addition to this, ground water as well as cultivable lands is also polluted. If the water is utilized for some other domestic purposes it leads to a lot of human illness.

To minimize these problems this waste effluent can be used for construction purposes without affecting the surrounding environment.

By utilizing this effluent, water scarcity can be reduced.

OBJECTIVES

Comparing the following properties of conventional concrete and concrete prepared by using rice mill effluent

Study of mechanical properties

a. Compressive strength
b. Split tensile strength

Study of durability properties

a. Chloride attack
b. Sulphate attack
c. Acid attack
d. Accelerated corrosion
e. Sorptivity

II. LITERATURE REVIEW

Kaushik S.K and Islam S. (1995) prepared and cured the concrete samples using sea water. They examined the concrete properties such as setting time, compressive strength of the concrete, corrosion of reinforcement bar embedded in the concrete and chloride ion penetration of the concrete over a period of 18 months.

They reported that the compressive strength of the concrete samples prepared using the sea water less than that of the concrete samples prepared by using the sea water. The corrosion of reinforcement bar embedded in the concrete and chloride ion penetration were more in the concrete specimen cast using the sea water.

Al-Harthy A.S., Taha R., Abu-Ashour J., Al-Jabri K. And Al-Oraimi S. (2005) replaced the potable water with the waste water obtained from oil production fields and other brackish ground water for making the concrete samples. They determined the compressive strength of the concrete samples after 7, 14, 21, 28, 35, 42, 49, 56 and 63 days of casting.

They reported that the compressive strength of the concrete prepared using waste water was less than that of the concrete prepared using potable water but the required target mean compressive strength was obtained by the concrete sample prepared using the water obtained from oil production fields and other brackish ground water.

Saricimen H., Shameem M., Barry M. and Ibrahim M. (2004), studied the effects of using treated effluent for preparing the concrete as a replacement to potable water. They prepared the concrete samples using both the potable water and the treated industrial effluent and allowed the concrete samples for curing in the respective water. The compressive strength of the concrete was determined after 7, 14, 28 and 90 days of casting

. They reported that the compressive strength of the concrete prepared using treated effluent was higher than that of the concrete samples prepared using the potable water. The strength of the concrete samples prepared using treated water was 112% higher than that of the concrete samples prepared using potable water. The strength of the concrete samples blended with 8% silica fume using treated effluent was 115% higher than that of the concrete samples prepared using potable water. There was 8% to 9% decrease in the setting time of the concrete prepared using treated effluent than that of the concrete prepared using potable water where as the setting time of the concrete blended with 8% silica fume prepared using treated effluent was 10% higher than that of the conventional concrete.

Ooi soon lee, Mohd razman salim, Mohammed ismail & MD. Imtiaj ali (2001) studied the feasibility of using treated effluent for concrete mixing and two tests were carried out namely compressive strength test and setting time.

The results were compared against the tests conducted on control specimens which used potable water. The results showed that treated effluent increases 7.2 -12.0% the compressive strength and setting time when compared with potable water.

D.Govindarajan, R. Gopalakrishnan (2009), studied the influence of different types of water on strength, porosity and hydric parameters of metakaolin admixtured cement. The present research deals with strength, porosity, and hydric behaviour of metakaolin cement admixture with different types of water. The hydration of ordinary Portland cement in the presence of 0%, 10%, 20% and 30% metakaolin treated with distilled ground and sea water with the water cement ratio of 0.4 was studied.

The experimental results on setting time, strength, porosity and hydric parameters are reported. The results show that, metakaolin percentage increases in strength with a decrease in porosity. Further, sea water accelerates the cement hydration at the early stages but retards it in the latter stages of hydration.

Marcia Silva and Tarun R. Naik, prepared the mortar samples using sewage treatment plant water. They examined the concrete properties such as flow and compressive strength of the mortar cubes.

The average flow for mortar cubes made of potable water and reclaimed water was 98.1% and 89.5% respectively and no significant differences exist between mortar cubes made of potable water versus sewage treatment plant water.

Ibrahim Al-Ghusain and Mohammand J.Terro (2003) studied the use of treated waste water for concrete. The concrete cube is prepared using tap water, tertiary treated waste water and allowed the concrete samples for curing in the respective waters. The compressive strength of the concrete was determined after 7, 14, 28 and 90 days of casting. They adopted a mix ratio of 1:2:4 with a water/cement ratio 0.6.

They reported that the compressive strength of the concrete prepared using preliminary treated waste water was less than that of the concrete prepared using potable water for ages up to 1year. At early 3 and 7 days, the strength of concrete made with tertiary treated waste water was higher than that of concrete made with tap water.

III. EXPERIMENTAL INVESTIGATION

TESTING OF CEMENT

Specific gravity of cement

A clean and dry Le Chatelier flask or specific gravity bottle with stopper is weighed (W1). Place the cement sample up to half of the flask (50 gm) and weigh with the stopper (W2). Then add kerosene to the cement in the flask till it is about half full. Mix thoroughly with glass rod to remove the entrapped air. Continue stirring and add more kerosene till it is flush with graduated mark. Then dry the outside and weigh (W3). Then empty the flask, clean it and refill with clean kerosene flush with graduated mark. Wipe outside and weigh (W4). The limit for the specific gravity of cement as per the code is 3.15 g/cc.

Fineness of cement

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength. The fineness of grinding has increased over the years. But now it has got nearly stabilised. Different cements are ground to different fineness. The disadvantages of fine grinding is that it is susceptible to air-sets and early deterioration.

Fineness of cement is tested in two ways:

By sieving

By determination of specific surface (total surface area of all the particles in one gram of cement) by air-permeability apparatus. Generally Blaine Air permeability apparatus is used.

Sieve test

Weigh correctly 100 grams of cement and take it on a standard IS Sieve (90 micron). Break down the air-set lumps in the cement sample with the fingers. Continuously sieve the cement giving circular and vertical motion for a period of 15 minutes. Then weigh the residue left on the sieve. The percentage residue should not exceed 10%.

Setting time test

Take 500 gram of cement sample and mix it with 0.85 times the water that is required to produce cement paste of standard consistency (0.85 P). The paste shall be gauged and filled into the Vicat mould in specified manner within 3-5 minutes. Start the stop watch immediately the moment water is added to the cement. Lower the needle gently and bring it in contact with the surface of the test block and quickly release. Allow it to penetrate into the test block. In the beginning, the needle will completely pierce through the test block. But after sometime when the paste starts losing its plasticity, the needle may penetrate only to a depth of 33-35 mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35 mm from the top is taken as initial setting time. Replace the needle of the Vicat apparatus by a circular attachment. The cement shall be considered as finally set when, upon lowering the attachment gently cover the surface of the test block, the centre needle makes an impression, while the circular cutting edge of the attachment fails to do so. The initial setting time is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moments the water is added to the cement.

IV. TESTING OF FINE AGGREGATE AND COARSE AGGREGATE

Specific gravity of fine aggregate and coarse aggregate

Take about 1 kg of fine aggregate sample and place them in the pycnometer containing approximately two inches of water. Screw the cap down into the proper position by lining up the mark on the pycnometer top. Then entirely fill the pycnometer by adding additional water through the hole in the pycnometer top. Hold one finger over the hole in the top and gently roll and shake the pycnometer to remove any trapped air in the sample.

Specific Gravity of aggregate = $\frac{S}{P+S-W}$

S = Weight in grams of aggregate in a saturated-surface-dry condition.
P = Weight in grams of the pycnometer filled with water.
W = Weight in grams of the pycnometer containing the sample and sufficient water to fill the remaining space in the pycnometer.

Sieve Analysis

This is the name given to the operation of dividing a sample of aggregate into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation.

A convenient system of expressing the gradation of aggregate is one which the consecutive sieve openings are constantly doubled, such as 10 mm, 20 mm, 40 mm etc. Under such a system, employing a logarithmic scale, lines can be spaced at equal intervals to represent the successive sizes.

The aggregates used for making concrete are normally of the maximum size 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 600 micron, 300 micron and 150 micron. The aggregate fraction from 80 mm to 4.75 mm is termed as coarse aggregate and those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The size 4.75 mm is a common fraction appearing both in coarse aggregate and fine aggregate (C.A. and F.A.).

From the sieve analysis the particle size distribution in a sample of aggregate is found out. In this connection a term known as “Fineness Modulus” (F.M.) is being used. F.M. is a ready index of coarseness or fineness of the material. Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves ranging from 80 mm to 150 micron and dividing this sum by an arbitrary number 100. The larger the figure, the coarser is the material.

Properties of potable water and rice mill effluent

S. NO	PARAMETERS	PERMISSIBLE LIMITS	POTABLE WATER	RICE MILL EFFLUENT
1	pH	6-8.0	7.1	7
2	Chlorides (mg/l)	500	321.3	375.86
3	Hardness (mg/l)	1000	300.18	680
4	Sulphate (mg/l)	600	430	486.32

V. DURABILITY PROPERTIES

Significance of durability

When designing a concrete mix or designing a concrete structure, the exposure condition at which the concrete is supposed to withstand is to be assessed in the beginning with good judgement. In case of foundations, the soil characteristics are also required to be investigated. The environmental pollution is increasing day by day particularly in urban areas and industrial atmospheres. It is reported that in industrially developed countries over 40 per cent of total resources of the building industries are spent on repairs and maintenance. In India, the money that is spent on repair of buildings is also considerable. Every government department and municipal bodies have their own “Repair Boards” to deal with repairs of buildings. It is a sad state of affairs that we do not give enough attention to durability aspects even when we carry out repairs.

Durability of reinforced concrete structures is a pervasive and universal problem. Many concrete structures deteriorate prematurely, and repair and maintenance costs amount to substantial proportions of public and private sector budgets. Durability problems cover a wide range including attack by external destructive agents (e.g. sulphates), internal material incompatibilities (e.g. alkali-aggregate reaction), and aggressive environments such as freeze-thaw. Nevertheless, the greatest threat undoubtedly is corrosion of embedded reinforcing steel, leading to cracking, staining, and spalling of the cover. This in turn can lead to unserviceable structures that may be compromised in respect of safety, stability, and aesthetics.

Sulphate attack

Most soils contain some sulphate in the form of calcium, sodium, potassium and magnesium. They occur in soil or ground water. Because of solubility of calcium sulphate is low, ground waters contain more of other sulphates and less of calcium sulphate. Ammonium sulphate is frequently present in agricultural soil and water from the use of fertilizers or from sewage and industrial effluents. Decay of organic matters in marshy land, shallow lakes often leads to the formation of H_2S, which can be transformed into sulphuric acid by bacterial action. Water used in concrete cooling towers can also be a potential source of sulphate attack on concrete. Therefore sulphate attack is a common occurrence in natural or industrial situations.

Solid sulphates do not attack the concrete severely but when the chemicals are in solution, they find entry into porous concrete and react with the hydrated cement products. Of all the sulphates, magnesium sulphate causes maximum damage to concrete. A characteristic whitish appearance is the indication of sulphate attack. The term sulphate attack denote an increase in the volume of cement paste in concrete or mortar due to the chemical action between the products of hydration of cement and solution containing sulphates. In the hardened concrete, calcium aluminate hydrate (C-A-H) can react with sulphate salt from outside. The product of reaction is calcium sulphoaluminate, forming within the framework of hydrated cement paste. Because of the increase in volume of the solid phase which can go up to 227 per cent, a gradual disintegration of concrete takes place. Calcium sulphate attacks only calcium aluminate hydrate producing calcium sulpho aluminate ($3CaO.Al_2O_3.3CaSO_4.32H_2O$) known as ettringite. Molecules of water may be 32 or 31. The extent to which concrete is affected by sulphate depends on several factors including its permeability, W/C ratio, type of cement, exposure conditions. To control the permeability of concrete, lower W/C ratio is required. Pozzolans reduce not only the permeability but also C3A amount if they are partial replacement of cement.

Acid attack

Structures which are constructed in marine areas are liable to be subjected to acid attack. The weight loss & deterioration of concrete under such attack needs investigation and an alternate solution should be brought out. One of the main causes in deterioration in concrete structures is distress of concrete due to its exposure to harmful chemicals that may be found in natures, such as in contaminated ground waters, industrial effluents and sea waters.

Concrete can be attacked by liquids with pH value less than 6.5, but the attack is severe only at a pH value 5.5. At a pH value 4.5, the attack is very severe. As the attack proceeds all the cement compounds are eventually broken down and leached away together with any carbonate aggregate material. With the sulphuric acid attack, calcium sulphate formed can proceed to react with calcium aluminate phase in cement to form calcium sulphoaluminate, which on crystallization can cause expansion and disruption of concrete. If acids are able to reach the reinforcing steel through cracks or porosity of concrete, corrosion will occur which will cause cracking. The following solutions were selected for immersion of concrete cylinders and cubes. 5%HCl, 5% H2SO4 .The pH of the solutions were regularly monitored and adjusted to keep them constant.

Chloride attack

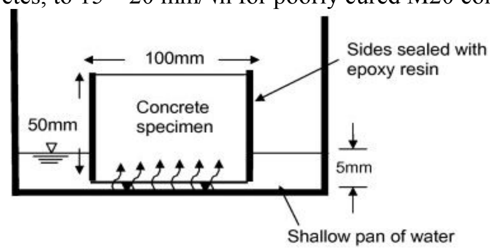
Chloride is one of the important aspects for consideration when we deal with the durability of concrete. Chloride attack is particularly important because it primarily causes corrosion of reinforcement. Statistics have indicated that over 40 per cent of failure of structures is due to corrosion of reinforcement.

Due to the high alkality of concrete a protective oxide film is present on the surface of steel reinforcement. The protective passivity layer can be lost due to carbonation. This protective layer also can be lost due to the presence of chloride in the presence of water and oxygen. In reality the action of chloride in inducing corrosion of reinforcement is more serious than any other reasons.

After the completion of 28 days curing, the initial weights of the specimens are noted. The specimens are immersed in 5% HCL and 5% H2SO4 solutions. The specimens are taken from the solution after 7 days. Visual observations are made, the weight of specimens are noted and again immersed in acid solutions. The test is repeated for 28 days.

Sorptivity test

Sorptivity is defined as the rate of movement of a wetting front through a porous material. The water sorptivity test involves the uni-directional absorption of water into one face of a pre-conditioned concrete disc sample[2, 8.At] predetermined time intervals, the sample is weighed to determine the mass of water absorbed, and the sorptivity is determined from the plot of mass of water absorbed versus square root of time. The lower the water sorptivity index, the better is the potential durability of the concrete. Sorptivity values typically vary from approximately 5 mm/√h, for well-cured M30-M50 concretes, to 15 – 20 mm/√h for poorly cured M20 concrete.



Setup for Sorptivity test

Accelerated corrosion test

Corrosion is initiated by a change in the nature of the pore solution surrounding the steel, due either to the penetration of a de-passivating carbonation front or, more dangerously, to ingress of chloride ions from a saline (e.g. marine or de-icing salt) environment. Durability is therefore largely controlled by the quality of the thin cover layer protecting the reinforcement. This layer is most susceptible to the negative influences of poor curing, early-age drying, inadequate compaction and penetration of aggressive agents from the environment. The problem reduces to one of being able to control the cover layer thickness and quality. For designers, this relates to the ability to quantify cover layer properties for specification purposes, while for constructors the issue is to implement suitable site practices that ensure the specified cover properties.

Setup for Accelerated Corrosion Test

VI. TEST RESULTS AND EVALUATION

Workability of concrete (slump)

The workability of fresh concrete is one of the most important and useful properties of concrete. The slump values of concrete with 0.45 w/c ratio were determined for both the potable water and the rice mill effluent are given below.

Slump value

S.NO	Grade of concrete	Water/cement ratio	Slump value(mm)	Type of water
1	M25	0.45	100	Potable water
2	M25	0.45	100	Rice mill effluent

VII. MECHANICAL PROPERTIES OF CONCRETE

Compressive strength of M25 grade concrete for rice mill effluent

Specimen No	Strength of concrete (MPa) 7 days	Strength of concrete MPa 28 days
1	18.281	32.383
2	20.016	33.274
3	19.380	31.155

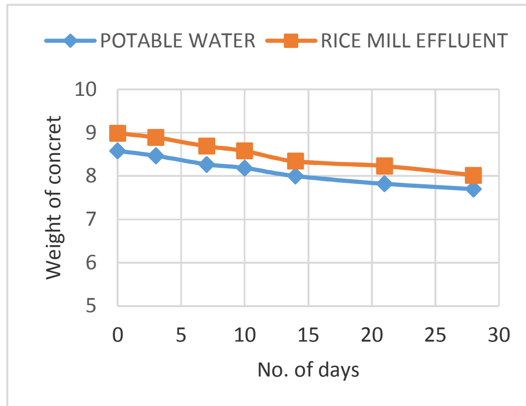
Split tensile strength of M25 grade concrete for rice mill effluent

Specimen No	Strength of concrete (MPa) 7 days	Strength of concrete MPa 28 days
1	**1.54**	**2.85**
2	**1.59**	**2.95**
3	**1.61**	**3.05**

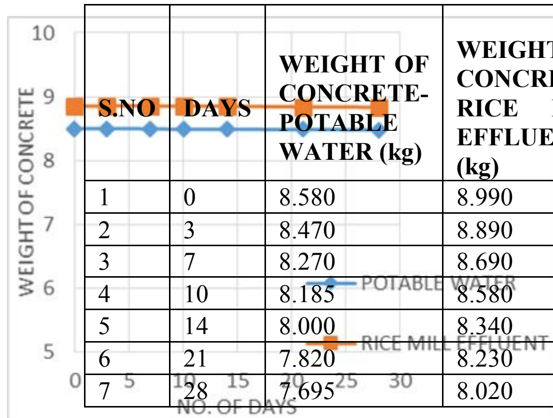
Acid test

S.NO	DAYS	WEIGHT OF CONCRETE-POTABLE WATER (kg)	WEIGHT OF CONCRETE-RICE MILL EFFLUENT (kg)
1	0	8.845	9.025
2	3	8.850	9.035
3	7	8.855	9.040
4	10	8.860	9.045
5	14	8.870	9.050
6	21	8.875	9.055
7	28	8.875	9.055

S.NO	DAYS	WEIGHT OF CONCRETE-POTABLE WATER (kg)	WEIGHT OF CONCRETE-RICE MILL EFFLUENT (kg)
1	0	8.500	8.850
2	3	8.500	8.855
3	7	8.495	8.855
4	10	8.495	8.850
5	14	8.490	8.850
6	21	8.485	8.840
7	28	8.480	8.835

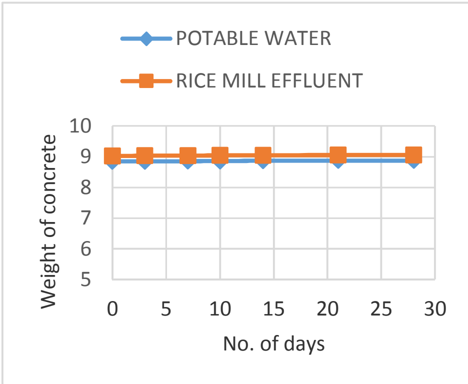


Sulphate attack test



S.NO	DAYS	WEIGHT OF CONCRETE-POTABLE WATER (kg)	WEIGHT OF CONCRETE-RICE MILL EFFLUENT (kg)
1	0	8.580	8.990
2	3	8.470	8.890
3	7	8.270	8.690
4	10	8.185	8.580
5	14	8.000	8.340
6	21	7.820	8.230
7	28	7.695	8.020

Chloride attack test



Sorptivity test

S.NO	DURATION (HOURS)	WEIGHT OF CONCRETE- POTABLE WATER (kg)	WEIGHT OF CONCRETE- RICE MILL EFFLUENT (kg)
1	0	2.450	2.530
2	0.5	2.465	2.555
3	1	2.470	2.562
4	1.5	2.475	2.564
5	2	2.475	2.564
6	2.5	2.475	2.565
7	3	2.475	2.565

Accelerated corrosion test

S.No	Type of concrete	Initial weight of reinforcement rod	Weight of reinforcement rod after 21 days
1	conventional	230g	225g
2	Rice mill effluent	235g	230g

CONCLUSION

Based upon the results obtained during this study, the following conclusion are drawn

- Chemical analysis and the various properties of rice mill effluent like chloride, sulphate and pH. The rice mill effluent contained about 1.33% of chloride and 1.23% of sulphate more than the potable water, which is under the permissible limit of BS recommendation.
- While considering the mechanical properties the compressive strength and split tensile strength is more or less equal to target mean strength.
- While considering the durability properties the sorptivity co-efficient, acid attack, sulphate attack and chloride attack values slightly varies from potable water.
- The result of mechanical properties and durability properties of rice mill effluent shows that it can be used for the construction purposes in the time of water scarcity.
- In the future consideration if admixtures such as (fly ash, silica fume, etc.,) replaced with cement will increases the strength of the rice mill effluent.

REFERENCES

[1] Al-Harthy A.S., Taha R., Abu-Ashour J., Al-Jabri K. and Al- Oraimi S, 'Effect of water quality on the strength of flowable fill mixtures', Cement and composites, Vol. 27, No.1, pp. 33-39.

[2] Kaushik S.K. and Islam S. (1995), 'Suitability of sea water for mixing structural concrete exposed to a marine environment', Cement and Concrete Composites, Vol. 17, pp. 177-185.

[3] Saricimen H., Shameem M., Barry M. and Ibrahim M. (2004), 'Testing of treated effluent for use in mixing and curing of concrete', Research Report, Metrology Standards and Materials Division, King Fahd University of Petroleum and Minerals Research Institute, Dhahran, Saudi Arabia, pp. 91-104.

[4] Cebeci, O. Z. & Saatci, A. M. (1989), 'Domestic sewage as mixing water in concrete', ACI Material, Vol. 86, No.5, pp.503-506.

[5] EI-Nawawy, O. A and Ahmad, S, 'Use of treated effluent in concrete mixing in an arid climate'. Cement and Concrete Composites, Vol. 13, pp. 137-141.

[6] Lee, OS., Salim, M. R., lsmail, M. and Ali, M. l.(2001), 'Reusing treated effluent in concrete technology', teknologi, Vol. 34 (F), pp.1-10.

[7] Santhanam M, Cohen M, Olek J, ' Differentiating seawater and groundwater sulphate attack in Portland cement mortars', Cement and concrete Research, Vol. 36, pp. 2132-2137.

[8] Saika N J, Sengupta P, Gogoi P K, et al, 'hydration behaviour of lime-co-calcined kaolin-petroleum effluent treatment plant sludge', Cement and concrete Research, Vol. 32, pp. 297-302.

[9] Tay, J. H. and Yip, W. K, 'Use of reclaimed water in cement mixing', Environmental Engineering, Vol. 113, no.5, pp. 1156-1160.

[10] Tay Joo Hwa. and Yip Woon Kwong, 'Use of reclaimed Wastewater in Concrete mixing', Environmental Engineering, Vol. 113, no.5, pp. 1156-1161.

[11] Yilmaz A.B., Yazici B. and Erbil M. (1997), 'The effects of sulphate ion on concrete and reinforced concrete', Cement and Concrete Research, Vol. 27, No. 8, pp. 1271-1279.