Providing the Sustainability with the Pozzuolana Concrete Used in Foundation

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Abstract

To provide concrete industry and sustainability development, the amount of cement which releases harmfull gases and wastes while being produced should be reduced. Because using less cement than the amount which is gained as a result of mixture calculation cannot provide necessary performance in the point of resistance, it should be predicated that using the materials which are appraised by changing places with the concrete which has connective quality to provide sustainability. In this study it is aimed to increase the strength by providing impermeability of underground building elements and to provide resistance by the puzzlans which are added in the mixture of concrete by changing places for sustainable environment. To prove impermeability for sustainable environment, a certain percentage of pozzuolanas added to the concrete mix by switching through cement. Permeability of pressure water, capillarity and compressive strength evaluation tests were carried out.on concrete specimens with pozzuolana additive.

Keywords: Foundation, building material, water isolation, sustainability

1. Introduction

Maintaining struggle for life in an environment where natural resources are being consumed rapidly becomes more difficult day by day. In this cycle, the gases which are because of the resources consumed in the production of concrete represents a large deterioration in in the global balance. Gases disclosure in the production of concrete causes increasing in the temperature by annihilating the global balance, reducing water resources by vaporing, creating adverse environmental conditions for respiration and disappearing of natural resources [Dağ, 2001]. Because of these problems with breathing and diseases, unhealthy individuals grow increasingly.

Such health problems can occurrence because of adverse living conditions on the scale of the building; In particular, underground structural elements are exposed to moisture, constant water and chemicals. If appropriate conditions not taken Allergies and respiratory problems can occur on building users in long term. However corrosion of reinforcement, degradation of basement walls by soil chemicals and formation of mold etc in the interior of building can be observed [Sahal, 1992.].

Unfortunately it is impossible to repair hazards in usage stage of building due to building elements replaced being underground like foundation, basement walls, e.c.t. Impermeability but underground structure against water for those parts in isolation may be accomplished by completely [Lufsky, 1980]. Foundations and basement walls covered with bitumen insulation materials to seal against water and chemicals may be concerned. But especially the use of plastic based materials, many of these materials in the production process leads to consumption of resources. Likewise once chemicals materials.etc. In the case of damage by, it is impossible to be repaired again [Neville, 1990]. Therefore in the process of making concrete itself, impermeability consuming natural resources such that the minimum production of sustainability and structure will contribute significantly to the long term performance [Nixon, et. al.,2004].

Consuming the present sources and giving more wastes to the environment result in increasing environmental pollution rapidly. Therefore, for a healthier environment and individuals, ways of destroying the wastes which are left on the environment should be examined and benefiting from the wastes should be considered. Beginning this improvement with the concrete which is produced artificially and appear everywhere provides advantages for the environment.

So the last twenty years, lots of studies have been made about the methods that improve the qualities of the materials by adding a certain range of other substances to the mixture except the main components of concrete. In the light of these advances in technology and science, after the each structure built, all materials produced, there are more efforts to reach the better. These advances have great importance on the point of raising the quality of life and minimizing the difficulties while producing and using. For this aim, it is an important step that using the industrial wastes as a fuel for producing concrete and using the thinnest ones which have the quality of connectivity for increasing the resistance of concrete, at the same time providing the sustainability with concrete by using low rates concrete [Biricik, 1999]. Every step that is made to improve the physical and mechanic qualities of concrete which is used widely in the construction industry because of its economic, plastic and easy application provides important advantages for the environment and resistance.

2. Sustainability in Terms of Environment

Increasing in the number of immigrations because of the limited opportunities in the rural areas, developing of nuclear family in the 20th century, as a result wants of the married young's to live in their own homes and raising in the density of the population cause a raise in the number of construction day by day. All these developments in the world cause rapidly consuming of natural sources used in the concrete and adverse effects on the environment by remaining free of industrial wastes and harmful greenhouse gases. Using the natural sources without thinking as not to be finished causes a raise in global warming and gives a start to natural disasters. The air temperature at more than normal and increasing in the storms, hurricanes and floods give damage to people, nature and structural environment. If it is thought that the structures are not constructed with the high resistance and quality against the natural disasters, the destructions ocur in much larger rates. One way to protect the natural balances is that the cement which is the only component of the concrete that doesn't ocur in the nature should be considered while production.

The things that should be done to provide the sustainability with the way of producing concrete can be summarized in 3 topics.

1. Using alternative fuels while producing concrete
2. Using another connector that can change places with the concrete
3. Using industrial wastes for the production of concrete

Instead of consuming natural sources while producing the concrete, it is an important step to maintain the sustainability by using waste fuels, which live in the nature very long and have harmful effects to the environment in the time that they are present, as a connector material and additive. If it is considered that the world production of concrete is on the level, it is seen that the energy obtained and the amount of using industrial wastes have a very high percentage. Because of this, to provide the sustainability in terms of environment with the way of concrete industry, instead of using natural sources for the production of concrete, using alternative fuels is preferred. To get the maximum efficiency from the alternative fuels, the wastes used should be homogeneous [Massazza, 2001]. In this sense, it is not appropriate that using domestic wastes, which includes variety of wastes, as a fuel before homogenizing. Although all these works cost energy and fuel, when looking at the whole work, it is appeared that 60-130 kg fuel, which is necessary for 1 ton concrete to pass from these works, and 110 kWh are saved.

It can be qualified as a first step to minimize the usage of natural sources in terms of progressing the sustainability. The second step is that reducing the amount of carbon dioxide which appears while the production of 1 ton concrete to minimum. For this aim, the rate of cement used for concrete should be decreased. It is predicted that using the other thinnest pieces of connectors ,which change its place with concrete, for concrete because the need for keeping the percentage of the connectivity which is determined by the mixture calculations constant to produce the concrete belonging to the ideal performance. These second connectors give opportunity to prepare a concrete which is full of cement. Fly ash collected from the chimneys of thermal power plants, slag ground at 6000 bleyn and silica fume are industrial wastes that many studies have been done on cement and concrete industry evaluation in recent years [Çelik, 2004].

3. Sustainability in the Long Term Performance In Under Ground Building Elements

It is not enough for the sustainability in terms of environment to reduce the amount of production of concrete.

On the point of consuming natural resources and reducing the damages to the environment, accomplishment of the service periods of concrete constructions in terms of sustainability without being damaged by the outside factors while being used, being included the process of caring and fixing is a positive development.

Unfortunately; most of the concrete constructions in the world cannot show the necessary resistance against water, chemicals of substructures, gases as radon and to the other environmental conditions. The precautions and reparations which are taken for the damages formed because of these problems show that the natural sources are used in a bad way. The constructions subjected to these problems become practicable after being fixed seriously as a result of high costs, according to the size of damage, and consuming more natural sources. In the situations in which the size of damage occurred is very high and the construction cannot convey the charge coming onto it on the ground, it is necessary for the construction to be collapsed wholly before accomplishing its service period. This situation causes unnecessary consuming of energy and sources and also double costs. Producing quality, strong and high resistance concrete and performing every kind of altruism while producing is necessary for not to encounter with these negative situations. While production of quality concrete, it is necessary that components of the concrete shouldn't have the quality of reducing the resistance and should have the quality of showing high performance. Nonetheless, disposing the concrete without compressing and with bad labour, and not caring the concrete on the necessary level at the end of the breakdown are important factors that affect the long-term performance. Besides all these factors, lots of additives are added into the concrete to increase the quality of concrete which is well-prepared. But it shouldn't be forgotten that whichever the additives are used, the concrete cannot provide the necessary resistance if the concrete is not cared and compressed enough. In the situations that the materials are applied correctly,it is an important reality, which affects the using rate of concrete, that the concrete has less protection against the outside factors in comparison with other materials.

The major factor that shorten the life of concrete constructions is that they are subjected to corrosion because of the interaction of the concrete and the metal with the subterranean or aboveground water. Because of this, to build construction long term service, a concrete that prevents the corrosion which occurs because of the chemical reaction as a result of contact of the construction with water should be produced. Present water source, power that pushes the water into the concrete and spaces that are in relation with each other and give opportunity for water to move into the concrete are needed for water to reach the metal in concrete. Water that pass through the concrete with the pressure of ground water or with the powers of capillary water absorption in concrete causes abrasion on the ground of accessory by moving through the capillary canals and reaching the accessory which meets drawing stress of concrete [Sümer, 1989]. As a result of occurring corrosion, accessory comes to a position that cannot meet the charge coming onto it. Furthermore, the rust that occurs on the ground of accessory causes the weak material to be broken by bringing pressure onto the concrete. The concrete construction that loses its quality of carrying because of corrosion in a situation while charging becomes unavailable before its service life.

Water, not only cause corrosion of the metal in concrete by breaking it but also causes the reduction of resistance of concrete by moving through the spaces of concrete with ions like sulfate etc. in the ground [Atahan et. al, 2003]. The sulfate ion that enters the concrete causes more spaces in the concrete in the length of time. Moreover, it makes the accessories in concrete to be open to outside effects by abrading the surface visibly. All these events cause the reduction in endurance and resistance of concrete. Resistance should be provided by using endurance in order to extend the usage life of concrete. Because of this, moving of the water which affects the concrete in a bad way into the material should be prevented [Aitcin and Neville, 2003]. This situation can only happen by producing a concrete without any spaces in it. For this reason, a material, which fills the capillary spaces in the concrete, which is thinner than cement and which has the high quality of connectivity, should be used in producing concrete. Because filling the spaces and breaking the relations between them prevent the moving of water, it will prevent the damages that are created by water. It is not enough for our aim that the concrete material, which is designed for the sustainability of the environment, is only resistance against the water. At the same time, it should be stabilized against the outside factors like gases as wind, radon and chemicals which the construction faces with.

In order to provide sustainability through resistance, silica fume, which is a fine grained industrial waste resistant to harmful chemicals having the binding characteristic,cinders and volatile ashes were added to concrete by replacing cement in certain percentages and the concrete that is resistant to all those outside influences is tried to be produced. With this method it is aimed that less carbon dioxide and harmful waste will spread to the environment and less natural source will be consumed by decreasing the production of cement.

Also, it is aimed that more resistant concrete will be produced by using the industrial waste in concrete industry. By this way, long-lasting concrete constructions will be built. For this aim, this experimental study is done with sample concrete produced by replacing cement with industrial waste in certain percentages

4. Materials and Methods (Experimental Study)

This experiment is done with the aim of providing sustainability by using the pozzuolana that are industrial wastes and producing high-performance concrete. Using industrial wastes in this way as concrete components provides an impervious pore structure that is high-compact in economy and concrete. It is also of high importance in terms of searching the effect of multicomponent on the resistance and sustainability of the concrete.

In this study, 42,5 per cent of dolomitic limestone aggregate, sea sand and Portland cement, details of mixture composition of which given in Table 4.1, are used. Water / binding proportion is fixed as 0.33, and taken as 400 kg/m3. In order to provide machinability Gleniurn is used in proportion of %0.9 of binding. In the production of concrete, sand is grouped by sifting to the size of broken stone pieces numbered as I and II, and the mixture is formed by taking from each group in certain percentages. Silica fume, cinders, fly ash, lime powder and limestone filler are added as cement and pozzuolana. Real amounts of all used components are given in table 4.2 and chemical analysis of cement and other mineral additions and mineralogical components are given in table 4.1[Şimşek, 2005].

Table 4.1: Real Material Proportions for 1 m^3 Fresh Concrete

Chemical Analysis	Cement	Silica Fume	Slag	Flay Ash
	(%)	(%)	(%)	(%)
SiO_2	19.86	83.84	35.80	51.50
Al_2O_3	5.50	0.46	13.78	23.08
Fe_2O_3	3.55	1.32	1.17	6.07
CaO	64.27	1.35	39.06	10.53
MgO	1.19	4.84	5.95	2.42
SO_3	2.66	1.30	1.31	1.32
Na_2O	0.23	0.53	-	0.77
K_2O	0.76	3.63	-	2.54
$CaCO_3$+$MgCO_3$	-	0.75	-	
Chloride (Cl^-)	-	0.14	-	0.0028
Loss of Ignition	1.81	2.47	0.71	1.06
Undissolved matter	0.31	-	-	-
COMPONENETS OF MINERALOGY (%)				
C_3S	54.23	-	-	-
C_2S	16.11	-	-	-
C_3A	8.58	-	-	-
C_4AF	10.80	-	-	-

Physical Properties	
İnitial Set (minute)	155
Final set (minute)	190
Stability of Volume (mm)	1.0
Specific Area (Blaine) (cm²/gr)	3670

MECHANİCAL PROPERTİES	
Days	**Compressive Strength (N/m)**
7	40.8
28	51.0

Note:
Silica fumes Spacific Area is 14,400 cm²/gr.

Slags Spacific Area is 5500 blaine

Flay ash's grain dispersion: 0.5-30µm

In each of the produced groups, the experiments of unit weight and precipitation in fresh concrete, compressive strength, pressure water permeability and capillary water absorption are done. The experiments are done on three each samples and the graphics are drawn through calculating their functional value using their arithmetic average. Impermeability (Maximum depth, done to the TSEN 12390---8 water manipulation depth standard, was measured.) and pressure experiments are done in cubic samples in the size of 15 cm, and the experiments of capillary water absorption are done in cylindrical samples in the size of 7/7 cm. 45 samples for pressure experiment on the 7th, 28th and 90th days, 30 samples for water manipulation and 30 for capillary water absorption experiments on the 28th and 90th day are produced. 105 samples are produced in total [Şimşek, 2005]. Also eculations showed in **Table 4.3** are used in concrete mixture calculations

Table 4.2: Details of Mixture Composition

Mixture Code	Cement (%)	Slag (%)	Silica Fume (%)	Flay Ash (%)	Lime (%)	Limestone Filler (%)
Şahit	100	-	-	-	-	-
1.serie	50	42	8	-	-	-
2.serie	50	38	8	-	4	-
3.serie	50	38	8	-	-	4
4.serie	50	38	-	8	-	4

Table 4.3 Mixture Calculations of 1000 m^3 Concrete

$v = v_ç + v_s + v_{ag} + h$
$fb = fb / ax w^2$
$1000 = W_c/\delta_c + W_s/1 + W_u/\delta_u + W_v/\delta_v + H$

4.1. Material Used in the Experiment

In the production, silica smoke from Antalya Ferrokrom facility, ct!ruf from AkçanSa Cement Factory, volatile ash from Yatağan Thermal Power Plant, lime stones from ÇimSa Cement Factory and lime (CaCO3) from Labor Company are provided. YKS Glenium 51 which is a new generation additive is used. Chemical and physical qualities of mineral additions which are used in the experiment are given in the table 2.1 [Şimşek, 2005].

The concrete which is produced without additive for preparing examples is called witness concrete which is produced for control. In other series, rate of 50% cement is kept constant and different pozzuolana additives are used in the other rate 50%. In the first one in the ratio of 42% cinder and 8% silica smoke are added. In the 2. 3. and 4. series, the rate of 38% cinder is kept constant. In the series 2, addictive to this, rate of 8% silica smoke and 4% lime are added. In the serie 3, keeping the rate of silica constant, limestoneare added instead of lime with the same rate of lime. In the series 4, different from series 3, volatile ashes are added instead of silica smoke with the same rate of silica. The details of prepared mixture composition specified in the table 4.2 [Şimşek, 2005].

All the components are mixed in a concrete mixer which has vertical axis, coercive blender and a kind of 50 ltlaboratory. After the mixture process, unit burden and consistency experiments are done, then, the concrete is disposed by being stabbed to the blocks which have 15 cm edge size; the surface of the blocks are fixed with templet and it is protected for 24 hours by being covered on a smooth ground by wet polymers.

After 24 hours of production, the examples are taken out from the units and left to water pools, which is statured with lime at 20 C° until the experiment day. They are left to get dry to the laboratory atmosphere, which has 18 ± 4 C° and %47.66 relative humidity, 24 hours before the pressure and impermeability experiment which would be done in 7. 28. and 90. days of the production and 48 hours before the capillary experiments.

To get the equal efficiency from the prepared examples, after the mixture process, experiments about unit burden, slump and amount of space are done. Air contents that are related to each series are given **Table 4.2** by benefiting from Mariotte laws to determine the amount of air in the prepared fresh concrete.

5. Results and of the Experiment and the Evaluation

On the 28. and 90. days of the concrete examples that completed its cure, impermeability, pressure and capillary experiments are applied orderly. While the pressure and capillary experiments are applied orderly on the same example, capillary experiment is done on an example which is designed only for this experiment.

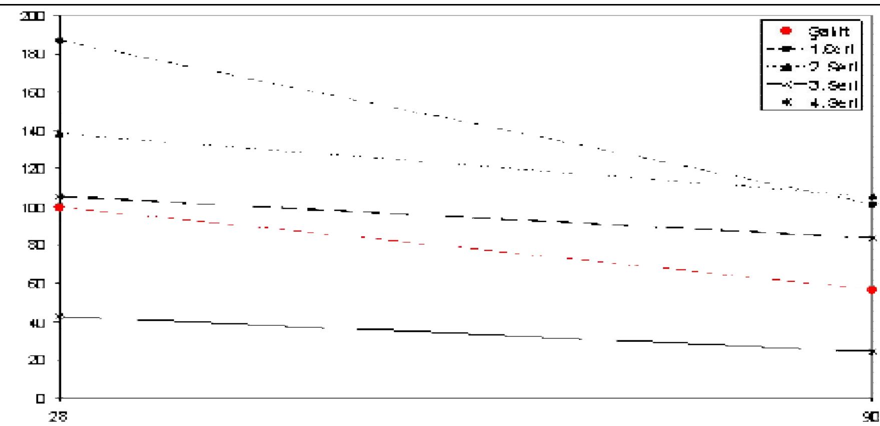
30 examples which will be used in the experiments that will be made on the 28. and 90. days of the production, are left to get dry in the laboratory conditions by takingout from the water 15 days before the day when the experiment is done. On the day of experiment, during 72 hours, permeability experiment is done to the measured dry examples with the impermeability tool under 5 KB pressure. At the end of 72 hours, the change of its burden on the body is observed by getting out the example which was connected to impermeability tool and measuring it again on the accurate steelyard.

5.1 Results of Impermeability Experiment

When looking at the average valuation which are shown on the Table 4.1;

- Permeability deepness of all series shows a decline on day 90 in comparison with the day 28.
- All series except the series 4 reach higher valuations on both the day 28 and 90 in comparison with the witness group.
- While the series 3 has the same valuations with the witness group, series 1 and 2 have higher permeability deepness, with the rate of orderly %87 and %38 on the day 28 and orderly %45 and %49 on the day 90. The serie 4 has lower valuations in comparison with the witness group with the rate of %57 on the day 28 and %33 on the day 90 (figure 5.1).

Max. Relative Permeability Deepness (%



Days

Figure 5.1: Water Permeability Deepness

- In accordance with these valuations, when permeability deepness is considered, series 1 and 2 showed lower and series 4 showed higher performance.

5.2. Results of Compressive Strength Experiment

When looking at the average valuation which are shown on the table 4.2;

- On the day 7 and 28, while all the series have lower rate of endurance in comparison with witness group, on the day 90, they reached higher rate of endurance. This situation has showed that the rates of additives have puzzonalaqualities. While pressure endurance of the puzzonalaadditive concretes have lower rates during the first 28 day, their endurance reaches the maximum rate on the day 90.
- While the witness group shows a decline of %3 rate on the day 90, serie 1 has showed an increase of %9, serie 2 %5, serie 3 %11, and seri4 %7 (figure 5.2).
- In addition to clinger, in the serie 4 where %8 volatile ash and %4 limestone are used and in the serie 1 where %8 silica smoke is used, same increase of compressive strength is observed.
- In serie 4 which includes %4 lime, minimum increase of pressure endurance is observed.
- Increasing the amount of cinder as an additive has increased the value of pressure. However, in the situation when lime is added to the concrete as a pozzuolana, decline of relative pressure rate is observed. In the serie 3 and 4 where %38 rate of cinder and %4 rate of limestone's are added,, different from serie 3, collative ash is added in the serie 4 instead of %4 rate of silica smoke.
- It can be said that the concretes which forms the serie 1 with the rate of %42 cinders and %8 silica provides the most appropriate performance. Because there is a difference between the serie 4 and 1 in terms of relative pressure with the rate of %0.3, it is possible to gain the high performance from this serie.

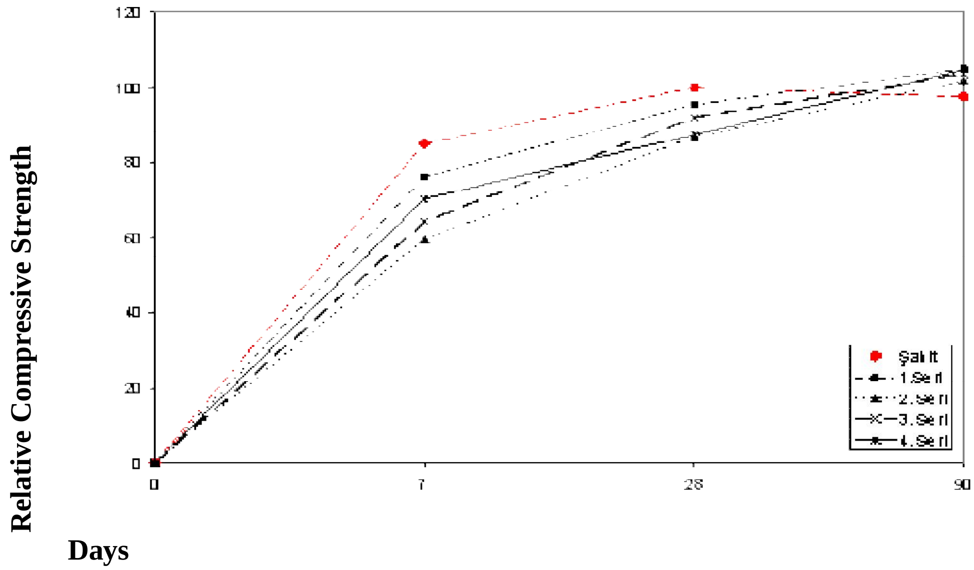


Figure 5.2: Compressive Strength

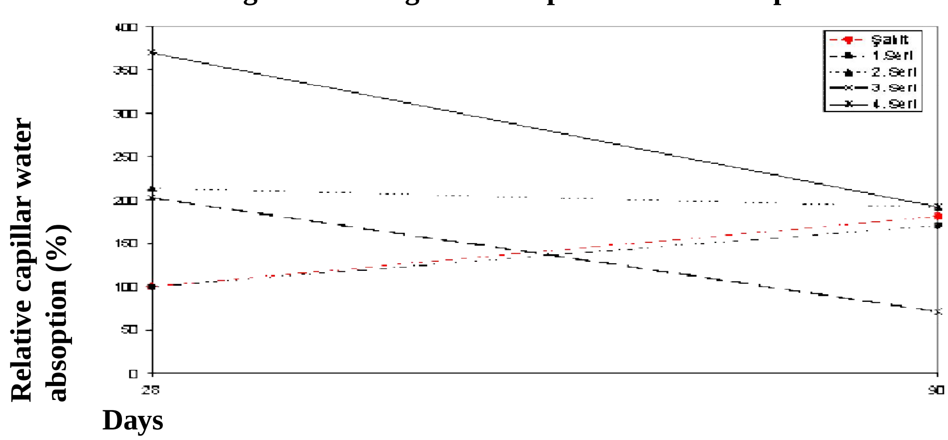
5.3 Results of Absorption of Capillary Water Experiment

Absorption of capillary water experiment is done on the day of 28 and 90 for all groups in the 70mm scale cylinder examples in which the burden units and size of water absorption is determined. The grounds which contact with water and has 70 mm scale is measured by 1/20 vemiyer sections and real values are calculated by taking the average. To prevent the capillary lines not to fill with outsider materials, being siliconized after being brushed, the surface of the dried examples which is in contact with water should be located in a steel tray on the glass baguettes. The inside of the tray is filled with water 3mm above the baguette bell. In this way, contact of the example with water is provided.

The amount of water Q which the examples absorb from the ground contacting with water by capillary is determined by being measured on the minutes 1..4.,9.,16.,25.,36.,49,64.. This experiment is repeated again for all the groups. To determine the quotient of capillary, linear connection between Q/F and q t is benefited. Relations about absorption of capillary water is shown on the table 3. When analyzing the table 3;

- Showing similarity with witness group capillary quotient of the series on the day 90 increased approximately %70 in comparison with the day 28 (figure 5.3).
- However, while all the other series have higher values on the day 28, on the day 90 values of capillary showed an decrease.
- Although the serie 4 which has the highest value on the day 28 with the rate 6,94E----09 showed a decrease with the rate of %48, with the serie 2 it reached the highest quotient which is 3,60E--09 on the day 90.
- The additive rate group which develops the serie 3 that reached the highest capillary rate 1,34E----09 at the end of the day 90 can be advised at the end of this experiment.

Figure 3.3: Diagram of Capillar Water Absoption



6. Discussion

İt is impossible to kept away ground water from the remaining parts of the building under the earth. However, it is possible to protect the underground building parts from the damages that may occur over time by prevented ground water penetration into the concrete. Ground water effects to building foundation basically in two ways;

- pressurized or
- unpressurized

In order to avoid water penetration of ground water, primarily it should be determined how it will effect to concrete and it should be determined a suitable concrete mix.

It is showed that, while the lime that added to the concrete mixture replacing with cement ratio shows a performance to decrease the pressure endurance, it decreases the permeability deepness with the value of water absorption. Using 4% lime in unexpected high strength performance building where built in places having rich ground water, may be provided Suitable water isolation by tightening the pores of the concrete structure and avoiding entry into water. Volatile ash and silica smoke show same qualities on the pressure endurance. However, using limestone's instead of lime increase the rate of pressure and decrease the rate of permeability deepness. Because of the fact that, using limestone instead of lime increase the compressive strength but also reduces the depth of water impermeability.

While silica smoke increases the compressive strength, it causes to decrease the rate of water absorption. While the volatile ash provides the raise in values of pressure and capillary water absorption, it decreases the permeability deepness.Both the permeability deepness in a pressurized situation and rates of capillary water absorption showed different performances in each additives. Because of this, both the present water source and the type of concrete creeping should be determined before and a solution should be found according to the source of problem.

Using the amount of cement by replacing with industrial wastes with the rate of %50, decreasing of production of concrete fifty fifty and using natural sources with the same rate provide a decrease for the harmful side line products and $CO^{2.}$ Furthermore, concretes that have more endurance, lower rate of permeability deepness and capillary water absorption, in brief, have more resistance against outside factors can be produced by using industrial wastes in this way. It can resist against outside factors as earthquake and help to provide security for life and property.

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