Study of Isolation Methods of Underground Structures By using Concrete Admixtures

A. A. Elsayed

Abstract:- Waterproofing of underground structures is frequently a problem and a range of solutions have been tried in the last two decades. Dominating the market are PVC and HDPE (high density poly ethylene) sheet membranes, but recently the alternative, is concrete admixtures for water permeability reducing and so that use in concrete isolation (waterproofing), the longevity of a concrete structure is influenced by the permeability of the concrete. The main objectives of the research are to study the mechanical properties of concrete and the improvement these properties by adding waterproofing using various mount percentages and two types of waterproofing (ADDICRETE DM2-PLASTOCRET-N) series of experimental studies were carried out on plain concrete with added, ADDICRETE DM2 and PLASTOCRETE-N in order to investigate their properties and influence on the water permeability of concrete. In this study, it has been addition ADDICRETE DM2 and PLASTOCRETE N to the mixture by difference ratio. 1%, 0.5%, 0.45% ,0.35% of cement weight, constant ratio from , sand, gravel, cement and water W/C equal to 0.45 in all tests that used in the research . The study of these tests by measuring the permeability of concrete specimens prepared in the laboratory. Many tests were carried out and the results were presented.

Keywords waterproofing; ADDICRETE DM2, PLASTOCRETE-N, permeability, concrete.

I. INTRODUCTION

Since the underground structures have existed, there has always been the problem of water infiltrations. Historically, we all know that water and moisture are the most important elements that cause damage to concrete structures. The reason is that the groundwater contains chemical substances that damage the structure and may lead to reinforcement corrosion and losing the structural ability of the structure. Some concrete crakes that would allow larger amounts of water and humidity to leak into concrete. As a result, the structure would collapse if it is not maintained properly. Such a problem would not enable us to use and infest this structure in an optimum right way, and would damage the materials stored inside and affected by humidity. Therefore, it was must to protect these structures against humidity by many ways. One of these ways by adding water isolating substances to the concrete mix to greatly reduce water permeability through concrete [6]. This substance must be designed and conducted according to the standards of the material used for isolation. It should be used according to the right rates, type of the structure, and the surrounding circumstances, as well [8]. Fundamental distinction has to be made between tunnels sealed against pressured water and against seepage loss water. In this case very heavy duty membranes are required and are necessary to apply on the full surface. In these underground structures, damage to various facilities inside the structure by the leakage of water, Or the extra costs required to prevent the leakage can become a problem as a measure, therefore it has been searched for many methods for isolating the underground structure from the ground water leakage into concrete. One of this problem of water infiltrations of interior of underground structures appeared in recent years of the Ahmed Hamdi tunnel. Rehabilitation of the ahmed hamdi tunnel under the suez canal. The Ahmed Hamdi Tunnel provides a crossing under the Suez Canal for motor vehicles. It was originally constructed as a shield tunnel by the British government in 1983. It is 1.63 km long and has an outside diameter of 11.6 m. Leakage of salt water through the reinforced concrete lining of the Ahmed Hamdi Tunnel was discovered very soon after construction was completed. The salty water quickly corroded the steel and degraded the concrete, leading to serious deterioration of the Tunnel lining, in 1992 construction commenced on a Japanese government grant aid project to rehabilitate the tunnel. NCC and Nippon Koei formed a joint venture and were engaged by the Japanese government to provide the engineering consulting services for the project. the joint venture thoroughly investigated the deteriorated tunnel lining, determined the appropriate rehabilitation method, prepared the design, supervised construction, and introduced monitoring and maintenance systems. The design called for first installing a 2 mm-thick waterproof sheet along the inside of the existing tunnel lining as a barrier to water. A sump pump drainage system was installed in the base of the tunnel to dispose of accumulated water. A secondary reinforced concrete tunnel lining was then constructed inside the original one, with the waterproof sheeting sandwiched in between. The secondary lining was designed to be structurally independent of the existing tunnel segments.

It is clear that leakage is the most significant problem. Not only does water leakage present a problem in itself, but most of the other structural problems encountered by tunnel derive from tunnel water intrusion, through walls and roof structures. To better understand the problems faced in the inspection of subway tunnel systems the deterioration mechanisms, the environmental factors that influence the rate of deterioration, and experiences with automated tunnel inspection systems in Japan, were reviewed. Deterioration Mechanisms

Subway tunnels are continuously subject to severe environmental and man-made conditions causing deterioration in materials. For example, New York City Transit has several tunnels under rivers. Leakage of water or flow of water between the soil and the tunnel walls is a major cause of deterioration in such tunnels. Some older tunnels also consist of thin steel tubes lined with masonry, which also are susceptible to moisture related deterioration.

Leakage of water leads to corrosion of the reinforcing steel in concrete, leaching of material from the concrete (e.g. calcium hydroxide), erosion of soil behind tunnel walls, changes in active earth pressure on tunnel walls, and cracks in tunnel linings.

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A.A. Elsayed, Associate Professor, Department of Civil Engineering, Modern Academy for Engineering and Technology, Cairo, Egypt.

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Water Leakage in tunnels is a major cause of damage to tunnels walls and linings. Many subway tunnels are either “under-river tunnels” or are constructed below the ground water table. Hence, leakage of water or flow of water through cracks causes corrosion in concrete, erosion of soil behind tunnel walls and propagation of cracks in tunnel linings [28]. The main objectives of the Research: Experimenting the substances that are going to be added to the concrete mix, Study of effect of the addition materials on the water permeability in underground structures concrete. and selecting a substance that is economical and useful in isolation of underground structures.

II. SCOPE OF ADMIXTURES

To create waterproofing concrete without the need for addition membranes or perhaps supplemented with additional protection is certain instances [17].

- Result in a concrete that is durable to environmental degradation, primarily through reduction in permeability, and perhaps also providing supplemental chemical protection.
- Result in no major side effects to the concrete .i.e. will not seriously affect concrete properties in negative manner.
- And that it is not overly expensive.

III. THE EXPERIMENTAL DESCRIPTION

The water impermeability test results on plates were presented in tables and figures. Each water impermeability test result was the average for 3 test specimens, as a rule testing of specimens begins at an age of 28 days [2,9,13]. Any device can serve as a test apparatus into which the test specimen of the given dimensions can be installed, so that the water pressure acts on the required face and the remaining faces can be observed see Figure (1) and which allows the following test procedure to carry out. Hence the water pressure may act downwards on the test specimens. At first a pressure of 1 bar is applied for 48 hours, then pressures of 3 bar and 7 bar, each for 24 hours, one after the other. The test can be stopped if water comes through. Next, one must determine whether and under what pressure and, as far as possible, also after what time the test specimen becomes damp, apart from the surface exposed to the water. Immediately after the test, the test specimen – plate lying flat- is to be plate in the middle (photo.1), e.g. by compression applied on two round steel bars lying on opposite sides, above and below. As soon as the split surface has dried somewhat, the greatest penetration depth in mm and the distribution of the water penetration are to be established. When splitting and making this examination, the side of the test specimen exposed to the water pressure should face downwards. The greatest water penetration depth [7], measured on the tested concrete, is taken as the average value of the greatest penetration depth on three test specimens.

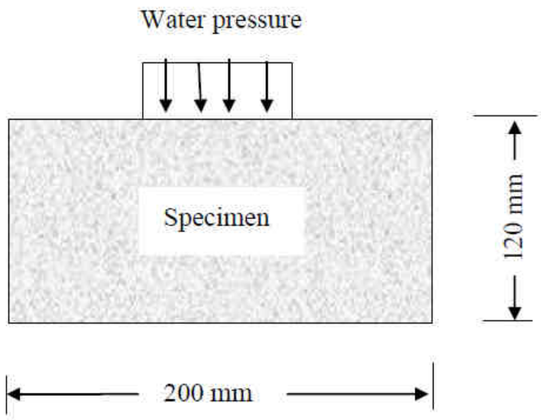

FIGURE (1) TESTING WATER IMPERMEABILITY ON SAMPLE, 120MMX200MMX200MM

PHOTO (1) DEPTH OF WATER PENETRATION INTO SAMPLE AFTER TEST.

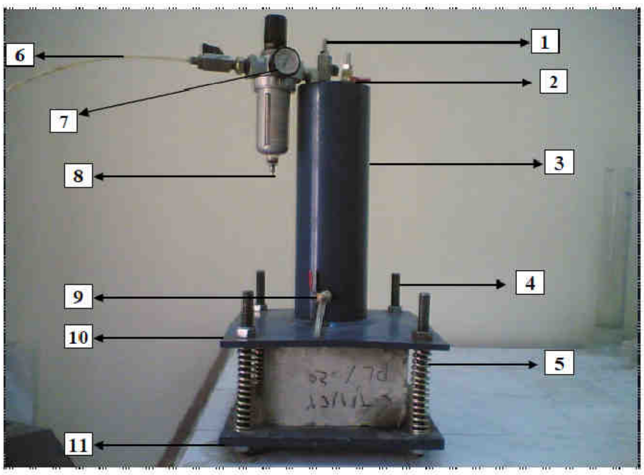

PHOTO (2) APPARATUS PERMEABILITY TEST

1. Water inter 1/4in	2. Ventilation (air out)	3. Water tank $\phi 100mm$
4. Screw bolt $\phi 16mm$	5.Spring	6.Air pressure
7.Pressure gauge	8. Water separator	9. Darning
10. Upper plate 30x30x1cm	11.lower plate 30x30x1cm	

IV. EXPERIMENTAL TESTS RESULTS

1.1. EFFECT OF ADDITIONS ON PERMEABILITY

1.1.1. FIRST CASE:

It has been added ADDICRETE DM2 [15] to the mixture by difference ratio. 1%, 0.5%, 0.45% ,0.35% of cement weight, constant ratio from , sand, gravel, cement and water

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in all tests that will used in research for reaching a suitable ratio from ADDICRETE DM2 and give us a good result to prevent penetration of water to concrete, we can using it as isolation material in underground structure and tunnel. And give us less cost.

Table (1) includes the results of testing three samples, where penetration of water was measured inside the sample after it was broken from the middle of span. The sample without any addition and was divided to (cm). The average of the three samples was drowned showing the average line of penetration of water as show in Figure (2). Table (2) includes the results of testing three samples to all ratios that used from ADDICRETE DM2 material, where penetration of water was measured inside the sample after it was broken from the middle of span. The sample divided to centimeters. An additive named (ADDICRETE DM2) was added to the sample with a ratio of 1%, 0.5%, 0.45%, and 0.35% of cement weight. The average of the three samples was drowned showing the average line of penetration of water as show in Figure (3).

TABLE (1) RESULTS OF TESTING THREE SAMPLES WITHOUT USING ADMIXTURE

Dimensions specimen	Admixture dose %	Specimen measure From start point (cm)	Penetration distance (mm)			Penetration Average (mm)
			Specimen (1)	Specimen (2)	Specimen (3)	
120 mm 200 mm × 200 mm	0	0	0	0	0	0
		2	18	0	0	6
		4	27	8	10	15
		6	27	16	22	21.6
		8	29	19	25	24.3
		10	24	22	24	23.3
		12	22	26	30	26
		14	27	21	36	28
		16	31	15	33	26.3
		18	26	10	28	21.3
		20	0	0	0	0

4.1.2. COMPARING THE RESULTS OF THE FIRST CASE

Of testing with respect to the ratios of the additives ADDICRETE DM2 0.0%, 0.35%, 0.45%, 0.5%, 1% of cement weight . The figure (3) shows the difference and pointing to the ratio of 0.45% that the best result as it was the smallest value of penetration in concrete with respect to the others.

1.1.2. SECOND CASE

It has been addition PLASTOCRETE- N to the mixture by difference ratio. 1%, 0.5%, 0.45% ,0.35% of cement weight, constant ratio from , sand, gravel, cement and water in all tests that will used in research for reaching a suitable ratio from PLASTOCRETE -N5 and give us a good result in prevent penetration of water to concrete we can using it as isolation material in underground structure and tunnel. And give us less cost. Table (3) includes the results of testing three samples to all ratios that used from Plastocrete N material, where penetration of water was measured inside the sample after it was broken from the middle of span. The sample divided to (cm). An additive named (PLASTOCRETE- N) [24], was added to the sample with a ratio of 1%, 0.5%, 0.45%, and 0.35% of cement weight. The average of the three samples was drowned showing the average line of penetration of water as show in Figure (4).

TABLE (2) SUMMARY OF THE DIFFERENT RATIOS WITH THE AVERAGE WATER PENETRATION DEPTHS BY USING ADDICRETE DM2

Specimen Measure From start Point (cm)	Penetration Average ADDICRETE DM2 0 %	Penetration Average ADDICRETE DM2 1%	Penetration Average ADDICRETE DM2 0.5%	Penetration Average ADDICRETE DM2 0.45%	Penetration Average ADDICRETE DM2 0.35%
0	0	6.3	0	0	0
2	6	10	0	0	2
4	15	11.3	14.6	0	10
6	21.6	21.3	11.3	9	16.6
8	24.3	27.3	11	14.3	14
10	23.3	21.6	15.6	4.3	23.3
12	26	19	7	1	19.3
14	28	14	6	0	9.6
16	26.3	7.6	5.6	0	5
18	21.3	7.6	3.3	0	2.3
20	0	2.3	0	0	0

4.1.4. COMPARING THE RESULTS THE SECOND CASE

The testing with respect to the ratios of the additives PLASTOCRETE- N 0.0%, 0.35%, 0.45%, 0.5%, 1% of cement weight . Figure (4) shows the difference and pointing to the ratio of 0.5% that the best result as it was the smallest value of penetration in concrete with respect to the others.

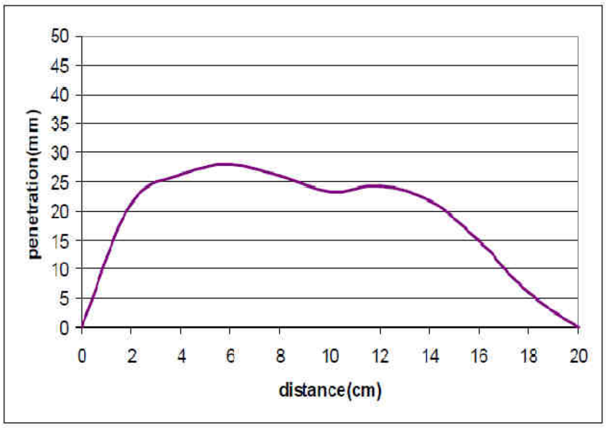

FIGURE (2) WATER PENETRATION AVERAGE CURVE IN SPECIMEN WITHOUT ANY ADMIXTURE

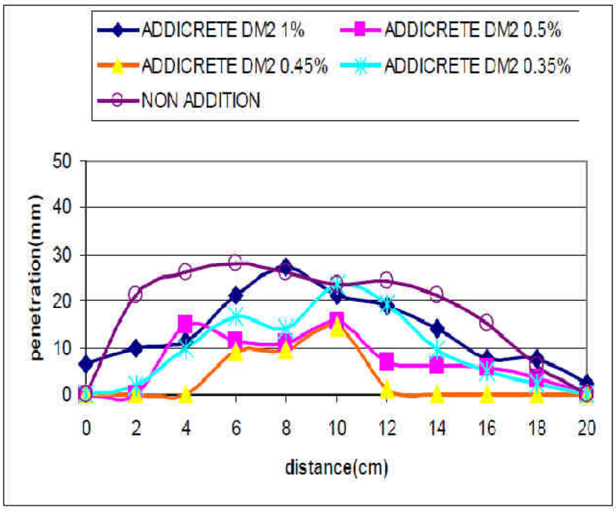

FIGURE (3) AVERAGE WATER PENETRATION CURVES WITH DIFFERENT ADDICRETE DM2 RATIOS.

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TABLE (3) SUMMARY OF THE DIFFERENT RATIOS WITH THE AVERAGE WATER PENETRATION DEPTHS PLASTOCRETE–N.

Specimen Measure From start Point (cm)	Penetration Average PLASTOCRETE N 0 %	Penetration Average PLASTOCRETE N 1%	Penetration Average PLASTOCRETE N 0.5%	Penetration Average PLASTOCRETE N 0.45%	Penetration Average PLASTOCRETE N 0.35%
0	0	0	2.3	11	0
2	6	15.6	5.6	15.6	13.3
4	15	23	17	20.6	21.3
6	21.6	19.3	9.3	16.3	26.6
8	24.3	18.6	13.6	17.3	26
10	23.3	23	11	22	21
12	26	22.3	15.6	23.6	21.3
14	28	21.3	17.6	22	15.6
16	26.3	18.3	7.3	20	21.6
18	21.3	9	5	17.3	17
20	0	0	1.3	9.6	3

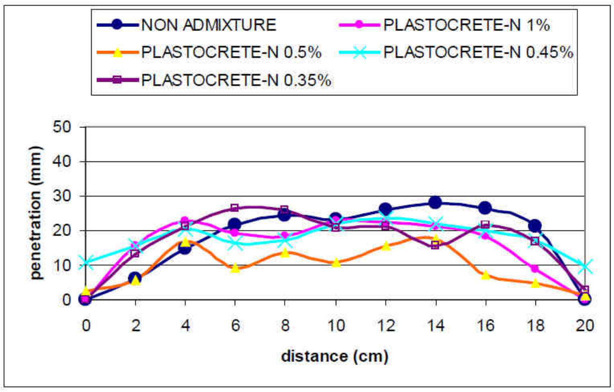

FIGURE (4) AVERAGE WATER PENETRATION CURVES WITH DIFFERENT PLASTOCRETE –N RATIOS

V. EFFECT THE ADMIXTURE ON COMPRESSIVE STRENGTH (THE SPECIMEN WAS TESTED AT 28 DAY)

5.1. First case: Admixture of ADDICRETE DM2 by ratio 0.35%, 0.45%, 0.5%, 1% of cement weight on concrete and we have good results, the best ratio was 0.45%, we have good stress at ratio (0.45%) compared with respected to the others and without any admixture on concrete it shows the flowing Table (4) and Figure (5). These results insure the effectiveness of the ADDICRETE DM2 to improve properties of concrete from against reducing permeability and increase the resistance.

5.2. Second case; Admixture of PLASTOCRETE- N by ratio 0.35%, 0.45%, 0.5%, 1% of cement weight on concrete and we have good results, the best ratio 0.5%, we have good stress at ratio (0.5%) compared with respected to the others and without any admixture on concrete it shows the flowing Table (5) and Figure (6) These results insure effectiveness the PLASTOCRETE N to improve properties of concrete from against reducing permeability and increase the resistance Figures (7) and (8) by comparing between Addicrete DM2 and plastocrete-N of so that (permeability, compressive strength), the ratio 0.45% of Addicrete is the best ratio for reducing permeability of concrete.

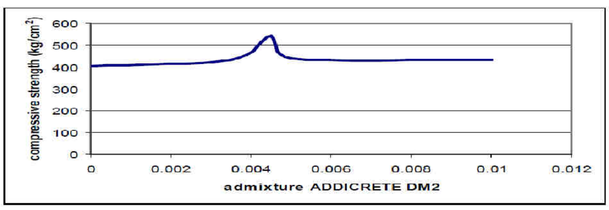

FIGURE (5) AVERAGE COMPRESSIVE STRENGTH CURVES WITH DIFFERENT ADDICRETE DM2 RATIOS

TABLE (4) COMPRESSIVE STRENGTH BY USING DIFFERENT ADDICRETE DM2 RATIOS.

Dimension of Specimen cm	Age of concrete	Admixture ADDICRETE DM2%	Compressive strength Kg/cm^2			Average Strength Kg/cm^2
			Specimen (1)	Specimen (2)	Specimen (3)	
15x15x15	28 days	0	426	453	342	407
		0.35	450	457	390	432
		0.45	455	515	551	540
		0.5	400	467	453	440
		1	453	422	431	435

TABLE (5) COMPRESSIVE STRENGTH BY USING DIFFERENT PLASTOCRETE N RATIOS.

Dimension of Specimen cm	Age of concrete	Admixture Plastocrete N %	Compressive strength Kg/cm^2			Average Strength Kg/cm^2
			Specimen (1)	Specimen (2)	Specimen (3)	
15X15X15	28 days	0	426	453	342	407
		0.35	422	400	414	412
		0.45	441	442	390	424
		0.5	453	444	398	432
		1	401	444	401	415

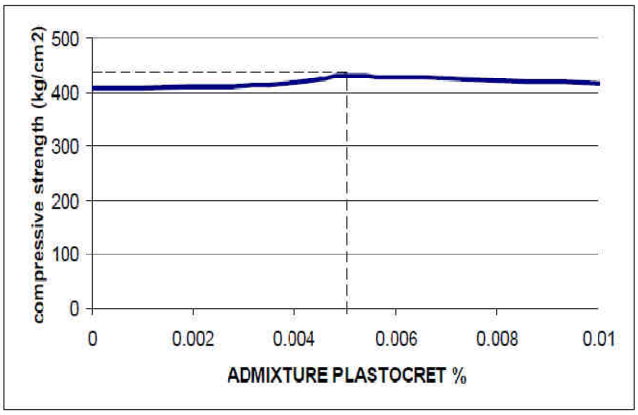

FIGURE (6) AVERAGE COMPRESSIVE STRENGTH CURVES WITH DIFFERENT PLASTOCRETE N RATIOS

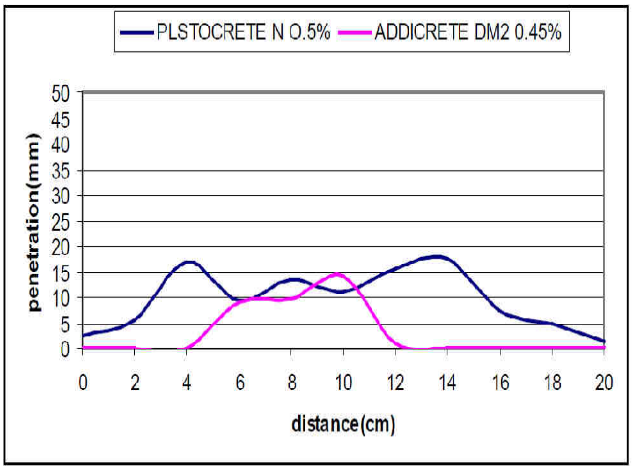

FIGURE (7) COMPARISON OF THE 0.45% ADDICRETE DM2 AND 0.50% PLASTOCRETE-N PERMEABILITY TEST RESULTS

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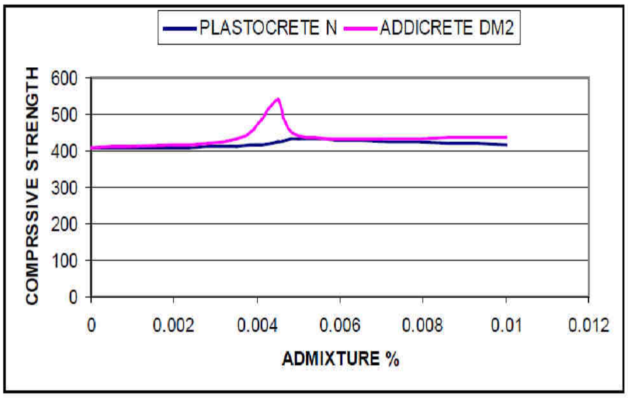

FIGURE (8) COMPARISON OF THE 0.45% ADDICRETE DM2 AND 0.50% PLASTOCRETE-N COMPRESSIVE STRENGTH TEST RESULTS

VI. CONCLUSIONS

1- The research quantify effectiveness the addition materials in reducing permeability and using in concrete isolation operation of underground structures
2- the results insure the effectiveness of ADDICRETE DM2 and PLASTOCRETE-N to improve properties of concrete to reduce permeability and to increase the resistance.
3- The ratio of 0.45% of cement weight of ADDICRETE DM2 gives the smallest value of 14.3mm water penetration.
4- The ratio of 0.50% of cement weight of PLASTOCRETE-N gives the smallest value of 17.6mm water penetration.
5- The ratio 0.45% of cement weight of ADDICRETE DM2 is the best ratio from ADDICRETE DM2 and PLASTOCRETE-N .It gives a good results in reducing permeability about 50% and increasing the compressive strength of concrete of 25%.

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