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Concrete Permeability as affected by Using Egyptian Local and Pozzolanic Materials

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Keywords

Hardened concrete, Metakaolin, Water permeability of concrete, Addicrete DM2, Addicrete BVF, Silica fume.

Abstract

This research presents experimental trials were done to evaluate optimum dose of SF and MK and super plasticizers by weight of cement the effect of using combination of silica fume (SF) and super plasticizer such as addicted DM2 and addicted BVF with Portland cement (EL-Mohandes Asyut Cement 42.5) and the effect of using of silica fume (SF), Metakaolin (MK) and addicted DM2 with Pozzolanic cement (Asyut Pozzolanic Cement 42.5) all separately on the permeability of concrete using three types of gravel red gravel and white gravel and two types of sand. The results showed that using combination of silica fume, metakaolin and super plasticizer in the concrete mix improves the properties of hardened concrete, especially concrete permeability. The optimum doses of SF, MK and super plasticizer such as addicted DM2 and addicted BVF were 14.3, 15, 0.3, and 2.2% respectively by weight of cement. Optimum dose of local materials SF and MK in this research equal to 14.3% and 15% by weight of cement. Also, optimum dose of super plasticizer type DM2 and BVF were 0.3% and 2.2% by weight of cement at which occurs maximum compressive strength of concrete. Results show that, Combination of local materials type SF and MK with their optimum dose in the concrete mix containing super plasticizer type DM2 and BVF leads to a noticeable decrease in the concrete permeability.

1. Introduction

Concrete is the main ingredient in ever growing construction industry of Egypt. It contains pores that allow Water substances to enter. Larger pores allow easier entry, while smaller pores decrease the rate at which these substances enter the concrete. Water Permeability is one of the main physical effects which lead to problems in the durability of structures.

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This effect can cause the structures to be out of service, and loss of life and property by occurring permanent damage in the structures. Resistance against water is a key parameter related to the durability of concrete structures under hydrostatic service conditions. Concrete, which is a kind of Water absorbent material, shows physical and chemical changes in its microstructure during the exposure of water or possible Humidity. Changes in the physical and chemical structures of concrete, exposed to the water, cause the decrease in its strength. Durability of concrete is determined by its resistance to the penetration of water and diluted deleterious substances. In a concrete structure, water may penetrate through cracks, joints, construction defects, and concrete matrix. Considering the greater sizes of the flow paths in cracks, joints, and construction defects, the volume of the penetrated water may be more significant compared to the water penetrated through concrete matrix. However, proper structural design (crack control), joint detailing, and construction practices can minimize the risk of water penetration through cracks, joints, and construction defects. In such cases, the water penetration through concrete matrix becomes more important and should be considered when the durability and water tightness of structures are to be assessed. Concretes containing pozzolanic materials such as Silica Fume (SF) and Metakaolin (MK) is used extensively throughout the world for their good performance in reducing water permeability. Previous research on permeability dealt with the use of materials such as fly ash, calcium carbide, rice husk bark ash, bagasse ash and palm oil fuel ash to reduce water permeability of concrete but all of research did not reach an impressive result to reduce permeability and these materials were of high cost. K. Ganesan, K. Rajagopal and K. Thangavel of concrete [1] observed that replacing ordinary Portland cement with different amount of rice husk ash (5%, 10%, 15%, 20%, 25% 30% and 35% by weight of cement) in dry condition leads to substantial improvement in the permeability properties of blended concrete when compared to that of unblended OPC concrete about 35% reduction in water permeability with reburn rice husk ash without any adverse effect. Nuntachai Chusilp [2] observed that replacing ordinary Portland cement with different amount of bagasse ash (0%, 10%, 20% and 30% by weight of cement) in dry condition a higher replacement proportion (30%) resulted in concrete with a lower water permeability and a lower compressive strength. Chai Jaturapitakkul [3] observed that the ground POFA was used to replace a portion of the OPC at 10%, 20%, and 30% by weight of binder and water permeability of ground POFA concrete decreased as the compressive strength increased. In addition, there was a good correlation between the compressive strength and the water permeability of ground POFA concrete. Ha-Won Song [4] observed that replacement silica fume by 5%, 10% and 20% by weight of cement in concrete reduce water permeability of concrete 7.5% at dose of 10% compared to control mix. Previous research on permeability dealt with the use of materials such as fly ash, calcium carbide, rice husk bark ash, bagasse ash and palm oil fuel ash to reduce water permeability of concrete but all of research did not reach an impressive result to reduce permeability and these materials were of high cost. In this research, water permeability was studied by using local materials of low cost as silica fume (SF) and Metakaolin (MK).

2. Experimental Program

The main object of this part of research is to describe the test program, instrumentation, and test procedure of specimens under static loading. The following variables were taken into consideration to study the possibility of reducing permeability of concrete by using local materials such as silica fume, Metakaolin and chemical admixtures. Compressive strength of the control concrete specimens was designed to be approximately 25 MPa at 28 days with slump of fresh concrete equal to 80 to 100 mm. In this study, experimental trials were done to evaluate optimum dose of SF and MK and super plasticizers by weight of cement. The optimum doses of SF, MK and super plasticizer such as addicted DM2 and addicted BVF were 14.3, 15, 0.3, and 2.2% respectively by weight of cement. Optimum dose of local materials SF and MK in this research equal to 14.3% and 15% by weight of cement. Also, optimum dose of super plasticizer type DM2 and BVF were 0.3% and 2.2% by weight of cement at which occurs maximum compressive strength of concrete. Then, concrete mixes were divided into 10 groups which have silica fume, Metakaolin, addicted DM2 and addicted BVF.

2.1. Properties of local materials:

Locally available aggregate used in this study included two types of red gravel and one type of white gravel and two types of sand. The physical and chemical properties of all used aggregates in Table (3,4) agreed with ECP 203-2020 requirements [5]. Natural size red gravel had the following properties specific gravity = 2.5, volume weight in compacted state = 1.64 t/m^3, Crushing value = 12.14%, specific surface area = 1.48 cm^2/gm respectively and shape factor = 1.069. Whereas small size red gravel and white gravel have properties specific gravity = 2.5, volume weight in compacted state = 1.58 t/m^3, Crushing value = 19.7, 18.75%, specific surface area = 1.96, 2.86 cm^2/gm respectively and shape factor = 1.096. Two types of medium sand were loaded from a quarry in the village of Basra, Assiut Governorate, having fainnes modules of 2.875 and 2.89, have properties specific gravity = 2.5, volume weight in compacted state = 1.67, 1.652 t/m^3, specific surface area = 44, 56.5 cm^2/gm respectively and shape factor = 1.144, 1.167. Two types of cement Portland Asyut cement (Elmohandes) and Pozzolanic Asyut cement of grade 42.5 N/mm^2 were used and their mechanical and physical properties shown in Table (1,2) met the requirements of ECP 203-2020 [5]. Silica fume was used with specific gravity of 2.0. Metakaolin was used with specific gravity of 2.5. Its chemical composition and physical properties shown in Table (5) met the requirements of ASTM C1240-03a [7]. The HRWR admixtures met the requirements for super-plasticizers according to ASTM-C-494 Types G and F [8] and BS EN 934 part 2 [9,10].

Table (1): Properties of cementitious materials.

Property		**Portland Cement**	**Pozzolanic Cement**	**E.S.S Limits**
				Cement
Initial setting time (minutes)		70	145	≥ 60
Final setting time (hours)		8.25	2.4	≤ 10
Specific surface area (cm2 / gm)		3500	3500	≥ 2750
Specific gravity		3.15	3.15	≈ 3.15
Compressive strength (MPa.)	3- day	27.1	21.88	≥ 18
	7- day	35.6	36.78	≥ 27
	28-day	42.6	50.58	≥ 36

Table (2): Chemical properties of cementitious materials.

Oxide compositions (%)		SiO2	AL2O3	Fe2O3	CaO	MgO	Na2O	K2O
Portland Cement		19.2	7.45	3.45	63.17	2.44	--	--
Pozzolanic Cement		24.69	5.92	7.27	53.55	2.37	.82	.25
E.S.S Limits	Cement	20-24	4-10	2-4	60-65	1-3	--	--

Table (3): Physical properties of aggregate.

Property		Sand1	Sand2	Natural Size Gravel	Small Size Gravel	White Gravel	E.S.S Limits	
							Sand	Gravel
Specific gravity		2.5	2.5	2.5	2.5	2.5	2.5-2.75	2.5-2.75
Unite weight(t/m³)	Loose	1.56	1.51	1.57	1.48	1.48	---	---
	Compact	1.67	1.652	1.64	1.58	1.58	---	---
Crushing value (%)		---	---	12.4	19.7	18.75	---	≤ 30
Maximum nominal size(mm)		---	---	40	40	40	---	---
Fineness modulus		2.875	2.89	7.11	7.11	7.24	2 – 3.75	5 - 8
Specific surface area (cm²/gm)		44	56.5	1.48	1.96	2.86	50 - 100	2 - 5
% Clay and fine dust		2.5	2.5	0.7	0.8	0.8	≤ 3	≤ 1
% Absorption of water		0.5	0.5	0.027	0.027	0.03	0 - 2	0.5 - 1

Table (4): Chemical properties of aggregate.

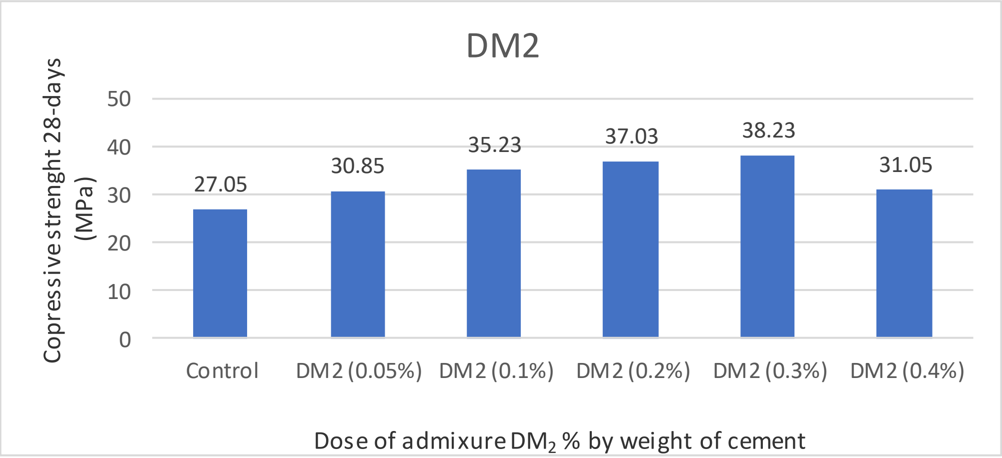
Property	Sand1,2	Natural Size Gravel	Small Size Gravel	White Gravel	E.S.S Limits	
					Sand	Gravel
% Chloride ions	0.039	0.012	0.012	.016	≤ 0.06	≤ 0.04
% Sulphates ions	0.177	0.021	0.021	.024	≤ 0.4	≤ 0.4
Power of Hydrogen (PH)	9	8	8	9	≥ 7	≥ 7

Table (5): Chemical properties of silica fume and metakaolin.

Properties	Silica fume	metakaolin
Silicon Dioxide (SiO2)	91.4%	54.3
Aluminium Oxide (Al2O3)	1.1%	38.3
Ferric Oxide (Fe2O3)	0.3% - 0.5%	4.28
Magnesium Oxide (MgO)	1.3%	0.08
Calcium Oxide (CaO)	0.7%	0.39
Sulphur Trioxide (SO3)	0.4%	0.22
Sodium Oxide (Na2O)	0.8%	0.12
Potassium Oxide (K2O)	0.5%	0.50
Loss of Ignition	2.4%	0.68

2.2 Concrete mixes

To achieve maximum compressive strength of concrete, mixing ratio of fine aggregate to coarse aggregate was calculated at which specific surface area of combined aggregate equal 25 cm^2/gram, Then S/G for red gravel and first type of sand = 0.64 and white gravel and second type of sand = 0.75. Optimum dose of super plasticizer type DM2 and BVF not mixing was calculated at constant slump value by using different dose of admixtures as shown in Fig. (1,2). To investigate the effect of the above parameters on permeability properties ten groups of concrete mixes were prepared. Mixes, description, and quantities of the various materials for each designed concrete mix are given in Tables (1).



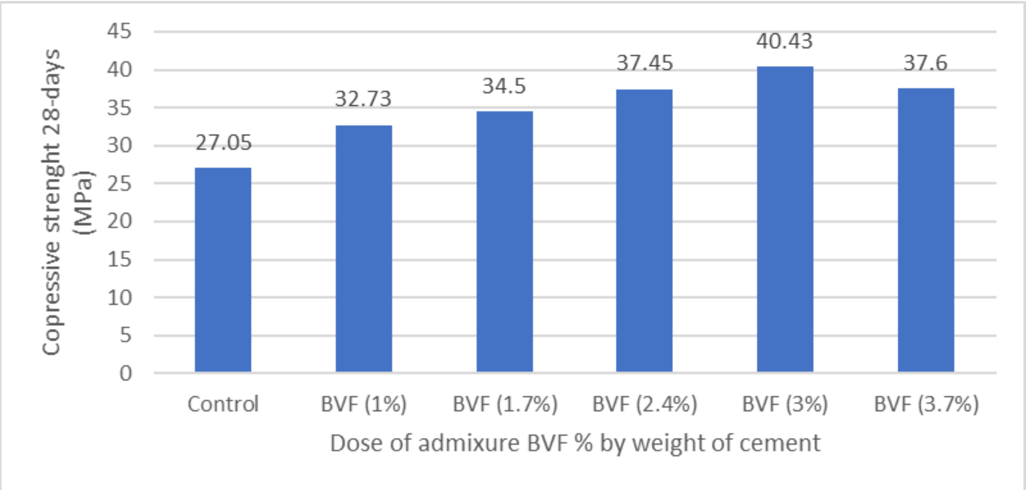
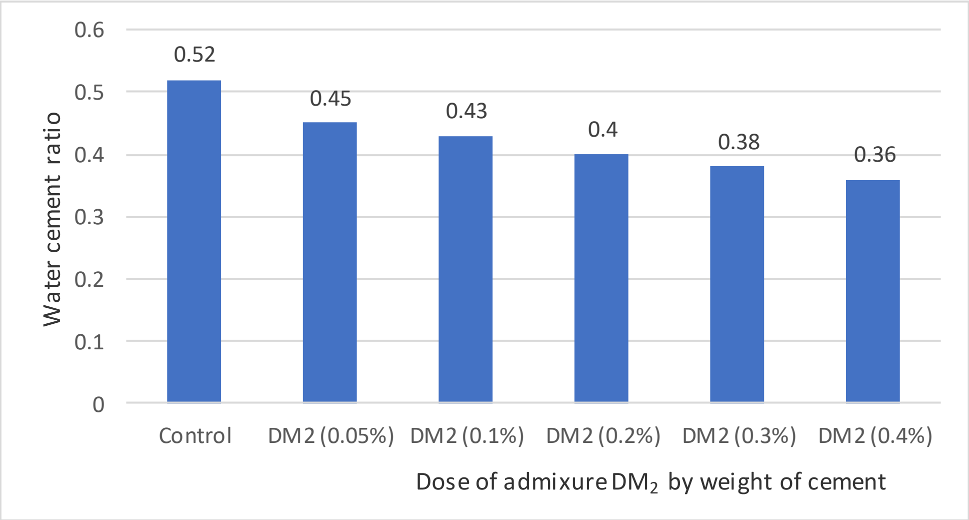


Fig (1): Compressive strength after 28 days as affected by different dose of admixtures DM2 and BVF (Slump constant = 8-9 cm).



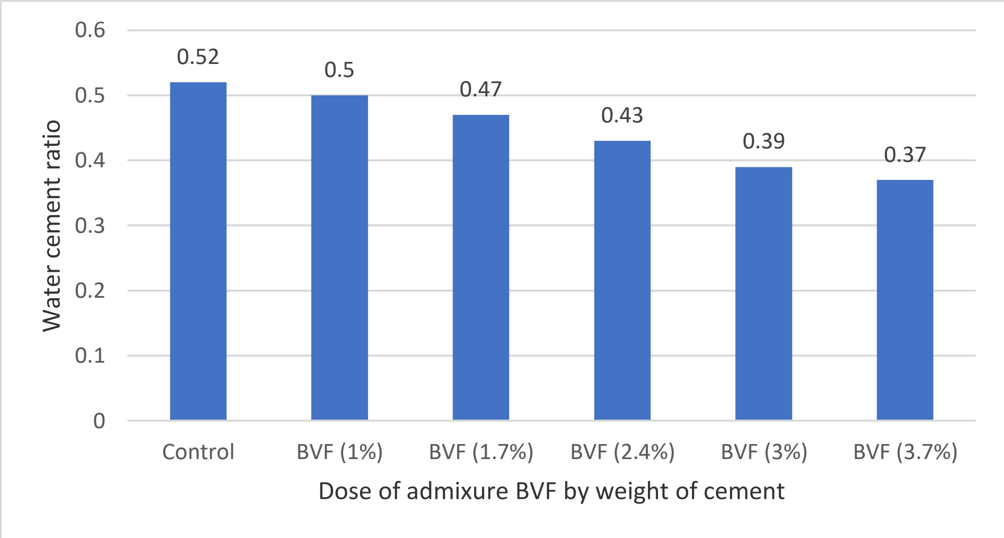


Fig (2): Water Cement ratio of concrete mix at different doses of admixture type DM2 and BVF (Slump constant = 8-9 cm).

Table (6): Constituent Materials for different concrete mixes (Slump constant = 8-9 cm).

Mix group	Mix No.	Mix type	Cement (kg/m^3)	W/C	DM_2 admixture (kg/m^3)	Metakaolin (kg/m^3)	Silica (kg/m^3)	Sand (1,2) (kg/m^3)	Gravel (1,2) (kg/m^3)	BVF admixture (kg/m^3)	Water (L/m^3)
1	1	Co	350	0.52	--	--	--	690	1078	--	182
2	2	S1	350	0.545	--	--	30	625	1019	--	207.1
	3	S2	350	0.545	--	--	50	632	988	--	218
	4	S3	350	0.545	--	--	70	613	958	--	228.9
	5	S4	350	0.545	--	--	90	593	927	--	239.8
	6	S5	350	0.545	--	--	110	574	897	--	250.7
3	7	D1	350	0.45	0.175	--	--	708	1107	--	157.5
	8	D2	350	0.43	0.35	--	--	713	1114.5	--	150.5
	9	D3	350	0.40	0.7	--	--	722	1128	--	140
	10	D4	350	0.38	1.05	--	--	727	1136	--	133
	11	D5	350	0.36	1.4	--	--	732	1144	--	126
4	12	B1	350	0.5	--	--	--	694	1084	3	175
	13	B2	350	0.47	--	--	--	702	1097	5	164.5
	14	B3	350	0.43	--	--	--	715	1116.5	7	150.5

Mix group	Mix No.	Mix type	Cement (kg/m³)	W/C	DM_2 admixture (kg/m³)	Metakaolin (kg/m³)	Silica (kg/m³)	Sand (1,2) (kg/m³)	Gravel (1,2) (kg/m³)	BVF admixture (kg/m³)	Water (L/m³)
	15	B4	350	0.39	--	--	--	727	1135	9	136.5
	16	B5	350	0.37	--	--	--	732	1143	11	129.5
5	17	SDo	350	0.38	1.05	--	50	686	1072	--	152
6	18	SBo	350	0.39	--	--	50	697	1089	9	156
7	19	$C_{pozzolanic}$	350	0.53	--	--	--	531	1235	--	185.5
8	20	S_P	350	0.56	--	--	50	506	1177	--	224
9	21	D_P	350	0.40	1.05	--	--	560	1302	--	140
10	22	MK_1	350	0.535	--	35	--	502	1169	--	205.9
	23	MK_2	350	0.54	--	52.5	--	488	1136	--	217
	24	MK_3	350	0.54	--	70	--	475	1105	--	227

2.3 Test specimens:

Concrete cubes (6 cubes) of size 150*150*150 mm were used for the determination of compressive strength and depth of water penetration.3 Cubes for each experiment of total 9 cubes of size 100*100*100 mm were used for the determination of permeability parameters partial absorption, total absorption, and humidity adsorption. Concrete prisms of size 500*100*100 mm were used for the determination of capillary and partial water absorption. Concrete cylinders (2 cylinders for each experiment of total 4 cylinders) of diameter 100 mm and height 300 mm were used for the determination of bond and indirect tensile strength.

2.4 Test procedure of determining Compressive strength, Bond load and splitting tensile strength:

The compression load was statically applied at constant rate (13 MPa/minute) using a compression machine with a capacity of 150 ton for 7 and 28 days in water tank shown in fig (3). Bond test is performed by reinforcing the concrete cylinders with a 16 mm diameter steel rod, after that, the sample is placed in a tension machine, and the steel rod is withdrawn until the sample is broken and the fracture load of the sample is recorded at 28 days in water tank shown in fig (5). Splitting tensile strength of concrete was poured into cylinders with a diameter of 10 and a length of 30 cm were treated in water tanks for 28 days and crushed horizontally on 150 tons press machine shown in fig (4).

2.5 Test procedure of determining water permeability parameters of hardened concrete:

From fig. (6-9), partial water absorption, measures the amount of water that penetrates concrete samples when submerged 24h in tank with temperature 27^{o}C. Total water absorption consists of two major steps, First, the concrete specimens are immersed in boiling water until change in mass for 4 hours, Second the specimens are dried in a ventilated oven at temperature of 105^{o}C until the deference in mass for 24 hours. Capillary water absorption specimens were first dried in the drying oven for 24 h where the temperature was kept around 105°C, and then the specimens were placed and cooled at room temperature, Finally, the capillary water absorption test was carried out, and the amount of absorbed water was determined at different time. Absorption values were determined by measuring the water length in the analysis. The penetration depth test is performed by exposing the surface of the specimens to a 5-bar water pressure in a closed circuit and leaving them for 24 hours, after that, the specimens are taken, it is broken, and the depth of water penetration into it is measured.

Fig (3): Digital universal testing machine capacity 150 ton for testing cubes and cylinders.

Fig (4): Splitting tensile stress test.

Fig (5) Shape of bond failure of concrete specimens.

Fig. (6): Partial water absorption test.

Fig. (7): Total water absorption test.

Fig. (8): Capillary water absorption test.

Fig. (9): Water Penetration test.

2.6 X-ray Diffraction Analysis (XRD):

The mineralogical analyses of these admixtures were performed by X-ray diffraction (XRD) test. XRD is one important method to identify the main minerals, and crystalline or amorphous states of the materials. The results from an XRD analysis are a diffractogram exhibiting the intensity as function of the diffraction angles. As well as, to check the disappearance of the characteristic peaks of these admixtures. This apparatus is existing in Faculty of Science, Assiut, Egypt. Quantitative and qualitative analyses have been computed and

the patterns characterize were obtained for these admixtures .X-ray Diffraction Analysis test is one of the most commonly used tests to clarify mineral content types and proportions of compounds, as well as the material states amorphous or crystalline.

3. Results

Table (2 & 3) present all data that was collected throughout experimental testing to determine the concrete water permeability changes. This data includes properties of fresh concrete mixes and properties of hardened concrete such as water absorption, capillary water absorption, total absorption, bond test, splitting tensile and compressive strength.

Table (7): Properties of fresh and hardened concrete for different series of mixes.

Mix Series	Mix components								Properties of fresh and hardened concrete				
	Cement kg/m³	Sand kg/m³	Gravel kg/m³	Water L/m³	Admixture kg/m³				Compressive Strength (MPa)		Slump (cm)	Bond (T)	Splitting Tension (MPA)
					SF	DM2	BVF	MK	7-Days	28-Days			
Co	350	690	1078	182	--	--	--	--	22.57	27.05	8	5.5	21
S1 (8.5%)	350	625	1019	207.1	30	--	--	--	26.55	29.9	8.5	--	--
S2 (14.3%)	350	632	988	218	50	--	--	--	27.0	31.57	8	--	--
S3 (20%)	350	613	958	228.9	70	--	--	--	23.45	28.8	8	--	--
S4 (25.7%)	350	593	927	239.8	90	--	--	--	21.1	34.0	8	6.7	22
S5 (31.5%)	350	574	897	250.7	110	--	--	--	20.0	26.0	8	--	--
D1 (0.05%)	350	708	1107	157.5	--	0.175	--	--	19.3	30.85	8.5	--	--
D2 (0.1%)	350	713	1114.5	150.5	--	0.35	--	--	23.9	35.23	8.5	--	--
D3 (0.2%)	350	722	1128	140	--	0.7	--	--	26.2	37.03	8.5	--	--
D4 (0.3%)	350	727	1136	133	--	1.05	--	--	30.0	38.23	8.5	5.6	24
D5 (0.4)	350	732	1144	126	--	1.4	--	--	28.0	31.05	8.5	--	--
B1 (1%)	350	694	1084	175	--	--	3	--	23.4	32.73	8.8	--	--
B2 (1.7%)	350	702	1097	164.5	--	--	5	--	26.7	34.5	8.5	--	--

Mix Series	Mix components								Properties of fresh and hardened concrete				
	Cement kg/m^3	Sand kg/m^3	Gravel kg/m^3	Water L/m^3	Admixture kg/m^3				Compressive Strength (MPa)		Slump (cm)	Bond (T)	Splitting Tension (MPA)
					SF	DM2	BVF	MK					
B3 (2.4%)	350	715	1116.5	150.5	--	--	7	--	27.2	37.45	9	--	--
B4 (3%)	350	727	1135	136.5	--	--	9	--	31.45	40.43	9	8.8	26
B5 (3.7%)	350	732	1143	129.5	--	--	11	--	29.88	37.6	9	-	--
SD (14.3% SF, 3.8% DM2)	350	686	1072	152	50	12	--	--	35.98	40.93	8.5	8	25
SB (14.3% SF, 3% BVF)	350	697	1089	156	50	--	9	--	41.3	52.2	9	9.7	32
Cp	350	531	1235	185.5	--	--	--	--	27.0	34.3	8	6.5	12.5
Sp (14.3%)	350	506	1177	224	50	--	--	--	32.0	41.5	8	8.9	22.2
Dp (3.8%)	350	560	1302	140	--	12	--	--	29.0	38.0	8.5	7.7	14.4
MK1 (10%)	350	502	1169	205.9	--	--	--	35	20.5	31.0	8	--	--
MK2 (15%)	350	488	1136	217	--	--	--	52.5	24.0	39.5	8	8.2	16.7
MK3 (20%)	350	475	1105	227	--	--	--	70	20.0	29.0	8	--	--

Table (8): Permeability index of related to water absorption and penetration test of hardened concrete.

Mix Series	Mix components								Permeability parameters of hardened			
	emen t kg/m 3	Sand kg/m 3	Grav el kg/m 3	Wat er L/m 3	Admixture kg/m3				Water absorption			
					SF	DM 2	B V F	M K	Partial water absorpti on (%)	Total water absorpti on (%)	Capillar y water absorpti on (cm)	Water penetratio n (cm)
C	350	690	1078	182	--	--	--	--	2.63	3.38	17.325	4.75
S1 (8.5%)	350	625	1019	207. 1	30	--	--	--	--	--	--	--
S2 (14.3 %)	350	632	988	218	50	--	--	--	--	--	--	--
S3 (20%)	350	613	958	228. 9	70	--	--	--	--	--	--	--
S4 (25.7 %)	350	593	927	239. 8	90	--	--	--	2.04	2.7	15.215	3.6
S5	350	574	897	250.	11	--	--	--	--	--	--	--

D1 (0.05 %)	350	708	1107	157.5	--	0.175	--	--	--	--	--	--
D2 (0.1%)	350	713	1114.5	150.5	--	0.35	--	--	--	--	--	--
D3 (0.2%)	350	722	1128	140	--	0.7	--	--	--	--	--	--
D4 (0.3%)	350	727	1136	133	--	1.05	--	--	1.7	2.01	14.775	3.1
D5 (0.4%)	350	732	1144	126	--	1.4	--	--	--	--	--	--
B1 (1%)	350	694	1084	175	--	--	3	--	--	--	--	--
B2 (1.7%)	350	702	1097	164.5	--	--	5	--	--	--	--	--
B3 (2.4%)	350	715	1116.5	150.5	--	--	7	--	--	--	--	--
B4 (3%)	350	727	1135	136.5	--	--	9	--	1.4	1.65	10.05	2.4
B5 (3.7%)	350	732	1143	129.5	--	--	11	--	--	--	--	--
SD (14.3 % SF, 3.8% DM2)	350	686	1072	152	50	12	--	--	1.56	1.8	10.3	2.5
SB (14.3 % SF, 3% BVF)	350	697	1089	156	50	--	9	--	1.05	1.59	9.2	1.7
Cp	350	531	1235	185.5	--	--	--	--	2.54	3.05	15.775	3.25
Sp (14.3 %)	350	506	1177	224	50	--	--	--	1.87	2.34	12.315	2.44
Dp (3.8%)	350	560	1302	140	--	12	--	--	1.45	2.06	11.22	1.95
MK1 (10%)	350	502	1169	205.9	--	--	--	35	--	--	--	--
MK2 (15%)	350	488	1136	217	--	--	--	52.5	1.96	2.76	13.315	2.6
MK3 (20%)	350	475	1105	227	--	--	--	70	--	--	--	--

4. Discussion

4.1 Properties of fresh and hardened concrete:

From Fig No. (7-8),

1- The optimum dose of the combined admixtures type (SB) that gives the highest value of compressive strength by about 51.8% compared to control specimen and compared to previous research that used silica fume and metakaolin increase compressive strength by about 22.5% [11] and 7% [12].
2- The optimum dose of the combined admixtures type (SB) that gives the highest value of indirect tensile strength by about 34.4% compared to control specimen and compared to

previous research that used silica fume and metakaolin increase indirect tensile strength by about 26.5% [11] and 8.3% [12].

3- The optimum dose of the combined admixtures type (SB) that gives the highest value of bond force by about 43.3% compared to control specimen.

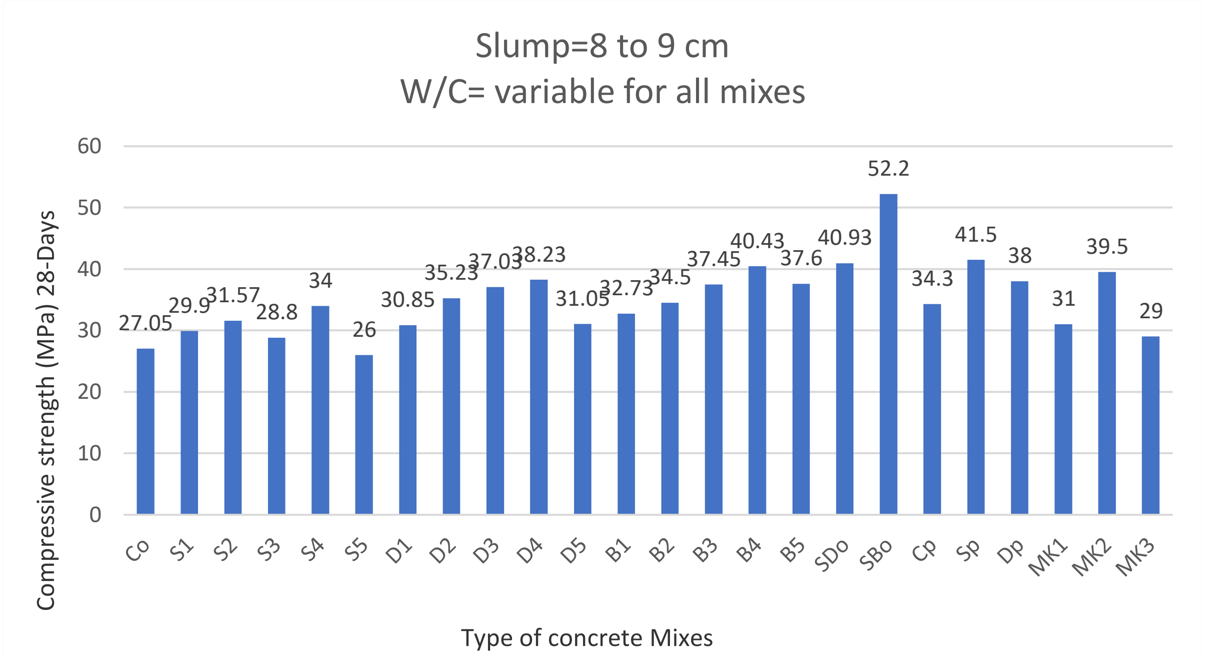


Fig (10): Values of compressive strength for different concrete mixes.

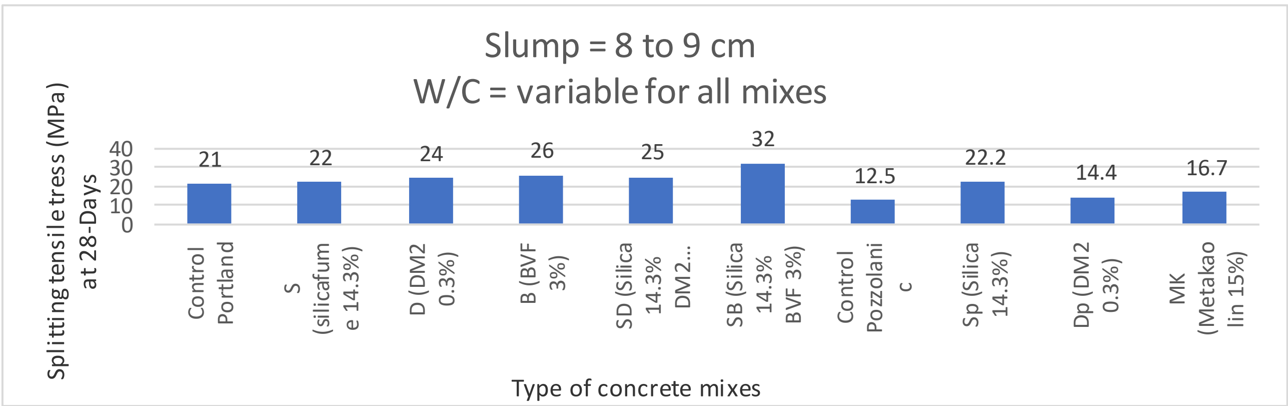


Fig (11): Values of splitting tensile stress for different concrete mixes.

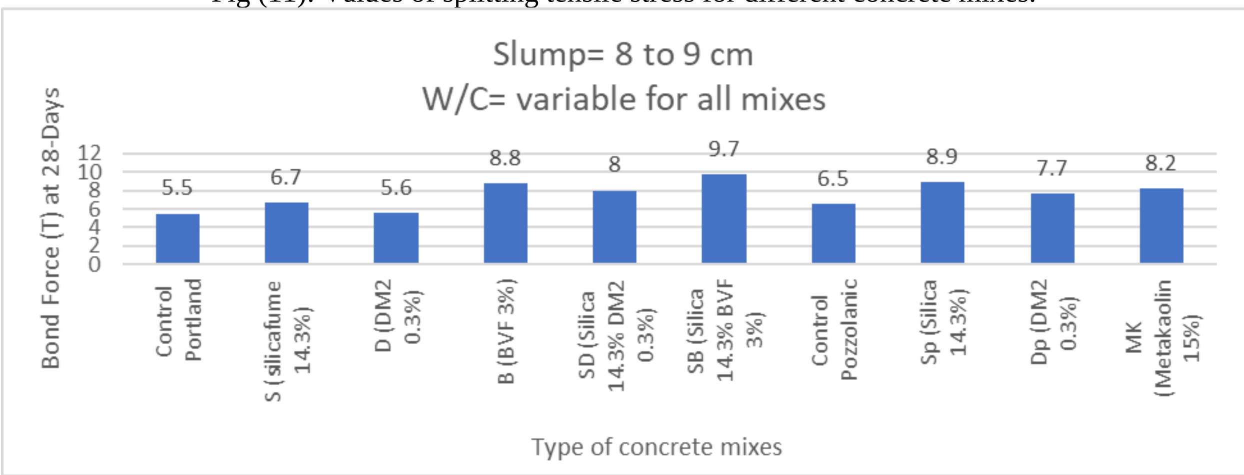


Fig (12): Values of bond test for different concrete mixes.

4.2 Permeability of hardened concrete:

From Fig. (9,10,11,12) it's clear that, combination of silica fume and super plasticizer BVF (SB) improves value of permeability parameters partial water absorption, total water absorption, capillary water absorption, humidity adsorption and penetration depth with optimum dose of (14.3% of SF and 2.2% of BVF by weight of cement) by about 64.2% compared to control specimen and compared to previous researches that used silica fume and metakaolin increase indirect tensile strength by about 26.5% [4] and 53.16% [12].

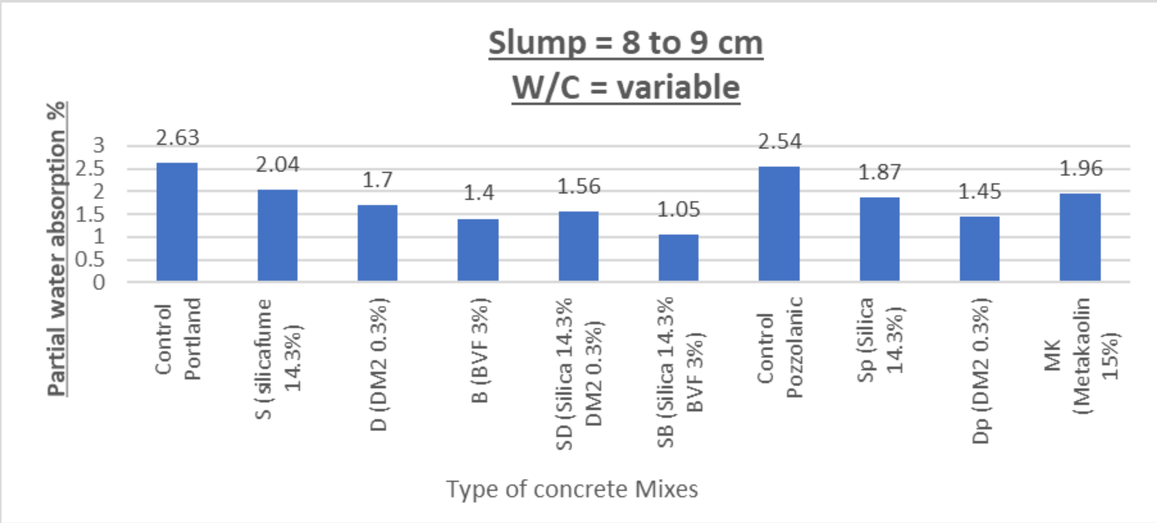


Fig. (13): Partial water absorption for different concrete Mix series (Cube specimens).

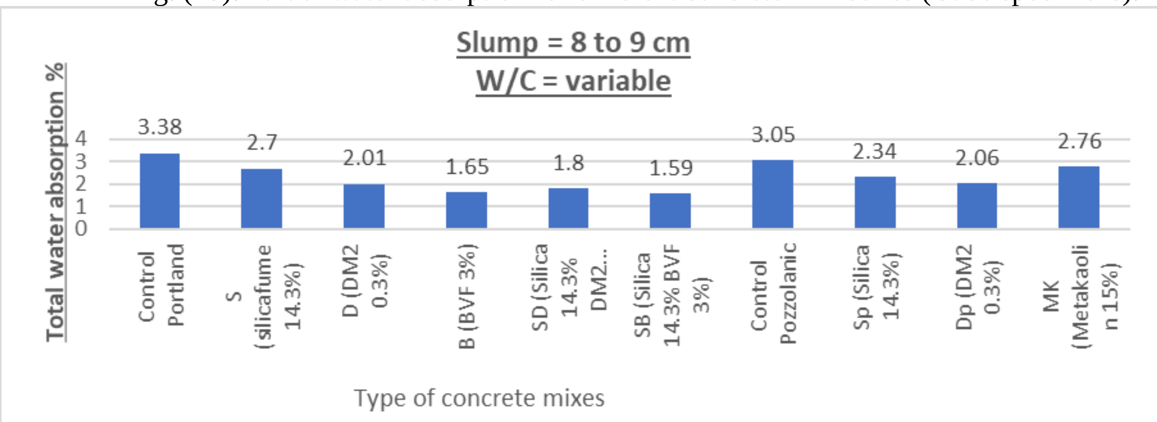


Fig. (14): Total water absorption for different concrete Mix series.

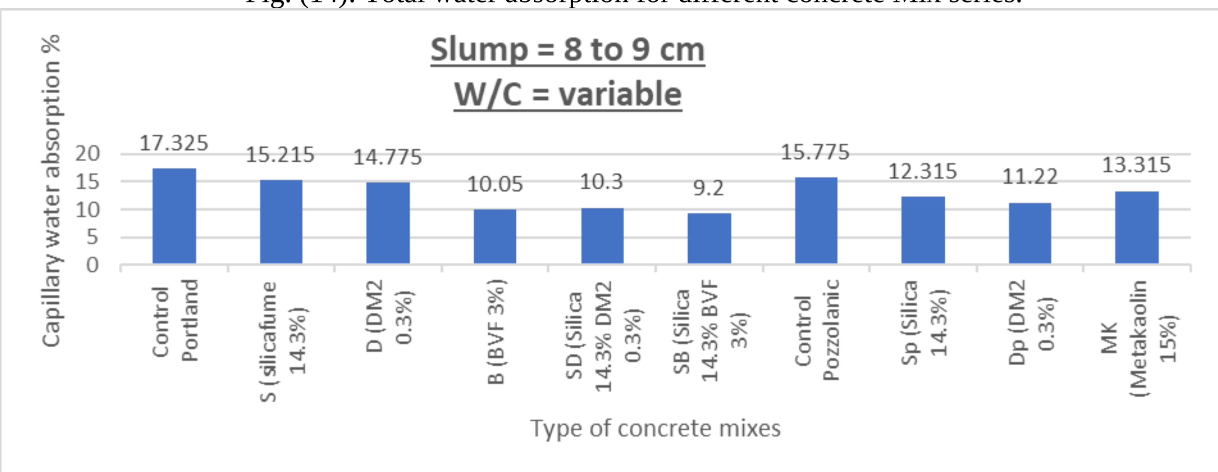


Fig. (15): Capillary water absorption test values (cm) for different concrete Mixes.

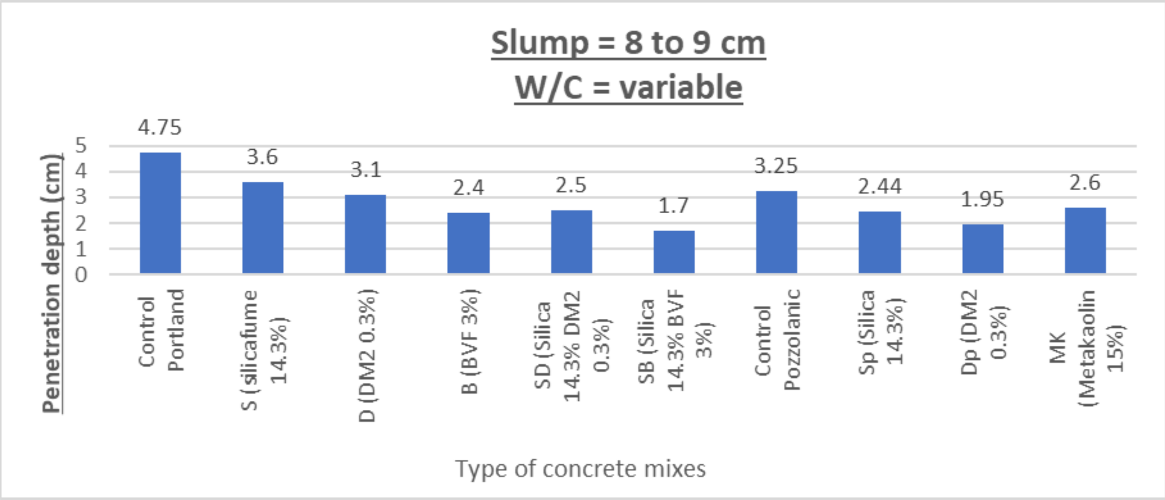


Fig. (16): Penetration depth for different concrete mixes (cm).

4.3 X-ray Diffraction Analysis (XRD) Results:

The obtained X-ray diffractograms of tested local admixtures (Control with Portland cement, Control with pozzolanic cement and SB (Silica fume 14.3% and BVF 3%)) are presented in Fig. (17).

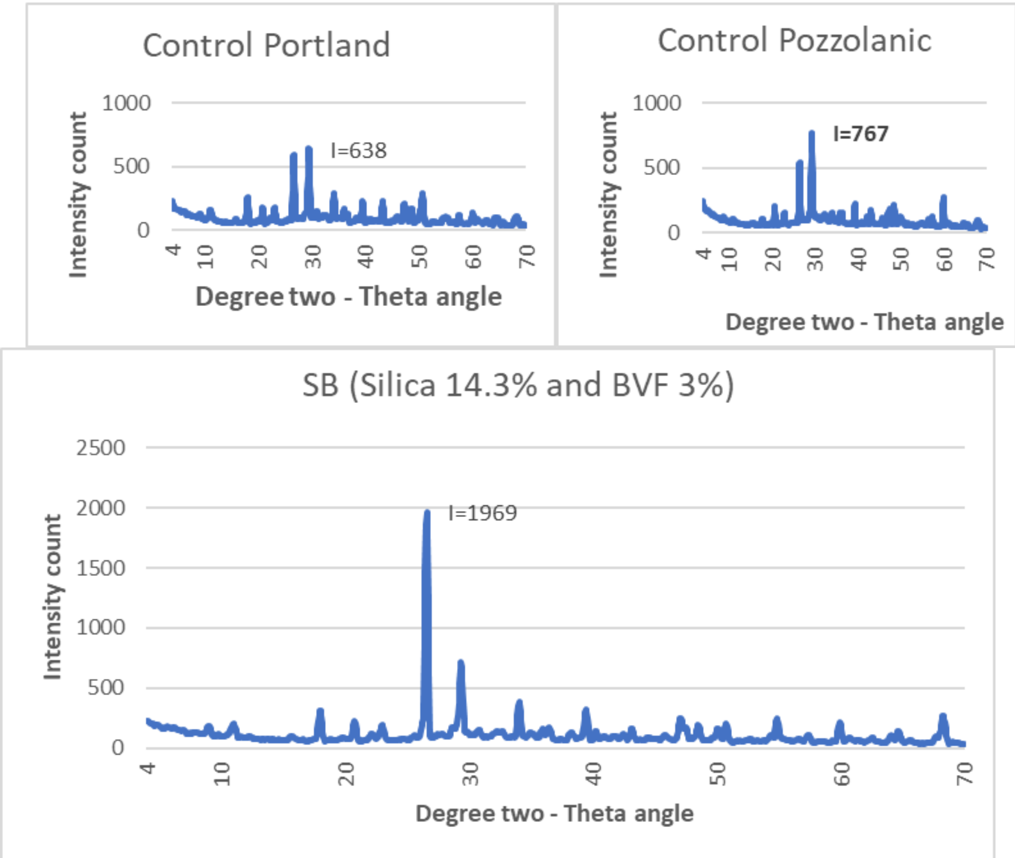


Fig. (17): XRD pattern of Co, Cp and SB sample

It can be noticed that XRD diffractogram of control mix with Portland cement (Co) almost similar to control mix with pozzolanic cement (Cp) diffractograms with a difference in the main beak intensity value, which was decreased and reached 638 in (Co). This observation clearly demonstrated that, the mineral origin of the composition of these materials is similar. Clearly notes SB has the highest sharp peaks 1969 which, indicated that, SB was highly crystalline material.

5. Conclusion

- Optimum dose of combined admixture type (SB) from silica fume and super plasticizer (BVF) at which occurred maximum compressive strength of concrete is achieved in this research, which equal 14.3% SF and 3% BVF by weight of cement.
- Using a mix with optimum dose of that admixture type (SB) leads to an increase of the compressive strength of concrete at 7 and 28 days by about 83% and 93% respectively compared to the control specimens.
- Optimum dose of combined admixture type (SB) improves bond strength and tensile strength compared to control specimens.
- Concrete mixes contained a combined mixture of (SB) have a good resistance to water permeability compared to control specimens.
- Optimum dose of this type of admixture (SB) reduces partial and total water absorption by about (1.05 and 1.59 %) compared to control mix which equal to (2.63 and 3.38%).
- Optimum dose of this type of admixture (SB) reduces capillary water absorption by about 35% compared to control specimens.
- Optimum dose of admixture SB occurs lowest humidity adsorption by about (0.6%) compared to control specimens which equal to (0.15%).
- This type of admixture reduces water penetration through concrete cubes subjected to water pressure = 5 bar in 24 h by about 35 % compared to the control specimens.
- Using pozzolanic cement improve properties of fresh and hardened and decrease permeability of concrete mix than Portland cement.
- Using a mix with optimum dose of that metakaolin (MK) leads to an increase of the compressive strength of concrete at 7 and 28 days and improve bond strength and tensile strength compared to control specimens.
- Using different local material gravel and sand improve permeability of concrete because it reduced voids in the concrete mixture.
- From XRD test results, the Control with Portland cement Co diffractogram is almost similar to that of Control with pozzolanic cement Cp and SB (Silica fume 14.3% and BVF 3%). This clearly confirms that, the mineral origin of the composition of these materials is actually similar.

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تقليل نفاذية الخرسانة باستخدام مواد محلية مركبة

الملخص بالعربى:

تعرض الخرسانة للماء هي واحد من أهم الآثار الانشائية الرئيسية التي تؤدي إلى مشاكل في متانة المنشآت. هذا التأثير يكون سبباً في أن تُصبح المنشآت خارج الخدمة وأن تحدث خسائر في الأرواح والممتلكات من قِبل الأضرار الدائمة التي تحدث في المنشآت. الخرسانة هي مادة تمسح بمرور الماء الى داخلها نظرا لحجم الفراغات بين حبوب الركام مقارنةً بالعديد من مواد البناء. تفقد الخرسانة جزء من مقاومتها نتيجة التغير في خواصها الفيزيائية والكيميائية لتعرضها للماء. تتعرض الخرسانة لمثل هذه الظروف في حال حدوث امطار او نسبة رطوبة عالية او منشات معرضة للماء مثل (منشات سكنية، مصانع، كباري على الماء، خزانات....).

من أهم الآثار الناجمة لتعرض الخرسانة للماء هي: ضعف في مقاومة الخرسانة، متانة الخرسانة، تآكل في الخرسانة، قصر العمر الافتراضي للمنشآت، ظهور شروخ. فمن الممكن الحد من الآثار الضارة الناجمة عن تعرض الخرسانة للماء وامتصاصها من خلال اتخاذ تدابير وقائية، مثل اختيار المواد المناسبة، خصائص الركام المستخدم، قوة الترابط بين عجينة الأسمنت والركام والتوافق الحراري بين الركام والأسمنت. تلك التدابير ممكن توفيرها من خلال استخدام مواد ذات مقاومة عالية لنفاذية الخرسانة وتقليل المسامات غبار السيليكا، ملدنات لتقليل نفاذية الخرسانة وتقليل الفراغات بين حبوب الركام في الخرسانة.

الخرسانة البوذولانية أي المحتوية على مواد معادة الاستخدام مثل غبار السيليكا والميتاكاولين أصبحت أكثر انتشاراً على مستوى العالم نظرا للسلوك الجيد لهذه المواد تحت تأثير تعرض الخرسانة للماء او الرطوبة، لأنها تمر بظروف مماثلة أثناء تصنيعها. ومن ضمن الأسباب أيضاً للانتشار الواسع لاستخدام تلك المواد، أنها متوفرة، غير مُكلفة وأقل ضرراً للبيئة مقارنة بالمواد الاخرى. وقد توصل الباحثون إلى نتائج طيبة في هذا المجال من حيث قدرتهم على استخدام تلك الخرسانة لمقاومة امتصاص الماء وكذلك الوصول للجرعة المُثلى لإضافة هذه المواد. كل الابحاث والجهود السابقة كانت مركزة على استخدام مواد اخرى أكثر تكلفة وغير متوفرة، واستخدام مواد كبديل جزئي للأسمنت. ولم يلجأ أحد إلى التفكير في استخدام السيليكا كإضافة للأسمنت مع استخدام ملدنات تقليل النفاذية.

البحث القائم بين أيدينا يحاول دراسة تأثير الملدنات المحلية والسليكا والميتاكاولين في الخلطة للوصول لأفضل خلطة خرسانية مقاومة لنفاذية الخرسانة للماء، حيث استُخدِم الملدنات والسليكا كإضافة للأسمنت واستخدم الزلط الاحمر لأنه يعطى معامل تهشيم أكبر من الزلط العادي مع ثبات محتوى الاسمنت مماثلا لعينات التحكم.