Journal of Engineering Sciences, Assiut University, Vol. 38, No. 3, pp. 569-617, May 2010.

REPAIR AND STRENGTHENING OF THE PIERS MODEL BY USING DIFFERENT TYPES OF INJECTED MATERIALS

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(Received January 5, 2010 Accepted March 11, 2010).

The water structures are difficult engineering structures and very sensitive to cracks inside or out side the body of it furthermore all its components need continuous check.

The new one needs big amount of budget if be built, at the same time the keeping on the existing structure can serve a lot of money and many benefits at the construction time.

The most important components for the water structures are the raft and the piers, and all can be repaired by injection.

The principal aim to fill of the voids that leads to improve the strength of the structure body and permeability especially for water structures.

The water structure is important structures need continuous check for all members to be at good efficiency to do the demand job which required.

There are two important variables effect on the condition of the water structure with high quality, the structure stability and permeability, to keep all the elements of structure at the high quality mean repair and strengthening all of them continuously.

The injection method in present time became very important method especially for treatment permeability for water structures.

In laboratory nine models with 1/8 percentage from the piers of barrages which was concerned in this study, with three grades from concrete (fcu=150-200-250 kg/cm^2).

Two cases of loading for the models, before loading and after loading.

The study concluded the effect of injection on the two variables which were studied the compressive strength and void ratio of the model concrete.

In compressive strength the best material is the French cement the conclusion was:

1-The ordinary cement (O.C), used as injected materials the compressive strength of the models concrete after injection increased by (70.79%-103.01%-77.43%) than the average compressive strength before injection respectively to the grade of concrete (fcu).

2- The French cement (F.C) (Vicalps type D) used as injected material: the compressive strength increased by (137.02%-120.53%-67.43%) than the average compressive strength before injection respectively to the grade of concrete.

3- The Epoxy Conbextra (PE .L.V) used as injected material: the compressive strength increased by (70.3%-104.47%-80.76%) than the average compressive strength before injection respectively to the grade of concrete.
In void ratio, porosity and density: the best material for treating this state is Epoxy material.

1- INTRODUCTION

This study concerns on the repair and strengthening of the laboratory piers models to reach the best injected type of materials for every variable in water structures, by taking the simulation in laboratory. The piers models of water structures with scale equal to 1/8 from the artificial structures to make simulation.

From three concrete grades (fcu) of the piers models were made with (150-200-250 kg/cm^2) and by using three injected type of materials .The effect of injection type of materials from {Ordinary cement (O.C) - French cement(F.C) (Vicalps type D) – Epoxy Conbextra (PE .L.V)} on concrete piers models was studied by comparing between compressive strength (fcu) without injection and with injection by different types of materials. Also the effect of injection by different types of materials on grading of concrete piers models was studied by comparing between the void ratio, porosity and density before and after injection by different type of materials. Also the comparison of all parameters was studied before and after loading on piers models.

2-EXPERIMENTAL WORK

The experimental works included two items:

2-1-The first item:

2-1-1-The concrete mix design for piers models:

The piers models from plain concrete have three grades of concrete strength (fcu) as shown in table (1)

Table (1) Concrete mix design

Type of Concrete grades	Characteristic strength (fcu) kg/cm^2	Cement kg/m^3	Gravel kg/m^3	Sand kg/m^3	Water liter/m^3
Weak concrete (W.C)	150	200	1344	677	130
Medium concrete(M.C)	200	250	1284	642	150
Normal strength concrete (N.C)	250	300	1232	616	165

In this study the above three grades from concrete were used and also using three types of injected materials {Ordinary cement (O.C), French cement (F.C) (Vicalps type D) and Epoxy Conbextra (EP .LV).}.The core samples were taken from the concrete piers models without and with injection materials.

2-1-2 The drilling and injection works:

The samples were taken from Piers Models by smaller drilling machine as shown in Fig. (1). The injection of the sampler by the injection machine as shown in Fig. (2)

Fig. (1) Drill machine for core samples

Fig. (2) Injection machine

2-2-The second item:

The second item concern on the tests which were performed on the piers models samples before loading and after loading as follows:

2-2-1Compression test:

For the two cases of loading, every case of loading contains:

- Samples without injection.
- Samples with injection by different types of materials.

2-2-1-1 Before loading:

Tables (2) & (3) contains the results of compression test {ultimate load (Pu) and the deformation (ΔL)} for the samples of piers models before loading without injection and with injection by different types of material

2-2-1-1-a Samples before loading without injection:

The results of compression test which were performed on the piers models samples were shown in table (2).

Table (2) The samples from the Piers Models before loading without injection

No	sample	Ultimate load (Pu) kg	Deformation (ΔL) mm	Grade of concrete (fcu) kg/cm^2
1	IIB	2200	1.03	Weak concrete (W.C) fcu=150kg/cm^2
2	IID1	2650	1.10	
3	IIIB1	2300	1.1	
4	IVB3	3200	0.985	Medium concrete (M.C) fcu=200kg/cm^2
5	IVB2	3190	0.985	
6	VID1	3100	1.9	
7	VII D2	4000	0.9	Normal strength concrete (N.C) fcu=250kg/cm^2
8	VIID1	4350	2.02	
9	IXD	4000	2.03	

The load-deformation curves for samples of the piers models were plotted in Figs. (3-4&5):

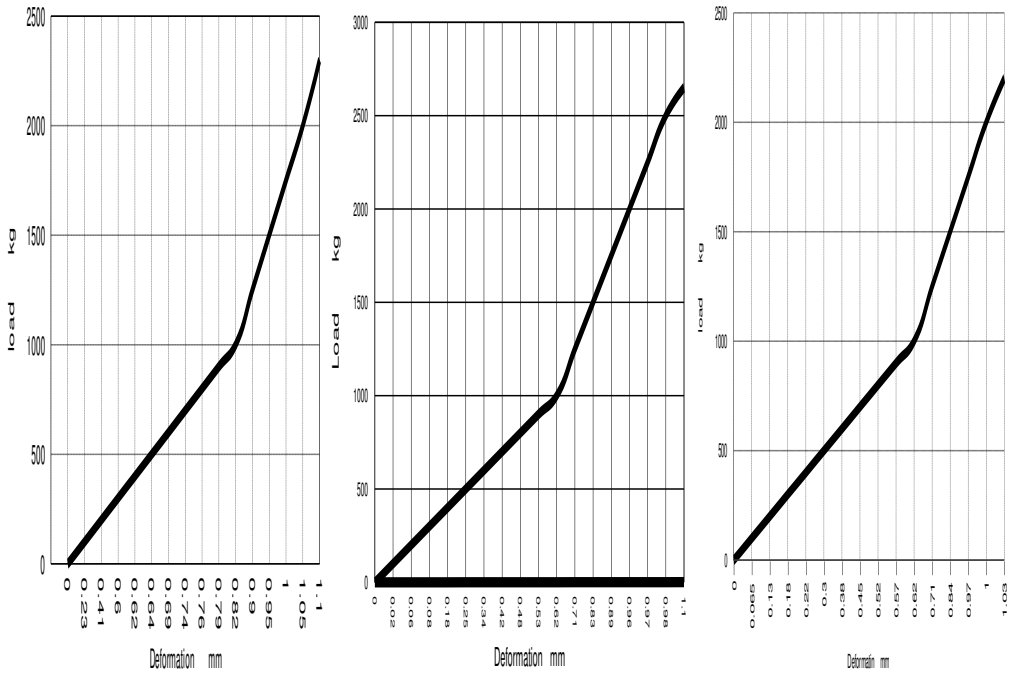


Fig. (3) p-ΔL for samples (II B) - (II D1) & (III B1) from piers models of weak concrete (W.C) fcu = 150 kg/cm^2

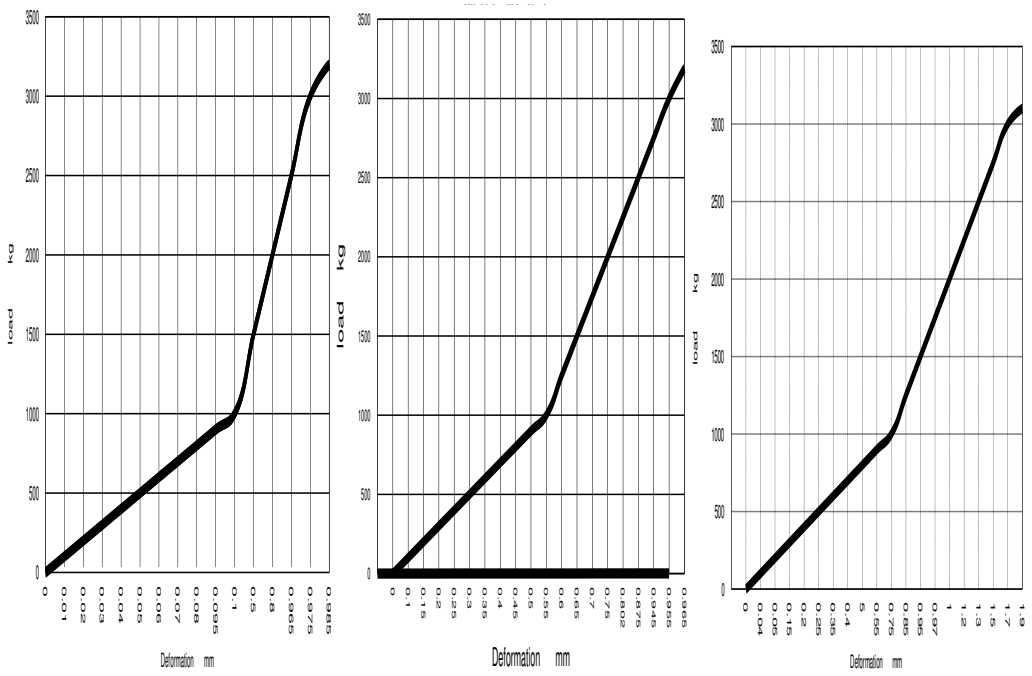


Fig. (4) p-ΔL for samples (IV B3) - (IV B2) & (VI D1) from piers models of medium concrete (M.C) fcu = 200 kg/cm^2

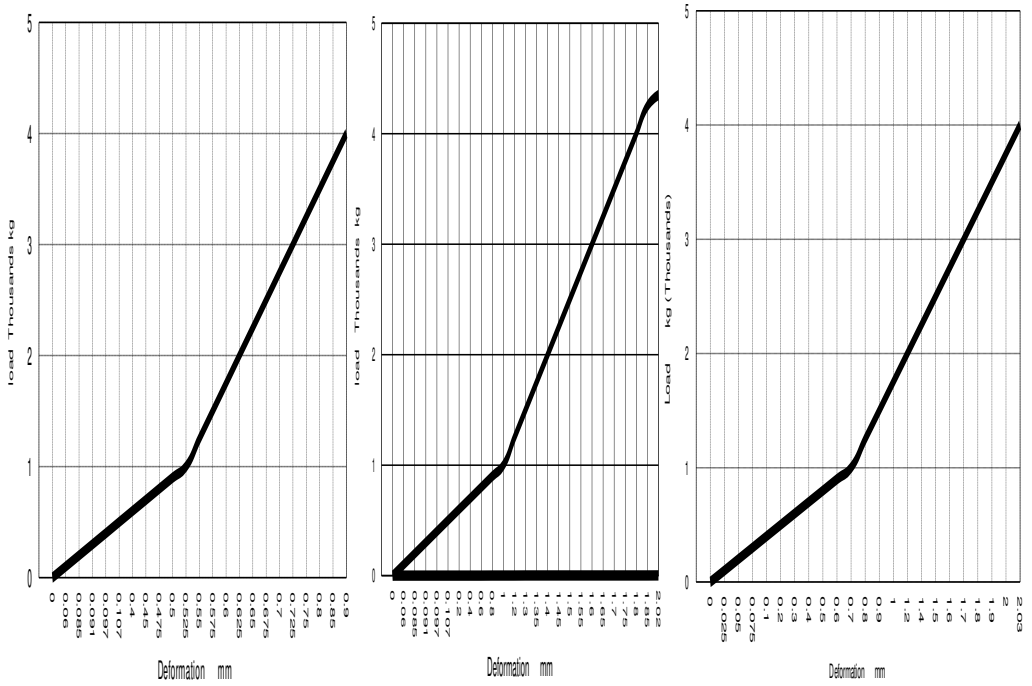


Fig. (5) p-ΔL for samples (VII D2) - (VII D1) & (IX D) from piers models of normal strength concrete (N.C) fcu=250 kg/cm^2

2-2-1-1-b- Samples before loading with injection by different types of materials:

The results of compression tests which were performed on the piers models samples before loading with injection by different types of materials were shown in Table (3).

Table (3) The samples from the Piers Models before loading with injection by different types of materials

No	Sample	Ultimate load (Pu) kg	Deformation (ΔL) mm	Type of Injected Material	Grade of concrete (fcu) kg/cm^2
1	I A1	2250	1.18	Ordinary cement (O.C)	Weak concrete (W.C) fcu=150 kg/cm^2
2	I C1	2750	1.32		
3	I C2	2650	2.3		
4	II A1	3050	1.25	French cement (F.C)	
5	II C2	2550	1.21		
6	II E2	2750	1.33		
7	III A1	2150	1.50	Epoxy (PE L.V.)	
8	III C	2750	1.60		
9	III C1	2800	1.11		
10	V A1	3150	1.1	Ordinary cement (O.C)	Medium concrete (M.C) fcu= 200 kg/cm^2
11	V A2	3300	1.1		
12	V C2	3650	1.21		
13	IV A2	3500	1.7	French cement (F.C)	
14	IV C1	3750	1.3		
15	IV E2	3550	2.0		
16	VI A1	3500	1.16	Epoxy (PE L.V.)	
17	VI E	3500	1.3		
18	VI C2	3600	1.21		
19	1X C1	4070	1.7	Ordinary cement (O.C)	Normal strength concrete NC) fcu=250 kg/cm^2
20	1X E	4150	1.5		
21	1X A2	4200	1.3		
22	VIIIA2	4250	2.4	French cement (F.C)	
23	VIII C	4250	1.8		
24	VIII E	4150	1.3		
25	VI1 A1	4200	1.22	Epoxy (PE L.V.)	
26	VI1 C	4000	1.17		
27	VI1 E1	4000	1.4		

The Load-deformation curves for the samples of the piers models was plotted to get the effect of the injection by different types of materials were plotted in Figs. (6 to 14):

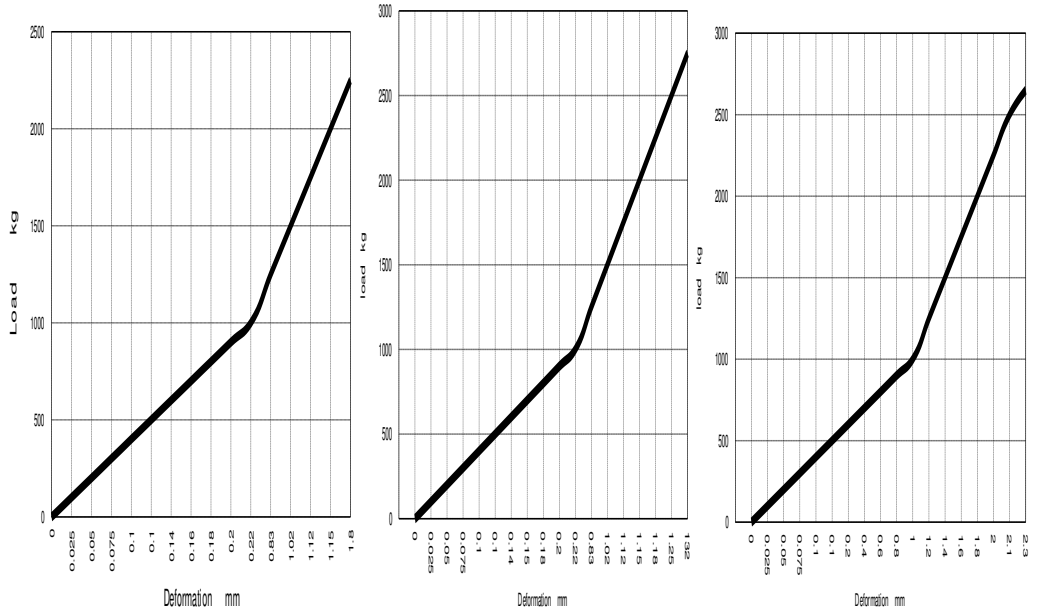


Fig. (6) p-ΔL for samples (I A1)-I C1) & (I C2) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2 injected by ordinary cement (O.C).

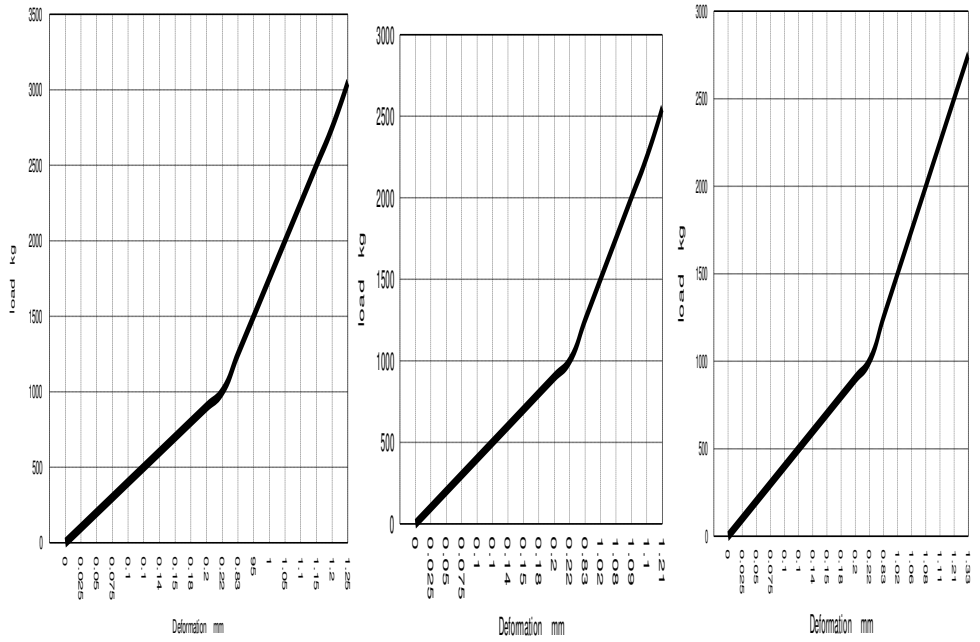


Fig. (7) p-ΔL for samples (II A1)-(II C2) & (II E2) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2 injected by French cement (F.C)

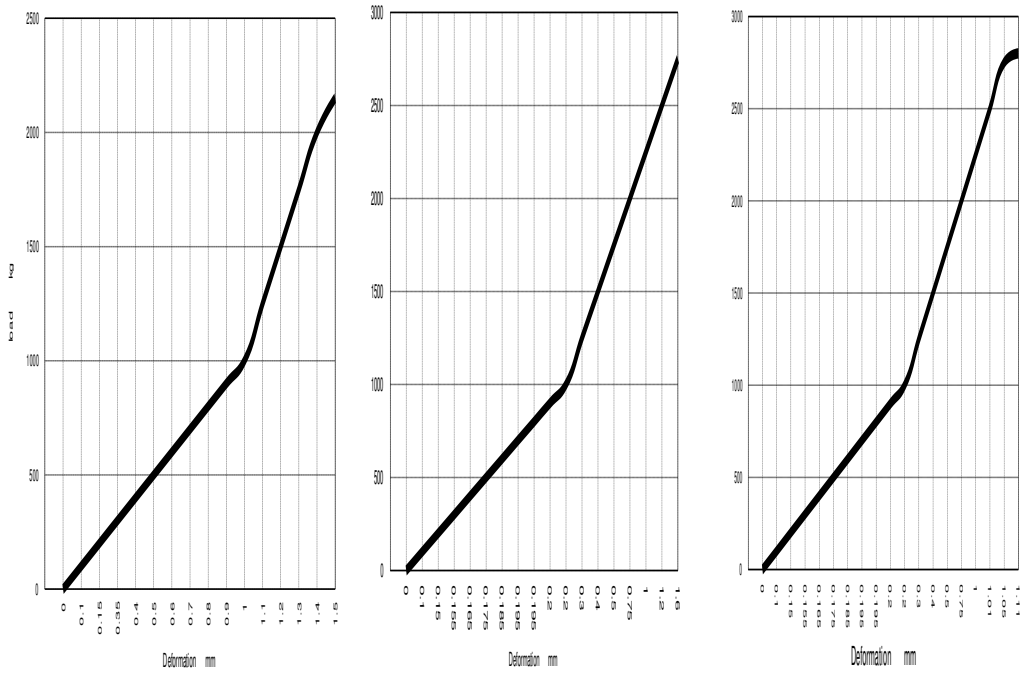


Fig. (8) p-ΔL for samples (III A1) - (III C) & (III C1) for piers models from weak concrete (W.C) fcu =150 kg/cm^2 Injected by epoxy (PE L.V.)

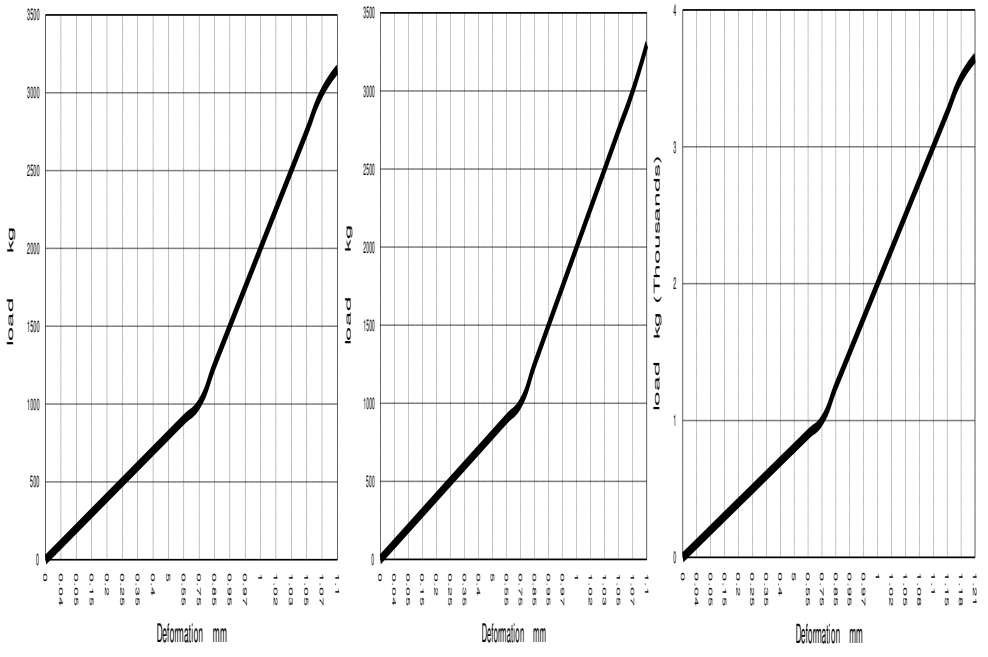


Fig. (9) p-ΔL for samples (V A1)-(V A2) & (V C2) for piers models from Medium concrete (M.C) fcu= 200 kg/cm^2 injected by ordinary cement (O.C).

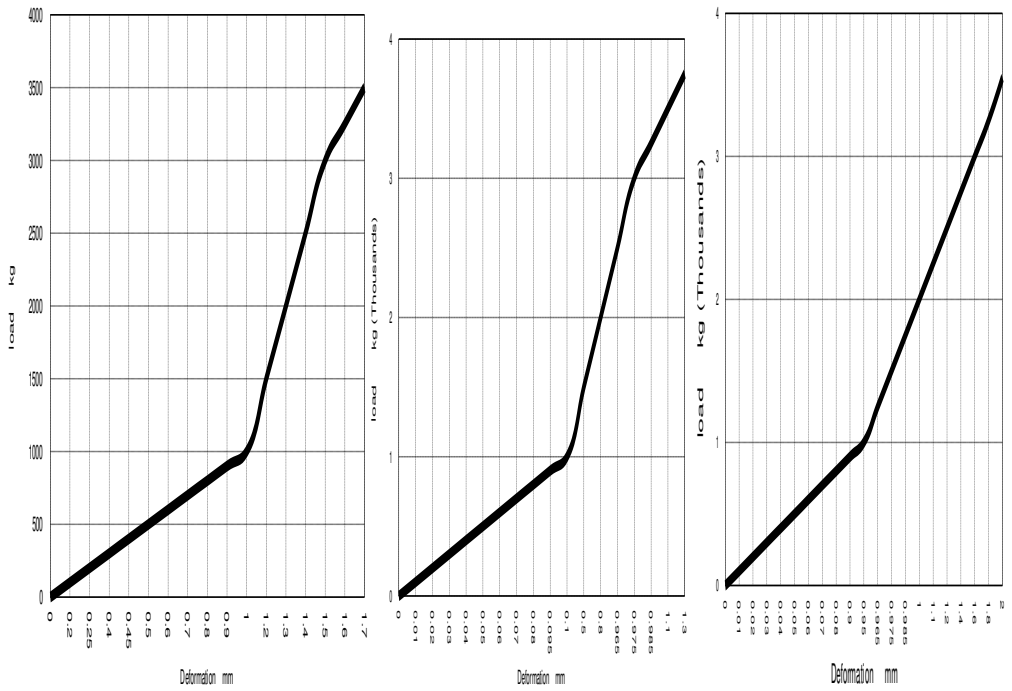


Fig. (10) p-ΔL for samples (IV A2)-(IV C1) & (IV E2) for piers models from Medium concrete (M.C) fcu=200 kg/cm^2 injected by French cement (F.C)

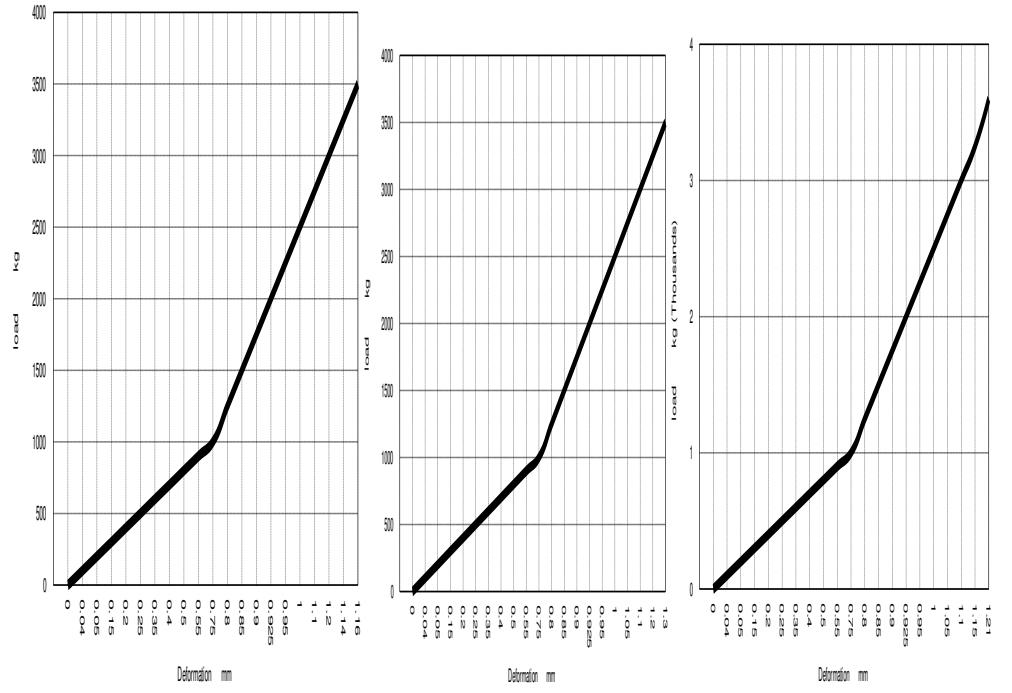


Fig. (11) p-ΔL (VI A1) - (VI E) & (VI C2) for piers models from medium concrete (M.C) fcu= 200 kg/cm^2 injected by epoxy (PE L.V.)

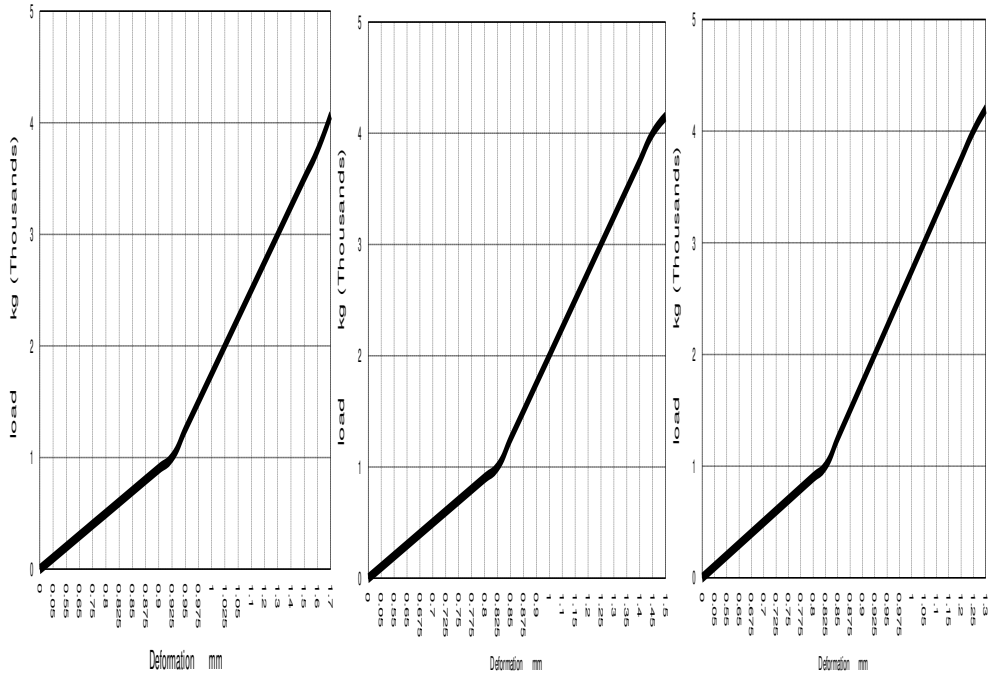


Fig. (12) p-ΔL for samples (IX C1) - (IX E) & (IX A2) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2 injected by ordinary cement (O.C).

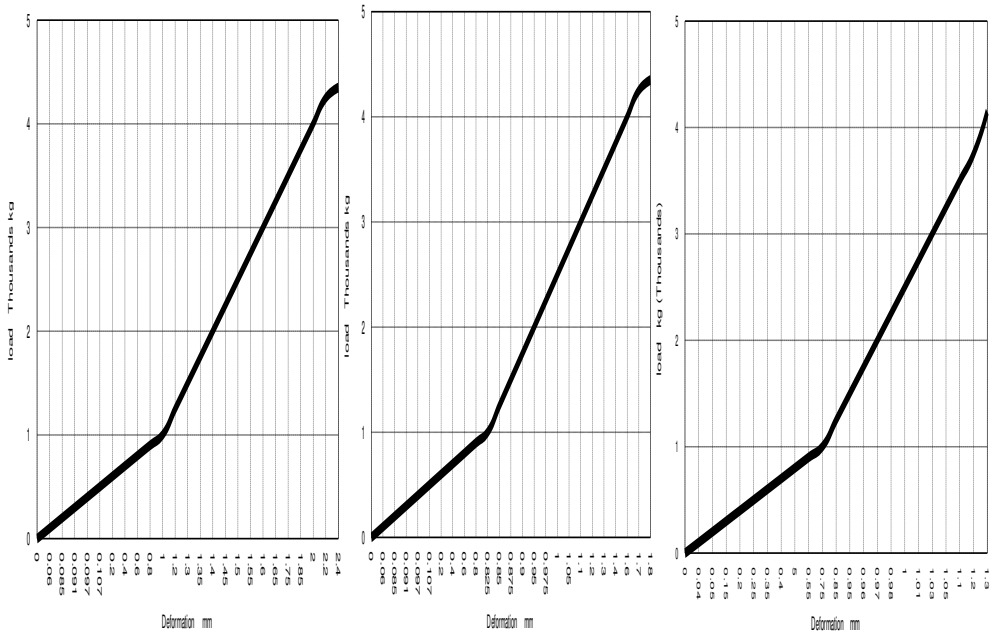


Fig. (13) p-ΔL for samples (VIII A2) - (VIII C) & (VIII E) for piers models from normal strength concrete (N.C) (fcu) =250 kg/cm^2 with type of injected material by French cement (F.C).

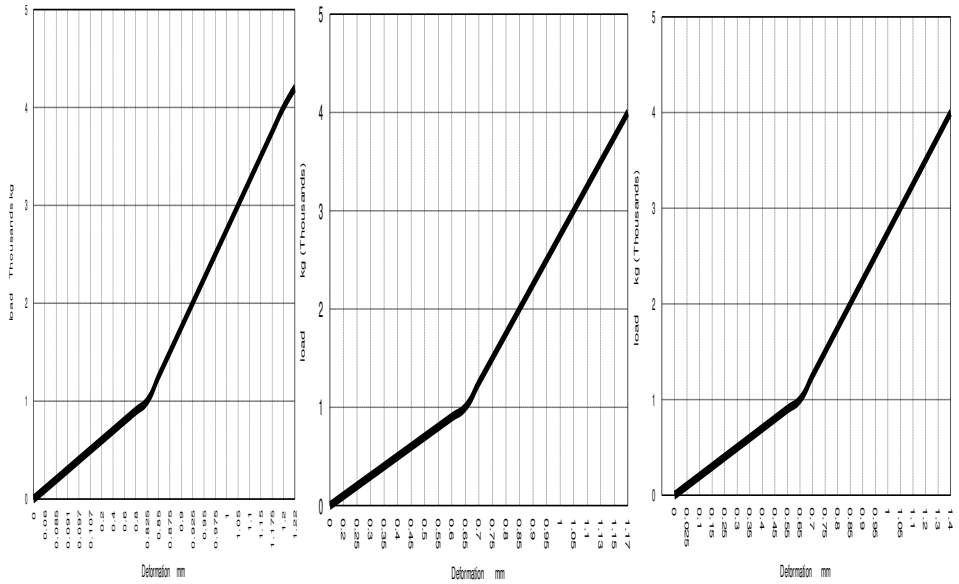


Fig. (14) p-ΔL for samples (VII A1) - (VII C) & (VII E1) for piers models from normal strength concrete (N.C) fcu = 250 kg/cm^2 with type of injected material by epoxy (PE L.V.)

2-2-1-2. Samples after loading in laboratory

By acting loads to produced cracks inside the piers models body before the failure condition assuming the crack load equal to 1/3 the max load depending on the Table (4).

Table (4) The cracks load

No	Grade of concrete	fcu (kg/cm^2)	fc=1/3 fcu (kg/cm^2)	Load (kg)
1	Weak concrete strength (W.C)	150	50	6875
2	Medium concrete strength (M.C)	200	67	92125
3	Normal strength concrete Strength (N.C)	250	83	114125

The loading operation occurred by put the piers models under the applied machine to produced cracked load in order to produced internal cracks to allow the injection by different types of materials to penetrate through these internal crakes and voids to finish the injection operation successfully, Figs. (15) and (16) show the loading operation

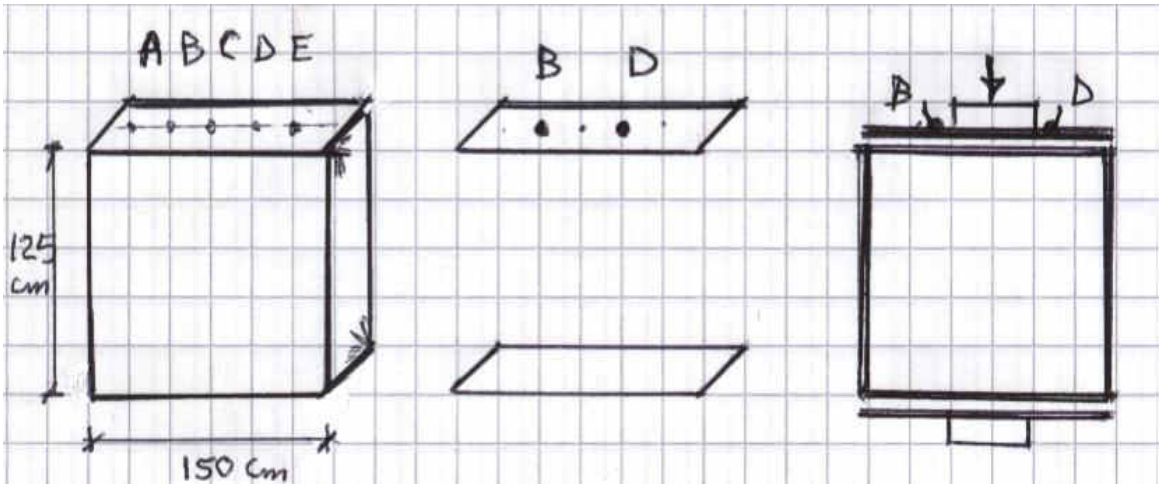


Fig. (15) Sketch of resist pier model

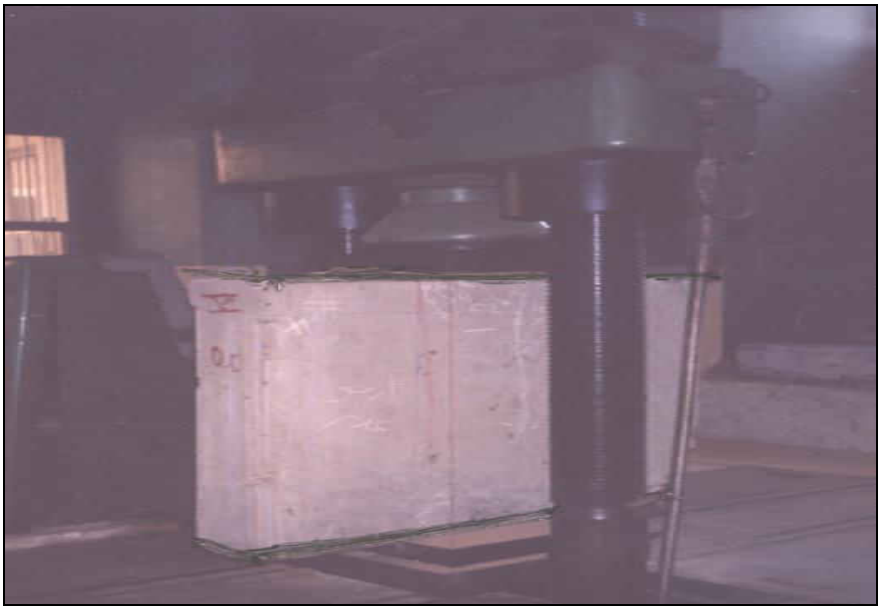


Fig. (16) The piers model loading

2-2-1-2-1. Samples after loading without injection by materials:

The results of compression test which was performed on the samples from the piers models ultimate load (Pu) and the deformation (ΔL) as shown in Table (5).

The load-deformation curves for the samples which their results were shown in Figs. (17 to 25).

Table (5) The samples from the Piers Models after loading without injection.

No	Sample	Ultimate load (Pu) kg	Ultimate strength (Su)B kg/cm^2	Deformation (ΔL) mm	Grade of concrete (fcu) kg/cm^2
1	I -1	1100.0	69.18	2.1	Weak concrete (W.C) fcu=150 kg/cm^2
2	I -2	1200.0	75.47	1.27	
3	I-3	1150.0	72.33	1.27	
4	II-1	1250.0	78.62	1.47	
5	II-2	1150.0	72.33	1.47	
6	II-3	1050.0	66.04	1.27	
7	III-1	1200.0	75.47	1.38	
8	III-2	1300.0	81.78	1.48	
9	III-3	1275.0	70.19	1.5	
10	V-1	1750.0	110.06	1.55	Medium concrete (M.C) fcu=200 kg/cm^2
11	V-2	1600.0	100.63	1.25	
12	V-3	1700.0	106.92	2.18	
13	IV-1	1700.0	106.92	0.98	
14	IV-2	1750.0	110.06	1.35	
15	IV-3	1600.0	100.63	1.25	
16	VI-1	1750.0	110.06	2.02	
17	VI-2	1750.0	110.06	2.15	
18	VI-3	1800.0	113.21	2.15	
19	IX-1	2150.0	135.22	1.8	Normal strength concrete (N.C) fcu=250 kg/cm^2
20	IX-2	2050.0	128.93	1.6	
21	IX-3	2100.0	132.08	1.65	
22	VIII-1	2000.0	125.79	1.75	
23	VIII-2	2000.0	125.79	1.6	
24	VIII-3	2000.0	125.79	1.7	
25	VII-1	1950.0	122.64	3.15	
26	VII-2	2150.0	135.22	2.45	
27	VII-3	2250.0	141.51	2.89	

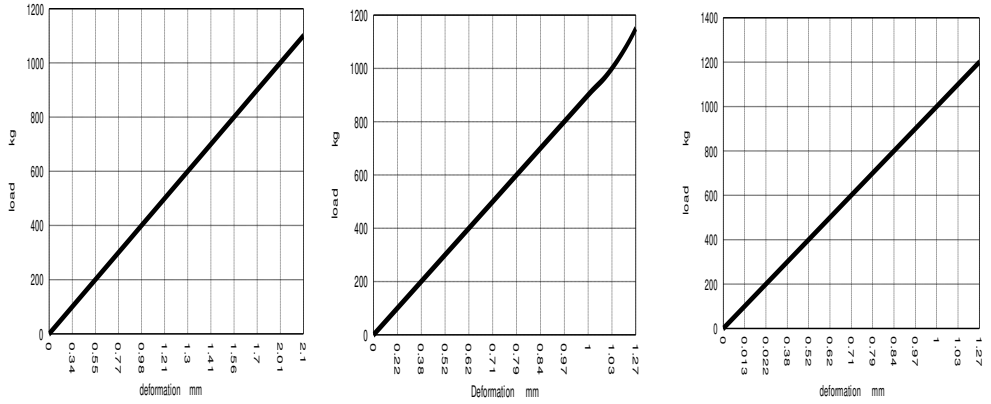


Fig. (17) p-ΔL for samples (I-1) - (I-2) & (I-3) for piers models from weak concrete (W.C) fcu =150 kg/cm^2

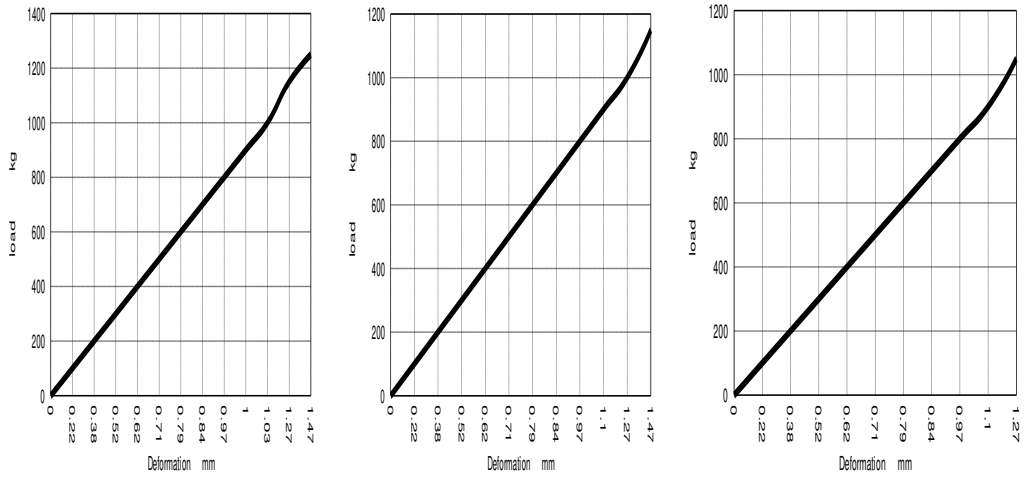


Fig. (18) p-ΔL for samples (II-1) - (II-2) & (II-3) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2.

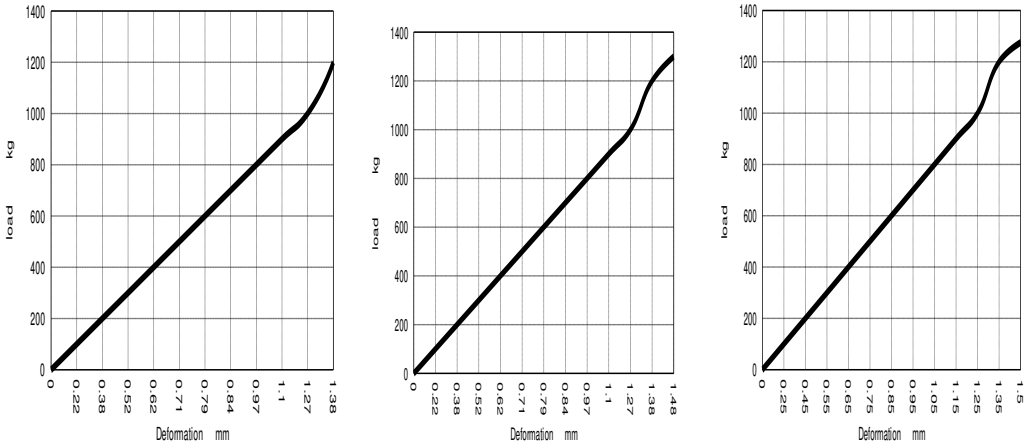


Fig. (19) p-ΔL for samples (III-1) – (II-2) & (III-3) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2

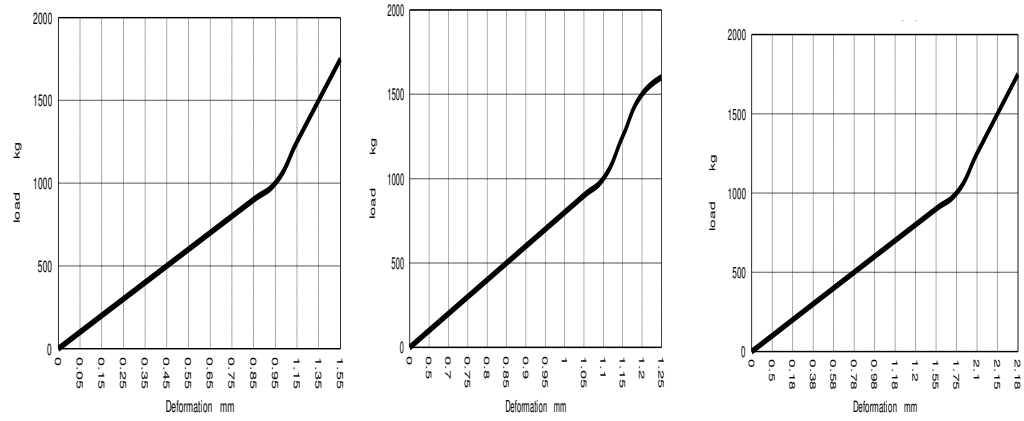


Fig. (20) p-ΔL for samples (V-1) - (V-2) & (V-3) for piers models from medium concrete (M.C) (fcu) = 200 kg/cm^2

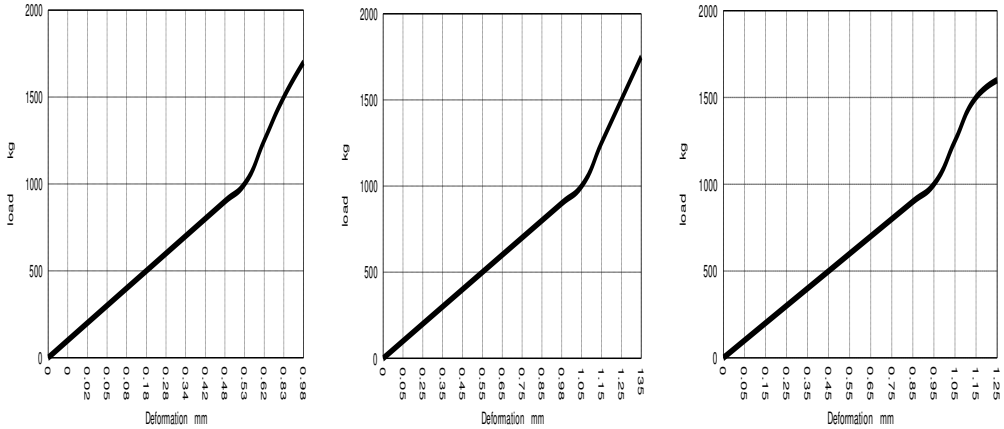


Fig. (21) p-ΔL for samples (IV-1) - Fig. (55) & (IV-3) for piers models from medium concrete (M.C) fcu= 200 kg/cm^2

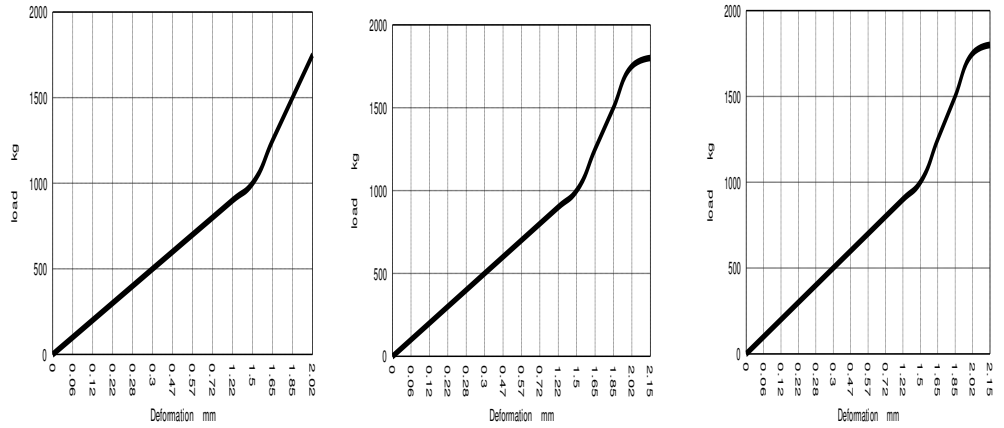


Fig. (22) p-ΔL for samples (VI-1) - (VI-2) & (VI-3) for piers models from medium concrete (M.C) fcu= 200 kg/cm^2

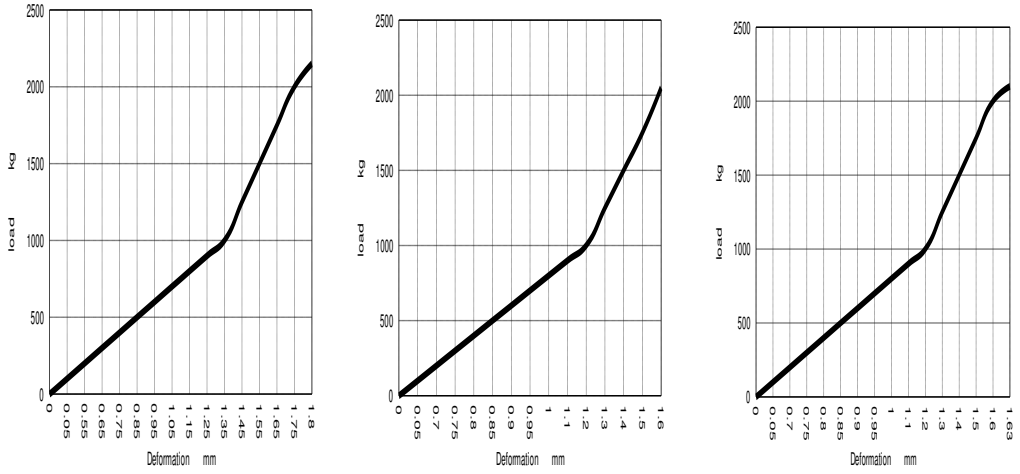


Fig. (23) p-ΔL for samples (IX-1) -IX-2) & (IX-3) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2

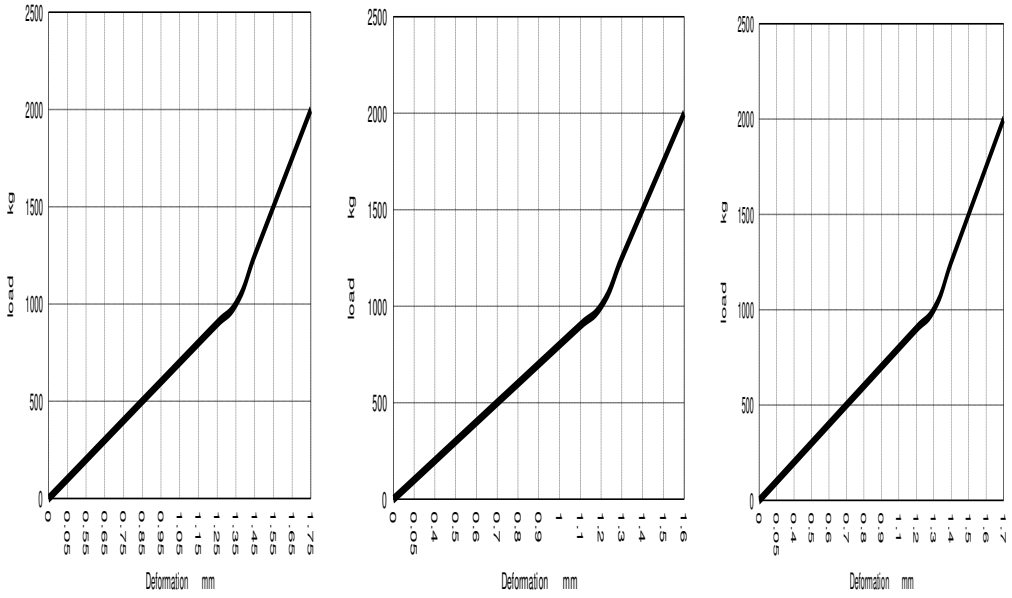


Fig. (24) p-ΔL (VIII-1)- (VIII-2) & (VIII-3) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2

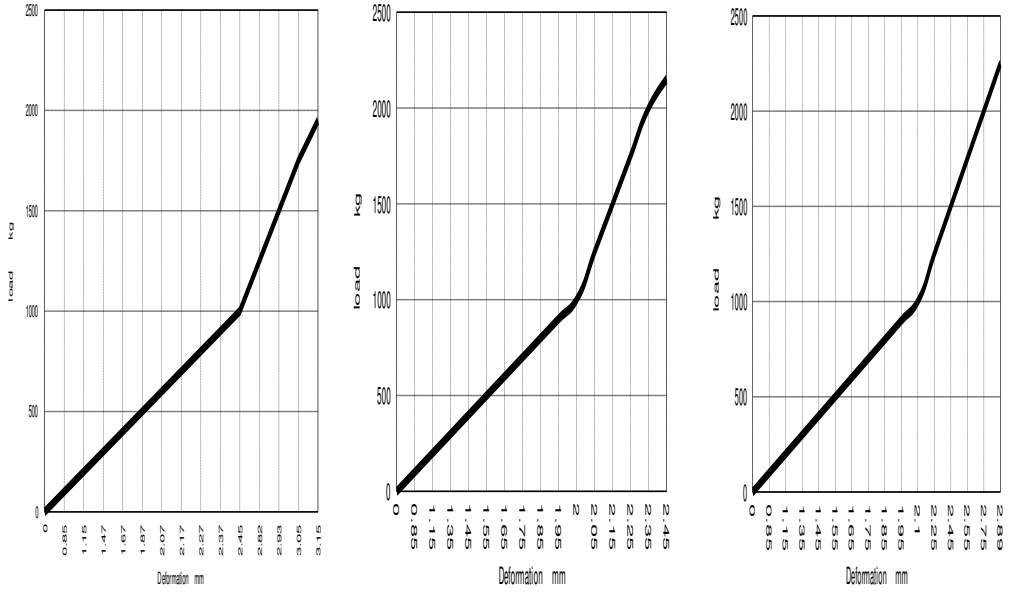


Fig. (25) p-ΔL for samples (VII-1)-(VII-2) & (VII-3) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2

2-2-1-2-2.-Samples after loading with injection by different types of materials:

The compression test results which were performed on the samples from the piers models after loading with injection by different types of materials are shown in Table (6).

Table (6) The samples from the Piers Models after loading with injection by different types of materials

No	Sample	Ultimate load (Pu) kg	Ultimate strength (Su) kg/cm^2	Deformation (ΔL) mm	Type of Injected Material	Grade of concrete(fcu) kg/cm^2
1	I-1	2250.0		0.85	Ordinary cement (O.C)	Weak concrete (W.C) fcu=150 kg/cm^2
2	I-2	2500.0		0.75		
3	I-3	2500.0		0.59		
4	II-1	2750.0		0.49	French cement (F.C)	
5	II-2	2500.0		0.45		
6	II-3	2550.0		0.55		
7	III-1	2350.0		0.40	Epoxy (PE L.V.)	
8	III-2	2050.0		0.38		
9	III-3	2950.0		0.44		
10	V-1	3750.0		1.23	Ordinary cement (O.C)	Medium concrete (M.C) fcu=200 kg/cm^2
11	V-2	4160.0		1.44		
12	V-3	4050.0		0.88		
13	IV-1	4300.0		1.8	French cement(F.C)	
14	IV-2	4160.0		1.5		
15	IV-3	4750.0		2.3		
16	VI-1	3260.0		0.66	Epoxy (PE L.V.)	
17	VI-2	4260.0		0.85		
18	VI-3	4250.0		0.77		
19	IX-1	4250.0		0.39	Ordinary cement (O.C)	Normal strength concrete (N.C) fcu= 250 kg/cm^2
20	IX-2	4250.0		0.44		
21	IX-3	5280.0		0.82		
22	VIII-1	5250.0		0.99	French cement (F.C)	
23	VIII-2	4950.0		0.88		
24	VIII-3	4350.0		0.69		
25	VII-1	4800.0		0.98	Epoxy (PE L.V.)	
26	VII-2	4100.0		0.43		
27	VII-3	4250.0		0.89		

The load-deformation curves for the samples of the piers models was plotted to get the effect of the injection by different types of materials were plotted in Figs. (26 to 34):

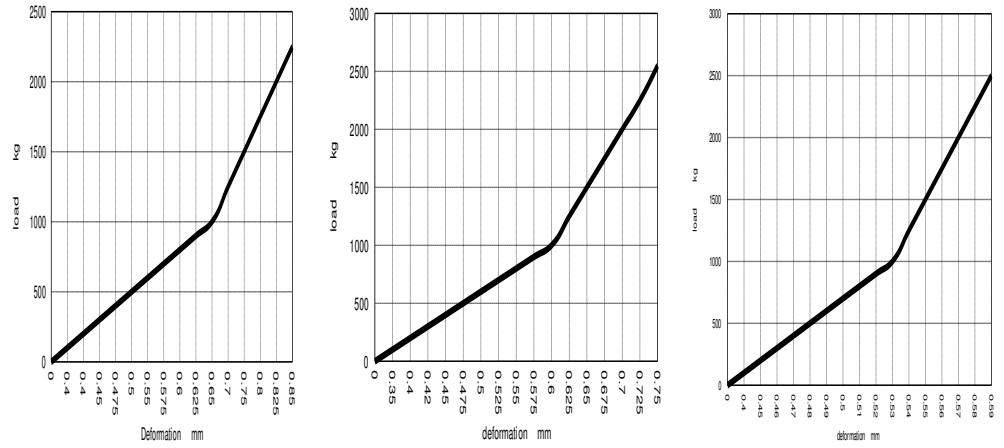


Fig. (26) p-ΔL for samples (I-1) - (I-2) & (I-3) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2 injected by Ordinary cement (O.C).

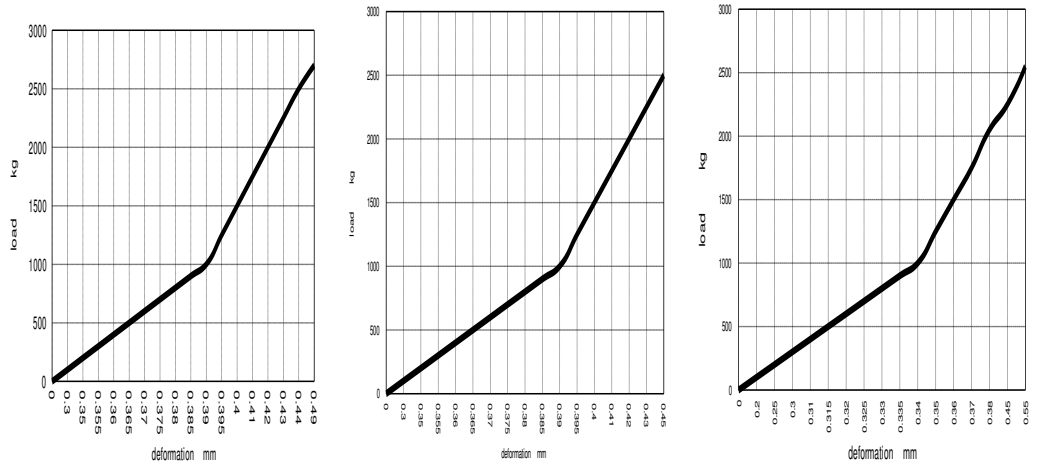


Fig. (27) p-ΔL for samples (II-1) - II-2) & (II-3)) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2 injected by French cement (F.C)

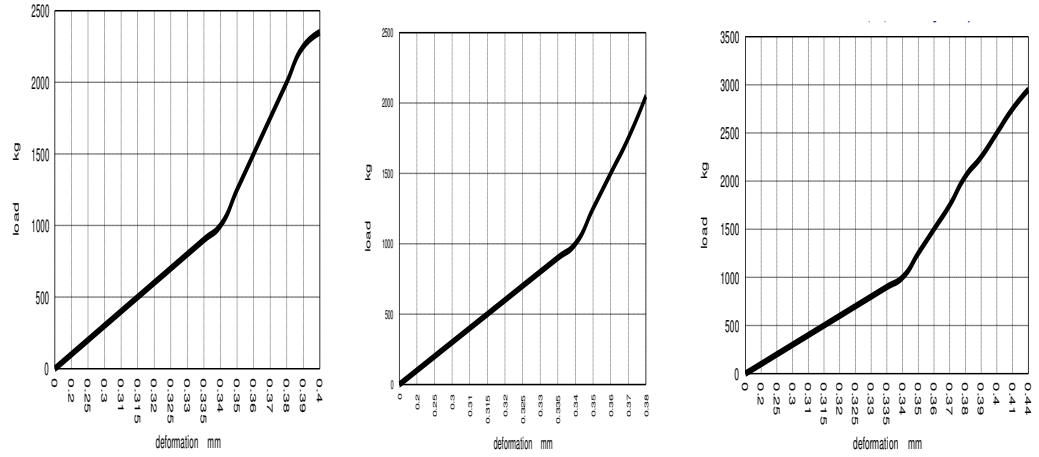


Fig. (28) p-ΔL for samples (III-1) - p-ΔL (III-2) & (III-3)) for piers models from weak concrete (W.C) fcu= 150 kg/cm^2 injected by epoxy (PE L.V.)

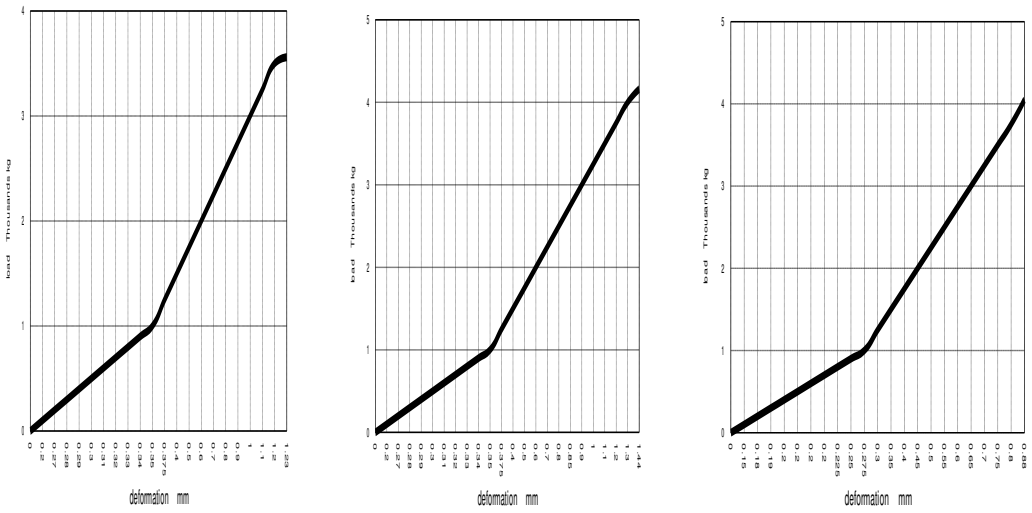


Fig. (29) p-ΔL for samples (V-1) - (V-2& (V-3)) for piers models from medium concrete (M.C) (fcu) 200 kg/cm^2 injected by ordinary cement (O.C).

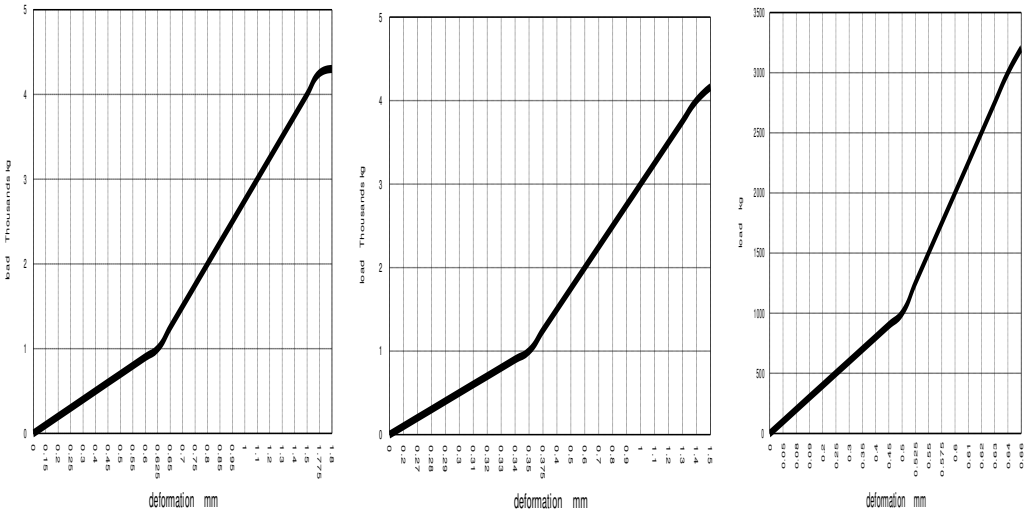


Fig. (30) p-ΔL for samples (IV-1)- (IV-2)Y& (VI-1) for piers models from medium concrete (M.C) fcu= 200 kg/cm^2 injected by French cement (F.C)

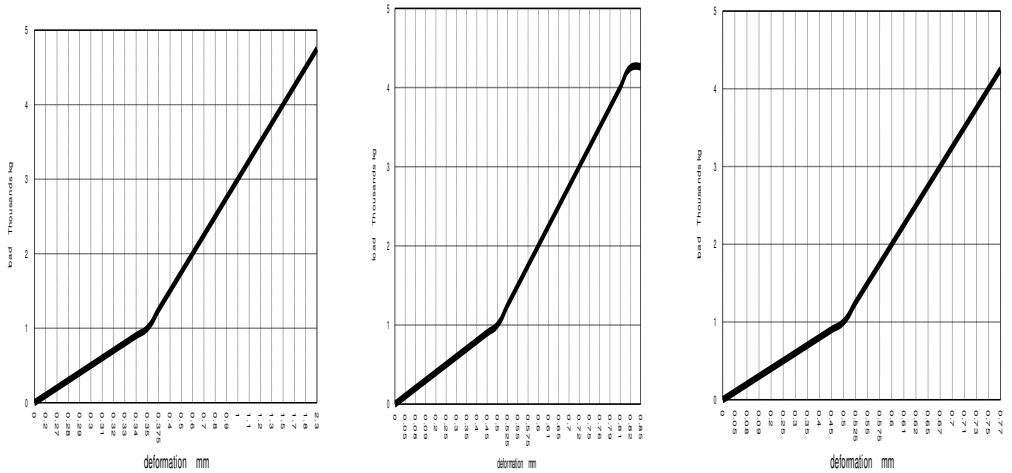


Fig. (31) p-ΔL for samples (VI-1) - (VI-2) & (VI-3) for piers models from medium concrete (M.C) fcu= 200 kg/cm^2 injected by epoxy (PE L.V.)

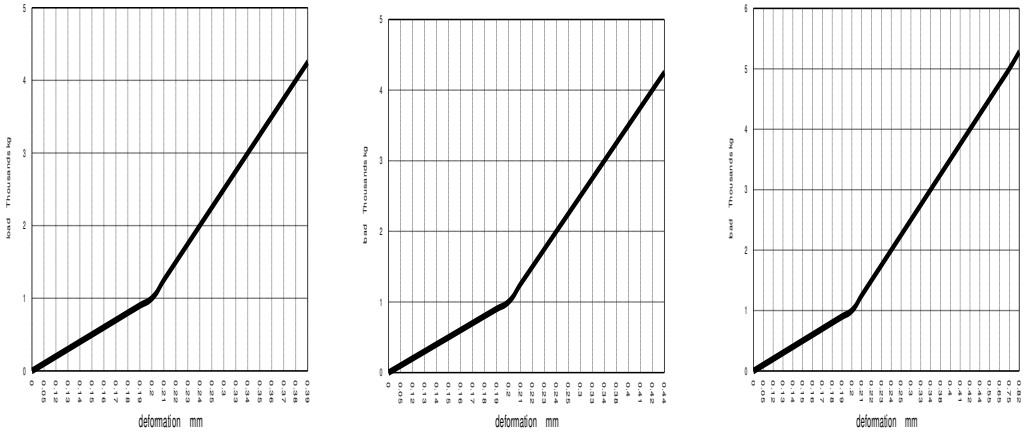


Fig. (32) p-ΔL for samples (IX-1) - (IX-2) & (IX-3) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2 injected by ordinary cement (O.C).

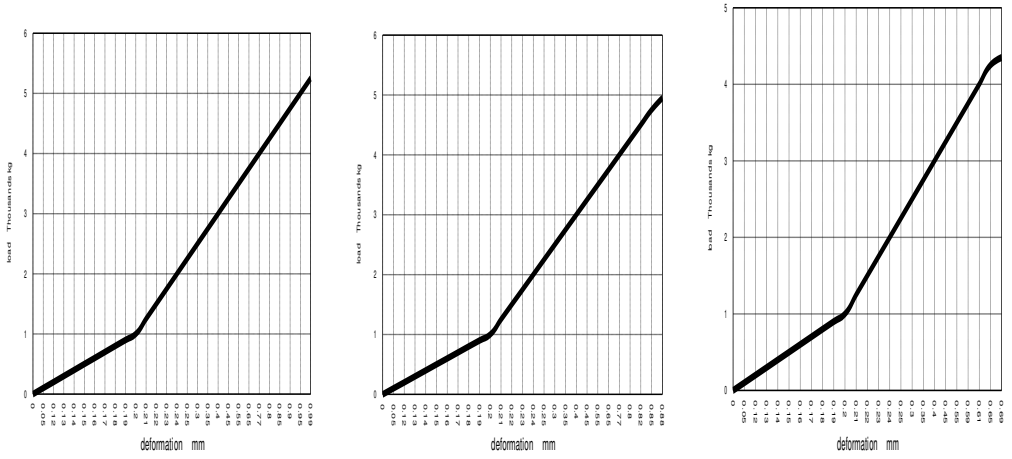


Fig. (33) p-ΔL for samples (VIII-1) - (VIII-2) & (VIII-3) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2 injected by French cement (F.C)

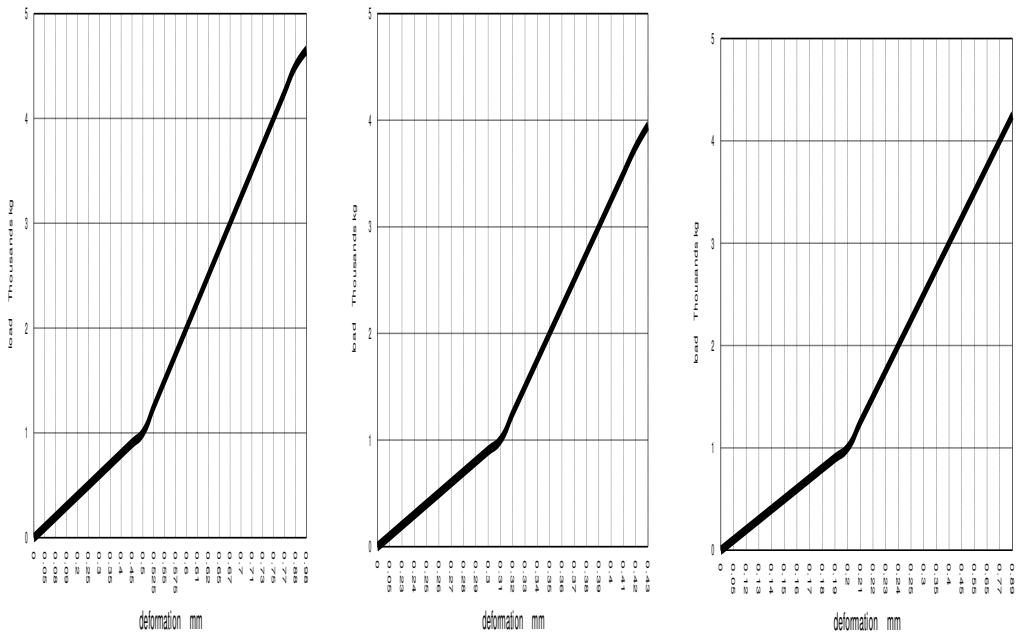


Fig. (34) p-ΔL for samples (VII-1) - (VII-2) & (VII-3) for piers models from normal strength concrete (N.C) fcu= 250 kg/cm^2 injected by epoxy (PE L.V.)

2-2-2-Void ratio, Porosity and Density:

For the two cases of loading, every case of loading contains:

- Samples without injection:
- Samples after injection by different types of materials.

The results of void ratio , porosity and density for the samples from the piers models for the two states before loading and after loading are given in tables (7) to(10)., every state without injection by materials and with injection by different types of materials.

2-2-2-1- Samples before loading:

Thirty six samples were taken from the piers models before loading state without injection and with injection by different types of materials and the results are given in table(7) &(8).

2-2-2-1-a- Samples before loading without injection:

The results for the samples of piers models before loading without injection are shown in table (7).

Table (7) Samples from the Piers models before loading without injection :

No	Sample	H (mm)	D (mm)	Wet wt (gm)	Dry wt (gm)	Grade of concrete(fcu) kg/cm^2
1	II B	42	45	139.2	128.7	Weak concrete (W.C) fcu= 150 kg/cm^2
2	II D1	49	45	153.1	141.4	
3	III B1	85	45	294.8	271.5	
4	IV B3	65	45	219.4	201.5	Medium concrete (M.C) fcu= 200 kg/cm^2
5	IV B2	44	45	140.0	127.4	
6	VI D1	82	45	217.5	250.4	
7	VII D2	43	45	139.5	130.9	Normal strength concrete (N.C) fcu= 250 kg/cm^2
8	VII D1	35	45	121.0	112.8	
	IX D	90	45	302.0	277.0	

2-2-1-b- Samples before loading with injection by different types of materials:

Table (8) Samples from the Piers models before loading with injection by different types of materials

No	Sample	H (mm)	D (mm)	Wet wt (gm)	Dry wt (gm)	Type of Injected Material l	Grade of concrete (fcu) kg/cm^2
1	I A1	67	45	230.3	219.0	Ordinary cement (O.C)	Weak concrete (W.C) fcu= 150 kg/cm^2
2	I C1	59	45	202.2	189.8		
3	I C2	103	45	348.1	323.6		
4	II A	80	45	280.2	264.5	French cement (F.C)	
5	II C2	56	45	193.6	182.6		
6	II E2	44	45	146.6	138.0		
7	III A1	70	45	254.0	237.2	Epoxy (PELV)	
8	III C	70	45	235.9	217.5		
9	III C1	56	45	189.5	174.4		
10	V A1	70	45	271.5	250.4	Ordinary cement (O.C)	Medium concrete (M.C) fcu= 200 kg/cm^2
11	V C1	56	45	202.5	189.8		
12	V E1	67	45	348.1	323.6		
13	IV E1	82	45	271.5	250.4	French cement (F.C)	
14	IV A1	59	45	202.5	189.8		
15	IV C2	103	45	348.1	323.6		
16	VI A	47	45	150.6	142.4	Epoxy (PELV)	
17	VI A1	58	45	205.8	19208		
18	VI A2	43	45	157.0	147.0		
19	IX C1	65	45	189.5	174.4	Ordinary cement (O.C)	Normal strength concrete (N.C) fcu= 250 kg/cm^2
20	IX E	65	45	219.4	201.5		
21	IX A2	67	45	139.5	131.7		
22	VIII A2	103	45	361.6	337.5	French cement (F.C)	
23	VIII C2	70	45	137.5	130.7		
24	VIII E2	47	45	157.0	147.0		
25	VII A1	70	45	254.5	234.7	Epoxy (PE L.V.)	
26	VII C1	88	45	305.3	275.3		
27	VII E1	80	45	284.2	266.3		

2-2-2-2- Samples after loading:

Fifty four samples were taken from the piers models after loading state without injection and with injection **by different types of materials** and the results are given in tables(9) &(10).

2-2-2-2-a- Samples after loading without injection:

The results of the tests void ratio , porosity and density for the samples of Piers Models after loading without injection are shown in table(9)

Table (9) Samples from Piers models after loading without injection

No	Sample	H (mm)	D (mm)	Vt (cm^3)	Wet wt (gm)	Dry wt (gm)	Grade of concrete (fcu) ($kg/cm^{2)}$
1	I-1	48	45	76.32	168.3	159.8	Weak concrete (W.C) fcu=150 kg/cm^2
2	I-2	58	45	92.22	218.4	196.3	
3	I-3	50	45	79.48	170.1	157.8	
4	II-1	45	45	71.55	150.3	137.4	
5	II-2	50	45	79.48	175.6	163.7	
6	II-3	47	45	74.73	162.9	153.1	
7	III-1	54	45	85.86	191.3	176.6	
8	III-2	49	45	77.91	175.8	162.8	
9	III-3	50	45	79.48	178.7	165.8	
10	IV-1	48	45	76.32	166.7	158.2	Medium concrete (M.C) fcu= 200 kg/cm^2
11	IV-2	45	45	71.55	151.8	141.8	
12	IV-3	60	45	95.4	217.2	206.2	
13	V-1	50	45	79.48	170.1	157.8	
14	V-2	50	45	79.48	175.4	164.7	
15	V-3	60	45	95.4	211.8	201.4	
16	VI-1	49	45	77.91	170.1	160.4	
17	VI-2	45	45	71.55	153.2	142.3	
18	VI-3	59	45	93.81	203.4	189.7	
19	VII-1	46	45	73.14	169.2	154.8	Normal strength concrete (N.C) fcu=250 kg/cm^2
20	VII-2	50	45	79.48	178.6	166.3	
21	VII-3	58	45	92.22	206.7	190.8	
22	VIII-1	60	45	95.4	211.8	201.3	
23	VIII-2	50	45	79.48	179.5	165.7	
24	VIII-3	50	45	79.48	173.8	162.6	
25	IX-1	43	45	68.37	152.8	142.6	
26	IX-2	44	45	69.96	153.5	142.2	
27	IX-3	60	45	95.4	218.7	204.2	

2-2-2-2-b- Samples after loading with injection by different types of materials:

The results of the tests void ratio, porosity and density for the samples of Piers Models after loading with injection **by different types of materials** are shown in table (10)

Table(10) Piers Models samples after loading with injection by different types of materials

No	Sample	H (mm)	D (mm)	Wet wt (gm)	Dry wt (gm)	Type of Injected Material	Grade of concrete (fcu) kg/cm^2
1	I-1	49	45	188.4	181.2	Ordinary ce ment(O.C)	Weak concrete (W.C) fcu=150 kg/cm^2
2	I-2	50	45	189.8	180.4		
3	I-3	48	45	185.4	179.3		
4	II-1	49	45	187.8	180.8	French cement(F.C)	
5	II-2	50	45	189.3	183.7		
6	II-3	58	45	210.4	201.2		
7	III-1	125	134	4217.7	4186.0	Epoxy (PE L.V.)	
8	III-2	53	45	215.6	211.7		
7	III-3	125	134	4238.5	4204.9		
10	V-1	47	45	181.3	174.6	Ordinary cement	Medium concrete (M.C) fcu=200 kg/cm^2
11	V-2	50	45	172.8	165.3		
12	V-3	57	45	211.3	208.3		
13	IV-1	65	45	209.2	201.2	French cement (F.C)	
14	IV-2	52	45	188.3	183.0		
15	IV-3	80	45	211.4	204.2		
16	VI-1	58	45	213.2	210.1	Epoxy (PE L.V.)	
17	VI-2	55	45	209.4	206.3		
18	VI-3	115	134	4264.2	4224.1		
19	IX-1	46	45	183.2	176.4	Ordinary cement (O.C)	Normal strength concrete (N.C) fcu=250 kg/cm^2
20	IX-2	115	45	4040.0	3996.0		
21	IX-3	125	134	4102.1	4071.0		
22	VIII-1	55	45	207.3	198.7	French cement(F.C)	
23	VIII-2	48	45	189.6	182.3		
24	VIII-3	80	134	2878.6	2832.3		
25	VII-1	54	45	212.6	206.5	Epoxy (PE L.V.)	
26	VII-2	52	45	208.6	203.2		
27	VII-3	115	134	4230.9	4201.6		

3- DISCUSSION

The two cases which the piers models samples were taken explained as follow:

3-1- Samples before loading:

This case before acting load on the piers models to produced internal cracks allow to the injected material to penetrate through these cracks and renew the desponding action between the aggregate fine or coarse and cement, for this the injection fit back the loss desponding .

3-1-1-comperssion test:

The results of the compression test for the samples that obtained from three types of concrete piers models and comparison between the ultimate strength of these samples before and after loading without injection and with injection by different types of materials are explained as follows:

3-1-1-a Samples before loading:

The compression test results for the samples of models before loading without injection and with injection by different types of materials are shown in tables (11) & (12)

3-1-1-a-1- Samples before loading without injection

The compression test results and the calculations of the average ultimate strength ($Su^{/}$) B and relative strain ($\zeta = \Delta L/L$) for the samples from the piers models before loading without injection are shown in table (11)

Table (11) The samples from Piers models before loading without injection

No	Sample	Ultimate strength (Su/)B kg/cm^2	Average ultimate strength (Su/)B kg/cm^2	$\zeta = \Delta L/H$	Grade of concrete (fcu) kg/cm^2
1	II B	138.36	149.89	0.0245	Weak concrete (W.C) fcu= 150 kg/cm^2
2	II D1	166.67		0.022	
3	III B1	144.65		0.025	
4	IV B3	201.25	200.62	0.028	Medium concrete (M.C) fcu= 200 kg/cm^2
5	IV B2	200.63		0.022	
6	VI D1	199.97		0.026	
7	VII D2	251.57	258.91	0.022	Normal strength oncrete (N.C) fcu= 250 kg/cm^2
8	VIID1	273.58		0.031	
9	IX D	251.57		0.023	

3-1-1-a-2- Samples before loading with injection by different types of materials

The compression test results for the samples of piers models before loading with injection by different types of materials are shown in table (12)

Table (12) The samples from Piers models before loading with injection by different types of materials

No	Sample	Ultimate strength (Su)A kg/cm2	Average Ultimate strength (Su/)A kg/cm^2 (Su/)A	ζ =ΔL/L	Type of Injected Material	Grade of concrete (fcu) kg/cm^2
1	IA1	141.51	160.38	0.018	Ordinary cement (O.C)	Weak concrete (W.C) fcu= 150 kg/cm^2
2	IC1	172.96		0.022		
3	IC2	166.67		0.022		
4	IIA1	191.82	175.07	0.016	French cement (F.C)	
5	II C2	160.38		0.022		
6	II E2	173.0		0.023		
7	IIIA1	135.22	161.44	0.021	Epoxy (PE L.V.)	
8	III C	173.0		0.023		
9	IIIC1	176.1		0.020		
10	V A1	198.11	211.74	0.016	Ordinary cement (O.C)	Medium concrete (M.C) fcu= 200 kg/cm^2
11	V A2	207.55		0.020		
12	V C2	229.56		0.018		
13	IV A2	220.13	226.42	0.021	French cement (F.C)	
14	IV C1	235.85		0.022		
15	IV E2	223.27		0.018		
16	VI A1	220.13	222.23	0.025	Epoxy (PE L.V.)	
17	VI E	220.13		0.022		
18	VI C2	226.42		0.015		
19	IX C1	256.00	260.38	0.024	Ordinary cement (O.C)	Normal strength concrete (N.C) fcu= 250 kg/cm^2
20	IX E	261.00		0.027		
21	IX A2	264.15		0.016		
22	VIII A2	267.30	265.20	0.023	French cement (F.C)	
23	VIII C	267.30		0.02		
24	VIII E	261.00		0.028		
25	VII A1	264.15	255.78	0.017	Epoxy (PE L.V.)	
26	VII C	251.60		0.018		
27	VII E1	251.60		0.020		

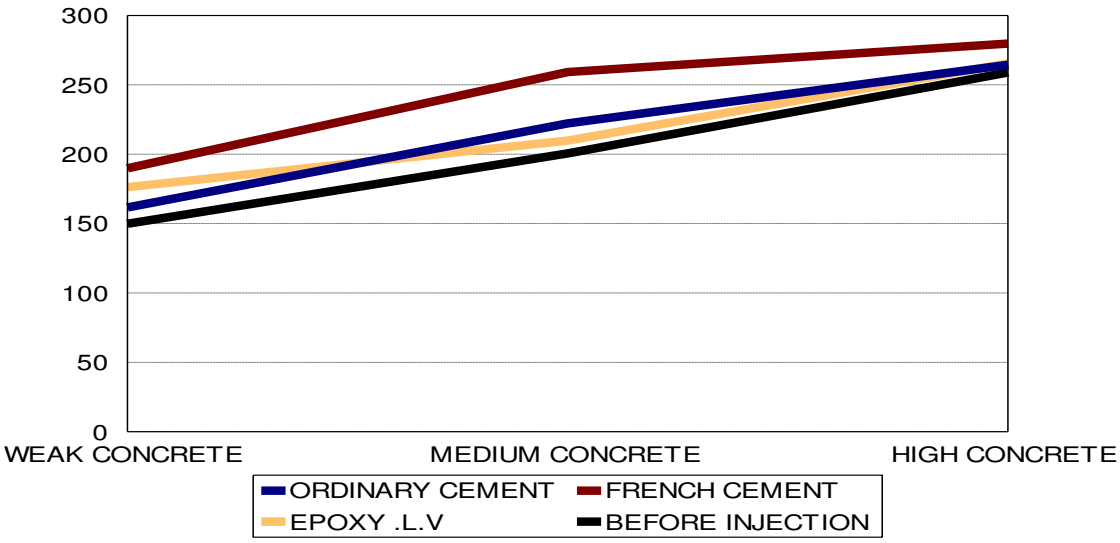


Fig. (35) The ultimate strengths with the concrete grades without injection: &with injection by different types of materials

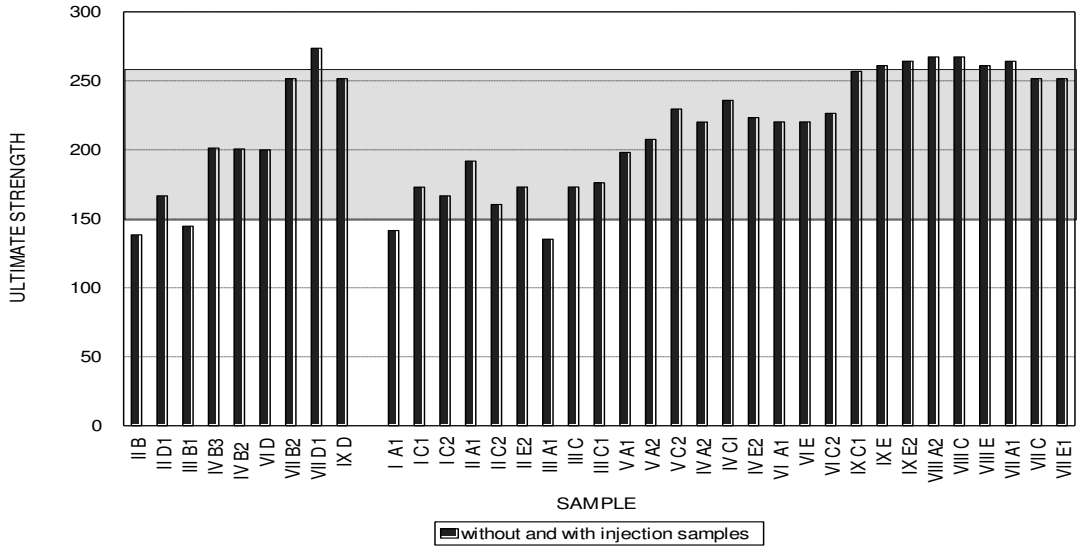


Fig. (36) The ultimate strength (Su) before loading without injection &with injection by different types of materials.

From Table (11). For the samples without injection (B and D), (A, C and E), Table (12) for the injected samples (A, C and E), Figs (35) & (36) indicated that:

The difference between the ultimate strength (Su) before loading without injection and with injection by different types of materials was very small for the three grades of concrete model.

3-1-2-1-a- Samples after loading

The compression test results for the samples of models after loading without injection by materials: and with injection by different types of materials are shown in Tables (13)& (14).

3-1-2-1-a-1 Samples after loading without injection:

The compression test results for the samples of piers models after loading without injection: are shown in table (13)

Table (13) The samples of Piers models after loading without injection:

No	Sample	Ultimate strength (Su) kg/cm^2	Average ultimate strength (Su/)A kg/cm^2	ζ=ΔL/L	Grade of concrete (fcu) kg/cm^2	Remarks
1	I-1	69.18	72.23	0.024	Weak concrete (W.C) fcu=150 kg/cm^2	Without injection.
2	I-2	75.17		0.022		
3	I-3	72.33		0.025		
4	II-1	78.62	72.33	0.027		
5	II-2	72.33		0.029		
6	II-3	66.04		0.027		
7	III-1	75.47	75.81	0.026		
8	III-2	81.78		0.028		
9	III-3	70.19		0.03		
10	V-1	110.06	105.87	0.029	Medium concrete (M.C) 200	
11	V-2	100.63		0.025		
12	V-3	106.92		0.025		
13	IV-1	106.92	105.87 kg/cm2	0.019		
14	IV-2	110.06		0.03		
15	IV-3	100.63		0.021		
16	VI-1	110.06	108.06 kg/cm2	0.029		
17	VI-2	113.21		0.024		
18	VI-3	100.92		0.029		
19	IX-1	135.22	132.08	0.026	Normal strength concrete (N.C) fcu=250 kg/cm^2	
20	IX-2	128.93		0.025		
21	IX-3	132.08		0.027		
22	VIII-1	125.79	125.79	0.029		
23	VIII-2	125.79		0.029		
24	VIII-3	125.79		0.025		
25	VII-1	122.64	133.12	0.029		
26	VII-2	135.22		0.027		
27	VII-3	141.51		0.029		

3-1-2-1-a-2 Samples after loading with injection by different types of materials

The compression test results for the samples of piers models after loading with injection by different types of materials are shown in Table (14).

Table (14).The samples from Piers models after loading with injection by different types of materials

No	Sample	Ultimate strength (Su)A kg/cm^2	Average (Su/)A kg/cm^2	ζ=ΔL/L	Type of Injected Material	Grade of concrete (fcu) kg/cm^2
1	I-1	141.51	151.99	0.017	Ordinary cement (O.C)	Weak concrete (W.C) fcu=150 kg/cm^2
2	I-2	157.23		0.015		
3	I-3	157.23		0.013		
4	II-1	172.96	163.52	0.010	French cement (F.C)	
5	II-2	157.23		0.009		
6	II-3	160.38		0.0095		
7	III-1	147.80	154.09	0.003	Epoxy (PE L.V.)	
8	III-2	128.93		0.008		
9	III-3	185.53		0.004		
10	V-1	235.85	250.72	0.026	Ordinary cement (O.C)	Medium concrete (M.C) 200
11	V-2	261.6		0.029		
12	V-3	254.7		0.015		
13	IV-1	270.40	276.93	0.028	French cement (F.C)	
14	IV-2	261.64		0.029		
15	IV-3	298.74		0.029		
16	VI-1	205.03	246.84	0.012	Epoxy (PE L.V.)	
17	VI-2	267.92		0.015		
18	VI-3	267.30		0.007		
19	IX-1	267.3	288.89	0.008	Ordinary cement (O.C)	Normal strength concrete (N.C) fcu= 250 kg/cm^2
20	IX-2	267.3		0.004		
21	IX-3	332.08		0.007		
22	VIII-1	330.19	305.03	0.018	French cement (F.C)	
23	VIII-2	311.32		0.018		
24	VIII-3	273.58		0.009		
25	VII-1	301.89	275.68	0.018	Epoxy (PE L.V.)	
26	VII-2	257.86		0.008		
27	VII-3	267.3		0.008		

Table (15) The Average ultimate strength ($Su^{/}$) for concrete grades and types of injected material

No	Grade of concrete (fcu) kg/cm^2	Average ultimate strength without injection ($Su^{/}$)B kg/cm^2	Average ultimate strength with injection ($Su^{/}$) kg/cm^2	%Exc. $Su^{/}$)A/ $Su^{/}$)B	Type of Injected Material
1	Weak concrete (W.C) fcu= 150 kg/cm^2	72.23	151.99 Ordinary.C (O.C)	110.04%	Ordinary .Cement (O.C)
		72.33	163.52 French.C. (F.C)	126.07%	French .Cement (F.C)
		75.81	154.09 Epoxy (PE L.V.)	103.27%	Epoxy (PE L.V.)
2	Mediu m concret e (M.C) fcu= 200 kg/cm^2	105.87	250.72 Ordinary.C. (O.C)	136.82%	Ordinary .Cement. (O.C)
		105.87	276.93 French .C. (F.C)	161.58%	French .Cement. (F.C)
		108.06	246.84 Epoxy (PE L.V.)	128.43%	Epoxy (PE L.V.)
3	Normal strength concrete (N.C) fcu=250 kg/cm^2	132.08	288.89 Ordinary.Concrete (O.C)	118.72%	Ordinary .Cement (O.C)
		125.79	305.03 French.Concrete (F.C)	142.49%	French .Cement (F.C)
		133.12	275.68 Epoxy (PE L.V)	107.09%	Epoxy (PE L.V.)

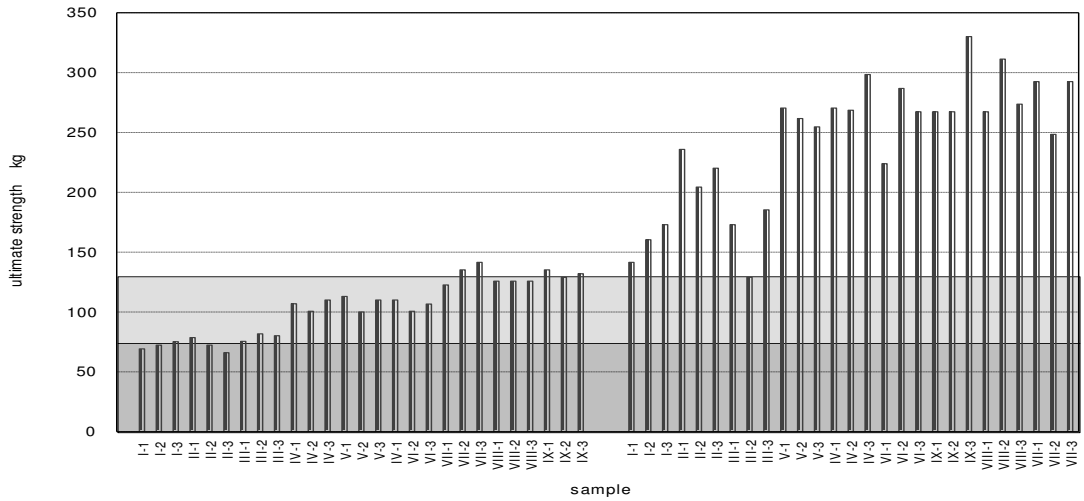


Fig. (37) Ultimate strengths (Su) without injection and with injection by different types of materials after loading.

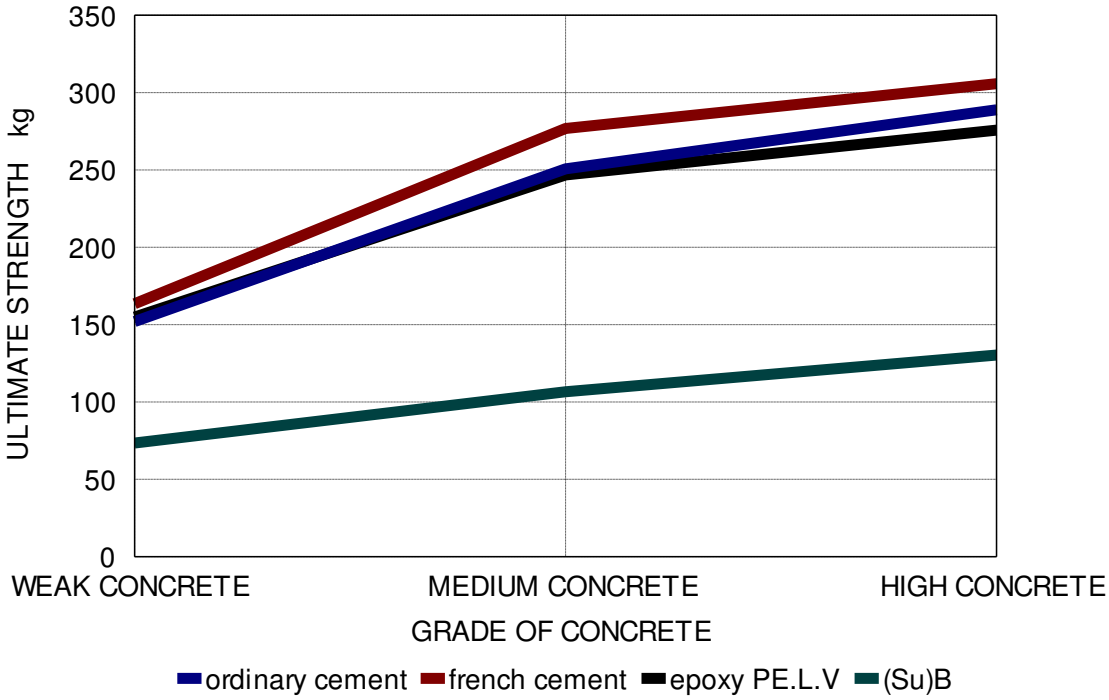


Fig. (38) The ultimate strengths (Su) with the concrete grades without injection & with injection **by different types of materials**

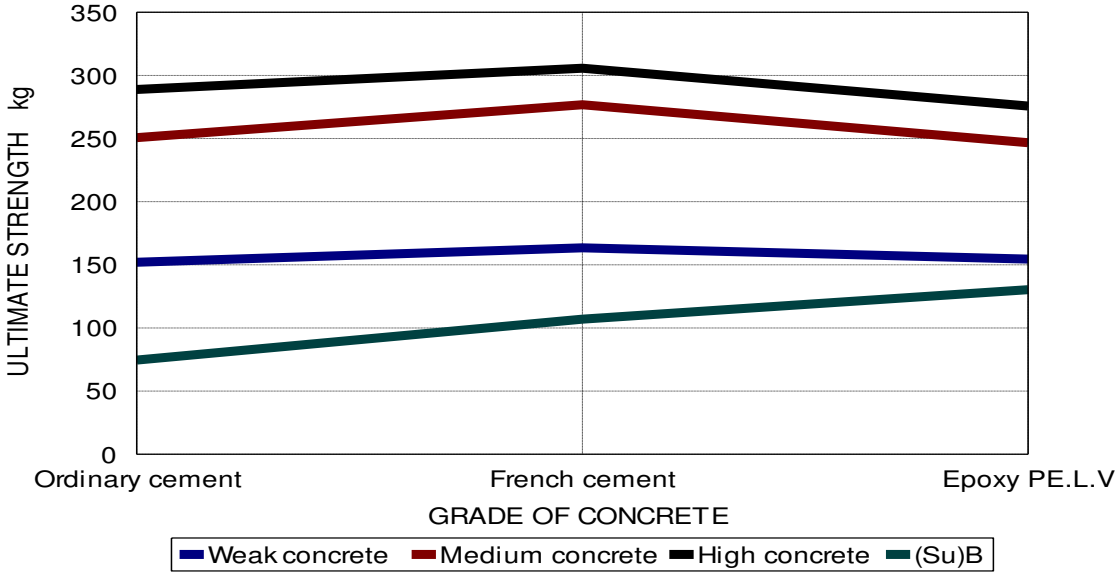
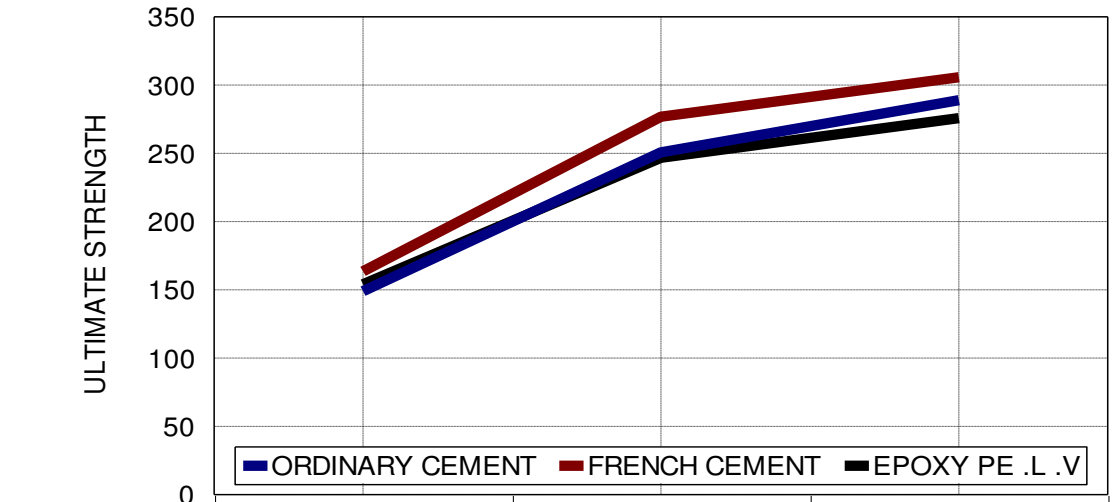


Fig. (39) ultimate strength (Su) for injected materials



	WEAK CONCRETE	MEDIUM CONCRETE	HIGH CONCRETE
ORDINARY CEMENT	149	250.73	288.9
FRENCH CEMENT	163.5	276.8	305.7
EPOXY PE .L .V	154.1	246.73	275.75

GRADE OF CONCRETE

Fig. (40) Ultimate strength (Su) with grades of concrete from tables (13) & (14) and Figs. (36) to (40), the analysis according the grade of concrete and according injected by different types of materials as follows:

a- Weak concrete (W.C) fcu= 150 kg/cm^2

b- The ultimate compressive strength (Su) without injection by materials and with injection by different types of materials for the samples which obtained from weak Concrete (W.C) fcu= 150 kg/cm^2 concrete Form piers models are shown in table (15).

Table (15) Samples from weak concrete(W.C) fcu= 150 kg/cm^2 Form piers models

No	Sample	Ultimate strength without injection.(Su)A kg/cm^2	Average ultimate strength without injection (Su/)B kg/cm^2	Ultimate strength with injection(Su) kg/cm^2	Average ultimate strength with injection (Su/)A kg/cm^2	% (Su) exc.	Type of Injected Material
1	I-1	69.18	72.23	141.51	151.99	96.0 %	Ordinary cement (O.C)
2	I-2	75.17		157.23		117.68%	
3	I-3	72.33		157.23		117.68%	
4	II-1	78.62	72.33	172.96	163.52	139.13%	French cement (F.C)
5	II-2	72.33		157.23		117.38%	
6	II-3	66.04		160.38		121.73%	
7	III-1	75.47	75.81	147.80	154.09	94.96%	Epoxy (PE L.V.)
8	III-2	81.78		128.93		70.07 %	
9	III-3	70.19		185.53		144.73%	

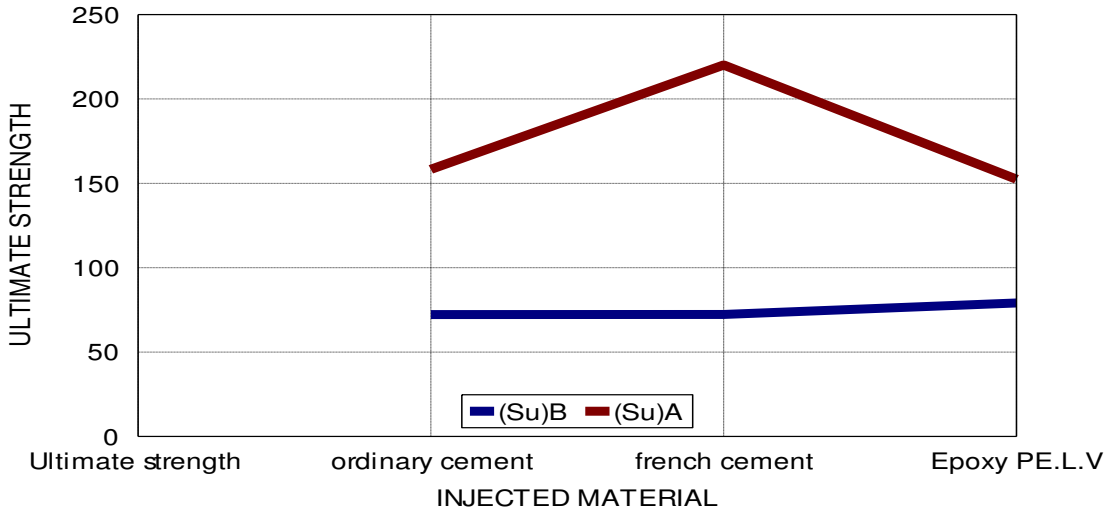


Fig. (41)Ultimate strength (Su)with injected by different types of materials for weak concrete

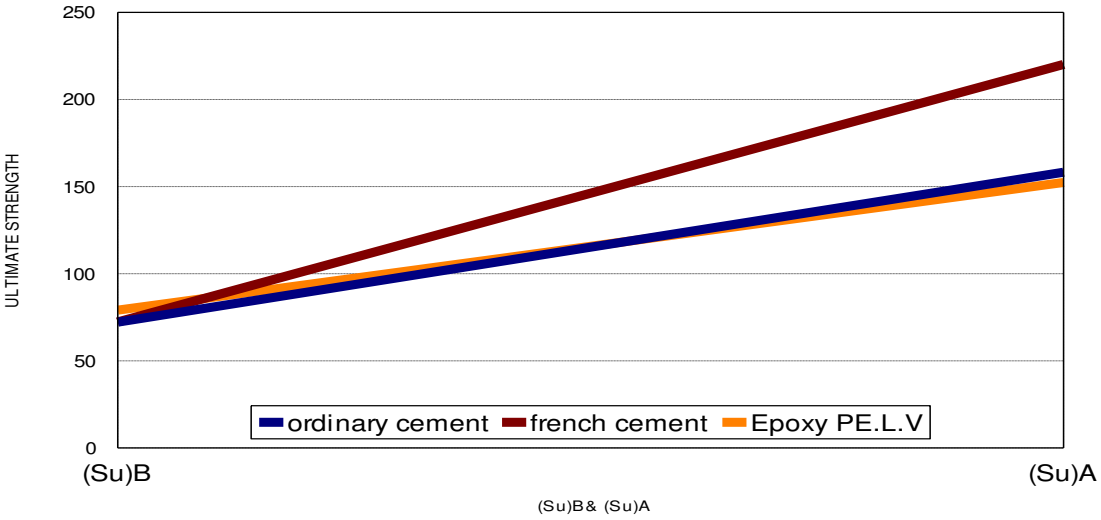


Fig. (42) (Su)B &(Su)A for weak concrete

From table (15) and Figs.(41&42) the results of ultimate compressive strength (Su) with injection (Su)A for weak concrete(W.C) fcu=150 kg/cm^{2}by different types of materials c.

1-for ordinary cement (O.C):

The ultimate strength (Su) with injection (Su$^/$) A between (141.51 kg/cm^2)to (157.23 kg/cm^2) by percentage exceeded between (96%) to (117.69%), the average percentage exceeded (110.45%) .

2-for French cement (F.C):

The ultimate strength (Su) between (157.23kg/cm^2) to (172.96kg/cm^2) by percentage exceeded between (117.38%) to (139.13%), the average percentage exceeded (126.08%)

3-for Epoxy (PE.L.V):

The ultimate strength (Su)between (128.93kg/cm^2) to (185.33kg/cm^2) by percentage exceeded between (70.07%) to (144.73%), the average percentage exceeded (103.25%).

4- The best injected material for weak concrete is the French cement (F.C).

b-Medium concrete (M.C) fcu= 200 kg/cm^2 .

The ultimate compressive strength (Su) without injection and with injection by different types of materials for the samples which obtained from medium concrete piers models are shown in table (16).

Table (16) Piers models Samples of Medium concrete(M.C) 200 kg/cm^2

No	Sample	Ultimate strength without injection (Su)B. kg/cm^2	Average ultimate strength without injection (Su/)B kg/cm^2	Ultimate strength with injection (SuA) kg/cm^2	Average ultimate strength with injection (Su/)A kg/cm^2	% exc. (Su)A	Type of Injected Material
1	V-1	110.06	105.87	235.85	250.72	122.77%	Ordinary cement (O.C)
2	V-2	100.63		261.40		146.91%	
3	V-3	106.92		254.70		140.58%	
4	IV-1	106.92	105.87	270.40	276.93	155.41%	French cement (F.C)
5	IV-2	100.63		261.64		147.13%	
6	IV-3	110.06		298.74		182.18%	
7	VI-1	110.06	108.06	205.03	246.84	89.74%	Epoxy (PE L.V.)
8	VI-2	113.21		267.92		147.94%	
9	VI-3	100.92		267.30		147.36%	

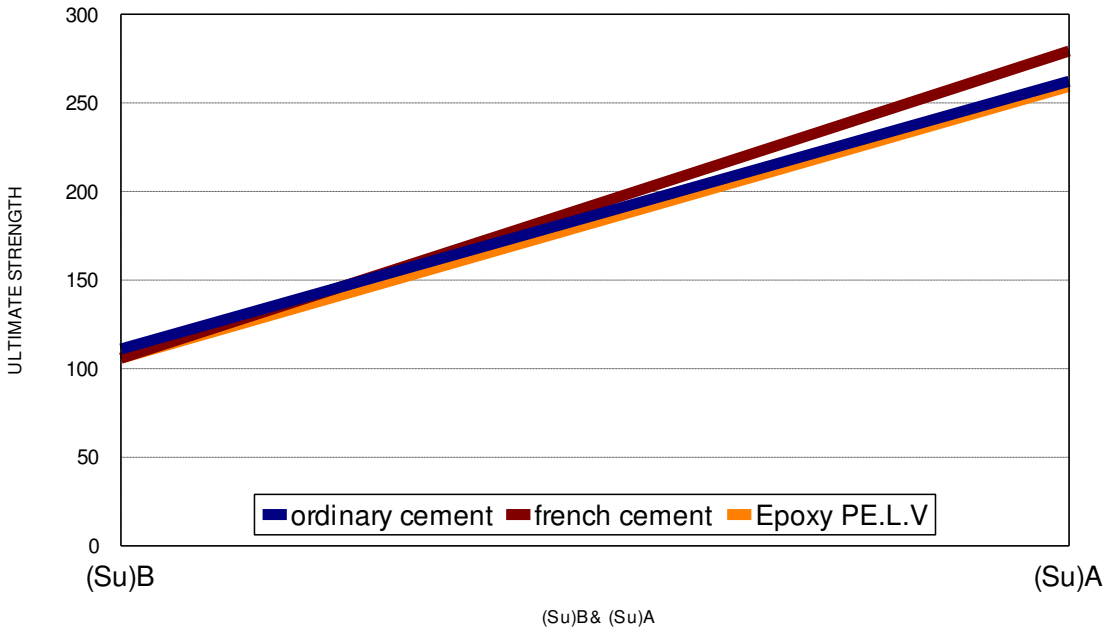


Fig. (43) (Su)B & (Su) A for Medium Concrete (M.C) 200 kg/cm^2

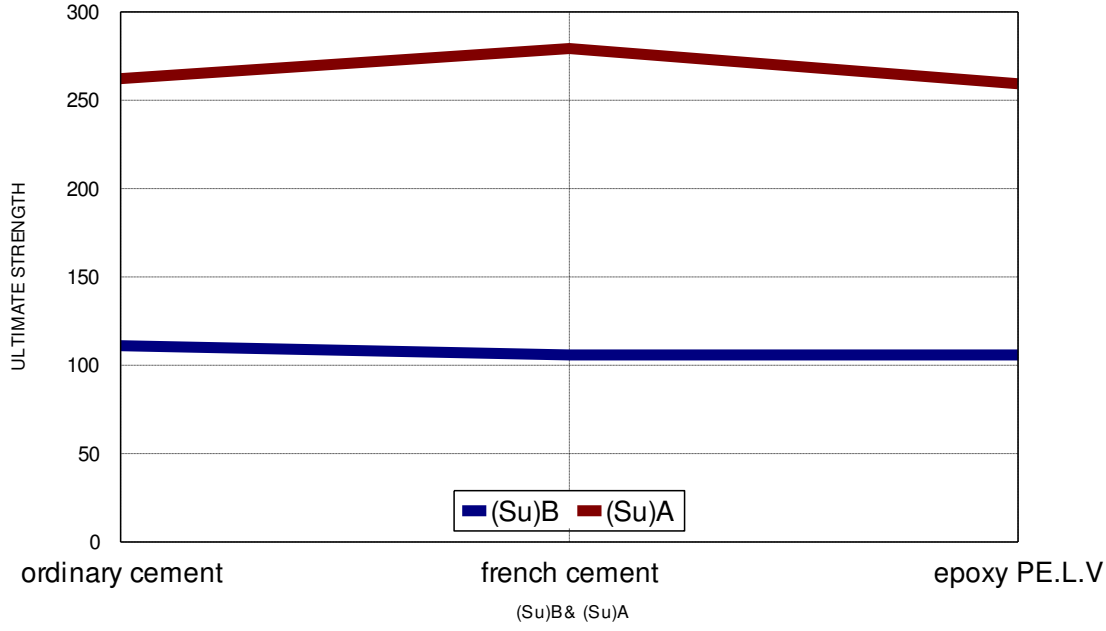


Fig. (44) ultimate strength (Su) for the different types of injected material:

From table (16) and Figs.(43&44) the results of the ultimate compressive strength (Su)A for Medium Concrete(M.C) fcu= 200 kg/cm^2 with injected by different types of materials were indicated that:

1- For ordinary cement (O.C):

The ultimate strength.(Su) between (235.85 kg/cm^2)to (261.4kg/cm^2)by percentage exceeded between (122.77%) to (146.91%) the average percentage exceeding was (136.75%).

2- For French cement (F.C):

The ultimate strength.(Su) between (268.8kg/cm^2) to (298.4kg/cm^2) by percentage exceeded between (147.13%) to (182.18%), the average percentage exceeding was (161.57%) .

3- For Epoxy (PE.L.V):

The ultimate strength.(Su) between (205.03 kg/cm^2) to (267.92 kg/cm^2) by percentage exceeded between (89.74%) to (147.94%) the average percentage exceeding was (128.35%

4- The best injected material for medium concrete (M.C) 200 kg/cm^2 is the French cement (F.C).

c- Normal strength concrete (N.C) fcu= 250 kg/cm^2:

The ultimate compressive strength.(Su) without injection and with injection for the samples which obtained from high concrete piers models are shown in table (17).

Table (17) Ultimate strength .(Su)exceeding for Normal strength Concrete (H.C)250 kg/cm^2 for Piers models

No	Sample	Ultimate strength without injection (Su)B kg/cm^2	Average ultimate strength without injection (Su/)B kg/cm^2	Ultimate strength with injection (Su)A kg/cm^2	Average ultimate strength with injection (Su/)A kg/cm^2	% exc. (Su)	Type of Injected Material
1	IX-1	135.22	132.08	267.3	288.89	102.38%	Ordinary cemen (O.C)
2	IX-2	128.93		267.3		102.38%	
3	IX-3	132.08		332.08		151.42%	
4	VIII-1	125.79	125.79	330.19	35.03	162.49%	French cemen (F.C) t
5	VIII-2	125.79		311.32		147.49%	
6	VIII-3	125.79		273.58		117.49%	
7	VII-1	122.64	133.12	301.89	275.68	119.7%	Epoxy (PE L.V.)
8	VII-2	135.22		257.86		93.7%	
9	VII-3	141.51		267.3		100.8%	

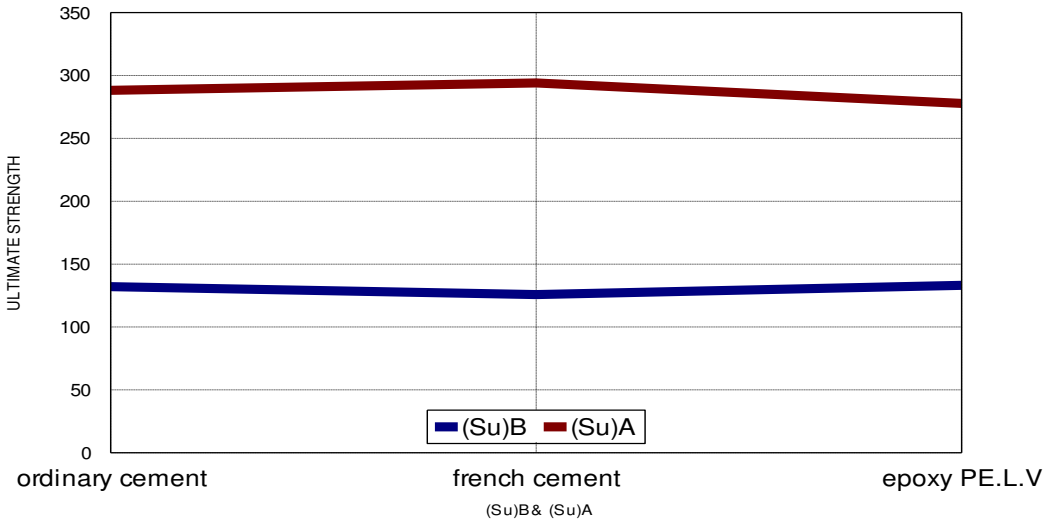


Fig. (45)Ultimate strength (Su) for injected materials High Concrete (H.C) fcu= 250 kg/cm^2

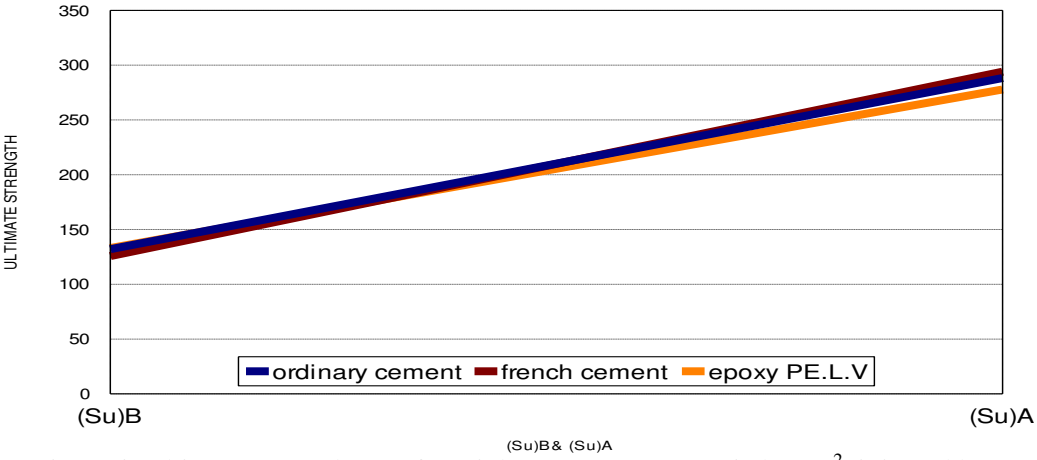


Fig. (46) Ultimate strength (Su) for High Concrete (H.C) 250 kg/cm^2 injected by different types of materials

From table (17) and Figs.(45&46) indicated that the results of ultimate compressive strength (Su) of High Concrete (H.C) fcu= 250 kg/cm^2 with injected by different types of materials as follows:

1-Ordinary cement (O.C) :

The value of ultimate strength.(Su) between (267.3 kg/cm^2)to (332.08 kg/cm^2)by percentage exceeded between.(102.38%) to (151.42%) and the average percentage exceeded (118.7%) .

2- French cement mix.(F.C):

The ultimate strength (Su) between (277.58kg/cm^2) to (330.19kg/cm^2) by percentage exceeded between (117.49%) to (162.49%) and the average percentage exceeded (142.46%).

3- Epoxy mix.(L.V):

The value of ultimate strength.(Su) between (257.86kg/cm^2) to (301.89kg/cm^2) by percentage exceeded between (93.7%) to (119.7%) and the average percentage exceeded (104.73%).

From the above results for three grades of concrete and three types of injected materials: the structure ultimate strength (Su) more improved by the French cement than others types.

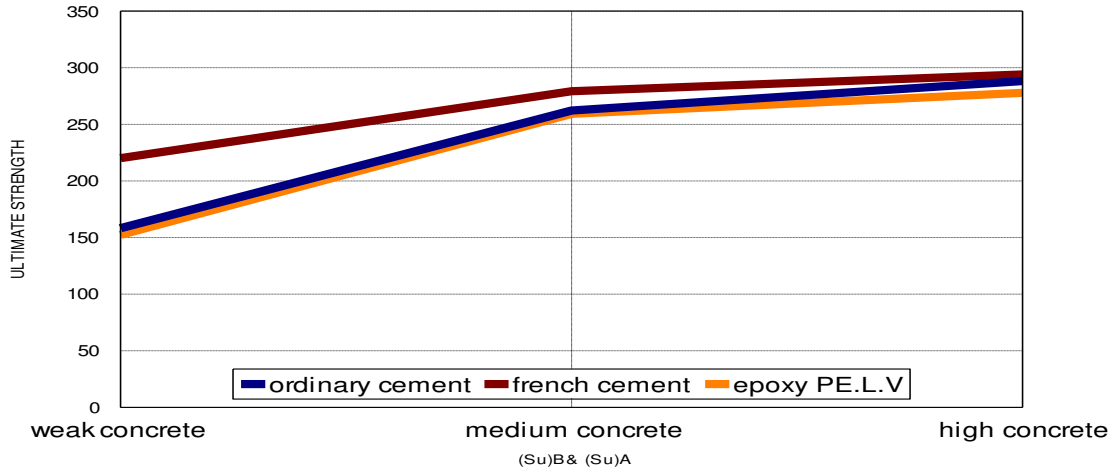


Fig. (47) Ultimate strength (Su) for grade of concrete

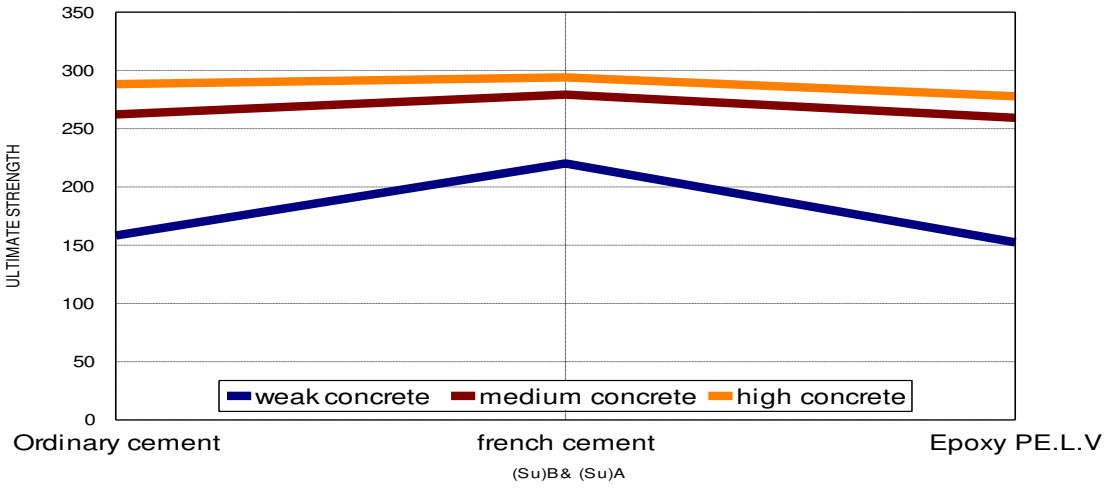


Fig. (48) Ultimate strength (Su) for injected materials

From the above results for three grades of concrete and three types of injected materials: the structure ultimate strength more improved by the French cement than others types**.**

2-The void ratio and density:

The results of void ratio, porosity and density for samples of piers models before and after loading without injection and with injection are given as follows:

2-1 Samples before loading:

The table.(18) & (19) contains results of the samples from the piers models before loading without injection by materials. and with injection by different types of materials.

Table (18) The samples from Piers models before loading without injection

No	Sample	H mm	D mm	Vt cm3	Wet wt gm	Dry wt gm	Vv cm3	n	e	Density gm/cm3	Grade of concrete
1	II B	42	45	66.78	139.2	128.7	10.5	0.157	0.186	1.93	Weak concrete (W.C) fcu=150 kg/cm2
2	II D1	49	45	77.91	153.1	141.4	11.7	0.15	0.176	1.81	
3	III B1	43	45	68.4	139.5	130.9	8.6	0.126	0.144	1.91	
Average (n, e and density without injection Weak .Concrete (W.C) fcu=150 kg/cm2								0.144	0.169	1.88	
4	IV B3	35	45	55.65	121.0	112.8	8.2	0.147	0.172	2.03	Medium concrete (M.C) fcu=200 kg/cm2
5	IV B2	44	45	69.96	140.0	127.4	13.2	0.189	0.233	1.82	
6	VI D1	82	45	130.4	271.5	250.4	21.1	0.162	0.193	1.92	
Average (n, e and density without injection Medium .Concrete (M.C) fcu= 200 kg/cm2								0.166	0.199	1.92	
7	VII D2	85	45	135.2	294.8	271.5	23.3	0.172	0.208	2.00	Normal strength concrete (H.C) fcu=250 kg/cm2
8	VII D1	65	45	103.4	219.4	201.5	17.9	0.173	0.209	1.95	
9	IX D	90	45	143.1	302.0	297.0	5.0	0.035	0.036	2.075	
Average (n, e and density without injection by materials for Normal strength concrete (H.C) fcu= 250 kg/cm^2								**0.127**	**0.151**	**2.01**	

- Samples before loading with injection by different type of materials:

The void ratio, porosity and density for the samples from piers models before loading with injection as shown in table (19)

Table (19) The samples from Piers models before loading with injection by different types of materials.

No	Sample	H (mm)	D (mm)	Vt (cm^3)	Wet wt (gm)	Dry wt (gm)	Vv. (cm^3)	n	e	Density (gm/cm^3)	Grade of concrete
1	I A1	67	45	106.5	230.3	219.0	11.3	0.106	0.119	2.06	Weak concrete (W.C) fcu= 150 kg/cm^2
2	I C1	59	45	93.81	202.5	189.8	12.7	0.135	0.156	2.02	
3	I C2	103	45	163.8	348.1	323.6	24.5	0.15	0.176	1.98	
Average void ratio, porosity and density with injection (O.C)								0.130	0.150	2.02	
4	II A	80	45	127.2	280.2	264.5	15.7	0.123	0.14	2.08	
5	II C2	56	45	89.04	193.6	182.6	11.0	0.123	0.141	2.05	
6	II E2	59	45	69.96	146.6	138.0	8.6	0.123	0.14	1.97	
Average void ratio, porosity and density with injection (F.C)								0.123	0.141	2.033	
7	III A1	70	45	111.3	254.0	237.2	16.8	0.151	0.178	2.13	
8	III C	70	45	111.3	235.9	217.5	18.4	0.165	0.198	1.95	
9	III C1	56	45	89.04	189.5	174.4	15.1	0.169	0.203	1.96	
Average void ratio, porosity and density with injection (E.P)								0.162	0.193	2.013	
10	IV A1	82	45	130.4	271.5	250.4	21.1	0.135	0.156	1.92	Medium concrete (M.C) fcu= 200 .
11	IV A2	59	45	93.81	202.5	189.8	12.7	0.173	0.209	2.02	
12	IV C2	103	45	163.8	348.1	323.6	24.5	0.189	0.233	1.98	
Average void ratio, porosity and density with injection (O.C)								0.166	0.199	1.973	
13	V A1	70	45	55.65	121.0	112.8	8.2	0.150	0.176	2.03	
14	V A2	56	45	89.04	189.5	174.4	15.1	0.111	0.125	1.96	
15	V C2	67	45	106.5	230.3	219.0	11.3	0.106	0.144	2.06	
Average void ratio, porosity and density with injection (F.C)								0.122	0.148	2.017	
16	VI A1	47	45	74.73	150.6	142.4	8.2	0.123	0.14	1.91	
17	VI E1	58	45	92.22	205.8	192.8	13.0	0.147	0.172	2.09	
18	VI C2	82	45	68.37	157.0	147.0	10.0	0.146	0.224	2.15	
Average void ratio, porosity and density with injection (E.P)								0.139	0.179	2.05	
19	VII A1	70	45	111.3	254.5	234.7	19.8	0.15	0.176	2.11	Normal strength concrete (N.C) fcu=250 kg/cm2
20	VII C1	88	45	139.9	305.3	275.3	30.0	0.146	0.171	1.97	
21	VII E1	80	45	127.2	284.2	266.3	17.9	0.178	0.217	2.09	
Average void ratio, porosity and density with injection (O.C)								0.158	0.188	2.07	
22	VIIIA2	103	45	163.8	361.6	337.5	24.1	0.214	0.272	2.06	
23	VIIIC2	70	45	62.01	137.5	130.7	6.8	0.147	0.172	2.11	
24	VIII E2	47	45	68.37	157.0	147.0	10.0	0.146	0.29	2.15	
Average void ratio, porosity and density with injection (F.C)								0.169	0.245	2.11	
25	IX C1	65	45	89.04	189.5	174.4	15.1	0.163	0.195	1.96	
26	IX E	65	45	103.4	219.4	201.5	17.9	0.11	0.124	1.95	
27	IX A2	67	45	62.01	139.5	131.7	7.8	0.125	0.143	2.12	
Average void ratio, porosity and density with injection (E.P)								0.133	0.144	2.01	
WEAK CONCRETE (W.C) fcu=150 kg/cm^2 Average void ratio, porosity and density.								0.13	0.15	2.08	
								0.123	0.141	2.03	
								0.161	0.193	2.01	
MEDIUM CONCRETE (M.C) fcu= 200 kg/cm^2 Average void ratio, porosity and density.								0.166	0.199	1.97	
								0.129	0.148	2.02	
								0.151	0.179	2.05	
Normal strength CONCRETE (N.C) fcu=250 kg/cm^2 Average void ratio .porosity and density.								0.158	0.188	2.06	
								0.195	0.245	2.11	
								0.133	0.154	2.01	

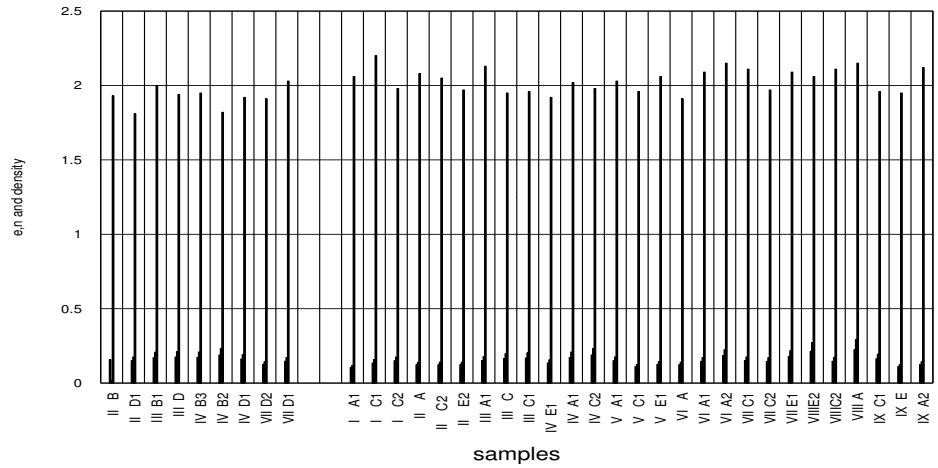


Fig. (49) e, n and density for the samples from piers models (without& with) injection

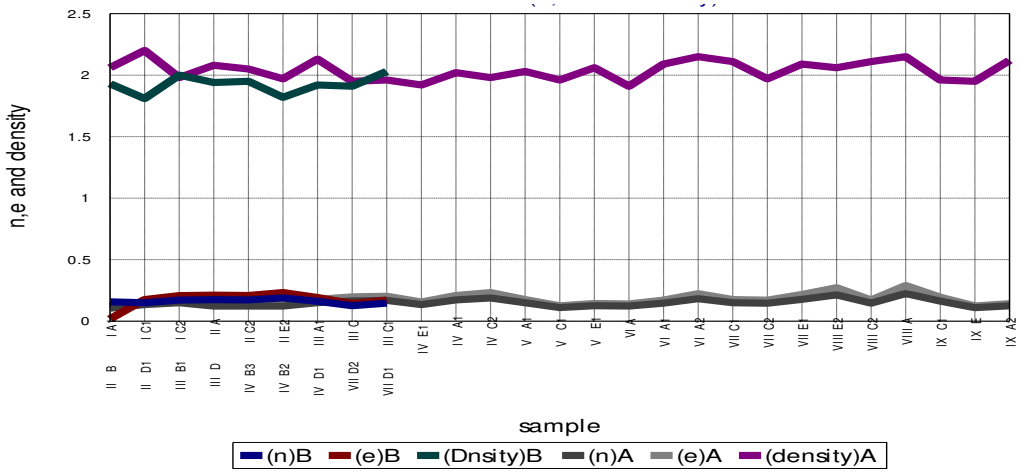


Fig. (50) (n, e and density) before loading without injection and with injection

From Tables (18) & (19) and Figs. (49& (50) the following results were obtained:

1-The highest density value because the lowest void ratio for the samples without injection and with injection.

2-The highest density value because the lowest porosity value for the sample without injection and with injection

3-For concrete models before loading: the injection effect was not observed.

4-The difference between (void ratio, porosity and density) of samples without injection and with injection was very small. This referred to the paths through the concrete models were not observed (not allow to the injected material mix to penetrate through them).

Samples after loading

The void ratio, porosity and density of the samples of models after loading without and with injection are shown in tables (20) & (21).

Samples after loading without injection:
The void ratio, porosity and density of the samples of piers models after loading without injection are shown in table (20.)

Table (20) The samples from Piers models after loading without injection

No	Sample	H mm	D mm	Vt cm3	Wet wt gm	Dry wt gm	Vv cm3	n	e	Density gm/cm3	grade of concrete (fcu) kg/cm2ete
1	I-1	88	45	79.48	170.1	157.8	12.3	0.155	0.183	1.985	Weak concrete fcu= (W.C) 150concrete
2	I-2	58	45	92.22	218.4	196.3	22.1	0.239	0.314	2.129	
3	I-3	50	45	76.32	168.3	159.8	8.5	0.111	0.125	2.094	
Average void ratio, porosity and density without injection								0.168	0.207	2.069	
4	II-1	54	45	71.55	150.3	137.4	12.9	0.180	0.22	1.920	
5	II-2	50	45	79.48	175.6	163.7	11.9	0.150	0.176	2.06	
6	II-3	47	45	74.73	162.9	153.1	9.8	0.131	0.151	2.049	
Average void ratio, porosity and density without injection								0.154	0.182	2.01	
7	III-1	54	45	85.86	191.3	176.6	14.7	0.171	0.206	2.057	
8	III-2	52	45	77.91	175.8	162.8	13.0	0.167	0.200	2.09	
9	III-3	50	45	79.48	178.7	165.8	12.9	0.162	0.193	2.086	
Average void ratio, porosity and density without injection								0.167	0.200	2.078	
10	V-1	54	45	79.48	175.4	164.7	10.7	0.135	0.156	2.072	Medium concrete fcu= (M.C) 200
11	V-2	60	45	95.4	211.8	201.4	10.4	0.109	0.122	2.111	
12	V-3	80	45	79.48	177.3	168.4	8.9	0.112	0.126	2.119	
Average void ratio, porosity and density without injection								0.119	0.135	2.101	
13	IV-1	48	45	71.55	151.8	141.8	9.9	0.138	0.160	1.982	
14	IV-2	45	45	95.4	217.2	206.2	11	0.125	0.13	2.161	
15	IV-3	60	45	76.32	166.7	158.2	8.5	0.111	0.125	2.073	
Average void ratio, porosity and density without injection								0.121	0.138	2.072	
16	VI-1	69	45	93.81	203.4	189.7	13.7	0.146	0.171	2.022	
17	VI-2	90	45	77.91	170.1	160.4	9.7	0.125	0.143	2.059	
18	VI-3	75	45	71.55	153.2	142.3	10.9	0.152	0.179	1.989	
Average void ratio, porosity and density without injection								0.141	0.164	2.023	
19	IX-1	65	45	73.14	169.2	154.8	14.4	0.197	0.245	2.116	Normal strength concrete fcu= (N.C) 250 kg/cm2 kg/cm2
20	IX-2	60	45	79.48	178.6	166.3	12.3	0.155	0.183	2.092	
21	IX-3	60	45	92.22	206.7	190.8	15.9	0.172	0.208	2.069	
Average void ratio, porosity and density without injection								0.175	0.212	2.092	
22	VIII-1	60	45	79.48	179.5	165.7	13.8	0.174	0.209	2.085	
23	VIII-2	54	45	95.4	211.8	201.3	10.5	0.110	0.123	2.110	
24	VIII-3	70	45	79.48	173.8	162.6	11.2	0.141	0.164	2.046	
Average void ratio, porosity and density without injection								0.142	0.165	2.080	
25	VII-1	110	45	68.37	152.8	142.6	10.2	0.149	0.175	2.086	
26	VII-2	90	45	69.96	153.5	142.2	11.3	0.162	0.200	2.033	
27	VII-3	85	45	95.4	218.7	204.2	14.5	0.152	0.179	2.140	
Average void ratio, porosity and density without injection								0.154	0.185	2.086	

Samples after loading with injection by different type of materials
The void ratio, porosity and density for the samples from piers models after loading with injection are shown in table (21).

Table (21) The samples from Piers models after loading with injection by different types of materials

No	Sample	H mm	D mm	V t cm^3	Wet wt gm	Dry wt gm	Vv cm3	n	E	Density gm/cm^3	Grade of concrete
1	I-1	49	45	77.91	188.4	181.2	7.2	0.09	0.099	2.326	Weak concrete (W.C) 150oncrete
2	I-2	50	45	79.48	189.8	180.4	9.4	0.12	0.136	2.27	
3	I-3	48	45	76.32	185.4	179.3	6.1	0.08	0.087	2.35	
Average void ratio, porosity and density with injection(O.C)								0.10	0.107	2.315	
4	II-1	49	45	77.91	187.8	180.8	7.0	0.09	0.099	2.321	
5	II-2	50	45	79.48	189.3	183.7	5.6	0.07	0.075	2.311	
6	II-3	58	45	92.22	210.4	201.2	9.2	0.10	0.111	2.182	
Average void ratio, porosity and density with injection(F.C)								0.087	0.095	2.271	
7	III-1	55	45	87.45	214.4	209.3	5.1	0.06	0.064	2.393	
8	III-2	53	45	84.27	215.6	211.7	3.9	0.05	0.053	2.512	
9	III-3	125	134	1761.9	4217.7	4186.	31.8	0.02	0.020	2.38	
Average void ratio, porosity and density with injection(E.P)								0.043	0.046	2.428	
10	V-1	47	45	74.73	181.3	174.6	6.7	0.09	0.099	2.339	Medium concrete (M.C) 200 0concrete
11	V-2	50	45	71.55	172.8	165.3	8.5	0.10	0.12	2.31	
12	V-3	57	45	89.04	211.3	208.3	3.1	0.03	0.032	2.3	
Average void ratio, porosity and density with injection(O.C)								0.076	0.084	2.316	
13	IV-1	65	45	89.04	209.2	201.2	8.0	0.09	0.099	2.26	
14	IV-2	52	45	77.91	188.3	183.0	5.3	0.07	0.075	2.35	
15	IV-3	80	45	89.04	211.4	204.2	7.2	0.08	0.087	2.293	
Average void ratio, porosity and density with injection(F.C)								0.08	0.087	2.301	
16	VI-1	58	45	92.22	213.2	210.1	3.1	0.03	0.031	2.278	
17	VI-2	55	45	87.45	209.4	206.3	6.1	0.07	0.075	2.359	
18	VI-3	115	134	1620.9	4264.2	4224.1	40.1	0.03	0.031	2.606	
Average void ratio, porosity and density with injection(E.P)								0.043	0.046	2.414	
19	IX-1	46	45	73.14	183.2	176.4	6.8	0.09	0.099	2.412	Normal strength concrete (N.C) 250
20	IX-2	115	134	1620.9	4040.0	3996.0	44	0.03	0.031	2.47	
21	IX-3	125	134	1761.9	4102.1	4071.0	31.1	0.02	0.020	2.310	
Average void ratio, porosity and density with injection(O.C)								0.047	0.050	2.397	
22	VIII-1	55	45	87.45	207.3	198.7	8.6	0.10	0.111	2.272	
23	VIII-2	52	45	82.68	208.6	203.2	5.4	0.07	0.075	2.46	
24	VIII-3	48	45	76.32	189.6	182.3	7.3	0.10	0.111	2.39	
Average void ratio, porosity and density with injection(F.C)								0.09	0.099	2.374	
25	VII-1	54	45	85.86	212.6	206.5	6.2	0.07	0.075	2.41	
26	VII-2	115	134	1620.9	4230.9	4201.6	29.3	0.02	0.020	2.60	
27	VII-3	80	134	1127.6	2878.6	2832.3	46.3	0.04	0.042	2.512	
Average void ratio, porosity and density with injection(E.P)								0.043	0.046	2.507	

The comparison between the three injected materials and their effects on the void ratio, porosity and density with the discussion as shown in table (21) and the comparison

between without injection samples and with injection samples by different types of materials as plotted in Fig. (51).

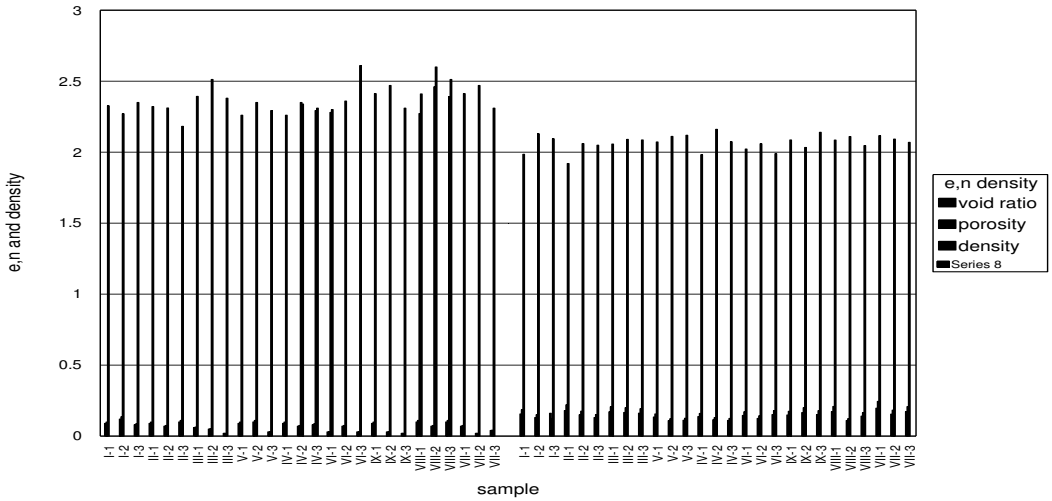


Fig. (51) e, n and density after loading without and with injection

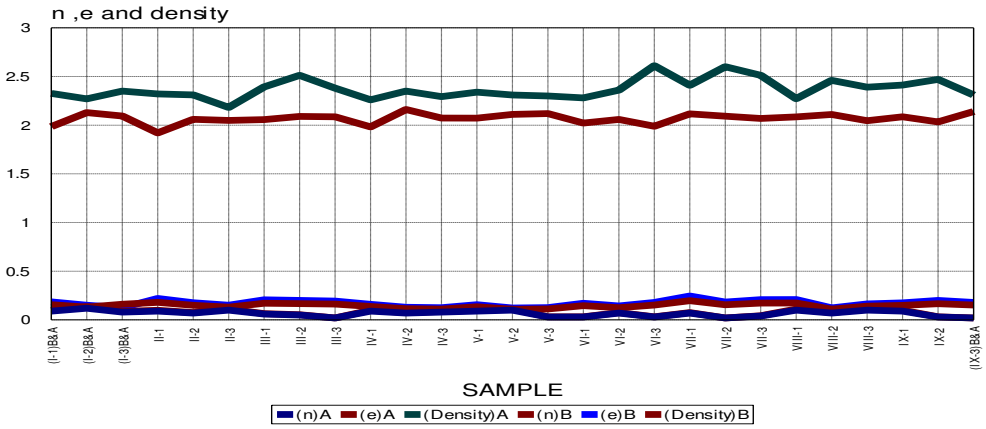


Fig. (52) After loading (n, e and density)

From tables { (20)& (21),} and Figs(51) & (52) indicated that:

1-The density was not high value because of the lowest void ratio and porosity for the piers models samples without injection by materials and with injection by different types of materials.

a-Weak concrete fcu = 150kg/cm^2 :

Table (22) Weak concrete analyses.

No	Type of Injected Material	Without injection			With injection			% exc.		
		n	e	Density	n	e	density	n	e	density
1	Ordinary cement(O.C)	0.155	0.183	1.985	0.09	0.099	2.326	40%	48%	11%
2		0.239	0.314	2.129	0.12	0.136	2.27			
3		0.111	0.125	2.094	0.08	0.087	2.35			
Avarage		0.168	0.207	2.069	0.10	0.107	2.315			
4	French cement(F.C)	0.180	0.22	1.920	0.09	0.099	2.321	40.5%	48%	13%
5		0.150	0.176	2.06	0.07	0.075	2.311			
6		0.131	0.151	2.049	0.10	0.111	2.182			
Avarage		0.154	0.182	2.01	0.087	0.095	2.271			
7	Epoxy (PE L.V.)	0.171	0.206	2.057	0.06	0.064	2.393	74%	77%	17%
8		0.167	0.200	2.09	0.05	0.053	2.512			
9		0.162	0.193	2.086	0.02	0.020	2.38			
Avarage		0.167	0.200	2.078	0.043	0.046	2.428			

From table (22) indicated that:

-The average void ratio with injection by different types of materials ($e^{/}$)A= 0.074) was improved by percentage 58% less than the void ratio without injection by materials {average void ratio($e^{/}$)B=0.178}.

-The average porosity with injection by different types of materials {($n^{/}$)A = 0.07} was improved by percentage 53% less than the porosity without injection by materials {average porosity ($n^{/}$)B = 0.15}.

-The average density with injection by different types of materials ($\gamma^{/}$)A=2.344gm/cm^3} was improved by percentage 14 % more than the average density without injection ($\gamma^{/}$)B=2.052 gm/cm^3}

b-Medium concrete fcu= 200 kg/cm^2 :

Table (23) Medium concrete analysis

No	Without injection			With injection			% Exceeding			Injected material
	n	e	Density	n	e	Density	N	e	Density	
1	0.135	0.156	1.982	0.09	0.099	2.339	36%	38%	10%	Ordinary cement(O.C)
2	0.109	0.122	2.161	0.10	0.12	2.31				
3	0.112	0.126	2.073	0.03	0.032	2.3				
Avarage	0.119	0.135	2.101	0.076	0.084	2.316				
4	0.138	0.160	2.072	0.09	0.099	2.26	34%	37%	11%	French cement(F.C)
5	0.115	0.13	2.111	0.07	0.075	2.35				
6	0.111	0.125	2.119	0.08	0.087	2.293				
Avarage	0.121	0.138	2.072	0.08	0.087	2.301				
7	0.146	0.171	2.022	0.03	0.031	2.278	69%	72%	19%	Epoxy (PE L.V.)
8	0.125	0.143	2.059	0.07	0.075	2.359				
9	0.152	0.179	1.989	0.03	0.031	2.606				
Avarage	0.141	0.164	2.023	0.043	0.046	2.414				

-The average void ratio with injection by different types of materials {($e^{/}$)A= 0.069} was improved by percentage 54% less than the average void ratio without injection by materials {($e^{/}$)B=0.15}.

-The average porosity with injection by different types of materials {($n^{/}$)A = 0.06} was improved by percentage 54% less than the porosity without injection by materials {average porosity ($n^{/}$)B = 0.13}.

-The average density with injection by different types of materials {($\gamma^{/}$)A=2.36 gm/cm^3} was improved by percentage 15 % more than the average density without injection by materials {($\gamma^{/}$)B=2.053 gm/cm^3}

c- Normal strength concrete (N.C) fcu= 250 kg/cm^2

Table (24) Normal strength concrete analysis

No	Without injection			With injection			% exceeding			Injected material
	n	e	Density	n	e	Density	N	e	Density	
1	0.197	0.245	2.116	0.072	0.075	2.41	75%	78%	20%	Ordinary cement(O.C)
2	0.155	0.183	2.092	0.018	0.020	2.60				
3	0.172	0.208	2.069	0.041	0.042	2.512				
Avarage	0.175	0.212	2.092	0.044	0.046	2.507				
4	0.174	0.209	2.085	0.10	0.111	2.272	37%	40%	14%	French cement(F.C)
5	0.110	0.123	2.110	0.07	0.075	2.46				
6	0.141	0.164	2.046	0.10	0.111	2.39				
Avarage	0.142	0.165	2.080	0.09	0.099	2.374				
7	0.149	0.175	2.086	0.09	0.099	2.412	69%	73%	15%	Epoxy (PE L.V.)
8	0.162	0.200	2.033	0.03	0.031	2.47				
9	0.152	0.179	2.140	0.02	0.020	2.310				
Avarage	0.154	0.185	2.086	0.047	0.050	2.397				

From table (24) indicated that:

-The average void ratio with injection by different types of materials {($e^{/}$)A= 0.061)} was improved by percentage 52% less than the average void ratio without injection by materials {($e^{/}$)B=0.127}.

-The average porosity with injection by different types of materials {($n^{/}$)A = 0.06} was improved by percentage .49% less than the average porosity without injection by materials { ($n^{/}$)B = 0.118}.

-The average density with injection by different types of materials {($\gamma^{/}$)A=2.44gm/cm^3} was improved by percentage (17%) more than the average density without injection by materials ($\gamma^{/}$)B=2.084 gm/cm^3}

1- Ordinary cement mix.(O.C) the average porosity (0.072), average void ratio(0.068) and average density (2.342).

2- French cement.(F.C) the average porosity (0.079), average void ratio(0.086) and average density (2.352).

4- CONCULTION

1-The injection way for repairing the structures is very effective ways .

2-The using of the injection way by different type of materials in new bodies is not effective way due to the body is not permeable and the depression of the grouting mix through the body is not enough.

3-For successfully injection operation by different type of materials its required to following the suitable system and must design suitable program with successive study steps.

4-The injection by different types of materials through the new concrete (in some requirements) needs check from all the variables of injection like the path of injection mixture, the pressure used, viscosity of mixture…. And so on.

5-From the results for the three grades of concrete and the three types of injected by different types of materials the French cement is consider the best injected material used in repair to increase the structure ultimate strength.

6-The Epoxy mix(L.V) is the best type (from the three types of injection by different types of materials which, were used) to improve the porosity, void ratio and density.

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ترميم وتقوية نماذج البغال باستخدام أنواع مختلفة من مواد الحقن

المنشات المائية ذات حساسة عاليه لأبه شروخ او فجوات أو أي انهيارات و لو طفيفة جدا داخل جسم المنشأ أوعلي محيطة الخارجي. الأمر الذي يستدعى دائما التأكد من سلامه عناصره المختلفه. هذا و قد قامت وزاره الموارد المائية و الري بترميم و تقويه جميع القناطرالكائنه على النيل وذلك بحقن بغال و فروشات هذه القناطر والتي تأكدت من خلال هذه الأعمال فعاليه و جدوى هذه الأعمال. وللقيام بأعمال الترميم و التقوية لأحد عناصر هذه المنشات فان طريقه الحقن هي الطريقة المناسبة لمثل هذه الأعمال الدقيقة. والعاملان المهمان لاعمال التقوية هما ثبات المنشأ و النفاذ يه. لذا فقد تم صب و تصنيع عدد تسعه نماذج خرسانية لمحاكاة المنشات المائية الكائنة وبمقياس 8/1 من المنشات ألا صليه وذلك من

ثلاثـة رتـب مختلفـة مـن الخرسـانة ذات مقاومـة للضـغط (150- 200-250 كج/سم^2). هـذا و قـد اسـتخدمت ثلاثـة أنـواع مـن مـواد الحقـن المختلفـة(الأسـمنت العـادي- الأسـمنت الفرنسـي- المـادة الايبوكسـيه) والتـي تـم حقنهـا وتسـجيل تأثيرهـا علـى النمـاذج الخرسـانية التـي تـم تجهيزهـا للاختبـارات المعملية.

و قد تمت الدراسة تحت حالتين للتحميل :الحالة الأولي و هي تمثل المنشأ بصورته العادية بدون تحميل والحاله الثانية وهي حاله المنشأ تحت التحميل لإحداث شروخ داخليه تساعد على انتشار مادة الحقن لضمان كفاءه أعمال الترميم و التقوية.

و قد أظهرت الدراسة النتائج الاتيه:

1-الأسمنت الفرنسي هو المادة الأحسن من المواد الثلاث التي استخدمت في أعمال الحقن لاعمال تقويه مقاومة الضغط.

ا-زادت مقاومة الضغط فى العينات المستخدم فيها الاسمنت الفرنسى بنسبه(137.02%-120.53%-67.43%) عن مقاومة الضغط قبل الحقن ويرجع ذلك حسب رتبه الخرسانه المحقونه.

ب- -زادت مقاومة الضغط فى العينات المستخدم فيها الاسمنت العادى بنسبه(70.79%-103.01%-77.43%) عن مقاومة الضغط قبل الحقن.

ج--زادت مقاومة الضغط فى العينات المستخدم فيهاالماده الايبوكسيه بنسب(70.3%-104.47%-80.76%) عن مقاومة الضغط قبل الحقن.

2 -المادة الايبوكسيه هي المادة الأحسن من المواد الثلاث المستخدمة في أعمال الحقن لاعمال تقليل نسبه الفراغات وتقليل المسامية و زيادة الكثافة للمنشأ.

ا-قلت متوسط نسبه الفراغات بنسب محسوسه عن متوسط نسبه الفراغات قبل الحقن

ب-قلت المسامية بقيم عاليه عن متوسط المسامية قبل الحقن.

ج- زادت كثافة المنشأ بنسبه عاليه عن متوسط الكثافة قبل الحقن.