CHAPTER FOUR

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

In this research, an intensive laboratory investigation, for the effect of superplasticizer on both fresh and hardened concrete mixes has been conducted. Preliminary tests for local ordinary Portland cement and aggregate used in the research have been carried out. In addition, large numbers of experiments concerning workability and compressive strength of concrete mixes, when adding superplasticizer, have been done. The ratios of superplasticizer added were 0.0 (as a reference mix), 0.4, 0.8, 1.2 and 1.5 Litre/ 50Kg cement for concrete ages of 3, 7 and 28 days by preparing 12 cubes for each sample. The fresh concrete mixes were casted in standard test moulds of 150mm cubic –according to BS1881: sections 108 and 116 (Also SABS standard method 863), whereas a standard slump cone of 300mm high, 150mm diameter cylinder – according to ASTM standard was used for measuring concrete slumps. The concrete mix design sheet is attached in appendix (B). The results of these experiments are shown in the following tables and figures.

4.2 Preliminary Tests Results of Cement:

Consistency Test:

This test is undertaken to determine the water requirement for the desired cement paste plasticity state required by the setting and soundness test for Portland cement. The normal consistency test is regulated in ASTM C187

Time of Setting:

This test is undertaken to determine the time required for the cement paste to harden. The initial set cannot be too early due to the requirements of mixing, conveying, placing, and casting. Final setting cannot be too late owing to the requirement of strength development.

Time of setting is measured by the Vicat apparatus with a 1-mm-diameter needle. The initial setting time is defined as the time at which the needle penetrates 25mm into the cement paste. The final setting time is the time at which the needle does not sink visibly into the cement paste.

Compressive Strength:

The strength of cement is measured on mortar specimens made of cement and standard sand (silica). Compression testing is carried out on a 50mm cube with an S/C ratio of 2.75:1 and w/c ratio of 0.485, for Portland cements. The specimens are tested wet, the time of mixing should not be less than3 minutes, the mortar is filled in to a cube mould and compact the mortar either by hand compaction, the cubes are removed from the mould after 24 hours and immersed in clean fresh water until taken out for testing.[12]

Table (4.1): Results of Preliminary Cement Tests

Test	Results	Requirements of BS 12 1996
Consistency	29.0%	26 -32%
Setting Time		
a) Initial	2 hrs	Not less than 60 min (-15 min)
b) Final	3 hrs: 10 min	Not more than 10 hrs.
Compressive Strength		
a) 2 days		Equal or Greater than 10 N/mm^2
١	17.6 N/mm^2	
٢	17.2 N/mm^2	
٣	17.32 N/mm^2	
b) 28 days		Equal or Greater than 42.5 N/mm2
١	45.6 N/mm^2	
٢	44.1 N/mm^2	
٣	46.2 N/mm^2	

4.3 Results of Aggregate Tests

Grading and size distribution:

The particle size distribution of aggregates is called grading. Grading determines the paste requirement for a workable concrete since the amount of voids among aggregate particles requires the same amount of cement paste to fill out in the concrete mixture. To obtain a grading curve for an aggregate, sieve analysis has to be conducted. The commonly used sieve designation is listed in Table ((4.2) and (4.3)). [21]

Table (4.2): Results of sieve analysis of coarse aggregate test

B.S seive (mm)	Retained				Average (%)	%age Passing	BS
	Sample (1)		Sample (2)				
	Wt. (g)	(%)	Wt. (g)	(%)			
25	٠	٠	٠	٠	٠	١٠٠	100
19.5	٠.١٢٩	٦.٤٥	٠.١٣١	٦.٥٥	٦.٥	٩٣.٥	85 to 100
12.5	١.١١٣	٥٥.٦	١.٢٦٥	٦٣.٢٥	٥٩.٤٢٥	٣٤.٠٧٥	0 to 70
9.5	٠.٥٦٧	٢٨.٣٥	٠.٤٥٠	٢٢.٥	٢٥.٤٢٥	٨.٦٥	0 to 25
4.75	٠.١٨٥	٩.٢٥	٠.١٥٥	٧.٧٥	٨.٥	٠.١٥	0 to 5
pan	٠.٠٠٦	٠.٣	٠.٠	٠	٠.١٥	٠	

Absorption ratio %= (1002-1000)/1000 = 0.2%

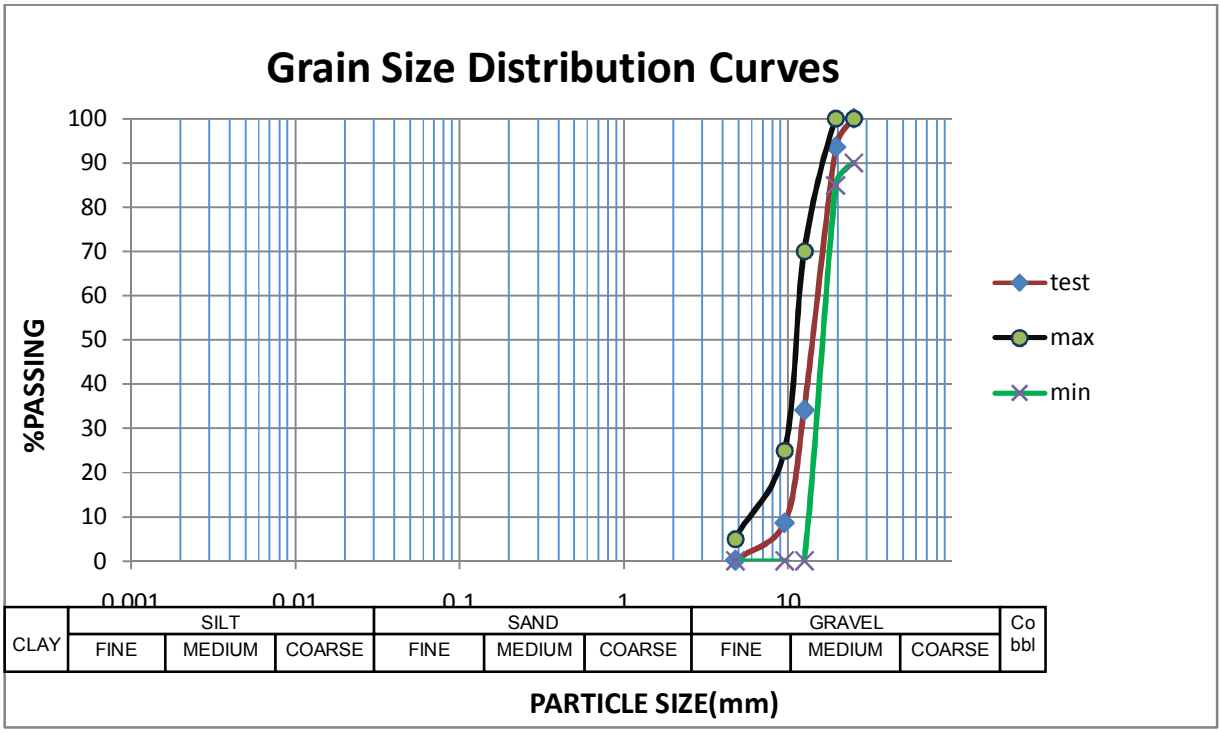

Fig (4.1): Grain Size of Coarse Aggregate Test

From graph (4.1) The distribution curves resulted in wall graded coarse aggregate.

Table (4.3): Results of sieve analysis of fine aggregate test

B.S sieve (mm)	Retained					%age Passing	BS
	Sample (1)		Sample (2)		Average		
	Wt. (g)	(%)	Wt. (g)	(%)	(%)		
4.75	0.016	1.6	0.019	1.9	1.75	98.25	89 to 100
2.36	.029	2.9	0.031	3.1	3	95.25	60 to 100
1.18	٠.052	5.2	0.052	5.2	5.2	90.05	30 to 100
0.600	٠.158	15.8	0.161	16.1	15.95	74.1	15 to 100
0.300	٠.626	62.6	0.656	65.6	64.1	10	5 to 70
0.150	٠.096	9.6	0.062	6.2	7.9	2.1	0 to 15a
0.075	0.023	2.3	0.019	1.9	2.1	0.4	-
pan		00	00	00	00	00	00

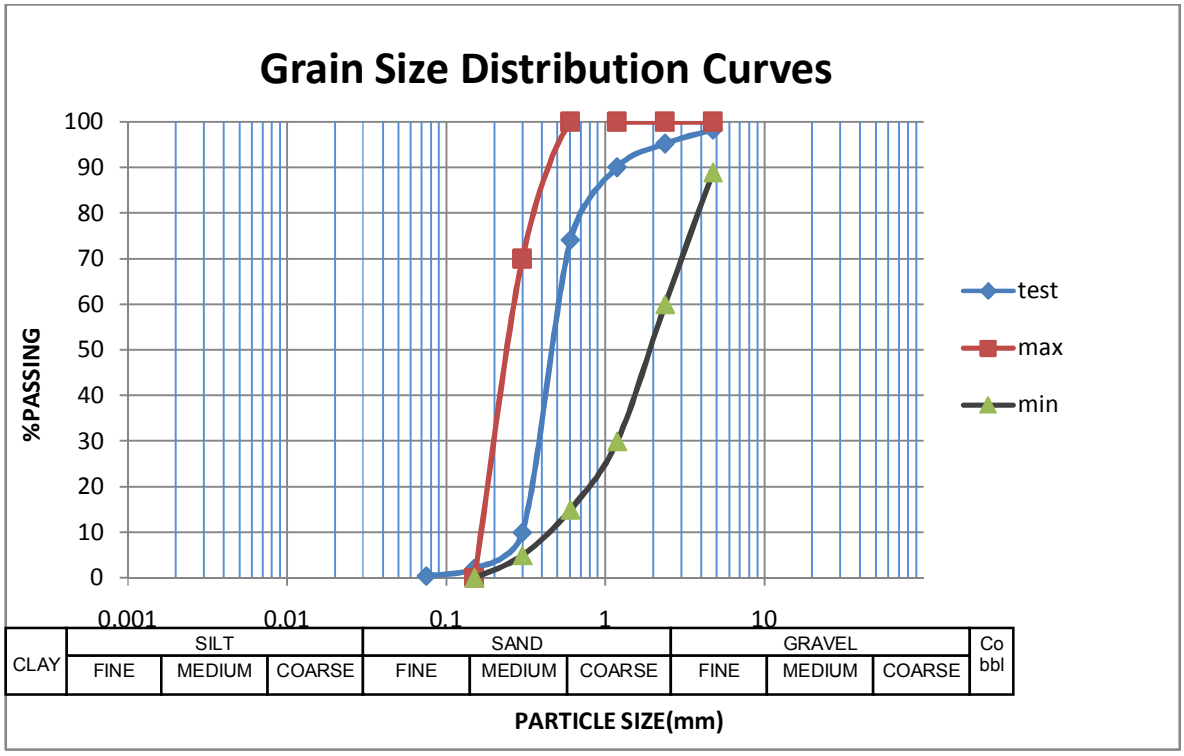

Fig (4.2) Grain Size of Fine Aggregate Test

Table (4.4): Silt content in fine aggregate

Sample No.	**1**	**2**
Sample Total Weight (g)	1000	1000
Weight (g) After Washing	992	991
Silt and clay (%)	0.8	0.9

4.4 Results of workability (slump) for Fresh Concrete Tests

Slump Test: The equipment for the slump test is indeed very simple. It consists of a tamping rod and a truncated cone, 300mm in height, 100mm in diameter at the top, and 200mm in diameter at the bottom. To conduct a slump test, first moisten the slump test mold and place it on a flat, nonabsorbent, moist, and rigid surface. Then hold it firmly to the ground by foot supports.

Next, fill 1/3 of the mold with the fresh concrete and rod it 25 times uniformly over the cross section. Likewise fill 2/3 of the mold and rod the layer 25 times, then fill the mold completely and rod it 25 times. If the concrete settles below the top of the mold, add more. Strike off any excessive concrete. Remove the mold immediately in one move. Measure and record the slump as the vertical distance from the top of the mold to average concrete level.[21]

Table (4.5): Results of Slump test improved by Superplasticizer ratios and water reduction

Superplasticizer (Litre/50kg cement)	0.0	0.4	0.8	1.2	1.5
Water reduction (%)	0%	10%	15%	20%	30%
Slump (mm)	40	90	180	190	185

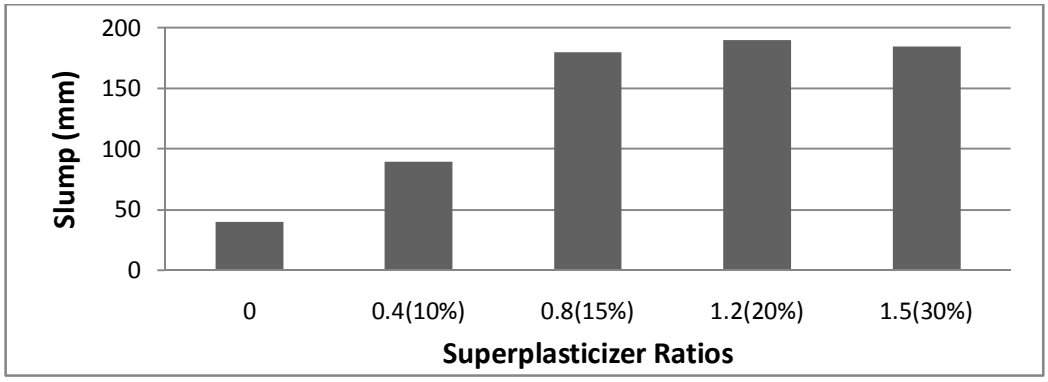

Fig (4.3): Relationship between Results of Slumps and Superplasticizer ratios and water reduction

Table (4.6): Results of Slumps test improved by Superplasticizer ratios with **(water and cement) reduction**

Superplasticizer (Littre/50kg cement)	0.0	0.4	0.8
Water reduction (%)	0%	10%	15%
Cement reduction (%)	0%	10%	15%
Slump (mm)	40	50	85

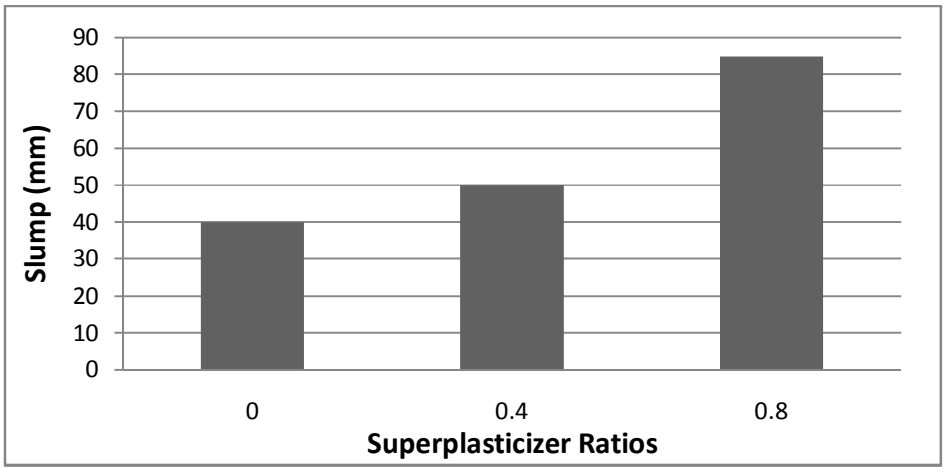

Fig (4.4): Relationship between Results of Slumps and Superplasticizer ratios and (water &cement) reduction

4.5 Results of Hardened Concrete Tests

Compressive Strength Test:

The tests are required to determine the strength of concrete and therefore its suitability for the job.

The equipment used in the test is crush machine (2000KN), curing tank, balance and moulds.

Procedure the Test:

- Representative samples of concrete shall be taken and used for casting cubes 15 cm x 15cm x 15cm.
- The concrete shall be filled into the moulds in layers approximately 5 cm deep it would be distributed evenly and compacted either by vibration or by hand tamping. After the top layer has been compacted, the surface of concrete shall be finished level with the top of the mould using atrowel; and covered with a glass plate to prevent evaporation.
- The specimen shall be stored at site for 24 hours under damp matting or sack. After that, the samples shall be stored in clean water until the time test.
- Specimen shall be tested immediately on removal from water and while they are still in wet condition.
- The load shall be applied slowly without shock and increased continuously.[21]

Compressive Strength is calculate using the following formula:

Compressive Strength (kg/cm2) = Wf / Ap

Wf = Maximum applied load just before load, (kg)

Ap = plan area of cube mould, (mm2)

Table (4.7): Results of compressive strength for control mixes (w/c = 0.48 and superplasticizer = 0)

Age	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive strength (N/mm^2)
3 days	8.118	593.2	26.37	27.03
	8.282	630.2	28.00	
	8.167	601.4	26.72	
7days	8.289	866.9	38.52	38.86
	8.265	890.2	39.56	
	8.296	866.8	38.52	
28days	٨.١٧٩	٩٥٣.٩	٤٢.٣٩	٤٧.٥٣
	٨.٢٢٠	١٠٧٧.٤	٤٧.٨٨	
	٨.١٦٧	١١٧٧.٣	٥٢.٣٢	

Table (4.8): Results of compressive strength improved by (0.4L per 50kg of cement) superplasticizer and 10% water reduction

Age	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
3 days	8.349	704.9	31.33	33.02
	8.444	780.75	34.70	
	8.395	693.45	33.02	
7days	8.298	1029.5	45.75	47.32
	8.236	967.05	47.32	
	8.402	1099.8	48.88	
28days	٨.١٤٧	١٢٠٩.٧	٥٣.٧٧	٥٢.٣٦
	٨.٤٤٥	١٠٦٤.٢	٤٧.٢٩	
	٨.٣٨٧	١٢٦٠.٧	٥٦.٠٢	

Table (4.9): Results of compressive strength improved by (0.8L per 50kg of cement) superplasticizer and 15% water reduction

Age	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive strength (N/mm^2)
3 days	5.734	948.9	42.17	42.17
	5.642	937.7	41.64	
	5.594	960.6	42.69	
7 days	8.490	1206.2	53.61	54.37
	8.435	1223.3	54.37	
	8.287	1240.9	55.13	
28days	8.475	1228.4	54.60	57.58
	8.463	1332.1	59.20	
	8.364	1326.2	58.94	

Table (4.10): Results of compressive strength improved by (1.2L per 50kg of cement) superplasticizer and 20% water reduction

Age	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive strength (N/mm^2)
3 days	8.437	681.3	30.27	30.73
	8.385	621.9	27.63	
	8.445	771.4	34.28	
7 days	٨.٥٠٤	٩٣٦.٠	٤١.٦٠	٤٦.٣٤
	٨.٤٣٨	١٢٦٧.٩	٥٦.٣٥	
	٨.٣٩٩	٩٢٤.٣	٤١.٠٧	
28days	٨.٦٢٤	١١٤٨.٦	٥١.٠٥	52.29
	٨.٦٧٩	١١٥٧.٩	٥١.٤٦	
	٨.٦٨٣	١٢٢٣.٣	٥٤.٣٦	

Table (4.11): Results of compressive strength improved by (1.5L per 50kg of cement) superplasticizer and 30% water reduction

Age	Weight of cubes (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive strength (N/mm^2)
3 days	٨.٥٣٣	٨٨٠.٧	٣٩.١٤	٤١.٢١
	٨.٥٩٦	٨٧٦.٦	٣٨.٩٥	
	٨.٥٤٨	١٠٢٤.٨	٤٥.٥٤	
7 days	8.648	875.5	38.85	٤٦.٨٤
	8.480	1249.4	55.52	
	8.682	1038.7	46.16	
28days	٨.٣٧٤	١٤٤٢.٢	٦٤.٠٩	61.1
	٨.٥٤٨	١٣٠٧	٥٨.١٣	
	٨.٤٠١	١٣٧٤.٤	٦١.٠٨	

Table (4.12): Results of compressive strength improved by (0.4 L per 50kg of cement) superplasticizer, 10% water reduction and 10% cement reduction

Age	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive strength (N/mm^2)
3 days	8.547	783.7	34.83	34.03
	8.612	764.0	33.96	
	8.297	748.9	33.29	
7 days	8.379	1028	45.72	45.48
	8.417	1017.9	45.24	
	8.420	752.9	45.48	
28days	٨.٦٦٦	١١٦١.٦	٥١.٦٣	٥٠.٧٨
	٨.٤١٦	١٠٩٠.٣	٤٨.٤٦	
	٨.٥٥٤	١١٧٦.٣	٥٢.٢٧	

Table (4.13): Results of compressive strength improved by (0.8L per 50kg of cement) superplasticizer, 15% water reduction and 15% cement reduction

Age	Weight of cubes (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive strength (N/mm^2)
3 days	8.352	559.0	24.85	25.35
	8.411	547.0	24.31	
	8.571	605.4	26.90	
7 days	٥.٧٧٠	٩٢٧.٧	٤١.٢٢	٤١.٧٠
	٥.٩٨١	٩٨٢.٦	٤٣.٦٦	
	٦.٠٠٢	٩٠٤.٧	٤٠.٢١	
28days	٨.٥١٨	٨٨٩.٦	٣٩.٥٣	٣٩.٢٨
	٨.٧٨٧	٩١٢.٦	٤٠.٥٦	
	٨.٧٦٥	٨٤٩.٩	٣٧.٧٦	

Table (4.14): Results of compressive strengths developed by using different ratios of superplasticizer and water reduction at 3 days of age

Type and doses of additive	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
Dosage (0)	8.118	593.2	26.37	27.03
	8.282	630.2	28.00	
	8.167	601.4	26.72	
Dosage (0.4)	8.349	704.9	31.33	33.02
	8.444	780.75	34.70	
	8.395	693.45	33.02	
Dosage (0.8)	5.734	948.9	42.17	42.17
	5.642	937.7	41.64	
	5.594	960.6	42.69	
Dosage (1.2)	8.437	681.3	30.27	30.73
	8.385	621.9	27.63	
	8.445	771.4	34.28	
Dosage (1.5)	٨.٥٣٣	٨٨٠.٧	٣٩.١٤	41.21
	٨.٥٩٦	٨٧٦.٦	٣٨.٩٥	
	٨.٥٤٨	١٠٢٤.٨	٤٥.٥٤	

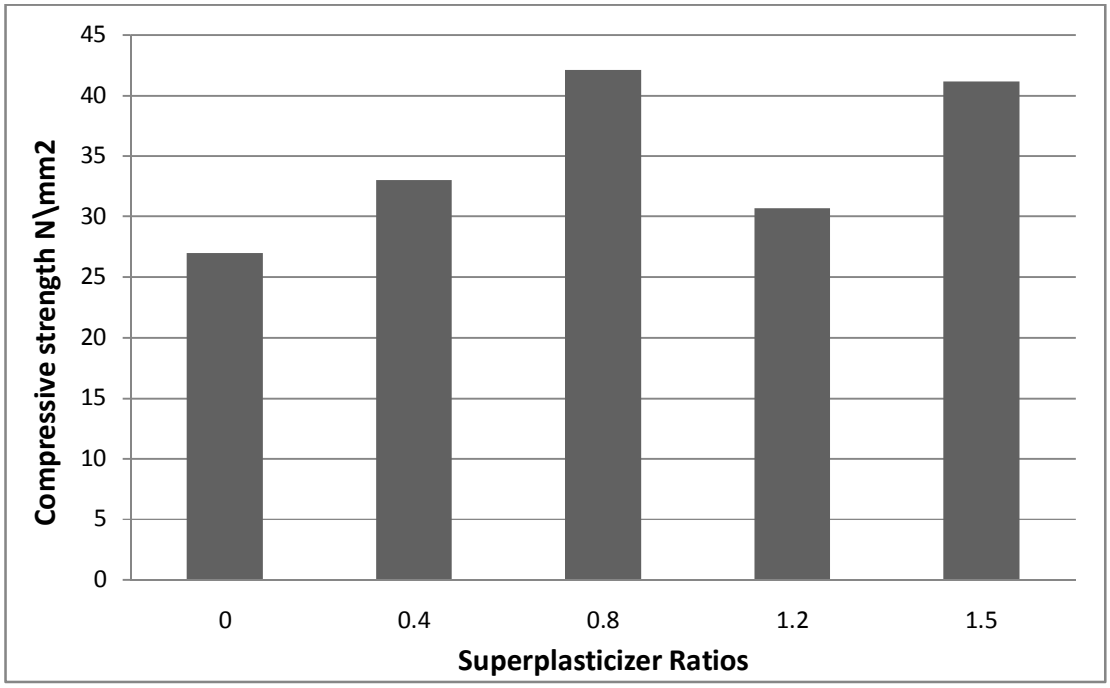

Fig (4.5): Relationship between compressive strength developed and different ratios of superplasticizer and water reduction at 3 days of age

Table (4.15): Results of compressive strength developed using different ratios of superplasticizer and water reduction at 7 days of age

Type and doses of additive	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
Dosage (0)	8.289	866.9	38.52	38.86
	8.265	890.2	39.56	
	8.296	866.8	38.52	
Dosage (0.4)	8.298	1029.5	45.75	47.32
	8.236	967.05	47.32	
	8.402	1099.8	48.88	
Dosage (0.8)	8.490	1206.2	53.61	54.37
	8.435	1223.3	54.37	
	8.287	1240.9	55.13	
Dosage (1.2)	٨.٥٠٤	٩٣٦.٠	٤١.٦٠	٤٦.٣٤
	٨.٤٣٨	١٢٦٧.٩	٥٦.٣٥	
	٨.٣٩٩	٩٢٤.٣	٤١.٠٧	
Dosage (1.5)	8.648	875.5	38.85	٤٦.٨٤
	8.480	1249.4	55.52	
	8.682	1038.7	46.16	

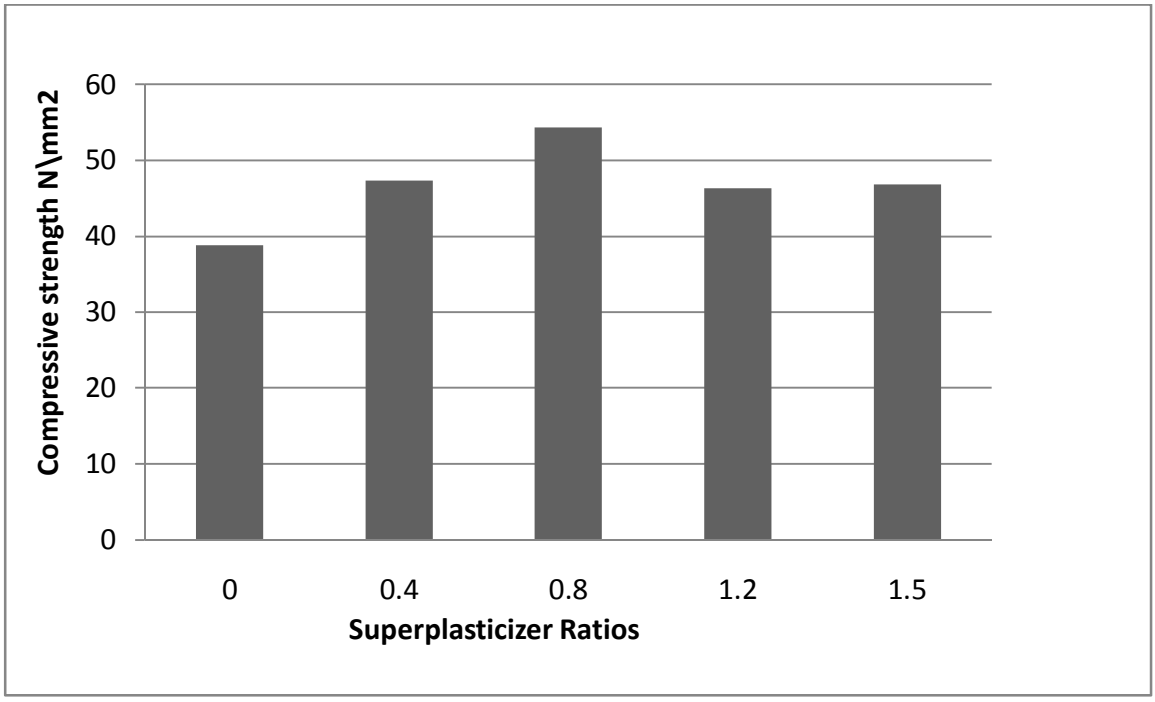

Fig (4.6): Relationship between compressive strength developed and different ratios of superplasticizer and water reduction at 7 days of age

Table (4.16): Results of compressive strength developed using different ratios of superplasticizer and water reduction at 28 days of age

Type and doses of additive	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
Dosage (0)	٨.١٧٩	٩٥٣.٩	٤٢.٣٩	٤٧.٥٣
	٨.٢٢٠	١٠٧٧.٤	٤٧.٨٨	
	٨.١٦٧	١١٧٧.٣	٥٢.٣٢	
Dosage (0.4)	٨.١٤٧	١٢٠٩.٧	٥٣.٧٧	٥٢.٣٦
	٨.٤٤٥	١٠٦٤.٢	٤٧.٢٩	
	٨.٣٨٧	١٢٦٠.٧	٥٦.٠٢	
Dosage (0.8)	8.475	1228.4	54.60	57.58
	8.463	1332.1	59.20	
	8.364	1326.2	58.94	
Dosage (1.2)	٨.٦٢٤	١١٤٨.٦	٥١.٠٥	52.29
	٨.٦٧٩	١١٥٧.٩	٥١.٤٦	
	٨.٦٨٣	١٢٢٣.٣	٥٤.٣٦	
Dosage (1.5)	٨.٣٧٤	١٤٤٢.٢	٦٤.٠٩	61.1
	٨.٥٤٨	١٣٠٧	٥٨.١٣	
	٨.٤٠١	١٣٧٤.٤	٦١.٠٨	

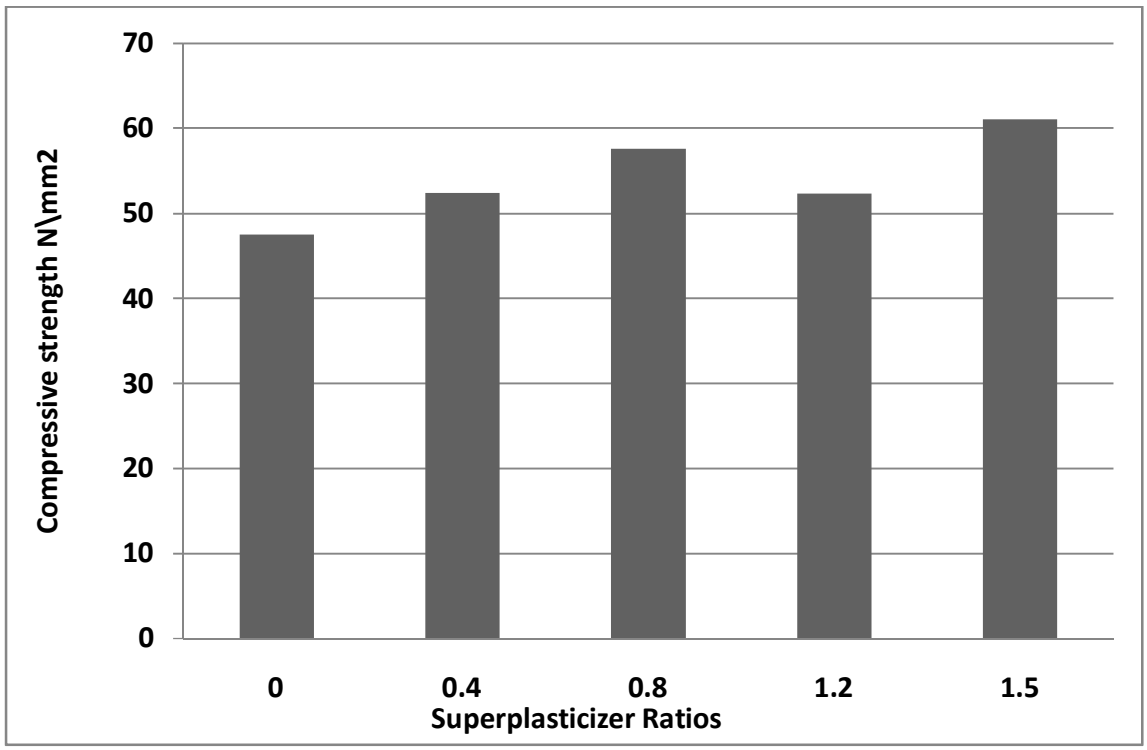

Fig (4.7): Relationship between compressive strength developed and different ratios of superplasticizer and water reduction at 28 days of age

Table (4.17): Compressive strength developed for concrete mixes using superplasticizer ratios of (0.4 - 0.8 - 1.2 -1.5) L per 50 kg cement and (10%, 15%, 20% and 30%) water reduction

Age	0	0.4		0.8		1.2		1.5	
	Compressive strength (N/mm^2)	Compressive strength (N/mm^2)	Increase (%)	Compressive strength (N/mm^2)	Increase (%)	Compressive strength (N/mm^2)	Increase (%)	Compressive strength (N/mm^2)	Increase (%)
3	27.03	33.02	22%	42.17	56%	30.73	14%	41.21	52%
7	38.86	47.32	22%	54.37	35%	46.34	19%	46.84	21%
28	47.53	52.36	10%	57.58	21%	52.29	10%	61.1	29%

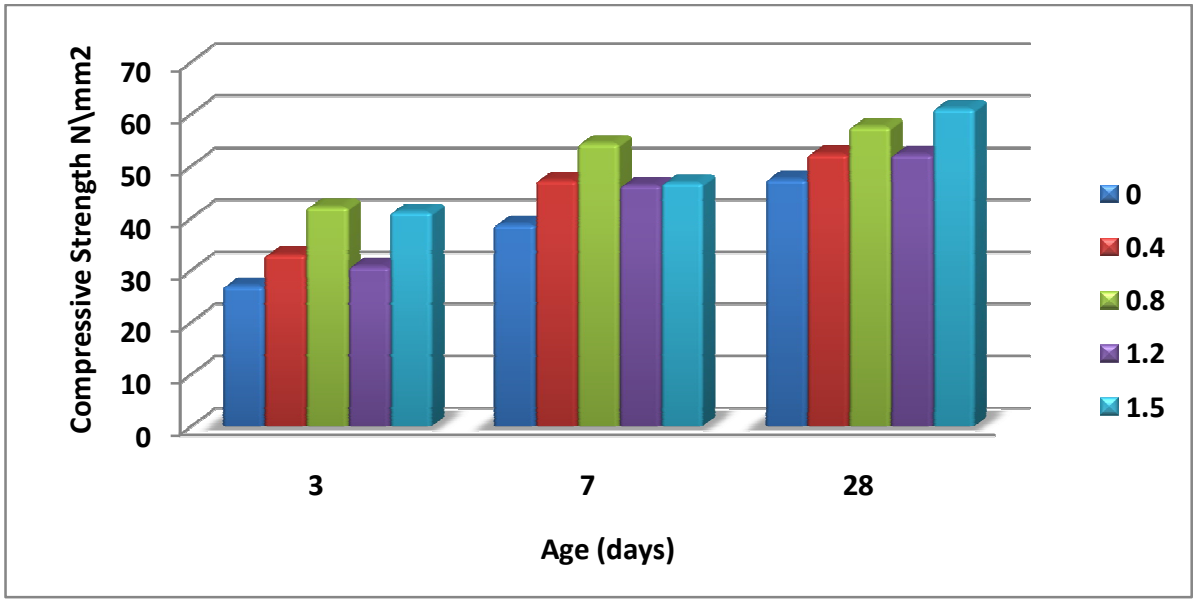

Fig (4.8): Compressive strength of concrete mixes developed by using different ratios of superplasticizer and water reduction

Table (4.18): Results of compressive strength developed using different ratios of superplasticizer and (water & cement) reduction at 3 days of age

doses of additive	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
0.0 L/50kg cement	8.118	593.2	26.37	27.03
	8.282	630.2	28.00	
	8.167	601.4	26.72	
0.4 L/50kg cement	8.547	783.7	34.83	34.03
	8.612	764.0	33.96	
	8.297	748.9	33.29	
0.8 L/50kg cement	8.352	559.0	24.85	25.35
	8.411	547.0	24.31	
	8.571	605.4	26.90	

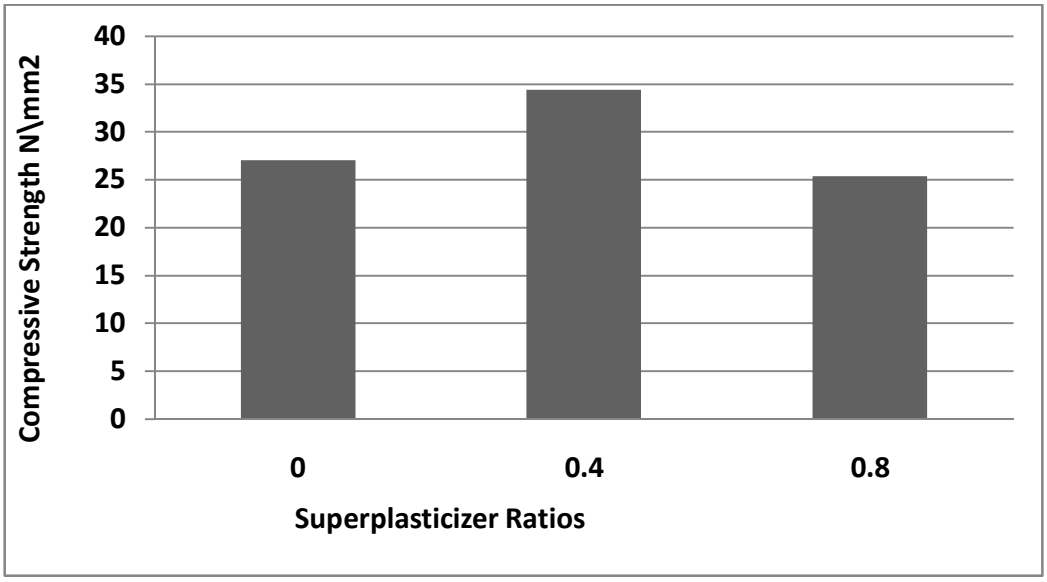

Fig (4.9): Relationship between compressive strength developed and different ratios of superplasticizer and (water &cement) reduction at 3 days of age

Table (4.19): Results of compressive strength developed using different ratios of superplasticizer and (water &cement) reduction at 7 days of age

doses of additive	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
0.0 L/50kg cement	8.289	866.9	38.52	38.86
	8.265	890.2	39.56	
	8.296	866.8	38.52	
0.4 L/50kg cement	8.379	1028	45.72	45.48
	8.417	1017.9	45.24	
	8.420	752.9	45.48	
0.8 L/50kg cement	٥.٧٧٠	٩٢٧.٧	٤١.٢٢	٤١.٧٠
	٥.٩٨١	٩٨٢.٦	٤٣.٦٦	
	٦.٠٠٢	٩٠٤.٧	٤٠.٢١	

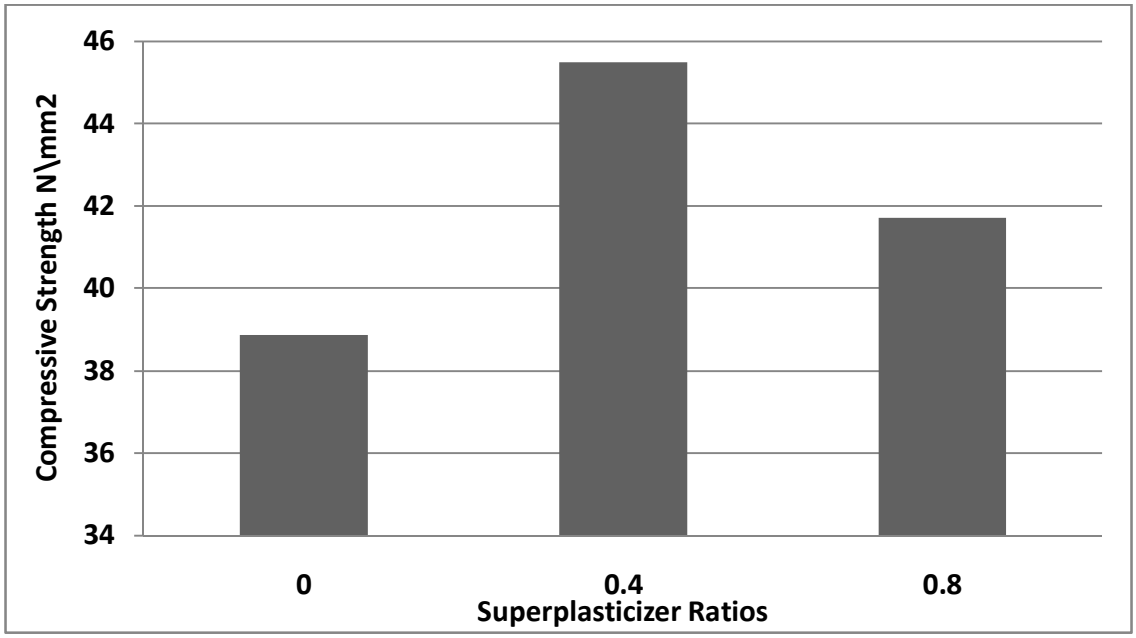

Fig (4.10): Relationship between compressive strength developed and different ratios of superplasticizer and (water &cement) reduction at 7 days of age

Table (4.20): Results of compressive strength developed using different ratios of superplasticizer and (water &cement) reduction at 28 days of age

doses of additive	Weight of cube (kg)	Ultimate Load (kN)	Compressive strength (N/mm^2)	Mean Compressive (strength N/mm^2)
0.0 L/50kg cement	٨.١٧٩	٩٥٣.٩	٤٢.٣٩	٤٧.٥٣
	٨.٢٢٠	١٠٧٧.٤	٤٧.٨٨	
	٨.١٦٧	١١٧٧.٣	٥٢.٣٢	
0.4 L/50kg cement	٨.٦٦٦	١١٦١.٦	٥١.٦٣	٥٠.٧٨
	٨.٤١٦	١٠٩٠.٣	٤٨.٤٦	
	٨.٥٥٤	١١٧٦.٣	٥٢.٢٧	
0.8 L/50kg cement	٨.٥١٨	٨٨٩.٦	٣٩.٥٣	٣٩.٢٨
	٨.٧٨٧	٩١٢.٦	٤٠.٥٦	
	٨.٧٦٥	٨٤٩.٩	٣٧.٧٦	

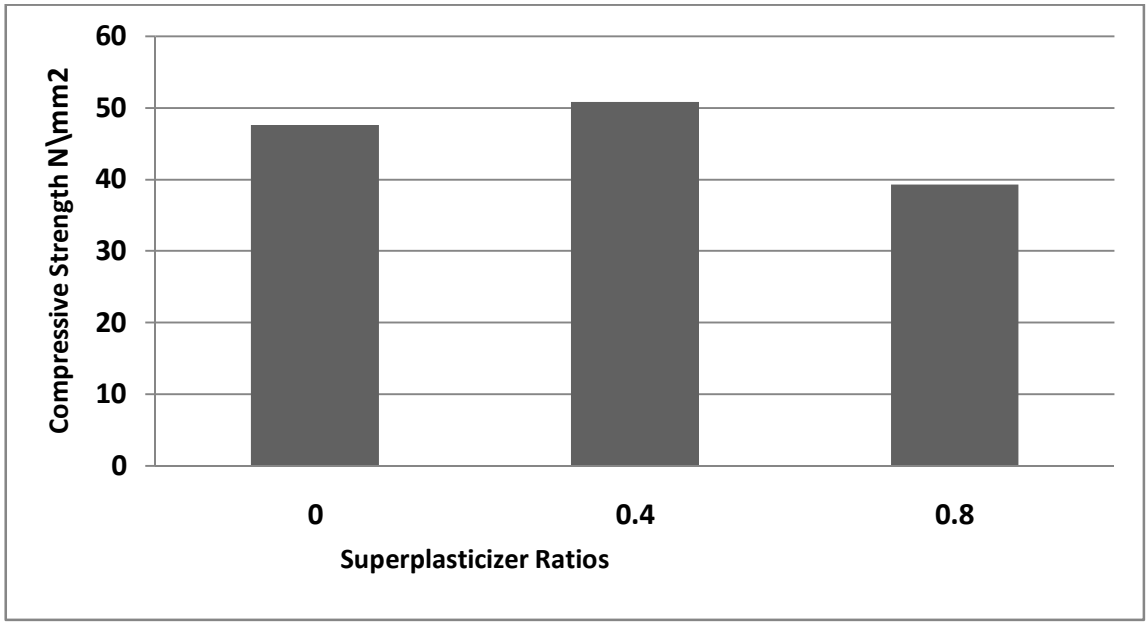

Fig (4.11): Relationship between compressive strength developed and different ratios of superplasticizer and (water &cement) reduction at 28 days of age

Table (4.21): Compressive strength of concrete mixes developed by using Super plasticizer ratios of (0.0, 0.4 and 0.8) Litre per 50kg of cement, water reduction of (10% and 15%) and cement reduction of (10% and 15%)

	0.0	0.4		0.8	
	Strength	strength	Difference %	strength	Difference %
3	27.03	34.38	27%	25.35	- 6%
7	38.86	45.48	17%	41.7	7%
28	47.53	50.78	7%	39.28	- 17%

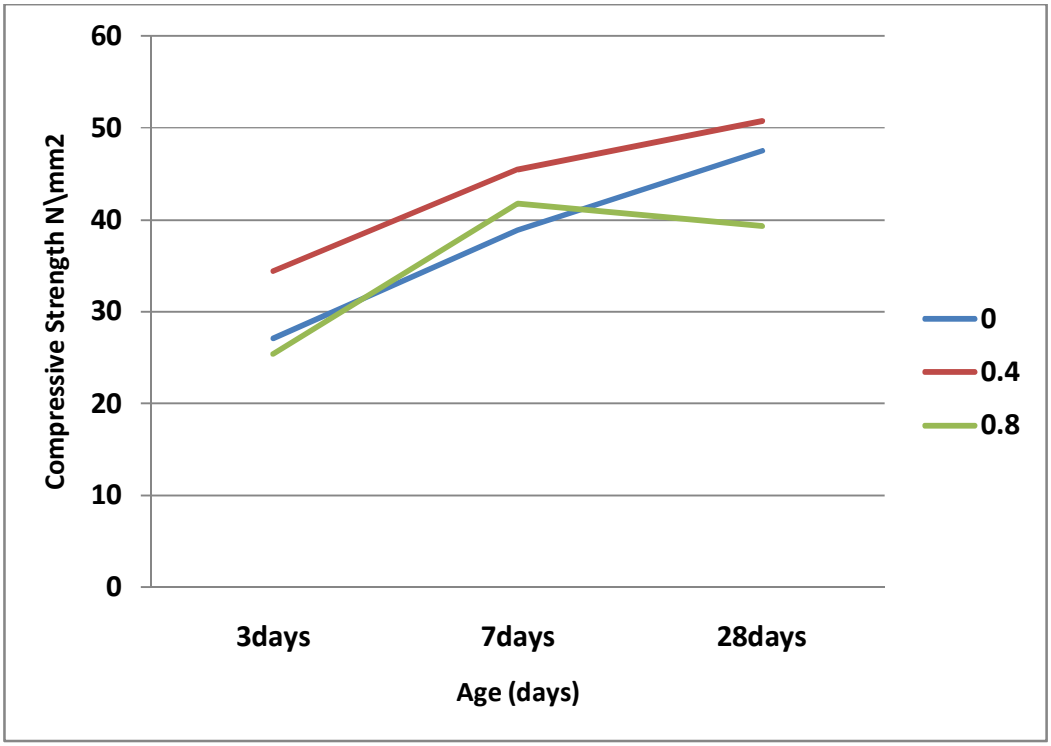

Fig (4.12): Compressive strength of concrete mixes developed by using Super plasticizer ratios of (0.0, 0.4 and 0.8) Litre per 50 kg of cement, water reduction of (10% and 15%) and cement reduction of (10% and 15%)

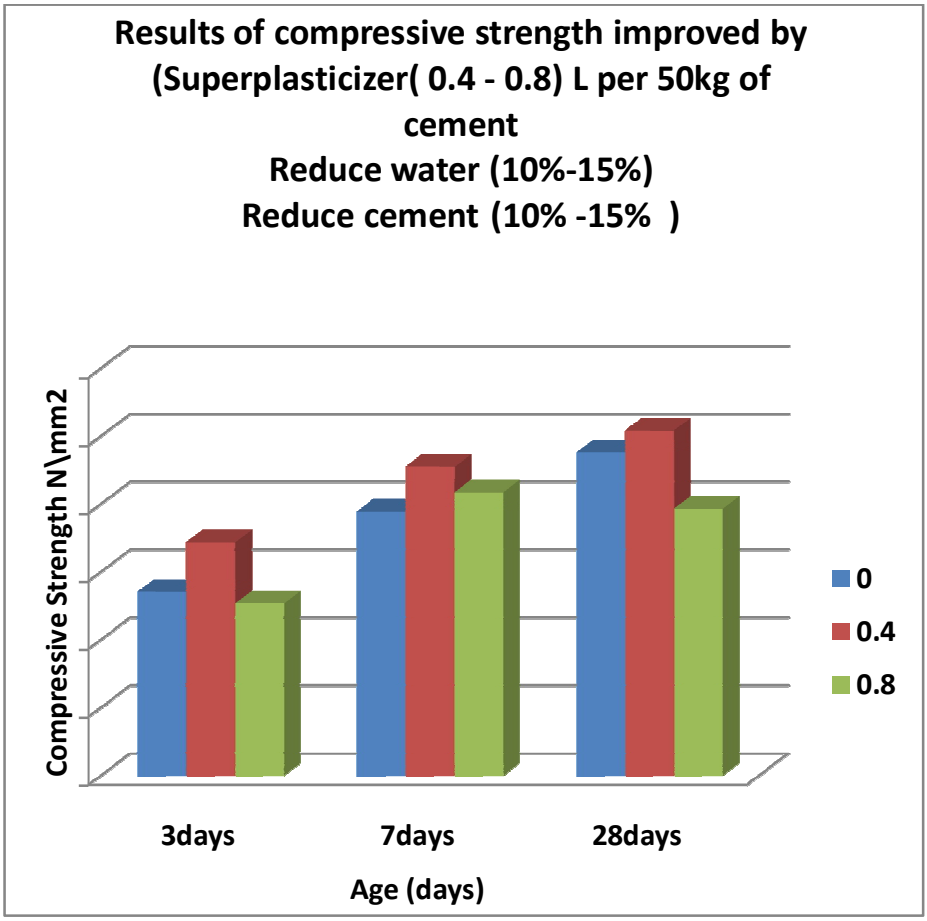

Fig (4.13): Compressive strength of concrete mixes developed by using Super plasticizer ratios of (0.0, 0.4 and 0.8) Litre per 50 kg of cement, water reduction of (10% and 15%) and cement reduction of (10% and 15%)

4.6 Results of Concrete Water Absorption Tests

The produced specimens were dried until the mass became constant (WO). Then the specimens were immersed in clean water at 28 days. After the desired immersion period had passed, the specimens were taken out and the surfaces were wiped quickly with wet cloth and then weighted (W1) immediately as illustrated in Table (4.22) to (4.29).

The rate of water absorption can be calculated from the following formula:

Water absorption (%) = {(W1 – WO)/WO} *100.

Table (4.22): Results of absorption after 28 days: control mix

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	8.٠٠٢	8.٣٤٧	0.345	3.42
2	8.٠٢١	8.٢٥١	0.23	
3	8.٠٨٨	8.٣٣٧	0.249	
Mean weight	8.037		0.275	

Table (4.23): Result of absorption after 28 days: (superplasticizer ratio = 0.4L per 50kg of cement) and 10% water reduction

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	٧.٩٥٤	8.٣٢٠	0.366	3.33
2	8.٢٨٣	8.٤٩٢	0.209	
3	8.١٦٧	8.٤٠٥	0.238	
Mean weight	8.135		0.271	

Table (4.24): Result of absorption after 28 days: (superplasticizer ratio = 0.8L per 50kg of cement) and 15% water reduction

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	8.٠٣٢	8.٣٣٣	0.301	3.62
2	8.٠٣٩	8.٣١٨	0.279	
3	8.٢٠٣	8.٥٠١	0.298	
Mean weight	8.091		0293	

Table (4.25): Result of absorption after 28 days: (superplasticizer ratio = 1.2L per 50kg of cement) and 20% water reduction

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	٨.٣٢٦	٨.٦٢٤	0.298	3.78
2	٨.٣٤٧	٨.٦٧٩	0.332	
3	٨.٣٦٥	٨.٦٨٣	0.318	
Mean weight	8.346		0.316	

Table (4.26): Result of absorption after 28 days: (superplasticizer ratio = 1.5L per 50kg of cement) and 30% water reduction

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	٨.١٨٧	٨.٣٧٤	0.187	2.21
2	٨.٣٥٢	٨.٥٤٨	0.196	
3	٨.٢٢٠	٨.٤٠١	0.181	
Mean weight	8.523		0.188	

Table (4.27): Result of absorption after 28 days: (super plasticizer ratio = 0.4L per 50kg of cement) 10% water reduction and 10% cement reduction

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	٨.٤٨٩	٨.٧٨٢	0.293	3.95
2	8.22	8.545	0.325	
3	٧.٩٥١	٨.٣٠٨	0.357	
Mean weight	8.22		0.325	

Table (4.28): Result of absorption after 28 days: (super plasticizer ratio = 0.8L per 50kg of cement) 15% water reduction and 15% cement reduction

Cube No.	Initial weight	Final weight	Differences	Absorption (%)
1	8.529	8.653	0.124	1.44
2	٨.٣٩١	٨.٥١٨	0.127	
3	٨.٦٦٧	٨.٧٨٧	0.12	
Mean weight	8.529		0.124	

Table (4.29): Effect of superplasticizer ratios on absorption of concrete mixes for 28 days of age

No	dosage	Water reduction (%)	Absorption (%)	Difference (relative to control mix)	% age difference
1	0.0	0.0	3.42	3.42-3.42 = 0	0
2	0.4	10.0	3.33	3.33-3.42 = - 0.09	3 (decrease)
3	0.8	15.0	3.62	3.62-3.42 = 0.20	6 (increase)
4	1.2	20.0	3.78	3.78-3.42 = 0.36	11 (increase)
5	1.5	30.0	2.21	2.21-3.42 =- 1.21	35 (decrease)

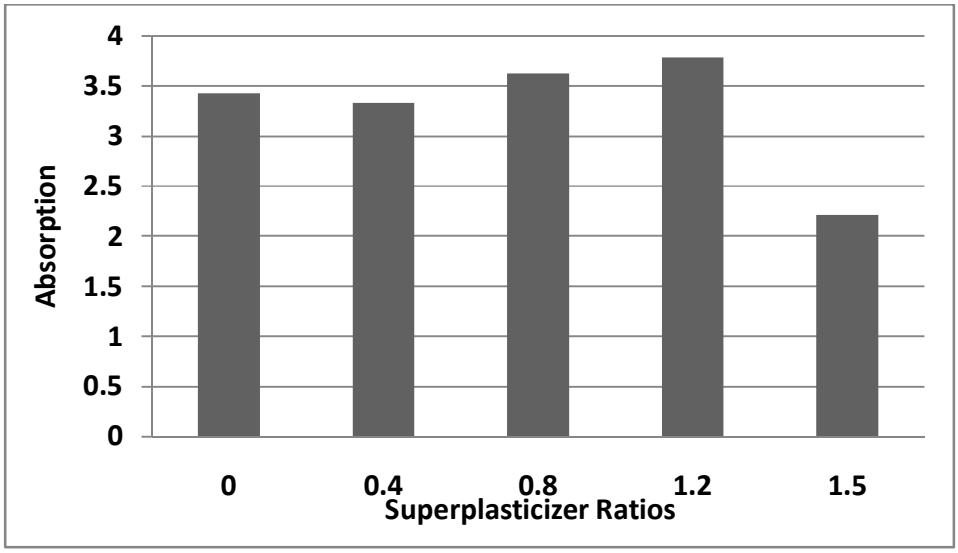

Fig (4.14): Relationship between superplasticizer ratios and absorption of concrete mixes for 28 days of age.

Table (4.30): Effect of (0.4 and 0.8) L per 50kg of cement superplasticizer, (10% and 15%) water reduction and (10% and 15%) cement reduction on absorption of concrete mixes for 28 days of age.

No	dosage	Water reduction (%)	Cement reduction (%)	absorption	Difference (relative to control mix)	% age difference
1	0.0	0.0	0.0	3.42	3.42-3.42 =0	0
2	0.4	10.0	10.0	3.95	3.95-3.42 = 0.53	15 (increase)
3	0.8	15.0	15.0	1.44	1.44-3.42 =-1.98	58(decrease)

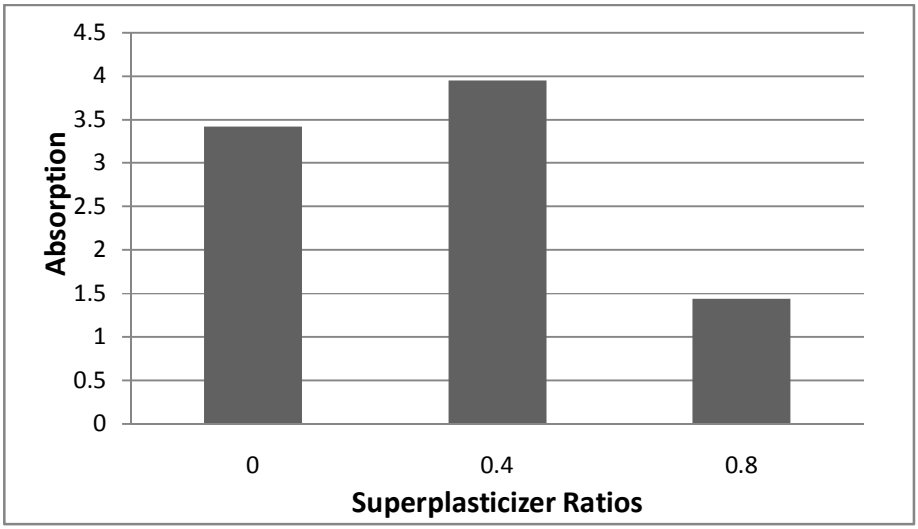

Fig (4.15): Absorption concrete mixes after 28 days: superplasticizer (0.4 and 0.8) L per 50kg of cement, (10% and 15%) water reduction and (10% and 15%) cement reduction

4.7: Discussions of the Results

4.7.1 Preliminary results and observations:

Laboratory Tests were carried out to ensure that the main constituents of concrete (cement & aggregates), are adequate and conforming with the requirements of the (BS) standards code (British standards)

I. Cement :

Setting times and compressive strength tests of cement were carried out for local Portland cement. The quantity of water necessary to produce a paste of normal consistency was found to be 29% by weight of cement which used in mixing cement paste for setting time experiments.

The results of initial and final setting times are shown in Table (4.1). The results of compressive strengths of cement mortar cubes for ages 2 days and 28 days are shown in Table (4.1).The results of these preliminary experiments shown that the cement used in this research comply with BS 12 1996.

II. Aggregates:

Tests were undertaken to study the suitability of aggregate for concrete making. Sieve analysis was done according to BS 812 and 882:1992. Results for coarse aggregate and fine aggregate are presented in Tables (4.2) and (4.3) respectively. From Table (4.2) and Fig.(4.1) it is noticed that the grading of coarse aggregate satisfied the BS 812-103.1 (882:1992), whereas Table (4.3) and Fig.(4.2) indicate that the fine aggregate grading satisfied the BS 812-103 and 882:1992.[16]

III. workability:

The slump test was used as a measure of consistency when admixtures were used with ordinary reference mix having w/c ratio (0.48). slumps of ordinary reference mix 40mm, Slumps of mixes containing (0.4, 0.8 , 1.2 & 1.5)L superplasticizer per 50kg cement and reduced water by (10%, 15%, 20%, 30%) respectively are 90 mm, 180mm, 190mm, and 185 mm respectively. Reduction in the slump in the

proportion of 1.5 as a result of a significant reduction in the proportion of w\c compared with other ratios presented in Table (4.5) and Fig (4.3). Slumps of mixes containing (0.4L & 0.8L superplasticizer per 50kg cement) reduced water by (10% , 15%) and reduced cement by (10%, 15%) respectively are (50mm & 85mm) respectively presented in Table (4.6) and Fig (4.4). The observed workability of mix containing admixtures was much higher than that of the ordinary reference mix but the workability of mix containing admixtures and reduced cement was low than that of the mix containing admixtures.

IV. Compressive Strength:

The experimental results shown in Table (4.14) and Fig (4.5) indicate that the three days compressive strength increases with increasing the dosage of superplasticizer. Addition of 0.4% superplasticizer increase the three days compressive strength from 27.03 N/mm^2 to 33.02 N/mm^2 (22%) from the reference concrete, but further increase of superplasticizer from 0.4% to 0.8% superplasticizer increase the three days compressive strength only from 27.03 N/mm^2 to 42.17 N/mm^2 (56%). increase of superplasticizer from 0.8L to 1.2L increase the three days compressive strength only from 27.03 N/mm^2 to 30.73 N/mm^2 (14%) but when the ratio of superplasticizer increased from 1.2L to 1.5L the three days compressive strength increased from 27.03 N/mm^2 to 41. 21 N/mm^2 by an amount of 52%. This fact is also true for ages 7 days and 28 days compressive strength which increased significantly as superplasticizer ratios increased as seen clearly in Tables (4.15-4.19) and Figures (4.6 - 4.10). For 7 days, the increasing rate of the compressive strength ranging from 19% to 35% with respect to control mix and ratios of additive, while for 28 days the increasing rate ranging from 10% to 29%. The experimental results shown in Table (4.20) and Fig (4.11) indicate that the addition of 0.4L increased the 28 days compressive strength from 47.53N/mm^2 to 50.78 N/mm^2 (7 %) and the addition of 0.8L decrease the 28 days compressive strength

from 47.78 N/mm^2 to 39.28 N/mm^2 (17 %). The decreasing in strength is thought to be due to reduction in cement contents. It has been shown from Table (4.21) that addition of super plasticizer to great extent with the reduction of cement and water leads to reduce strength as in case of 0.8L and the best results were achieved when adding 0.4L.

V. **Absorption**

As it can be seen from Table (4.29) the values of absorption are fluctuating irrespective to ratios of superplasticizer or rates of water reductions. Table (4.30) shows that the values of absorption decreased with increasing superplasticizer ratios (0.4% and 0.8%) and increasing the reduction of water and cement content.