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Concrete Water-Reducing Admixtures between Laboratory and Site.

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CONCRETE WATER-REDUCING ADMIXTURES BETWEEN LABORATORY AND SITE

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الخلاصة

انتشر في خلال الاعوام العشرة الاخيرة استعمال الاضافات لتحسين خواص الخرسانة في العديد من مواقع الانشاء وعادة ما يتم استعمال هذه الاضافات بناء على التوصيات العامة الموجودة بالكتيبات الاسترشادية لمنتجي هذه الاضافات مما قد يؤثر على الاستخدام الامثل لتلك المواد من الناحية العلمية والاقتصادية . هذا البحث يحتوى على دراسة لتأثير احدى الاضافات المخفضة لماء الخلط والشائعة الاستعمال في مصر على خواص الخرسانة في حالتها الطازجة وبعد التصلد . الخواص التي تم دراستها تشمل زمن الشك للاسمنت وقوام الخرسانة الطازجة ومقاومة الضغط للخرسانة المتصلدة . ولقد اجريت الدراسة على خلطات تختلف في محتوى الاسمنت ونسبة الاضافات ونسبة الماء الى الاسمنت . ولقد روعى في هذا البحث استعمال مواد من احد المواقع التي تستخدم الاضافات محل الدراسة في تحسين تشغيلية الخرسانة . ولقد توصل البحث الى انه يمكن تحقيق درجة تشغيل عالية مع تحسين مقاومة الخرسانة للضغط مع زيادة طفيفة في زمن شك الاسمنت في الحدود المنصوص عليها بالمواصفات وذلك عن طريق الاختبارات المعملية على المواد المستخدمة في الموقع لتحديد جرعة الاضافات التي تعطي الخواص القصوى والتي اختلفت عما اوصى به منتج هذه الاضافات ودأب المقاول على استعماله قبل اجراء هذا البحث .

SYNOPSIS

This research was planned to study the effect of water-reducing admixtures on the properties of cement paste and concrete. These properties included setting time of cement paste, consistency of fresh concrete and compressive strength of hardened concrete. The main variables taken into consideration in this study were cement content, water/cement ratio and admixture/cement ratio. A comparison was made between the properties of concrete according to the usage of the optimum dose of the admixture as a result of the experimental test results and the properties of concrete when the dose recommended by the producer was used.

Great improvement was achieved in both the workability of fresh concrete and the compressive strength of hardened concrete when optimum dose of the water-reducing admixture was used which depends on many factors among which are the cement content and water content. The initial and the final setting time of cement increase with the increase of the water-reducing admixture in the cement paste. However, the limits of the setting time recommended by the specifications have to be taken into consideration when determining the optimum dose of the admixture.

INTRODUCTION

During the last four decades extensive research have been carried out on concrete admixtures. Concrete admixtures have shown great potentialities in many structural applications (1 - 5). Admixtures can be generally classified into accelerators, retarders, water - reducing admixtures, pigments and water repelling admixtures.

Deep understanding of the nature of the admixtures used and their role in modifying the concrete properties is essential and vital for their application with optimum benefit. The use of an admixture necessitates a great degree of control than normally applies to the other mix constituents. Most admixtures have to be dispensed in small doses which are susceptible to proportionately large errors. Uniform dispersion of an admixture in a concrete mix has to be considered which requires thorough mixing. Admixtures are usually delivered to site in steel or plastic drums . These should be kept indoors since the quantity required at any one time is usually small. Admixtures can degrade at extremes of temperature, causing their physical properties to change and making dispensing difficult (1).

Water-reducing admixtures have been widely used during the last decade in many concrete structural works in Egypt. However, during the writers consultation works it was found that the general instructions and informations supplied by the admixtures manufacturer to the user should be modified according to the characteristics and the proportions of the concrete constituents used in a specified job. However, the main goal of this research is to throw light on the effect of very commonly used water-reducing admixture in the Egyptian market on concrete properties. A comparison was carried out between the experimental test results and the information supplied by the manufacturer for site application.

EXPERIEMENTAL WORK

The materials used in this work are El-Sharkia quarries gravel and sand, Ordinary Portland Cement and tap drinking water. The nominal maximum size of the coarse aggregate used was 20 mm. The water-reducing admixture under investigation is a Modified Ligno-Sulphonate liquid of a brown colour commercially available and widely used in Egypt. To measure the setting time cement pastes were prepared and tested according to the Egyptian Standard Specification, 373, 1984 using a Vicat apparatus. The concrete mix proportions by weight were 1 cement : 2 sand:4 gravel. Three cement contents of 300, 350 and 400 kg/m3 of concrete were used. Ten admixture/cement percentages ranged between 0.1%to 1.0%with,1%increase were used. However, seven water/cement ratios ranged between 0.3 to 0.6 with 0.05 increase were used. Table (1) shows the scheme of testing. Control mixes without adding admixtures were also cast and tested for comparison. All tests were carried out in laboratory atmosphere at 25°C and 70 R.H.

TEST RESULTS

Initial and Final Setting Time of Cement Paste

Table (2) and Fig. (1) represent the effect of the addition of the water reducing admixture used in this research on the initial and final setting time of cement paste. It is indicated that within the range of the admixture/cement percentages used in this work, both the initial and the final setting time increase as the admixture dosage increases. The rate of increase of the setting time slightly increases till certain admixture dosage after which the rate greatly increases. At an average value of admixture/cement of 0.4 % the initial and the final setting time were 1.11 and 1.15 times that of the control cement paste without admixtures. Inspite of this increase, the initial and final setting time are still within the limits recommended by Egyptian standard specifications.

SLUMP TEST RESULTS OF FRESH CONCRETE

The effect of the water reducing admixture used in this research on the consistency of the fresh concrete was determined through the slump test. Figure (2) shows that irrespective to the cement content, the slump increases with the increase of the admixture dosage in the concrete mix. The rate of increase of the slump with the increase of the admixture dosage in a concrete mix is almost constant for low admixture/cement percentages. However, the slump dramatically increases at high admixture/cement percentages which causes difficulties in handling and compaction of fresh concrete. Higher admixture/cement percentages are needed for mixes with higher cement contents to obtain the same consistency. An addition of the admixture with 0.4 % of the cement content by weight increases the slump 187 %, 195 % and 250 % for those mixes with cement content 300, 350 and 400 kg/m3 of concrete, respectively in comparsion with the reference mixes. However, doubling the amount of the admixture increases the slump to 700 %, 450 % 350 % for those mixes with cement content of 300, 350 and 400 kg/m3 of concrete successively in comparsion with the reference mixes.

Figure (3) shows that a specific slump of a fresh concrete mix can be achieved with reducing the water/cement ratio by using water-reducing admixture. The addition of the admixture with a dosage of 0.4 % of the cement content by weight shows a reduction in the water/cement ratio of about 15 % in average to obtain the same slump as the reference mix.

COMPRESSIVE STRENGTH OF CONCRETE

Figure (4) and Table (3) show the effect of the water reducing admixture on the compressive strength of concrete specimens with different cement conctents. The specimens were cured in laboratory atmosphere till the date of testing at 28 days age. Generally speaking, for all the concrete mixes tested in this research, the increase of water-reducing admixture increases the concrete compressive strength till certain admixture dosage after which the compressive strength decreases. Higher admixture/cement percentage is needed for concrete mixes with lower cement contents to achieve the optimum compressive strength. Using the optimum dosage of the admixture showed higher increase in comparison with the control specimens for mixes with lower cement content. The addition of the optimum dosage of the admixture leads to an increase in the compressive strength of 31.7 % , 32.6 % and 28.0 % of the reference mixes with cement contents of 300, 350 and 400 kg/m3 of concrete, respectively.

Figure (5) shows that for low water/cement ratios the addition of the water reducing admixture increases the compressive strength of concrete, while it decreases the compressive strength when high water/cement ratios are used.

BETWEEN LABORATORY AND SITE

It was recommended by the water-reducing admixture producer to use a dosage of admixture of 0.6 % by weight of the cement amount used in the concrete mix in the site. The experimental study showed that using a dosage of admixture of 0.4 % of the weight of cement caused a reasonable workability with just 13 % reduction in the slump comparing to the concrete mix with a dosage of admixture with 0.6 % of the cement content. On the other hand , using an admixture dosage of 0.4 % of the cement content caused an increase of up to 20 % in the compressive strength over that of the

concrete mix with an admixture dosage of 0.6 % of the cement content.

CONCLUSIONS

This research study led to the following conclusions:

1. The general recommondations and instructions of the concrete admixture producers are not fully reliable and have to be checked for each specific job. Laboratory testing is of a great improtance to determine the optimum dosage of an admixture used to achieve the atmost improvement in the concrete properties. This greatly affects the final products economically.

2. Water-reducing admixtures increase the setting time and the workabillty of concrete, and also the compressive strength up to a certain percentage of admixture after which they adversely affect the strength.

3. The use of water-reducing admixtures can contribute in reducing the amount of cement used in the concrete mix without reducing the strength desired.

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Table (1)

Scheme of Testing of the Different Mixes

Concrete Mix Proportions	Cement Content kg/m³ Conc.	Water/Cement ratio	Admixture/Cement %	Tested Property
C 4 : : S 2 : : C 1	300, 350 and 400	0.4	0.0 0.1 , 0.2 0.3 , 0.4 0.5 , 0.6 0.7 , 0.8 0.9 and 1.0	1- Setting time of Cement paste 2- Slump of fresh Concrete
	350	0.3 , 0.35 , 0.4 , 0.45 0.5 , 0.55 and 0.6	0.0, 0.4 %	3- Compressive* Strength of hardened concrete

* Compression test was carried out on concrete cubes 150 mm size cured in laboratory atmosphere for 28 days after casting.

Table (2) Effect of Water Reucing Admixture on Setting Times of Cement Paste

mix No.	Admixture % cement	Initial setting time(I.S.T)		Final setting time (F.S.T)		I.S.T ** / I.S.T of Ref*	F.S.T. ** / F.S.T.of Ref*
1	0.0	hr.	min	hr.	min		
		1	45	4	30	1.0	1.0
2	0.1	1	48	5	-	1.03	1.11
3	0.2	1	51	5	06	1.06	1.13
4	0.3	1	57	5	10	1.11	1.15
						1.20	1.18
5	0.4	2	06	5	18		
6	0.5	2	-	5	25	1.14	1.20
7	0.6	2	30	5	40	1.45	1.26
8	0.7	2	45	5	48	1.57	1.29
9	0.8	2	50	6	10	1.62	1.37
10	0.9	2	53	6	-	1.65	1.33
11	1.0	3	30	6	30	2.0	1.44

* I.S.T = Initial setting time

** F.S.T = Final setting time

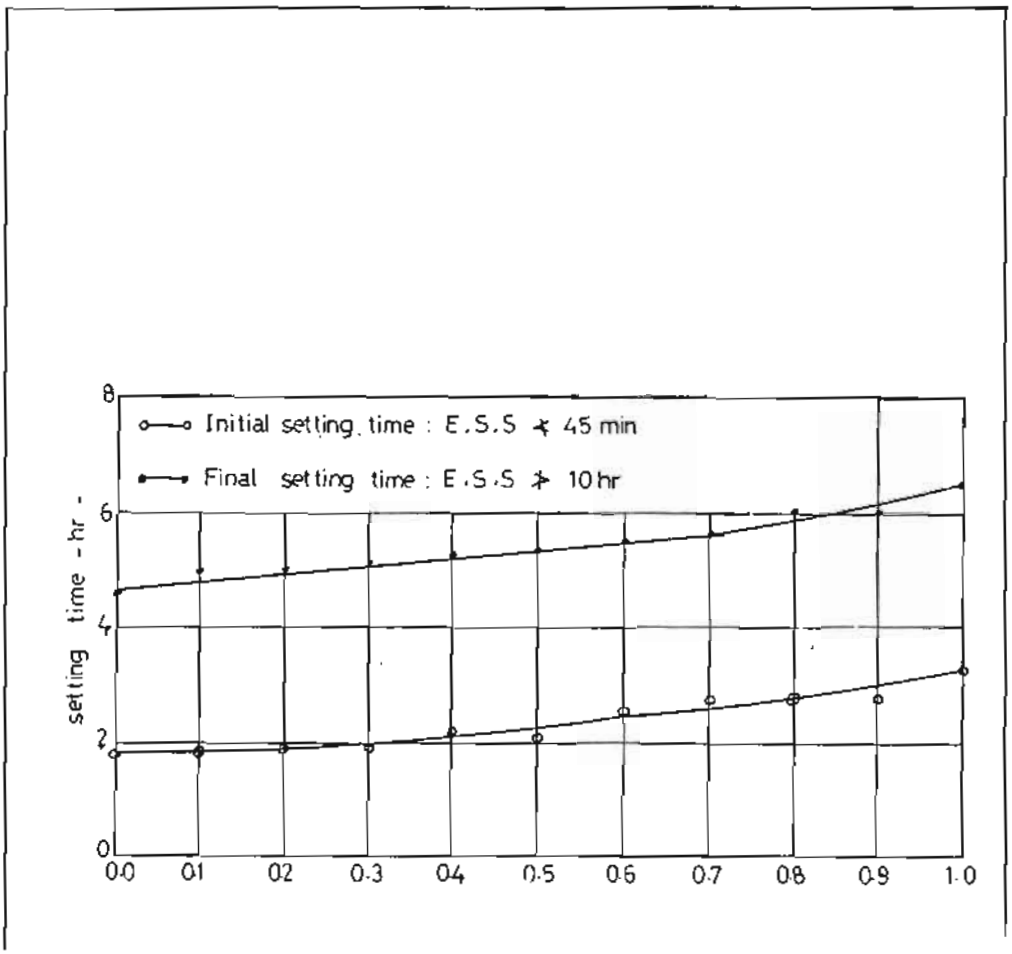
. Reference mix without admixtures

Table (3)
Effect of Water-Reducing Admixture on the Compressive Strength of Concrete at 28 Days Age

Admixture % cement (by weight)	Compressive Strength (kg/cm^2)*			Comp. Str./Comp.Str. of Ref. mix**		
	Cement Content (kg/m^3) of Concrete			Cement Content (kg/m^3) of Concrete		
	300	350	400	300	350	400
0.0**	205	230	250	1.00	1.00	1.00
0.1	207	233	253	1.01	1.01	1.01
0.2	213	236	266	1.04	1.03	1.06
0.3	227	257	290	1.11	1.12	1.06
0.4	245	305	320	1.21	1.32	1.28
0.5	270	280	293	1.32	1.22	1.17
0.6	230	255	270	1.12	1.11	1.08
0.7	210	235	254	1.02	1.02	1.02
0.8	205	225	243	1.00	0.98	0.97
0.9	203	222	235	0.99	0.97	0.94
1.0	200	220	230	0.98	0.96	0.92

* Average of the results of three test specimens

** Ref.mix = mix without admixtures


Initial setting time : E.S.S < 45 min
Final setting time : E.S.S > 10 hr
setting time - hr -
0
2
4
6
8
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

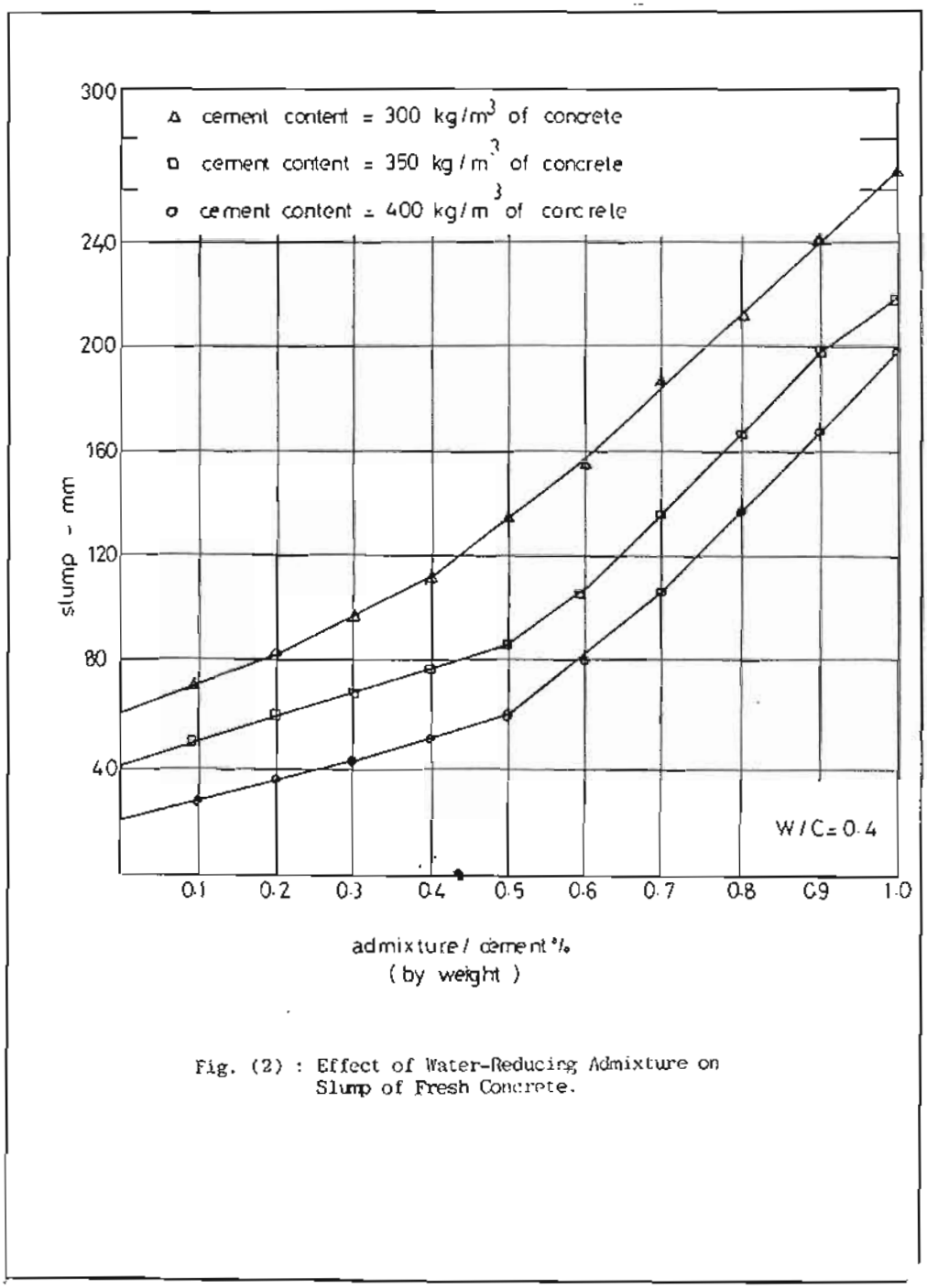


Fig. (2) : Effect of Water-Reducing Admixture on Slump of Fresh Concrete.

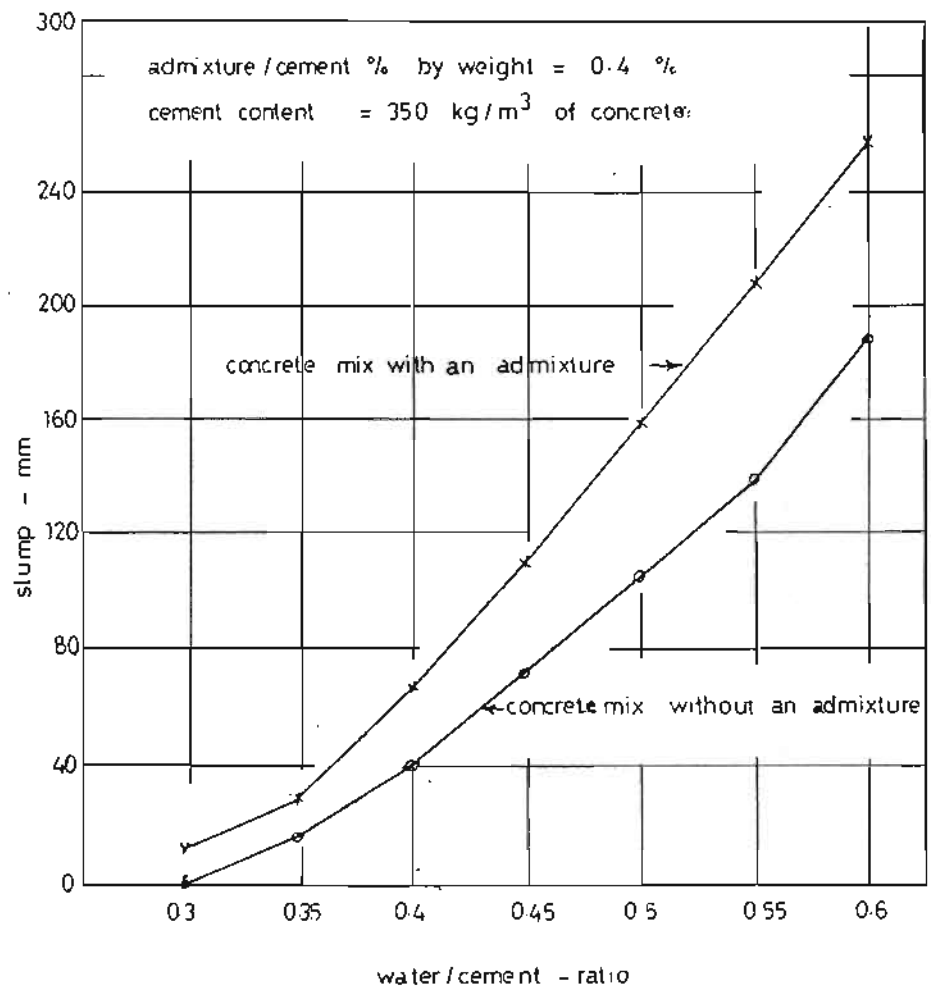


Fig. (3) : Effect of Water/Cement Ratio on Slump of Fresh Concrete.

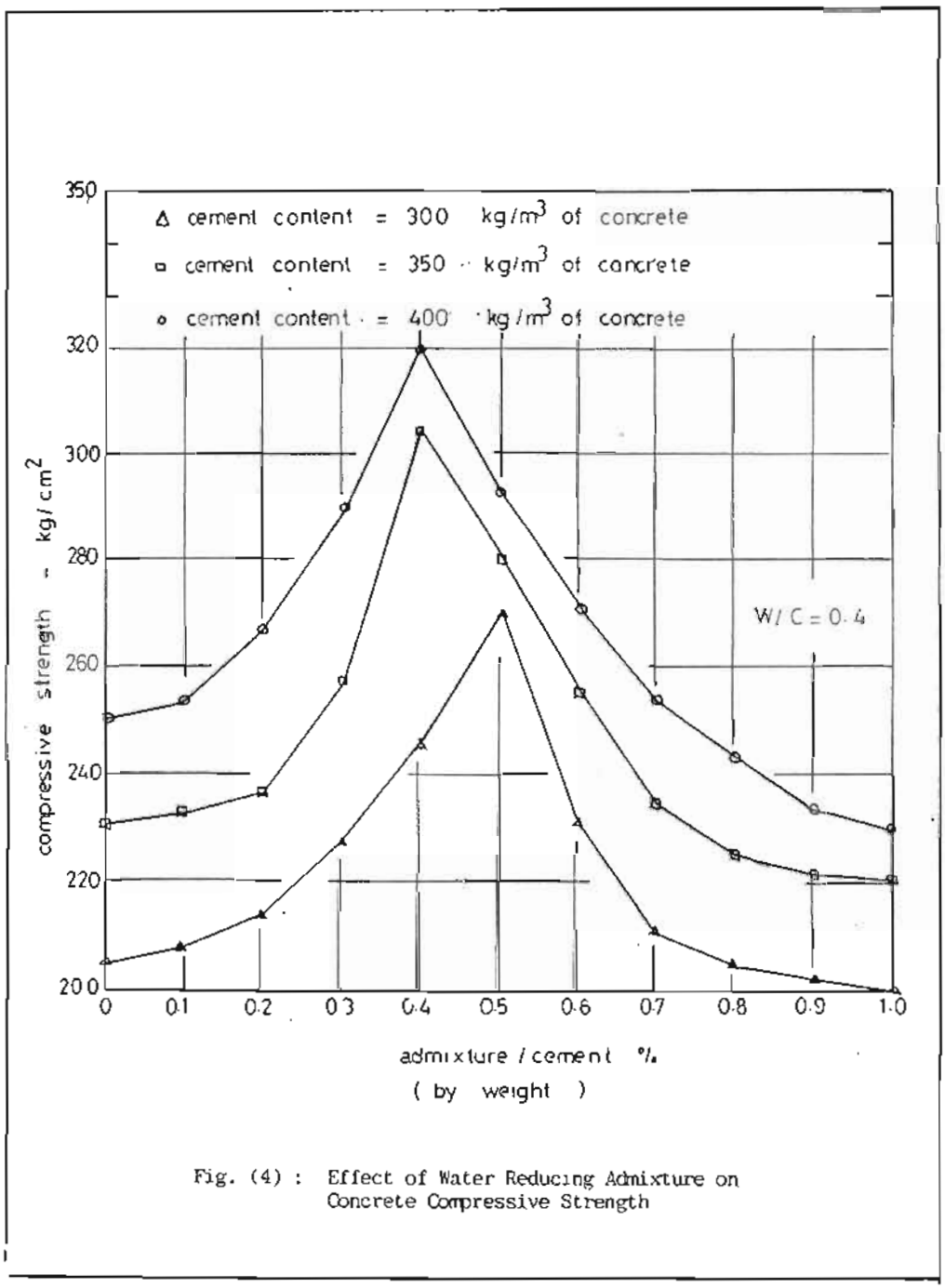


Fig. (4) : Effect of Water Reducing Admixture on Concrete Compressive Strength

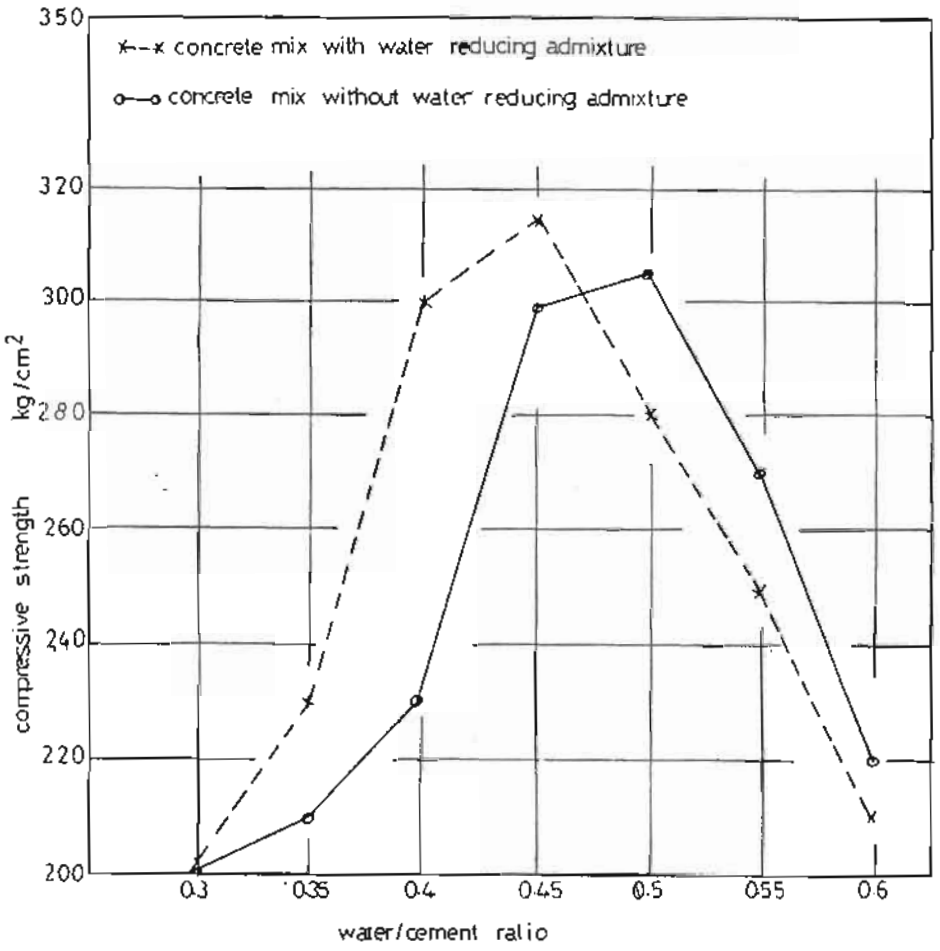


Fig. (5) : Effect of Water/Cement Raito on Concrete Compressive Strength