Anbar Journal for Engineering Sciences © AJES / 2007

Effect of Admixture Type on Compressive Strength and Modulus of Elasticity of Rubber- Tire - Waste Concrete

Khalid Battal Najim
College of Engineering / Al-Anbar University

ABSTRACT
The presented work investigates the effect of addition admixtures (superplasticizer and polymer) to Chopped Worn-Out Tire concrete as a partial replacement of cement weight. Superpasticizer was addition by 4% and polymer (SBR) by 15%. The Chopped Worn-Out Tire (Ch.W.T.) addition to reference concrete with the three proportions as a Partial Replacement Ratio (PRR) of (25,25),(20,30),and (30,20) by volume of (sand and gravel) respectively. Three mixes were selected with above PRR for each type of admixture in additional to three mixes for Ch.W.T. concrete without admixtures and three reference mixes with admixtures without Ch.W.T. Thus, twelve mixes could be used in this investigation. Compressive strength and modulus of elasticity (static and dynamic) were tested. The test results indicated that the use of admixture led to significant improvement in concrete properties in general. Superplasticizer gave best results comparative with polymer, for example at 28 day the compressive strength of superplasticizer Ch.W.T. concrete Csp25,25 was 32.5 MPa, while compressive strength of polymer modified Ch.W.T. concrete CB25,25 was 28 MPa and compressive strength of Ch.W.T. concrete C25,25 was 21.2 MPa.

Key word: Waste Concrete, Polymer, Admixtures, Compressive strength, Modulus of elasticity

تاثير نوع المضاف على مقاومة الانضغاط ومعامل المرونة لخرسانة الاطارات المطاطية المستهلكة

خالد بتال نجم
كلية الهندسة، جامعة الانبار

الخلاصة
يدرس هذا البحث تأثير إضافة بعض أنواع المضافات (الملدن المتفوق والبوليمر) إلى خرسانة الإطارات المطاطية المستهلكة. حيث تم إضافة الملدن المتفوق بنسبة ٤% والبوليمر بنسبة ١٥% من وزن الاسمنت. تم إضافة مفروم الإطارات المطاطية المستهلكة إلى الخلطات الخرسانية كجزء مستبدل من حجم الركام الخشن والناعم بثلاث نسب استبدال هي (٢٥، ٢٥)، (٢٠، ٣٠) و (٣٠، ٢٠) (ركام خشن وناعم على التوالي). تم اختيار ثلاث خلطات بنسب الاستبدال أعلاه لكل مضاف إضافة إلى ثلاث خلطات بدون مضافات وثلاث خلطات مصدرية مع المضافات وبدون مفروم الإطارات وبذلك يكون مجموع الخلطات اثنا عشر خلطة. تم إجراء فحص مقاومة الانضغاط ومعامل المرونة (الساكن والديناميكي)، وقد أظهرت نتائج الفحص تحسن ملحوظ لخواص الخرسانة عند إضافة المضافات وكانت الأفضلية باستخدام الملدن المتفوق بشكل عام.فعلى سبيل المثال بعمر ٢٨ يوم كانت مقاومة الانضغاط لخرسانة الإطارات الحاوية على الملدن المتفوق Csp25,25 32.5MPa بينما كانت مقاومة الانضغاط لخرسانة الإطارات المطورة بالبوليمر ٢٥CB، ٢٥ هي 28 MPa وكانت مقاومة الانضغاط لخرسانة الإطارات بدون مضافات C25, 25 هي 21.2 MPa.

1. INTRODUCTION

To reduce the problem of waste material dumping, it is imperative that waste materials showed be utilize in an environmentally safe manner either as raw materials for other products or for some other beneficial purposes. While such large quantities of waste material get accumulated facing very serious problems of safe disposal, it could be possible with the help of the building material industry to sensibly put to use such waste products into very useful, interesting and cast effective item. The idea of "no waste" that is accepted and followed in the developed countries can be transferred to our situation [1]. For example in 1990, over 24 million scrap tires were discarded in the united state [2]. And in Iraq , it is estimated two million scrap tires are thrown into the environment per year [3].

Some countries use a small part of worn-out tires to manufacture shock protection larger for platforms subjected to sea waves and ship movement. However, with time there is an increase in the idea of using worn-out tires in concrete compsites material industry. It enjoys several favorable characteristics such as high resistance to weathering conditions, low water absorption and lightweight compared with other materials that are usually used. it is also characterized by its high-impact resistance. Chopped worn-out tires (Ch.W.T) was also expect to improved the dynamic impact-absorbing capacity due to the ductile property of the crumb rubbers added to the brittle concrete

Chopped worn-out tires concrete (Ch.W.T.conc.), consist of cement, aggregate (gravel and sand),Ch.W.T and water at various proportions and since the density of chopped worn-out tire is relatively low, thus the product has the property of being lightweight. But the use of admixture, such as polymer modified(SBR),with Ch.W.T. concrete mixes is expected to improve the bonding between the tire crumb the hydrated Portland past as a polymer latex particles coalesce to form continuous close-packed layer on the surface of the cement past and unhydrated cement particle mixes during the hydration process[4]

2. LITERATURE REVIEW

Jafer.s.f.[5],investigated some properties of Ch.W.T concrete. His experimental program included using three percentages of Ch.W.T by volume of concrete and mortar (25, 30, and 35) percentage. He found that the inclusion of Ch.W.T. in concrete affects the properties of the matrix significantly in its fresh and hardened states. The results of this research were compatible with previous in general. Also, he tested two types of brick masonry walls that were built up by using two types of Ch.W.T. brick concrete masonry units. He concluded that the Ch.W.T. concrete masonry units offer satisfactory or even better alternative units for wall construction compared with the traditional brick masonry unit.

Jiei,hosek[6], stated that in general the polymer emulsion is acting as a hydration retarder and delaying both the beginning and the end of the hydration process. Latex modified mortar and concrete show appreciable increase in tensile and flexural strength, but decreases in compressive strength as compared with plan cement mortar and concrete

Gubezhen et.al[7], found that compared with reference cement paste made of 0.25 w/c ratio, the superplasticizer paste containing one aphthalene-condensate had less water of hydration. In addition, they found that the 7and 28 day compressive strength of superplasticized concrete was higher by 5 to 10% and test on the 7 months old specimens showed that the strength advantage disappeared in them

Mac and fischer[8], found that the loignosulfonate admixture increases bond strength by about 15-20% and reduces the slip between reinforcing bar and concrete at a given bond stress.

The effect is ascribed to the decrease in w/c ratio, consequently the reduction in bleeding and shrinkage can be contributing to better adhesion and hence improved bond strength.

3. EXPERMENTAL WORK

3.1 Materials

3.1.1 Cement

Ordinary Portland cement was used throughout this work. The physical test results of the used cement are given in Table (1). It conforms to the Iraqi specification No.45/1984. The content of cement used was 400 kg/m^3.

3.1.2 Fine Aggregate

Sand of 4.75-mm maximum size was used for concrete mixes of this investigation. The specific gravity, absorption, sulfate content and material finer than sieve No.200 (75µm) of the used fine aggregate were (2.65, 0.75%, 0.15% and 0.8 %) respectively.

3.1.3 Coarse Aggregate

The washed coarse aggregate of 10mm maximum size were used. The specific gravity, absorption, sulfate content and material finer than No, 200(75µm) sieve of the used coarse aggregate were (2.68, 1.07%, 0.07%, and 0.2%) respectively.

3.1.4 Mixing Water

Potable water was used for mixing and curing purposes.

3.1.5 Chopped Worn-Out Tires

The maximum size of chopped worn-out tires particles was 6.35 mm. The sieve analysis, the chemical composition and some properties of the chopped worn-out tires are shown in reference No.(9).

3.1.6 Superplasticizer

High Range Water Reducing Agent (HRWRA), which is known commercially as Melment L10, was used throughout this work. The technical description of this type is given in Table (2).

3.1.7 Polymers

Styrene butadiene rubber was used in this work of which the chemical composition is shown in Table (3).

4. EXPERIMENTAL PROGRAM

The experimental program is planned to investigate the effect of using different type of admixture (superplastecizer and polymer) as a partial replacement of cement on the compressive strength and modulus of elasticity (static and dynamic) of Ch.W.T. concrete. Table (4) shows the details of reference and admixture Ch.W.T. concrete mixes used throughout this work

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5. MIXING PROCEDURE

A mechanical mixer of (0.1) m^3 capacity was used. The interior surface of the mixer was cleaned and moistened before placing the materials. The raw materials such that gravel, sand, cement, and Ch.W.T were first mixed dry for about one minute then water, or water content of admixtures was added to the mixer. After that mixing continued for about three minuets until the concrete becomes homogenous in consistency.

6. CASTING COMPACTION AND CURING

The molds were lightly coated with mineral oil before use, concrete casting was carried out in different layer each layer of 50 mm. Each layer was compacted by using a vibrating table for (15-30) second until no air bubbles emerged from the surface of the concrete, and the concrete is level off smoothly to the top of the molds. Then the specimens were kept covered with polyethylene sheet in the laboratory for about (24±2) hrs. After that, the specimens remolded carefully, marked and immersed in water until the age of test.

7. TESTING OF HARDENED CONCRETE

7.1 Compressive Strength Test:

The compressive strength was determined according to B.S.1881.part 4, 1970. The average of compressive strength of three cubes was recorded for each testing age (7, 28, and 90) days.

7.2. Static and Dynamic Modulus of Elasticity (MOE and DMOE):

The static modulus of elasticity was calculated at age of 90 day according ASTM C469-87a. The dynamic modulus of elasticity was determined at age of (7, 28, and 90) day on the laboratory, specimens subjected to longitudinal vibration on their natural frequency; according to B.S.1881.1970.

8. RESULTS AND DISCUSSION

8.1 Compressive strength:

The compressive strength was determined at age of (7, 28, and 90 day) for moist cured concrete specimens. The test results are summarized in Table (5). It is show that the compressive strength was increase with age for all type of Ch.W.T. concrete Fig.(1) and the compressive strength for Ch.W.T. concrete decreases appreciably with adding of Ch.W.T as PRR of aggregate (sand and gravel). For example the 28 day compressive strength decreased from (40.5)MPa of reference concrete mix No.l to (21.2,19.5,and 20)MPa for mix No.4,7,and 10 respectively.

The test results illustrated that the compressive strength of Mix C25,25 was higher than the compressive strength of C20,30,and C30,20 mixes. This is due to the microstructure of cement past, concrete matrices, and transition zone between the aggregate particles and the cement past.

In general, the addition Ch.W.T. reduces the compressive strength, Fig (2). This reduction can be explained by the following:

1. The Ch.W.T. partials are weak materials and compressible with flexibility, hence the compressive strength of concrete will be reduced because it is affected by the strength of its components.
2. The Ch.W.T. concrete required higher W/C ratio to achieve the suitable workability. This property results in the lower strength.
3. The number of voids increases in the mixes containing Ch.W.T., which would affect the compressive strength negatively.

Compressive strength of concrete with superplasticizer are given in Table (1), and presented in Fig (3). From Table(5), the compressive strength of superplasticizer concrete containing Ch.W.T. is higher compared with corresponding concrete containing Ch.W.T. without superplasticizer at all ages of test and all PRR of sand and gravel. For example, the compressive strength of concrete mixes type C25,25, C20,30, andC30,20 at 28 days age were (21.2, 19.5, and 20)MPa respectively, and it is increased to be (32.4, 27.5, and 26.7) MPa for superplasticizer concrete mixes of Csp25,25, Csp20,30, and Csp30,20 respectively. This improvement in compressive strength of superplasticizer concrete containing Ch.W.T. is due to the effect of superplasticizer with reduces the required amount of w/c ratio for the same workability. This increase can also be attributed to the better hydration of cement as a result of more scattered cement particles when using superplasticizer and less entrapped air voids are produced because of the better performace of concrete mixes with superplasticizer in mixing, placing, compacting and finishing.

The compressive strength of polymer modified concrete containing Ch.W.T. increased with age for all type of Ch.W.T. polymer concrete Fig.(4), and its higher than that compared with their corresponding concrete mixes containing Ch.W.T. without superplasticizer and without SBR at all ages and all PRR of concrete specimens, Table (5). For example the compressive strength of C25,25, C20,30, and C30,20 concrete at 28 days age were 21.2, 19.5, and 20 MPa respectively ,and it increased to be (28, 21.9, and 21)MPa for Ch.W.T. polymer modified concrete mixes CB25,25, CB20,30 and CB30,20 respectively. This improvement in compressive strength of polymer modified Ch.W.T. concrete is due to the effect of polymer modified to reduce the w/c ratio and due to the lesser entrapped air voids are produced because of the better performance of concrete mixes containing SBR.

The reduction of compressive strength of polymer modified concrete containing Ch.W.T at 28 days was (30.8, 45.9 and 48.1)% for CB25,25, CB20,30 and CB30,20 respectively relative to reference concrete Co. This reduction can be attributed to the change of PRR of Ch.W.T. from gravel and sand, which affects the homogeneity and compatibility at the mix.

Table (5), and Fig.(1) illustrate that the addition of superplasticizer to Ch.W.T. concrete gave best results compared with polymer.

8.2 Modulus of Elasticity

The static modulus of elasticity (MOE) was determined at age of 28 days and dynamic modulus of elasticity (DMOE)was determined at ages of (7,28,and90)days. The test results are given in Table (6) for all concrete mix. From this table, it can be seen that the MOE decreases with addition of Ch.WT. . The percentage degreases of MOE relative to reference concrete Co were 41.3% and 44.2%and 43.4%for mixes No.4, No7, and No.10 respectively. While the percentage degreases of DMOE of mixes no.4, no.7, and no.10 relative to mix no.1 at age of 28days were 46.7%, 50.2% and 49.3%respectivly.

Generally, the content of Ch.W.T in concrete is the principle factor that affects the value of MOE and DMOE, which is show in Fig. (5). The decrease of MOE and DMOE, with addition of Ch.W.T is attributed to the low MOE of Ch.W.T it self which affects the MOE and DMOE of concrete.

It is known that the factors which influence the strength of concrete, generally influence the MOE in similar trend, or a little to a lesser degree. The relationship between (DMOE and MOE) and compressive strength of Ch.W.T concrete is show in Fig (6).

The effect of superplastisizer on modulus of elasticity is shown in Table (6), and Fig (7). Form these results the following can be noticed:

1. The static and dynamic modulus of elasticity of superplasticizer reference concrete is higher than that of normal reference concrete at all ages of concrete specimens. This is attributed to the ability of superplasticizer to reduce water and achieve a very higher strength compared to that of reference concrete.
2. The static and dynamic modulus of elasticity of superplasticizer concrete containing Ch.W.T. is higher compared with corresponding concrete mixes containing Ch.W.T. without superplastisizer at all ages of test. For example the percentage increasing at 28 days of DMOE of Csp25,25,Csp20,30,and Csp30,20 were 45.3%, 34.6%and 20.4% respectively relative to C25,25, C20,30,and C30,20 respectively.
3. The DMOE of all concrete mixes is higher than that of MOE. For example, the 28-day DMOE of superplasticizer-concrete mix Csp25,25 was 34.52 GPa, while its MOE was 28.35 GPa.

The ratio of 7 days to 28 day dynamic modulus of elasticity was (91.9%) for reference Ch.W.T concrete mix (C25,25) and from (88.87-98.31)% for all type of superplasticizer concrete even that containing Ch.W.T this means that the rate of development in dynamic modulus of elasticity for superplasticizer concrete is very high at the first 7days.

The relationship between modulus of elasticity and the compressive strength for superplasticizer concrete mixes containing Ch.W.T concrete is show in Fig.(8). At a low compressive strength, there are no significant difference between MOE and DMOE for all type of concrete mixes. Superplastisizer-concrete mixes containing Ch.W.T. exhibited higher dynamic modulus of elasticity with an increase in the compressive strength. The relationship between strength and modulus of elasticity depends on the aggregate used, the mix proportion, age of concrete, type of concrete and the curing condition [10].

The following empirical formula can be derived to product the MOE for concrete type Cspx,y:

$$MOE = 0.445\ fcu + 13.578 \qquad R = 0.9905 \qquad (1)$$

Where:
fcu =28-day compressive strength of 100mm concrete cub, MPa

And for DMOE the suggested empirical formula for concrete type Cspx,y is:

$$DMOE = 0.637\ fcu + 12 \qquad R = 0.9895 \qquad (2)$$

The relationship between MOE and DMOE is:

$$DMOE = 1.433\ MOE - 7.416 \qquad (3)$$

Static and dynamic modulus of elasticity test results of polymer-modified concrete containing Ch.W.T. are given in Table (6) and plotted in Fig. (9), these results indicate the following:

1. It can be noticed that the MOE and DMOE of polymer modified concrete CB and reference concrete Co are generally comparable
2. The static and dynamic modulus of elasticity of polymer modified concrete containing Ch.W.T is higher compared with the corresponding concrete containing Ch.W.T without polymer at all ages of concrete specimens. This improvement in modulus of elasticity is attributed to same causes mentioned before that , which lead to improve the compressive strength of Ch.W.T. polymer modified concrete. For example the percentage increasing in MOE of CB25,25, CB20,30,and CB30,20 at 28day were 9.2%,7.3%, and 1.7% respectively relative to C25,25,C20,30, and C30,20 respectively. And for DMOE of polymer modified concrete at 90day, the percentage increasing for CB25,25, CB20,30,and CB30,20,were 6%,19.4%and 12.2% respectively relative to C25,25,C20,30,and C30,20 respectively.
3. The DMOE of all concrete mixes is higher than that MOE for example at 28days the DMOE of polymer modified mix type CB30,20,was(24.68)GPa ,while its MOE was (22.34)GPa .
4. The polymer modified concrete containing Ch.W.T have MOE and DMOE less than that of polymer modified reference concrete at all ages of concrete specimens. This can be attributed to the inclusion of Ch.W.T in the mix, since the Ch.W.T has a low modulus of elasticity.

The ratio of 7 days to 28 day dynamic modulus of elasticity was (91.9%) for reference Ch.W.T concrete mix (C25,25) and from (93.69-97.04)% for all type polymer modified concrete even that containing Ch.W.T this means that the rate of development in dynamic modulus of elasticity for polymer modified concrete is very high at the first 7days.

The relationship between modulus of elasticity and compressive strength for polymer modified concrete mixes containing Ch.W.T is show in Fig. (10).From this figure, it can be seen that the DMOE higher than MOE significantly even at a low compressive strength, this increment competition with increase of compressive strength. The relationship between strength and modulus of elasticity depends on the aggregate used, the mix proportion, age of concrete, type of concrete and the curing condition.

The following empirical formula can be derived to product the MOE for concrete type CBx,y:

$$MOE = 0.531\, fcu + 11 \qquad R = 0.9916 \qquad (4)$$

And for DMOE the suggested empirical formula for concrete type CBx,y is:

$$DMOE = 0.687\, fcu + 10.1 \qquad R = 0.9838 \qquad (5)$$

The relation ship between MOE and DMOE is:

$$DMOE = 1.294\, MOE - 4.145 \qquad (6)$$

8.3 Comparison between the effects of admixtures on properties of concrete

The test results of the effects of admixtures on compressive strength and modulus of elasticity of Ch.W.T concrete are shown in Table (1) and figures (1-10). From these results, the following points may be noticed.

1. The use of admixtures in concrete mixes with or without Ch.W.T improves the compressive strength of all types of concrete mixes. The rate of improvement was higher when the superplasticizer was used compared with SBR admixture.
2. All admixture-concrete mixes led to improve the static and dynamic modulus of elasticity for all types of concrete by various degrees, the best improvement was achieved with superplasticizer admixture.
3. At low compressive strength, there are no significant difference between MOE and DMOE for all type of superplasticizer Ch.W.T. concrete mixes. However, for polymer modified Ch.W.T. concrete mixes the DMOE higher than MOE significantly.
4. The rate of development in dynamic modulus of elasticity for both polymer modified and superplasticizer concrete are very high at the first 7 days.

9. CONCLUSIONS

Depending on the results of the investigation, the following conclusions can be drawn.

1. The compressive strength decreases significantly with the inclusion of Ch.W.T. to the concrete. The reduction of compressive strength range between (48.2% to 54.2%)
2. The compressive strength of superplasticizer concrete containing Ch.W.T. is higher than corresponding compressive strength of Ch.W.T. concrete and polymer-modified concrete containing Ch.W.T. for all mixes and ages. For example the percentage increasing in compressive strength at 28day for Csp25,25 was 52.8%relative to C25,25 and 15.7% relative to CB25,25 respectively .
3. The compressive strength increases with age for all type of Ch.W.T. admixture concrete, but the most of compressive strength values of admixture concrete with Ch.W.T. were gained at early ages. For example the ratio of 7days to28day compressive strength for C25,25, Csp25,25,and CB25,25 were 68.4%, 76.5% and 76.4% respectively.
4. The static and dynamic moduluse of elasticity of superplastizer concrete containing Ch.W.T. is higher than that of Ch.W.T. concrete and Ch.W.T. polymer modified concrete. For example the MOE of Csp20,30 was (26.86)GPa and MOE of C20,30 and CB20,30 were 21.65 GPa and 23.23 GPa respectively. And the DMOE at 28 day of Csp30,20 was (27.25)GPa comparative with DMOE of C30,20 and CB30,20 were 22.63 GPa and 24.68 GPa respectively.

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NOMENCLATURE

C0 = Reference concrete.
Cx,y = Ch.W.T. Concrete with PRR of Sand and Gravel Equal to x and y Respectively.
Cspx,y = Superplasticizer Ch.W.T. Concrete with PRR of Sand and Gravel Equal to x and y Respectively.
CBx,y = Polymer Modified Ch.W.T. Concrete with PRR of Sand and Gravel Equal to x and y Respectively.
Ch.W.T. = Chopped Worn-Out Tire.
DMOE = Dynamic Modulus of Elasticity.
MOE = Static Modulus of Elasticity.
PRR = Partial Replacement Ratio.
S.B.R. = Styrene Butadiene Rubber.

Table (1): Physical properties of cement

Physical properties	Test result	Limits of Iraqi spec. No.5/1984
Specific surface area Blaine Method, m^2/kg	379	≥ 230 m^2/kg
Setting time, Vicat's method:		
Initial setting hrs:min.	3:17	≥ 1 hour
Final setting hrs:min.	4:45	≤ 10 hours
Soundness	0.2%	≤ 0.8%
Compressive strength of mortar, N/mm^2:		
3 – day	15.8	≥ 15 N/mm^2
7 – day	27.5	≥ 23 N/mm^2

Table (2): Technical data of Superplasticizer (Melment L10)

Property	Result
Density	1.1 gm/cm^3
Solid content	20 %
Appearance	clear to slightly milky
Sugar content	none
PH value	7 – 9
Storage life	at least two year
Chloride content	less than 0.005 %
Frost resistance	it should be thawed before use

Table (3): Chemical composition of Styrene butadiene rubber (SBR).

Infra-Red (I.R) Test	pH %	Humidity	Solid particles content %
Styrene butadiene rubber with small percentage of admixtures	8.2	42.4	57.42

Table (4): Details of the experimental program

No. of Mix	Mix. Des.	w/c ratio	Admixture (%) by weight of Cement	Mix. Properties by weight	Ch.W.T Proportion % by volume		Compressive strength (MPa)at 28 day
					Sand	Gra.	
1	Co	0.5	0	1: 2: 2.5	0	0	48.8
2	Cspo	0.5	4	1: 2: 2.5	0	0	67.6
3	Cbo	0.5	15	1: 2: 2.5	0	0	53
4	C25.25	0.5	0	1: 2: 2.5	25	25	23
5	Csp25,25	0.5	4	1: 2: 2.5	25	25	35
6	CB25,25	0.5	15	1: 2: 2.5	25	25	30.8
7	C20,30	0.5	0	1: 2: 2.5	20	30	20
8	Csp20,30	0.5	4	1: 2: 2.5	20	30	29.6
9	CB20,30	0.5	15	1: 2: 2.5	20	30	24.8
10	C30,20	0.5	0	1: 2: 2.5	30	20	21.3
11	Csp30,20	0.5	4	1: 2: 2.5	30	20	28.5
12	CB30,20	0.5	15	1: 2: 2.5	30	20	22.2

Table (5): Average compressive strength results of various type of concrete.

No. of Group	No. of Mix	Mix. Desg.	Compressive strength (MPa) at age of		
			7 days	28 day	90 day
1	1	C0	28	40.5	48.8
	2	Csp	47.5	61	67.6
	3	CB	37.5	51.4	53
2	4	C25.25	14.5	21.2	23
	5	Csp25,25	24.8	32.4	35
	6	CB25,25	21.4	28	30.8
3	7	C20,30	12.8	19.5	20
	8	Csp20,30	22.4	27.5	29.6
	9	CB20,30	18.6	21.9	24.8
4	10	C30,20	13.6	20	21.3
	11	Csp30,20	21.2	26.7	28.5
	12	CB30,20	17.4	21	22.2

Table (6): Average modulus of elasticity (MOE &DMOE) results of various type of concrete.

No. of Group	No. of Mix	Mix. Desg.	Static Modulus of Elasticity(GPa) at 28 day	Dynamic Modulus of Elasticity (GPa) at age of		
				7 days	28 day	90 day
1	1	C0	38.82	41.42	44.62	47.20
	2	Csp	40.62	47.50	50.62	52.53
	3	CB	38.5	43.53	45.75	48.43
2	4	C25.25	22.76	21.83	23.75	27.46
	5	Csp25,25	28.35	30.68	34.52	38.75
	6	CB25,25	24.86	25.89	27.56	29.12
3	7	C20,30	21.65	20.96	22.19	23.23
	8	Csp20,30	26.86	28.15	29.88	33.62
	9	CB20,30	23.23	24.68	26.34	27.75
4	10	C30,20	21.96	21.34	22.63	23.91
	11	Csp30,20	24.12	26.79	27.25	30.21
	12	CB30,20	22.34	23.95	24.68	26.83

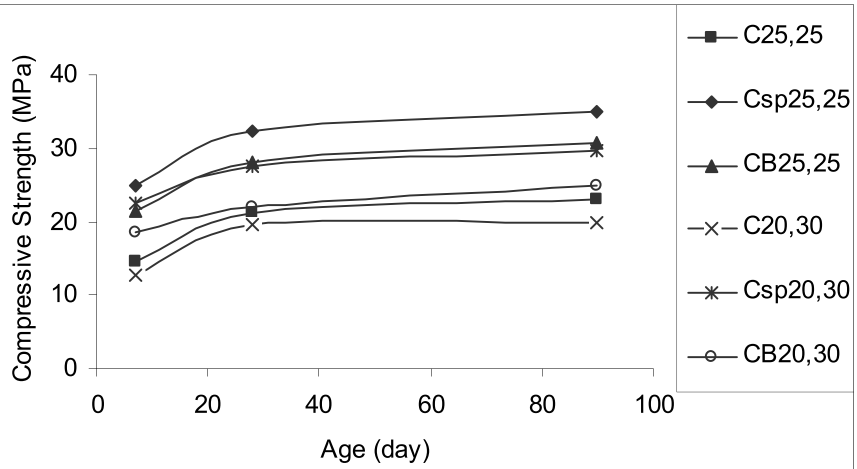

Fig.(1): Relationship between age and compressive strength for different type of concrete

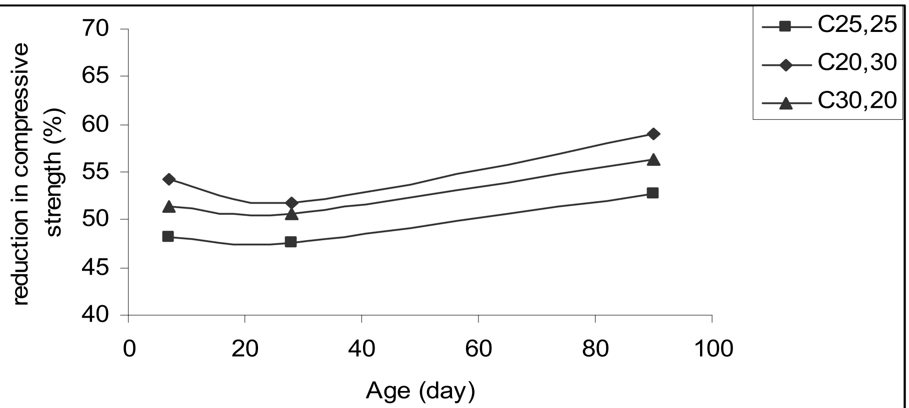

Fig.(2): Relationship between the reduction in compressive strength of Ch.W.T concrete type cx,t and age

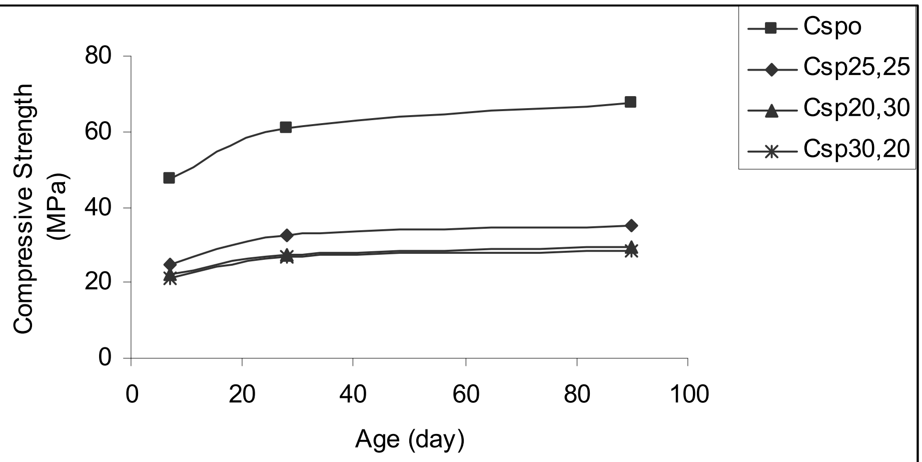

Fig.(3): Relationship between compressive strength and age for superplastesized Ch.W.T. concrete

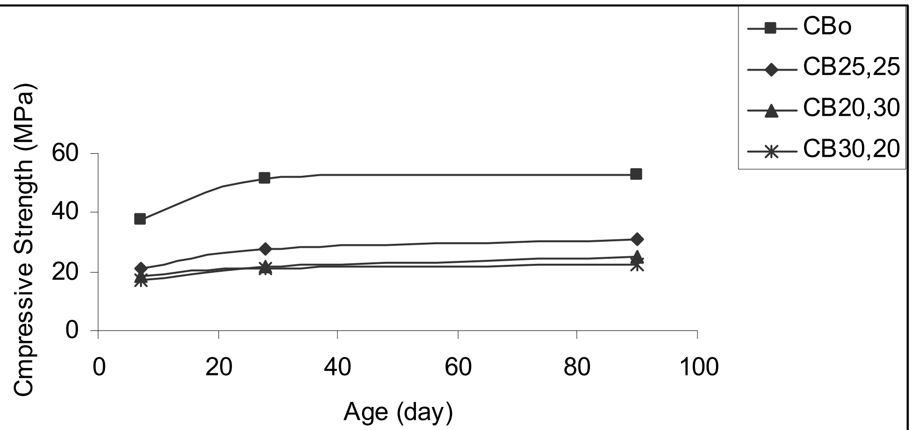

Fig.(4): Relationship between compressive strength and age of polymer modified Ch.W.T. concrete

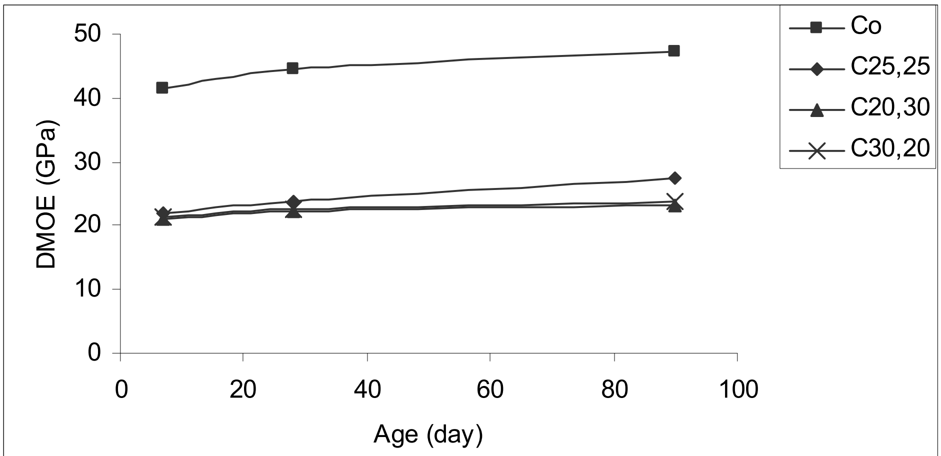

Fig.(5): Relationship between DMOE and age for Ch.W.T. concrete

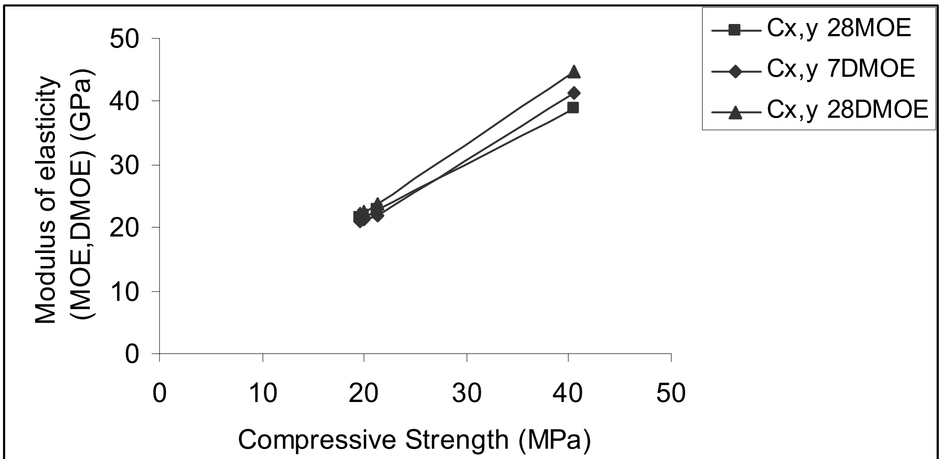

Fig. (6): Relationship between compressive strength and (MOE and DMOE) of concrete

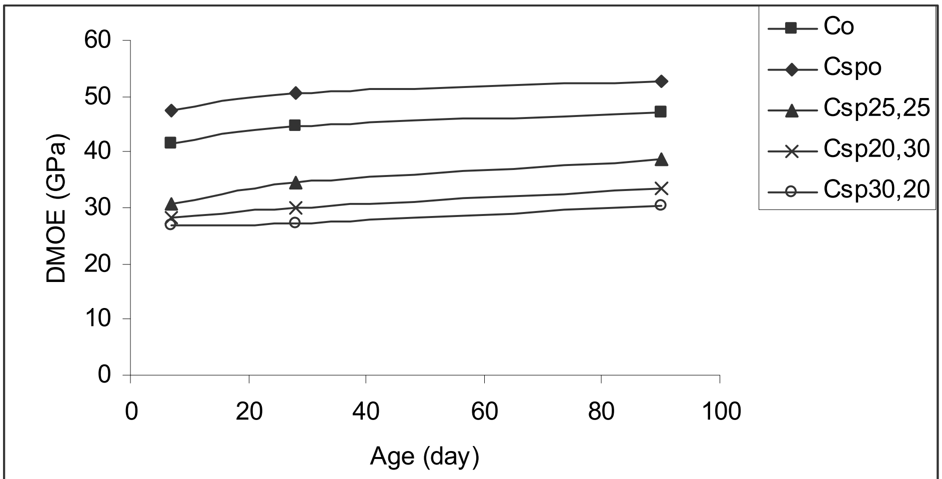

Fig.(7): Relationship between DMOE and age of superplasticizer Ch.W.T. concrete

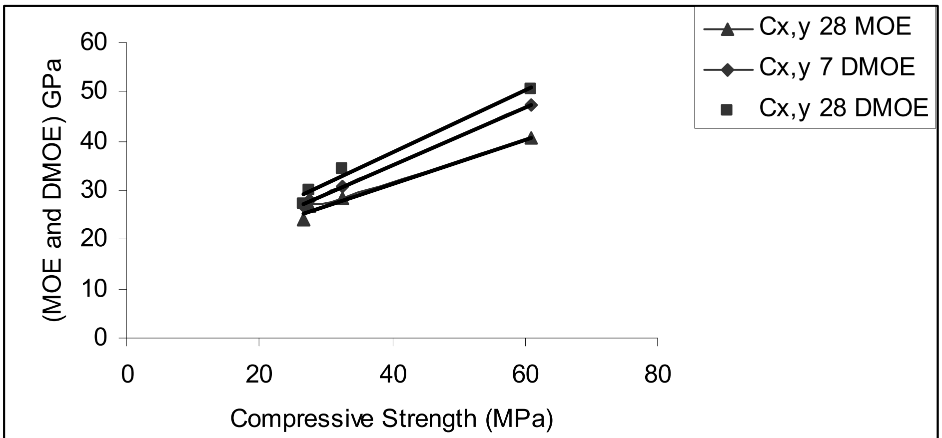

Fig.(8): Relationship between compressive strength and (MOE and DMOE) of superplasticizer Ch.W.T. concrete

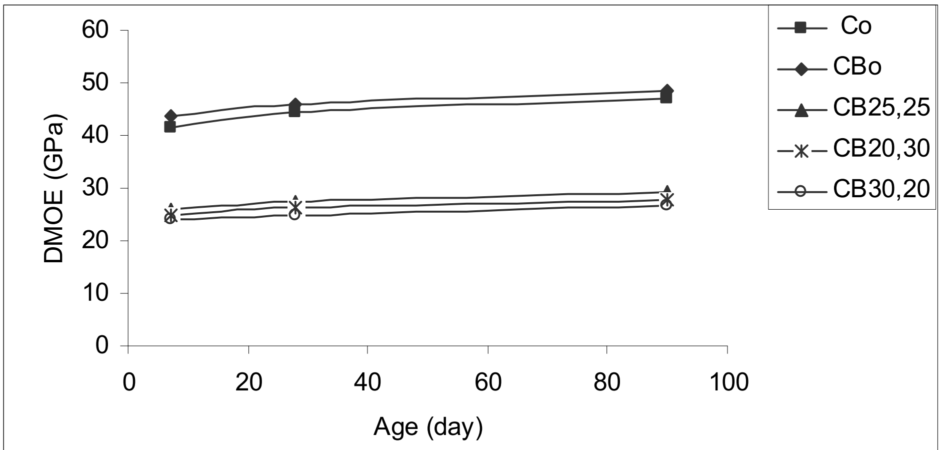

Fig.(9): Relationship between DMOE and age of polymer modified Ch.W.T. concrete

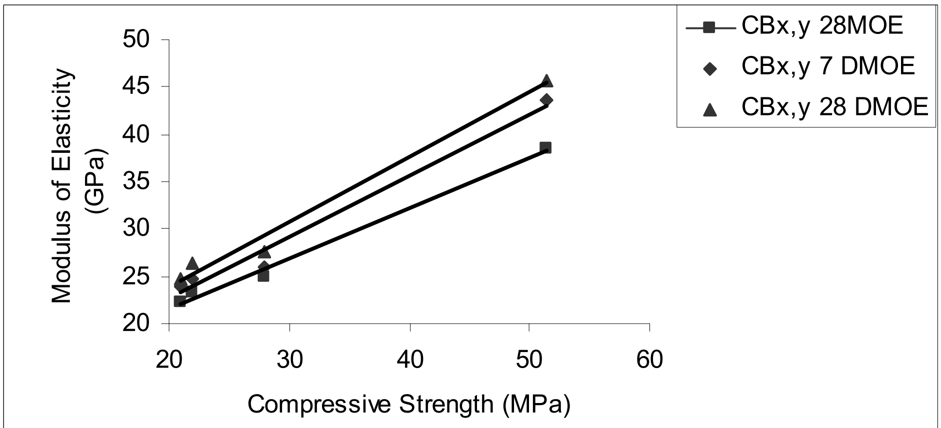

Fig.(10): Relationship between compressive strength and modulus of elasticity (MOE and DMOE) of polymer modefied Ch.W.T. concrete