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Full Length Research Paper

The effect of mineral admixture type on the modulus of elasticity of high strength concrete

Kürşat Yıldız[1*] and Latif Onur Uğur[2]

[1]Gazi University, Technical Education Faculty, Department of Construction Education, Teknikokullar, Ankara, 06500, Turkey.
[2]Ahi Evran University, Kaman Vocational Collage, Kaman,Kırşehir, 40300, Turkey.

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In this article, 2 sources was studied, rich in reserves, pumice and zeolite's effects on elasticity modulus which is an important criterion of high strength concrete (HSC), for this reason, HSC was produced by pumice and zeolite's replacement for the concrete in proportion of "0, 5, 10 and 15%" to the binder mass. Deformation controlled compressive strength tests was performed on concrete samples to determine elasticity modulus. We have formed the mathematical model equations using the stress strain data obtained from the deformation controlled compressive tests. The elasticity modulus was determined for each concrete type using the secant method on model equations graphs. The elasticity modulus was also determined using some empirical equations and the relation between 2 groups of data. As a result, there is decreasing ratio of pumice replacement with increasing quantities of zeolite in high strength concrete and effects of modulus elasticity is positive in all stages of concrete age.

Key words: High strength concrete (HSC), pumice, zeolite, modulus of elasticity, mineral admixture.

INTRODUCTION

A volcanic originate pumice is a new rock in world Industry and is becoming more and more popular and useful in time, and is used in Turkish industry for the last 20 years. The Al_2O_3 in its structure gives its strength against fire and high temperature. There are 2 kinds of pumice in nature, Acidic and alkaline. Pumice has its usage in construction sector due to its high silica component. Turkey has high reserves of pumice. There has been an estimated 3 billion m^3 in explored fields (Gündüz, 1998; S.P.O, 2000). Pumice is a natural pozzolana with a volcanic origin. Besides its pozzolanic properties, it has not got sufficient usage in cement industry. Although there are several studies to use it as a light aggregate in concrete production, there are only a few to use it as a mineral admixture. After searching the literature, we have find out limited number of studies on pumice's usage in cement as pozzolana. There is a suggestion of replacement of pumice powder for cement up to 15% to produce portland volcanic pumice cement (Khandaker, 2003). In the article, convenience of volcanic ash and volcanic pumice powder in addition to cement production is studied and they substituted for volcanic ash and volcanic pumice powder for portland cement between "0 - 50%". The research includes the fresh and hardened concrete tests. The standard tests conducted on volcanic ash and volcanic pumice powder substituted for mixtures gives more encouraging results compared to volatile ash cements and it showed good potential up to 20% replacement in terms of its high setting time and lower hydration heat in mixed portland volcanic ash cement and mixed portland volcanic pumice cement production (Hossain, 2003).

Zeolites are irreplaceable raw materials to today's industry due to its crystalline structure and chemical properties. Some of the main physical and chemical properties of zeolite minerals are ion change, adsorption and dehydration and its silica content. These properties vary for each zeolite mineral and it is a function of its skeleton structure and channel and space systems cationic composition. Some or one of these physical and chemical properties of natural zeolites is benefited in all commercial applications. Although the usage and production of natural zeolites are increasing in the world scale,

*Corresponding author. E-mail: kursaty@gazi.edu.tr. Tel.: +90 312 202 88 76. Fax: +90 312 212 00 59.

the lack of information about the size, quality and operability of the zeolite seams and its usage areas avoid utilization of the sources in Turkey. There has been approximately 50 billion tons zeolite reserves determined in Balıkesir Bigadiç (Çetinel, 1993; Mumpton, 1973).

HSC name used for chemical and mineral added concrete appeared inadequate to current researchers and considering other improvements as well, “high performance concrete” (HPC) name is preferred. Considering the production of concrete, we may not prioritize the strength at first. Endurance is a characteristic observed when in service after solidification or even much afterwards. However endurance is an important concrete characteristic which should be taken into consideration like strength and economy while producing good concrete. The concrete which can’t show the necessary endurance can not be a good one. The rule of thumb to obtain a durable concrete is to produce it with a low water/cement ratio, to use well selected strong aggregate, good workmanship during installation and application of convenient construction techniques to get dense and quality concrete, and the sufficient treatment after installation (Hilsdorf, 1995).

HSC are better in terms of its workability, compressive strength and durability whether it is unhardened or hardened. HSC are special concretes having high workability with quality aggregate, super plasticizer admixtures, low water/cement ratio and silica fume which necessitates a pozzolanic material like fly ash (Nawy, 2001; Koca, 1996). There have been many researches on HSC for the last 15 years. These studies broaden the scope of the specification and cause the design of the concrete structures which goes beyond the compressive strength class C 100 (Walraven, 1999). According to recent studies, filling space effect of the minerals is as important as pozzolanic effect and for some researchers it can be more important than the pozzolanic effect (Goldman, 1992). İt was seen that it is possible to produce high strength lightweight concrete using expanded clay aggregate, the cement content with 450 kg/m3 among concrete mixtures had the highest strength values, mechanical properties of concrete could be enhanced by using 10% fly ash, thus a saving in cement amount could be achieved (Subaşı, 2009). Concrete is defined as a 3 phase anisotropic ductile material and shows different attitudes with different loads. The deformation amount of a body obtained from an elastic material under P load is directly proportional to load applied and the length and inversely proportional to cross sectional area of the body. Concrete is not an elastic material as it is a composite one which has ductility and varied phases. Alternatively, it can show elasticity under minor tensions. In theory, this corresponds to a value equal to 30 to 40% of the compressive strength (Mehta, 1986). Nevertheless, concrete is accepted as an elastic material in engineering calculations (Erdogan, 2003 Mindess, 1981). The $\sigma-\varepsilon$ relationship which explains elasticity characteristics of the concrete can be obtained by empirical methods. Concretes heterogenic internal structure shows different characteristics under load as it contains various phases like different aggregates, cement mortar matrix, various space systems, aggregate-cement mortar interface (Shah et al., 1994). Therefore, changes in one of these quality or quantities generate diverse consequences. For instance, 2 concretes having similar compressive strength values but having different compound characte-ristics and different components can show dissimilar elasticity values.

When we analyze the previous research articles about using pumice and zeolite in cement and concrete, we come across the following.

An experimental study has been conducted on the production of moderate-strength lightweight concrete with pumice, according to the ACI standard. In this article by using the gradation curves which fall within A16–C16 curves, (Turkish Standard Code, TS706) and addition of super plasticizer and air-entraining admixtures improved the strength-to-density ratio of the hardened concrete and the workability of fresh concrete. As a result of this study, lightweight concrete blocks having a minimum compressive strength of 6.56 N/mm^2 and a density of 1300 kg/m^3 were obtained (Sarı, 2005). In an experimental study to design a structural lightweight high strength concrete made with mineral admixtures, a control lightweight concrete mixture made with lightweight basaltic-pumice containing normal portland cement as the binder was prepared. The control lightweight concrete mixture was modified by replacing 20% of the cement with fly ash and replacing 10% of the cement with silica fume one at a time. A ternary lightweight concrete mixture was also prepared modifying the control lightweight concrete by replacing 20% of cement with fly ash and 10% of cement with silica fume. 2 normal weight concrete were also prepared for comparison purpose. Laboratory test results showed that structural lightweight concrete can be produced by the use of basaltic-pumice and mineral additives (Kılıç et al., 2004). Increasing thinness of the natural zeolite powder lessens the pH of the environment. Increasing the quantity of zeolite powder decreases the alkali ions’ concentration and it prevents the formation of silicate-gel. The reasons of decreasing alkali ion concentration are: ion change, absorption and pozzolanic reactions. It is also stated that, in addition to ion change, the porosity of zeolite powder has an effect on decreasing the alkaline properties (Naiqian et al., 1998). Zeolitic mineral admixture (ZMA) is made of the finely divided powder of natural zeolite with a bit of other agent such as triethanolamine. When ZMA is used to displace about 10% (by mass) of the ordinary portland cement (OPC) (strength grade No. 525) in concrete and mixed with a suitable amount of super plasticizer (W/C = 0.31 to 0.35), then a high-strength concrete with compressive strength of about 80 MPa and a slump of about 180 mm can be obtained. The strength of this concrete is about 10 to 15%

Table 1. Properties of the aggregate.

Test type		Standard	Test report			
Organic material		TS EN 1744-1	Harmless			
Unit weight	Loose	TS 3529	2,40 g/cm^3			
	Compact		2,57 g/cm^3			
Specific gravity and water absorption ratio (TS EN 1097-6)						
Class of aggregate			0/2	2/4	4/8	8/16
Dry unit weight (g/cm^3)			2,05	1,56	1,67	2,45
Saturated unit weight (g/cm^3)			2,29	1,63	1,70	2,49
Water absorption ratio (%)			10,3	4,7	2,1	1,5

higher than that of the corresponding concrete mixed with pure OPC and its bleeding decreases greatly (Feng, 1990).

In this article, 2 sources was studied, rich in reserves, pumice and zeolite's effect on elasticity modulus which is an important criterion of HSC. For this reason we have designed 4 types of HSC with different ratios by guidance of the literature. We have performed deformation controlled compressive strength tests on concrete samples to determine elasticity modulus. Also elasticity modulus was determine using empirical equations given in national and international standards and determined the relation between 2 groups of data.

MATERIALS AND METHODS

Materials used

In this study, the following was used, 0/2 - 2/4 mm broken sand, 4/8 - 8/16 mm basaltic broken stone aggregate taken from Aegean region and CEM I 42.5 cement, pumice from Nevşehir region, zeolite from Balıkesir-Bigadiç region, Ankara city tap water, Glenium 51 type super plasticizer from Degussa construction chemical company. One type of aggregate granulemeter (TS 802, 2002) was used. The characteristics of the used aggregate types, determined the using of related standards given in Table 1. (TS EN 1744 -1, 2000; TS 3529, 1980; TS EN 1097-6, 2002).

The CEM I portland cement used as a binding material, pumice and zeolite's physical chemical and mechanical characteristics are given in Table 2.

Polycarbonic ether was use based new generation super plasticizer concrete admixture complying with TS EN 934-2 and ASTM C 494-92 type F "plasticizer concrete admixture" standards, for high ratio water reduction, concrete's stiffness loss prevention, necessity of high strength and durability TS EN 934-2, 2002; ASTM C 494-92, 1994). The technical characteristics of Glenium 51 type SAK obtained in +20°C and 50% relative humidity is given in Table 3. We have used Ankara city tap water as mix water in this research. Used water's chemical analysis and related standard limit values are given in Table 3 (TS 266, 2005).

Method

We have used the software called "HSC mixing design" in microsoft excel spreadsheet application for the HSC mixing design complying with the methods indicated in TS 802 and ACI 211,1 standards and quantities determined by means of literature research (TS 802, ACI 211.1, 1994). We have produced 4 types of concrete, according to type and quantity of the mineral admixture used as a replacement for concrete. The information for the concrete types produced is given in Table 4.

We have used 3 pieces of having 10 x 20 cm dimensions cylinder samples for each group of concrete to determine the elasticity modulus. The material quantities and fresh concrete's characteristics of the samples used is given in Table 5.

Determination of the modulus of elasticity

For the determination of elasticity modulus, deformation controlled test setup was utilized. This setup can record longitudinal, lateral deformations and applied load every second. For each test sample approximately 100 data were recorded. These data were transferred to Statistica 7.0 software. By using this software stress- strain graphs, regression graphs, mathematical models and their fitting degree were determined. For the determination of elasticity modulus secant method and parobolical model were used together. Independent variable "X" is accepted as 40% strain value in the stress strain plot. Dependent variable "Y" was calculated using the independent variable "X". Accordingly by calculating the ratio of "Y" to "X" elasticity modulus "E" was calculated. In order to get concrete compressive strength length and width deformation of the samples under the load should be determined and was measured with data logger the load, length deformation and width deformation simultaneously every second using sample comparator mechanism shown in Figure 1.

We have determined a high statistical relationship between the observed strain unit deformation data. Starting from the observed relationship, we have reached parabolic form $y = ax^2 + bx + c$ model equations between dependent tension variable and independent unit deformation data. Using the Secant method which is a method to calculate static modulus of elasticity, unit deformation value which satisfies the stress that corresponds to 40% of the maximum stress value, is obtained from the model equation. We have determined the modulus of elasticity by taking the ratio (σ/ε) of these 2 calculated values (TS 3502, 1981; Neville, 2003; ASTM C 469, 1994). Turkish standards institute (equation 1), American concrete institute (equation 2), British standards institute (equation 3), committee Euro-ınternational (equation 4), developed some empirical relations to calculate concretes elasticity modulus using concrete unit weight and compressive strength.

$$E = 14000 + 3250\sigma^{1/2} \quad (1)$$

$$E = 0.043\omega^{3/2}\,\sigma^{1/2} \quad (2)$$

Table 2. Properties of binders used for the HSC mix.

Properties		Portland cement (CEMI 42.5 R)	Pumic	Zeolite
Physical and mechanical properties				
Blaine fineness (m^2/kg)		314	474,9	290,5
Specific gravity (kg/m^3)		3.08	2,39	2,23
Setting		135	-	-
Final setting		200	-	-
Strength (kg/cm^2)	7 days	244	-	-
	28 days	424	-	-
Chemical properties		**Weight percentage, %**		
SiO_2		19.80	71,93	77,54
Al_2O3		5.61	13,14	13,25
Fe_2O_3		3.42	1,07	0,936
CaO		62.97	0,76	2,156
MgO		1.76	0,73	0,945
SO_3		2.95	0,02	0,06
Na_2O		0.47	4,10	0,05
K_2O		0.87	4,42	3,39
Loss on ignition		2.17	4,11	-
Bogue composition		**Weight percentage, %**		
C_3S		54.88	-	-
C_2S		15.88	-	-
C_3A		9.08	-	-
C_4AF		10.41	-	-

Table 3. Some properties of the super plasticizer and mix water.

Specifications of the super plasticizer admixture		
Color	Amber	
Density	1,082 - 1,142 kg/l	
Chlorine % (EN 480 - 10)	< 0,1	
Alcali % (EN 480 - 12)	< 3	
Chemical analysis of system water used		
Parameters	Average value	Limit values (TS 266)
Color	0.30	20
Blurriness	0.30	5
pH	7.35	$6.5 \leq pH \leq 9.5$
Manganese (µg/l)	0	50
Fluoride (µg/l)	0.5	1.5
Chloride (mg/l)	8.0	250
Total iron (µg/l)	<5	200
Aluminum (µg/l)	55	200
Ammonium (mg/l)	---	0.5
Nitrite (mg/l)	---	0.5
Nitrate (mg/l)	0.17	50
Oxidation (mg/lO_2)	2.2	---
Remainder chlorine (mg/l)	0.7	---

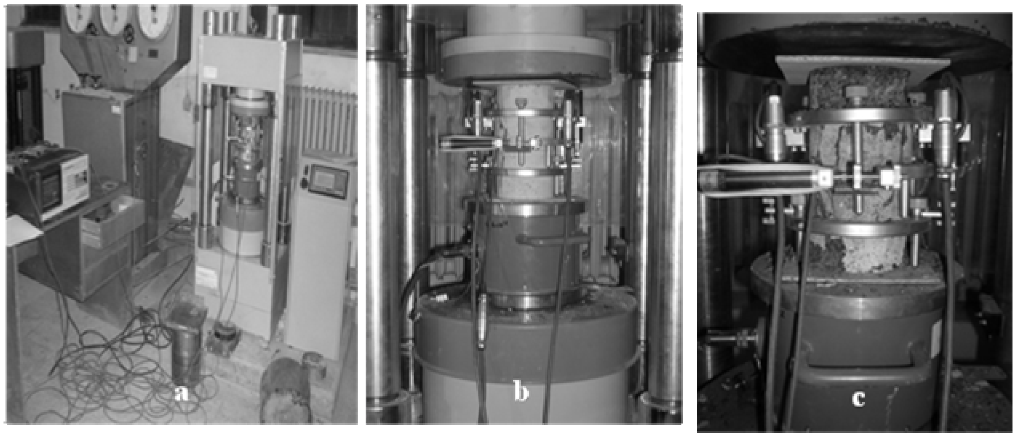

Figure 1. [a]Comparator mechanism and data logger, [b]unbroken specimen and [c]broken specimen.

Table 4. Concrete groups.

Group number	Replacement ratio (%)	Mineral admixture type	Concrete code
I.	15 0	Pumice Zeolite	15P0Z
II.	10 5	Pumice Zeolite	10P5Z
III.	5 10	Pumice Zeolite	5P10Z
IV.	0 15	Pumice Zeolite	0P15Z

$$E = 9100(\sigma)^{1/3} \quad (3)$$

$$E = 9500(\sigma + 8)^{1/3} \quad (4)$$

RESULTS

Calculated static modulus of elasticity for 4 groups of HSC produced in Table 6. In relation to Table 6, values of modulus of elasticity according to concrete's age and type are given in Figure 2.

Consistent with evaluation of empirical data with theoretical and regression model equations:

i.) 0P15Z type concrete has a decrease in modulus of elasticity with increasing concrete's age 7.5 and 2.48% respectively.
ii.) 0P15Z type concrete has a difference, between the modulus of elasticity estimates from the model equations and modulus of elasticity from the theoretical calculations, for TSE, ACI, BSI and CEP respectively of 19.2, 0.25, 6.85 and 19.51% in average on 28th day, 28.38, 9.11, 14.65% and 28.75% on 56th day, 32.57, 13.23, 18.51 and 32.89% on 90th day.
iii.) 5P10Z type concrete has a change in modulus of elasticity with increasing concrete's age 0.59% decrease and 5.76% increase respectively.
iv.) 5P10Z type concrete has a difference, between the modulus of elasticity estimates from the model equations and modulus of elasticity from the theoretical calculations, for TSE, ACI, BSI and CEP respectively 39.47, 16.90, 24.11 and 40.03% in average on 28th day, 45.08, 24.38, 28.96 and 44.48% on 56th day, 40.36, 23.12, 26.04 and 40.44% on 90th day.
v.) 10P5Z type concrete has an increase in modulus of elasticity with increasing concrete's age 2.98 and 1.53% respectively.
vi.) 10P5Z type concrete has a difference, between the modulus of elasticity estimates from the model equations and modulus of elasticity from the theoretical calculations, for TSE, ACI, BSI and CEP respectively of 41.12, 22.37, 26.28% and 41.41% in average on 28th day, 31.35, 10.27, 16.63 and 31.96% on 56th day, 31.90, 12.43%, 16.58% and 32.36% on 90th day.
vii.) 15P0Z type concrete has a change in modulus of elasticity with increasing concrete's age 1.5% decrease and 2.55% increase respectively.
viii.) 15P0Z type concrete has a difference, between the modulus of elasticity estimates from the model equations and modulus of elasticity from the theoretical calculations, for TSE, ACI, BSI and CEP respectively 34.58, 12.82, 19.34 and 35.28% in average on 28th day, 39.24, 18.34, 23.80 and 39.78% on 56th day, 38.55, 19.89, 23.74 and 38.93% on 90th day.

RESULTS AND CONCLUSION

In this study, pumice and zeolite's effects was investigated on HSC as a natural pozzolana empirically and theoretically. Nevertheless, the results acquired was compared. According to the acquired results.

If we compare 4 types of concretes used in the research, we have determined that; 0P15Z type concrete

Table 5. Material quantity in the mix for each concrete groups.

Material	Type	Specific gravity (g/cm³)	15P0Z weight (kg)	10P5Z weight (kg)	5P10Z weight (kg)	0P15Z weight (kg)	Final total (kg)
Sand	0 - 2	2,13	2,139	2,188	2,236	2,285	8,847
Sand	2 - 4	2,30	0,866	0,886	0,905	0,925	3,582
Aggregate	4 - 8	2,55	1,281	1,309	1,339	1,368	5,296
Aggregate	8 - 16	2,63	1,651	1,688	1,726	1,763	6,827
Cement	PÇ 42.5	3,08	2,751	2,671	2,591	2,511	10,523
M. admixture	Pumice	2,39	0,486	0,314	0,153	0	0,952
M. admixture	Zeolite	2,23	0	0,157	0,305	0,443	0,905
SPA	Glm. 51	1,112	0,042	0,041	0,04	0,038	0,161
Water	System Water	1	0,971	0,943	0,914	0,886	3,714
Properties of fresh concrete				15P0Z	10P5Z	5P10Z	0P15Z
Water/ cemet ratio				0.3	0.3	0.3	0.3
Slump (cm)				0.2	0.7	1.1	1.7
Theoretic results of unit weight (kg/m^3)				2163	2165	2167	2169
Experimental results of unit weight (kg/m^3)				2295	2357	2356	2293

Table 6. Modulus of elasticity values calculated with different methods of HSC.

Concrete type	Concrete age	Specimen number	Model equation $y = ax^2 + bx + c$ y: Stress (N/mm^2) x: Strain	Compressive Strength (MPa)	R^2	Elastic modulus Prediction (MPa)	Turkish Standards Institute (MPa)	American Concrete Institute (MPa)	British Standards Institute (MPa)	Committee Euro-International (MPa)
0P15Z	28	1	y = -2E+06x^2 + 27276x + 0,1178	81,4	0.996	24729	32546	27645	29060	32642
		2	y = -2E+06x^2 + 29708x + 4,5278	83,6	0.976	31934	32800	28012	29324	32881
		3	y = -2E+06x^2 + 28049x + 0,0308	87,2	0.999	25673	32800	26888	29324	32881
	56	1	y = -2E+06x^2 + 27684x - 1,9617	81,7	0,994	26855	32593	27703	29108	32686
		2	y = -920877x^2 + 26037x - 0,1573	85,3	0,999	25382	32986	28289	29518	33056
		3	y = -1E+06x^2 + 25400x - 0,2173	78,3	0,999	23918	32192	27106	28688	32308
	90	1	y = -1E+06x2 + 25575x +0,1841	77,1	0,998	24460	32057	26887	28546	32180
		2	y = -1E+06x2 + 26678x - 0,5483	84,0	0,999	24929	32847	28063	29373	32925
		3	y = -946379x2 + 26116x -0,1933	90,4	0.999	24870	33543	29138	30092	33579
5P10Z	28	1	y = -1E+06x2 + 23765x - 0,5735	76,4	0,999	21960	31969	26808	28453	32097
		2	y = -1E+06x2 + 25464x + 0,1293	78,9	0.999	24268	32269	27255	28769	32380
		3	y = -937403x2 + 23394x - 0,4096	73,4	0.99	22494	31612	26275	28075	31760
	56	1	y = -945675x2 + 23643x - 0,6962	104	0.999	21455	34967	31382	31537	34910
		2	y = -855829x2 + 23354x - 0,2987	89,4	0.999	21771	33445	29103	29991	33486
		3	y = -2E+06x2 + 28633x - 1,5317	66,0	0.995	25088	30700	24995	27098	30898
	90	1	y = -2E+06x2 + 27282x - 0,2789	88,8	0.999	24151	33371	29067	29915	33418
		2	y = -2E+06x2 + 30090x - 2,0922	86,1	0.998	25854	33079	28629	29614	33143
		3	y = -945675x2 + 23643x - 0,6962	104	0.999	22246	34967	31261	31537	34910
10P5Z	28	1	y = -1E+06x2 + 26737x - 0,3526	89,0	1.000	25071	33399	29220	29943	33443
		2	y = -2E+06x2 + 24850x + 0,6682	84,8	0,989	21239	32931	28515	29460	33004
		3	y = -2E+06x2 + 25919x - 0,0627	82,3	0,991	23828	32650	28093	29168	32740
	56	1	y = -4E+06x2 + 31335x - 3,1848	63,3	0.998	24103	30359	24642	26728	30575
		2	y = -1E+06x2 + 26532x - 0,2571	81,0	1.000	25024	32508	27879	29020	32606
		3	y = -1E+06x2 + 26462x - 0,2278	76,8	1.000	23108	32017	27139	28504	32143

Table 6. Contd.

	90	1	Y = -1E+06x2 + 28110x - 0,1919	79,5	0,999	26750	32336	27620	28840	32444
		2	y = -635959x2 + 23462x + 0,3037	78,1	1.000	22823	32173	27374	28669	32290
		3	y = -2E+06x2 + 26665x - 0,3222	78,7	0,999	23774	32240	27475	28739	32353
15P0Z	28	1	y = -1E+06x2 + 24812x - 0,5195	69,2	0.999	23183	31106	25898	27535	31282
		2	y = -1E+06x2 + 25139x - 0,1747	75,8	1.000	23771	31900	27100	28380	32032
		3	y = -1E+06x2 + 25005x - 0,1232	69,2	1.000	22971	31106	25898	27535	31282
	56	1	y = -2E+06x2 + 26832x - 0,6121	87,4	0.999	23436	33227	29072	29766	33282
		2	y = -1E+06x2 + 24156x - 0,3299	57,6	0.999	22812	29600	23588	25894	29856
		3	y = -1E+06x2 + 24760x - 0,9327	86,1	0.999	22628	33079	28849	29614	33143
	90	1	y = -2E+06x2 + 26113x - 0,1802	80,7	0.999	23201	32470	27999	28980	32570
		2	y = -2E+06x2 + 26749x - 0,646	78,2	0.999	23621	32182	27562	28678	32298
		3	y = -1E+06x2 + 25143x + 0,2203	87,4	0.999	23816	33217	29131	29756	33273

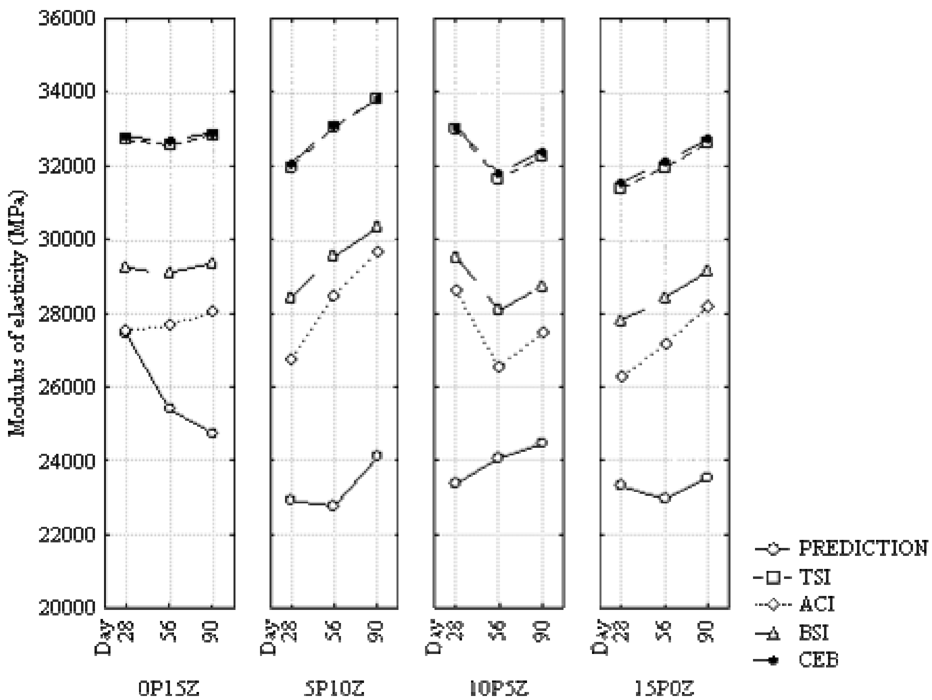

Figure 2. Modulus of elasticity values according to concrete age and concrete type.

has maximum decrease in its modulus of elasticity by increasing concrete's age, 5P10Z type concrete has maximum increase in its modulus of elasticity by increasing age, 10P5Z type concrete has similar characteristics of elasticity with 5P10Z type concrete and 10P5Z type concrete has minimum increase in their modulus of elasticity by increasing concrete's age.

For every type of concrete, the difference between the calculated average modulus of elasticity values obtained from theoretical methods and calculated average modulus of elasticity values obtained from model equations of empirical data, is increasing with the increasing concrete's age. This difference is minimal for 0P15Z type concrete and maximum for 5P10Z type concrete.

The difference between the calculated average modulus of elasticity values obtained from model equations of empirical data and the values obtained from the formula offered by ACI is observed as minimum and the difference between the modulus of elasticity values from model equations of empirical data and the values from the formula offered by TSE and CEB is found as maximum. For every type of concrete, among the theoretical formulas to calculate modulus of elasticity, TSE and CEB formulas gives similar results to each other and ACI and BSI formulas gives similar results to each other.

With increasing pumice amount in concrete, the difference between the estimated average values of elasticity modulus and calculated average elasticity modulus reaches to double.

In 4 groups of concrete types, with increasing pumice amount and decreasing zeolite amount, the average estimated modulus of elasticity values show 16.53% decrease, 2.06% increase and 0.30% decrease in 28th day, 10.29% decrease, 5.73% increase and 4.56% decrease in 56th day, 2.70% decrease, 1.51% increase and 3.69% decrease in 90th day.

Mineral admixtures with different types and ratios resulted in different elastic behavior of concrete. It is tough that this behavior is due to concrete's composite composition and binding difference between cement matrix and aggregate depending on mineral admixture type and amounts.

Increase of elastic behavior depending on time factor of different concrete types, is due to the strengthening of binds between cement and aggregate which is a result of pozzolanic properties of mineral admixtures.

If the study is analyzed, we can conclude that the increase of pumice amount in HSC, affects the modulus of elasticity - which is a very important parameter of a HSC negative in the early ages, but this negative effect decreases by passing time. We can evaluate this as the active role in concrete played by the used pozzolana's in the later stages. The increase of zeolite amount with decreasing pumice amount in HSC shows positive effect for modulus of elasticity in all ages. Nevertheless, comparing the estimated modulus of elasticity values and the empirical formulas provided by some institutions, we can conclude that the formula offered by ACI provides more parallel results. The formula offered by ACI to calculate modulus of elasticity includes compressive strength and unit weight together and this can be a reason to obtain more parallel results. The effects of pumice and zeolite's to the other properties of concrete should be investigated.

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