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The Pozzolanic Activity of Datça Earth and Perlite -Turkey

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ABSTRACT

Since ancient times one of the main problem of construction technology is cementing materials. Stone, adobe and brick walls were used to be constructed by earth, lime and gypsum. Lime has considerable importance in the invention of cement. Since then the main aim has been to invent a hydraulic cementitious material that is not soluble in water and has efficient strength. The main structure of cement which consists of calcium silicates and aluminates was tried to be achieved by mixing lime with some other materials like pozzolanic earth or fired clay. Pozzolans also play an important role when added to Portland cement because they increase the mechanical strength and durability of concrete structures.

On the other hand utilizing indigenous materials in construction seems to be a realistic approach in the sense of realizing an ecological and economical construction. Each ton of portland cement throws out into the environmental loading about one ton of CO_2 and cement clinker which is replaced by natural pozzolans has a tremendous benefit in economical cement production. In this respect, the pozzolanic activity of the Datca Earth and Perlite have been evaluated in the present work by means of a combination of mechanical, physical and chemical methods and an attempt is made to determine their contribution to the strength of lime.
Keywords: Pozzolan, earth, perlite, pozzolanic activity, strength, XRF analysis.

1. Introduction

Hydrated lime $Ca(OH)_2$ hardens temporarily by the formation of crystalline structure. When it encounters with water it again softens. The hard, insoluble $CaCO_3$ could form only by the chemical reaction between lime and dry air contains CO_2. The hardening process of $Ca(OH)_2$ is very slow because of two reasons: it has to get dry thoroughly and the diffusion of CO_2 into the material takes a long time. There are evidences that the carbonation process of the foundations of 1000 year old buildings still is not completed yet (1). The hardening process of lime- pozzolan mixtures is attributed to the formation of insoluble calcium silicate salts resulting from acid (active SiO_2)-base (lime) reaction. Puzzolans are substances of natural or artificial origin reacting with Ca^{2+} or $Ca(OH)_2$ in the presence of water, and their pozzolanic activity is defined as an index reflecting the degree of proceeding of the chemical reaction (2). This reaction is also slow but, there is no need to have a CO_2 at the medium, contrarily reaction medium needs to be wet.

Lime mixed with pozzolanic additions has been used extensively in the past as mortars for the construction of historical and traditional buildings. Mortar/plaster or concrete produced by the mixtures of lime and calcined clay supplied from ground or broken clay tiles, known as Horasan was extensively used in Roman, Selchuk and Ottoman Buildings in Turkey.

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Therefore, nowadays in the restoration interventions that take place in historic buildings, in order to assure compatibility of the restoration mortars to authentic ones, analogous materials should be used. One of the major problems of selecting the appropriate pozzolan used as a pozzolanic addition in restoration mortars is its reactivity since the use of high reactive pozzolans as an addition to lime mortars produce hydraulic, durable mortars with sufficient mechanical strength, similar to historic ones. Today, mixtures of PC (Portland cement) and pozzolan, are used in concrete, to help alleviate the energy crisis and to achieve specific technical benefits like: lower permeability, reduced heat of hydration, reduced alkali-aggregate expansion, reduced concrete drying shrinkage, higher strengths at later ages, and increased resistance to attack from sulfates in seawater or from other sources (3) (4) (5) (6).

When a mixture of PC and pozzolan reacts, the pozzolanic reaction progresses like an acid-base reaction of lime and alkalies with oxides (SiO_2+$Al2O_3$+Fe_2O_3) of the pozzolan. Two things happen: first, there is a gradual decrease in the amount of free calcium hydroxide ($Ca(OH)_2$) with time, and second, there is an increasing formation of CSH and calcium aluminosilicates that are similar to the products of hydration of PC. The end result will be that the paste will contain less $Ca(OH)_2$ and more CSH and other products of low porosity. The properties of natural pozzolans vary considerably depending on their origin. This is caused by:

- The variable proportions of the active minerals and
- The mineralogical and physical characteristics

Most natural pozzolans contain substantial amounts of constituents other than silica, such as alumina and iron oxide, and alkalies, which will also react with calcium hydroxide and alkalies (sodium and potasium) to form more complex compounds. But the molecular structure of the silica is very important as well as the amount present in determining pozzolanic activity (7).

A good pozzolan should possess a sufficient amount of reactivity that is expressed as ‘pozzolanic rectivity’. The origin of pozzolanic reactivity lies in the high content of reactive silica in pozzolans. The reactivity of silicate minerals in saturated calcium hydroxide solution having pH=12.6 increases with the degree of disorder in their cristalline structure. So, the nature and the amounts of siliceous and aluminous materials in pozzolans have important effects on their pozzolanic activities. Pozzolans can include combinations of various silicate minerals such as quartz, feldspar, mica, hornblend, pyroxene, zeolite, cristobalite, clay minerals, amorphous pumice, and glass shards. In general, a good pozzolanic tuff has low quantities of clay minerals, low quantities of alkali faldspar, high quantities of zeolite minerals, and volcanic glass. In addition, it should exhibit high porosity and specific surface area.

There is no clear line of seperation between silicious materials that are considered as pozzolans and those that are not. Generally, amorphous silica reacts with calcium hydroxide and alkalies more rapidly than the does silica in the crystalline form (quartz). As is the case with all solid state chemical reactions, the larger the particles (the lower the surface area) the less rapid the rate of reaction. Thus, the chemical composition of a pozzolan does not clearly determine its ability to combine with calcium hyroxides and alkalies. Research on the hydration of blended cements made with natural pozzolans of volcanic origin, has confirmed that rather than the chemical manifestation, the physical manifestation of the pozzolanic reaction that involves pore refinement of the cement paste is probably more important for the enhancement of chemical durability and mechanical strength (8). The shape, fineness, particle size distribution, density and composition of natural pozzolan particles influence the

properties of freshly mixed unhardened concrete, and the strength development of hardened concrete (3).

Volcanic glasses and zeolitic tuffs, when mixed with lime, produce calcium silicate hydrates (CSH) as well as hydrated calcium aluminates and calcium aluminasilicates. These materials were proved to be good pozzolans long ago. Clays and shales are not pozzolanic or only weakly so, since clay minerals do not readily react with lime unless their crystalline structure is destroyed by heat. Mehta, classifes natural pozzolans in four categories on the basis of the principle lime-reactive constituent present: 1. unaltered volcanic glass; 2. volcanic tuff; 3. calcined clay or shale; 4. raw or calcined opaline silica. This classification is not readily applicable to pozzolans of volcanic origin (categories of 1 and 2) because volcanic tuffs commonly include unaltered siliceous glass. This is the sole or main source of pozzolanic activity in siliceous glass, opal, zeolites, or clay minerals, the activity of the last two being enhanced by calcinations (3).

The efficacy of the pozzolanic reactivity of the natural pozzolans is determined by physical, chemical and combined methods tested on the pozzolan-cement/lime compositions:

- $Ca(OH)_2$ **consumption rate (pozzolanic reaction rate) as measured by reduction in free** $Ca(OH)_2$ (5). This can be determined by chemical hydraulic activity method (to investigate the coefficient of pozzolanic activity from the quantity of $Ca(OH)_2$ in mg, consumed by 1 g of admixture for a specified time) (2), by thermogravimetric analysis (based upon the mass loss due to the dehydration of $Ca(OH)_2$ (5) or by simultaneous differential thermal and thermogravimetric analysis (DTA/TG) (to investigate the rate of $Ca(OH)_2$ consumption in time and the relative weight loss amount measured by TG to determine the pozzolanic reaction products) (9)
- **Strength development (so-called Breakdown-method) to assess the admixture contribution to the strength of cement stone.**
- Petrographical analysis by means of optical microscopy, X-ray powder diffraction (XRD), scanning electron microscope equipped with an energy dispersive X-ray system (SEM-EDX) and spectroscopic techniques are useful for the evaluation of the suitability of tuffs in pozzolanic cements. They are fast and easily accessible techniques to reveal the petrographical, mineralogical, and textural characteristics that may have important control on the technical behavior of pozzolanic cements (10).

There is no direct relationship between strength and degree of chemical reaction completion in cement stone. The mechanical strength and the structural investigations should therefore supplement the chemical methods for pozzolanic activity assessment (2). In a research done to investigate pozzolanic activity of natural and artificial pozzolan used for preparation of restoration mortars, it is concluded that, the DTA/TG results should be correlated with mechanical strength and X-ray diffraction data at time of 1, 3 and 6 months in order to investigate the correlation among rate of $Ca(OH)_2$ consumption, mechanical parameters, and the formation of pozzolanic reaction products (9).

There are several techniques to improve the pozzolanic reactivity of natural pozzolans: Calcination, acid treatment, thermal activation (elevated temperature curing of lime-pozzolan pastes), mechanical activation (prolonged grinding of natural pozzolans with the effect pore structure, particle shape, particle size, paricle size distribution) (11) (8) (12) and chemical activation (use of chemical treatments based on the weight of lime-pozzolan blend) (5) (13) On the other hand lime content and lime type mixed with the pozzolan also shows a

significant effect on the strength development and pozzolanic reaction rate. The increase of lime content over a critical value results in an increase in water requirement and initial porosity. At the same time the remaining unreacted $Ca(OH)_2$ weakens the hardened paste. The replacement of hydrated lime with CaO results in a faster strength gain and a higher pozzolanic activity at early ages due to the heat liberation from the hydration of quicklime and to the lower initial porosity of CaO pastes (14).

The purpose of this study is to explore if the Earth of Datça and Perlite have pozzolanic reactivity or not by examining the chemical structure, strength development (pozzolanic reaction rate) and the hydration products of the mortar produced.

2. Materials and Methods

2.1 Raw Materials

2.1.1 Lime

Typical commercial type quicklime was used as a testing lime for the evaluation of the pozzolanic reactivity of the earth of Datça (ED) and perlite (PE). Its chemical composition as supplied from its producer is given in Table 1. Quicklime was slaked to obtain hydrated $Ca(OH)_2$ and stored in the moist state by covering it for minimum15 days until used. It was sieved from 600 μm (no.30) sieve in order to remove unslaked particles if any.

2.1.2 Earth of Datça

The earth which tested was derived from Datça-located in South-West of Turkey. The material is called as Horasan in the area, the name of the lime-calcined clay mixtures which was extensively used in the historical buildings in Turkey. It is widely utilised by the villagers as a cementing material in load bearing walls as well as a plastering material. The material is extracted from the deposit by open pit mining without the use of explosives to maintain the integrity of the original granular shape (Fig. 2).

Figure1. Earth of Datca quarry.

2.1.3 Perlite

Crushed and screened perlite which is produced from raw perlite by reducing its particle size was obtained from Eti Mine Works General Management, the state owned mining

establishment in Turkey. It was produced in particle size given as follows: 0-0.6 mm, 0.6-1.2 mm, 1.2-2.5 mm. Perlite is hydrated volcanic glass, generally of rhyolitic composition. Petrologically, it is defined as a glassy rhyolite that has a pearly luster and concentric, onionskin parting. In its naturally occuring form, it contains 2-5% combined water. What sets perlite of commercial significance from other volcanic glasses is the fact that under the proper conditions of preparation-crushing and sizing-it will, when rapidly introduced into a flame of sufficient temperature (800-1200 °C), expand or 'pop' (15). Turkey has perlite resources exceeding 4000 m.tonnes, representing some 60% of world resources estimated at 6600 m. tonnes. Turkey is the second largest source of perlite in Europe. Historically, perlite was known as glass sand and used locally in lime and cement mortars. In some areas it is still used in this way (16).

The chemical analysis and some physical properties of the lime, Earth of Datça (ED) and perlite (PE) used for the paste preparation are listed in Table 1.

2.1.4 Preparation of Specimens

Four seperate pastes were prepared by mixing commercial lime, standard sand (TS 819) (17) with two types of volcanic glass: Earth of Datça (ED) and Perlite (PE). All of them were prepared according to the TS 25 (18). Only the water/binder ratios of the first two pastes (one for ED and one for PE) and second two pastes (one for ED and one for PE) were different where 15.46% for the first two groups (Batch 1) and 18.33% for the second two groups (Batch 2). All the materials tested as pozzolans present a cumulative passing percentage at 90 micron of 100%. The mixing procedure was the same for all pastes: first, the amount of hydrated lime was mixed with the total amount of sand, it was stirred for 3 min in a mixer and afterwards the amount of pozzolan was added gradually in the paste and it was stirred for other 20 min. The pastes were casted in moulds 40x40x160 mm.and coded as EDT for the specimens produced from Earth of Datça and PET for the specimens produced from perlite respectively. 3 specimens were produced for testing each characteristic. The pastes were investigated regarding their pozzolanic reaction at time of 7 and 14 days and, curing at 55 °C and 70 °C using strength development tests and XRF and XRD analysis. The specific density of all the pozzolans were also tested and given in Table 1.

2.2 Experimental Techniques

2.2.1 XRF and XRD Analysis of the materials

Semi quantitative element analysis on the pozzolanic samples (ED and PE) and the specimens produced from these samples (EDT and PET) according to the TS 25 were done by Philips PW-2404 model XRF (X-ray Fluoresant spectometer) equipment. The results of the tests were given in Table 1. Qualitative phase (minerological) analysis of all four samples were carried out on a Shimadzu XRD-6000 equipment using Cu X-ray tube (=1.5405 Angstrom). X-ray diffraction (XRD) analysis indicated the hydration products in lime-natural pozzolan pastes. Hydration products were identified with the help of the characteristic peak database from the Powder Diffraction File of the Joint Committee on Powder Diffraction Standards (13).

2.2.2. Blaine air permeability surface area

Blaine air permeability surface area measurement as per Turkish Standard TS 24 (19) was used to measure the fineness of the ED and PE. The principle of the Blaine air permeability measurement is based on the measurement of air when it flows through a given thickness of powder. The smaller the particle size of the powder, the narrower the space between the

particles and the higher the resistance to air: thus, it takes a longer time for air to pass through a layer of fine powder. According to TS 24, the specific surface area can be calculated by

Table 1. Chemical composition of lime and other mineral admixtures and specimens after 7 days.

Oxides Percentage by mass(%)	**CaO**	**Natural Pozzolan (ED)**	**7 days (specimen with EDT)**	**Perlite (PE)**	**7 days (specimen with PET)**
SiO_2	1	75.289	58.934	75.559	61.007
Al_20_3	0.5	15.991	11.510	15.678	10.873
Fe_2O_3	(R_2O_3	0.984	0.829	0.697	0.638
Na_2O	-	2.211	1.361	2.090	1.174
K_2O	-	3.026	2.408	4.217	3.001
CaO	85	1.222	21.377	0.758	20.388
CO_2	5	-	-	-	-
MgO	1.5	0.772	2.870	0.312	2.375
P_2O_5	-	0.072	0.077	0.063	
TiO_2	-	0.149	0.148	0.101	0.096
MnO_2	-	0.047	0.050	0.067	0.050
Cr_2O_3	-	0.005	-	-	-
NiO	-	0.004	0.005	-	-
CuO	-	0.002	-	-	-
ZnO	2.23	0.002	0.006	0.004	0.005
Rb	-	0.006	0.007	0.015	0.010
SrO	-	0.015	0.019	0.011	0.014
V_2O_5		-	0.022	-	-
Y_2O_3	-	0.002	0.006	0.006	0.004
ZrO_2	-	0.010	0.015	0.011	0.010
Nb_2O_5	-	0.001	0.008	0.002	-
BaO	-	0.097	0.075	0.153	0.095
Cl	-	0.092	0.078	0.170	0.073
SO_3	0.8	-	0.194	0.076	0.182
PbO	-	-	-	0.009	0.004
ThO_2	-	-	-	0.002	-
Total	93.8	100.00		100.00	
Specific density (gr/cm³)	2.23	2.44		2.36	
Specific surface area,cm²/gr	-	5044.12		3474.71	

$$\mathbf{S} = \frac{S_s\, d_s\, (1-e_s)\, \sqrt{e^3}\, \sqrt{t}}{d\,(1-e)\, \sqrt{e_s^3}\, \sqrt{t_s}}$$

where S=specific surface area of the test material (cm^2/g); S_s= specific surface area of the standard cement used in callibration of the apparatus (3774 cm^2/g); e_s= porosity of a prepared bed of standard cement (0.5); e= porosity of a prepared bed of test material (0.5); t_s: measured time interval of manometer drop for standard cement (sn); t: measured time interval of manometer drop for test material (sn); d_s=density of standard cement (3.15 gr/cm^3); d=density of the test material (gr/cm^3). The ambient temperature is 22 °C with the 45% relative humidity. The test materials were sieved from 211 μm (no.72) sieve as directed by the standard.

2.2.3. Pozzolanic Reactivity

The pozzolanic activity, the behavior of pozzolan mortar, was determined according to the Turkish Standard (TS 25). According to the TS 25, at least three mortar specimens were

prepared by mixing slaked lime, standard sand and pozzolan (tuff) having the weights shown in Table 2. Immedietly after molding, the mortar specimens were covered to prevent evaporation and cured in moist environment (at T=23±2 °C and RH= 90%) for 24 h. Then, they were cured at 55±2 °C, to increase the role of reaction, in an oven for 6 days. After removing from the oven and cooling at desicators for 4 h, the specimens were tested for their 7th day flexural and compressive strengths according to the TS 24 by the Rilem-Cembureu Method. A 200 kN press was used in the test with a loading rate of 0.9 kN/s. Before testing smooth metal sheets were placed on the bottom and top of the specimens during the test to minimize the end effects.

Table 2 Proportions of the ingredients of mortar specimens according to TS 25

Material	**Weight (in gram)**
Slaked lime Ca(OH) 2	150
Pozzolan	2x150x*N*=*T*
Standard Sand (TS 819)	1350
Water	0.5x(150+*T*)
N=factor obtained by dividing density of tuff by the density of lime.	

2.3 Experimental Results and Discussion

2.3.1 Chemical and petrograhic analysis of the materials

The results of the chemical analysis are compared with the chemical requirements in TS 25. The amounts of SiO_2+$Al2O_3$+Fe_2O_3 that play an important role in the occurance of pozzolanic reactions are ≥ 70 %. They also fulfill the chemical limitations for MgO, SO_3. So, the materials tested for pozzolanic activity fit well with the chemical requirements prescribed in Table 3.

Various types of mineral crystals was detected in XRD patterns (Figure 2) . A compound in the amorphous structure was determined in the entire samples which could be Si.

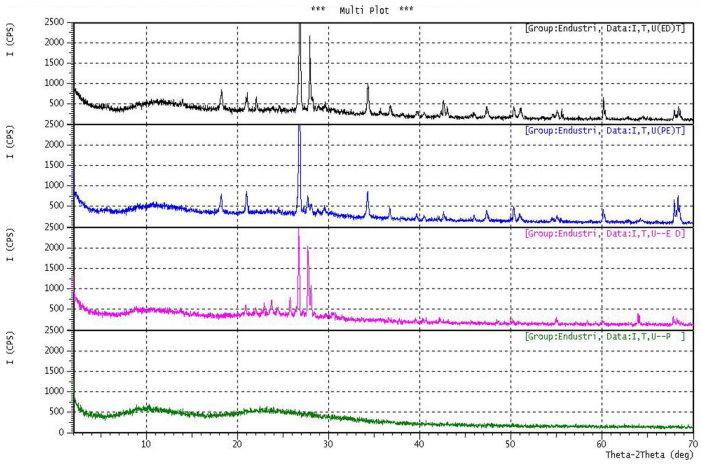

Figure 2. The results of the XRD analysis. They are overlaid in the order from the top to below: EDT, PET, and ED, PE.

In the pozzolan samples the detected compounds are: PE: it is totally in amorphous structure, there is no any crystal formation; ED: quartz, feldspar, cristobalite in low quantities. In the mortars produced from these pozzolans the detected compounds are; EDT: quartz, feldspar, cristobalite, portlandid; PET: quartz, feldspar and portlandid. In PET results it is observed that after the material was produced according to the TS 25, new crystals was started to form. The

$Ca(OH)_2$ consumption that takes place in lime-pozzolan pastes could be a reliable factor for the evaluation of the pozzolan reactivity and the detection of the pozzolanic products. Therefore although the results of the strength development cured at 7 days comply with the TS 25, XRD analysis should also be carried out on the specimens cured at periodic time intervals like 14, 28, 90 days in order to gain sufficient results.

2.3.2 Blaine fineness

The test data of Blaine are listed in Table 3. The specific surface areas of the pozzolan dusts are found 5044.12 cm^2/gr for ED and 3474.71cm^2/gr for perlite repectively. The specific surface area of ASTM Type I cement is 3830 m^2/gr. The specific surface area of the pozzolans are more than satisfactory since they are greater than 3000 cm^2/gr required according to the TS 25.

2.3.3 Pozzolanic activity of Pozzolans

The results of the pozzolanic activities of 3 test specimens both for EDT and PET series are shown in Table 3 and Figure 3.

Table 3.TS 25 standard requirements and test results.

TS 25 standard requirements	**SiO_2+ $Al2O_3$+ Fe_2O_3 (%)**	**MgO (%)**	**SO_3 (%)**	**Blaine surface area of the pozzolan cm^2/gr**	**7th day flexural strength (MPa)**	**14th day flexural strength (MPa)**	**7th day comp. strength (MPa)**	**14th day comp. strength (MPa)**
	≥ 70	≤ 5	≤ 3	≥3000	≥ 1	-	≥ 4	-
EDT	92.264	0.772	0	5044.12	1.20	1.07	8.10	8.04
PET	91.934	0.312	0.076	3474.71	1.27	1.03	7.49	7.50

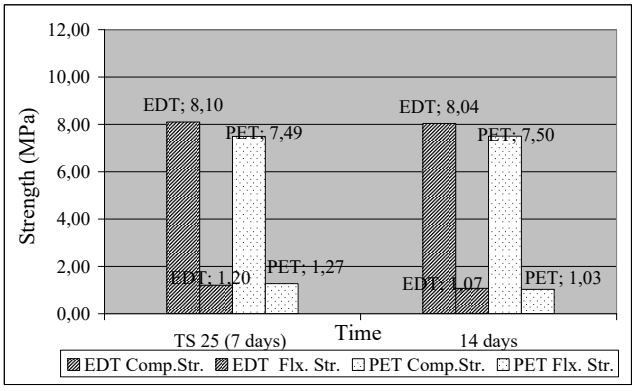

Figure 3.Relationship between Strength Developments of the Mortars with Time (Batch 1) Water/Binder Ratio: 15.46%

Flexural strength was found 1.20 MPa for EDT and 1.27 MPa for PET, while their compressive strengths were 8.10 MPa for EDT and 7.49 MPa for PET respectively. These values fulfill the mechanical requirements of the standard as given in Table 3. 3 specimens were left at room temperature for one more week in order to investigate the curing effect of time on pozzolanic reactivity. After 14 days of curing (7 days at 55 °C+7 days at 23°C and RH= 90%) there is a slight change in compressive strengths of the both samples where EDT samples decrease by 0.75% and PET samples increase by 0.09%. But flexural strengths of both types of the samples decrease by 10.85% for EDT and 18.93% for PET respectively. After the flexural strength tests applied on the specimens cured at 7 and 14 days, it was

observed from the section of the specimens that there was still some moisture in their body which may affect their strength. Hence, it can be said that additional 7 days curing at room temperature is not enough to achieve adequate strength development.

The water/binder ratio of the first two groups of mixtures (Batch 1) was found as 15.46% according to the TS 25. Since the workability of the Batch 1 was observed as low, another batch (Batch 2) was prepared which has a water/binder ratio of 18.33%. The above tests were repeated and besides, 3 specimens were tested seperately after they were cured at 70 °C for 1 week in order to compare the temperature effect on the strength development. The entire mechanical test results of the samples produced from Batch 2 is given in Table 4 and Fig. 4, 5, 6 and 7.

Table 4. Batch 2 test results. (Water/Binder Ratio is 18.33%)

Sample Name (Batch 2)	**Compressive Strength (MPa)**			**Flexural Strength (MPa)**		
	7 days (TS 25)	**14 days**	**70 °C**	**7 days (TS 25)**	**14 days**	**70 °C**
EDT	7,28	8,86	8,03	1,32	1,20	1,01
PET	10,09	9,40	10,14	2,14	1,06	2,04

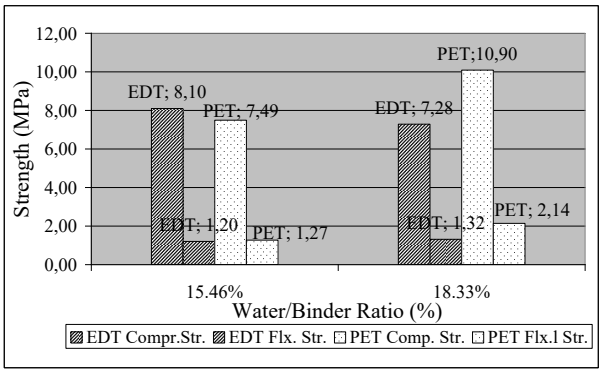

Figure 4. Relationship between the Strength Developments of the Mortars with Water/Binder Ratio at 7 days

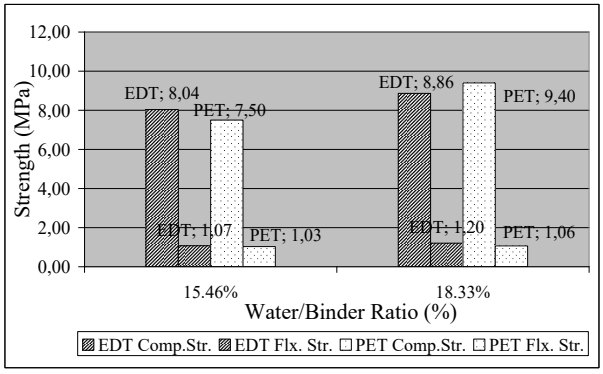

Figure 5. Relationship between the Strength Developments of the Mortars with Water/Binder Ratio at 14 days

The effect of the water/cement ratio on the mechanical tests after 7 and 14 days is seen in Fig. 2 and 3. The test results of both EDT and PET specimens having 18.33% water/binder ratio are greater than the results of the specimens having 15.46% water/binder ratio, except the 7 days compressive strength of EDT. It decreases from 8.10 MPa to 7.28 MPa, which indicates approximately 10.03% strength loss. The amount of water is an important parameter especially for the PET specimens. The compressive strengths of PET specimens increase by 34.68% after 7days and 25.36% after 14 days curing. The relevant results were achieved also for flexural strengths.

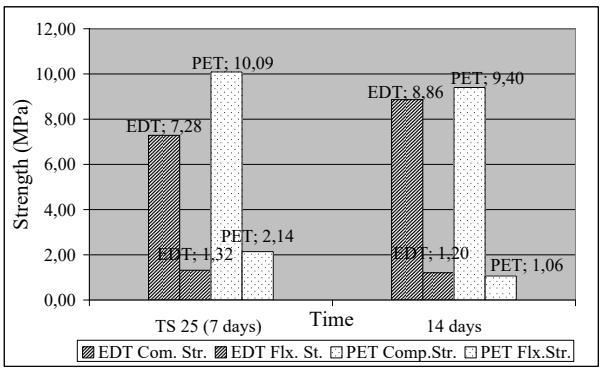

Figure 6. Strength Development of the Mortars by Time (Batch 2)
Water/Binder Ratio: 18.33%

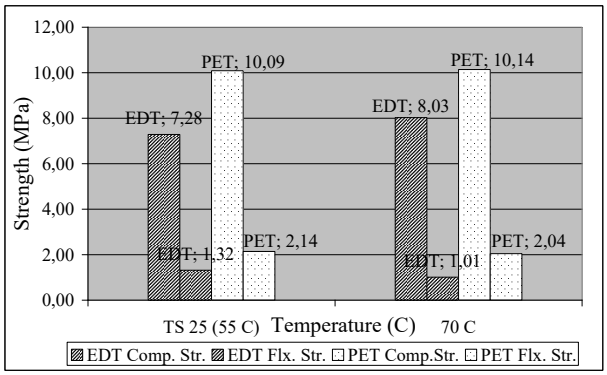

Figure 7. Strength Development of the Mortars by Temperature (Batch 2)
Water/Binder Ratio: 18.33%

The effect of the curing time on the specimens prepared with 18.33% water is almost same with the results obtained from the Batch-1 having %15.46 water/binder ratio. The compressive strength of EDT series increased approximately 21.67% after they were cured 14 days, while the PET series decreased approximately 6.82%. The flexural strength of PET series has the same trend and decreases 50.26% after curing. Although there is an increase in compressive strength, it's flexural strength decreases 8.48%. This can indicate the fragile structure of their body. The same trend is also seen in the results cured at 70 °C. Although the compressive strengths of both EDT and PET series increase by 10.17% and 0.50% respectively, their flexural strengths decrease by 23.21% and 4.46%. But, it can be expressed that curing at 70 °C has an affirmative effect on the strength development of both types of pozzolans.

CONCLUSION

- The chemical compositions of pozzolans conform well to the requirements of the Turkish Standard TS 25, and SiO2+Al2O3 + total Fe2O3 exceeds 70%. Pozzolanic activities of EDT and PET were determined according to their 7th day flexural and compressive strengths and vary between 1.20 and 1.27 MPa and 8.10 and 7.49 MPa, respectively. These values fulfill the mechanical requirements of the standard.
- XRD analysis determined a compound in the amorphous structure in the entire samples which could be Si.
- The specific surface area of the pozzolans are more than satisfactory since they are greater than 3000 cm^2/gr required according to the TS 25.
- Additional 7 days curing at room temperature is not enough to achieve adequate strength development for both of the specimen types.
- The water/binder ratio is an important parameter especially for the PET specimens.
- Prismatic mortar strength results indicated that curing temperature has a greater influence on the pozzolans tested than that the applied curing time.

This is a preliminary study in order to identify the pozzolanic reactivity of Earth of Datca and Perlite. Various physicochemical characteristics influence pozzolan reactivity such as: the glassy compounds content, the total and active silica content, the grain size distribution, the specific surface area. However, these factors are only indicators of the pozzolanic reactivity and they could not assure that the lime-pozzolan mortar produced would present the best potential behavior. Therefore although the results of the strength development comply with

the TS 25, more detailed research under the mentioned curing conditions should also be carried out in order to gain sufficient results.

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References
(1) Akman, S., Güner, A., 'Historical and Technical Characteristics of Horasan Mortar and Concrete', II. International Congress of Turkish-Islamic Science and Technology History, ITU, 28 April-2 May 1986, 1-18 (In Turkish).

(2) Lilkov, V., Stoitchkov, V., 'Effect of the 'Pozzolit' Active Mineral Admixture on the Properties of Cement Mortars and Concretes, Part 2: Pozzolanic Activity', Cement and Concrete Research, Vol.26, No. 7, pp.1073-1081.

(3)ACI Committee 232 Report, 'Proposed Report: Use of Natural Pozzolans in Concrete, ACI Materials Journal, July-August 1994, 410-428.

(4) Low-cost Cements, IT, (Intermediate Technology Development Group Ltd. Company Reg. No. 871954, England. Reg.Charity No. 247257.

(5) Shi, C, Day, R.L., Comparison of different methods for enhancing reactivity of pozzolans', Cement and Concrete Research, 31 (2001), 813-818.

(6) Turanlı, L., Uzal, B.,Bektaş, F., Effect of material characteristics on the properties of blended cements containing high volumes of natural pozzolans, Cement and Concrete Research, 34,(2004) 2277-2282.

(7) Davraz, M., Gunduz, L., 'Engineering properties of Amorphous Silica as a new Natural Pozzolan for use in Concrete', Cement and Concrete Research, 35, 2005, 1251-1261.

(8) Mehta, P. K. 'Role of Flyash in Sustainable Development', Concrete, Flyash, and the Environment-Proceedings (A Forum held 8 December 1998-Sponsored by EHDD Architecture and Pacific Energy Center), Environmental Building News: http:// www.ebuild.com/Archives/Features/Flyash /mehta.html.

(9) Moropoulou, A., Bakolas, A, Aggelakopoulou, E., 'Evaluation of pozzolanic activity of natural and artificial pozzolans by thermal analysis', Thermochimica Acta, 420(2004)135-140.

(10) Türkmenoğlu, A.G., Tankut, A., 'Use of Tuffs from Central Turkey as admixture in Pozzolanic Cements Assessment of their Petrographical Properties', Cement and Concrete Research, 32(2002)629-637.

(11) Isaia, G.C., 'Physical and Pozzolanic Action of mineral additions on the mechanical strength of high performance concrete', Cement and Concrete Composites, 25 (2003) 69-76.

(12) Shi, C., Wu, Y., Riefler, C., Wang, H., 'Characteristics and Pozzolanic Reactivity of Glass Powders, Cement and Concrete Research, 35, 2005, 987-993.

(13) Shi, C., Day, R.L., 'Pozzolanic Reaction in the Presence of Chemical Activators Part II: Reaction Products and Mechanism, Cement and Concrete Research, 30 (2000) 607-613.

(14) Shi, C., Studies on Several Factors Affecting Hydration and Properties of Lime-Pozzolan Cements, Journal of Materials in Civil Engineering, November/December, 2001, 441, 445.

(15) Kadey, F.L.'Perlite', Industrial Minerals and Rocks, Volume 2, 5th Edition, Ed. Lefond, S.J., American Inst. of Mining Metallurgical and Petroleum Engineers, Inc. Printed in USA, Port City Press, Baltimore, Maryland, 1983, pp. 997-1015.

(16) Özgür, Y., An Industry Review-Turkish Perlite, Industrial Minerals, June 1997, pp.73-75.

(17) (TS 819), Rilem-Cembureau Standard Sand, 1988.

(18) TS 25, Trass, UDK 666.95, Turkish Standards Institute, Ankara, Turkey, 1975.

(19) TS 24, Physical and Mechanical Testing Methods of Cement, UDK