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Producing New Composite Materials by Using Tragacanth and Waste Ash

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Abstract—In present study, two kinds of thermal power plant ashes; one the fly ash and the other waste ash are mixed with adhesive tragacanth and cement to produce new composite materials. 48 new samples are produced by varying the percentages of the fly ash, waste ash, cement and tragacanth. The new samples are subjected to some tests to find out their properties such as thermal conductivity, compressive strength, tensile strength and sucking capability of water. It is found that; the thermal conductivity decreases with increasing amount of tragacanth in the mixture. The compressive, tensile strength increases when the rate of tragacanth is up to 1%, whilst as the amount of tragacanth increases up to 1.5%, the compressive, tensile strength decreases slightly. The rate of water absorption of samples was more than 30%. From this result, it is concluded that these materials can not be used as external plaster or internal plaster material that faces to water. They can be used in internal plaster unless touching water and they can be used as cover plaster under roof and riprap material in sandwich panels. It is also found that, these materials can be cut with saw, drilled with screw and painted with any kind of paint.

Keywords—Fly ash, tragacanth, cement, composite material.

I. Introduction

FLY ash chemically reacts with the byproduct calcium hydroxide released by the chemical reaction between cement and water to form additional cementitious products that improve many desirable properties of concrete. All fly ashes exhibit cementitious properties to varying degrees depending on the chemical and physical properties of both the fly ash and cement. Compared to cement and water, the chemical reaction between fly ash and calcium hydroxide typically is slower resulting in delayed hardening of the concrete [1,2]. Delayed concrete hardening coupled with the variability of fly ash properties can create significant challenges for the concrete producer and finisher when placing steel-toweled floors [3].

Unfortunately, the production of portland cement releases CO_2 gases into the atmosphere and contributes to the greenhouse effect and global warming. For that reason, replacing 15% to 20% of the portland cement with fly ash is important for the environment because it reduces cement usage [4]. The aim of this study is to investigate the availability of usage of fly ash in building materials. In addition the waste ash which remains in the chimney after burning is used produce new composite materials. Although the fly ash has been used in concrete materials with cement the residue waste ash has not been used much. The authors would like to find usage areas of waste ash indeed.

In present study both the waste ash and fly ash are used to produce building materials. The tragacanth which has an adhesion property is used as binder material when it is mixed with cement. Hence, six kinds of mixtures including fly ash, waste ash, tragacanth and cement have been prepared.

The concepts of the samples are: (*i*) fly ash & tragacanth (FT), (*ii*) waste ash & tragacanth (WT), (*iii*) fly ash & tragacanth & cement (FTC), (*iv*) waste ash & tragacanth & cement (WTC), (*v*) fly ash & cement (FC) and (*vi*) waste ash & cement (WC). The mixing ratio of the cements varies as 0, 10, 20, 30, 40 and 50%, while the percentages of the tragacanth in the mixture varies as 0, 0.5, 1 and 1.5%. The new-produced samples are subjected to some tests to find out their properties such as thermal conductivity, compressive strength, tensile strength and sucking capability of water.

II. Properties of Mixing Materials

A. Fly Ash and Waste Ash

The coals having low calorific value are burnt by spraying into the furnace in the pulverized form with water. Considerable amount of ashes produced in the combustion are in the form of hollow spheres and carried easily by flue gas which are then removed in the cyclones and electro filters of the plants. They are called "fly ash" because of their low weight [5]. Some of them assume hollow sphere shape due to the instantaneous cooling upon contact with the atmospheric air. One of the most important problems of thermal power stations is the storage and transportation of these ashes. Some of the ashes formed in combustion assume hollow spherical shape with pores which are of (1-200) $x10^{-6}$ m in diameter. These pores resist the conduction and make the fly ash an insulator. Their densities were determined to be in the range of 2 - 2.2 $g.cm^{-3}$. In a material, porous structure provides reduced heat transfer and thus fly ash may be an alternative solution to reduce the energy consumption of the buildings.

One aim of this study was to determine the value of the fly ashes as a new building material. Second major goal of the study is to use waste ash which is a kind of residue in the chimney after burning.

The fly ash and waste ash used in the experiments are supplied from *Afşin-Elbistan Thermal Plant*. The chemical

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composition of fly ash is given in Table I [5]. The general usage area of the fly ash is additionally presented in Table II.

B. Tragacanth

Tragacanth is a natural gum obtained from the dried sap of several species of Middle Eastern legumes of the genus *Astragalus*, including *A. adscendens*, *A. gummifer*, *A. brachycalyx*, and *A. tragacanthus*. Some of these species are known collectively under the common names "goat's thorn" and "locoweed" [5]. Gum tragacanth is also used in incense making as a binder to hold all the powdered herbs together. Its water-solubility is ideal for ease of working and an even spread.

It is a viscous, odourless, tasteless, water-soluble mixture of polysaccharides obtained from sap which is drained from the root of the plant and dried. The gum seeps from the plant in twisted ribbons or flakes which can be powdered. It absorbs water to become a gel, which can be stirred into a paste. The gum is used in veg-tanned leatherworking as an edge slicking and burnishing compound and is occasionally used as a stiffener in textiles [6].

TABLE I
FLY ASH USED IN THE PRESENT STUDY AND STANDARDS OF THE ASH [2]

Fly ash used in present study		Standards		
		ASTM C 618 limits		
Chemical composition	(%)	F type	C type	EN 450
SiO_2	27.4	-	-	-
Al_2O_3	12.8	-	-	-
Fe_2O_3	5.5	-	-	-
MgO	2.5	<5	<5	-
SO_3	6.2	<5	<5	<3
S+A+F	45.7	>70	>50	>70
Na_2O	0.3	<1.5	<1.5	-
K_2O	-	-	-	-
CaO	47	-	-	-
Loss on ignition	2.4	<6	<6	<5

TABLE II
USAGE AREA OF THE FLY ASH [5]

Usage area	Proportion (10^3 tons)
Light weight agregate	304
Air concrete block	597
Other concrete block	1038
Concrete	126
Cement production	489
Injection	144
Road fill	1860
Construction site fill	412
Other areas fill	100
Breeding site	7266
Total	12336

Fig. 1 View of dry tragacanth

In the new-produced samples, as a binder in addition to cement, tragacanth is used. It is obtained from the south and south-east regions of Turkey. In Fig. 1 some pieces of tragacanth are viewed by a taken photo. In Fig. 2 the melting phase and after filtering phase of the tragacath are viewed.

(a)

(b)

Fig. 2 Tragacanth views; (a) melting phase (b) after filtration

C. *Portland Cement*

Portland cement is the most common type of cement in general use around the world because it is a basic ingredient of concrete, mortar, stucco and most non-specialty grout. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a limited amount of calcium sulfate (which controls the set time) and up to 5% minor constituents as allowed by various standards such as the European Standard EN197-1 [7].

III. Experimental Method

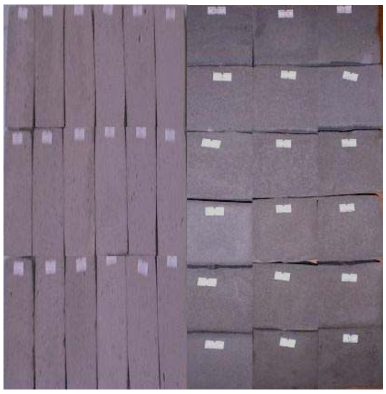
As previously told, the fly and waste ash used in the experiments are supplied from *Afşin-Elbistan Thermal Power Plant*. Mixture of tragacanth and portland cement are used as binding materials. The new samples are produced by varying the kind and percentage of cement and tragacanth (Table III, Fig. 3). The new productions are subjected to some tests to find out their properties such as thermal conductivity coefficient, sucking capability of water, compressive strength, and tensile strength.

A *shotherm-QTM unit (Showa Denko)* which runs based on the hot wire methodology of *DIN 51046* is used to measure the thermal conductivities of the specimens. Its range and sensitivity are 0.02-10 W/mK and ± 5 % of its scale respectively [8, 9]. The measurements on three locations of each sample block are repeated three times to reflect the average of nine values.

Mechanical strength tests on the samples are undertaken according to the *ASTM C 109-80 standard*. Compressive strength and tensile strength tests are applied on each sample block.

The aim of water absorption test is to investigate the maximum amount of water uptake by the different samples. This property is important for determining the suitability of this material against freezing hazards. The critical amount of moisture is 30% of the total dry volume, below which the material does not deform on freezing [10]. The experiments are performed according to the *BS 812 Part 2* standard by keeping the specimens in water for 48 hours.

(a)



(b)

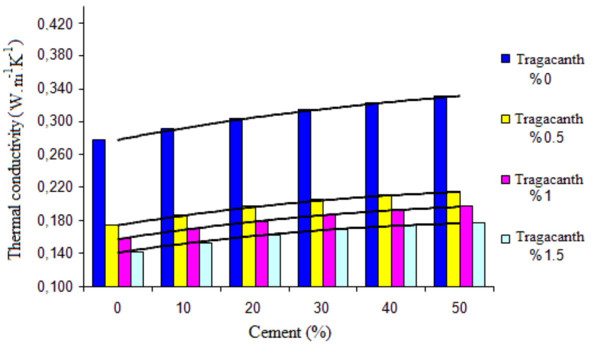
Fig. 3 New-prepared samples (a) fly ash, (b) waste ash

IV. Results and Discussions

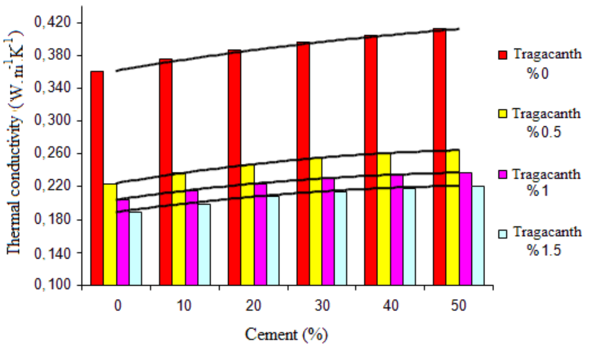
Thermal conductivity values for different materials which are measured by QTM Shoterm device and the samples prepared of the smallest thermal conductivities, are shown in Table IV. As can be seen from the table, prepared samples have smaller thermal conductivity coefficients than the building materials do.

The most important reason of this result is; the porous nature of the ashes of thermal power plant and the usage of tragacanth as a binder. Thermal conductivity of tragacanth in powder form is found to be 0.165 W/mK, and it is seen that depending on the increase in the quantity of tragacanth used at the prepared samples, the thermal conductivity decreases. In this study, the lowest thermal conductivity coefficient value is found to be 0.142 W/mK which belongs the sample FTC1.5 (see Table IV for the details of the samples), which has low fly ash and cement and 1.5% tragacanth in the mixture. Also the highest thermal conductivity coefficient is 0.412 $W.m^{-1}K^{-1}$ and it belongs to WC50 that is produced with waste ash and cement, without tragacanth. In Fig. 3, variation of thermal conductivity coefficient with respect to the amount of tragacanth and cement in samples are shown for samples of waste and fly ashes.

The samples in which fly ash and tragacanth (FT) are used together the compressive strength increases. When tensile and compressive strength are rewired in fly ash samples, the value of compressive strength varies between 3.43 and 15.34 N/mm2 and the value of tensile strength is in the range of 0.64-1.36 $N.mm^{-2}$. For the samples WT, the values of the compressive strength and tensile strength are respectively in the ranges of 14.92–37.55 N/mm2, 1.34–2.13 $N.mm^{-2}$. In the FT samples depending on the mixing ratio of tragacanth, such as 0.5% , 1% and 1.5%, the compressive strength increases up to the percentages of 31.5%, 40%, 33.2% respectively. And for the WT samples the increments rates are respectively 1.4%, 29.2%, 24.1%.



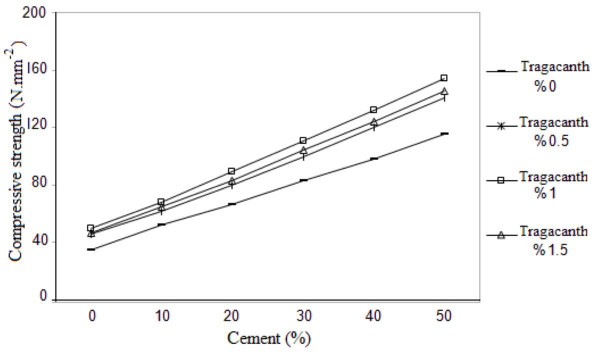
(a)



(b)

Fig. 4 Thermal conductivity-cement and tragacanth percent relation in the ash specimens; (a) fly ash (b) waste ash

The compressive strength-cement versus tragacanth percent in the specimens are presented in Fig. 5. Furthermore, the tensile strength-cement versus tragacanth percent variation is presented in Fig. 6. For the samples WTC the increment of compressive strength is respectively 21%, 33%, 25%, for the mixing cement ratios of 0.5%, 1% and 1.5%. Similarly, for WTC samples the enhancement rates are 19%, 24%, 21%. Hence, the compressive and tensile strength are increasing depending on the amount of tragacanth used in the sample.



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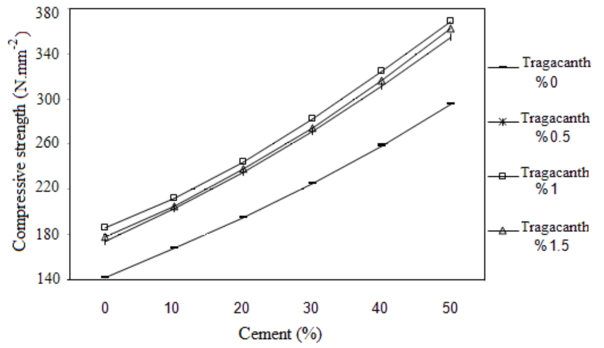
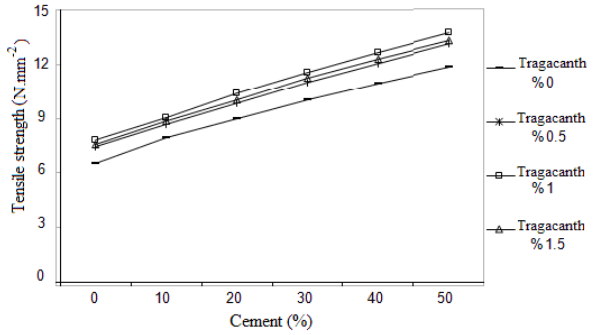
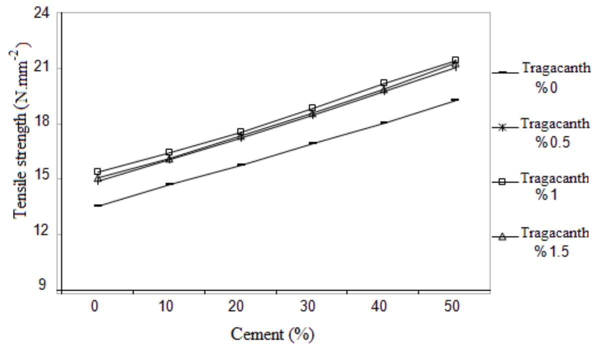


(b)

Fig. 5 Compressive strength-cement and tragacanth percent relation in the ash specimens (a) fly ash, (b) waste ash



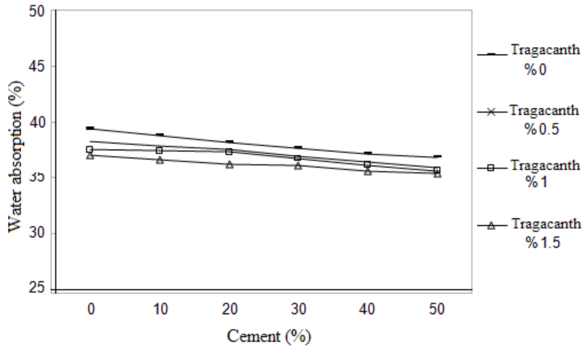
(a)



(b)

Fig. 6 Tensile strength-cement and tragacanth percent relation in the ash specimens; (a) fly ash, (b) waste ash

Water absorption test results of cement and tragacanth mixtures are presented in Fig. 7. The water absorption rates of the produced samples reach above the critical value 30%. So that, that kind of building material cannot be used at the places where they are directly associated with water. In contrast, they can be used as an interior plaster material, intermediate filling material at the sandwich walls, plaster material for under rooftop plating.



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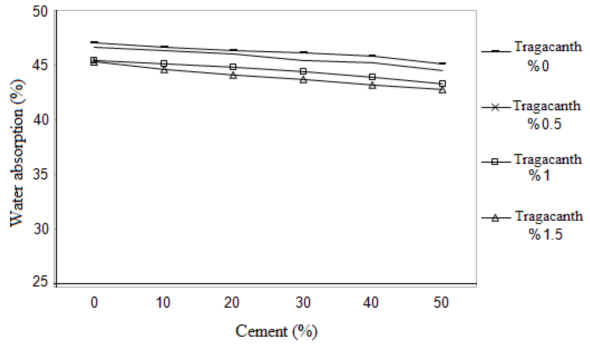
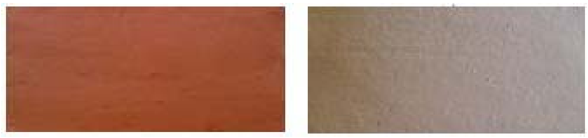


(b)

Fig. 7 Water absorption-cement and tragacanth percent relation in the ash specimens a) fly ash, b) waste ash

There are some applications made on the samples which are produced by ashes and it is seen that these samples can be cut bye saw, screwed in, available to the opening of the channel for plumbing work and also can be drilled. Also to determine the dye retention property of produced samples different types of dyes are applied and at the end it is seen that dye retention property of these samples have been found to be extremely well (Fig. 8). Due to processing faults, cracking may occur, as well as deformation on the surface of the samples.

(a) (b)



(c) (d)

Fig. 8 Samples can be drilled a) fly ash, b) waste ash and different types of dyes can applied, c) silicone rubber coating, d) oil painting

V. Conclusions

The produced samples have lower thermal conductivity than most of the building material does, so they can be claimed as 'good insulators'. The tragacanth and ash blended composite type materials can be used as an insulation plaster for the inner walls of the building and rooftop. These features, the ability to breathe, dye retention property, can be drilled with drill, available to the opening of the channel shows that type of plasters are usefully materials.

TABLE III
Context of New Produced Samples

Sample code	W %	F %	T%	C %	Sample code	W %	F %	T%	C %
WC10	100	0	0	10	FC10	0	100	0	10
WC20	100	0	0	20	FC20	0	100	0	20
WC30	100	0	0	30	FC30	0	100	0	30
WC40	100	0	0	40	FC40	0	100	0	40
WC50	100	0	0	50	FC50	0	100	0	50
WT0.5	100	0	0.5	0	FT0.5	0	100	0.5	0
WTC0.5-10	100	0	0.5	10	FTC0.5-10	0	100	0.5	10
WTC0.5-20	100	0	0.5	20	FTC0.5-20	0	100	0.5	20
WTC0.5-30	100	0	0.5	30	FTC0.5-30	0	100	0.5	30
WTC0.5-40	100	0	0.5	40	FTC0.5-40	0	100	0.5	40
WTC0.5-50	100	0	0.5	50	FTC0.5-50	0	100	0.5	50
WT1	100	0	1	0	FT1	0	100	1	0
WTC1-10	100	0	1	10	FTC1-10	0	100	1	10
WTC1-20	100	0	1	20	FTC1-20	0	100	1	20
WTC1-30	100	0	1	30	FTC1-30	0	100	1	30

WTC1-40	100	0	1	40	FTC1-40	0	100	1	40
WTC1-50	100	0	1	50	FTC1-50	0	100	1	50
WT1.5	100	0	1.5	0	FT1.5	0	100	1.5	0
WTC1.5-10	100	0	1.5	10	FTC1.5-10	0	100	1.5	10
WTC1.5-20	100	0	1.5	20	FTC1.5-20	0	100	1.5	20
WTC1.5-30	100	0	1.5	30	FTC1.5-30	0	100	1.5	30
WTC1.5-40	100	0	1.5	40	FTC1.5-40	0	100	1.5	40
WTC1.5-50	100	0	1.5	50	FTC1.5-50	0	100	1.5	50

TABLE IV
MEASURED THERMAL CONDUCTIVITIES [1]

	Measured Values			Values in Literature		
Material	**Density ($g.cm^{-3}$)**	**T_{avr} (°C)**	**Thermal Conductivity ($Wm^{-1}K^{-1}$)**	**Density ($g.cm^{-3}$)**	**T_{avr} (°C)**	**Thermal Conductivity ($Wm^{-1}K^{-1}$)**
Outher Plaster	1.856	31	1.173	1.600	20	0.930
Inner Plaster	1.763	33	1.163	1.800	20	1.163
Gypsum thin plaster (Perlite)	0.465	34	0.244	0.40-0.50	20	0.139-0.162
Gypsum rough plast. (Perlite)	0.465	50.7	0.168	0.40-0.50	20	0.139-0.162
Plaster With Cement (Perlite)	0.672	51.3	0.173	0.700	20	0.244
Gypsum Block (Perlite)	1.047	40	0.372	0.900	20	0.221
Cement Block (Perlite)	0.427	37.7	0.292	0.1046	20	0.300
Concrete	2.500	27	1.420	2.272	24	1.512
Ceramic	1.077	27.7	0.214	2.00	20	0.988
Strophore	0.016	26.3	0.0308	0.200	20	0.0395
Ytong	0.617	38.7	0.180	0.800	20	0.383
Brick Wall	2.093	45.7	1.148	1.8-2.0	20	0.972
Tragacanth		31	0.165		20	0.150
Sample FTC1.5 *		31	0.142			
Sample WC50 **		30	0.412			

REFERENCES

[1] Y. Bicer, K. Pihtili, T. Ayhan, An Investigation on the Heat Insulation Plaster Including Fly Ash of Thermal Power Stations, Journal of Thermal Sciences and Technology, 15(3), 24-29, 1992.
[2] S. Ural, Comparison of fly ash properties from Afsin – Elbistan coal basin, Journal of Hazardous Materials, B119, 85 – 92, TURKEY, 2005.
[3] S. Yıldırım, Y. Bicer, C. Yıldız, Utilization of the fly ash and polypropylene wastes in the production of a new material, Journal of Porous Materials, Vol.3, pp. 189-191, 1996.
[4] K. D. Basham, M.Clark, T.France, P. Harrison, Adding Fly Ash to Concrete Mixes for Floor Construction, Concrete Construction Annual Floors Issue, 2007,
[5] S.Yilmaz, Evaluation of Thermal Power Plant Ash in Tragacanth Binder Combinations as a New Construction Material, Ph.D. thesis, Firat University, Elazig, Turkey. 2010.
[6] http://en.wikipedia.org/wiki/Tragacanth
[7] A. J. Francis, The Cement Industry, 1796-1914, 1977.
[8] S. Denko, Shotherm operation manuel No, 125-2 K.K Instrument Products Department 13-9 Shiba Daimon, Tokyo, 105, Japan, 1981.
[9] V. V.Vysniauskas, A. Zikas, and B. Zaliauskas Determination of the Thermal Conductivity of Ceramics by the Hot-Wire Technique, Heat Transfer-Soviet Research, 20(1), 137-142, 1988.
[10] K. W. NASSERand P.S.H. LAİ, Resistance of Fly Ash Concrete to reezing to Thawing " ACI SP-132, Vol 1, pp. 205-226, 1992.