FACTA UNIVERSITATIS
Series: **Architecture and Civil Engineering** Vol. 16, N^o 3, 2018, pp. 329-342
https://doi.org/10.2298/FUACE170706012B

EFFECT OF EGG WHITE, PERLITE, GYPSUM AND FLY ASH IN ENVIRONMENT FRIENDLY INSULATION MATERIALS

UDC 691.1

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Abstract. *In this study, engineering features of insulation materials produced from egg white, perlite, gypsum and fly ash were investigated. Densities, water absorption ratios, ultrasonic velocities and thermal conductivity coefficients of samples were determined. Furthermore, linear absorption coefficient were measured by gamma ray saturation levels at 17.7, 26 and 60 keV energies. Thermal conductivity coefficients of the produced composites were found to be in the range 0.0882- 0.0995 Kcal/mh°C. Egg white decreased the linear absorption coefficients. Unit weights of samples were found to be dependent on their contents. As gypsum rate increased, unit weight also increased. As perlite rate increased thermal conductivity coefficient decreased. As egg white decreased the linear absorption coefficient decreased, also.*

The most important benefits of these types of materials are their being impermeable and perfectly compatible with the environment. These lighter type materials were/are compatible with Turkey and the Middle East environment. Egg white has been resistant to radiation. Hence, it is highly compatible with the environment. The compressive and flexural strengths of mortars decreased with the use of egg whites in mortar. So, egg white enhances the binding property of samples. In most cases, some organic and/or inorganic additives are used as well, to improve the physical and mechanical properties of mortar, such as egg whites and others. Finally, this study shows that it is possible to produce an insulation material resistant to sound and radiation by using egg white, perlite and fly ash. It is seen that the samples incorporating egg white could be used at hospitals, military and industrial facilities and shelters which are under radiation hazard. Furthermore, this insulation materials will be put to use in industry in Turkey after many experiments have been done on laboratory.

Key words: *Egg white, fly ash, perlite and insulation.*

Received July 6, 2017 / Accepted September 8, 2017
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1. INTRODUCTION

Intensive works are still performed on the alternative energy production methods due to the rapid decrease in energy resources. In this context insulation has an important place in terms of energy saving. Energy loss can be minimized through insulation technologies. Buildings and settlements are responsible for the 40% of CO_2 that is the primary cause of the global warming. For this reason, in order to minimize the energy required to heat buildings various insulation systems and materials are used [1, 2]. In recent years new environment friendly gypsum materials with perlite are being developed. Usage of light natural aggregates in different industrial fields is becoming widespread. In addition, it is stated that expanded perlite aggregate additive has a positive effect on gas concrete features. Perlite is a natural building material whose usage in construction industry as concrete aggregate has a positive effect on national economy and global warming. Because of its thermal insulation and lightweight features [3, 4]. As in building elements, light gypsums are becoming widespread in civil engineering works for the purpose of construction of wall cross-sections particularly for heat and sound insulation properties. Natural, porous, and light aggregates can be used as primary raw material to obtain such mortars. Among these, natural materials such as pumice, volcanic ash, expanded perlite, scoria, opened vermiculite, and tuff can be counted as the most popular ones.

Mortar is an important material which has been present in structures dating back thousands of years. The use of mortars began with mud and clay-based mortars as low-cost and easy to use natural materials used by the early civilisations. In Egypt this progressed to mortars made with gypsum, the natural material produced by heating on small fires. The use of the resulting mortar (really a gypsum) was acceptable in this relatively dry climate, but gypsum is somewhat soluble, so its use elsewhere in wetter conditions was a problem. Bio-based admixtures have been used in construction and building materials for centuries. Furthermore, in India and Ottoman empire, many indigenous materials such as crushed bricks, sweet sugar drops, white lentil, egg white, cream, juice of tobacco were largely used as a additives to mortar which were introduced in Akbar‘s period but extensively used as adhesives [5-7].

The mass spectrometry creates the possibility to distinguish the main groups of protein acetous additives which are, usually in extremely low concentrations, often present in historical mortars. The two types of these additives were identified in the mortars in the rotunda of Saint Catherine in Znojmo (12^{th} century) [8]. The ancient history of using natural polymers including asphalt to modify lime and clay mortars goes back to the Babylonians, Egyptians and ancient India. Europeans in the Middle Ages knew how to use oxblood and egg white to increase the toughness and durability of lime mortars[9,10].Egg-containing mortar (Sarooj) was used in Kabar dam, which was built during the Sassanid Empire and also in Bandben Castle in Gilan (in the north of Iran)[11]. Archaeologists believe that egg could enhance the mortar strength. Common ingredients in most other lime-based mortars are slaked lime, water, fibre as reinforcement and sand, but the rest of the ingredients such as milk, egg specially albumin, fertilizer, dung (manure) made Sarooj slightly much different [12], In order to modify and/or improve some of the properties of the mortars, traditionally they have been mixed, with some different products or additional constituents. These products have evolved for a long time. In the beginning the admixtures were composed of natural substances such as blood and egg, etc. The current admixtures are generally industrial by-products, like fly ash or blast furnace slag or other more elaborated products, like organic polymers, acrylic resins, epoxy resins, etc. [13]. According to the mechanical tests, it is identified that egg white and yolk have positive impact on mechanical strength of lime mortars and this impact relatively decreases on the basis of increasing mixture rate; whereas, other additives have a retarding effect [14].

Ionized radiation that can be specified as radioactive is the most dangerous radiation type as it can easily pass through human body and it destroys human cells and genes. Even low amounts of radiation can be harmful [15, 16].Nowadays radiation is widely used in medical, energy, and military fields. Frequent use of radiation negatively affects human health. The most effective way to prevent the harmful effects is armouring of places. Heavy concretes are used to prevent carcinogenic effects of radioactive rays from harming living beings and to avert leakages that might happen in radioactive buildings [17]. Egg white and waste battery coal were identified as radiation absorbent materials [18]. In the last century, there was an increase in the levels of natural radiation due to X-rays used for medical, agricultural and industrial purposes. [19]. It was found out that insulation materials that would be produced from organic and inorganic materials with thin sections instead of thick sections can be used to provide protection against radiation [20, 21].

In all of these studies, egg whites were used as binder instead of cement in masonry wall mortars. We focus on the study of the different steps of the gypsum and egg white as a conceptual framework to underline past applications and performance of these binders, and their current use in building construction. For the first time, this material was also used as a binder, such as plaster, cement or epoxy, in insulation materials. Both the binding and other durability properties of egg white were investigated in samples produced with egg white. Densities, water absorption ratios, ultrasonic velocities, thermal conductivities of samples were investigated. Furthermore, linear absorption coefficients were measured by gamma ray saturation levels at 17.7, 26 and 60 keV energies.

2. Material and Method

2.1. Materials

2.1.1. Egg white

Egg white has been used in mortars as a binder together with lime. Carbonation rate is around 10% in samples produced with lime binder in addition to egg whites. Increasing the egg white additive ratio much more did not increase the carbonation speed so much, but had a retarder effect. However, 28-day compressive strengths of these samples had higher values in comparison to lime mortar [22, 23]. On the other hand, egg white, lime and sand were used to produce mortar by the Turks in Central Asia with the name "Horasani Mortar." Presumably, a similar mortar model was used in the central Anatolia also [24]. Eggs and egg whites used in this work are demonstrated in Fig. 1.

Fig. 1 Egg white

Essentially water contains around 11% protein and substantial amounts of sodium, potassium, and chlorine. Egg white contains more than half of the niacin and riboflavin of the whole egg and most of the carbohydrates are found in egg white. 63% of egg white proteins consist of ovalbumin.

2.1.2. Perlite

Perlite is the name given to naturally occurring siliceous volcanic rocks. It contains 74% SiO_2 and 15% Al_2O_3. The most important feature which makes it different from other volcanic glasses is that it can expand its volume up to twenty-four times when it is heated around its softening temperature. This expansion depends on the sap that is found in raw perlite around 2-4%.When rapidly heated, at 870 degrees it explodes like corn grains due to the evaporation of the sap in its structure and many pores are formed on the heat-expanded perlite. Expanded perlite is a perfect heat and sound insulation material. Perlite particles smaller than 1mm was used in the work.

2.1.3. Gypsum

Gypsum is a building material that is obtained by evaporation and grinding of the gypsum that has two molecules of crystal water in its compound ($CaSO_4\,2H_2O$). When it is heated it leaves half molecule of water. Then, being mixed with water it gains a binding property by re-solidifying. Dehydrated gypsum powder was used in this work.

2.1.4. Fly ash

Fly ash is formed by holding the particles present in chimney gases on electro-filters when pulverized coal is burnt alone in thermal plant boilers. Ashes being collected by mechanic and electrostatic methods are stored in convenient places. As time passes, these ashes begin to cover large places and become a problem for plant management. Presently, fly ash amount generated around world is around 600 million ton per year. Ash used in this work was provided from Kahramanmaras Afsin-Elbistan thermal plant.

2.1.5. Water

Tap water was used in this study.

2.2. Method

In this study, it is aimed to produce an insulation material that is light and resistant to radiation, and that provides heat and sound insulation. Accordingly, materials used were egg white and fly ash against radiation, sand size perlite as it is light and perfect for heat and sound insulation, and egg white and gypsum since they are good binder materials. Chemical and physical properties of materials are given in Table 1. Water and egg whites were used with different amounts to obtain sufficient consistency in the samples. To determine these amounts (g) the following formula was used:

$$[\text{Water} + 0.5 \text{ egg white}] / [\text{binder (perlite + gypsum + fly ash)}] = 0.5 \qquad (1)$$

For this purpose, samples, 160 x160x 40 cm in size, were produced and the amounts (g) used are given in Table 2.

Table 1 Chemical and physical properties of materials used

Materials	Component (%)						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Ignigation loss
Fly ash	18.8	9.17	3.37	53.48	1.78	10.43	-
Perlite	67.0	11.8	3.73	1.25	0.16	2.25	2.05

	Physical properties			
	Density (g/cm^3)	Blaine (cm^2/g)	Fineness	
			Residue on 90 µm, %	Residue on 200 µm, %
Fly ash	2.684	4000	0.4	0.04
Perlite	1.641	-	-	-

3. Experimental Study

3.1. Mixture preparation

Materials used in this work are egg white, perlite, gypsum and fly ash as a binder (Table 2). Various samples were produced by using different amounts of materials (Fig. 2).

Table 2 Components of Composites (g)

Sample	Egg white	Perlite	Gypsum	Fly ash	Water
S1	100	150	250	-	160
S2	100	160	250	-	170
S3	100	180	250	-	165
S4	200	-	400	-	100
S5	250	-	500	-	125
S6	300	-	600	-	150
S7	200	150	300	90	170
S8	250	150	300	100	150
S9	300	150	300	130	140
S10	200	150	300	130	190
S11	250	150	300	130	165
S12	300	150	300	130	140

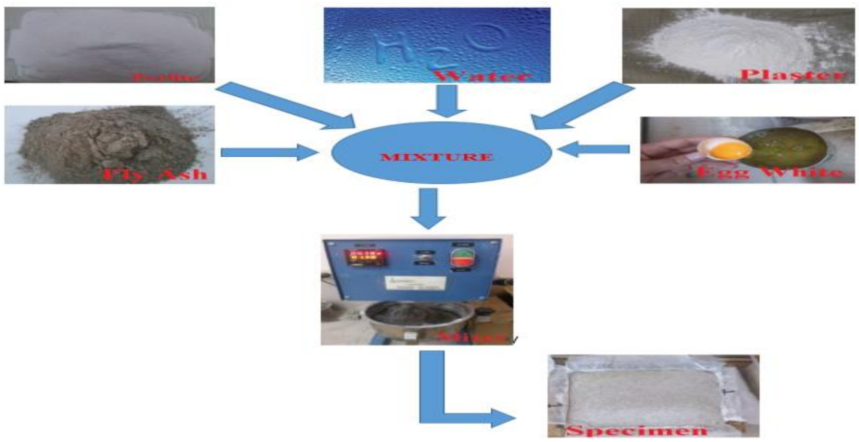


Fig. 2. Sample preparation scheme

3.2. Material characterisation

At the initial stage, the optimization of the egg white to be used in the samples took into account the characteristics of the available raw materials and the existing laboratory infrastructure. Gypsum was, also, added to ensure the adhesion of the particles and manufacture the samples with adequate strength (0.1 MPa). The work also considered the experience accumulated from previous studies in similar fields. In this context, perlite was added to the ingredients to ensure thermal insulation. Thus, all components of samples were mixed as shown in Fig. 2. Perlite was added to the mortar to improve thermal insulation, gypsum to act as a binder and egg white and fly ash to increase radiation resistance. The mortar obtained were poured, under their own weights, into steel moulds of 160 x 160 x 40 mm dimensions. After being poured in moulds, the mortar was compacted with a hydraulic press at 5 MPa and then, kept at 130°C there for approximately 24 hours. During this time, a good bond between the egg white and the other components is expected to have taken place. In addition, the samples were, presumably, dried and hardened.

3.3. Unit weights

Unit weights of all dry samples were found using the following formula:

$$d=M/V \quad (2)$$

where m= sample weight (g), v= sample volume (cm^3) and d= sample unit volume.

3.4. Water absorption

Water absorption is the capacity of a material to absorb and retain water; .Dry material is fully immersed in water and water absorption is defined either as % of weight or % of volume of dry material. In this work the following definition has been used:

$$\text{\% of water absorption} = ((W2–W1\ ) / W1)\ X\ 100 \quad (3)$$

where W_2 =wet weight and W_1 = dry weight.

3.5. Ultrasonic pulse velocity

The composites produced in this work were investigated for their ultrasonic pulse velocity. There are two steel discs on the test machine setup, one conveys the sound, and one receives the sound. Before testing the samples the surface of these discs were greased. Sound permeability times of all the samples were measured longitudinally on the device and, thus, ultrasound speeds (according to EN 14579 standard) were identified (Fig. 3).

Fig. 3. The experimental setup for measuring ultrasonic pulse velocity

3.6. Thermal conductivity coefficient

According to the Turkish Standards TS 825 and German DIN norm 4108 a material with thermal conductivity value below 0.1 Kcal/mh°C is called to be a thermal insulation material. The results given in Fig. 7 were found in the thermal conductivity coefficient device in Fig. 4.

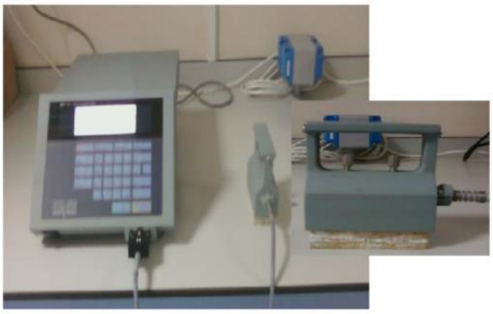


Fig. 4. The experimental setup for measuring thermal conductivity coefficient

3.7. The linear absorption coefficients of the samples

First of all the dimensions of each sample were measured. The linear radiation absorption coefficients were measured in the Radiation Laboratory of the Physics Department of Kahramanmaras Sutcu Imam University using the radioisotope source of the Am-241 as a source of radiation. In this study, an Si(Li) solid state detector with 60, 26 and 17.7 Kev resolution was used. The spectra obtained were counted and an S 100 card was used to evaluate the results. The linear absorption coefficients were determined by measuring what percentages of the rays coming at two different energy levels were passing and what percentages were absorbed while traveling through the samples

3.8. Compressive and flexural strengths

The Diwick Roell Z010 Universal test device was used to determine the compressive strengths of the samples having dimensions 120 x 120 x 20 mm and the flexural strengths of the samples having dimensions 2.5 x 2.5 cm. According to the Turkish standard, which is similar to the European standard BS EN 310, the flexural strength at rupture tests were conducted by using a three-point bending test with the universal testing machine Emic DL 30000, with a load cell capacity of 5 kN. The tests were carried out with a span of 200 mm at a loading speed of 9 mm/min.

4. RESULTS AND DISCUSSION

4.1. Unit weights and water absorption

Unit weights and water absorption values of the samples are shown in Figs. 5 and 6, respectively. The unit weights of perlite added samples were found to be lower. As the amount of gypsum additive increases, the unit weights of the samples also increase. The unit weight values of the samples meet the required limit values in the Turkish standards. Since insulation materials are lightweight, it is important that they do not cause additional load. During earthquakes, the weights of buildings also affect collapsing. Furthermore, lightweight buildings are affected by smaller earthquake forces than heavier ones under the same earthquake acceleration [25, 26].

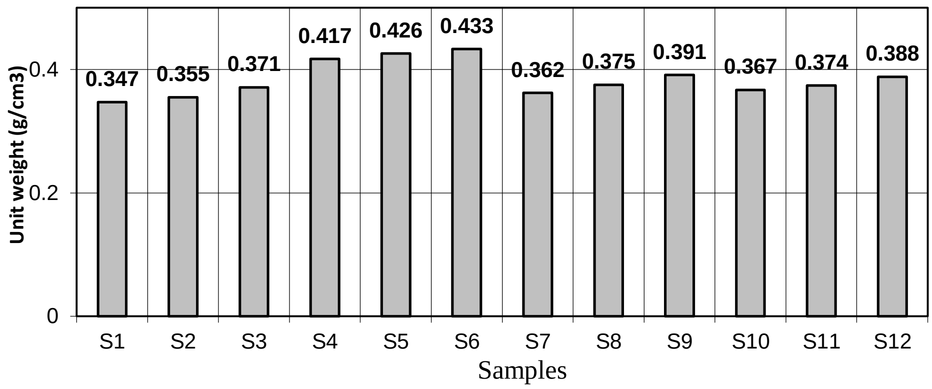


Fig. 5. Unit weights of samples

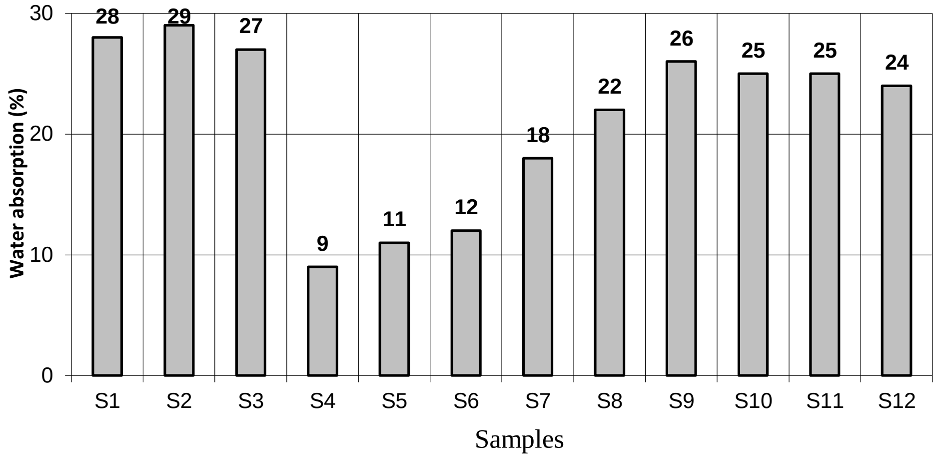


Fig. 6. Water absorptions of samples

4.2. Ultrasonic pulse velocity

Ultrasonic pulse velocity values of the samples are shown in Fig.7. Ultrasonic pulse velocity rates were similar to the unit weights. In other words, samples with low unit weight values were found to have low ultrasonic pulse velocities. This can be explained via voids inside the samples. The actual velocity in these materials may vary significantly due to a variety of causes such as specific composition or microstructure, grain and porosity.

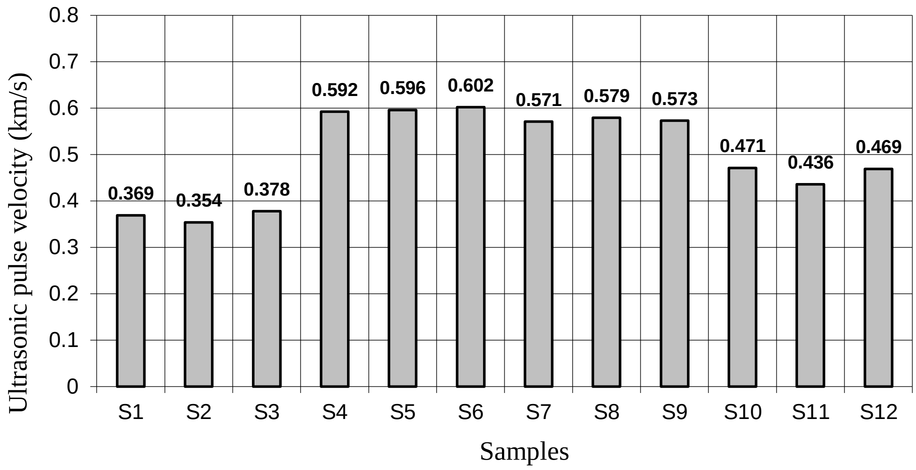


Fig. 7 Ultrasonic pulse velocities of samples (km/s)

Ultrasonic sound waves from egg white with low water rate was found to have higher velocity. This can be explained by the presence of fewer pores in the micro- and macro-structure of egg white-added samples. The ultrasonic sound velocity test showed similar results with thermal conductivity coefficient test. Because both of these results are associated with the density and porosity of material. Egg white addition increased the ultrasonic pulse velocity of composites because it creates a dense and compact structure.

4.3. Thermal conductivity coefficients

The thermal conductivity coefficient tests of samples were performed and the results obtained are given in Fig. 8. The thermal conductivity coefficient of perlite added samples was found to be lower. This is explained by the pore structure of perlite. On the other hand, the thermal conductivity coefficients of samples with less voids and egg whites were found to be higher. When the amount of perlite was kept constant, the thermal conductivity coefficients of samples with higher egg mass was found to be lower. On the other hand, the thermal conductivity coefficients of the samples with the same amount of egg whites were found to be lower than those of the samples with more perlite. These results suggest that both the egg white and the perlite decrease the thermal conductivity coefficients of the samples. According to the Turkish standards, the thermal conductivity coefficient of a material must be less than 0.1 in order to be accepted as an insulation material. In this case, all the samples in this study can be accepted as insulation material.

High performance thermal insulators are materials with a thermal conductivity lower than 0.02 Kcal/mh°C. However, this value for insulator materials like expanded polystyrene (EPS) and extruded polystyrene (XPS) are around 0.03-0.06 [27]. Those values are, of course, greater than those of the rival. However, the material obtained in this work is totally bio-based.

Furthermore, the values found can be further improved with more extensive studies. After that, mixing ratios are further elaborated and more work is planned on the subject.

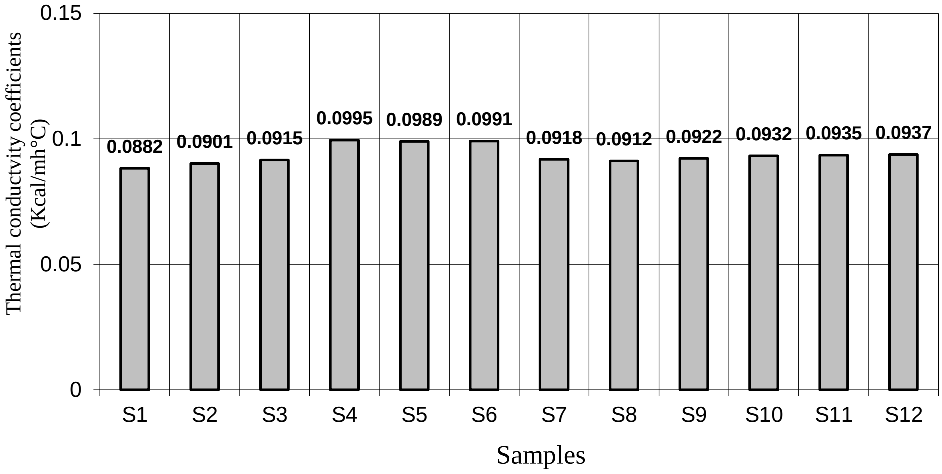
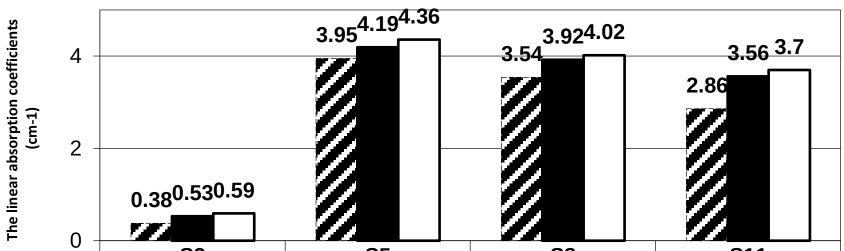


Fig. 8 Thermal conductivity coefficient results (Kcal/mh°C)

4.4. The linear absorption coefficients of the samples

The linear absorption coefficients of the samples are given in Fig. 9. Gypsum and perlite added samples have lower linear absorption coefficients than the other samples. The linear absorption coefficient of the sample S8 which had egg white, gypsum, perlite and fly ash was found to be the largest. The linear absorption coefficients of both egg white and fly ash added samples were found to be higher than the others. Sample S8 absorbed on the average four times more radiation than that of sample S2. Generally, as the radiation energy level increases, the percentage of absorption decreases. These results were similar to those obtained in some previous studies [21, 28].



	S2	S5	S8	S11
60keV	0.38	3.95	3.54	2.86
26keV	0.53	4.19	3.92	3.56
17,7keV	0.59	4.36	4.02	3.7

Samples

Fig. 9 The linear absorption coefficients (cm^{-1})

3.7. Compressive and flexural strengths

The compressive and flexural strengths of the samples are given in Figs. 10 and 11, respectively. The compressive strengths of the samples made with perlite additive is found low, due to its porous structure. Sample S4 had the highest compressive strength. This is due to the high degree of adhesion of the egg white after thermal processing. Egg whites provide high rigidity. Materials with low compressive strengths low thermal conductivity coefficients are expected to have low thermal conductivity coefficients, too. The compressive strength of each material with a high flexural strength is not expected to be high, also.

The flexural strength values of the samples are very close to each other. The obtained compressive strength values and bending strength values had a very similar trend. Compressive and flexural strength values of samples with egg white additive were found higher than the other samples. The compressive and flexural strengths decreased with the use of egg whites in the mortar. The higher compressive and flexural strengths of the egg white added samples improved the ability of the egg white to adhere after heat treatment. In addition, the strengths of these samples due to less voids in their structures.

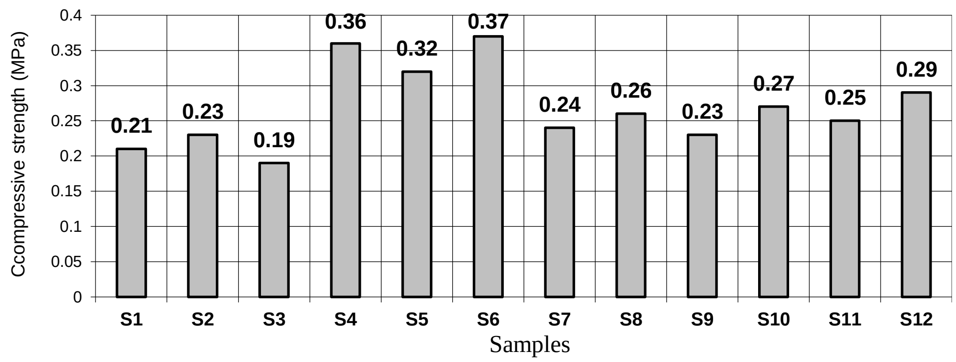


Fig. 10 Compressive strengths of the samples (MPa)

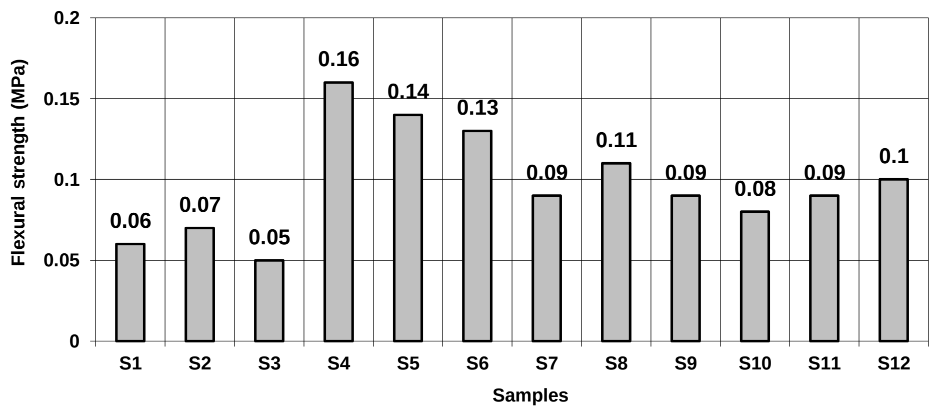


Fig. 11 Flexural strengths of the samples (MPa)

5. CONCLUSIONS

Based on the present study, the following conclusions can be drawn:

1. Radioactivity shielding performance of mortars is very important for radiotherapy rooms, nuclear reactors and similar buildings [20]. This research provides sufficient information for the use of egg whites as an additive to increase the radiation absorption property of mortars.
2. Unit weights of the samples whereas found to be dependent on their contents.
3. The compressive and flexural strengths decreased with the use of egg whites in mortar. So, egg white enhances the binding property of samples.
4. In most cases, some organic and/or inorganic additives are used as well, to improve the physical and mechanical properties of mortar, such as egg whites and others.

Finally, this study shows that it is possible to produce insulation material resistant to sound and against radiation by using egg white, perlite and fly ash. It is seen that samples incorporating egg white could be used at hospitals, military and industrial facilities and shelters which are under radiation hazard. Furthermore, this insulation material is going to be put into industrial production in Turkey after many experiments have been done in laboratories.

Acknowledgement: *The authors would like to thank Prof. Dr. Adnan Kucukonder for his invaluable contribution to the present study.*

REFERENCES

1. Binici H, Aksogan O, Demirhan C., Mechanical, thermal and acoustical characterizations of an insulation composite made of bio-based materials, Sustainable Cities and Society 20 (2016) 17–26.
2. Topcu IB., Properties of heavy weight mortar produced with barite, Cement and Concrete Research 33(2003) 815–22.
3. Demir F, Budak G, Sahin R, Karabulut A, Oltulu M, Serifoglu K., Radiation transmission of heavyweight and normal-weight mortars containing colemanite for 6 MV and 18 MV X-rays using linear accelerator, Ann Nuclear Energy 37(2010) 339–44.
4. Aksogan O, Binici H, Ortlek E., Durability of concrete made by partial replacement of fine aggregate by colemanite and barite and cement by ashes of corn stalk, wheat straw and sunflower stalk ashes, Construction and Building Materials 106 (2016) 253–263.
5. Acharya A, Archroy S, Gokhale A.V., Role of Additives in Mortars: Historic Precedents, Int. Journal of Engineering Research and Application 7(2017) 07-12.
6. Binici H, Arocena J, Kapur S, Aksogan O and Kaplan H., Investigation of the Physico-chemical and microscopic properties of Ottoman mortars from Erzurum (Turkey), Construction and Building Materials 24 (2010) 1995–2002.
7. Lauren B, Sickels-Taves, Philip D.A, Arch D.R., Lime and its place in the 21st century: combining tradition, innovation, and science in building preservation, International Building Lime Symposium 2005 Orlando, Florida, March 9 -11, 2005, 1-14.
8. Kuckova S, Hynek R, Kodicek M., Application of peptide mass mapping on proteins in historical mortars, Journal of Cultural Heritage 10 (2009) 244–247.
9. Coppola L., Properties of Polymer-Cement Coatings for Concrete Protection, Fifth Canmet/ACI Conference, Super plasticizers and other chemical admixtures in Concrete, ACI SP 173 (1997) 267-286.
10. Moropoulou A,Tsiourva T, Bisbikou K, Bakolas A and Zendri E,. Hot lime technology imparting high strength to historic mortars, Construction and Building Materials 18(1996) 151-159.
11. Database of Administration of Cultural Heritage, Handicrafts and Tourism Gilan Province, (in Persian), access in May 2013 on: http://www.gchto.ir/en/
12. Masoumi M.M, Banakar H, Boroomand B., Review of an ancient Persian lime mortar, Malaysian Journal of Civil Engineering 27(2015) 94-109.

13. Van Balen K, Toumbakari EE, Blanco-Varela M.T, Aguilera J, Puertas F, Palomo A, Sabbioni C, Zappia G, Gobbi G., Procedure for mortar type identification: A proposal, Proceeding of International Workshop on Historic Mortars: Characteristics and tests. Rilem technical committee, University of Paisley 3(1999) 23-32.
14. Tekin C, Kurugol S., Impacts of various organic additives on carbonization of lime, Gazi University, Faculty of Engineering and Architecture Magazine 27(2012) 717-728.
15. Binici H, Gemci R, Kucukonder A, Solak H., Thermal conductivity, sound insulation and radiation transmission of cotton waste, fly ash and barite reinforced chipboards, Electronic Journal of Construction Technologies 8 (2012) 7-15.
16. Akkurt I, Basyigit C, Kilincarslan S, Mavi B., The shielding of c-rays by mortars produced with barite, Prog Nuclear Energy 46 (2005) 1–11.
17. Akkurt I, Basyigit C, Kilincarslan S, Mavi B, Akkurt A., Radiation shielding of mortars containing different aggregates, Cement Mortar Composite 28(2006) 153–7.
18. Binici H, Temiz H, Sevinç A, Eken M, Kucukonder A, Ergul T., Waste material in battery production of coal and egg shell holder using radiation, KSU, Journal of Engineering Sciences 16(2013) 12-19.
19. Binici H, Gemci R, Kucukonder A., Investigating the sound insulation, thermal conductivity and radioactivity of chipboards produced with cotton waste, fly ash and barite, Construction and Building Materials 30(2012) 826–832.
20. Binici H, Aksogan O, Sevinç A.H, Canpolat E., Mechanical and radioactivity shielding performances of mortars made with cement, sand and egg shells, Construction and Building Materials 93 (2015) 1145–1150.
21. Binici H, Aksogan O, Sevinc A.H, Kucukonder A., Mechanical and radioactivity shielding performances of mortars made with colemanite, barite, ground basaltic pumice and ground blast furnace slag, Construction and Building Materials 50 (2014) 177-183.
22. Boke H, Akkurt S, Ipekoglu B, Ugurlu E. ,Characteristics of brick used as aggregate in historic brick-lime mortars and gypsums, Cement and Concrete Research 36(2006) 1115–1122.
23. Tekin C, Kurugol S., Impacts of various organic additives on carbonization of lime, Journal of the Faculty of Engineering and Architecture of Gazi University 27(2012) 717-728.
24. Sahin N., Prisons in Afyonkarahisar in early years of 20th century, Nevsehir Haci Bektas Veli University Journal 5(2015) 21- 45.
25. Binici H., March 12 and June 6 2005 Bingol-Karliova earthquakes and the damages caused by the material quality and low workmanship, Engineering Failure Analysis 14 (2007) 233-238.
26. Bayraktar A, Coskun N, Yalcin A., Damages of masonry buildings during the July 2, 2004 Dogubeyazit (Agri) earthquake in Turkey**,** Engineering Failure Analysis 14**(**2007) 147–157.
27. Pacheco-Torgal F, Ivanov V, Karak N, Jonkers H., Biopolymers and Biotech Admixtures for Eco-Efficient Construction Materials, Elsevier, Langfordlane, UK. 2016, p. 449.
28. Binici H, Aksogan O., Insulation material production from onion skin and peanut shell fibres, fly ash, pumice, perlite, barite, cement and gypsum, Materials Today Communications 10 (2017) 14–24.

UTICAJ DODATKA BELANCA IZ JAJETA, ELEKTROFILTERSKOG PEPELA, PERLITA I GIPSA NA EKOLOŠKE IZOLACIONE MATERIJALE

U ovoj studiji, istražuju se inženjerska svojstva izolacionih materijala proizvedenih sa dodatkom belanca iz jajeta, elektrofilterskog pepela, perlita i gipsa. Ispitivani su specifična težina, odnos upijanja vode, brzina prolaza ultrazvuka i koeficijenti toplotne provodljivosti. Dalje koeficijent linearne apsorpcije je meren putem zaćienja gama zracima sa energijama od 17.7, 26 i 60 keV. Koeficijenti toplotne provodljivosti proizvedenih kompozita se nalaze u rasponu 0.0908- 0.1112 Kcal/mh°C. Belance iz jajeta smanjuje koeficijente linearne apsorpcije. Jedinična težina uzoraka je zavisila od njihovog sadržaja. Kako se povećavao udeo gipsa, sa njim se povećavala jedinična težina. Kako se udeo perlita povećava, tako se povećava i koeficijent toplotne provodljivosti. Koeficijent linearne apsorpcije se smanjuje sa smanjenjem količine belanca iz jajeta.

Najvažnija korisna osobina ovih tipova materijala je njihova nepropustljivost i izuzetna kompatibilnost sa prirodnim okruženjem. Ovi laki materijali su bili kompatibilni u turskim uslovima i uslovma Srednjeg istoka. Belance iz jajeta je otporno na radijaciju. Stoga je i veoma ekološki *kompatibilno. Čvrstoće na pritisak i savijanje maltera u kojima je korišćeno belance iz jajeta su smanjene. Belance povećava vezivnu čvrstoću uzoraka. U nekim slučajevima, korišeni su i drugi organski i neorganski aditivi, da bi se poboljšale fizička i mehanička svojstva maltera, kao što su belanca i neki drugi. Konačno, ova studija pokazuje da je moguće proizvesti izolacioni materijal za izolociju od zvuka i radijacije korišćenjem belanca od jajet, perlita i elektrofilterskog pepela. Videlo se ad uzorci koji sadrže belance iz jajeta mogu biti korišćeni u bolnicama, vojnim i industrijskim objektima i skloništima za zaštitu od radijacije. Dalje, ovi izolacioni materijali će biti pušteni u industrijsku proizvodnju u Turskoj nakon ispitivanja u laboratoriji.*

Ključne reči: *Belance iz jajeta, elektrofilterski pepeo, perlit i izolacija*