Determining the Conformity to Standards of Clay Deposits in Tokat-Zile Region As Raw Material In Brick-Tile Production

Sedat KARAMAN[1], Ahmet ESMERAY[2]
[1] Gaziosmanpaşa Üniversitesi, Ziraat Fakültesi, Tarımsal Yapılar ve Sulama Bölüm, Tokat
[2] Gaziosmanpaşa Üniversitesi, Meslek Yüksek Okulu, İnşaat Programı,Tokat

ABSTRACT: Brick is an important construction material and widely used in rural areas of Tokat Province. One of the important factors for bricks and tiles to be to standard is the soil used in manufacturing. The aims of this study were to investigate mineralogical, chemical, and mechanical characteristics of raw material obtained from Sarac clay mineral and to determine quality of this material for brick and tile production. According to the results, quary crude material possesses proper mechanical characteristics such as low plasticity or good plastibility, chemical properties such as SiO_2, Fe_2O_3, CaO, MgO, K_2O content and minerological properties such as illite, chlorite and quartz, which are necessary for materials to be used in brick and tile manufacturing. Results further revealed that physical and chemical properties of the bricks produced by the factories in the region met the standarts.
Keywords: Bricks, bricks soils, clay mineralogy, physical and mechanical features

Tokat-Zile Yöresindeki Kil Yataklarının Tuğla-Kiremit Ham Maddesine Uygunluğunun Belirlenmesi

ÖZET: Tuğla, Tokat yöresi kırsal kesiminde yaygın olarak kullanılan önemli bir yapı malzemesidir. Tuğla ve kiremitlerin standartlara uygun olmasında rol oynayan en önemli faktör kullanılan topraktır. Bu araştırmanın amacı; Zile ilçesi Saraç kil ocağından alınan malzemenin minerolojik, kimyasal ve mekanik özelliklerini saptayarak tuğla-kiremit yapımına uygunluğunu belirlemek ve yörede bu malzemeyi kullanan fabrikalardan alınan tuğlaların mekanik ve fiziksel özelliklerini saptamaktır. Araştırma materyalinin tuğla-kiremit sanayisinde kullanılabilecek malzemede aranan plastiklik gibi mekaniksel; SiO_2, Fe_2O_3, CaO, MgO ve K_2O içeriği gibi kimyasal ve illit, klorit ve kuvars içeriği gibi minerolojik özelliklere sahip olduğu saptanmıştır. Tokat yöresinde faaliyet gösteren ve söz konusu ham maddeyi kullanan tuğla fabrikasında üretilmekte olan tuğlaların mekanik ve fiziksel özelliklerinin, standartlara uygun olduğu belirlenmiştir.
Anahtar Kelimeler: Tuğla, tuğla toprakları, kil minerolojisi, fiziksel ve mekanik özellikler

INTRODUCTION

Agricultural structures are one of the most important factors which have indirect influence on the development of agriculture. As the development of agricultural structures is closely related with the material which forms the structural components, it is necessary that appropriate materials, planning and construction techniques be investigated and found. Though there are many studies on the features of construction materials, there is still a lot to be learnt about material nowadays. Particularly, is needed to learn to use construction materials more economically and confidently (Ekmekyapar and Orung, 1993).

Brick is produced by firing clay with sand in special ovens or kilns after it is mixed with water and molded (Tekinel et al, 1989). Bricks which are blended and molded by hand are called harvest bricks, and the ones which are molded and fired automatically in factories are called factory bricks. Factory bricks are quite homogeneous, and they don't have a cavity. They have vertical and horizontal holes. They are divided into three groups with respect to their dimensions: normal, modular and block. The dimensions are 19x9x5 cm for normal type and 19x9x8.5 for modular. A block brick is larger than a modular brick, and has a size of a definite number of modular bricks' size (Taymaz, 1992; Ekmekyapar and Orung, 1993).

Clay used in production has an to important role in the conformity of bricks and tiles in standards. The raw material of bricks which forms an important part of soil industry can be found with several regions of our country. The demand for bricks has increased significantly in parallel with the rapid development in construction sector, and therefore, efforts to meet the brick demand have gained speed. Mechanical and mineralogic features are more important than chemical features in the choice of soil used for construction bricks (Ozısık, 2000). Soil material preferred for brick-tile production consists of 25%-50% thin gravel. Material which can be used in brick-tile industry should also have features such as low or medium plasticity, low swelling-shrinking and moisture. If the soil used is rich in kaolinite**,** illite, chlorite, talc, vermiculite and quartz, it causes the material to have the features mentioned above. The most appropriate clay mineral for brick-tile production is illite. The distance between the layers in illite does not increase or decrease, so it does not swell or shrink. Smectite group minerals in the raw material cause the ingredient to hold too much water and swell, and therefore lead to extreme plasticity, and shrinking in volume during firing. Therefore, to avoid shrinkage and cracking, raw material should not contain smectite type clay or it should be at a minimum level (Grim, 1962; Guz, 1978; Munsuz, 1985; Ozısık, 2000).

The technical features expected from bricks are adequate resistance to pressure, little change in size, smoothness in shape, lightness, and endurance to external factors. The quality of a brick changes according to composition of raw material used (gravel and clay), production method, firing method and the temperature (Ozcelik, 1975; Tekinel et al, 1989).

Brick has been intensively used in agricultural structures in the Tokat region. The soil appropriate for brick production is abundant in the area, and this leads to cheap and easy production in the district. Particularly, the production of Tokat region meets the brick demand of the cities in East Black sea region and East Anatolia. However, although there are 38 brick factories, only 18 of them are working. Some of the active factories is in Zile region. Unit production of the factory per year is 14 000 000, and soil consumption is 8 000 m^3/year (Anonymous, 2000).

The aim of this study was to determine whether the raw material in Sarac clay deposit is suitable for brick production with respect to technological, chemical and minerological features. In addition, brick samples were obtained from the factories in the Tokat-Zile region which uses this raw material, in order to investigate their compliance with the standards, and their physical and mechanical features were determined with respect to standards of Turkish Standards Institute.

MATERIALS and METHOD

Materials

Ten kg of decomposed soil samples taken from five different parts of the Sarac region clay deposit (Figure 1) and the bricks taken from the factory using material from the Sarac clay deposit formed the materials in this study (Anonymous, 1985a; Anonymous, 1985b). The bricks used in the study were block bricks with holes, and they were 19x19x13.5 cm as stated in Anonymous (1985b). This type of brick is used widely in the agricultural structures in region, and it forms the largest part of the brick production.

Method

SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, K_2O and Na_2O contents, and the amount of firing loss were applied according to the principles stated in Arkun (1980). The minerologic analyses of the samples were done using the method stated in Jakson (1975), and were determined using an X-ray diffractometer. A Bouyocous hydrometer was used to determine the body (Gee and Bouder, 1986), and liquid and plastic limits were determined according to Mitchell(1976). The principles in Arkun (1980) and Ozısık (2000) were used to evaluate the results.

Randomly selected brick samples in accordance with the principles in Anonymous (1985a) were examined. Their features such as volume weight, resistance to frost, hazardous material (manganese and lime), and the size and the shape of the bricks' surface features were determined according to Anonymous (1985a) and Anonymous (1985b). PÇ 325 (Portland cement) produced in the Sivas Cement Factory and 0/1 mm washed sand were used to cap the samples undergoing the pressure resistance test. To determine the thawing and defrosting resistance of the samples, a cooler 0.6 m^3 in size and -15 ^{0}C adjustable, and a water tank with a adjustable temperature adjustable feature were used. To determine the size, a furnace adjustable to 110 ^{0}C±5 ^{0}C, and a scale of 0.1 g sensitivity were used. A metal ruler, a metal set square, and a compass of 0.1 mm sensitivity were used to examine the shape and appearance of the samples. A 200 tone capacity hydraulic press was used to test the pressure resistance. The mean value was obtained for every feature, and their conformity was determined by comparing them to the values suggested in the standards.

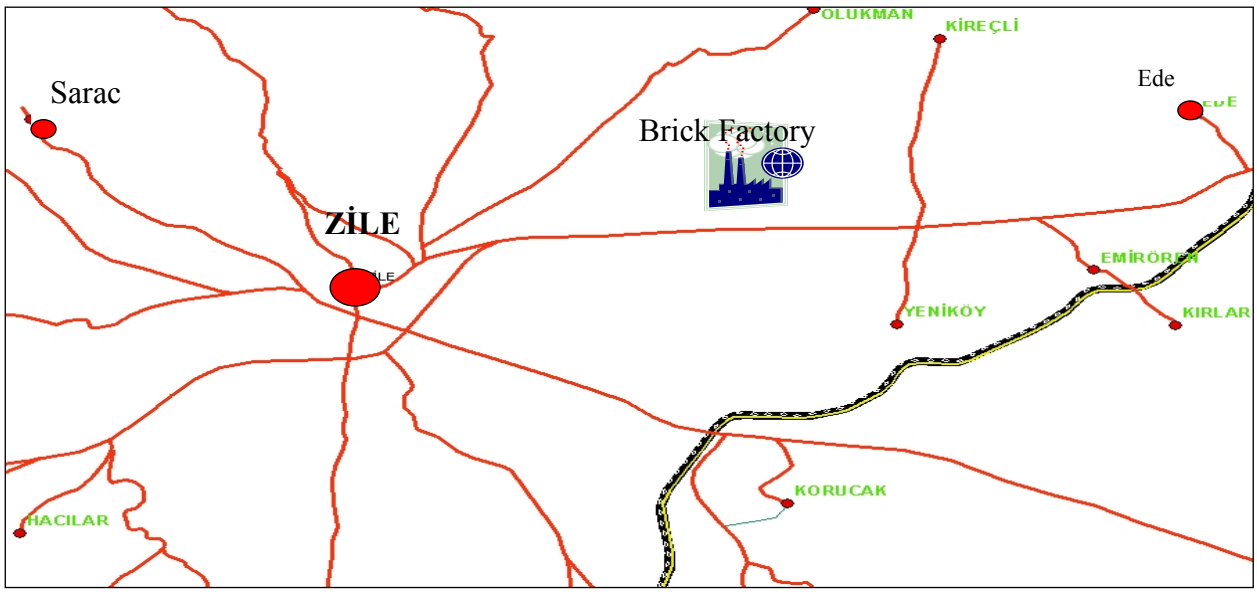

Figure 1. The location of brick plant raw material areas

RESULTS and DISCUSSION

The material field conforms with the open operating system, and it is in medium hard soils class. As the natural conditions are suitable, it does not have ground water. The material fields is fifth class land (non agricultural field). Raw material need of the Zile brick factories is 9 000 m^3 per year.

The chemical analysis of the soils reveals minerologic composition, and clay composition indirectly. The chemical analysis of clay minerals generally helps determine the type of clay mineral (Munsuz, 1985). To determine whether clay minerals will be used in soil product industry or not, or what type of soil product industry will use them, it is necessary to know their silica, aluminum, calcium, magnesium, potassium and sulfate content, and the amount of loss after firing. Table 1 presents the results of the chemical analysis of the samples and the limit values.

Table 1. The chemical compositions of the samples and the limit values relating to these compositions.

Chemical properties / Samples	SiO_2 (%)	Al_2O_3 (%)	F_2O_3 (%)	CaO (%)	MgO (%)	K_2O (%)	Na_2O (%)	Burning losses (%)
1	45.72	17.89	7.83	8.91	3.73	2.17	1.37	7.93
2	57.56	15.25	5.69	5.56	2.54	2.18	1.92	7.82
3	50.89	15.74	6.61	7.83	4.45	2.59	1.39	7.84
4	52.06	17.20	7.19	5.10	3.45	2.65	1.28	4.94
5	48.92	21.15	7.19	3.55	3.85	2.65	1.21	4.84
X_{ort}	51.03	17.45	6.88	6.19	3.60	2.45	1.43	6.67
Limit values (%)	42.7-64.5	16.3-20.6	2.8-7.0	0.7-9.5	0.8-6.2	0.6-1.7	0-6	6.3-11.5

The arithmetic mean values of the results of the material taken from the operation field match the limits stated in Arkun (1980). In addition, high Fe_2O_3 content, which can also be observed morphologically, removes the color problem of this material. While the amount of lime, which is viewed as an important problem in brick-tile production, is preferred at less than 9.5% (Arkun, 1980), it varied between 3.55%-8.91% in the samples.

The minerals in the samples were determined by comparing the minerologies of the samples from the study field to data obtained from standard minerals. The analysis of clay fractions of the samples revealed that in chlorite and illite type minerals were dominant (Figure 1). Smectite type clay minerals, which are not suitable for brick production, were absent and is an indication that the minerologic structure of the material used is suitable for brick production.

The mechanical analysis revealed that the material used in the study had low plastic limit and liquid limit values. According to the results, the clays obtained from the Sarac clay deposit, had the following average values; 37.86 liquid limit, 29.54 plastic limit and 9.4 plasticity index (Table 2). According to Mitchell (1976), in soils which are dominant in illite, chlorite type clay mineral, Attaberg limits (liquid limit, plastic limit and plasticity index) are much lower when compared to the soils which are dominant in other clays (montmorillonite**,** allophane**,** etc.), and the plastic limit ranges between 19% and 40%, and the liquid limit ranges between 30% and 90%. Soils with plasticity index between 8 and 25 are suitable for brick production (Ozısık, 2000). When these values are considered, the plastic limit values and the liquid limit values of the samples are low. That the difference between plastic limit values and liquid limit values were not high resulted in a low plastic index.

The particle size percentages are 17.92% gravel, 48.15% silt and 33.93% clay. A very subtle gravel and silt content results in low plasticity. The plastic limit values are 17% and 20% for gravel, 20% and 25% for silt, and 25% and 35% for clay. All clay soils, which have the ability to be shaped, which become sinter to resist every type of climatic condition when fired, and whose tile form color, are suitable for brick-tile production. More than 50% of the material used in the study is from clay class with silt sifted from the fine sieve no 200, and it can be used in brick- tile production as it does not have a large fraction content, and it has an appropriate fraction distribution.

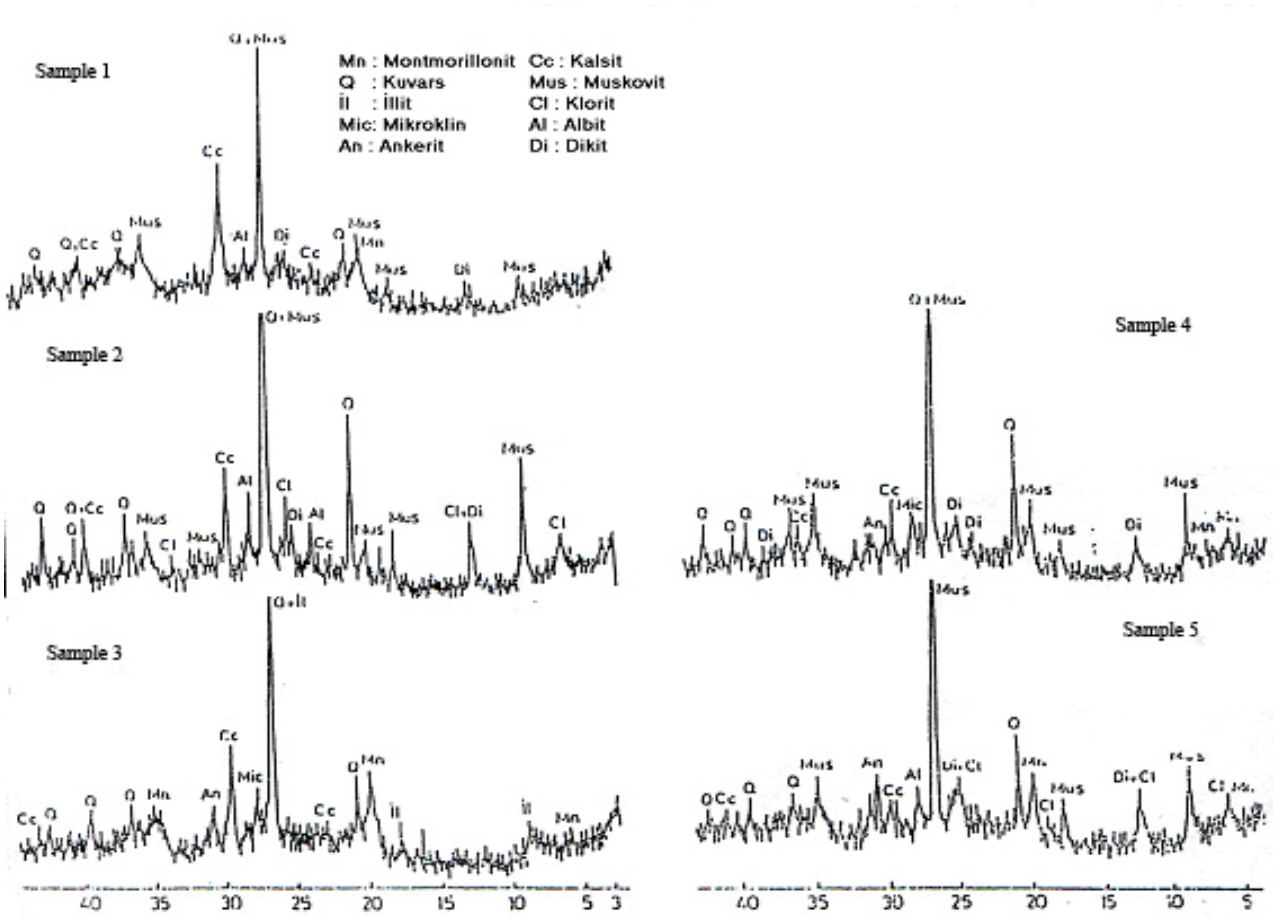

Figure 1.X-ray diffractograms of raw material used in sample preparation.

Table 2. Some of the mechanical properties of the samples

Samples	Liquid limit (LL) (%)	Plastic limit (PL) (%)	Plasticity index (PI) (%)	Particle size (%)			Texture class
				Sand	Silt	Clay	
$\mathbf{X}_{avg}$	37.86	29.5	9.4	17.92	48.15	33.93	SiC

Volume weight equals unit weight of a brick, and as unit weight decreases, its resistance and temperature conductivity decrease as well (Ekmekyapar and Orung, 1993). The average volume weight of the brick samples was 690 kg/m^3. All of the brick samples with holes are competent, with a minimum volume value of 901-501 kg/m^3, as suggested in Anonymous (1985b).

Pressure endurance is the most important feature of a brick, and it changes depending on a number of factors. The amount of cavity in a brick, firing temperature, production method, the number and the location of holes, the shape of the borders, loading directions etc. influence the endurance to pressure. Apart from this, the features of the soil, a brick is made of, also have an effect on the endurance (Mc.Burney, 1970). The results of the pressure test done were between 33 and 86 kgf/cm^2, and the average was 64 kgf/cm^2. These values match the limits of pressure endurance which a brick should have, as stated in Anonymous (1985a). The pressure endurance difference among bricks used in construction may lead to major problems in load bearing walls. Samples which are high in volume weight are also high in pressure endurance. As the amount of cavity in a brick increases pressure endurance decreases parallel with it. The amount and shape of the holes in a brick has an effect on pressure endurance. A brick with the same proportion of hole volume but having a lot of small holes has a higher pressure endurance.

When the frost endurance test was applied, none of the samples had cracks or trash. As stated in Anonymous (1985b), the samples which were exposed to frost endurance test were also endurance tested and the results matched the values suggested.

The results of lime and manganese analysis done according to Anonymous (1985a) indicated that there were no cracks, breaking off or scaling on the brick samples. Ekmekyapar or Orung (1993) stated that bricks should not have a high CaO and MgO content, otherwise, it could lead to wearing of the bricks when they contact water.

In conclusion, it was determined that the mineralogical, chemical and mechanical features of the raw material from the Zile-Sarac clay deposit is appropriate for brick-tile production. With respect to technologic features, all of the bricks produced from this material conformed to the standards relating to pressure endurance, volume weight, frost endurance, and harmful manganese and lime content.

REFERENCES

Anonymous, 1985a. Inşaat Muhendisliğinde Sondaj Yolları ile Orselenmiş ve Orselenmemiş Numune Alma Yontemleri. TS 1901, Türk Standartları Enstitusu, Ankara, 88s.

Anonymous, 1985b. Fabrika Tuğlaları-Duvarlar İçin. TS 4563, Türk Standartları Enstitusu, Ankara, 16s.

Anonymous, 2000. 1999 Yılı Ekonomik ve Ticari Durum Raporu, TC. Tokat Valiligi, Sanayi ve Ticaret Il Mudurlugu, Tokat.

Arkun, N., 1980. Tubitak Bilgi Profili. No:14, Ankara. 26.

Ekmekyapar,T. and Orung, İ.,1993. Inşaat Malzeme Bilgisi. Atatürk Univ. Ziraat Fak. Derg. Yay., No: 145, Erzurum. 224s.

Gee, GW and Bouder, JW. 1986. Methods of Soil Analysis Part 1. Physical and Mineralogical Methods. Second Edition. Arnold Klute (ed). American Society of Agronomy. 383p.

Grim, R., E., 1962. Applied Lay mineralogy. McGraw-Hill Com., Inc., New York.422p.

Guz, H.,1978. Dinlenme ve Kurutmanın önemi. Tugla-Kiremit Semineri, Imar ve İskan Bakanlığı Yayınları, No:5, Sayı:20, Ankara, 63.

Jackson, M.L., 1975. Soil Chemical Analysis. Adv. Course Dept. Soil Sci., Madison,Wisc., 121.

Mc.Burney, W. J. 1970. The Effect of Strength of Brick on Compressive Strenght of Brick Masonry. Process ASTM, Vol.28, Part II, 57.

Mitchell , J. K., 1976. Fundamentals of Soil Behavior. John Wiley Sons Inc. New York, 84-99.

Munsuz, N., 1985. Toprak Mekaniği ve Teknolojisi. Ankara Üniv. Ziraat Fak. Yayınları,No:922, Ankara, 448p.

Özcelik, N., 1975. Inşaat Bilgisi. İstanbul Univ. Orman Fak., Yayınları, 1135, İstanbul, 132.

Ozısık, G., 2000. Yapı Muhendisliğinde Kagir Yapı, Tuğla Elemanlar ve Yapı Sistemleri. Birsen Yayınevi, İstanbul. 164p.

Taymaz, H., 1992. Yapı Bilgisi. Milli Eğitim Bakanlığı Yayınları No: 4/4, Ankara, 360 p.

Tekinel, O., Cevik, B. ve Tekinsoy, M.A., 1989. Inşaat Malzeme Bilgisi. Cukurova Univ. Ziraat Fak. Ders Kitabı, No:103, Adana, 134p.