WHITE CERAMIC BODIES FOR CLINKER TILES

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1. INTRODUCTION

Clinker tiles possess high mechanical strength, low water absorption, high density, high wear resistance and high frost resistance. Natural raw materials are generally used for clinker tile production. However, a particular interest exists in finding less expensive raw materials, such as scrap from other ceramic productions. The aim of the present work is to formulate and test new white ceramic bodies for clinker tiles using scrap from porcelain production, such as fired porcelain scrap, porcelain green body scrap and chamotte scrap.

2. EXPERIMENTAL

Ceramic bodies for clinker tiles were formulated for firing at a temperature of 1150°C. The bodies contained porcelain green body, fired glazed porcelain scrap and chamotte. The clinker body compositions are presented in Table 1. The chemical analyses of the raw materials are given in Table 2. Plastic forming and semi-dry pressing were used for preparation of the ceramic clinker bodies. The clinker tiles were fired in industrial conditions at the manufacturer SHAMOTE Ltd. at 1150°C, with a cycle of 48 hours. For the body characterization, the following analyses were used: X-ray diffraction analysis / diffractometer DRON 3M – Russia, Co Kα radiation/ and SEM /apparatus PHILIPS 515 - Holland/. The physico-mechanical properties of the white ceramic bodies in the green and fired state were determined by standard methods. Their phase composition was also established.

RAW MATERIALS	Composition number of the ceramic body for clinker tiles				
	1	2	3	4	5
Green porcelain body, %	80	70	60	50	40
Fired glazed porcelain scrap, %	10	15	20	25	30
Chamotte, %	10	15	20	25	30

Table 1. Studied ceramic body compositions for clinker tiles.

RAW MATERIALS	OXIDES, %											
	LOI	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	Na_2O	K_2O	MnO	SO_3	P_2O_5
Green Porcelain body	7.55	64.70	17.44	2.58	0.69	1.15	0.46	1.54	3.89	0.02	0.09	0.09
Fired Porcelain scrap	0.28	70.09	23.06	0.57	0.25	0.81	0.42	2.76	1.52	<0.01	0.06	0.13
Chamotte	3.09	58.70	33.85	1.21	0.29	0.19	0.48	0.18	1.81	<0.01	0.08	0.09

Table 2. Raw materials chemical composition.

3. RESULTS AND DISCUSSION

The phase composition of the raw materials is shown in Figure 1. The identified non-plastic components in the raw materials were quartz, cristobalite, Na-Ca plagioclase, mullite and zircon. The presence of mullite is favourable because it assures

higher mechanical strength of the clinker tiles. The X-ray diffraction data of the fired clinker body compositions are presented in Figure 2. The same crystal phases can be observed in the bodies, but with a decrease in the quantity of porcelain body and an increase in the chamotte and porcelain scrap quantities, the amount of mullite increases.

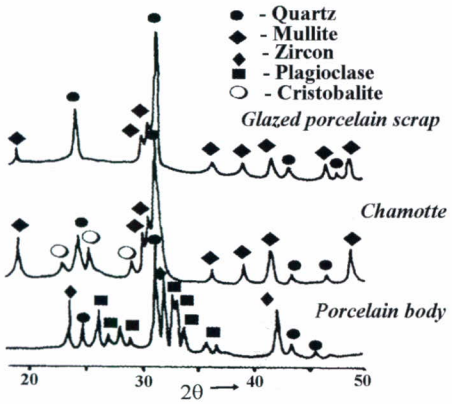

Figure 1. XRD of the raw materials.

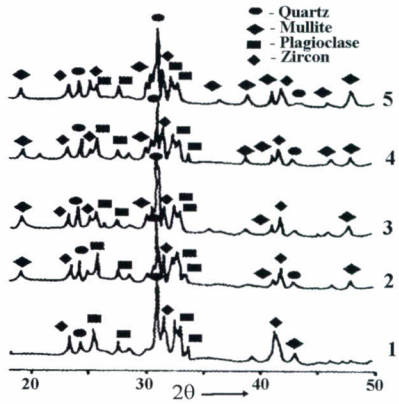

Figure 2. XRD of the ceramic bodies.

The results of the measured physico-mechanical properties: drying and firing shrinkage, plasticity, mechanical bending strength, mechanical breaking strength and water absorption are given in Table 3. The values of the physico-mechanical properties vary within the following limits: green bending strength increases from 2.5 to 3.1 MPa; fired bending strength – from 38.70 to 48.40 MPa; breaking strength – from 100 to 127 MPa, water absorption – from 0.20 to 4.70 % for the plastic bodies and from 1.65 to 2.70 % for the semi-dry pressed ceramic bodies. Increasing the content of the fired components in the clinker bodies, such as porcelain scrap and chamotte, raises water absorption and lowers shrinkage. The white clinker tiles obtained from the new studied ceramic bodies meet the requirements of the EN standards for clinker tiles.

PROPERTIES	COMPOSITION OF CERAMIC BODY									
	BODY 1		BODY 2		BODY 3		BODY 4		BODY 5	
	Plastic forming	Semi-dry pressing	Plastic forming	Semi-dry pressing	Plastic forming	Semi-dry pressing	Plastic forming	Semi-dry pressing	Plastic forming	Semi-dry pressing
Drying shrinkage, %	5.7	-	5.9	-	4.8	-	4.2	-	3.9	-
Firing shrinkage, %	10.4	6.5	10.0	6.0	9.8	5.9	9.1	5.7	8.3	5.6
Plasticity by Pfefferkorn, %	27.00	-	25.70	-	25.50	-	24.65	-	23.80	-
Green bending strength, MPa	3.1	2.8	3.0	2.8	2.7	2.7	2.6	2.6	2.4	2.5
Fired bending strength at en cocido 1150°C, MPa	45.60	43.60	48.40	47.50	40.70	41.00	38.70	40.00	38.70	39.90
Breaking strength at 1150°C, MPa	100	115	100	100	105	100	116	127	125	112
Water absorption, %	0.25	1.65	0.20	1.77	3.20	1.33	4.40	1.75	4.70	2.70

Table 3.

Figure 3 shows the structure of the fired clinker tile obtained from the ceramic body with composition 4. The SEM micrograph shows a dense-sintered ceramic body with uniformly distributed spherical or long narrow pores. The fracture surface of the clinker tile obtained from ceramic body 4 is shown in Fig. 4. A dense-sintered ceramic body can be observed.

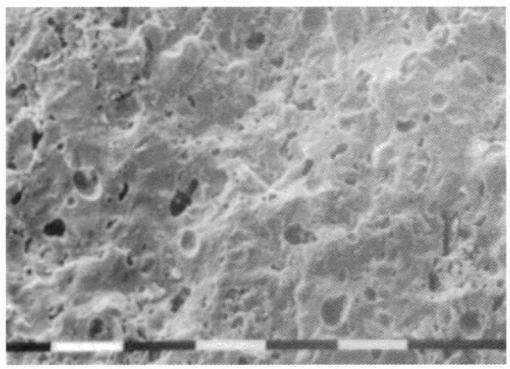

Figure 3. SEM micrograph of the clinker tile from body composition 4, x 100.

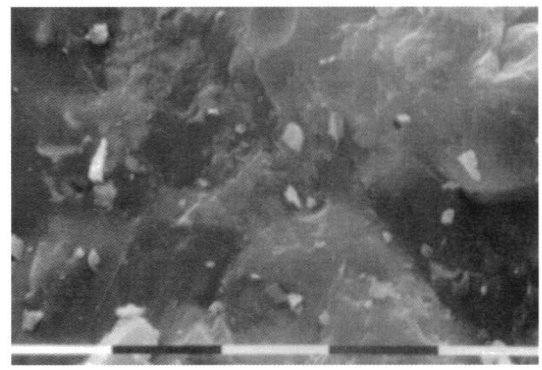

Figure 4. SEM micrograph of the fracture surface of the clinker tile from body composition 4, x 1500.

4. CONCLUSIONS

New ceramic bodies for clinker tiles were formulated using scrap from porcelain production, such as fired porcelain scrap, porcelain green body scrap and chamotte scrap.

Clinker tiles were fabricated, fired at 1150°C, with a dense-sintered structure and very good physico-mechanical properties, which demonstrate the favourable role of fired porcelain scrap in ceramic clinker bodies.