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Effect of moulding humidity on the properties of dry pressed ceramic tiles

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Summary

The aim of the work was to describe moulding humidity influence on the properties of dry pressed ceramic tiles from fly ash – clay mixture (70 % fly ash and 30 % stoneware clay). It was determined properties of green body (bulk density) and fired body (water absorption, bending strength, bulk density and apparent porosity according to EN ISO 10545 standards) by the mathematical functionalities.

KEYWORDS: Dry pressed ceramic tiles, pressing water content, bulk density, water absorption, green ceramic body, fired ceramic body.

1. INTRODUCTION

The enormous amount of fly ashes generated during mineral coal burning is still far from being used in its totality as a product or by-product, making technological alternatives needed in order to reduce its possible environmental impact. The paper present one of the possibilities how to use fly ashes – as a basic raw material for the production of ceramic tiles.

It is evident, that moulding moisture influenced properties of dry pressed green or fired ceramic body very much. It was determined optimal water content to get maximal compact green body and the best properties of the firing fly ash - clay bodies according to EN ISO 10545 standards (e.g. water absorption, bending strength) and properties of the fly ash body microstructure. The properties of firing fly ash – clay body (water absorption, bending strength) were compared in accordance with requirements of EN 14411 for dry pressed for ceramic tiles (Table 1).

Table 1 - The choose properties of ceramic tiles - group B

Characteristics		BIa	BIb	B IIa	B IIb	B III
Water absorption [%]	average individually	≤ 0,5 Max. 0,6	0,5 - 3 Max. 3,3	3 - 6 Max. 6,5	6 - 10 Max. 11	> 10[2]) Min. 9
Bending strength [MPa]	average individually	≥ 35 Min. 32	≥ 30 Min. 27	≥ 22 Min. 20	≥ 18 Min. 16	≥ 15[1])
Breaking strength (t ≥ 7,5 mm)		1300 N	1100 N	1000 N	800 N	600 N

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2. RAW MATERIAL PROPERTIES

The fly ash utilized in this work was originated in the burning process of mineral brown coal in a pulverized coal-fired plant of Thermoelectrical Power Station, which is located in Melnik (Czech Republic). This thermoelectrical process has good efficiency in the combustion of the mineral coal and the residual carbon is very low - 1,2 wt%. Stoneware clay (from region Postorna CZ) was used as a binder for non plastic fly ash grains. The chemical composition of raw materials is showed in Table 2.

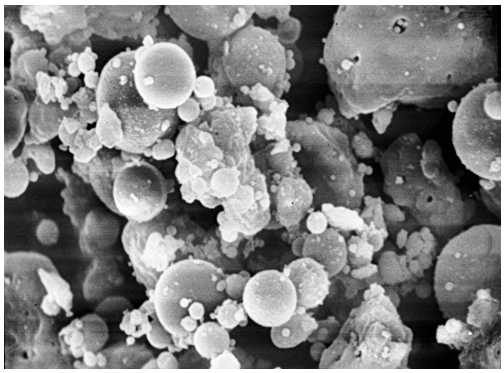

Figure 1. Microstructure of used fly ash (2000x).

Table 2. Average chemical composition of used raw materials

[mass-%]	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	S	IL
Fly ash	55,9	29,3	4,7	1,7	2,2	1,4	1,6	0,1	0,1	1,2
Clay	62,2	18,8	4,2	1,5	1,4	1,4	2,3			9,3

Particle size distribution of fly ash was studied by using of the floating method through the 0,063 mm sieve. The fly ash was grinded in the dry laboratory ball mill with clay together to get minimal residue on the 0,063 mm sieve.

Table 3. Particle size distribution of fly ash

	Original	After Ball grinding with clay
Sieve residue 0,063 mm [%]	43,2	5,9

3. SPECIMEN SHAPING AND FIRING

The mixture of raw materials (70 % mass fly ash + 30 % mass clay) was milled in dry ball mill together. Test specimens measuring 100 mm x 50 mm x 10 mm were shaped in a laboratory press from granulate = moistened mixture with a different

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water content were pressed through a 1 mm sieve. The pressing pressure corresponds to used values for dry pressed ceramic tiles industrial production from spray-dried granulates (40 MPa).

The firing of test specimens proceed in the industrial tunnel kiln – maximal firing temperature 1020 °C with 5 hours soaking time in this temperature. After firing, It was determined properties of firing body: E – vacuum water absorption, B – bulk density (B_g – bulk density of green (not fired, only after drying) body, B_f – bulk density of fried body), P – apparent porosity, T – apparent relative density according to EN ISO 10545 – 3 and capillarity in dependence on moulding humidity. Frost resistance of firing body was determined by using indirect method - T – value (saturation value according to DIN 52253 – 3) describes the amount of open pores capable of filing with water under atmospheric pressure, in relation to the pores which fill with water at a vacuum of 30 mbar. Frost resisted bodies embody low T – values (under 0,75).

5. RESULTS

According to figures 2, 3 and tables 4, 5 it is evident, that all determined properties of green or fired bodies are depended on the pressing moisture of pressing granulate – it is concerned linear dependence. With increasing of pressing moisture the body is more compact and decreased the capillarity of fired fly ash – clay dry pressed body.

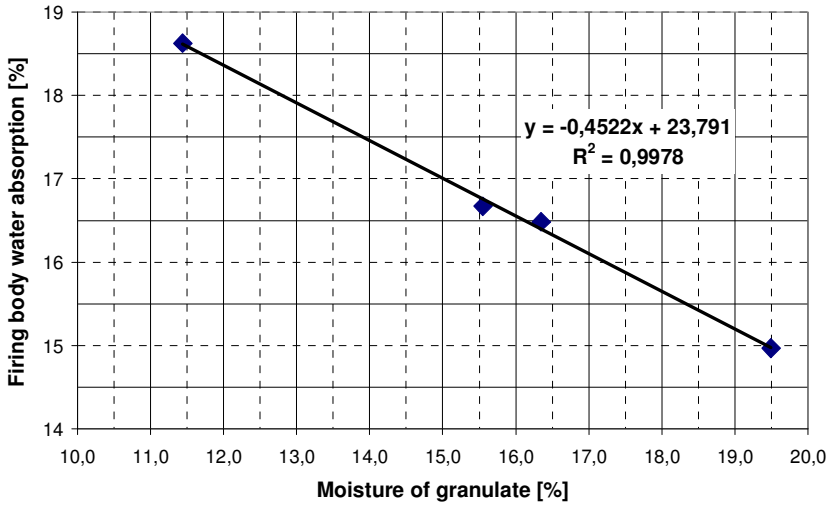

Figure 2. Fired body water absorption in dependence on pressing moisture of granulate

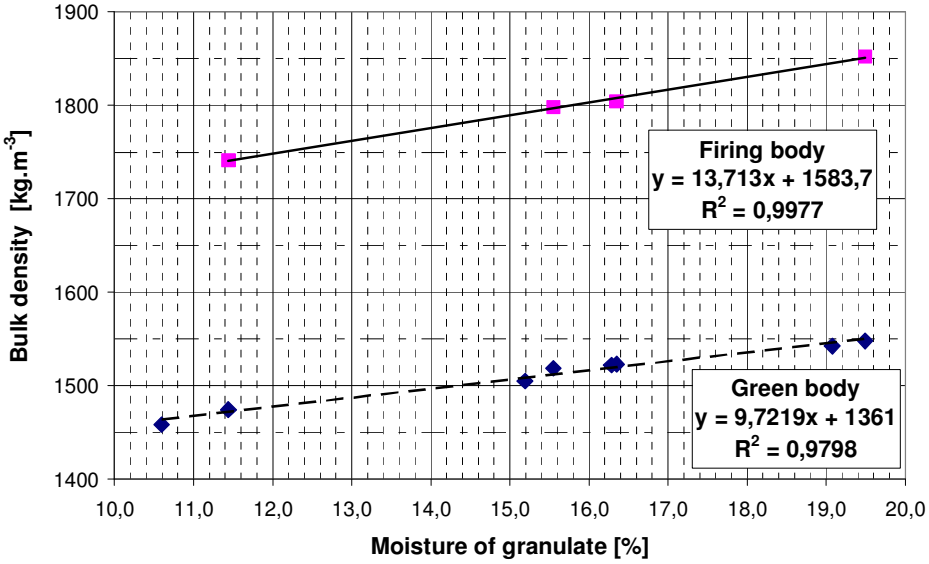

Figure 3. Bulk density of green and fired body in dependence on pressing moisture of granulate

Table 4. Properties of green and fired body

Moisture [%]	B_g [kg.m^{-3}]	B_f [kg.m^{-3}]	P [%]	E [%]	T [kg.m^{-3}]	T-value [-]
10,6	1458					
11,4	1475	1741	32,4	18,6	2577	0,988
15,2	1505					
15,6	1519	1798	30,0	16,7	2568	0,981
16,3	1523	1804	29,7	16,5	2569	0,976
19,1	1542					
19,5	1548	1852	27,7	15	2563	0,963

Table 5. Capillarity of fired bodied in dependence on pressing moisture of pressing granulate

Moisture [%]	Capillarity [mm] – after 5-10-20-30-40-50-60-70 min							
	5	**10**	**20**	**30**	**40**	**50**	**60**	**70**
11,4	47	64	76	85	all			
15,6	40	54	65	74	83	95	all	
16,3	36	50	60	69	77	83	all	
19,5	34	45	54	62	69	75	86	all

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6. CONCLUSION

Possibility of dry pressed ceramic tiles production explicitly on base of Czech fly ashes is quite real. To get optimal properties of final fired body it must be determined optimal water content of pressing granulate.

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