SINGLE FIRED FLOOR TILE BODIES CONTAINING FELDSPAR AND PERLITE

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INTRODUCTION

In the production of ceramic tiles several minerals and rocks such as K-Na feldspar, talc, magnesite, wollastonite, pegmatite, dolomite, limestone, etc. are used as fluxes. Talc is considered an effective mineralizer of the ceramic bodies in fast single firing (at 1080°C for under 40 min) of white earthenware tiles[1]. An addition of 5 wt% talc reduces water absorption and increases tile mechanical strength from 19 to 22.5 MPa. Talc influences the vitrification of single fired floor tiles, reduces firing temperature and increases their mechanical strength at the same time[2]. Floor tiles that contain 34% feldspar and 6% talc, after firing at 1135°C have 5.3% shrinkage and 43 MPa bending strength. In floor tile production, in order to achieve fully sintered masses at 1190-1230°C, together with the pegmatite or K-Na feldspar, additives such as magnesite, dolomite, talc and wollastonite are used[3]. The addition of 3 wt% talc instead of pegmatite or K-Na feldspar improves the sintering of the masses, reduces firing temperature and porosity and increases bending strength and abrasive resistance. The use of wollastonite in tile production provides constant tile dimensions in fast firing (less than 30 min), reduces shrinkage and moisture expansion and increases strength[4].

EXPERIMENT AND DISCUSSION

In a floor tile body that contains (% by weight): 30 refractory clay, 5 washed kaolin, 20 raw kaolin and 45 K-Na feldspar, the last material is partially or fully replaced by perlite with an insignificant supplement of limestone and dolomite (Table 1).

Sample	Composition (wt%)							
	Yellow clay	Gray clay	Washed kaolin	Raw kaolin	K-Na feldspar	Perlite	Limestone	Dolomite
P0	10	20	5	20	45	-	-	-
P7	10	20	5	20	35	7	1	2
P15	10	20	5	20	25	15	2	3
P35	10	20	5	20	-	35	3	7

Table 1. Ceramic bodies for floor tiles.

The refractory clay is represented by yellow clay and gray clay that are characterized by the following properties: water absorption - 3.38% and 11.20%; drying shrinkage – 10.0% and 4.5%; firing shrinkage – 15.0% and 7.4% and plasticity – 34.4% and 18.0%. The perlite contains 90-95% volcanic glass and 5-10% K-feldspar and quartz.

The ceramic bodies are ground in a porcelain ball mill with an input:milling media:water ratio of 1:1.5:1. The grinding process is conducted to 1-2% residue on a 10 000 mesh sieve. The obtained slip is dried to pressing powder with 6-8% moisture content. The pressing powder is placed in polyethylene bags and left to mature for 24 h.

Ceramic samples with the following dimensions: 1.2x9.0x0.5 cm and 4.0x4.0x0.5 cm are formed under 40 MPa pressure. The prepared samples are dried at 110°C – 2 h after which they undergo single fast firing in the temperature range of 1075-1215°C in each 25°C, with a holding of 15 and 30 min at maximum temperature. The chemical composition of the white glaze is (% by weight): 59.4 SiO_2, 0.1 Fe_2O_3, 5.3 CaO, 0.3 MgO, 1.0 ZnO, 9.3 ZrO_2, 12.8 B_2O_3, 5.5 Na_2O and 0.6 K_2O. The glaze is applied on the tile through semidry pressing at less than 20 MPa pressure, after which the samples are repressed under 40 MPa. The physico–mechanical properties of the single fired ceramic bodies are displayed in table 2.

Sample	1150°C – 30 min			1150°C – 15 min		
	σ_0, MPa	WA, %	S, %	σ_0, MPa	WA, %	S, %
P0	46.1	0.37	8.27	45.3	0.40	8.17
P7	53.2	0.31	7.34	50.0	0.35	7.26
P15	50.9	0.30	7.25	47.8	0.34	7.19
P35	42.7	0.28	7.13	38.6	0.30	7.05

Table 2. Bending strength (σ_0), water absorption (WA) and shrinkage (S) of the unglazed ceramic bodies.

The sintering range of the ceramic masses has been established as well as the optimal firing temperature. The ceramic bodies are sintered in 1125-1200°C range and the optimal firing temperature is 1150°C for 15-30 min. Single fired ceramic samples have a light brown dense texture, high mechanical strength and low water absorption (table 2). The hold at maximum temperature has no effect on the physico–mechanical properties of the samples, so it can be reduced to 15 min. The combined addition of perlite, limestone and dolomite up to 20 wt% to the ceramic body for floor tiles instead of K-Na feldspar improves the vitrification of the ceramic bodies and enables reducing firing temperature, increasing mechanical strength and lowering water absorption and shrinkage. The optimum amount of the addition (% by weight) is 7 perlite, 1 limestone and 2 dolomite. When K-Na feldspar is fully replaced with perlite, limestone and dolomite, the fired samples have lower mechanical strength compared to those made from the basic composition, and they show a tendency to deform, assumed in this paper to be caused by the fast firing method.

The ceramic samples of the basic composition (P0), single fired at 1150°C, have 46.1 MPa bending strength; 0.37% water absorption and up to 8.27% linear shrinkage. Under the same firing conditions, the samples obtained from the mass P7 with the optimum addition of perlite (7 wt%), limestone (1 wt%) and dolomite (2 wt%) have 53.2 MPa bending strength, 0.31% water absorption and 7.34% linear shrinkage. The samples have no deformations. The glazed samples, single fired at 1150°C – 30 min, made from the P7 mass have 54.6 MPa bending strength, 0.22% water absorption and 7.34% shrinkage. The glaze coating shows no defects.

The ceramic tiles fired at 1150°C for 15-30 min are built up of relict quartz grains (0.334 nm) and the new mineral formations are represented by mullite (0.338-0.220-0.341 nm) and anorthite (0.321-0.324-0.411 nm), which are included in the glass phase. The microstructure of the samples is porphyroclastic because of the presence of coarser clastic particles of quartz, situated amongst main matrix with vitrophyric structure.

CONCLUSION

The prepared feldspar-perlite masses for floor tiles composed of (% by weight) 30 refractory clay, 25 raw and washed kaolin, 0-45 K-Na feldspar, 0-35 perlite, 0-3 limestone and 0-7 dolomite have high mechanical strength and low water absorption. The combined addition of 7 wt% perlite, 1 wt% limestone and 2 wt% dolomite instead of K-Na feldspar increases bending strength, lowers water absorption and linear shrinkage of the ceramic samples fired at the optimum temperature 1150°C for 15-30 min.

REFERENCES

[1] GROSJEAN P., Talc: An effective mineralizer in white earthenware tiles, Tile and Brick Int., 6, 465-466 (1995).
[2] GROSJEAN P., Influence of talc on single fired white body tile compositions, Tile and Brick Int., 4, 292, 294-295 (1995).
[3] GROSJEAN P., An auxiliary flux for fully vitrified unglazed floor tiles, Tile and Brick Int., 2, 126-128 (1996).
[4] RIEGER KONRAD C. Wollastonite, Amer. Ceram. Soc. Bull., 75, 6, 161 (1996).