DESIGN OF MIXTURES FOR THE FORMULATION OF MULTICOMPONENT TILES

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1. INTRODUCTION

The design of mixtures appears to be an interesting instrument for the development and optimisation of ceramic tile formulations, since it allows the individual technological behaviour of the raw materials in the mixtures to be evaluated. The validity of the industrial application of the statistical methodology has been evaluated with formulations that contained a similar number of raw materials as those in the industrial ceramic mixtures. Ceramic tiles are mainly made up of variable group of natural raw materials, from which nine were selected in order to compare these mixtures in this study.

2. METHODS AND RESULTS

The experiments were performed at the laboratories of the company T-cota Engenharia de Minerais Industriais, Tijucas, SC, Brazil, where industrial porcelain tile manufacturing stages were reproduced on a smaller scale. The raw materials were referenced in terms of the role that the materials played in the mixtures: "F" for flux and "P" for plastic material. The formulations of the mixtures processed for porcelain tile are given in table 1. Table 2 details the process parameters for this system.

Each formulation was used to prepare four cylindrical test pieces (50 mm in diameter and 5 mm thick) and six rectangular test pieces (110x70x6 mm) for the tests, in order to obtain the vitrification diagram, pyroplastic deformation, and bending strength according to standard NBR 13818:1997.

For each studied response variable, a model was prepared and an analysis was obtained with a high significance and good linear fit for all the properties at issue. In order to validate the experimental design methodology, in accordance with the linear models obtained, verifications tests were proposed of the predictive capability, in order to be able to put forward a composition based on properties determined by the user. Two formulations were processed and characterised in order to compare the relevant properties and the measurements. Table 3 presents the experimental results of the verification. The measured values and the predicted values are observed to lie close together, confirming the good predictive capability of the models, tested through their R2 values. The property with the largest absolute variation was dry bending strength, which had the smallest value of R2 (0.619).

3. CONCLUSIONS

The linear models fitted to the tile mixtures exhibited high significance, with P values smaller than 0.05, and high predictive power with R2 values close to 1. That indicated that there was no need to use more complex models, since the experimental region was correctly determined. The predictive capability of the fitted linear models for tiles is acceptable, since the formulations presented measured values close to the values estimated by the models.

	Composition (% by weight)								
Mixture	**F1**	**F2**	**F3**	**F4**	**F5**	**P1**	**P2**	**P3**	**P4**
1	28			30		20	5	10	7
2	30		20				20	10	20
3	10	15				20	5	30	20
4	30			3	10		20	30	7
5	10		20		10	20	20	13	7
6	15	15	20		10	18	5	10	7
7	25			30	10		5	10	20
8	10		10		10	15	5	30	20
9	10			30		20	20	10	10
10	15	15				20	20	10	20
11	30		8			20	5	30	7
12	10	15		8	10		20	30	7
13	10	15	20	10	10		5	10	20
14	30				10	20	10	10	20

Table 1. Formulations for ceramic tiles.

Milling	Water (%)		36
	Solids (%)		64
	Additives	Deflocculant (%)	0.6
		Binder (%)	0.45
	Residue	Mesh	325
		Oversize (%)	12 a 15
Pressing	Moisture content (%)		6
	Pressure (kgf/cm^2)		280
Firing	Total time (min)		32
	Residence at peak firing temperature (min)		10
	Peak firing temperature (ºC)		1150, 1165, 1180, 1195

Table 2. Process parameters.

Property	Predicted	Measured	Variation (absolute	Variation (percentage)
Dry bulk density(g/cm^3)	1.977	1.987	-0.010	-0.5
Dry mechanical strength (kgf/cm^2)	41.1	44.0	-2.9	-6.6
Pyroplastic deformation (mm)	4.1	4.5	-0.5	-10.0

Table 3. Experimental data for the evaluation of the models.

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