

DESIGN AND MANUFACTURING OF MODULAR PARQUET FLOORING IN INDUSTRIAL SYSTEM

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Abstract:

The paper submits constructive options and methods to design and manufacture modular parquet flooring, as well as fastening methods in constructions. Likewise, it presents the branches of civil engineering where modular parquet flooring may be turned to profit – industrial buildings, company premises or residential premises. The turn towards the achievement of private constructions, such as individual houses, led to losing control of the modular system applied in defining the inner sizes of the constructions and implicitly to the apparition of dimensional incompatibilities between the parquet flooring and the built spaces. The paper sets out (to solve by an individualized design procedure) to achieve modular parquet flooring in industrial system, in correspondence with the sizes of the inner spaces afferent to the constructions.

Key words: modular parquet flooring; boarded floor; border.

GENERAL ELEMENTS - INTRODUCTION

The massive turn towards the development of the constructions type individual houses, to the detriment of the constructions type block of flats resulted in the abandonment of the modular system in defining indoor spaces. According to the modular system, the indoor spaces of the constructions are integral multiples of a dimensional modulus – in general M100, to wit modulus of 100mm.

On this occasion, the modular parquet flooring system “was forgotten”, as the sizes of the standardized parquet blocks could no longer achieve the aesthetic proportion of the boarded floors.

The return to the use of modular parquet flooring presupposes the achievement of the dimensional proportions by the design and implicitly, by the manufacturing of the parquet flooring.

Under the present conditions, the computer-aided design, as well as the conception and enhancement of the manufacturing technologies for modular parquet flooring enable the rapid flexibilization of the conception and execution in the field, with the achievement of the aesthetic effects and dimensional proportions. Besides, when wood is used for flooring, strict selection procedures are needed to assure satisfactory aesthetic results. To obtain beautiful and uniform surfaces, wood has to be carefully graded by fibre type and colour tone (Bianconi *et al.* 2013). Color, as a main characteristic in design of wood flooring, is investigated by researcher in order to assure a constant and stable input (Luostarinen and Luostarinen 2001).

The manufacturing and use of modular parquet flooring may surpass the level of the living spaces and may be applied to industrial premises in the field of clothing, computer science, electronics or social fields (socio-cultural spaces, museums, exhibitions etc.). For living quality, people like to use wood as the material of floors inside rooms or as one of the materials for decoration because wood has elegant texture, appropriate flexibility, natural warmth, and special material feelings; besides, it can adjust humidity and temperature (Lu 1987, Chen *et al.* 2014).

The extension of modular parquet flooring manufacturing may result in significant rises of productivity, enhancement and efficiency of the wood mass and improvement of the aesthetics specific to the indoor spaces. As some researchers investigated, the arrangement of wood by structure, color and position has an important role in the appreciation of wood flooring by the final customers (Chen *et al.* 2014). In the same time mass customizing parquet flooring could open new business opportunities for the industry. In order to offer customers the possibility of individually composed floors, several types of customized modules instead of the currently produced floor boards can be manufactured (Häuslmayer *et al.* 2007).

Various constructive solutions may be thought to achieve the parquet flooring modules – at producer level – and to achieve the fastening in construction, at beneficiary level, which also leads to solving the

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thermal-transfer problems for the constructions with various structures and for the spaces situated at various levels on the vertical of the constructions (Menetrey 1968, Duma 1973, Cismaru 2006, Cismaru and Salcă 2009).

DESIGN ELEMENTS FOR MODULAR PARQUET FLOORING

In designing modular parquet flooring, determining the sizes of the module and its shape (quadratic or rectangular) are envisaged. The sizes of the parquet flooring modulus are determined in correlation with the inner sizes of the rooms and with the dimensional ratio to achieve between them (Cismaru 2006, Fotin and Cismaru 2011).

For an adequate aesthetics of the parqueted inner surfaces, the following dimensional ratios are recommended:

- for rooms with inner sizes smaller than or equal to 2m the ratio L/l or B/b (size of the space / size of the module) is recommended to be: 1/10; 1/20;

$$\eta_L = \frac{L_1}{l} ; \eta_B = \frac{B_1}{b} \quad (1)$$

where: η_L – dimensional ratio in length;
 η_B – dimensional ratio in width;
 L_1 – length of the space, in m;
 B_1 – width of the space, in m;
 l – length of the module, in m;
 b – width of the module, in m.

- for rooms whose dimensions range between 2 and 3m the ratio L/l or B/b , is recommended to be: 1/10; 1/20; 1/30;

- for rooms whose dimensions range between 3 and 5m the ratio L/l or B/b , is recommended to be: 1/10; 1/20; 1/40; 1/50;

- for rooms whose dimensions range between 5 and 10m the ratio L/l or B/b , is recommended to be: 1/10; 1/20; 1/40; 1/50; 1/100.

Small ratios 1/10, 1/20 or 1/30 are recommended for the spaces that are not covered, whereas high ratios 1/40, 1/50, 1/100 for the surfaces that are covered to the greatest possible extent with furniture or carpets (in this case, the parquet flooring looks like a border “field” of the carpet).

Choosing the ratio L/l or B/b must therefore consider the loading (coverage) level of the parqueted surface, so that the integral model might be visible on some portions.

Designing the modular parquet flooring likewise considers defining the methodology to fasten the modules on surfaces, depending on the even or uneven number of modules, which result from the calculation (Cismaru 2006).

The design methodology may appear as an algorithm, namely:

- defining the sizes L , B of the indoor spaces;
- defining the purpose intended for the room;
- defining the coverage degree of the parqueted surface (with furniture or carpets);
- choosing the ratio L/l and B/b (in 2 or 3 variants);
- calculating the number of modules lengthwise and crosswise, by reserving at the border of the rooms a space of 60-80mm for the wall friezes (where one desires to achieve border strips, the space sizes diminished by the border-strip sizes are considered (see Fig. 1), the number is rounded to the closest integral value;
- achieving the scheme to fasten the modular parquet flooring in the construction (see Fig. 2).

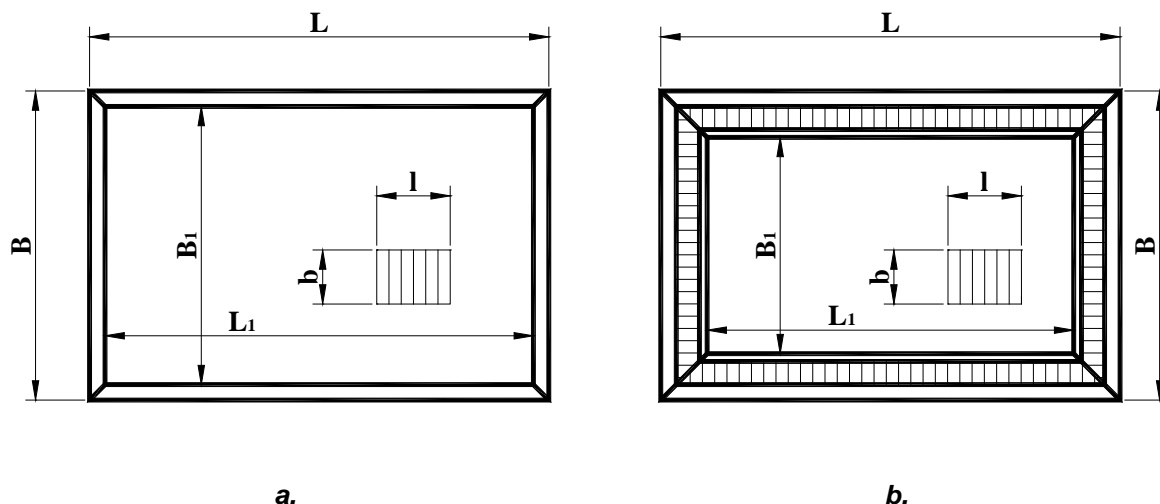


Fig. 1.
Determining the inner sizes L_1 and B_1 for calculating the number of modules in length and width: a – with wall slat; b – with frame.

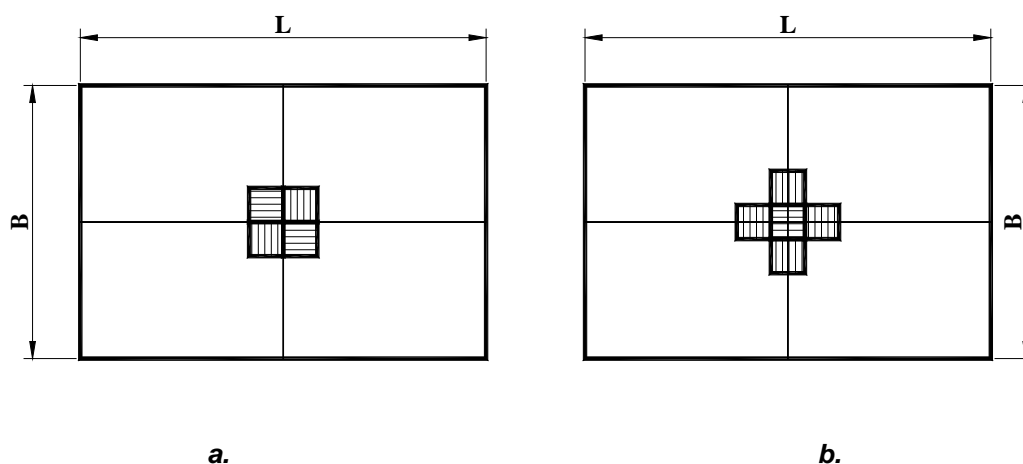


Fig. 2.
Determining the scheme for fastening the modular parquet flooring in constructions: a – for an even number of modules; b – for an uneven number of modules.

- making the scale drawing of the parqueted surface for the 2 or 3 variants and analyzing in terms of aesthetics;
- defining the final variants;
- dimensionally correcting the wall friezes or the width of the frame;
- manufacturing on a 1:1 scale the parquet flooring module, depending on the constructive structure;
- defining the sizes of the elements in the structure of the parquet flooring module.

Therefore one can say that the “design stage” ends with the dimensional definition of the elements participating in the parqueting, namely:

- structural elements of the module – depending on its constructive structure;
- wall friezes (in terms of the widths on the length and width of the indoor space – considering that between the wall friezes and the building wall, a space of 10-20mm is reserved for taking the non-linearity or non-flatness of the building);
- structural elements of the frame, depending on its structure, reserving likewise in this case the 10-20mm for the vacant space to the wall.

STRUCTURAL ELEMENTS OF THE PARQUET FLOORING MODULES

Modular parquet flooring may be achieved of rectangular or quadratic blocks with the anatomical structure of the wood longitudinally or transversally placed, as shown in Fig. 3, the number of the blocks enclosed in a module differing according to the shape and sizes of the module (Menetrey 1968, Cismaru 2006, Fotin and Cismaru 2011).

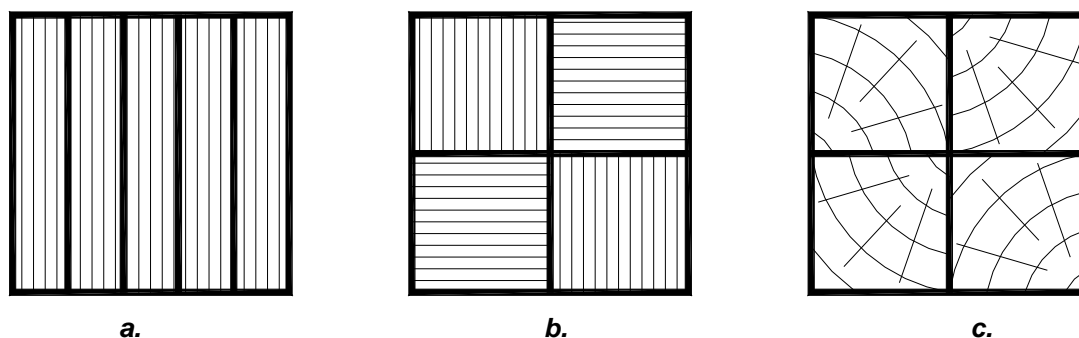


Fig. 3.

Title: Orientation of the anatomic structure and parquet-block forms for the modular parquet flooring: a – rectangular parquet blocks with longitudinal structure; b – quadratic parquet blocks with longitudinal structure; c - quadratic parquet blocks with transversal structure.

In the case of the quadratic module (prevailing situation in terms of the modular parquet flooring shapes) there must be a dimensional correlation between the length and width of the blocks, as shown in Fig. 4.

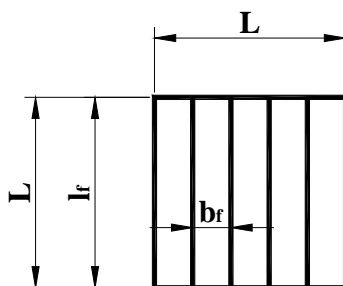
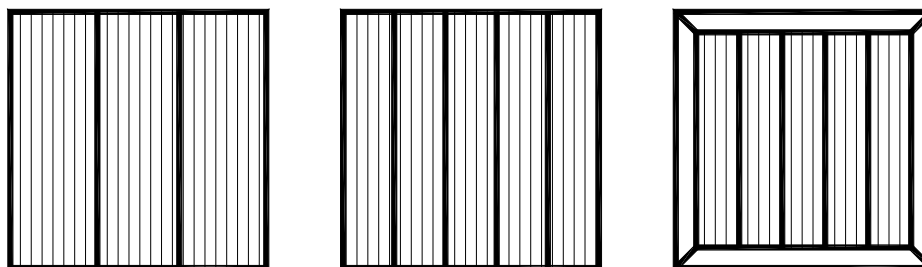


Fig. 4.

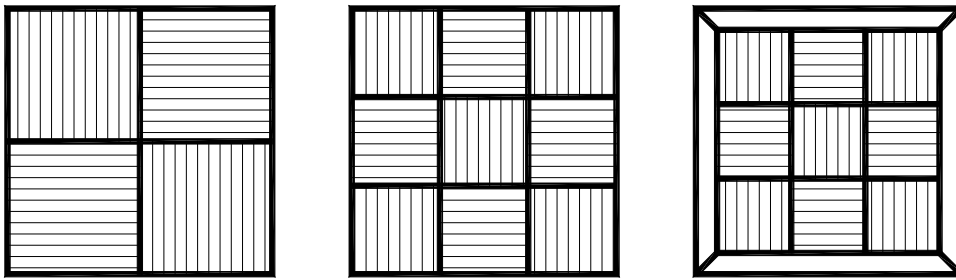
Title: Dimensional correlation of the blocks with the module sizes.

$$l_f = L ; b_f = \frac{L}{n} \tag{2}$$

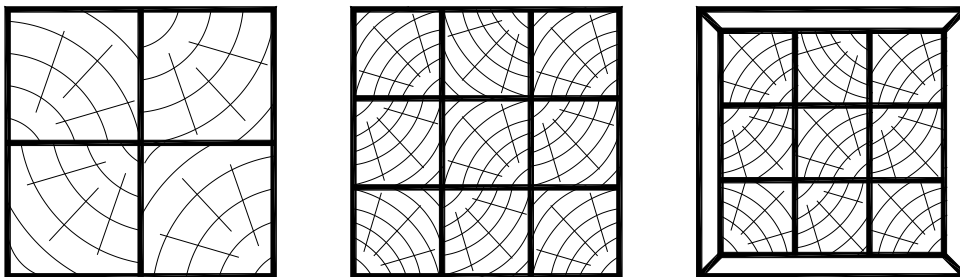
where: l_f – length of the blocks, in mm;
 b_f – width of the blocks, in mm;
 L – dimensions of the module, in mm;
 n – number of blocks in a module.



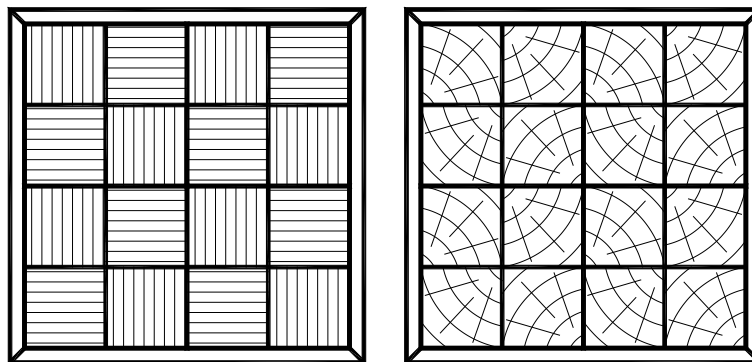
a. – simple module with longitudinal blocks, with or without outline frame.



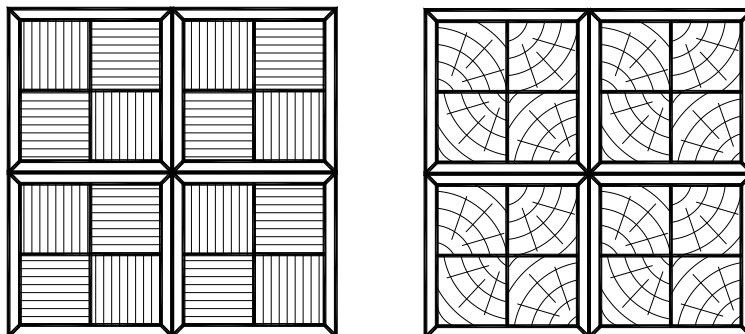
b. – simple module with quadratic blocks, of longitudinal structure.



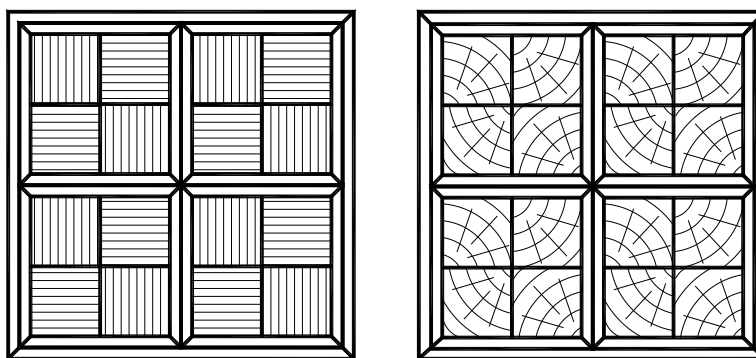
c. – simple module with transversal blocks.



d. – multiple module with outline frame.



e. – multiple module by association of simple modules with outline frames.



f. – multiple module with additional outline frame.

Fig. 5.

Modular parquet flooring structure: a – simple module with longitudinal blocks, with or without outline frame; b – simple module with quadratic blocks of longitudinal structure; c – simple module with transversal blocks; d – multiple module with outline frame; e – multiple module by association of simple modules with outline frames; f – multiple module with additional outline frame.

The structure of the parquet flooring modules may range from the simplest to more complex variants, depending on the role we want to associate to parquet flooring in the aesthetics of the parquetered space, as shown in Fig. 5.

As results from the analysis of the structures shown in Fig. 5, one can say the modules may be simple or multiple, with or without outline frame – applied, in general, to the simple modules (Fig. 5a, b, c.) but also to the multiple modules (Fig. 5d.), or with additional outline frame applied to the multiple modules (Fig. 5f.).

Of course, for the purpose of technological efficiency, likewise for transport efficiency and especially for assembling efficiency, the solution of simple modules is the most recommended; nevertheless, one can see that the existence of outline frames requires higher consumption of workmanship and energy, yet the aesthetic effect is superior, especially when the outline frames are manufactured of dark wood species, achieving thereby a play of colour, in the area of the “parquet flooring field”.

MANUFACTURING OF MODULAR PARQUET FLOORING

Depending on the shape of the parquet blocks and on the orientation of the wood structure, one can say that various technologies are necessary, with a view to achieving the simple, respectively the multiple modules, which technologies are also possible due to the new types of adhesives, characterized by higher properties in terms of gluing resistance (Cismaru *et al.* 2005, Cismaru *et al.* 2006).

Variant 1 – with rectangular parquet blocks, with longitudinal orientation of the wood structure

The achievement of such modules supposes the following technological succession of the parquet blocks and working operations (see Fig. 6).

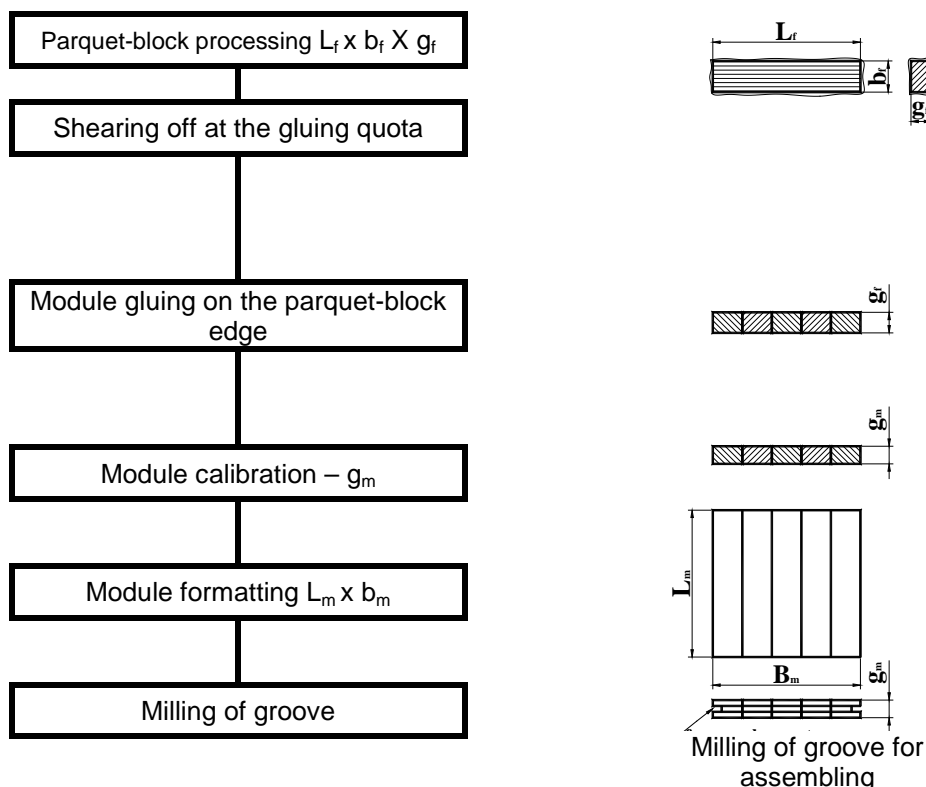


Fig. 6.
Technological scheme for the achievement of the simple modules.

Modular parquet flooring may be achieved at various final thicknesses, depending on the sizes of the modules, as shown in Table 1.

Small thicknesses are recommended especially when the parquet blocks are made of hard wood species, and high thicknesses, when soft wood species are resorted to.

The thicknesses of the parquet blocks may be reduced (generally resorting to the minimal values) when the parquet blocks are fastened on a support panel (PAL, MDF) which will constitute both the support of the module, and the connecting element with the fastening surface of the construction.

Table 1

Correlation between the sizes of the parquet modules and the final thickness of the parquet blocks

Module thickness Sizes of the modules $L_m \times B_m$, [mm]		Final thicknesses of the parquet blocks, [mm]								
		10	15	17	20	22	25	30	40	50
Simple module	100 x 100	X	X							
	150 x 150	X	X	X						
	200 x 200			X	X	X				
	250 x 250				X	X	X			
	400 x 400					X	X	X		
	500 x 500						X	X	X	
Multiple module	200 x 200		X	X	X					
	300 x 300			X	X	X				
	400 x 400				X	X	X			
	500 x 500					X	X	X		
	600 x 600					X	X	X		
	800 x 800						X	X	X	
	1000 x 1000							X	X	X

In the case of the modules fastened on panels, the usable technology is shown in Fig. 7.

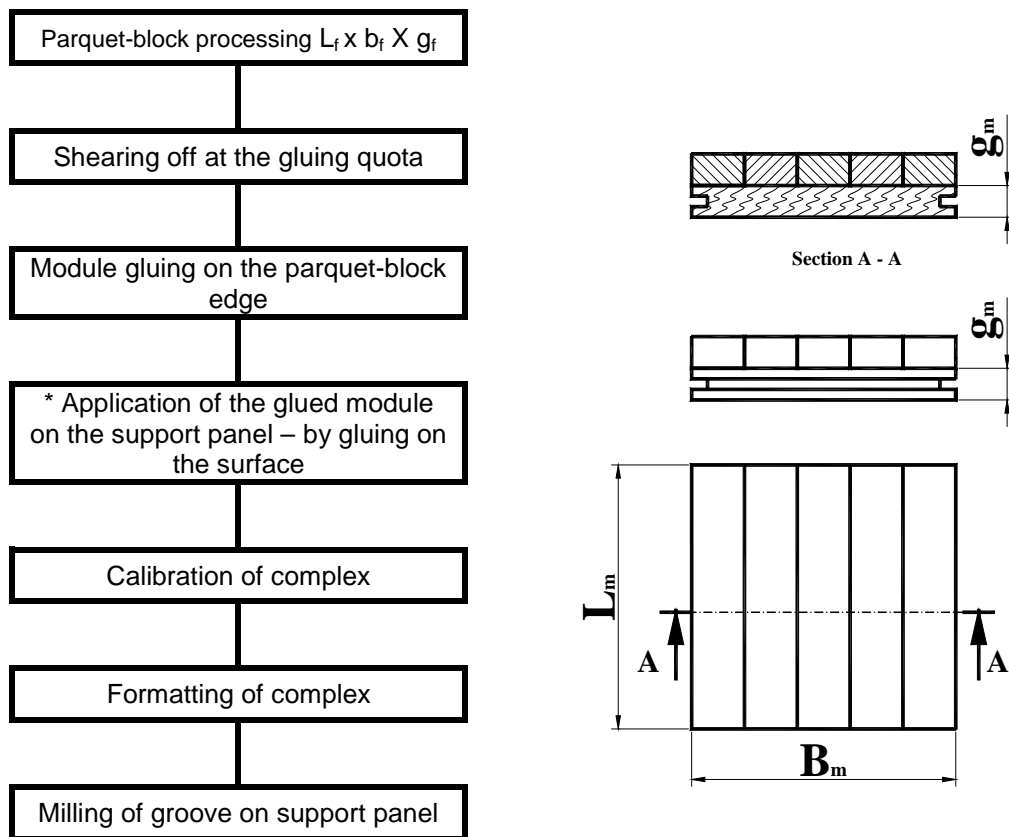
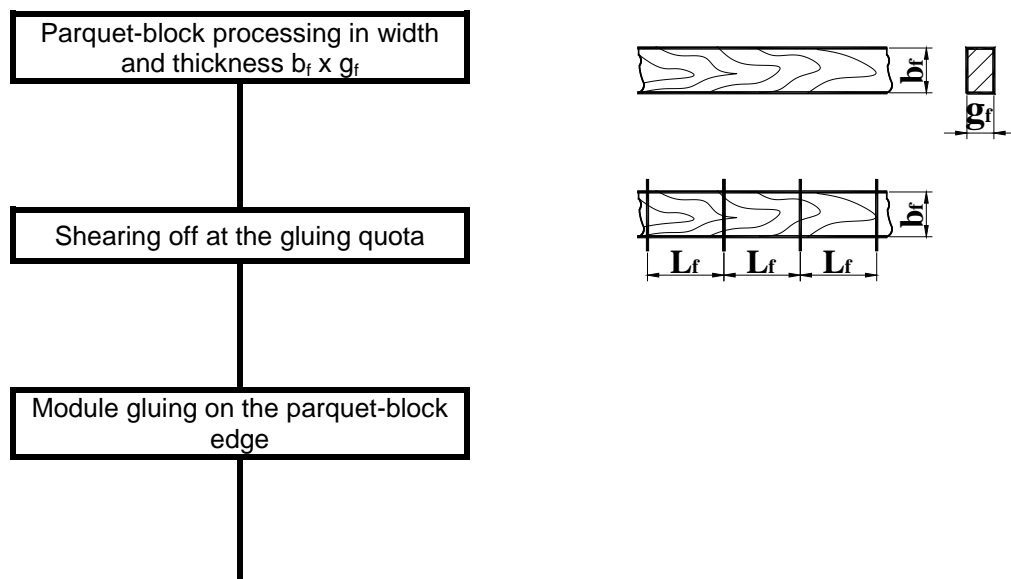


Fig. 7.
Technological scheme for modules applied on a support panel.

Variant 2 – with quadratic parquet blocks, with longitudinal orientation of the wood structure

The technological phases are approximately identical to variant 1 with the difference that parquet blocks are processed in two stages, namely (see Fig. 8). In the first stage, the parquet blocks are processed in width and in thickness; in the second stage, they are cut off lengthwise, in order to obtain the quadratic shape.



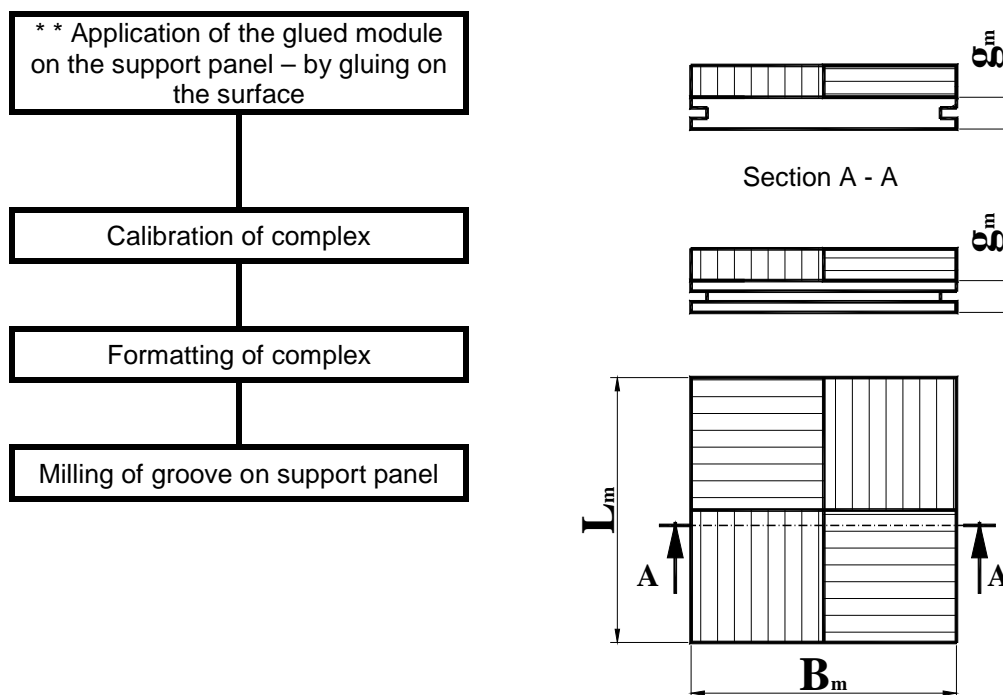


Fig. 8.
Technological particularities.

Variant 3 – with quadratic parquet blocks, with transversal orientation of the wood structure

In this case, the most efficient technology envisages the reconstitution of a wood structure shaped as “square trunk”, of wooden rules, by gluing on the surface and at edges, as in Fig. 9, which is to be cut off, there resulting modules at the rough sizes thereof (Cismaru 2006, Cismaru M. 2009, Fotin and Cismaru 2011).

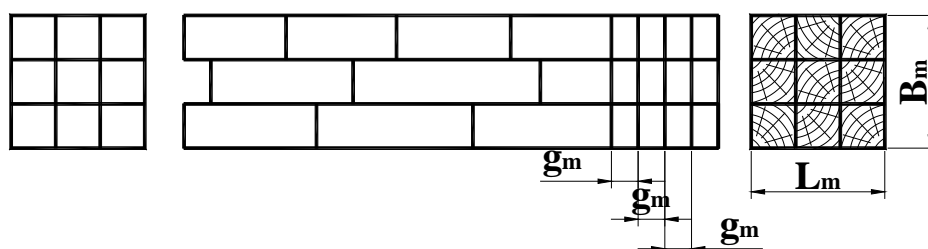
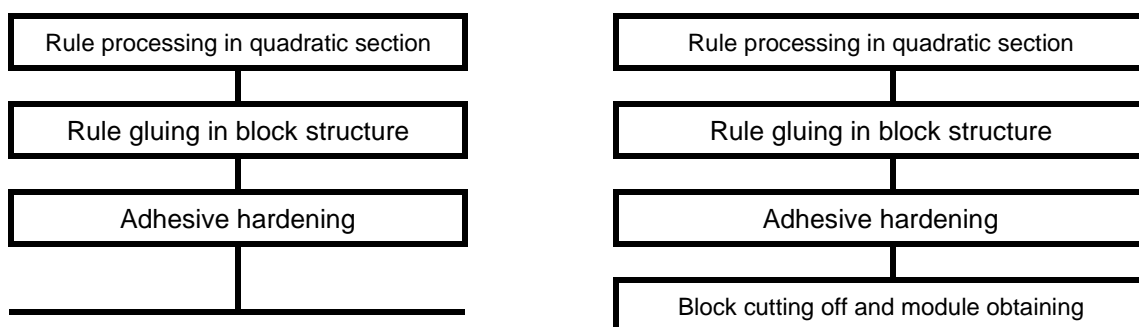
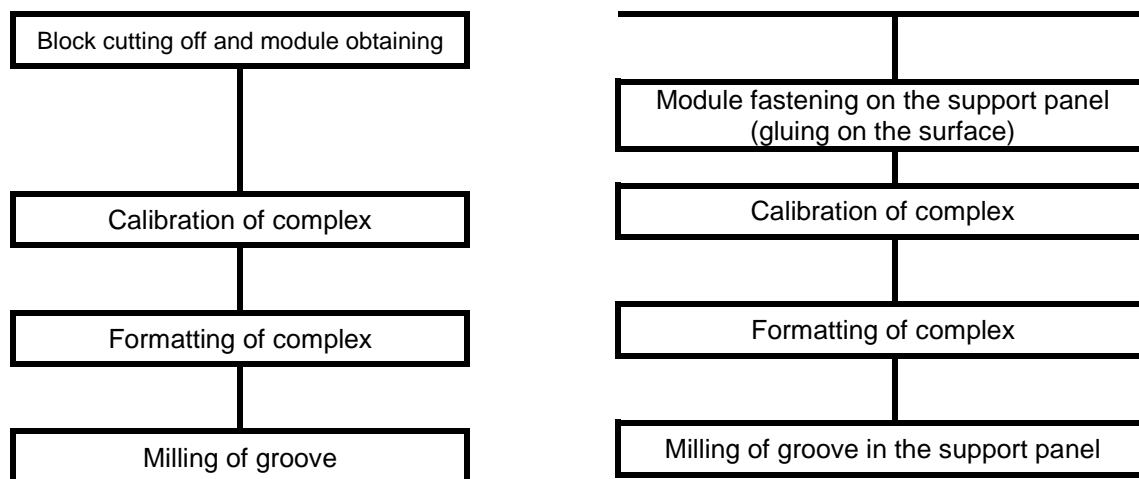


Fig. 9.
Scheme for obtaining modules with quadratic parquet blocks, with transversal orientation of the wood structure.

The technological schemes to be used for these types of modules are shown in Fig. 10.





a - with modules applicable on the support surface

b - with modules fastened on additional support panels

Fig. 10.

Technological scheme for the modular parquet flooring with transversally oriented parquet blocks.

For the compound modules or for the ones with outline frame, the associated technological phases are the ones meant to achieve the outline frames and to apply them, after having previously associated several modules. In general, the compound modules associate by fastening on additional support panels, this method being recommended by virtue of its securing the structure integrity during calibration, storage, transport and workmanship for assembling purposes.

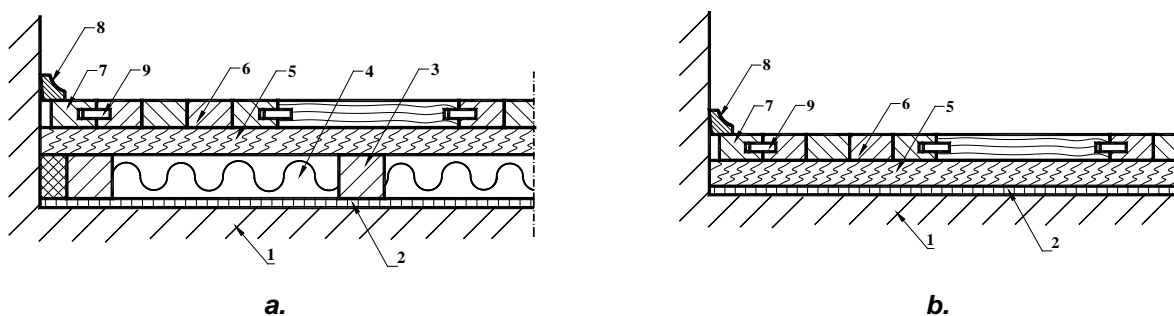
FASTENING OF THE MODULAR PARQUET FLOORING IN CONSTRUCTIONS

In constructions, the fastening technique of the modular parquet flooring depends on the constructive variant adopted for the parquet flooring – simple modules or compound modules, as well as on the level along the vertical afferent to the construction, of the space where they are assembled (ground-floor or higher floors).

The fastening can be achieved directly on the resistance elements of the construction (reinforced-concrete floor) or through additional structures with a role of thermal, phonic insulator etc. The fastening is generally achieved through the adhesives, with or without the use of the barrier layers consisting of vapours or hydro-insulation (Cismaru 2006, Cismaru M. 2009, Fotin and Cismaru 2011).

The independent or compound modules are interconnected through the applied tongues, in the case of the compound modules, intermediate structure elements being likely to be used. Fastening variants of the modular parquet flooring, in constructions, are shown in Fig. 11.

Modular parquet flooring may be achieved with insets (generalized, stylized structure elements etc.) applied either centrally or in several points of the parqueted surface, the insets further contributing to the aesthetics of the interior space.



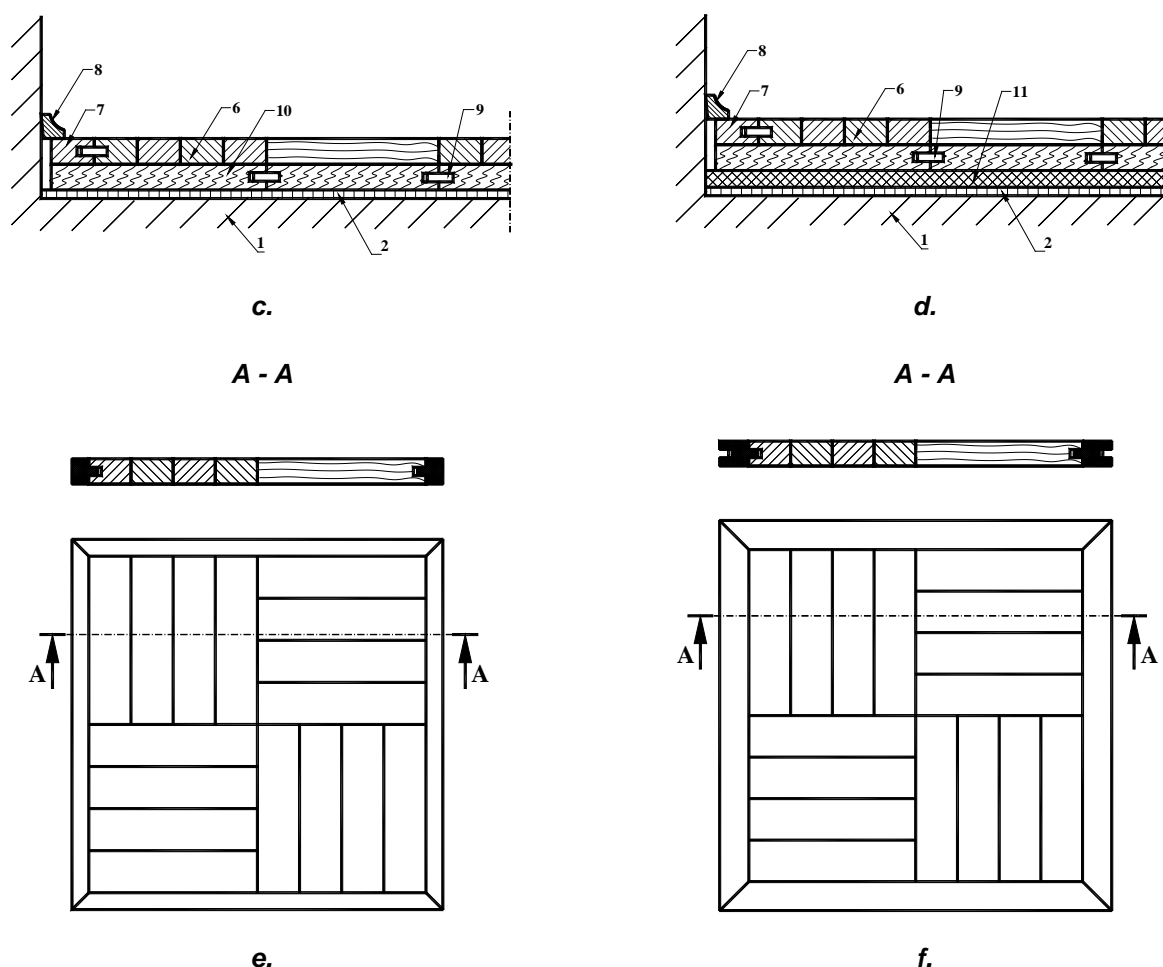


Fig. 11.

Fastening solutions for the modular parquet flooring in constructions: a – fastening on the ground - floor of the construction; b, c, d – fastening on higher floors; e – compound model fixable by joining – with or without fixation of the support panel; f – compound module fixable with applied tongues – with or without fixation on the support panel; 1 – structure of the platform; 2 – adhesive layer or vapour barrier; 3 - small beam network; 4 – filling material; 5 – support panel (dead floor); 6 – parquet flooring module (simple or compound); 7 – wall strip; 8 – drainage board; 9 – applied tongue; 10 – support panel for the parquet module; 11 – equalizing blanket; 12 – antiphonic material.

CONCLUSIONS

The use of modular parquet flooring for covering the indoor spaces of the constructions brings a series of particularities both in terms of design (to wit defining the module sizes in correlation with the dimensions of the indoor spaces) and in terms of the module manufacturing and fastening, in constructions.

The turn towards modular parquet floor manufacturing and its use in constructions might result in the diversification of the material base as regards the floors type parquet, as well as a consequential shift towards the improvement of the indoor spaces covered with this type of parquet flooring. Moreover, the wood of the valuable species may be turned to better account, concomitantly with the simplification of the fastening in constructions.

The use of modular parquet flooring supposes the achievement of a project for each indoor space, with a view to dimensionally correlating the module with the indoor space.

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