

## BASALT COMPOSITES – INTERNAL STRUCTURE INVESTIGATION

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### Abstract

In this paper, analysis of the internal structure of basalt textile composites is provided. Woven and knitted basalt fabrics were saturated with resin Lukosil M130, further were composed together and pressed at 200 ° degrees Celsius. Effect of adding knitted layers between woven layers on the volume fraction of composite components and impact on the inflow and leakage of composite resin have been investigated.

**Key words:** basalt composites, textile reinforcement, internal structure imperfection

### 1. Introduction

Analysis of the composite internal structure is an important fact to study composite behaviour. Imperfections, that arise in the manufacture of composite, affecting mainly the mechanical and electrical properties. Perfect imperfection study makes possible establish the characteristics of the structures into computational models for more accurate calculations [2]. In terms of structure is very important to follow a sequence of composite - textile layer – bundle fiber - fiber. This is important to derive the resulting characteristics and especially the microscopic examination of the impact response of various elements on the macroscopic response of composite. Structural elements at the macro level there were mainly studied.

### 2. Experiment

Six types of composite plates was made by prepreg technology. Each layer were impregnated with resin Lukosil M 130 and layer were dried for four hours at room temperature. Lamination between two metal plates and pressing in oven at 200 degrees Celsius during six hours followed. According to the following schema lamination were provided, see Fig. 2.1 [3]:

Sample no.1 – knitted/knitted on rows

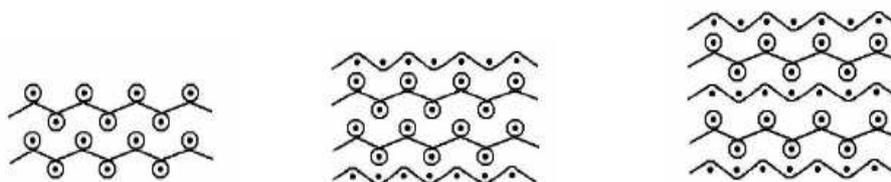
Sample no.2 – knitted/knitted on columns

Sample no.3 – woven/knitted/knitted/woven on warp and columns

Sample no.4 – woven/knitted/knitted/woven on weft and rows

Sample no.5 – woven/knitted/woven/knitted/woven on warp and columns

Sample no.6 – woven/knitted/woven/knitted/woven on weft and rows



**Figure 2.1** Layer setting - a.) knitted / knitted, b) woven / knitted / knitted / woven, c) woven / knitted / woven / knitted / woven

Resin Lukosil M 130 is modern type of varnish medium and leader in its category. It is a solution of silicone resin in xylene solvent, at room temperature creates a sticky, flexible and relatively mechanically resistant film [4].

Basalt fabric in the form of roving in plain weave 1:1 was used, fineness of yarn 1000 dtex, warp texture 160 yarns/100 mm, weft texture 70 yarns/100mm, thickness 0,286 mm, area weight 0.270 kg / m<sup>2</sup>. Basalt weft-knitted fabric with double-jersey was used, column density 40/100mm and row density 50/100mm.



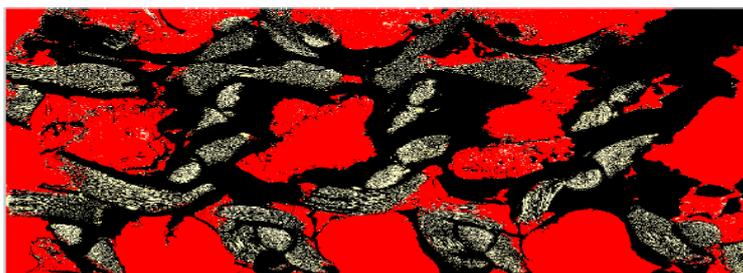
**Figure 2.2** Types of reinforcement - a.) Basalt fabric, b.) Basalt jersey



**Figure 2.3** Cross-section

Furthermore, cross-sections of internal structure were produced, adherence pressure 50 N, grinding head speed 200 rpm, see Fig. 2.3.

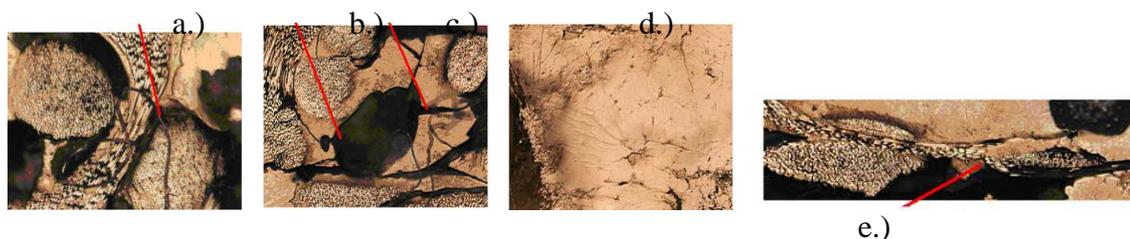
Microphotographs of internal structure were created. There were used polarized light microscope and scanning compose image technique. Each sample was scanned three times, the total number of pictures was eighteen, which represents approximately 100 hours of work. Images were processed by tools of image analysis (see Fig. 2.4) to obtain structural elements contour -reinforcement, matrix and voids. Furthermore, different types of structural imperfections were observed, see below.



**Figure 2.4** Thresholding image matrix

## 2.1 Imperfections

Imperfections were studied from the macro level structure point of view, further work will be examined images from micro and meso structural levels. Imperfections on Fig. 2.5 were found after reconnaissance.



**Figure 2.5** Structure imperfections – a.) rip out fiber , b.) voids, c.) crack, d.) shrinkage matrix, e.) fiber failure

## 2.2 Measurement

Following characteristics were measured on all eighteen images by tools of image analysis separately for the matrix, reinforcement and voids:

- Area fraction
- Equivalent diameter
- Circuit
- Max Feret
- MinFeret
- Maximum Feret of 90;
- Circularity

### 2.2.1 Results

Fig. 2.6 represents average area fraction of individual components - voids, matrix, reinforcement. There is show that the largest percentage of reinforcement was found in the type of composite No. 1 and No. 2. This is due to the type of composite, which is composed from two knitted fabrics. This result can be expected because the knitted fabric isn't compressed between woven layers. That is due to its freer structure and more space in structure, which knitted occupies in a cross-section. This fact corresponds to samples No.5 and No.6, which have the lowest percentage of reinforcement. It is apparent downward trend in species No. 1 and No. 3, which may be caused by way of setting (warp - columns, weft - row). Throughout the experiment, beyond the value of the type No 4. These values are probably due to unspecified phenomenon in the manufacture of fabric or manufacture of composite, such as for example grouping multiple fibers in cross-section. One reason may be a random place with a low concentration of voids in the composite. The proportion of matrix increased by adding fabric to knitting, especially for species which have only the outside layers of fabric. This fact is due to better enclosure of resin between knitted fabrics. Types No. 5 and No. 6 have lower proportion of matrix, which may be according to fact, that the middle layer of woven fabric separates two knitted fabrics. Resin extrusion is after-effect.

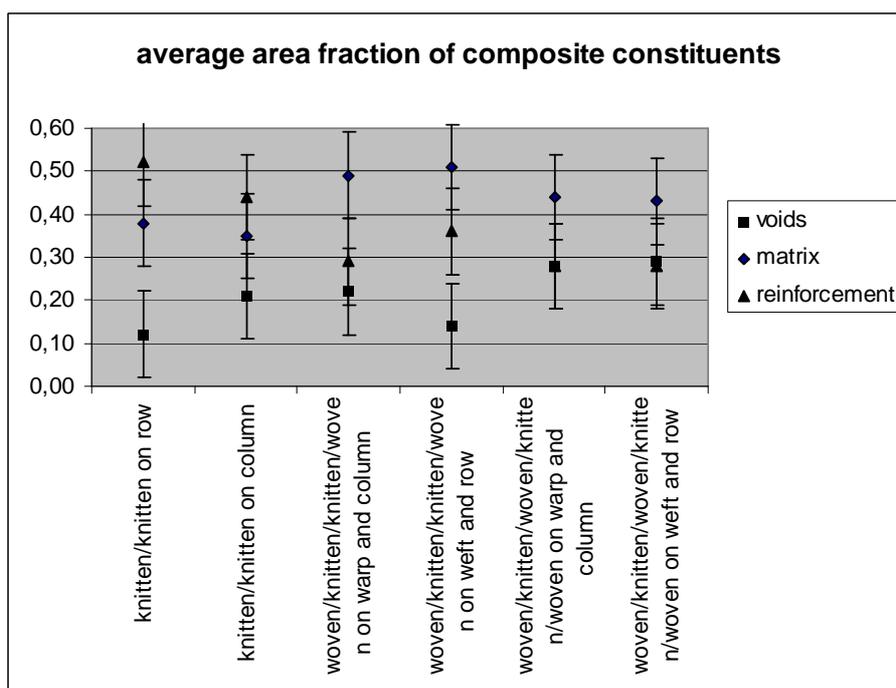


Figure 2.6 Measurement results

Area fraction of voids could be grow with advance fabric layer. According to fact that knitted fabrics are flexible, during molding process it will be pushed more air than by using only woven fabric. Woven fabric holds more air, as seen in the type of No. 5 and No. 6 .

Measured characteristics on Figure 2.7 show that the voids occupy the highest area of composite sample No. 6, the lowest on sample No.4, highest equivalent has sample No.1, the lowest sample No. 5, the highest circuit has sample No. 6 and the lowest sample No. 4, max Feret is the highest sample No.1 and the lowest for sample No.6, min Feret is the highest for sample No.1 and the lowest for sample No.6, max feret 90 is the highest on sample No.1 and the lowest for sample No. 6, circularity is the the highest for sample No.1 and the lowest for sample No. 2

Measured characteristics on Figure 2.8 show that the matrix occupies the highest area of composite sample No. 2, the lowest on sample No.5, highest equivalent has sample No.1, the lowest sample No.4, the highest circuit has sample No.1 and the lowest sample No.4, max Feret is the highest sample No.1 and the lowest for sample No.4, min Feret is the highest for sample No.1 and the lowest for sample No.4, max feret 90 is the highest on sample No.1 and the lowest for sample No.4, circularity is the the highest for sample No.1 and the lowest for sample No.3.

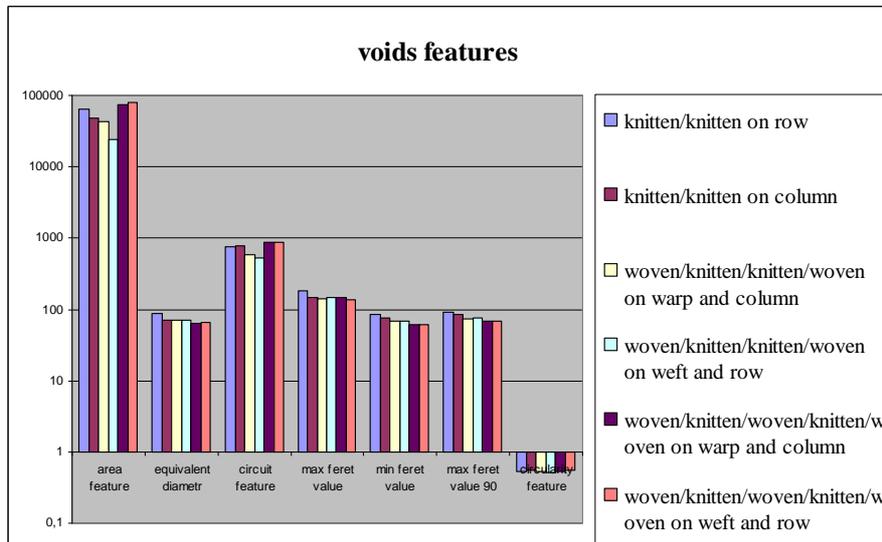


Figure 2.7 Measurement results

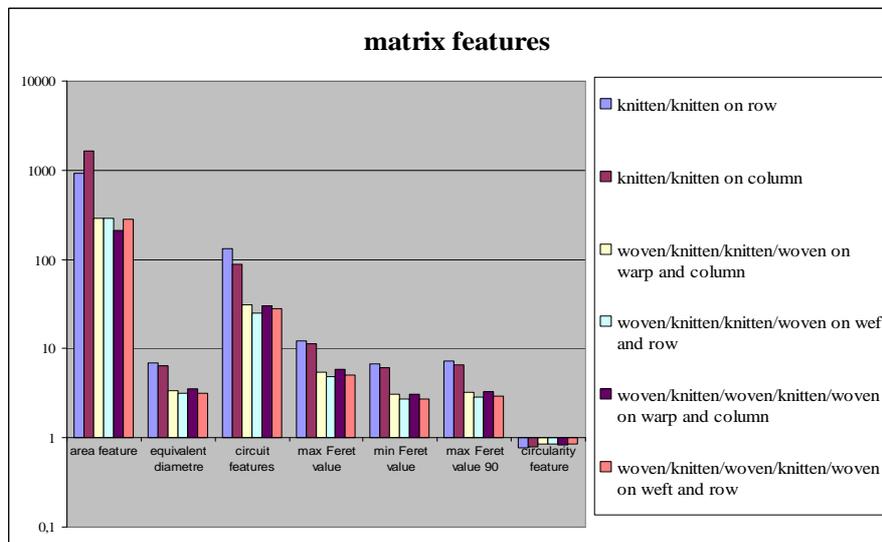


Figure 2.8 Measurement results

### 2.3 Discussion

In terms of the matrix there was to increase the number of layers with increasing area fraction of matrix, except sample No 5. and No. 6 with the highest number of layers. Area fraction of voids had increased trend with the addition of layers. In contrast, area reinforcement was decreased. Adding layers to knitted fabric layers affected a number of structural elements in the composite. Area fraction matrix is influenced by the addition of knitted fabrics. With the growing number of fabrics, this area fraction increases. Middle layer of fabric divides the space between knitted fabrics and undermines the integrity of whole area.

Sample No.1 and No.2 had the largest average area of the circuit matrix objects, which could indicate a big massive area, which is located between the knit. It would be necessary to perform a greater number of confirmatory tests.

An interesting result has compared sample No. 1 and sample No. 2. It is apparent that the proportion of matrix in samples No.1 (knitted in row) is higher than for sample No.2 (knitted columns). Lower strength, higher deformation and higher proportion of matrix in sample No.1 (knit in lines) may be the reason. It appears that only a combination of two knitted fabrics, which were cutted in rows, not closed much air in the structure. This may be caused by adding the composite fabrics are becoming stronger and less flexible.

Knitted fabric loses its elasticity and air can't go away from them. As another factor, it appears that outside layers of woven fabric prevent exhaust air from the whole composite structure. Fiber reinforcement percentage decreases with increasing number of layers of fabric.

### 4. Conclusion

This work is as primary research of structural parameters of composites reinforced with knitted and woven fabrics. There were studied composites of macro structural level. Composite has been studied from a geometric point of view, but not from material point of view. Geometry of the reinforcement, such as number and shape of objects in the composite matrix or the number and shape of voids in the composite, it is important fact to monitor modeling of result properties. Too, it was examined impact the combination of knitted and woven fabrics on the inflow and leakage of composite resin, on area fraction of reinforcement, voids and matrix.

### 5. References

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