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OPTICAL ASPECTS ON THE MINERAL MATRIX – FIBRE BONDING (PART 1)

BY

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Abstract. The choice of textile reinforcement for composites is a sensitive topic. To obtain a certain behavior or properties for the composite material might require the use of complicated textile structures. The problem of using various reinforcements is directly connected to the possibility of a good fibre embedment. In general, the mineral matrices are viscous and also require some time for setting, thus using sophisticated textile reinforcement will result in a poor covering and a weak interface bonding. In the present paper is experimentally analyzed the possibility of embedding several textile structures with a typical mineral matrix.

Keywords: cement based composite; textile reinforcement; mesh.

1. Introduction

The previous researches in the area of fibre reinforced composites (FRC) tend to the development of textile reinforced composites (TRC) (Peled *et al.*, 2008).

The textile structures gain interest as an application in reinforcing due to their multiple benefits as: ease of positioning and manipulation, keeping the

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particular shape and position of the fibres. The one layered bidirectional reinforcement has increased impact strength, stops the cracking process and transfers the stresses to the matrix uniformly. When compared to the unidirectional fibres, a mesh reinforced composite generates more balanced properties.

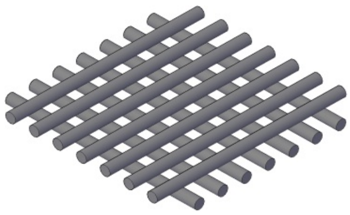

Fig. 1 – Mesh reinforcement.

For mesh reinforcement, Fig. 1, the number of fibres and mail dimensions can be varied and the overlapping angle can be changed to develop particular properties on some directions. It is desired to minimize the thickness of the fibres so as the textile structure can be completely embedded with the matrix (Egan and Newton, 2006).

2. Mineral Matrix Particularities

In constructions, the mineral matrices are also known as binders and are used to bind up granular materials (aggregates) or unit materials (bricks, plates) to obtain construction elements. The most common mineral matrix composites are the cement based composites which developed substantially in the last 40 years. The mineral binders are known since Antiquity and their main components (Portland cement, aggregates and several admixtures) are kept the same even though their proportions suffered some changes.

Nowadays the development of mineral based materials is mostly connected to the modern composite material principles. Using composites brings several advantages when compared to traditional materials as weight and cross-sectional reduction. To be able to create thin cross-sections using mineral based materials these must be reinforced. Fibre reinforced mineral based composites generally have high compressive strengths, good tensile and bending properties and can be formed in thin sections (Mobasher, 2012).

The criteria essential to develop an optimum bond at the interface between the matrix and the fibres are connected to:

- quality, shape, length and type of the fibres;
- the possibility of the matrix to pass through the textile structure;
- the possibility of the matrix to embed the fibres;
- the chemical compatibility between the matrix and the fibre.

According to these criteria only a few types of textile structures are adaptable to the mineral matrices. Since the matrix must embed the fibres opened structures are utilised, these allowing an appropriate impregnation. The well embedded fibres ensure the interfacial region where all the reactions to develop a connection are formed (Chou, 2005).

The possibility of the matrix to pass through the gaps of the textile structure and embed every fibre is an important factor in the development of the system. This penetration is dependent on the size of the mails and the matrix viscosity. The passing of the mineral matrices though any type of textile structure requires a corresponding workability. There is the risk to affect the reinforcement during impregnation if the matrix is too consistent or not have enough adherence if it is too fluid (Mobasher, 2012).

Several experiments (Peled *et al.*, 2008) showed that the geometry of the textile material influences the performances of the mineral matrix, thus the choice of reinforcement for mineral matrices is a delicate topic.

3. Experimental Samples

To optically analyse the possibility of the mineral matrix to pass through the textile structure and embed the fibres several samples were casted. The textile structures used in the experimental process had different fibre thicknesses, number of filaments and mail dimensions, Fig. 2.

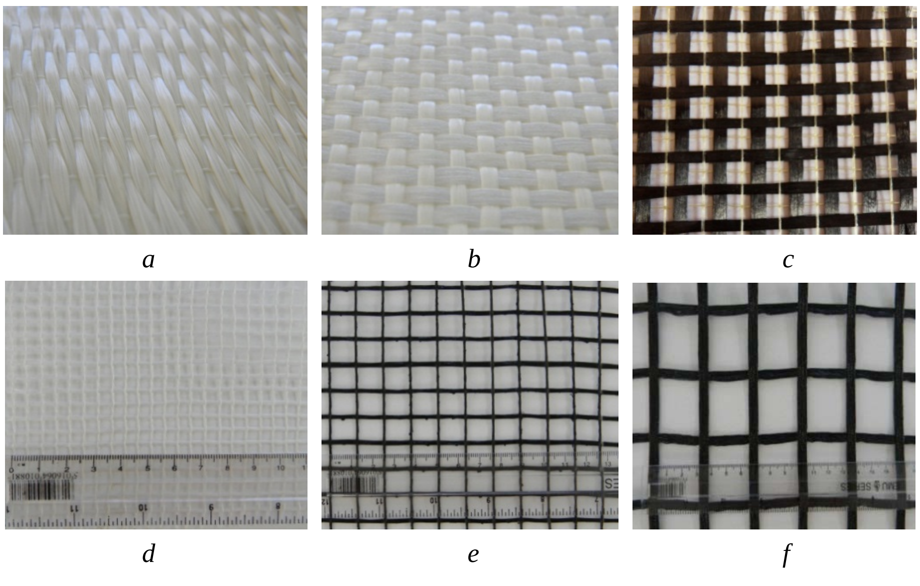

Fig. 2 – Textile structures with different mail dimensions:
a) 0 mm; *b*) 0.1x0.1 mm; *c*) 0.7x0.7 mm; *d*) 0.5x0.5 mm; *e*) 12x12 mm; *f*) 27x27 mm.

The matrix used in this study was a traditional cement based matrix, a mixture between Portland cement (CEM I), Fig. 3*a*, aggregate (fine sand of 0.1-1 mm), Fig. 3*b*, and water. The proportions between the constituents was of 50 – 50% and a water-binder ratio of 40%. The final mixture, Fig. 3*c*, resulted in a viscous material that was difficult to pour.

a *b* *c*

Fig. 3 – *a*) Cement; *b*) Sand; *c*) Mixture.

The resulted mixture did not spread over the textile structures and took some time to harden. It should be noted that this time was normal for mineral based materials but long when compared to the polymeric matrices.

The first type of reinforcement, Fig. 2*a*, was a unidirectional reinforcement with no mail. The viscous mixture did not manage to pass through this textile structure and the fibres were easily detached from the matrix Fig. 4.

Fig. 4 – Mineral matrix with unidirectional reinforcement.

The second type of reinforcement, Fig. 2*b*, was bidirectional reinforcement with very small mail dimensions (0.1x0.1 mm). Neither in this case the passing of the matrix through the textile structure was possible. Compared with the previous case on the matrix were noticed the marks of the textile structure, Fig. 5, suggesting a light embedding.

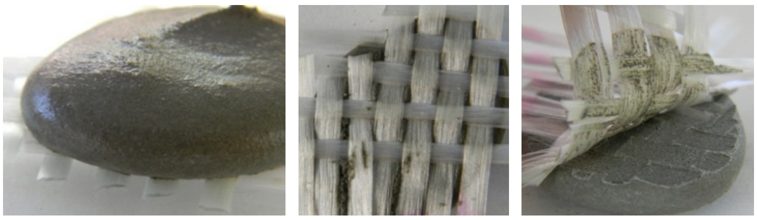

Fig. 5 – Mineral matrix with bidirectional reinforcement with no mails.

The third structure was the bidirectional reinforcement with mail dimensions of 0.5x0.5 mm, Fig. 2*c*, and thick fibres. The predominant marks left by the textile shape into the hardened matrix show a partial passing of the matrix through the structure, Fig. 6.

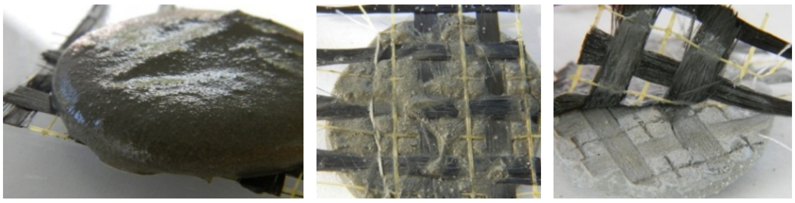

Fig. 6 – Mineral matrix with bidirectional reinforcement.

The fourth textile structure was a unidirectional mesh having the mail dimensions of 0.7x0.7 mm, Fig. 2*d*, and thin bundles of fibres. The passing of the matrix through this structure was good; the matrix managed to pass and left obvious marks on the hardened matrix. Unfortunately, there was not a complete embedment of the fibres comprising the structure, Fig. 7.

Fig. 7 – Mineral matrix with unidirectional mesh.

The fifth textile structure used in the experiment was a bidirectional mesh with the mail dimensions of 12x12 mm, Fig. 2*e*. Similar as in the previous case the passing of the matrix was possible leaving marks on the hardened matrix, but there was no complete and perfect embedment of the structure, Fig. 8.

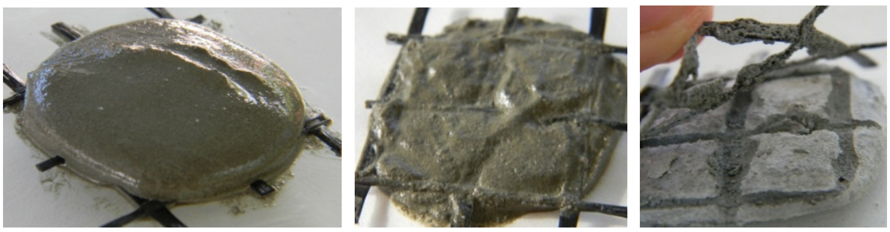

Fig. 8 – Mineral matrix with bidirectional mesh.

The last textile structure was also a bidirectional mesh but with big mail dimensions, 27x27 mm, and thick fibres, Fig. 2*f*. The passing of the matrix through this structure was facile. As in the other two previous cases the embedment of the fibres was poor, the fibres remaining at the surface of the matrix from where can be easily pulled out, Fig. 9.

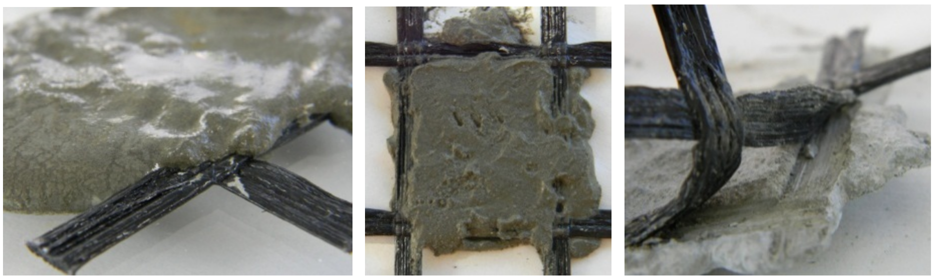

Fig. 9 – Mineral matrix with bidirectional mesh.

4. Conclusions

Not all matrix types are compatible with the textile structures and the mineral matrices are even more selective when it comes to embedding them.

Analyzing the casted samples it was observed that, in most cases, the passing through the fibres was difficult for the typical mineral matrix. Although it should be noted that using more complicated shapes for the textile structures has the advantage of an anchorage or a superior mechanical coalescence by blocking the matrix in the nodes or in the region of fibre overlapping.

For textile structures with no mails the mineral matrix cannot embed the fibres unless there is a significant increase in the workability of the matrix. The meshes with bundles of fibres had problems with complete embedding and deep crossing of the matrix leading to weak interface bonding and resulting in less strength for the composite material.

The results in the mesh type reinforcement case are better. Using fibres in which the filaments are glued together in one single fibre increases the ability of the matrix to create a better bonding between the materials; in this case not being required a passing through the filaments, just a fibre perimeter bonding. It is also observed that there is a better embedding in the case of the meshes with fibres of small diameter due to the limited possibility of the matrix to completely embed on both sides thick fibres or materials.

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ASPECTE OPTICE ASUPRA LEGĂTURII FIBRE – MATRICE MINERALĂ (PARTEA 1)

(Rezumat)

Alegerea structurilor textile pentru armarea compozitelor este un subiect sensibil. Obținerea unei anumite comportări sau a unor anumite proprietăți pentru materialul compozit ar putea necesita folosirea unor structuri textile complicate. Folosirea diferitelor armări este strâns legată de posibilitatea de a avea o îmbibare bună a fibrelor. În general, matricele minerale sunt vâscoase și necesită timp pentru întărire, iar folosirea structurilor textile sofisticate vor determina o acoperire neadecvată și o legătură slabă la interfață. În prezenta lucrare este analizată experimental posibilitatea înglobării structurilor textile cu o matrice minerală uzuală.