FLEXYBRICK – REVOLUTIONARY SOLUTION FOR POLYURETHANE APPLICATION

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Polyurethane has been used in thousands of application all around the globe in different fields. From boots to skateboards, furniture, thermoinsulation and even mobile phones, polyurethane is an indispensable material today. Even though in the construction field its applicability has been widely increased, the paper proposes an innovative application for this material. The considered material is an eco-friendly one with low self weight and reduced needed labor. Detailed analysis are done between curent used solutions – masonry, light weight concrete, wood and the innovative solution called FlexyBrick. FlexyBrick is a new product based on polyurethane. The following parameters are analyzed: thermal rezistance, self weight, compression strength, bending strength and price. FlexyBrick is reinforced with recycled or organic materials in order to reduce costs (crashed glass, sand, cigarettes filters, straw, chopped rubber) and to improve mechanical properties. Using this new infill material the heating costs will be reduced and the execution time will decrease. The polyurethane bricks are easily adapted to any climatic condition and allow the water vapor transfer from the inside to the exterior side of the masonry, preventing condensation.

Keywords: infill, eco-friendly material, polyurethane.

INTRODUCTION

Polyurethane is a mixture between two substances and was initially discovered in the 1940s. Since then it has been used in a wide range of items, from baby toys, skateboards, surfboards to beehive, snow blades for machines, vehicle suspension bushings, airplane wings, and it continues to be adapted for contemporary technology. Polyurethane can be manufactured in any colour, can take any shape, size or any geometrical complexity.

Polyurethane chemistry began in 1937 when H. Rinke first prepared 1,6-hexamethylene diisocyanate (HDI) and Otto Bayer developed the diisocyanate polyaddition process.

Widespread use of polyurethanes was first seen in Germany, during World War II, when it was utilised to replace rubber, which at the time was expensive and hard to obtain. During the war, other applications were developed, largely involving coatings of different types, from aeroplane finishes to resistant clothing (Olteanu and Toma, 2012).

By the end of the war, polyurethane coatings have started to be used on an industrial scale and could be custom formulated for specific applications. By the mid-50's, polyurethanes could be found in coatings and adhesives, elastomers and rigid foams. It was not until the late-50's that comfortable cushioning flexible foams were commercially available. With the development of a low-cost polyether polyol, flexible foams opened the door to automotive applications known today.

In the 1990s new two-component polyurethane and hybrid polyurethane-polyurea elastomers were used to spray-in-place load bed liners and military marine applications for the U.S. Navy.

While polyurethane is a product that most people are not overly familiar with, as it is generally 'hidden' behind covers or surfaces made of other materials, it would be hard to

imagine life without polyurethanes today (Olteanu *et al.*, 2011), (Pastia and Luca, 2013).

In Romania, the polyurethane was introduced in 1978 and it is manufactured by Oltchim SA. In 2007, consumption of polyurethane raw materials was more than 12 million metric tona, the annual average increase being of approximately 5%.

Polyurethane in Construction

Polyurethane is used in construction since 1950 and its main application is building insulation, thus achieving roof insulation panels, walls, ceilings and floors, Figure 1.

Metal-faced polyurethane sandwich panels are the system of choice today for large industrial buildings, refrigerated and other warehouses, office blocks, exhibition halls, fair pavilions, schools and sports halls. Prefabricated sandwich wall and lightweight roofing consist of metal facings bonded tightly together by a core of rigid polyurethane foam. The aluminium or steel facings themselves are surfaces coated and can be manufactured either flat or with profiles of various depths. Polyurethane sandwich panels come complete with specially formed tongue-and-groove joints ensuring a perfect fit and maximum integrity (Woods, 1982).

Polyurethane foam sandwich panel is fit for the projects which have serious requirements regarding constant temperature, or strict hygiene maintenance, because polyurethane core material is considered the best material in keeping warm and thermal insulation.

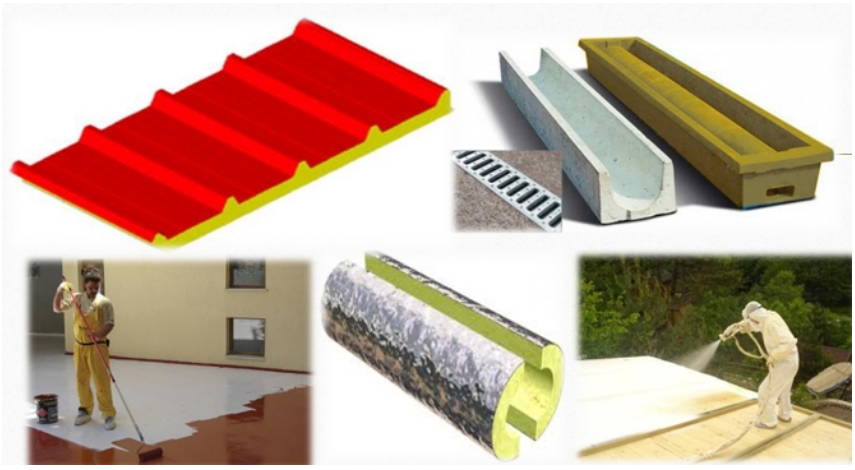

Figure 1. Polyurethane applications in construction

FLEXYBRICK CONCEPT

Base Constituent Material

Polyurethane properties depend on the type of isocyanate and polyols used. In some ways, a piece of polyurethane can be considered a giant molecule. As a consequence, typical polyurethanes do not soften or melt when heated. Isocyanates and polyols avaible options, compared to other additives and processing conditions, allow the

polyurethane to have a wide range of properties that make it such a widely used polymer. The polymerization reaction is a polymer containing urethane linkages, and it is catalyzed by tertiary amines such as diazabicyclo [2.2.2] octane, and metal compounds such as dibutyl tin dilaurate or bismuth octane (Hepburn, 1991).

If water is present in the reaction mixture, isocyanate reacts with water to form a urea linkages and carbon dioxide, and the resulting polymer contains both urethane and urea linkages. This reaction is reffered to as the expansion reaction and is catalyzed by tertiary amines such as bis (2 – dimethylaminoethy) ether. Another very important reaction in making rigid insulating foams is the trimerization reaction of isocyanate, which is catalyzed by potassium octoate. One of the desirable attributes of polyurethanes is their ability to be converted to foam. Making foam requires the formation of a gas, at the same time as the urethane polymerization. The gas may be carbon dioxide, either generated by the reaction of isocyanate with water, or added as a gas or liquid boiling volatile product. In the latter case, polymerization temperature leads to liquid vaporization. Thus, combining these two reactions, a foam expansion is being made, and because of the limited dimensions of the mold, physical properties of the polyurethane bricks are obtained.

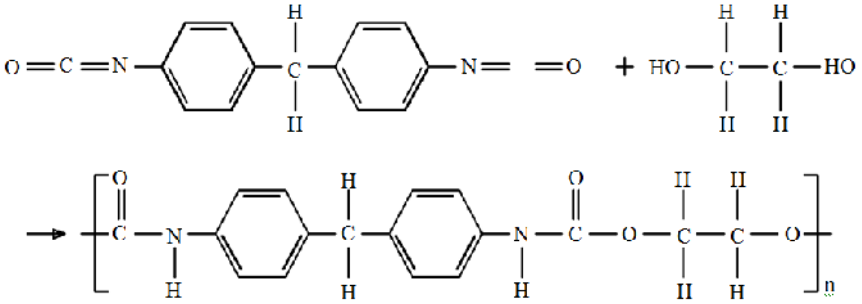

Figure 2. Chemic formula of polyurethane

FlexyBrick Masonry Block

FlexyBrick is the name given to the flexible masonry block the authors are proposing. This new polyurethane application comes as a response to an existing problem for the reinforced concrete frame structure with infill material – meaning poor interaction between the structural system and the infill material.

FlexyBrick, are made using a mold that has a special machine with a dosing device, in order to obtain the required density. During the manufacturing process it is desired the best quality of the material components, compliance with technological parameters and quality of finished products, in order to ensure proper operating behaviour.

Various sizes of polyurethane masonry block can be produced, depending on the construction site, the destination of the building, the size of the reinforced concrete frames structure. By creating appropriate mould, polyurethane can take even the shape of a round section. In this way polyurethane masonry block can replace the log required for the construction of a country-house, the environmental advantage being in this major issue.

Reinforcement

In order to prevent cracking and to provide higher mechanical properties it is required to use reinforcement for the masonry blocks.

Due to the progressive increase in the price of steel – concrete on the world market, and as a result to the technical and economic studies that were made, it was chosen polymer fibre as reinforcement. In order to find the most suitable reinforcement material, masonry blocks of various type of reinforcement have been tested in compression test. The used materials for this purpose were: fibre glass mesh, crashed rubber, geogrid mesh, metal mesh, broken glass. Another important advantage for using reinforcement is the reduction of polyurethane material, diminishing total cost also.

FlexyBrick Masonry

The FlexyBrick masonry is realized using polyurethane as adhesives in order to obtain a homogenous infill material. No specific training is required, only fast execution workers. The masonry is connected to the structural system with steel bars and has fibre glass mesh between the masonry block as longitudinal reinforcement.

Operations that must be strictly controlled:

- good adhesion between polyurethane masonry blocks and adhesive;
- horizontal and vertical joints shall be well filled with adhesive all over achieved;
- vertical joints will be weave as shown in Figure 3, with reinforcing mesh fiberglass, geogrid etc.;

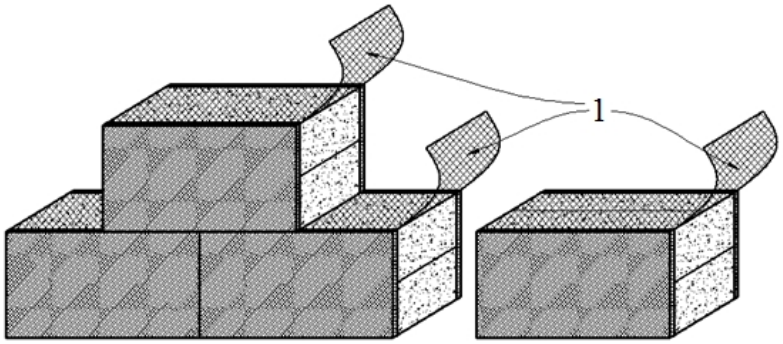

Figure 3. Masonry weaving using reinforcement mesh around the horizontal joints,
1. Reinforcement mesh

- vertical joints will be woven so that the superposition height of two succesive rows, both in the field and at the corners intersection, to make be minimum of ¼ from the brick lenght, and ½ of its thickness. Weaving is required in each row;
- the horizontality of the bricks rows will be watched;
- the interruption of the mansory work will be done in steps;
- the connections between walls, corners, junctions and branches will be made alternatively;
- the anchoring of the infill masonry is made with stell – concrete whiskers of Ø 8 = 50 cm or creating strep to achieve weaving ancient masonry;
- corrosion protection of the anchors will be provide;

- partition walls (bricks edge) are stiffen by weaving and anchoring steel – concrete bars Ø 6 OB37 every 3-4 rows in horizontal joints, according to the P2-85Standard.

OTHER USES OF POLYURETHANE

Lintels

Lintels are auxiliary construction elements that look like a beam, positioned above an opening in the masonry wall, which supports the gravitational load coming from adjacent mullions. Before fixing the lintel, the size of the hole in the masonry will be checked.

When building the part of the wall above the lintel, it is forbidden to introduce inside the lintel any kind of clamping elements by drilling, as these can affect its strength.

It should be taken into account that the extremities of the lintels need to lean on the walls with a length equal to the height of the lintel, which needs to be at least 25 cm, Figure 4.

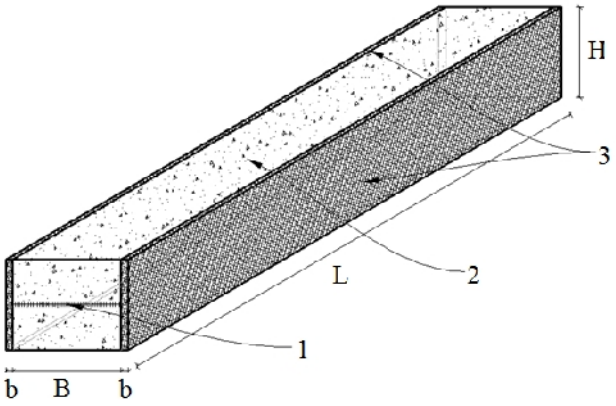

Figure 4. Lintels: 1. Reinforcement mesh; 2. Rigid polyurethane; 3. Fibrocement

Ventilated Facades

Ventilated facades are currently made of: tiles HPL (High Pressure Laminate), cement, ceramics, klinker, terracotta, artificial stones, recomposed materials (marble, granite, travertine), composite wood, aluminium, decorative glass, steel, natural stone. By its insulating qualities, for both low and high temperature, a ventilated facade has the economic advantage of reducing costs for cooling or heating. This is because the structure of this system is protecting the building against the environmental factors.

Using a ventilated facade, the building structure may represent the most modern and attractive line, its maintenance being simple, with no major problems. Getting the stereotomy provided by the arhitect means the individualization of the fixing system which is made through technological design.

The development of the technical documentation as stated above is customized for each application, depending on the complexity and specific characteristics.

CONCLUSION

Modern engineering takes architecture to a new level, making possible to build all sorts of structures, even the parametric ones. In order to change the perspective in the engineering field reserch is carried out all around the world to produce new materials or improve the characteristics of the existing ones.

The article presented an revolutionary application for a relative olt material, polyurethane. The possibility to have in the future a entire structure made of material, produced entirely mechanically and adapted to all the elements a structure has, becames more possible

Among the advantages there are: low price, big geometrical variaty, fast erection and increase thermal resistance properties. The research is still under development and the latest results will be presented in the near future.

REFERENCES

Hepburn, C. (1991), *Polyurethane Elastomers*, 2nd Ed.; Elsevier Appl Sci; London.

Olteanu, I. and Toma, A.M. (2012), "Applicability of vulnerability index of reinforced concrete frame structure in seismic", 4th International Conference on Advanced Materials and Systems, 27-29 September 2012, Bucharest, Romania, ISSN 2068-0783, 559-564.

Olteanu, I., Vargas, Y.F., Barbat, A.H., Budescu, M., Pujades, L. (2011), "Vulnerability and risk evaluation for a reinforced concrete frame", *Bulletin of the Polytechnic Institute of Jassy*, Romania, Tomme: LVIII, Fasc. 3, ISSN 1224-3884, 9-20.

Pastia, C. and Luca, S.G. (2013), "Vibration Control of A Frame Structure using Semi-Active Tuned Mass Damper", *Bulletin of the Polytechnic Institute of Jassy*, Romania, Tomme: LIX (LXIII), fasc. 4, ISSN 1224-3884, 31-40.

Woods, G. (1982), "Flexible Polyurethane Foams, Chemistry and Technology"; *Appl Sci Pub Ltd*; Essex, England.