EXAMPLES OF USING OF RECYCLED POLYMERS (HDPE, PP) FOR SOLUTION OF CONSTRUCTION DETAILS

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Summary

The article deals with potential use of waste materials in construction industry specifically use of high density polyethylene (HDPE) and polypropylene (PP). The article is focused in particular on recycled polymers application in products designed for construction industry, especially for passive houses.

Currently certain building details of passive houses are not perfect or their solution results in higher economic demands related to house purchase and its further use. For the purpose of this thesis details of windows installation in external walls and elimination of thermal bridges in wall footing have been chosen. Products were subject to numerical FEA modeling of thermal technique and statics. The executed numerical models documented that products are fully functional and that the suggested product successfully eliminate insufficiencies of some currently applied solutions.

Keywords: Recycle, polymer, HDPE, PP, construction detail

1 Introduction

Using of waste and waste material is a frequent and actual topic, which corresponds to current trends associated with the decreasing of power exigency and sustainable development, i.e. development described by Brundtland in [1]. Current capacity of natural resources is limited in the same way as the possibility to store wastes produced by human population. The tool to reduce usage of natural resources and decrease the produced waste consists in an efficient and possibly repeated use of resources – recycling. The advantage of recycling is the minimization of originating wastes as well as decrease of CO_2.

The biggest waste producer is the industry and power engineering producing fly ash, slag etc. Another important producer of waste is the construction industry. The construction industry produces civil waste that represents an important share of the wastes of all the society. In the countries of the European Union there are approximately 700 to 800 kg of civil waste falling on one citizen annually (without excavated earth). The advantage of civil waste consists in its relatively easy recyclability. In some civil areas civil engineering represents an important replacement of primary raw materials. It is however necessary to mention that in spite of relatively good utilization the civil waste as the source of raw material has not found application yet in areas of civil engineering.

An important subgroup of municipal waste is formed by polymers (plastic materials) in various forms, for example PP, PE, PET, PVC, PUR etc. According to the data from Plastics Europe, BASF and K2004 there were approximately 221 mil. tons of plastic materials and caoutchouc (of which 176 mil. t of materials) in the world, including 19 mil. t of caoutchouc for technical rubber and tyres. Figure (**Fig. 1**) shows global production of polymers according to [2] with prediction until 2010. In 2006 the value of 245 million tons and it grows every year approximately by 5 to 8%. This high production of polymers is associated also the increased production of waste plastic. It is therefore a possible substantial source of material usable for other applications in various industries.

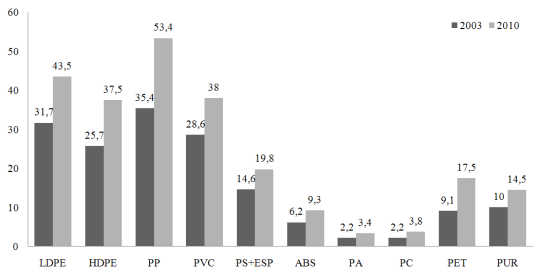

Fig. 1 Global production of polymers in mil. tons with prediction until 2010 [2]

Properties	HDPE	modified HDPE
Volume mass	952,81 kg/m^3	1206,43 kg/m^3
Thermal conductivity (ČSN 64 0526)	0,418 Wm^{-1}K^{-1}	0,339 Wm^{-1}K^{-1}
Notch impact resistance (ČSN EN ISO 179-1)	as HDPE	4,8 kJm^{-2}
Flexural elasticity modulus (ČSN EN ISO 178)	904 MPa	1001 MPa
Yield stress	23,1 MPa	18,7 MPa

Fig. 2 Excerimentally specified average values and material and thermal-technical characteristics of HDPE and modified HDPE material

One of the groups of polymers are thermoplasts. This group includes predominantly linear polymers like PP, PE, PS etc. Advantage of using polymers consists in their basic property – thermal plasticity that ensures softening of polymers after heating and their subsequent cooling and bringing to solid state of creation of a new product having the same properties as the original material and in possibility of improvement of their properties. With regard to the usability of polymers in the area of construction industry it is possible to modify the resistance of polymers against atmospheric ageing, fire technical resistance, thermal-technical and mechanical properties.

The lists of advantages predict the possibility of using polymers or sorted waste polymers in various areas including construction industry. For use it is necessary to select such polymers that have suitable thermal technical and mechanical properties and it is possible to modify their final properties and behavior. The example of polymers meeting the above requirements is the waste polypropylene PP and waste polyethylene PE in low-density LDPE or high density HDPE form or in modification form. The above polymers represent more than 50% ratio of the total global production of plastics (**Fig. 1**). The figure (**Fig. 2**) shows an example of material characteristics of recycled HDPE and retarded i.e. modified recycled HDPE. The retardation by means of fire retardation and additives was made in order to improve the fire and thermal-technical properties, so that it meets the requirements for reduced combustibility according to UL-94.

2 Example of using of recycled polymers

Current trend of energy savings in civil engineering is the proposal and construction of low-energy and passive houses. This new concept is associated with the arisen need in these types of houses to solve the originated details both in terms of the design and material. The details that can constitute problematic places in designing and construction

are especially the following: corner details, wall beams details, opening fillup embedding detail, wall footing detail and others. These details form thermal bridges with power loss if they are performed incorrectly.

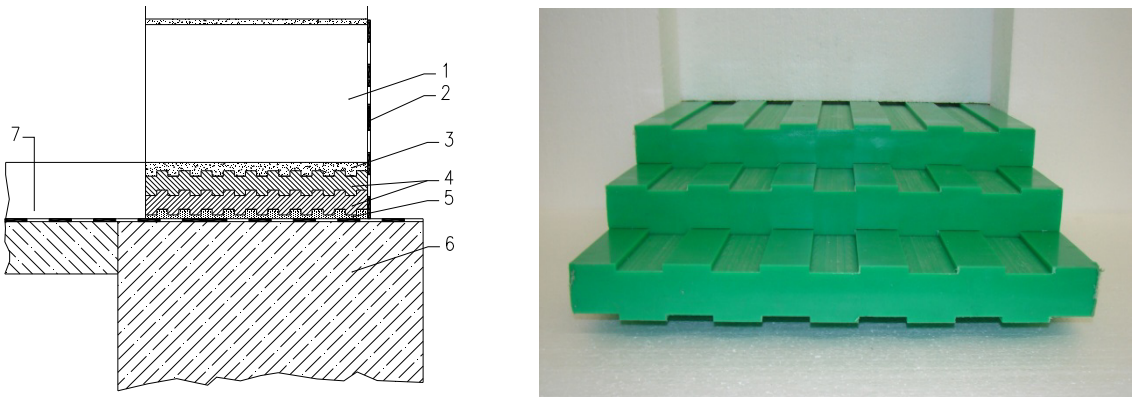

Fig. 3 Insulation block: 1 - masonry, 2 - water-proofing, 3 - cement mortar or concrete, 4 - insulation block, 5 - paste, 6 - foundation, 7 - floor

For detail of the installation of opening and detail in the wall foot were newly developed products that are made of recycled sorted waste HDPE, or their composites. It is the insulation block [3] (**Fig. 3**) and wall-box frame [4] (**Fig. 4**).

Fig. 4 Wall box frame

In development of these products the developers used numerical modeling method. Using FEA thermal-technical as well as statistic calculations and assessments were made. Functional samples (**Fig. 3**, **4**) of these products were also manufactured and they were and are experimentally tested on long-term tests (**Fig. 5**). Also for absence of material characteristics of the recycled sorted waste polymers in long-term load their long-term experimental testing was performed including the process of modification of material and thermal-technical properties. The long-term experimental testing was done using designed testing devices.

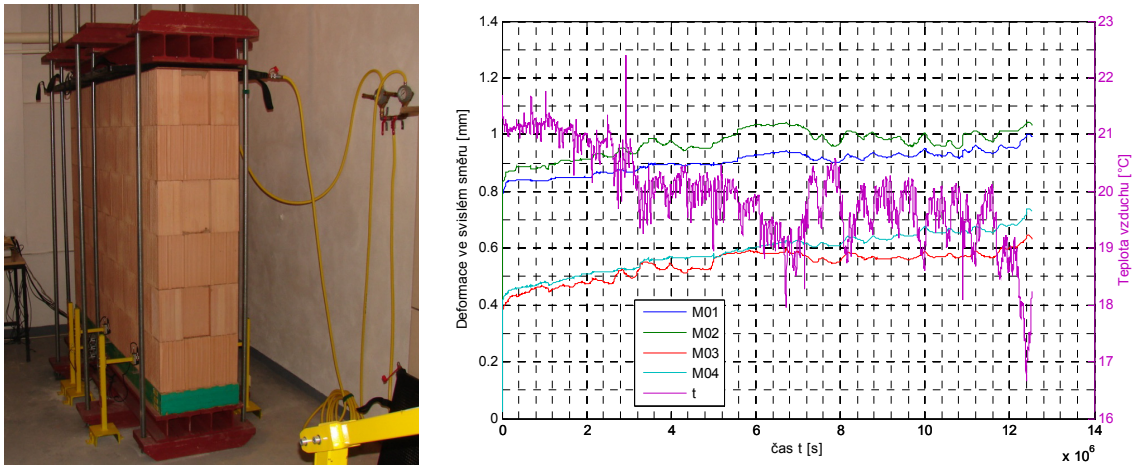

Fig. 5 Stressing frame with high-pressure pneumatic bellows and measuring device, graphic record from the measuring

3 Conclusions

Recycled polyethylene and other waste plastic materials in general may form an important element in selection of building materials in the future. Although the article deals only with one plastic material HDPE from the whole portfolio of materials potentially applicable in construction industry, it has been documented, that through scientific and practical approach a way for alternative use of every waste material can be found and this thesis may suggest a way how to proceed. The vision of the future is a house built solely from products based on waste raw materials. Currently, there is still a long way to go to such house, however every gap filled will contribute to implementation of this environmental goal.

Acknowledgement

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References

[1] G.H. BRUNDTLAND. Naše společná budoucnost. Zpráva mezinárodní komise OSN pro životní prostředí“. pp. 1-297. ISBN 80-85368-07-2. (in Czech).

[2] OECD. Organisation for Economic Co-operation and Development. Online at http://www.oecd.org, 2008.

[3] MATĚJKA, L., ŠINOGL, J., PĚNČÍK, J. Insulation block element for interrupting thermal bridges in the transition area between a wall and a foundation. No. EP 1918471, Europänisches Patentamt München, 2009.

[4] MATĚJKA, L., ŠINOGL, J., PĚNČÍK, J. Blind frame. No. EP 1918500, Europänisches Patentamt München, 2009.