

# Secondary Raw Materials in Construction

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**Abstract.** The paper describes and evaluates the use of secondary materials in construction details of buildings, primarily in the area of flat roofs. The roofs have a large number of technologies that are necessary for the smooth and healthy use of buildings according to current standards. We are currently discussing the take-back of PET bottles in the Czech Republic. New materials must meet specified parameters. Not only thermal, but also hygienic and fire-fighting. Primarily failures of roof structures are problematic parts during repairs.

## 1. Introduction

The Czech Republic sometimes takes over the standards of neighboring countries. However, differences in climatic conditions can be quite crucial. The need for own standards is therefore evident. In this respect, it can also be implemented in the concept of recycling and in civil engineering as a whole. Very frequent wastes are from demolition of unsatisfactory buildings, asphalt wastes and plastics in large quantities. Generated municipal waste in large cities is sorted and unsorted, primarily as glass, plastic, paper and electrical components. From a logical point of view, the polymeric secondary material is unsuitable for primary use in the food industry. It is already hygienically defective and cannot be fully cleaned. However, it is suitable to use the polymer in the construction industry, for example as substructure for flat roof technology. It creates flat surfaces that do not prevent water runoff and do not obstruct roof maintenance.

## 2. Potential use of recycled materials in construction details

On flat roofs it becomes necessary to apply technological equipment to a large extent. The location in the upper part of the building is offered from several points of view - spatial, financial and operational. The secondary requirements for roofing layers, such as the maintenance of technological equipment and the safety of movement on the roof, need to be evaluated.

Primary requirements on elements:

- long life span,
- frost resistance,
- constant volume,
- tolerance of other materials (material corrosion),
- strength – resistance to impacts and constant load,
- fast and all-year-round construction without technological changes,
- meeting requirements for fire resistance.



The above parameters are necessary for good function and durability of the inserted element.

## 2.1 Production and testing of testing samples

### 2.1.1 Production of testing samples

Test flat plate elements of 150 x 150 x 15 mm were produced from waste HDPE [1]. Other elements such as sawdust and blowing agents have been produced, tested and measured to primarily improve thermal, technical and mechanical properties. After measuring the coefficient of heat penetration, the boards were tested for peeling at connections [2, 3].



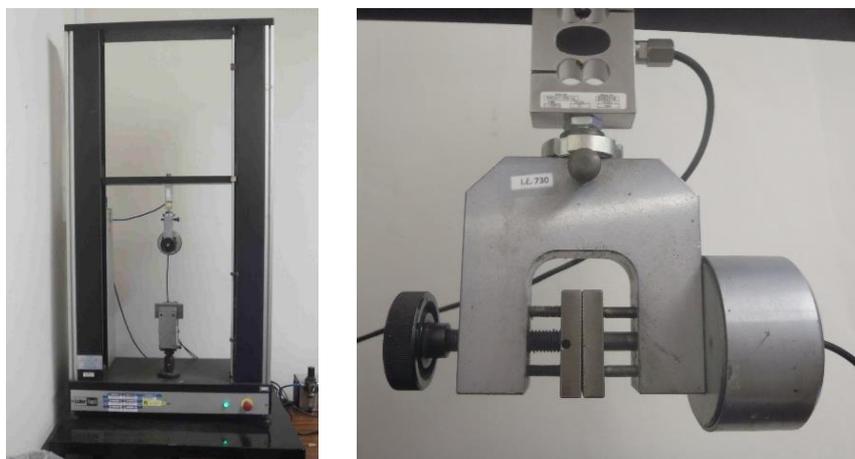
**Figure 1.** Testing board – HDPE with added sawdust.

Four elements of bitumen sheets were applied on the testing board by fusing. Two on each side.

### 2.1.2 Resistance from peeling at connections

The test was performed in a laboratory of company Dehtochema bitumat-tn a.s. The testing method is designed for testing connections in mechanically fixed one-layer bitumen roofing. Technical Definition - resistance to peeling is a tensile force necessary to complete separation of prepared connections. During testing, the testing body is pulled by a constant speed up to its complete separation.

The test was performed with the use of a testing tearing device LABORTECH 2.050, which is shown in Figure 2. The device is equipped with continuous recording of force which corresponds with the distance of grips and it is able to keep balanced speed of separating the grips. The grip width may not be lower than 50 mm. The speed of separating is defined as 100 mm  $\pm$  10 mm per minute. The testing body is secured against displacement by an inserted stopper.



**Figure 2.** Testing tearing device Labortech 2.050 and a detail of its upper grips.

The testing samples for connections were tempered (left) for 48 hours at the temperature of 22°C – 24°C under relative humidity of 60 %. The tempering conditions met the standard conditions as well as the necessary standard conditions [4,5], i.e. 20 hours at the temperature (23 ± 2) °C and relative humidity of (50 ± 20) %.

The measured values showed the possible use of secondary plastic raw materials in the construction details of buildings, in this case flat roofs. The tests were also positive for use with a common type of waterproofing. Physical, mechanical, and chemical properties puts them in polymer-compositions where traditional heat insulation materials are used. Using a product from secondary materials results in a lower thickness of a structure, since no other waterproofing or spreading layers are necessary, while the requirements of technological standards, regulations, and legislation acts are met. The big advantage is theoretically lower financial burden.

### 3. Classification of current critical details

At present, the base layer is laid directly on the waterproofing layer. (Figure 3a, 3b). The concrete distribution block is used as a suitable base distribution element, but it constitutes an obstacle to the natural runoff. It is therefore very difficult to create scattering wedges and to drain water from such inaccessible areas of the section blocks and technological systems.



**Figure 3a, 3b.** Pushing of distributing concrete structure to roof cladding.

In order to avoid the above-mentioned errors and imperfections, it is possible to use a thermal insulator which has higher thermal performance than the polymer but has a lower compressive strength. In this case, however, there is a possible additional failure of the waterproofing layer, which cannot withstand the pressure increase and a depression is formed.

The figures (Figures 4a, 4b) above illustrate a relatively common phenomenon of an improperly selected distribution structure below the process equipment. Rainwater settles at the point of extrusion and does not flow smoothly from the roof structure, which may result in gradual degradation of the waterproofing layer. A similar phenomenon also occurs at a point load from the technology support structure.



**Figure 4a, 4b.** Technological device on band supports and detail support.

Previously, it was not considered in the design with the location of technology, such as the installation of air conditioning and air conditioning units. The roofs were therefore not primarily intended for the installation of fixtures.

#### **4. Application of plastic in flat roofs**

This chapter discusses the possible use of secondary plastics in the construction details of buildings. The test sample is designed and produced is considered to be placed on the surface as well as at the end detail, e.g. at the attic. The connection of the element with the waterproofing layer is necessary for its proper functioning.

On the basis of measurements and tested, primary points have been defined that must be met within the framework of the introduction of the element into the field of building construction. The product should be able to withstand heavy loads, be heat insulating, be waterproof (secondary), allow easy and smooth installation and should not suffer from material corrosion. All newly designed buildings can therefore be equipped with the necessary technology either in the design or in the future.

The following basic properties the element should have are considered:

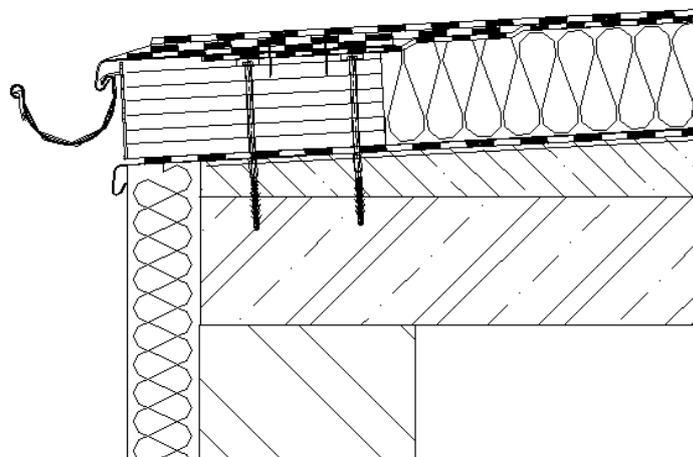
- long life span,
- constant volume,
- tolerance of other materials (material corrosion),
- strength – resistance to impacts and constant load,
- fast and all-year-round construction without technological changes,
- meeting requirements for fire resistance,
- harmless to health,
- sound insulation.

The above-mentioned characteristics are necessary for correct and long-term function and long life of the designed product [6-9].

#### **5. Conclusion**

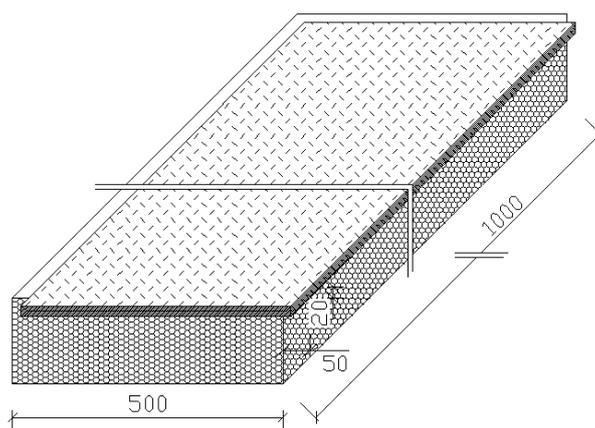
Designed base plate that summarizes these important parameters was subjected to measurements peeling in joints confirmed placement of plastic boards in construction details of roof structures. Checking:

- a) potential local joining,
- b) potential all-area setting.



**Figure 5.** Scheme of construction detail at the gutter – local joining.

Horizontal joining of boards (Figure 5) is suitable for roof construction details, their locks are multipurpose and can be used as corners at the attic, at the end of the structure at the light well, at roof hatches, etc. Thus, the proposed board can very well replace standard thermal insulators such as XPS.



**Figure 6.** Designed board for full-area setting.

A polymeric element which may be provided with an integrated thermal insulator layer at the factory (Figure 6) is designed for larger areas. The product already has overlaps of 50 mm. These overhangs serve as locks and thus continuously transmit the load on the surface to adjacent plates. The products are therefore suitable for roofing as a distribution layer.

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### References

- [1] L. Matejka, and R. Smolka, *Support structures for a doors threshold. EP 2159364 B1, patent. Munchen, 2012.*
- [2] V. Duchacek, *Polymers – production, properties, processing, applications, 2006.*
- [3] ČSN EN 12316-1 (727638). *Flexible sheets for waterproofing - Part 1: Bitumen sheets for roof waterproofing - Determination of peel resistance of joints.* Praha: Úřad pro technickou normalizaci, metrologii, a státní zkušebnictví, 11/2000.

- [4] R. Smolka., and J. Sobotka, “Application of Recycled Plastic in Flat Roofs,” *MATEC Web of Conferences*, vol. 146, 02009, 2018.
- [5] J. Plachý, “The problem of the compatibility of bitumen sheets for the reconstruction and rehabilitation of roofs,” *MATEC Web of Conferences*, vol. 93, 02004, 2017.
- [6] P. Kacálek, R. Smolka, and T. Petříček, “Design Properties of Log Walls with Respect to Building Physics,” *Advanced Materials Research*, vol. 1041, pp. 288-292, 2014.
- [7] T. Petříček, P. Kacálek, and R. Smolka, “Single-Layer Mechanical Fastening Waterproofing Systems,” *Advanced Materials Research*, vol. 1041, pp. 71-74, 2014.
- [8] T. Petříček, and P. Kacálek, “Dependence between the width of strip overlap and the strength of joints of one-layer bitumen sheets,” *MATEC Web of Conferences*, vol. 146, 02007, 2018.
- [9] J. Sobotka, and R. Smolka, “The temperature distribution during the microwave drying of wooden elements for structural defects in buildings,” *MATEC Web of Conferences*, vol. 146, 03008, 2018.