

# Material Properties

## RAW MATERIAL

Household plastic waste that meets the conditions of acceptance as described previously. The majority of this waste consists of one-time use household plastic packaging. After treatment in the recycling line (reducing, washing, separating, drying...) the various plastics are processed into end products. Raw material composition of the end products may vary depending on shape, size and area of application of the end products. The end products consist roughly of 60-95% polyolephines (PE-PP), supplemented with the necessary plastic types PVC, PS and PET.

## PROPERTIES

### 1. Strength properties

End products measuring 120 mm x 120 mm x 700 mm were tested for three-point flexural strength. Blocks with a 120 mm side were tested for compression strength.

The results were as follows:

- flexural strength: 14,5 N/mm<sup>2</sup>
- compression strength: 7 N/mm<sup>2</sup>
- E-module: 600 N/mm<sup>2</sup>

These conditions are situated well below the values for wood. Wood has at least double the flexural strength and six times as much for the elasticity module. Sagging would be considerably greater, helped along by exposure to sun.

This will already result in warping without stress.

This means that when the material is used in a post subject to flexural stress, the occurring stress values for the flexural strength should be taken into account. In a 3-point flexural stress in accordance with DIN 53452 temperature dependence was also verified.

Measurements showed that under the influence of the sun no area in the material exceeded a temperature of 30°C due to the low heat conductivity.

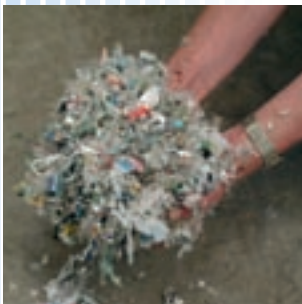
In calculating the stability, the following limit values were used:

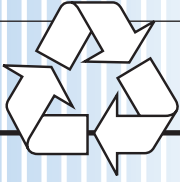
- flexural stress  $\sigma_b = 10 \text{ N/mm}^2$
- stretching  $\epsilon_B = 5\%$

However, the material is a suitable substitute for concrete (traffic islands, channelling elements...).

Creep typical for plastic, i.e. the sagging under constant pressure, was also studied.

It was determined that sagging of a board under constant pressure reached the final value after 12 weeks and stopped creeping after that.





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## 2. Thermal behaviour

Tests exposed the material to strong sun. Due to the low heat conductivity of the material (1.25 kJ/mhK) it was determined that the material does not exceed 30°C.

### 2.1 Shrinkage

Determining change in size due to shrinkage in accordance with DIN 51962 indicated that size change is negligible.

### 2.2 Behaviour in heat

Determination of the penetration depth in accordance with DIN 53460 as a measure for dimensional stability. This shows that the material is dimensionally stable at 30°C.

### 2.3 Behaviour under fire

#### 2.3.1 Flame on horizontal surface

Determination in accordance with DIN 51960.

This shows that the material falls under class I.

No smouldering could be observed after the flame was put out.

#### 2.3.2 Flame on vertical surface

Determination in accordance with DIN 53438.

Here as well the material falls under class I.

No smouldering could be observed after the flame was put out.

#### 2.3.3 Oxygen index

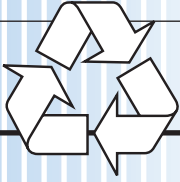
Determined according to ASTM D 2863-1977 for  $n = \frac{O_2}{O_2 + N_2}$

For air  $n = 0.21$

The  $O_2$ -value was determined when the samples are not yet burning. This oxygen index equalled 25.5. This leads to conclude that in a normal, free atmosphere the material will hardly burn.

#### 2.3.4 Test UL 94: (US-norm)

- The material falls under 94 V-O, i.e. no sample burns longer than 10 sec.
- No burning drops fall off any of the samples.
- No sample smoulders to the holder.



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## 2.3.5 Behaviour under fire of building materials

Determined in accordance with DIN 4102 T 1

The material falls under building material class B2.

The material has a certain degree of fire resistance.

## 2.4 Heat conductivity

Determined in accordance with DIN 52612 T 1 in function of the temperature.

As indicated above, this showed low heat conductivity and a low heating under sun exposure.

## 3. Chemical physical action of chemical substances

A very high resistance to common chemical substances was demonstrated using tests in accordance with DIN 51958.

## 4. Water absorption, frost-thaw behaviour

This is important for use in marine applications (pontoon, bank reinforcements).

Water absorption is minimal, 15 times less than wood. Other important factors are that the material does not rot and does not contain impregnating agents.

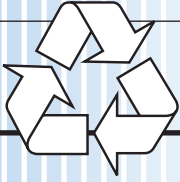
## 5. Weather sensitivity

### 5.1 Weather-o-meter-test

A period of time equivalent to 6 months is simulated to determine the effect of UV-light and precipitation. After 4 weeks, the affected layer is only 1/100 mm thick. Since the products are thick-walled, there is no expectation of the strength properties being affected.

### 5.2 Temperature and humidity

A natural cycle of 2 years was simulated. Again, no effects on the strength properties were observed.



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## 6. Density

The density of the material is around 1 g/cm<sup>3</sup>.

## 7. Ecological requirements

### 7.1 Toy guideline

The material was tested according to toy guideline DIN EN 71 part 3, which determines the migration of metal elements.

All recorded values were well below the norm.

Therefore, the material is suited for use in children's playgrounds.

### 7.2 Leaching study in accordance with KTW

This studies the potential use of the material in drinking water applications.

The following criteria were studied:

Migration of carbon compounds, chlorine consumption, lead concentration, phenol and formaldehyde levels.

The KTW-limits distinguish 4 levels:

- A: suited for pipes
- B: suited for tanks
- C: suited for fittings
- D: suited for elastic seals

A is the highest level, D the lowest. Again comparisons to wood and concrete were made. The plastics met the requirements for B and C, concrete met the requirements for B. No wood type, impregnated or not, met the requirements. These tests show that no adverse environmental effects should be expected from the use of recycled mixed household plastic waste.

### 7.3 Microbial damage

Purpose of the tests in accordance with 53739 was to determine the sensitivity to algae and bacterial growth. Tests indicated that the damage was negligible. The mixed plastic products were equivalent or superior to conventional materials such as wood and concrete.