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CONSIDERATIONS WHILE USING PANELTIM® PANELS

PANELTIM®
Pioneer in plastic sandwich panels

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CONSIDERATIONS

Paneltim® panels give endless possibilities to creative minds. The panels are easy to process using regular hand tools: sawing, drilling, screwing, etc. Moreover, using plastic welding techniques like butt welding, hot air welding, extrusion welding, the panels can be processed to any desired size.

Implementing newly developed lightweight but durable and ecologic materials into new applications, while meeting all state-of-the-art design standards and creating a competitive advantage, is the goal of every one of our creative partners.

In this magazine we will discuss some important considerations to be made while crafting structures with Paneltim®. When considered in your design, they will ensure a durable result.
These considerations are based on and explained in detail in the Paneltim® Technical Standard (PTS).

1. THERMAL EXPANSION

2. CREEP

THERMAL EXPANSION

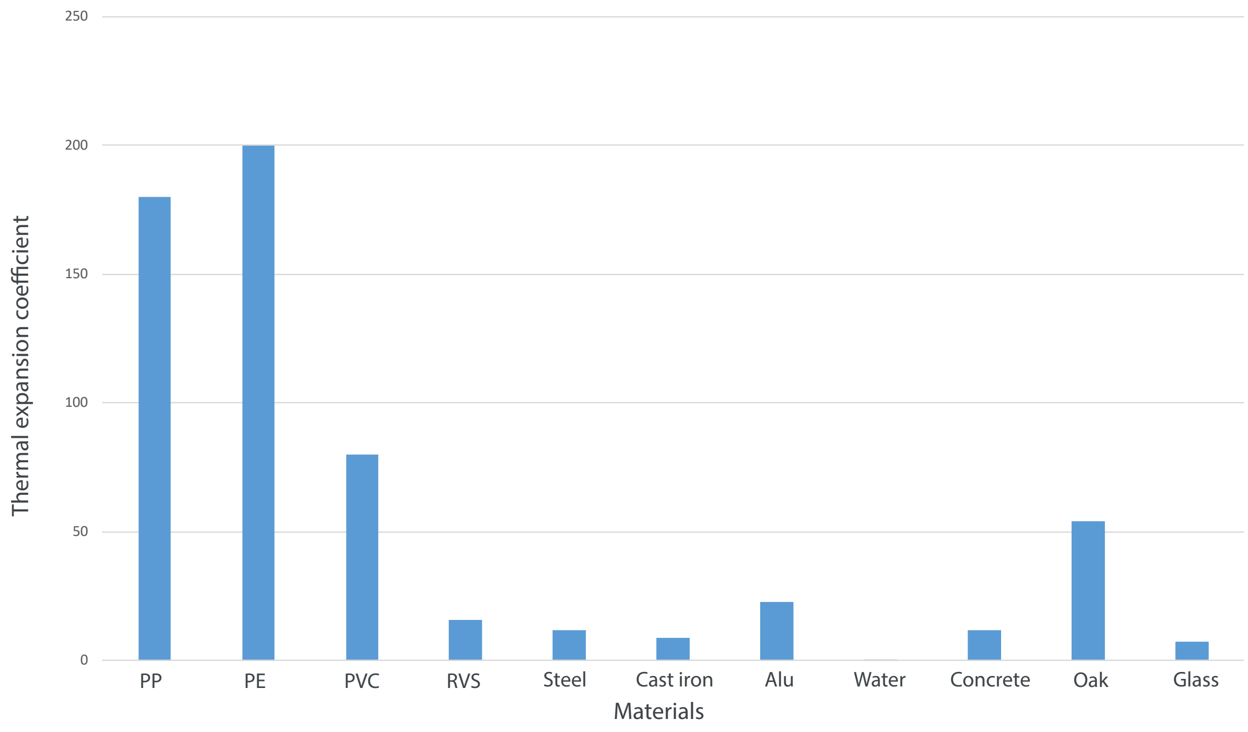
Materials have a tendency to expand and contract when subjected to changes in temperature. This phenomenon is especially relevant in bridges, highways and buildings. That is why a certain clearance in joints between building elements is necessary to allow the materials to expand freely. E.g. in road construction, flexible rubber joints are necessary to allow road sections to expand without causing internal stresses and deformation.

Also, when building concrete structures, if a sizable section of concrete is not provided with properly spaced joints to accommodate temperature change, then the concrete will start cracking in a regular pattern under temperature variations.

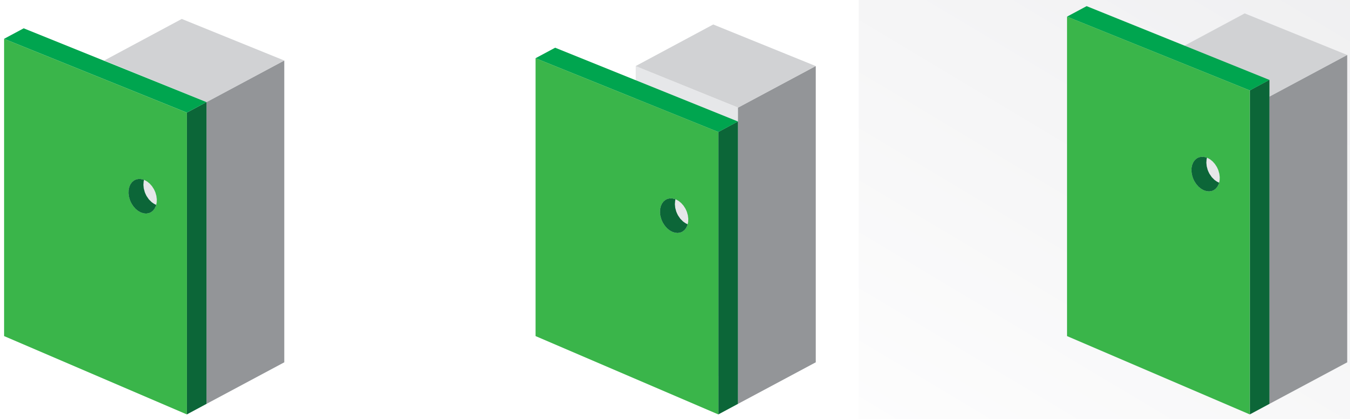
And so also with Paneltim® panels, thermal expansion and the associated stresses need to be considered and designed for.

Solutions to avoid deformation and failure caused by thermal expansion and contraction.

All materials, including concrete steel and also plastic panels, have a thermal expansion coefficient. This coefficient of expansion is a material property. It describes the level of expansion and contraction under temperature variations and is different for different materials. The figure below shows the thermal expansion coefficient of different materials.



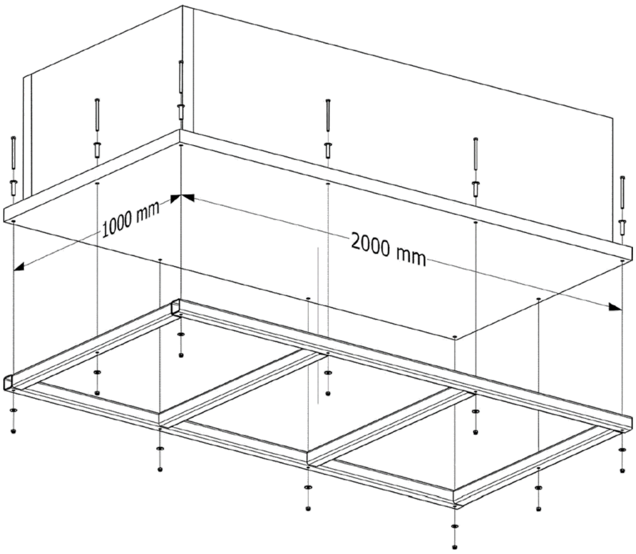
Thermal expansion will cause the dimensions of a product to change under temperature changes. When, for instance, a Paneltim® plastic panel is fixed to a supporting steel structure, both will behave differently under the temperature change, i.e. expansion will be different for the different materials.



Schematic representation of the thermal expansion coefficient.

Practical example:

A reservoir made of Paneltim® panels is mounted on a steel supporting structure. The difference between the thermal expansion coefficients is $168 \cdot 10^{-6}$ K^{-1}. Under normal circumstances, the temperature in the building is 18°C, but during the operation of the installation, the reservoir is filled with a liquid at 45°C. The temperature difference is 27°C. The construction is mounted with M8 bolts and bushes as shown in the figure below.



The difference in thermal expansion can be calculated with the following formula:

$\Delta x/l = \Delta\alpha \cdot \Delta T = 168 \cdot 10^{-6}\ K^{-1} \cdot 27° = 0.004536\ m/m = 4.536\ mm/m$

This means that on the shorter side of the reservoir there will be a difference of 4.5 mm between frame and reservoir. On the longer side the difference will be 9 mm. This will produce extra strain on the bolted joints. Therefore if the joints would not be appropriately dimensioned to allow for expansion/contraction differences, permanent deformation and damage could occur.

Practical example:

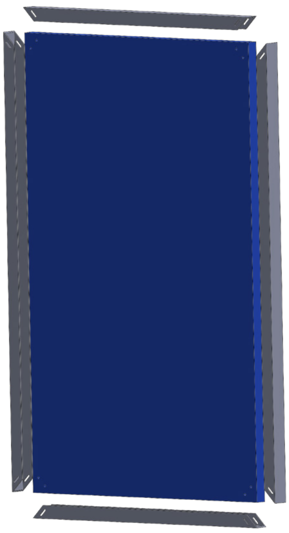
A Paneltim® panel is fixed to a steel supporting structure. The linear expansion coefficient of steel is $12 \cdot 10^{-6}$ K^{-1} and of polypropylene is $180 \cdot 10^{-6}$ K^{-1}. The difference between the thermal expansion coefficients is $168 \cdot 10^{-6}$ K^{-1}. The construction is installed in a building where temperature in winter reaches -10 °C and in summer +38°C, so the difference in temperature is 48°C. The calculation for the difference in expansion will be:

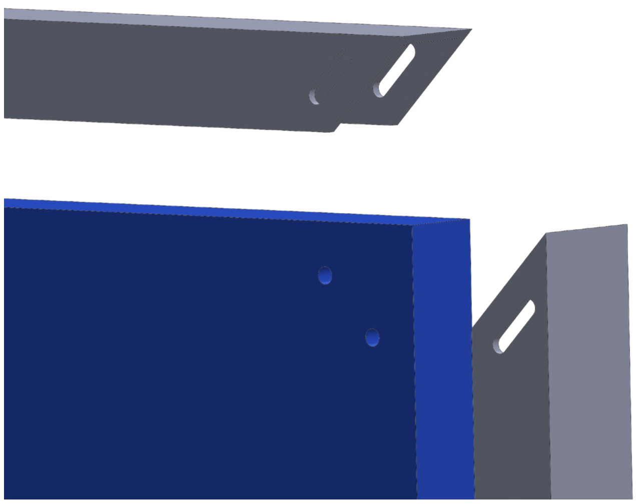
$\Delta x/l = \Delta\alpha \cdot \Delta T = 168 \cdot 10^{-6}\ K^{-1} \cdot 48° = 0.008064$ m/m = 8.064 mm/m.

This means that the panel will expand 8.064 mm more per metre than the steel structure. If there would be a bolted joint every metre, these holes would move approx. 8 mm relative to the steel construction. A clearance of 8 mm should therefore be added in the design.

Practical example:

For the **construction of a metal frame around a Paneltim® Lightweight panel** a reinforcement of metal U-profiles around the outside is used. This metal profile is fixed to the panel using bolted connections. However, anticipating different expansion of the metal profile versus the plastic, a sufficient degree of tolerance should be allowed at the metal profile corners. So rather than using round holes to bolt the panel to the metal profile, slotted holes should be used instead, allowing the panel to move freely in the profile under different expansion/contraction effects.





HEAT ABSORPTION

Plastic panels absorb heat by radiation. That is why constructions exposed to the sun heat up quickly. This must be taken into account in design and material choice.

Panels with a darker colour are more heat-absorbing than panels with a lighter colour. Hence panels in darker colours will reach higher temperatures, causing more expansion and internal strain. Once the maximum tolerated level of stress is reached, the panel would lose its durability.

Therefore, for panels exposed to direct sunlight light colours would be the best choice.

CREEP

DEFINITION

WHAT IS CREEP?

Creep is the permanent deformation of a material under long-term mechanical stresses, i.e. under tensile or pressure loading, or under torque loading.

HOW DOES CREEP WORK?

Creep is undesirable and reduces the effective life of an application.

When a material is subjected to mechanical stress it will deform. Under moderate stresses this deformation will be elastic, which means that the deformation is reversible: the deformation occurs according to Hooke's law, which means that the deformation is proportional to the applied force.

Figure 1: No creep: when the apple is picked, then the twig will move back to its original position.

Δ L = E x F

Δ L is the elongation (or deformation), E is the elasticity modulus of the material (in other words, it is a material property), and F is the applied tensile force.

When the force is removed, the material will return to its original length, meaning the deformation is reversible.

The elasticity modulus E is a material constant (a material property) - but only under condition of short term loading and under constant temperature.

Depending on the type of material and depending on the level as well as the time span of the applied force, the material will at some point no longer return to its original length, but will show permanent elongation (deformation); this is when creep is occurring. Furthermore when creep persists long enough rupture will occur**. If creep persists for a prolonged period, the object will break!**

CREEP IN DAILY LIFE

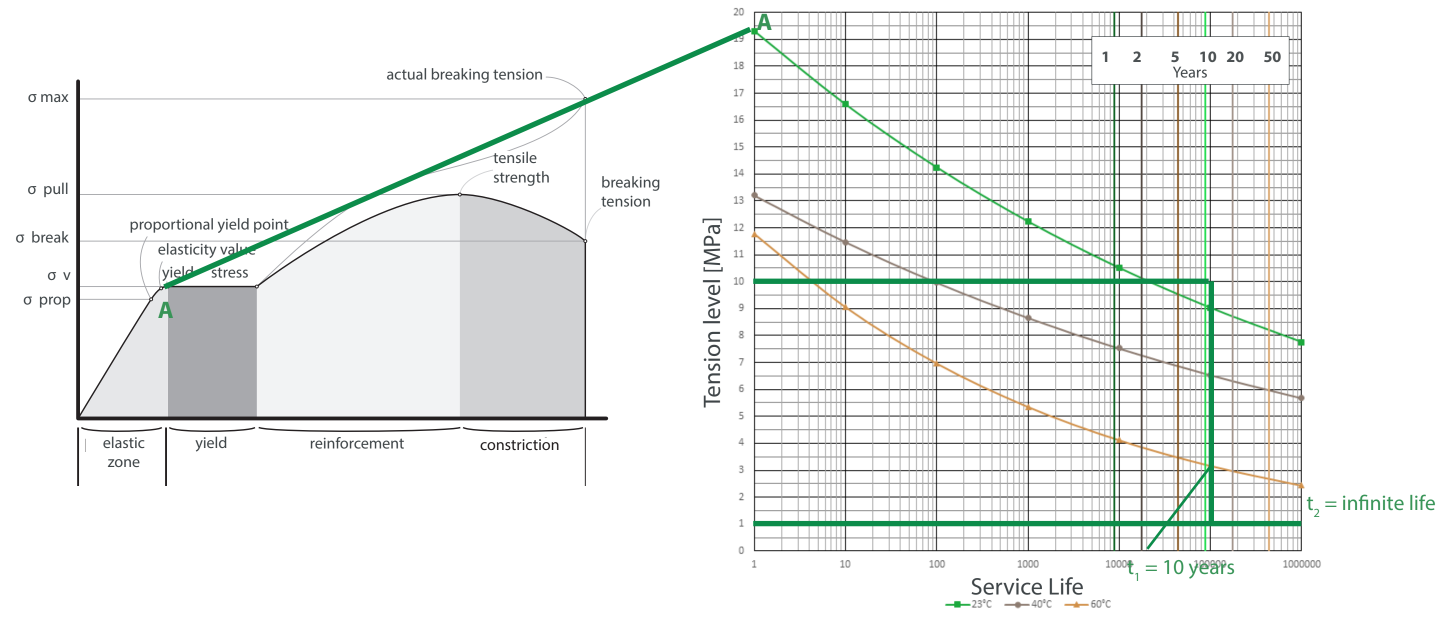
Practical examples:

A shelf under permanent load
will deform permanently after a while.

A clothes rail will start bending under loading
and at some point will be bent permanently.

RELATION BETWEEN STRESS-STRAIN AND CREEP

Using data of tensile stress testing, stress and related elongation/deformation can be calculated. Representing this data graphically in a curve results in a so called stress-strain diagram (figure on the left). Point A, which is the elastic limit or yield stress of the stress-strain diagram, corresponds with the beginning of the creep curve, at time 0. Over time this yield stress will decrease under permanent loading and as a result plastic behavior will start to occur at lower stress levels.



Stress-strain diagram & creep curve.

Practical example:

A line load of 73 kg applied to a panel of 1 m^2 corresponds to a load of 9.10 MPa (Mega Pascal) on the material. At 23°C we see on the creep curve that there will not be a permanent deformation. Indeed the maximal allowable stress at time 1 is approx. 19 MPa (A).

However, if a constant load of 9.10 MPa would be applied on the material, the situation would change over time. By following the green line going to the right until reaching the creep curve, clearly at some point permanent deformation will occur. It will take 10 years for the material to start showing permanent deformation, when applying a permanent force of 9.10 MPa. Hence after 10 years, the yield value has “moved down”.

Furthermore, the chart shows that temperature is a defining factor in the calculation of service life time. The higher the temperature, the lower the allowed stress at the same service life time.

IMPORTANT NOTICE:

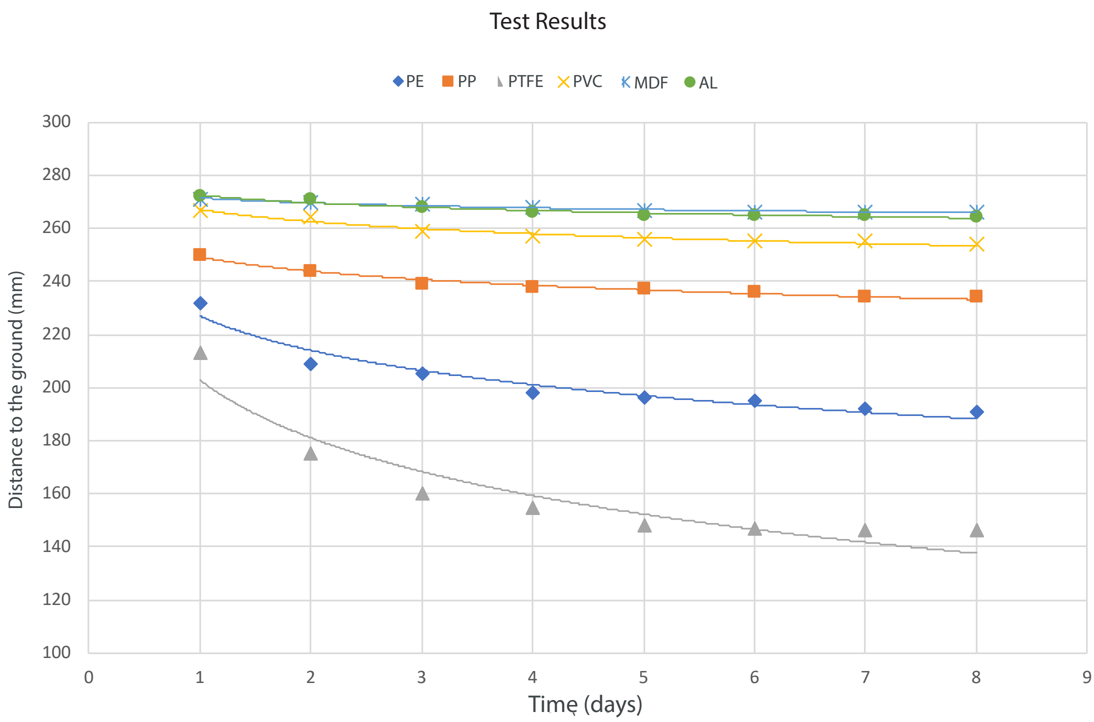
- **‘Temperature’ refers to the material, not the environmental temperature.**
- **A black panel can show deformation earlier than a white panel at the same temperature.**

DIFFERENCE IN CREEP BEHAVIOR

The images on the right page show an experiment demonstrating the difference in creep in different materials.

Within a time span of 7 days, the distance to the ground is measured. As the days go by, the materials bend more and more. PP and HDPE are more affected by creep than aluminium and MDF. This experiment is carried out at constant environmental temperature.

Experimental setup demonstrating creep.



Comparing creep of PP and HDPE vs aluminum and MDF.

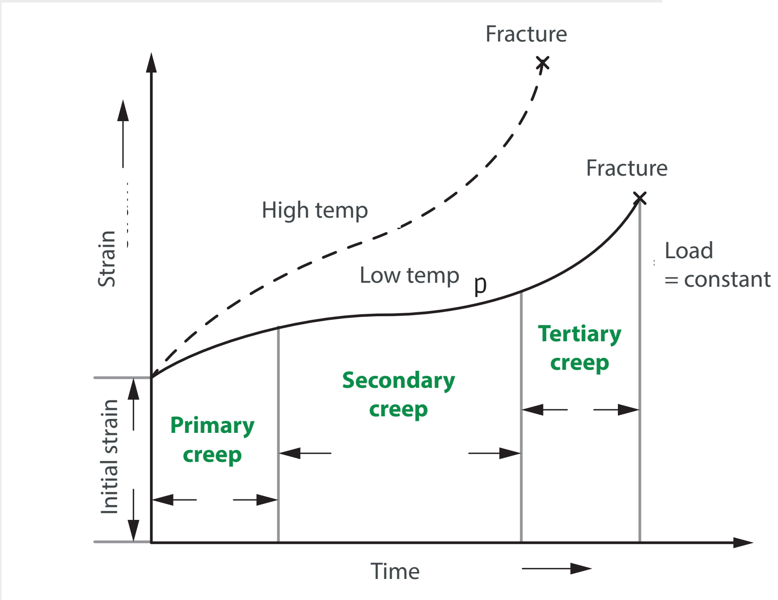
RUPTURE

The creep curve below (strain versus time) shows creep developing in three phases before final rupture.

Primary creep is the first phase in which creep speed slowly decreases. Apparently in this phase a certain strengthening of the material is occurring.

During **secondary creep** the creep speed is constant because of a certain balance between the material strengthening on the one hand and some softening of the material through "recovery" on the other hand. Usually this section of the curve is the longest.

During **tertiary creep** the creep process is accelerating, ultimately leading to rupture of the material. This rupture usually occurs at the intergranular level of the material.



Practical example:

When a tank is subjected to mechanical stress over a prolonged period of time, the tank will pass through the above-mentioned three phases:

• In the first phase, the tank will expand under the mechanical load. = **Primary creep**

• After a while, the tank will move into the second phase where little to no expansion will take place.= **Secondary creep**

• When transitioning into the third and last phase, the tank will start expanding again at a faster pace, until rupture occurs. = **Tertiary creep**

The time period over which the tank passes through the different phases depends on the materials used as well as the actual load exerted on the tank; but after a defined period of time, the tank will fail.

It has become necessary to use not only lightweight, but also sustainable and ecological materials in new applications.
The Paneltim® Technical Standard (PTS) provides all the necessary data to accelerate and improve the design of light and durable thermoplastic panel structures. Thus not only providing guidelines for manufacturing and installation, but also with regard to data, calculations and practical examples.
The PTS forms a strong, scientific, design basis for constructions made with Paneltim® panels and provides guidelines for making safe structures.

A NEW STANDARD FOR CALCULATING STRUCTURAL APPLICATIONS WITH DOUBLE WALL PLASTIC PANELS

Contact Paneltim to register for the PTS
and have access to the most recent technical information at any time.

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