PEIKKO
# WHITE PAPER


# SURVIVING THE FLAMES

## HOW EBEA® RESISTS EVEN WHEN EXPOSED TO EXTREME FIRE

Published: 05/2023

**Seref Diler** M.Sc.
Product Manager
Peikko Group Corporation

**Silvija Gasiūnė**
Sales Engineer
Peikko Lietuva

Load-bearing thermal insulation elements such as Peikko EBEA® cantilever slab connections are common practice when cantilevered reinforced concrete components such as balconies are thermally decoupled. They are required to avoid constructive thermal bridges.

Nowadays it is more important that buildings are of high quality, energy efficient and that the right building products are used. Quality no longer just means avoiding damage such as mold that can occur as a result of constructive thermal bridges, but also avoiding energy losses in the building.

That is why load-bearing thermal insulation elements are state of the art in Europe and Switzerland today. However, since they also have a statically relevant function in addition to their thermal insulation properties, they are regulated and verified by the building authorities through approvals and static tests.

This is also the case with Peikko EBEA®, the balcony connector, which consists of insulating and load-bearing components. EBEA® was originally developed in Switzerland and several tests were performed at universities and accredited institutions.

Peikko acquired EBEA® in 2019 and based on these tests and additional tests for EBEA® received product approvals in many other countries including Finland, Hungary and Slovakia. EBEA® has experienced growing acceptance beyond Switzerland, with more and more organizations around the world adopting this innovative approach.

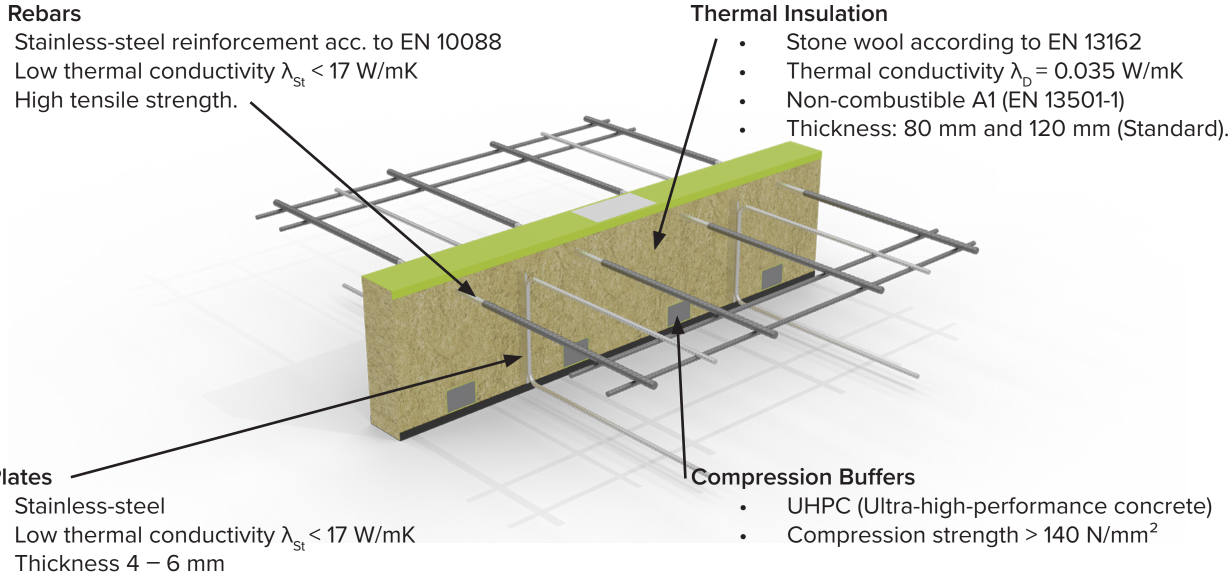


*Figure 1. EBEA® Balcony Connector – load-bearing thermal insulation element.*

In addition to the static properties to be tested, thermal break elements must also meet other criteria, some of which may differ from country to country, including fire protection. Load-bearing thermal insulation elements such as EBEA® are often located in the thermal insulation level of the outer façade and are the connecting link between the balcony slabs on the outside and the ceiling slabs on the inside. They therefore represent an interface between these components, which in turn can have different fire protection requirements. Depending on the use of the building and the design of the façade, these components must have a fire resistance period of 30 to 90 minutes, a requirement EBEA® fulfils. The fire protection properties are evaluated and classified according to the European harmonized standard EN 13501 -1/2 or the Swiss standard SIA 183 according to VKF (Swiss fire protection authority).

In EN 13501-1, building materials are tested according to their material properties and classified from flammable to non-flammable. There are several distinctions, and the drip behavior and flammability of the material are also tested. In EN 13501-2, building products that consist of several components as well as entire components are regulated with regard to their fire protection behavior. Depending on the application of the construction, these must together meet different requirements in construction tests and under fire exposure. The "R criterion" such as R30 to R90 symbolizes the classification of fire resistance and the associated fire resistance period. This applies to all components and construction products. If components and building products need to meet additional fire safety requirements such as air-tightness in enclosed spaces, they must also comply with the "E-criterion" which can range from E30 to E90.

Here it is measured how much smoke penetrates through the construction and when the critical amount is reached. The last criterion that can be measured in a fire test is the "I criterion". This criterion applies above all when building products and components have an insulating function in the event of fire, which prevents the side of the component that is not exposed to the fire from exceeding the critical temperature of 180 °C. The time it takes to reach this critical temperature is measured in a fire test, e.g. I 30 to I 90. Components with a space-enclosing function must therefore generally meet the REI criterion in accordance with EN 13501-2.

Load-bearing thermal insulation elements such as EBEA® are also tested in fire tests according to EN 13501-2 and their fire behavior is evaluated in their area of application. Large-scale fire tests are very complex and must be carried out in order to evaluate the product in terms of fire protection. The construction product is tested in use, meaning the test specimen consists of balcony slabs and ceiling slabs, which are thermally decoupled from one another by EBEA®.

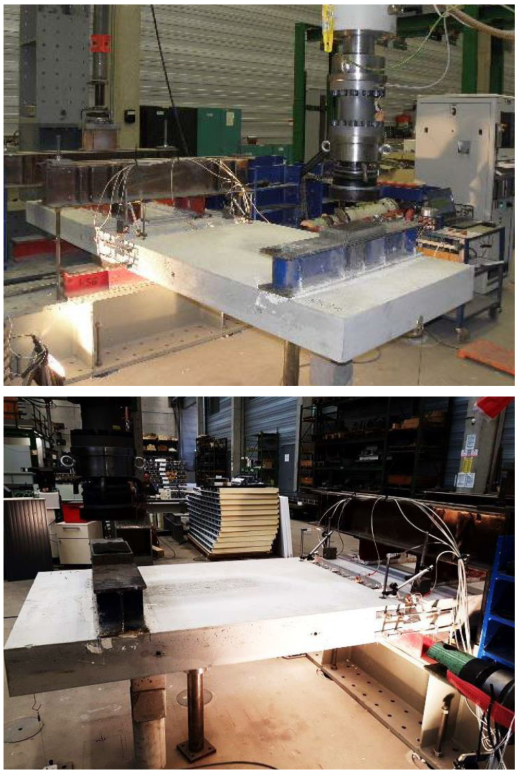

*Figure 2. Static tests at Technical University of Darmstadt to verify the functionality of EBEA® Balcony Connector.*

*Figure 3. Fire test specimen with EBEA® at ITB – Technical Institute for Constructions in Poland, Approval Department.*

After the test specimens have been produced, they are required to dry out for a period of 90 - 100 days, since the concrete used has residual moisture that can falsify the result. In addition, the specimens must be suitably stored. Nevertheless, the quality of the concrete and the storage behavior will always have an influence on the large fire tests, since these boundary conditions can never be completely neglected. The longer the drying time, the better. The test specimens are then placed in the large oven and sealed all around so that EBEA® can be tested as a connection joint. Since this is a statically relevant building product, the balcony side is loaded with a test load that corresponds to the service load. The service load corresponds to the load at which the construction is used according to the expected stress. In addition, the smallest possible connection height of the product is selected. The test load is applied linearly and depends on the lever arm and the load capacity of the product. During a fire test, it is important to simulate any scenario that could potentially occur under real conditions. Nevertheless, worst-case scenarios are assumed for large-scale fire tests since the fire exposure takes place in a closed furnace under an expected test load with a low connection height and in accordance with the standard temperature curve according to ISO 834. The standard temperature curve is based on temperatures at which over 1000 °C are reached after 90 minutes and well over 600 °C after just 15 minutes in the furnace. In addition, the product was tested in a closed room furnace, which is not always the case with a cantilevered balcony.

A large-scale fire test thus simulates a fire scenario that in most cases certainly deviates from practice or would not occur in this way. Since the fire tests take place in a controlled oven, the test specimens are produced under laboratory conditions, stored constantly and for a sufficiently long period of time, and the materials used are qualitatively evaluated. But what happens if there really is a fire, and the balcony is exposed to a façade fire? How safe are the balconies in practice and what happens with EBEA® under real conditions? Hopefully this never happens because lives can depend on it. And if it does happen, then it is a question of safety concepts that are generally relevant to fire protection, such as the Grenfell Tower Fire.

Nevertheless, fire protection can be unpredictable at times, leading to unexpected incidents that may result in property damage, but with no harm to persons nearby. Something like this recently happened in Lithuania. A fire broke out on the construction site during the construction of a residential building. Since the residential building was uninhabited, no one was injured. The façade consisted of external insulation based on combustible EPS (Styrofoam), which is usually covered with a layer of mineral plaster. Within a few minutes, the entire façade was exposed to fire and almost completely burned down. The balconies of the residential building were also exposed to the construction site fire. The precast balconies were installed a few weeks prior. EBEA® was used as the load-bearing thermal insulation element.

*Figure 4. EBEA® – Balcony Connector during fire tests according to EN 13501-2 classification.*

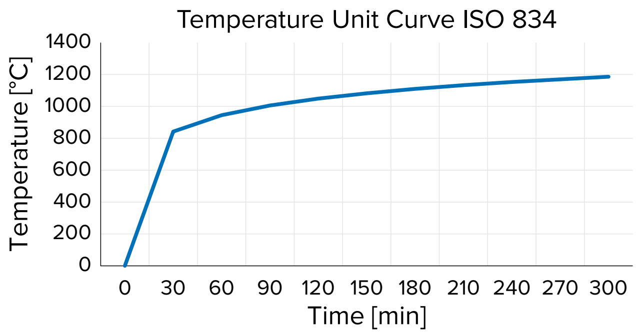


*Figure 5. ISO 834 fire temperature curve which is used for fire tests with EBEA® Balcony Connector.*

The fire load from the combustible exterior insulation was so enormous that the balconies were exposed to fire for several minutes. There were some concrete splinters on the underside of the balconies. Although the fire did not last longer than 30 minutes and the fire was extinguished quickly, the façade with the external insulation was completely destroyed. Luckily, the load-bearing structure of the outer walls was preserved because it was saved in time by extinguishing measures.

The question now arose as to whether the balconies could continue to be used with EBEA® as a load-bearing thermal insulation element. Were the balconies still safe and did the insulating and load-bearing properties of EBEA® work as originally planned? Peikko Lithuania's application engineers and product management were contacted, and an external engineering office was also consulted. After an inventory on site, it was decided to subject the balconies to a functional test and also to assess the quality of the load-bearing components. The concept was created by the external engineering office and coordinated with those responsible at Peikko.

EBEA® was exposed from above and the tension and shear rebars were examined for color changes that could result from the fire. If the tension rebars had suffered from the fire, bluish discoloration would be visible. But neither the tension nor the crossbars showed discoloration. As a first step, it could be determined that the stainless-steel reinforcement of the EBEA® types was not affected by the fire. Due to the special quality of the stainless-steel reinforcement, which has high mechanical parameters, they were also on the safe side. Another important indicator for the assumption that EBEA® was not damaged by the fire was the quality of the insulation. Stone wool was used as the standard insulation material for EBEA®, which has a relatively high density and corresponding robustness to external environmental influences. The stone wool purchased by Peikko is subject to the requirements of the EN 13162 standard and is hydrophobic. It has a very low thermal conductivity and is non-flammable, i.e., fire protection class A1 according to EN 13501-1. In particular, the combination of good thermal conductivity and non-combustibility make stone wool a multifunctional product.

In addition, stone wool is a mineral product obtained from rock types of volcanic origin and offers ecological benefits. Artificial insulating materials made of plastic are combustible and are therefore required to be protected from fire by non-combustible fire protection panels. However, should the fire protection slabs fail, because a gap forms between the load-bearing thermal insulation elements during installation or because the fire can penetrate from the side, the insulation melts, and the load-bearing components such as reinforcing rebars are then exposed to high temperatures. Above 500 °C, steel rebar loses its load-bearing capacity. That is why stone wool, which has a temperature resistance of over 1000°C, is also used for EBEA®. Stone wool ensures that the load-bearing components of EBEA® are also protected in the event of fire.

*Figure 6. Fire at façade of residential building with balconies and EBEA® – balcony connectors.*

Due to these properties of the stone wool, after scraping the surface of the EBEA® we were able to determine that the stone wool was still in order as insulation and had fulfilled its function in the event of a fire.

Because water was used to extinguish the fire, the belief that stone wool would absorb moisture and lose its properties could be countered, as the scraped stone wool was both bone dry and fully functional. Unless specifically submerged in water, stone wool is hydrophobic and water-repellent. Even if minimal moisture should penetrate into the areas of stone wool near the edge zones, stone wool has the property of quickly releasing this moisture to the environment, including the concrete. These properties are also tested in EN 13162. Stone wool must not be stored completely in a closed box, otherwise the penetrating moisture cannot escape. In order to finally assess the functionality of the balconies with EBEA®, deformation tests were carried out on all balconies. There was also a detailed test concept that was created by an external engineering office in cooperation with Peikko. First, the height of the balconies was measured, and the reference value was determined.


*Figure 7.   Balconies with EBEA® Balcony Connectors – Assessment of fire damage.*

The load was then applied in several stages over a longer period of several hours in the form of 25 kg cement bags each until the maximum serviceability load was reached. The deflection was measured at each load application. The interval between the respective load applications was approximately one hour. After reaching the serviceability load, the deflection was then measured over a further period of several hours. Thus, it was possible to analyze how the balcony behaves under serviceability load over a longer period of time.

Fortunately, no subsequent deformations that could have been caused by the fire were measured on any of the balconies. The quality of the EBEA® elements contribute to this, as they are very robust due to their high rigidity and existing security. The result was then summarized in a report and handed over to the investor. Finally, the balconies, which were thermally decoupled with EBEA®, could remain in place and the client only had to renew the façade that had been damaged by the fire.


*Figure 8. Balconies with EBEA® – measurements of balcony deflections by applying additional loads.*

In conclusion, it can be said that fire tests are absolutely justified and necessary to classify products. But ultimately there are many factors that can affect the fire. The building fire on the site in Lithuania showed: **Even in the even of fire, you can rely on EBEA®!**


# A faster, safer, and more sustainable way to design and build

Peikko is a leading global supplier of slim floor structures, wind energy applications and connection technology for precast and cast-in-situ. Peikko's innovative solutions offer a faster, safer, and more sustainable way to design and build.

www.peikko.com

peikko®