Seismic Isolators Protect a Wooden Wave-Shaped Airport Roof

New main terminal at the Portland International Airport is equipped with pendulum isolation bearings.

Portland. **The appearance is stunning: a wooden roof floats above the reconstructed and expanded Portland airport terminal. Y-columns support the roof. The visionary design became earthquake-resistant using 68 double concave SIP®-Bearings, which sit on top of the Y column tines: posing a challenge to MAURER's experts in seismic protection.**

In a multi-year project, the main terminal of the Portland International Airport (PDX) in Oregon, USA, was expanded, renovated and equipped with seismic protection. The existing buildings are not designed for the newly applicable specifications and earthquake intensities. The approximately 32,500 m² new timber roof will be visually distinctive. The roof is modelled in arches and scalloped shapes, a design of ZGF Architects and KPFF Consulting Engineers. The roof rests on 34 approximately 16.2-metre-high steel Y-columns filled with concrete, which are arranged at a distance of more than 30 metres.

Beyond the appearance, the seismic isolation of the wooden beauty posed a challenge. The seismic design aimed to cover all possible load cases during normal operation and in the event of earthquakes.

Per code requirements, the structure was analysed for the MCER (Risk-Targeted Maximum Considered Earthquake) case, which is approximately equivalent to the maximum conceivable earthquake in Portland in 2,500 years. In addition the structure was also analysed for the deterministic seismic hazard of a Mw 9.0 event on the Cascadia subduction zone which is approximately 100 km west of Portland. In the end, this resulted in large roof displacements of ± 406 to ± 572 mm.

These large displacements are accommodated by SIP®-D-Bearings; see below for details. The design of the bearings was developed in close coordination between KPFF Consulting Engineers and MAURER Munich.

Rendering of how the new main terminal in Portland will look from August 2024 onwards. Clearly visible, the load-bearing function of the Y-columns.
Graphic: Port of Portland

Installation of the SIP®-Bearings on top of the Y-columns. Work performed at night as the airport is being renovated while continuing to operate.
Photo: W&W | AFCO Steel

Installed SIP®-Bearings on top of the tines of the Y-columns.
Photo: KPFF Consulting Engineers

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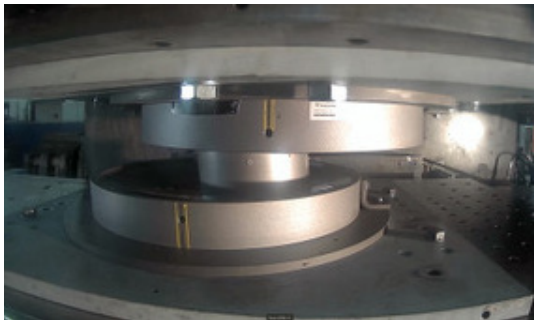
SIP®-D: Double Sliding Isolation Pendulums

SIP® stands for Sliding Isolation Pendulum. They have four functions:

- They isolate and separate the terminal roof from the columns and allow horizontal movement in all directions.
- They limit the seismic movements through internal friction by converting kinetic energy into heat.
- They recentre the roof back to its original position following an earthquake due to their concave sliding surfaces.
- They transmit vertical loads of up to 4,115 kN.

"D" for Double, indicates that the bearings have two concave surfaces (instead of one) between which a puck slides. The reason for this detail is that the large horizontal seismic displacements would require very large bearings. In the case of SIP-D bearings, the displacement is evenly distributed over two concave surfaces which reduces the required diameter by approximately one third. This means that SIP®-D-Bearings can be built smaller, which complied with the architects' specifications.



Prototype testing of the SIP® bearing at EUCENTRE Pavia.

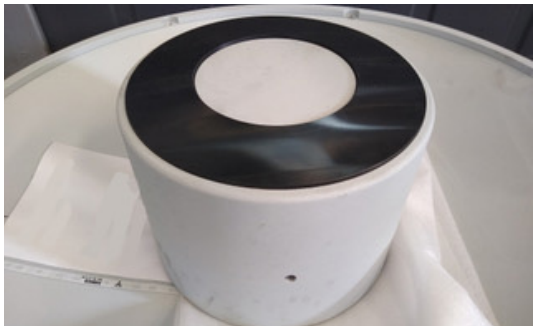
Photo: MAURER

High-performance sliding material MSM®

"Overall, however, it was not only about the design of our bearings. The requirements for movements and superimposed loads in a highly confined space could only be met with our high-performance sliding material MSM®," reports Mark Kaczinski, MAURER USA.

MSM® stands for MAURER Sliding Material. In contrast to other alternatives such as PTFE, it is PFAS-free. MSM® also has a much longer service life (more than 50 years) and double the compressive strength. The bearings can therefore be built smaller and the largest have a maximum diameter of only 1,000 mm.

A total of 68 Double Sliding Isolation Pendulums from MAURER lie on top of the two tines of each Y-column. The bearings have been designed for the most extreme seismic loads and an extensive test programme was therefore carried out.



Unusual insight: a puck, the centrepiece of a SIP®-Bearing. The photo was taken during the overhaul of a prototype bearing following testing.

Photo: MAURER

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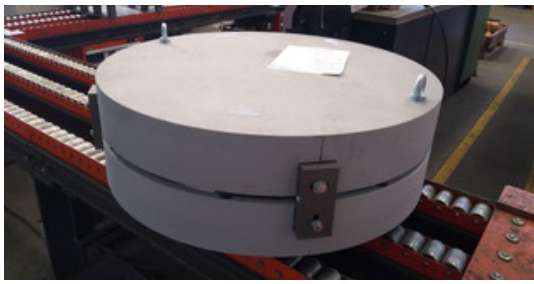
Several test series in special testing laboratories

Prototypes of all four bearing types were manufactured in their full-scale size and dynamically and statically tested at the EUCENTRE (Pavia).

To simulate real earthquake conditions, the bearings were tested at velocities up to 1 m/s and up to ± 380 mm displacement with a maximum 420 tonnes superimposed load. Even more challenging, half of the prototypes were tested again in SISMALAB (Crispiano) to ensure that the subsequent production tests also provided valid results. These tests simulated more than three maximum earthquakes. "Even with these high requirements, the bearings showed no signs of wear or damage," reports Mark Kaczinski.



Assembled SIP®-Bearing.

Photo: MAURER

The combination of a robust design procedure and SIP®-D-Bearing performance will ensure passenger safety and significantly reduce building damage from the worst possible earthquakes and allow the airport to resume operations without a long interruption.

Phase one of the new PDX Airport Terminal is scheduled to open in August 2024 with full completion in late 2025.

Text: 4,677 characters

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Quick facts about MAURER SE

MAURER SE is a leading specialist in mechanical engineering and steel construction with over 1,500 employees worldwide. The company is a market leader in the fields of structural protection systems (bridge bearings, expansion joints, seismic devices, vibration absorbers, and monitoring systems). It also develops and manufactures vibration isolation for buildings and machinery, roller coasters, Ferris wheels and special structures in steel construction.

MAURER is involved in many spectacular large-scale projects, such as the world's largest bridge bearings in Wazirabad, earthquake-resistant expansion joints on the world's longest suspension bridge (1915Çanakkale), tuned mass dampers in the Baku and Socar Tower or the unique guided cross-ties with derailment protection on the Champlain railway bridge in Montreal. Complete building isolation ranges from the Acropolis Museum in Athens to the new major airport in Mexico. Spectacular amusement rides include the Munich Ferris wheel Umadum, BOLT™ as the first roller coaster on a cruise ship or the world's first duelling roller coaster at Mirabilandia Park in Ravenna.

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