INDONESIA

Borobudur Temple

The Borobudur Temple was built in the 8th century by a king of the Sailendra dynasty. It is one of the biggest Buddhist monuments in the world. The layout of the temple in the shape of a Mandala is composed of a basement, the so-called hidden foot

Borobudur Temple before the restoration by Theodore van Erp

Sunrise over Borobudur Temple

and four square terraces with 1460 reliefs showing the life of Buddha and Buddhist mythological scenes. Nearly countless niches with sitting Buddha statues adorn these four levels. The upper three levels consist of circular terraces with 72 bell-shaped stupas containing Buddha statues and of the central huge stupa at the top. The ashlars and sculptures are made of intermediate and basic volcanic rocks (andesite, basalt) from the surrounding volcanoes Gunung Merapi, Gunung Merbabue, Gunung Sindoro and Gunung Sumbing and were quarried in the river beds. The basement is built up by a natural hill and backfill; the ashlars were dry set.

The temple was covered with soils and ashes from volcano eruptions and had gradually overgrown with trees and shrubs when it was rediscovered in the 19th century by Sir Thomas Stamford Raffles. In 1991 the 'Borobudur Temple Compounds' were inscribed on the UNESCO World Heritage List, underlining their significance as a site of outstanding universal value.

The first restoration intervention was undertaken between 1907 and 1911 by Theodore van Erp. He consolidated the upper three terraces of the temple-mountain, reconstructed the bell-shaped stupas and the central stupa and stabilised the walls of the lower galleries and the stairs and gates. Furthermore, he improved the water drainage system. During this intervention a considerable amount of concrete was brought into the structure. The middle terraces were not consolidated. During this restoration phase many of the bas-relief panels were painted with ochre yellow, the so-called "van Erp paint".

From 1973 until 1982 the second large-scale, international rescue campaign was led by UNESCO. Large parts of the temple mountain and of the bas-reliefs in the galleries above the so-called hidden foot were dismantled and reassembled on a stabilized construction. During this intervention, concrete slabs with vertical epoxy tar layers and horizontal lead sheets, functioning as waterproofing for a new internal draining system, were built into the temple structure. The concrete slabs collect the water on the different platforms and serve also as circular reinforcements ("Ringanker") for the stabilisation of the temple mountain. PVC pipes channel the water from the upper to the lower levels.

All these interventions could not stop water seepage. Therefore, a third big intervention took place between 2011 and 2013, carried out by the Borobudur Conservation Office (BCO). Most of the balustrades were dismantled and reassembled and new epoxy tar coated lead sheets were inserted underneath. However water seepage still occurs.

Sitting on the edge of the 'ring of fire', the most active volcanic region in the world, the temple has been repeatedly damaged by natural disasters. In October and November 2010 big eruptions from the Mount Merapi volcano covered its surrounding areas and the temple with a blanket of volcanic ash. The November 5, 2010 eruption alone covered the Borobudur Temple Compounds with a layer of around 45 mm.

The cleaning of the volcanic ash from the surface of the monument began immediately after the first eruption in order to prevent any damage to the reliefs. The work was nearly completed when the second eruption took place on November 5. The cleaning operation was carried out by the staff of the Borobudur Con-

Temple front showing different types of decay

Bas-relief with pustules

Detail of a relief showing severe rounding

servation Office and by hundreds of people from the local community and volunteers under the supervision of the site office of the Ministry of Culture and Tourism. It was assisted by UNESCO and the international community, including the German government.

The risk of a direct damaging influence of the ashes on the temple's carved reliefs and Buddha statues inside the stupas and chapels was negligible; those responsible had been afraid of a potentially corrosive reaction of solutions from the ash on the reliefs. However the blockage of the internal water drainage system by the ashes would have caused unpredictable serious problems.

In February 2014, the ash of the Kelud volcano in East Java blanketed the temple compound again with ashes. Due to the preventive disaster management project of the BCO the Borobudur Temple could be immediately protected by sliding covers and the damages could be mitigated.

The most severe stone conservation issues on the bas-reliefs of the temple walls and the balustrades are so-called pustules, crust formation with different compositions, cracks, and uncontrolled water seepage. They are independent of the ashes and solutions from the ashes. Everywhere breakages at the horizontal joints can be observed which derive from the dismantling and reassembling of parts of the temple during the intervention of the 1970s. Other negative influences are salts with damaging effects on building materials and microbiological contamination. They cause the loss of the precious carved surface in very small fragments. The

Relief showing biological growth and breakage

weathering dynamics are not very rapid, but it is currently impossible to provide a reliable prognosis as to further weathering.

The ongoing research therefore focuses on the leakages and the formation of pustules and crusts. It is carried out by the authors in close cooperation with the colleagues of the BCO and other German and Japanese experts, organized by UNESCO Jakarta office and supported by the German Federal Foreign Office. A full photographic documentation of the bas-reliefs was carried out during the dry and the rainy season. It provides the basis for a comparison with the older documentation (van Erp), but also for the long-term monitoring and observation of the leaking areas. Detailed mapping of deterioration patterns on test areas and extensive material testing at the site and in the lab as well as practical conservation tests have been undertaken. Another particular project focuses on the question of the participation of microbiology in the alteration process. The internal drainage system was investigated in a first phase. It could be demonstrated that most of the PVC pipes still function and are in good condition. Another mission is necessary to prove whether the water-collecting concrete slabs show leakages anywhere and whether the filter and waterproofing layers still function. Several years ago a comprehensive environmental monitoring system was already established. The structural stability of the temple is monitored and evaluated by means of sophisticated technical devices and a regular monitoring of movement marks.

Hans Leisen and
Esther von Plehwe-Leisen