



The Charles Bridge in Prague

An ancient and picturesque monument withstanding damages and floods

The Charles Bridge, one of the most visited touristic spots in Prague, links the city centre (Staré Mesto) with Malá Strana, a small district next to the Prague castle. It is the oldest standing bridge over the river Vltava in Prague and it is the second oldest preserved bridge in the Czech Republic. The Charles Bridge substituted the

Photo 1. View of the Charles Bridge during the restoration works. On the background, Prague's Castel and Cathedral.

Photo 2. The Old Tower Bridge, entrance gate to the Charles Bridge from Prague old town.

previous Judith bridge which was broken down during the spring thaw in 1342. The Charles Bridge construction was started, under the auspices of the Charles IV king of Bohemia and Holy Roman Emperor, by the foundation stone laying down in 1357. The construction of the bridge was finished in 1402. It was assumed for a long time that Petr Parléř was

the builder of the bridge. However, it was made clear in 2007, that the first builder of the bridge was a stonemason and Prague citizen Oto, called Otlin. The bridge was attacked by floods many times (the worst flood in the last 500 years was in 2002), but managed to withstand them. Until 1841 the bridge was the only connection over the river Vltava in Prague. Thanks to this bridge, Prague became an important way point on the European trade routes. The bridge was subsequently decorated with thirty statues and sculptural groups. It was originally called Stone or Prague Bridge. The name Charles Bridge has been used since 1870 at the instance of Karel Havlíček Borovský (1821-1856, an important politician, journalist, writer and literary critic).



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The Repairing Interventions

The Charles bridge is 515.76 m long and 9.40 – 9.50 m wide. The height of the pavement is 13 m above the normal water level. It is created by 16 arches. Their span is 16.62 m – 23.38 m. Bridge pillars were not founded in the rock because it was too deep. Therefore the bridge was founded in the foundation pit on running stones which were supported by oak piles. The bridge is made of blocks from different types of sandstones which make the framework; most of the pillars are bricked. There are also three towers on the bridge.

Building investigation in 1966-1967 revealed that the bridge was endangered especially by small cracks which allowed ingress of rainwater with soluble salts used

for the winter pavement maintenance. It was decided that the bridge opening had to be blocked off by the framework of anchors. The reinforced concrete slab with a net of tow bars was inserted longwise. Temperature fluctuations and water ingress had to be reduced by insulation layers.

Damaged sandstone blocks were changed in the whole bridge cladding. The previous bituminous surface created in the 1920s was substituted by split granite strips. The bridge was intended for pedestrian traffic only after the repair.

Probably since 2001 specialists and also the public authorities and Prague citizens have been discussing about subsequent repairs of the bridge. The previous capital repair had some problems: the waterproofing treatment under the pavement did not perform very well and did not prevent the rainwater ingress into the construction. The reinforced concrete slab had to be restored to have a stability function of the bridge construction and reduce the possible span failure

during dangerous floods, join the enclosure walls and function as substrate for an insulation layer. An acrid dispute over the future of the slab (there were the following possibilities: to leave it as it was, to cut it into pieces or to remove it) was subdued by the flood in 2002 which the bridge underwent without visible damage.

The Last Restoring Intervention

In 2004-2005 the last repair intervention schedule was set down. Finishing building investigation and gathering complete documentation had to be done in 2005 and 2006. In 2006 the first two pillars (the eighth and ninth from the Little Quarter side) were anchored to concrete sarcophaguses.

The bridge masonry repair is considered to be the most difficult phase of the whole repair. Every stone block was investigated by experts who decided whether it was to preserve, clean or substitute.

The upper construction repair started in August 2007 and took approximately 3 years. The bridge repair proceeded in parts and under working arrangements, with the four-meter corridor left for pedestrians. The spans will be repaired in the second phase and it will take from five to ten years.

One of the most important things before the beginning of the repair itself is to choose the adequate locality for the sandstone mining. The Charles Bridge repair is the reason of long standing disputes and discussions relating to too many substituted stone blocks, inappropriate use of materials, use of technologies insensitive to the historical monument, comments on the repair procedures, etc. It is interesting to note that the quality of the original sandstone is higher than the quality of the one used during the latest capital repair in the 1970s.

Mapei Joins the Game

Mapei has been participating in this world famous historical monument repair since 2005. Long and inten-





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Photo 3. The Charles Bridge is made of blocks from different types of sandstones which make the framework and were carefully analysed. Damaged sandstone blocks were changed in the whole bridge cladding.

Photos 4 e 5. After careful analysis MAPE-ANTIQUE LC, cement-free, Eco-Pozzolan-based binder was used to repair the sandstone blocks.

Photo 6. A detail view of the bridge after completion of the repairs.



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sive negotiations among Mapei spol. s r.o. (the Group's subsidiary in Czech Republic) General Manager Zdeněk Runštuk, Mapei spol. s r.o. sales representative for Prague and Central Bohemia Pavel Jarolím and the experts from the Czech Authority for the Historical Monuments Preservation, the Faculty of Building of the Czech Technical University in Prague, the designers and involved building companies preceded Mapei's entering.



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Samples of the natural stone and the historical mortar from the existing masonry were taken in order to carry out tests in the R&D laboratories of Mapei S.p.A (mother company of the Group, located in Milan, Italy). Several analyses of the samples had been carried out and on their basis appropriate materials for the repair were recommended. The proposal of the products to be used was made by Giulio Morandini, Product Manager of the Mapei Structural Strengthening Materials Line, and Pasquale Zaffaroni, Product Manager of the Mapei Building Speciality Line.

First working phase

Two different aspects were solved in the first phase of the bridge pillars repair. The first one was the appropriate formula of the mortar to be used under water level (some pillars under water level), which would have met the requirements for the permanent contact with water and would feature higher abrasion resistance and sufficient strength.

The original intention of the repair under water level with proposal of a mixture made of MAPEPOXY epoxy adhesive or another kind of mixture with RESCON T admixture (both products are manufac-

of buildings affected by strong presence of chlorides. It can be applied as a dehumidifying render on masonries subject to rising capillary damp; as a dehumidifying render on structures built by lagoons or by the sea; as a dehumidifying mortar over stone (especially porous, such as those of lime nature) or bricks, including burnt bricks, walls, columns, vaulting, etc. and wherever saline efflorescence exists; for restoring stone, brick or tuff renders bond with mortars which were originally mechanically weak; for grouting between stones, bricks and tuff of quarry-faced masonry. It conforms to standard **EN 998-1** and has been awarded the **CE** mark in compliance with standard **EN 998**.

IN THE SPOTLIGHT

MAPE-ANTIQUE LC

It is a premixed cement-free light-coloured dehumidifying mortar for the restoration of damp stone, brick and tuff masonry. It can be used for the restoration of stone, brick or tuff buildings damaged by rising capillary damp (suitable for historical buildings) or the restoration of structures damaged by sulphate salts. Applied after MAPE-ANTIQUE RINZAFFO, MAPE-ANTIQUE MC is suitable for the restoration





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From the 7th of May to 15th of June 2010 a photograph exhibition was held along the Vltava river banks and was open day and night to all citizens in an open-air location. It showed the Charles Bridge's birth, historical ups and downs, and its importance for the city of Prague and its inhabitants. Mapei was also among the sponsors of the event.

tured by Rescon Mapei AS, the Group's subsidiary in Norway) was not accepted by the contracting authority. Finally, a wall made of steel casing was built up around the pillars in order to increase their protection and resistance and MAPEGROUT T60 sulphate-resistant shrinkage-compensated fibre-reinforced thixotropic mortar was used for the repairs.

The second aspect was to find the substitution of the original historical mortar for walling and grouting of the sandstone masonry above water level (only with random flooding during spring thaw). Cement-free, hydraulic binder MAPE-ANTIQUÉ LC for light-coloured dehumidifying lime and Eco-Pozzolan based mortars, was used in this case.

MAPE-ANTIQUÉ I Eco-Pozzolan-based, fillerized hydraulic binder was used for the repair by injection of some sections in the bridge pillars.

Second working phase

The second phase consisted of the complete removal of the original bridge deck, bridge drainage, mounting the electricity distribution cables for bridge lighting, casting of a new bridge deck construction including paving and enclosure wall repairs.

In 2008 the Czech association STOP (Association for the Historical Monuments Preservation Technology) asked for Mapei presentation at their conference in Prague. Giulio Morandini and Jiří Zadorožný, Head of Mapei spol. s r.o.'s Technical Service

Photo 7. Olga Menzelova Kelymanova, responsible for the organization of a photo exhibition on the Charles Bridge, Ondřej Ševců, an architect, the Head of the Czech Authority for the Historical Monuments Preservation, and the Mayor of Prague Pavel Bém.

Photo 8. Olga Menzelova Kelymanova, Adriana Spazzoli, Operational Marketing & Communication Director for the Mapei Group and Zdeněk Runštuk, Mapei spol. s r. o.'s General Manager.

Photo 9. From left on: Giulio Morandini, Product Manager of the Mapei Structural Strengthening Materials Line, Veronica Squinzi, Global Development Director for the Mapei Group, Adriana Spazzoli, Pasquale Zaffaroni, Product Manager of Mapei Building Speciality Line and Fabio Fenech, Mapei Area Manager for the Czech Republic.

Department performed the presentation together. It was very successful, the participants liked it and it definitely increased the credit of Mapei in the Czech Republic.

Construction is going on after the inevitable winter break because it is not possible to use the mortar based on hydraulic binders at low temperatures.

The repairs of the enclosure walls and bridge deck are also going on according to the schedule.

The repair of spans is expected to

be completed in late 2010.

It was a great honour for all Mapei Group employees participating in the bridge repair to help with such an important and famous national cultural monument restoration. The repair intervention was also further proof of Mapei's ability to supply high level technical assistance, solving numerous on-site problems. This was made possible by a highly efficient company structure which performs well in all building operations.

TECHNICAL DATA

Charles Bridge, Prague (Czech Republic)

Period of Construction: 1357-1402

Period of the Intervention: 2005-2010

Intervention by Mapei: supplying products for structural strengthening of the bridge pillars

Client: Prague City Council

Contractors: SMP CZ a. s. and AVERS spol. s r.o.

Technical Survey: Mott MacDonald

Mapei Co-ordinators: Zdeněk Runštuk, Jiří Zadorožný, Pavel Jarolim (Mapei spol. sr.o., Czech Republic), Giulio Morandini and Pasquale Zaffaroni (Mapei SpA, Italy)

MAPEI PRODUCTS

The products mentioned in this article belong to the "Building Speciality Line" range. The technical data sheets are available at the web site: www.mapei.com.

Mapei mortars for renders conform to standard EN 998 and have been awarded the CE mark in compliance with standard EN 998. Mapei products for the protection and repair of concrete surfaces and structures have been awarded the CE mark in compliance with EN 1504.

Mape-Antique I: Eco-Pozzolan based, fillerized hydraulic binder for the consolidation, by injection, of stone, brick and tuff structures.

Mape-Antique LC (CE EN 998-1): cement-free hydraulic binder for light-coloured dehumidifying lime and Eco-Pozzolan-based mortars for the restoration of damp stone, brick and tuff masonry.

Mapegrout T60 (CE EN 1504-3, R4): sulphate-resistant shrinkage-compensated fibre-reinforced thixotropic mortar for the repair of concrete.