Technique for transportation of stone sculptures damaged by salt crystallization

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Abstract

The paper presents a technique for handling and transportation of stone sculptures damaged by salt crystallization. A limestone sculpture from the Cathedral of St. Lawrence in Trogir was studied and pre-consolidated with cyclododecane. First, test were performed in the lab. On 5 glass slides were applied powder of the Seget stone and then consolidated with 50% solution of CCD in Shellsol T, 50% solution of CCD in white spirit, 50% solution of CCD in toluene, with holt melted CCD and hot melted CCD with cotton gauze. After the tests were performed, a technique of pre-consolidation with melted cyclododecane and facing tissue was used in situ on the sculpture. Practical uses of the technique were considered in the paper.

Keywords: cyclododecane, stone, pre-consolidation, salts.

1. Introduction

The Cathedral of St. Lawrence in Trogir (Croatia) is a Roman Catholic triple-nave basilica constructed in the Romanesque-Gothic style. Trogir Cathedral was constructed over a period of four centuries (1200-1598), and it illustrates all the successions of styles in that time in Dalmatia. It is one of the most important monuments in Croatia, and was declared a World Heritage Site by UNESCO in 1987. The integral part of the cathedral is the richly decorated Renaissance Chapel of St. John (The Chapel of the Blessed Giovanni Orsini), created by the masters Nikola Firentinac and Ivan Duknović in the period from 1461 to 1497. The chapel was restored and cleaned in between 2000 and 2002 as part of the American foundation project - Venetian Heritage.
The Croatian Conservation Institute started the monitoring and preliminary investigations of the chapel in 2016 because some adverse changes were obsereved on the surface of sculptures and stone interior. In a few locations, it was possible to notice high levels of powdering, sanding and sugaring of the stone, which was caused by salt crystallization.
The Annunciation group (sculptures of the Angel and the Virgin) positioned on the triumphal arch of the chapel was in a terrible state. The bases and lower back zones of both sculptures were extremely damaged, and were in unstable conditions with a high loss of the substrate. First analyses of samples from the background zones of both sculptures showed presence of the following salts: chlorides and nitrates, in concentrations ranging from 0,13-0,17%. Both sculptures were made of local limestone (called Seget).

2. Methods and materials

The presence of water soluble salts in the samples was determined by chemical analyses and UV/VIS spectroscopy with a Perkin Elmer Lambda 25 instrument. Compositional salt analysis was performed using X-ray diffraction method with a Philips Vertical X-ray Goniometer

(X-Pert type). Water content measurement of the stone showed that the water coefficient values were within the reference values for the same type of stone collected from the Seget quarry.

Considering the extremely damaged state of the sculptures and their original position (5m above the floor level), we decided to dismantle them and carry out the conservation work of desalination in the workshop.

Before the dismantling and transportation of the sculptures it was necessary to pre-consolidate the most unstable powdery areas of the sculptures. Cyclododecane was chosen as consolidant.

Cyclododecane (abbreviated CDD) is a waxy 12-carbon cyclic hydrocarbon ($C_{12}H_{24}$) that sublimes from a solid to gas at room temperature.[1] This has made it an appropriate material in conservation as a temporary consolidant, adhesive or barrier layer during the last few decades.[2] When the object is highly damaged and contaminated with soluble salts, and when it needs to be transported, CDD is an appropriate solution. One of the main reasons is that harmful soluble salts are not locked in the material. Some successful cases have already been reported in literature.[3]

CDD can be applied as a melt or as a solution [Burton, 2009]. In order to choose an appropriate technique and method of application, some test were performed in the laboratory prior using it on the sculptures of Trogir. On glass slides we applied powder of the Seget stone, and then we applied 50% solution of CDD in Shellsol T *(glass slide 1, Fig. 1)*, a 50 % solution of CDD in white spirit *(glass slide 2, Fig. 1)*, a 50 % solution of CDD in toluene *(glass slide 3, Fig. 1)*, hot melted CDD *(glass slide 4, Fig. 1)* and hot melted CDD with cotton gauze *(glass slide 5, Fig. 1)*.

After a visual observation, it was possible to conclude that the hot melted CDD in both cases formed a dense film, and the stone powder was consolidated and packed (the particles of powder are interconnected). When CDD was dissolved in solvent, the layer was less dense and the powder was less consolidated and packed.

After a fingernail scratching test (after 24 hours) it was possible to conclude that the powder treated with hot melted CDD (in both cases, glass slide 4-5 with hot melted CCD and hot melted CCD with gauze, *Fig. 2*) was stable and still packed. Powder treated with CDD dissolved in the solution *(glass slide 1-3, Fig. 2)* after the

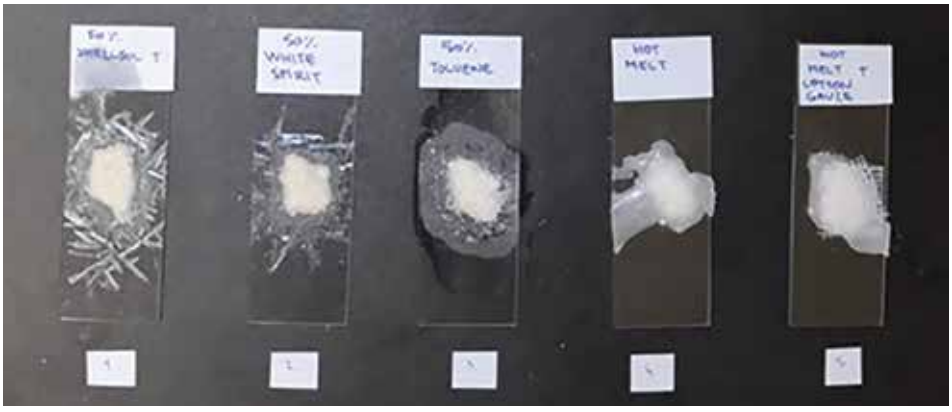

Figure 1: Glass slides with Seget powder and different types of application of CDD (from left to right: 50% solution of CDD in Shellsol T; 50 % solution of CDD in white spirit; 50 % solution of CDD in toluene; hot melted CDD; hot melted CDD with cotton gauze)

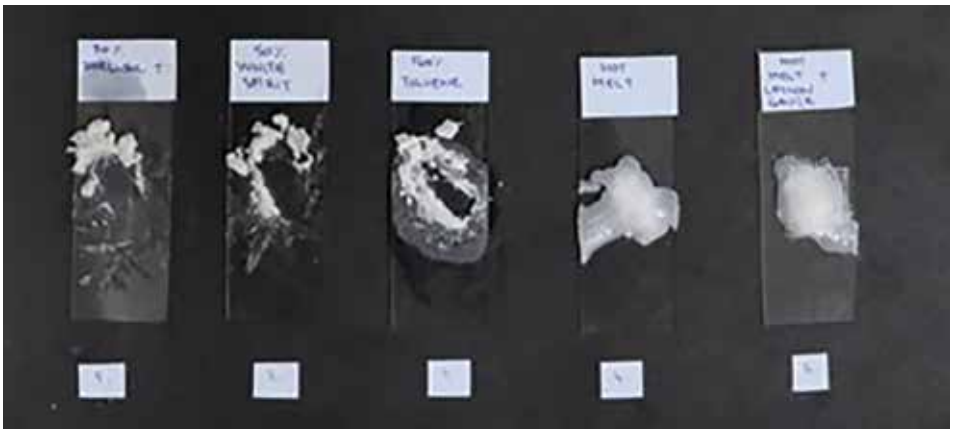

Figure 2: Glass slides with Seget powder and different types of application of CDD after fingernail scratching test (from left to right: 50% solution of CDD in Shellsol T; 50 % solution of CDD in white spirit; 50 % solution of CDD in toluene; hot melted CDD; hot melted CDD with cotton gauze)

test was unstable, and the consolidation effect was less effective.

After the preliminary laboratory tests, the technique of pre-consolidation with melted CDD and facing tissue was used in situ. CDD was reactivated with heat and applied on the surface of the sculpture of the Angel using a brush. Simultaneously, on the surface we applied two layers of cotton gauze. After the pre-consolidation, the sculpture was wrapped in foil and lowered to the ground using a crane. The facing tissue did not detach in 10 days in the lab environment (approximately 20°C with moderate airflow). CDD was reactivated with a heating gun and removed.

3. Results

Laboratory and field tests of pre-consolidation, handling and transportation of stone sculptures damaged by salt crystallization showed good results when the technique with hot melted cyclododecane and facing tissue was used. The sculpture of the Angel from Trogir Cathedral was successfully transported to the workshop using the aforementioned method. A minimum of unstable material was lost. Other negative changes were not recorded on the surface of the stone.

4. Disscusion

Only practical uses of the technique were considered in the paper. The investigations were limited because of technical and financial issues. Future analytical research should provide answers to the following questions:

- depth of the penetration of CCD on the Seget stone,
- sublimation rates,
- negative aspects in the presence of harmful soluble salts.

5. Conclusion

Cyclododecan (CDD) has been used increasingly as a temporary consolidant for a variety of weak or fragile materials. This contribution focuses on the practical use of cyclododecane as a temporary consolidant in cases of handling and transportation of stone sculptures damaged by salt crystallization. Melted

CDD, melted CCD with facing tissue and saturated solutions of consolidant in white spirit, shelsoll T and toluene were applied on glass slides with stone powder. By visual observation and using a fingernail scratching test, it was possible to conclude that the best effect of consolidation was obtained during the application of hot melt CDD. After the lab tests, the technique of pre-consolidation with melted cyclododecane and facing tissue was used in situ. The extremely damaged sculpture of the Angel from Trogir Cathedral was consolidated with melted CDD and cotton gauze. After the consolidation, it was transported to the workshop of the Croatian Conservation Institute. During the intervention, a minimum of unstable material was lost.

Acknowledgements
The project is supported by the Ministry of Culture of the Republic of Croatia.

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