MDDS – VENICE: TRY OUT AND IMPROVEMENTS OF THE EXPERT SYSTEM

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Riassunto

MDDS (Masonry Damage Diagnostic System), il sistema esperto del TNO, è stato utilizzato con profiito, durante in progetto CORILA, per la diagnosi di forme di degrado non strutturale presenti in monumenti veneziani. Per poter ottenere una diagnosi del danno di origine strutturale è stato creato un ‘Atlante del Danno Strutturale a Venezia’, facendo riferimento ai risultati di casi – studio. I più rilevanti tipi di degrado sono stati definiti e illustrati al fine di creare uno strumento valido per fare una diagnosi basata su un’indagine visiva. Un nuovo progetto sul danno strutturale consentirebbe un ulteriore sviluppo dell’Atlante e del sistema.

Abstract

TNO’s expert system MDDS (Monument Damage Diagnostic System) was successfully employed during the CORILA project to diagnose non structural damage types found in Venetian buildings. To reach a diagnosis in case of structural damage a ‘Venice Structural Damage Atlas’ was created, taking into account the results of case studies. The most relevant types were defined and illustrated aiming at creating a valid instrument to make a diagnosis on the basis of a visual inspection. It would be profitable to start a new project focused on structural damage and aiming at further developing the Atlas and the system.

1 Introduction

TNO’s task in the CORILA project [Scientific Research and Safeguarding of Venice – CORILA Research programme 2004-2006, Venice] was to verify whether TNO’s expert system MDDS (Monument Damage Diagnostic System) [Balen, et al., 1999] could be used to identify and diagnose the damage found in Venetian buildings. The system was tried out and proved to meet the needs of the users and to be suitable for the diagnosis of most forms of recurrent damage, like salt damage. For what concerns structural damage, more work needed to be done to the system to enhance its performance and make it a valid instrument to be used in the conservation of monuments in Venice. A ‘Venice Structural Damage Atlas’ containing significant examples of structural damage and based on case studies locally carried out was developed and inserted in MDDS. Therefore, the Atlas does not contain a complete overview of structural damage types: its aim is to meet the needs of the users in Venice. A
more comprehensive Atlas has been worked out in the meantime for MDDS.

The newest version of MDDS will be officially handed over to the representatives of CORILA and, on that occasion, a workshop on MDDS will be given.

MDDS, the Monument Damage Diagnostic System, is meant to guide the user in the process leading to the identification and the diagnosis of the damage to monumental buildings. Only on the basis of a sound and well supported diagnosis, in fact, the necessary interventions can be planned.

MDDS is both an expert system and a 'decision supporting tool'.

An expert system for diagnosing cases of damage, will ask the user questions, and achieve its goal on the basis of the provided information, by means of deductions and inference procedures. The damage will be associated to one or more damaging processes within a certain context.

A 'decision support tool' is not only meant to lead the user to the diagnosis, step by step, by means of questions and answers, but also to provide the user with the necessary, practical information to formulate himself a sound diagnosis.

In order to make a diagnosis, the user needs to obtain specific data, e.g., by visual inspection or by means of laboratory tests or measurements, and to insert them into the system.

MDDS is a very flexible system, meant to meet the needs of different users (from restoration architects to university students of Monument Watch). In the course of time it has been constantly updated with the knowledge derived from research, experts, and EU projects. Information is structured to be practice-oriented and easily retrievable.

2 The try out of MDDS in Venice

The information of cases of damage to Venetian buildings deriving from studies carried out within the CORILA project was elaborated at TNO (Delft, Netherlands) and inserted in the system. Five case studies concerning salt crystallisation problems were successfully carried out (see report on Ex Scuola dei Calegheri building, fig. 1). Notwithstanding the absence of important data on salt and moisture, the diagnosis was reached, on the basis on known facts, like the presence of rising damp and salt (sources: ground, flooding etc.). Still, it should be stressed that data on salt and moisture type and distribution should be gained in order to complete the investigation and provide it with a scientific basis.

All types of damage found in the cases could be defined referring to the Atlas contained in MDDS, including description and illustration of all types of damage to buildings, which can be distinguished in practice.

The background information section can be consulted by the CORILA members to carry out measurements and obtain some data, necessary and sufficient for a sound scientific evaluation of all made hypotheses. Such measurements are very little destructive and do not disturb the perception of the building.

Advice is also given by the system in terms of a reminder: methods to hinder rising damp, the most recurrent source of moisture, for instance, should be carefully evaluated and both the consequences and the expected effectiveness of a treatment very well thought of.

3 Data on moisture and salt types (L.A.M.A.- IUAV)

The assessment of several types of damage to buildings achieved with the support of MDDS (WP6) showed that salt damage - mostly involving rising damp - is the cause of very severe and dangerous damaging processes in Venice.

MDDS makes it possible to show - in the form of a graph - the presence and distribution of salt and moisture in walls, thus furnishing important evidence on the state of the masonry. On this basis, the parts of the building most prone to decay can be pointed out.

A try out of the method to obtain salt and moisture distribution profiles was done at Palazzo Pisani near to campo Santa Marina, in Cannaregio.

The building is dated to the XV cent. (1460) and was transformed in the XVII cent. It has two important facades on canals. In the brick masonry there are
replaced areas, in particular on the basement part of two walls on canal, in the chimney areas and near the portal. The bedding mortar is not homogeneous, due to replacements. The facade was furnished with an old plaster named “iglazio” on small areas and a more recent (XIX cent.) plaster consisting of lime and sand.

A newly applied lime plaster is now present.

Fig 2 - Palazzo Pisani near campo Santa Marina, in Cannaregio.

In co-operation with L.A.M.A. – IUAV (Stefano Cancelliere) two profiles have been obtained by drilling powder at various heights (cm 20, cm 50, cm 100 e cm 180) and depths of the wall (cm 0 - 2, cm 2 - 5, cm 5 - 10, cm 10 - 15, cm 15 - 20 and 20 - 30). At some heights the masonry was hollow, and the drilling was performed again, near the location. The drilling itself shows much of the continuity of the masonry.

Fig 3 - Palazzo Pisani, plan of ground floor. The masonry where the drilling was done is highlighted. It was originally an external wall, ca. 60 cm thick. The wall became internal due to transformation of the palace when an adjacent building was made higher.

The samples are transported, hermetically closed in containers to the laboratory, where they are weighted, dried, and weighted again, to assess their actual moisture content.

The presence of salt is also gravimetrically assessed, deriving it from the hygroscopic moisture uptake of the sample due to the contained salt.

The analysis of the salts was carried out by means of ion chromatography, which is different from the method proposed in TNO's MDD5. In this way the type and amount of ions were determined.

Results

There is a very high moisture content with peaks which are difficult to explain (see tables). The pattern of the distribution of the moisture points at the presence of rising damp, but no final conclusion can be drawn because the upper fringe of the rising damp was not measured (being higher than 200 cm).

At the surface, where evaporation occurs, there is a still very high moisture content, sometimes even higher than inside the wall.

This may be due to:

1. the presence of a newly applied plaster and also
2. differences in material properties (porosity and pore size distribution).

There is a lot of salt. The main types of salt present are chlorides, which is to explain as:

1. the building lies near the water
2. there are frequent floodings
3. the wall used to be external, and therefore directly exposed.

Further the context favours the presence of chlorides in the wall (sea-salt spray, ground water rich in salt and rising damp). Like in the case of the moisture
distribution, the pattern of salt distribution due to rising damp is not very clear. Chlorides, the most soluble salts, accumulate not only at the surface and in the upper part of the wall (evaporation area, rising damp pattern), but they are rather spread. The amount of salt present in the plaster is not as high as expected; this is due to the fact that this plaster has been very recently applied.

4 The Venice Structural Damage Atlas

Originally created for brick masonry, MDDS has been further developed including stone and mortar problems, and has been constantly improved with updated scientific information. A sound information section on structural damage was worked upon when the Venice project began. At that time structural problems were only tackled within an Atlas on Cracks. This Atlas included annotated examples of cracks, from micro cracks in single materials to long cracks running along the wall height. The cracks were described and illustrated using a method already employed for creating other atlases contained in MDDS. Damage Atlases on different problems had also been produced within various EU projects, as they had proven to furnish a good basis for focussing problems and to provide the partners with a common terminology [Naldini et al., 2003 and 2006, Van Hees et al., 2005].

Within the CORILA project a new Atlas on structural damage has been created, based on case studies carried out in Venice. Its aim is to identify and define cracks and deformation patterns [Dogliani, 2000], and to help the user recognise them in situ. The most recurrent types of structural damage have been defined and organized in categories and the possible causes leading to them have been pointed out. It should be underlined that most damage types result from a synergistic action of various forces and may easily include cracking and deformation patterns. Besides, some types of damage looking similar may have different causes, even non structural.

The Venice Structural Damage Atlas represents a practical way of facing the problems daily met in the conservation of local buildings. It allows to identify the damage and to lay a basis for planning an intervention, when needed.

The Atlas is now part of the ‘Background information section’ of the expert system MDDS (fig. 6).

In the Atlas the damage types are organised in relation to the most relevant mechanism(s) causing them. All defined types are in fact visually recognizable patterns, because the first analysis and diagnosis on the cause of damage should be the result of a visual inspection. When needed, measurements and testing will be planned.

Some types of damage are the consequence of wrong restorations, whereas others are strictly related to the building techniques used in Venice.

It is advisable to carefully read the definitions of all damage types, in order to be aware of all differences and similarities (Tab. 1).

Tab. 1 – Types of damage and damaging mechanisms
VENICE STRUCTURAL DAMAGE ATLAS

**Settlement**
Process: vertical displacement of a building due to changes (settlement) in the ground or in the foundations.

**Overloading**
Process: the structure is more loaded than it can bear, due to its own weight or an external load.

**Creep**
Process: long term overloading, depending on the materials. The process concerns especially slender, high structures, like towers, columns and pillars.
Cracks may develop very slowly, over decades or even centuries, but can eventually lead to sudden collapse, if the process is not stopped.

**Damage patterns**
- Arch-like pattern
- Parallel vertical cracks in the lowest zone of the façade
- Cracks running along one vertical line over the whole height
- Subsidence of a corner
- Leaning (e.g. of tower)

- Cracking and detachment of a corner, starting from the base
- Displacement of part on columns/pillars
- Deformation of façade out of plane, e.g. at floor level
- Cracking Barbacane
- Top corner of façade cracks and detaches and/or deforms
- Vertical, parallel cracks in old area between new areas
- Creep
- Vertical, parallel cracks in a certain area of the construction

In the Atlas there are very clear patterns of damage, like the ‘arch-like pattern’ (fig. 7), well illustrated by a couple of examples and to be related to a settlement process. There are other types, still, like the ‘cracks running along one vertical line over the whole height’ (fig. 8), which characteristics can be less easily pointed out and translated into a pattern, especially if the origin of the damage should also be included.

**Conclusions**

MDDS can be used for assessing the damage found in Venetian buildings and for planning interventions. The tried out method to obtain salt and moisture content and distribution in walls proved to be very useful.

The Structural Damage Atlas created for Venice aims at providing support in the identification of the most recurrent visible types of structural damage. It is also part of the expert system MDDS, which will be given to the representatives of the CORILA project. The use of MDDS for carrying out investigations will show whether the Atlas is developed enough or needs to be further broadened. It would be profitable to organize a new phase of the project centered on
structural damage.

References


