



# CIB – W086 Annual Meeting

May 10<sup>th</sup>, 2008

## Annual Meeting 2008 W086 - Building Pathology

**Istanbul - Turkey**

In conjunction with  
the 11th International Conference on Durability of Building Materials and  
Components

**dbmc**  
11th International Conference on  
Durability of Building Materials and Components

11-14 May 2008 Istanbul Turkey  
Lütfi Kırdar Convention & Exhibition Centre



**NIST**



## CIB – W086 Annual Meeting 2008

### FINAL AGENDA

**Date:** 10 May 2008, 9:00 - 12:30 and 14:00 - 16:00

**Venue:** Dedeman Hotel (see map attached)

#### Agenda

Topic	Member	Time
1. Welcome and brief presentation of the hosting Institution		9:00
2. Members self-introduction		9:10
3. Agenda approval	Sergio Croce / Vasco Freitas	9:20
4. CIB Activities & Creation of different types of membership of CIB - W086	Sergio Croce / Vasco Freitas	9:30
5. The New W086 State of the Art Report		
5.1) Contributions		
a) General presentation	Vasco Freitas	9:50
b) The history of building technologies through related building pathologies	W086 Members	10:00
c) The importance of building pathologies	W086 Members	10:15
<b>Coffee Break</b>		<b>10:30</b>
d) Methodology of investigation	W086 Members	11:00
e) Causes	W086 Members	11:20
f) Cases of failure	W086 Members	11:40
g) Costs	W086 Members	12:00
h) Information dissemination	W086 Members	12:15
<b>Lunch</b>		<b>12:30</b>
5.2) Discussion		
a) Index Approval		14:00
b) Structure approval and strategy		14:20
c) Calendar planning		15:00
6. Next W086 meetings		
a) 2009: PATORREB 2009 in Porto	Vasco Freitas	15:20
b) 2010: CIB World Congress in Manchester	Sergio Croce	15:40

<b>1.</b>	<b>INTRODUCTION</b>		
<b>2.</b>	<b>THE HISTORY OF BUILDING TECHNOLOGIES THROUGH RELATED BUILDING PATHOLOGIES</b>	▪ Sergio Croce ▪ Enrico de Angelis	<b>Y</b>
<b>3.</b>	<b>THE IMPORTANCE OF BUILDING PATHOLOGY</b>	▪ Bill Porteous;	<b>Y</b>
3.1	General definitions		
3.2	Responsibilities		
3.3	Pathology & Defect	▪ Mendes da Silva	
3.4	Pathology & Durability	▪ Antonella Guida; ▪ Antonello Pagliuca; ▪ Ippolita Mecca.	<b>Y</b> <b>Y</b> <b>Y</b>
3.5	Risk	▪ Giambattista de Tommasi Group	<b>Y</b>
<b>4.</b>	<b>METHODOLOGY OF INVESTIGATION</b>	▪ Bill Porteous; ▪ Antonella Guida; ▪ Antonello Pagliuca.	<b>Y</b> <b>Y</b> <b>Y</b>
4.1.	Investigation process	▪ Giambattista de Tommasi Group	<b>Y</b>
4.2.	Investigation methods	▪ Attila Koppány ▪ Giambattista de Tommasi Group	<b>Y</b> <b>Y</b>
4.2.1	Non-destructive survey	▪ César Diaz	<b>Y</b>
4.2.2	Destructive survey		
<b>5.</b>	<b>CAUSES</b>	▪ Bill Porteous; ▪ Filiberto Lembo; ▪ Francesco Marino; ▪ Isabel Torres.	<b>Y</b> <b>Y</b> <b>Y</b> <b>Y</b>
<b>6.</b>	<b>CASES OF FAILURES</b>	▪ Filiberto Lembo; ▪ Attila Koppány; ▪ Francesco Marino.	<b>Y</b> <b>Y</b> <b>Y</b>
6.1.	Defects Information Sheets	▪ Vasco Peixoto de Freitas	<b>Y</b>
6.2.	Databanks		
6.3.	BP Websites	▪ Vasco Peixoto de Freitas	<b>Y</b>
<b>7.</b>	<b>COSTS</b>	▪ Vítor Cóias	<b>Y</b>
<b>8.</b>	<b>INFORMATION DISSEMINATION</b>	▪ Attila Koppány ▪ Enrico de Angelis	
8.1.	Bibliography – Books		
8.2.	Related Software		
8.3.	Congresses		
	REFERENCES		
	APPENDIX A. Example of a check list	▪ Mendes da Silva	
	APPENDIX B. Terminology		

**OTHER CONTRIBUTIONS:**

Erik Brandt

Luis Villegas

1 – Abstract submitted (Yes / No)

Green: W086 Member

**State of the Art Report – Building Pathology**

**Chapter 2. The History of Building Technologies through related Building Pathologies**

**by Sergio Croce**

**Abstract**

An historical analysis of the evolution of building materials and technologies, starting from their failures, is not frequently performed. From it, on the contrary, lessons useful to improve design and materials production quality could actually be elicited.

From these analyses we can understand the way a building material or component is related to the universe of physical signals that characterize the external environment and this can be very instructive.

Many errors that, despite the progress in the sector, we continue to make, perhaps stems from an excessive trust on building material and component ability to perform as expected, wherever it is integrated in and whatever is the specific meteo-climate environment that stresses it.

The history of the evolution of flat roofs waterproofing membranes is a paradigmatic example of how a specific industry has improved over time its production on the basis of pathological experience in the field.

## **State of the Art Report – Building Pathology**

### **Chapter 3. The Importance of Building Pathology**

**by Dr W A Porteous**

#### **Abstract**

The contribution will argue that building pathology is as important to the science of building as pathology is to the science of medicine. Pathology provides the opportunity to discover what has gone wrong with a building and to provide a guide to prevention as well as repair.

Pathology investigations carried out on a large enough sample of buildings will reveal patterns of building failure by identifying the common features of buildings that exhibit failure. If such investigations are carried out over an extended time trends in failure type and frequency may be detected.

Building pathology provides convincing evidence because it involves buildings that have actually been constructed and tested in a real environment rather than tested or modelled in a laboratory or on a computer.

When buildings fail it is tempting to attribute the failure to some visible or superficial aspect of the building. The rigour of the building pathologist's approach is much more likely to unearth the true cause(s) of the failure.

## **State of the Art Report – Building Pathology**

### **Chapter 3. The Importance of Building Pathology**

#### **3.4 Pathology & Durability**

**by Antonella Guida & Antonello Pagliuca & Ippolita Mecca**

#### **Abstract**

The conservation intervention of built heritage is appropriate if it puts particular attention at the impact of the modern systems to this heritage.

The research methodology is based on a fundamental aspect of the project of recovery and/or restoration which is that cognitive, foreseeing investigation on site and laboratory, the realization and validation of the intervention, through new tests and a periodical monitoring. The model proposed has been applied to a case study (the “Sassi di Matera” – UNESCO heritage), emblematic site with a strong bind between architecture and natural environment.

Technological tests were executed to determine the physical, chemical and mechanical characteristics of the materials used in the ancient “Rioni Sassi” to evaluate the compatibility with new materials. This surveys plan presents as a further knowledge instrument and as a mean to programme any recovery intervention in the respect of the original character, without compromising the requisites of durability and safety

## **State of the Art Report – Building Pathology**

### **Chapter 3. The Importance of Building Pathology**

#### **3.5 Risk**

**by Giambattista de Tommasi Group (Giambattista de Tommasi, Albina Sciotti, Mariella de Fino, Fabio Fatiguso & Francesco Fiorito)**

#### **Abstract**

##### **Risk assessment methods for building pathology**

The paper is going to provide with an overview of some methods to assess building pathologies, in terms of critical performances referred to the whole system, as well as to the single subsystems. Specifically, the paper will describe consolidated survey methods to gather, record and manage information about geometrical, functional, technical and technological features of the building, as well as about pathologies and anomalies (PSA, MER, UNI and so on). Then, the paper will focus on some methodologies of damage assessment by means of value analysis.

Since the description of the main interpretative models (MAGEC, Reliability Analysis, Defects Scoring, MER, Habitatge Test), some guide lines will be pointed out to mark pathology and technological decay indexes and to assess the risk associated with them.

## **State of the Art Report – Building Pathology**

### **Chapter 4. Methodology of Investigation**

**by Dr W A Porteous**

#### **Abstract**

The contribution will describe a methodology that ensures an objective approach is taken to the assessment of evidence, by defining what a building failure is and obtaining some degree of corroboration that each sample of failure is fairly assessed.

The methodology uses a model of building failure that combines human error and natural causes since each or both these play a part in building failures. The model assists the classification of the failures that are being studied in the course of building pathology. The model has been tested successfully by the author.

It is important for the methodology to be consistent and reproducible so that one person applying the methodology will find the same results as any other when assessing the same data. Without a high level of consistency of approach the accumulation of consistent data for deeper (ie larger sample) or wider (ie elongated sample) studies is difficult to achieve.

The contribution that instrumentation such as moisture-meters and X-ray devices can make to the methodology of modern building pathology will be described in the light of recent New Zealand experience.



## **State of the Art Report – Building Pathology**

### **Chapter 4. Methodology of Investigation**

**by Antonella Guida & Antonello Pagliuca**

#### **Abstract**

The conservation intervention of built heritage, both historic or not, is appropriate if it is depth the knowledge of the building.

In fact, it is no possible to ignore the importance of the diagnostic phase both "to control" the interventions and to study the global feature of the system, especially in a program of long-term maintenance in order to guarantee the interventions durability.

The research focuses on the possibility/need to operate a comprehensive diagnostic analysis of the building and to make a comparison between the different tests performed; it is possible to cross the results obtained from tests - destructive and not – in order to get data that are qualitatively and quantitatively correct and extensible to whole building. The analysis and qualification of the buildings walls point out that this approach is useful for the classification of building pathological events and for the implementation of innovative solutions, in order to guarantee the interventions durability.

## **State of the Art Report – Building Pathology**

### **Chapter 4. Methodology of Investigation**

#### **4.1 Investigation process**

**by Giambattista de Tommasi Group (Giambattista de Tommasi, Albina Sciotti, Mariella de Fino, Fabio Fatiguso & Francesco Fiorito)**

#### **Abstract**

##### **Diagnostic methodological approaches**

The paper is going to describe methods and procedures to carry on the diagnostic project. Specifically, it will point out a decision support model to get suitable choices according to the several specific purposes. First, the overview will focus on the general consolidated refurbishment process (that is composed of different macro tasks: Basic Knowledge- Data collection and record - Preliminary Analysis and Diagnosis - Further Specific Knowledge - Diagnosis - Project – Intervention – Intervention Assessment – Maintenance). Then, it will detail each macro task into subordinate activities. So, all the diagnostic decision process will be clearly referred to all the previous stages, particularly with reference to available data bases (atlas of constructional typologies, materials, pathologies, methods and knowledge techniques) and normative references. As a result, some guide lines will be pointed out to lead the choice of diagnostic methods and techniques and an algorithm will be addressed to relate diagnostic tests and key parameters for structural health assessment.

## **State of the Art Report – Building Pathology**

### **Chapter 4. Methodology of Investigation**

#### **4.2 Investigation methods**

**by Giambattista de Tommasi Group (Giambattista de Tommasi, Albina Sciotti, Mariella de Fino, Fabio Fatiguso & Francesco Fiorito)**

#### **Abstract**

##### **Traditional and modern techniques for building monitoring and control**

Structural and environmental monitoring, namely the system of methods, procedures and devices to control local and global conditions, by means of an equipment that may measure deformations, inclinations, displacements, temperatures, humidity and/or vibrations, can be used to:

- (i) assess the evolution of crack, deformation and/or damping patterns that are due to an anomaly (static monitoring);
- (ii) analyse the structural dynamic behaviour, in terms of control of vibration motion due to surrounding conditions (seism, traffic, wind, vibrating machines), as well as damage detection and localization (dynamic monitoring).

Beside several traditional devices, namely fissuremeters, inclinometers, diastimeters, strain gauges, thermocouples and accelerometers, some innovative techniques are recently developing that are based on optic fibre sensors for continuous structural health control.

The paper is going to provide with an overview of different technologies, in terms of functioning principles, application fields, critical issues, as well as further research developments.

## **State of the Art Report – Building Pathology**

### **Chapter 4. Methodology of Investigation**

#### **4.2.1 Non-destructive survey**

**by César Díaz Gómez**

#### **Abstract**

##### **Applying non-destructive testing to the Technical Inspection of Buildings**

A few years ago, Technical Inspections of Buildings (TIB) began to be carried out in many Spanish cities. TIB are governed by a specific legal framework, which varies slightly in different cities. However, all such regulations state that property owners must periodically carry out inspections in order to detect risk situations in their buildings. Inspections are performed by trained technicians who establish whether action needs to be taken, the urgency of any action, or the need for a complete diagnostic report, for which appropriate technical resources will be needed in each case. Thus, in order to limit costs, the initial compulsory inspection of a building consists in observing the state of its components, taking several samples and undertaking very basic tests and operations that can be accomplished with tools that are easy to transport and handle.

For this type of inspection, non-destructive tests and trials—aimed at obtaining information that can be used to establish an initial diagnosis of the state and safety of the components of a building that are most likely to collapse or fall off—are of unquestionable interest, both from the perspective of exchanging data and experiences and from that of the search for and experimentation with new testing and surveying techniques.

## **State of the Art Report – Building Pathology**

### **Chapter 5. Causes**

**by Dr W A Porteous**

#### **Abstract**

The contribution will describe an analysis of perceived causes of building failure derived from a study of some samples of houses in New Zealand. It will describe the model representation of building failures that was first tested in the late 1980's in a study of a sample of building failure claims made to an insurer.

Twenty years later there was discovered to be a considerable number of leaking buildings in New Zealand. The results of a nation-wide inquiry by officials have been well-publicised in New Zealand.

A comparison of the causes of these more recent failures with the general causes of failures identified twenty years earlier will be made. The comparison will establish the on-going validity of the model of building failures, and especially the of the range of causes first identified and described in the late 1980's.

The contribution will propose that analysis of building failures from a building pathology viewpoint is not concerned with the legal issues of so-called negligence or blame. It is concerned with acknowledging that people do make errors and that contributing to the anticipation of errors, and the design of buildings to prevent them, or to ameliorate their effects, is the business of building pathology.

## **State of the Art Report – Building Pathology**

### **Chapter 5. Causes**

**by Isabel Torres**

#### **Abstract**

We can think “Building Pathology” as being the systematic study of the construction defects, its causes, consequences and solutions. In this way when we approach the thematic of “Building Pathology” we can’t set aside its causes.

The complexity of the theme is due not only to the multiplicity of the possible construction defects but also to the diversity of the probable causes as well as the respective consequences.

In this sub-theme we intend to analyse with care the causes. In order to achieve the main goal which is building with quality, that is to say building conferring to all construction elements the ability to satisfy the finality for which they have been projected is of extreme importance to analyse the causes of the observed pathologies. This is the right way to avoid future defects.

The large number of intervenient in the constructive process (from the promoters to the final utilization) associated to the behaviour of construction materials, the complexity of the physical phenomenon, the constant development of the construction techniques and also other fortuitous conditions of technical nature can make the analysis of the pathologies very complex.

With this text we intent to systemize and analyse all the possible causes of building pathologies whether they are due to project errors, concept errors or due to execution errors. The intention is to analyse the underlying physical phenomenon and the involved mechanisms.

# **CIB W086**

## **State of the Art Report – Building Pathology**

### **Chapter 5. Causes**

**by Filiberto LEMBO**

#### **Abstract**

To define a scale of importance and role played, in causing pathologic processes, by elements like process, project and product, it's of great importance understanding if a productive process is correctly conducted and controlled to achieve quality objectives; if not, the obvious consequence of the process is that pathologies arise, expressed by characteristics of the project and product.

In other words, we would state that the main cause of pathology may be the process, if not controlled under the qualitative point of view, even if disorders and pathologies may be the result of specific errors in planning or executing.

**State of the Art Report – Building Pathology**

**Chapter 5. Causes**

**by Francesco Paolo R. MARINO**

**Abstract**

By the study of a large and significant sample of buildings, neither complete nor homogeneous in terms of building technique and typology, by the analysis of single cases and the diagnosis of decay process, we studied aging state, quality performance, functional defects or anomalies, decay situations and more frequent pathologies of all interventions.

It was found out an exact correlation between building techniques, building typologies and durability, characterizing the recurring defects for each building typology, linking the anomalies' causes to bad functioning and defects in building, to defects in designing and techniques of realization or in the maintenance actions.

In this way, this study makes it possible to realize projects of maintenance and/or validated retrofitting interventions that could avoid the repetition of errors made in the past, setting new and more precise “rules of the art”.



## **State of the Art Report – Building Pathology**

### **Chapter 6. Cases of Failures**

**by Filiberto LEMBO**

#### **Abstract**

Thanks to a deep analysis of 14 interventions, for an amount of about 4.500 flats realized in the Middle-South of Italy (Lazio, Campania and Basilicata regions), we have worked on the data collection of the recurrent pathologies and of the durability characteristics of the industrialized and traditional building systems of residential structures, on their causes, as well as on their characteristics of curability.

For these interventions it was noticed a structural lack of quality control processes both on the project and the realization, which is typical of the administrative instruments used for these works, especially the Italian systems of awarding of contract “concessione di sola costruzione” and “appalto concorso”. This seems to be one of the main causes of quick decay and bad durability that characterizes the most part of these interventions, corroborating the negative experience of other European Countries, such as England.

In particular: on one hand, “special new failure cases” came out, which are worth of attention from specialists, in order to avoid their recurrence; on the other, it was also noticed that a correct project and realization can make durable and efficient, as far as performances go, also these building systems and that it is unavoidable a deeper investigation in knowledge and data about their performance variation with time.

## **State of the Art Report – Building Pathology**

### **Chapter 6. Cases of Failures**

**by Francesco Paolo R. MARINO**

#### **Abstract**

The objective of the collection and analysis of the whole stock of interventions (12.500 flats) that the E.P.E.R. (Provincial Bureau for Residential Building of Province of Potenza, i.e. the old Istituto Autonomo per le Case Popolari) realized during the last century in the Province of Potenza, is the will of analyzing its contents according a typological and technological point of view, considering the using and aging state, the performance quality, functional anomalies or defects, situations of decay and recurrent pathologies.

Within a more complex research that, thanks to an organic analysis of the E.P.E.R. flat real estate, had the aim of realizing a sort of reliable catalogue of pathologies and appropriate maintenance techniques in specific cases, it has been adopted a proper procedure to give support to decisions made within the cataloguing process, based on the analysis of single cases and the diagnosis of the decay process.

The standardization of recurrent defects made it possible on one hand to achieve “databanks of failure cases”, on the other to express typical solutions for regenerating works, that have the value of “rules-conforming solutions”.

## **State of the Art Report – Building Pathology**

### **Chapter 6. Cases of Failures**

#### **6.1 Defects Information Sheets**

**by Vasco Peixoto de Freitas**

##### **Abstract**

In Portugal, despite the growing concern over the quality of construction, the quality of recent buildings falls short of expectations. There are several thousand of recent buildings with very serious pathologies that limit their use.

Building Pathology has been the subject of numberless studies and there is a huge amount of technical information available. However, this information is much dispersed and the specificity of construction technologies used in each country does not allow the spread of information. It is necessary to systematize it, in order to make easier to analyze causes and to solve the problems.

In the last twenty years, the Building Physics Laboratory (LFC) of the Engineering Faculty of Porto University (FEUP) studied a large quantity of buildings with pathologies, and this allowed for a large amount of information to be gathered. It is based on the acquired experience that we propose the elaboration of defect information sheets.

In this paper we list some examples of defects information sheets related with the following phenomena:

- Internal condensations;
- Hygrothermal expansion on brick masonry;
- Durability of cementitious adhesives.

## **State of the Art Report – Building Pathology**

### **Chapter 6. Cases of Failures**

#### **6.3 Building Pathology Websites**

**by Vasco Peixoto de Freitas**

##### **Abstract**

Building physics is an important instrument for design, but the available knowledge is not always used to solve and prevent the development of a Building Pathology. Understanding a problem requires knowing how materials and components perform, and it is essential to design the most appropriate solutions from a technological point of view. We consider that the available information on cases of building pathology should at least be used to avoid the same problems recurring. Recording the errors, analyzing their causes, and disseminating this information, are fundamental procedures to understanding the most frequently occurring pathologies and preventing the problems.

In relation to this the Building Pathology Study Group – PATORREB has been created. It is coordinated by the Building Physics Laboratory (LFC) of the Engineering Faculty of Porto University (FEUP), and its principal objectives are to identify and disseminate the most frequent pathologies in Portuguese buildings.

This Study Group created a Website at [www.patorreb.com](http://www.patorreb.com), where a Pathology Catalogue, compiled by the various Portuguese universities has been posted. It is based on research and experimental studies of building pathology. The Catalogue consists of a set of Pathology Reports that contain a description of the problem, the diagnostics methods used, the definition of the main causes and possible solutions for repair.

## **State of the Art Report – Building Pathology**

### **Chapter 5. Causes**

### **Chapter 6. Cases of Failures**

**by Filiberto LEMBO & Francesco Paolo R. MARINO**

#### **Abstract**

To define a scale of importance and role played, in causing pathologic processes, by elements like process, project and product, it's of great importance understanding if a productive process is correctly conducted and controlled to achieve quality objectives; if not, the obvious consequence of the process is that pathologies come out, expressed by characteristics of the project and product.

In other words, we would state that the main cause of pathology may be the process, if not controlled under the qualitative point of view, even if disorders and pathologies may be the result of specific errors in planning (in most cases) or executing.

This thesis is demonstrated in the illustration of cases of failure related to a large and significant sample of investigation.

Thanks to a deep analysis of 14 interventions, for an amount of about 4.500 flats realized in the Middle-South of Italy (Lazio, Campania and Basilicata regions), and the study and analysis of more than the full estate of 12.500 flats of the E.P.E.R of Potenza, we have worked on the data collection of the recurrent pathologies and of the durability characteristics of the industrialized and traditional building systems of residential structures, on their causes, as well as on their characteristics of curability.

The great part of the interventions relating to the 4,500 flats, bear witness to the spread of techniques of industrialization in building (great load-bearing panels systems, tunnels and banches-tables with plugging panels, steel structures and mixed steel-in situ concrete) in Italy was limited to high-densely populated urban areas where important interventions of residential building were made thanks to agreement and public aid. These techniques were also used to resolve emergencies such as the necessity of re-building the building estate after the 1980 earthquake in Campania and Basilicata.

For these interventions it was noticed a structural lack of quality control processes both on the project and the realization, which is typical of the administrative instruments used for these works, especially the Italian systems of awarding of contract “concessione di sola costruzione” and “appalto concorso”. This seems to be one of the main causes of quick decay and bad durability that characterizes the most part of these

interventions, corroborating the negative experience of other European Countries, such as England.

Furthermore, tank to the study that collects and analyzes the whole stock of interventions that the E.P.E.R. (Provincial Bureau for Residential Building of Province of Potenza, i.e. the old Istituto Autonomo per le Case Popolari) realized during the last century in the Province of Potenza, it was found out an exact correlation between building techniques, building typologies and durability, characterizing the recurring defects for each building typology, linking the anomalies to causes of bad functioning and defects in building, to defects in designing and techniques of realization or in the maintenance actions.

By a specifically technical point of view, all interventions were studied considering aging state, quality performance, functional defects or anomalies, decay situations and more frequent pathologies, trying to find out causes and possible solutions by the analysis of single cases and the diagnosis of decay process, trying to find out causes and possible solutions.

“Special new failure cases” came out, which are worth of attention from specialists, in order to avoid their recurrence. And, by the realization a sort of reliable catalogue of pathologies and appropriate maintenance techniques in specific cases, it is possible to adopt a proper procedure to give support to the decisions made within the cataloguing process, based on the analysis of single cases and the diagnosis of the decay process.

This study makes it possible the realization of projects of maintenance and/or validated retrofitting interventions that could avoid the repetition of errors made in the past, setting new and more precise “rules of the art”. Likewise the standardization of recurrent defects made it possible to express typical solutions for regenerating works, that have the value of “rules-conforming solutions”.

## **State of the Art Report – Building Pathology**

### **Chapter 7. Costs**

**by Vítor Cóias**

#### **Abstract**

This chapter will deal with building pathology related costs. Building pathology and building economy. Sustainable exploitation of the building stock: economical, social and environmental costs. Building life cycle costs. Quality costs. Failure costs. Maintenance costs. Rehabilitation costs. Data on building failure costs in different countries and different building types. Costs associated to different causes of failure to the different stages of the building process and to the different actors and stakeholders. Failure costs in new construction and rehabilitation projects. Failure costs contribution for life cycle costs.

A case study will be presented, analyzing the quality costs in a contractor specializing in constructive and structural rehabilitation and the failure costs in a hospital facility extension project.

Reducing failure costs. Recommendations.

Bibliography on building pathology related costs.

Lisbon, 2008-03-31