SMART STRUCTURES

Smart Structures are structures, that have implemented different kind of sensors to get data about the health of the building (deformations, cracks, humidities, corrosions, etc.)

Introduction

In this project for the European Project Semester 2015 we are working together with the innovation agency Neàpolis on a cost-benefit analysis for Smart Structures in buildings. To accomplish this research two real buildings have been selected. In order to have a wide approach, one building is quite modern (Neàpolis building), and the other one is old (San Antoni Church, main church of Vilanova i la Geltrú). Therefore, in these two buildings we propose the implementation of Smart Structure systems and we estimate the consequent cost-benefit analysis. These two real cases allow us to get some general conclusions about the cost-benefit analysis of smart structures in buildings. The final goal is to determine whether these smart systems are worth or not to be implemented in buildings, from an economic point of view.

Team

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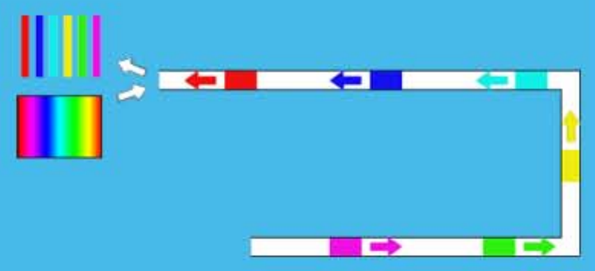
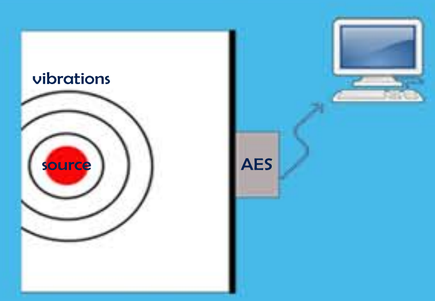
Fibre Optic Sensor

In this project multiplexed Fibre Bragg Grating Sensors (FBG) are used. To detect deformation, cracks or temperature white light is sent through the wire and the gratings (sensors) reflect particular wavelengths. If there are slight changes of the environment the color will be different and the measuring device can convert this information into analysable data.



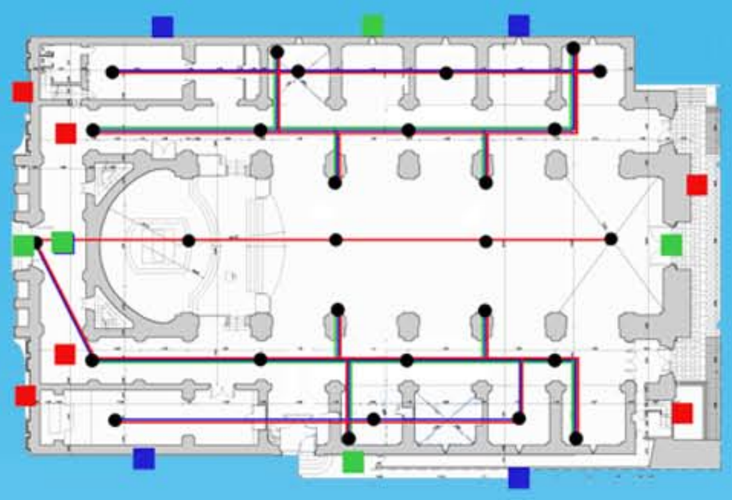
Acoustic Emission Sensor

A system of Acousic Emission Sensors (AES) is able to measure corrosion by listening vibrations. These vibrations spread from the source through the whole system. The AES is located on the surface of a wall and converts the frequency waves into an electrical signal. The signal can be digitalized and analysed by a special software.



San Antonio Church, Vilanova i la Geltrú

In the blueprints of the San Antonio Church you can find different shapes in different colors. The colors are relating to the different intensity concepts. The lines illustrate the Fibre Optic concept and the black dots ● are the locations of the sensors. In this graphic you can also find squares, which get more with every concept. That means the red concept includes also the green and blue squares.



Different Intensity Concepts

Low Intensity

Medium Intensity

High Intensity

The different intensity concepts differentiate between the amount of sensors/data and initial costs.

Neàpolis Building

In the blueprints of the Neàpolis building you can find dots and lines in different colors. The lines show the Fibre Optic concepts, which have different intensities. In this solutions the sensors will be placed between all columns on the lines. The purple dots ● are marking the colums where the compressing should be measured. The Acoustic Emission sensors are pictured as orange dots ● .

Cost-Benefit-Analysis - the proposed formula

$$\text{Feasibility} = \frac{\text{Preventive Maintenance Cost} * \text{time}}{\text{Initial Costs} + (\text{Smart System Costs} + \text{Smart Maintenance Costs}) * \text{time}}$$

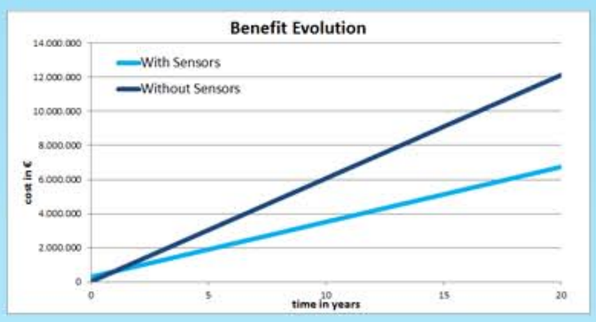
Preventive Maintenance Costs:	maintenance cost during the year without the sensors
Initial Costs:	cost to set up the system of Smart Structures
Smart System Costs:	cost to maintain the system of Smart Structures
Smart Maintenance Costs:	maintenance cost during the year with sensors

Example for the Neàpolis Building

Preventive Maintenance Costs:	ca. 12.129.000 €
Initial Costs:	ca. 277.000 €
Smart System Costs:	ca. 360.000 €
Smart Maintenance Costs:	ca. 6.091.000 €

$$\text{Feasibility} = \frac{12.129.000\ € * 20\ \text{years}}{277.000\ € + (360.000\ € + 6.091.000\ €) * 20\ \text{years}} = 1{,}88$$

<1	It's not profitable
1,01 – 1,25	It's profitable but there is a small margin for errors or deviations
1,26 – 1,50	It's profitable, there is room for errors and deviations because of a good margin gap
> 1,51	It's a solid investment and there is a high return on investment



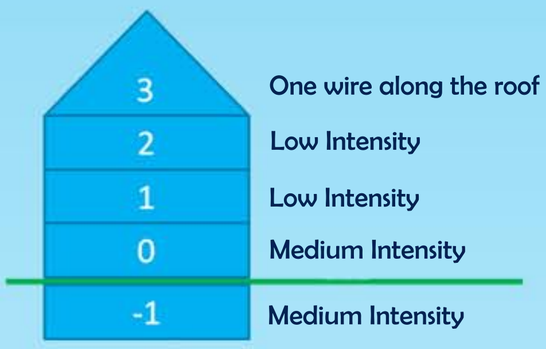
Recommendation

San Antonio Church:

For the San Antonio Church the best solution will be the medium intensity concerning the fibre optic sensors. Because most of the damages are already visible, the sensors are only used to control them. Thats why the medium intensity concept is adequate. For the corrosion detection the high intensity concept will be used, because the salty air in combination with the wind makes harsh conditions for the building. Therefore it is nessassary to monitor as detailed as possible.

Neàpolis Building:

This is the suggestion of the sensor systems for the Neàpolis building. Based on the forces of weight, environmental influences and the basic structure of the individual floors this system was created.
The sensors for compressing will be applied in all floors due to the reason it is included in every intensity level.
As there is only one solution for the Acoustic Emission Sensors this one is used but only in the basement and ground floor.



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