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OPERATION OF AN INTERACTIVE VIBRATION MONITORING SYSTEM AD-HOC DESIGNED FOR TRACKING HISTORIC FAÇADES DURING CONSERVATION WORKS.

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Abstract. *Heritage-listed façades may require relocation when the supporting building is at serious risk of collapse. Such is the case described in this paper, where entire façades must be cut into large sections of up to 200* m^2 *and 150 tonnes in weight. Various engineering works must be carried out to ensure the structural integrity. Each section, which must be able to be handled by heavy-lift autocranes, is reinforced by a temporary steel structure prior to the disengagement from the supporting building structure. These operations demand heavy cutting tools which can induce potentially damaging vibrations. Likewise, the handling of the detached section, if not done carefully, can lead to catastrophic shocks. It is necessary to install a system that, in real time, acquire and process acceleration recordings and draw out commands that can alert to the operators, about the level of vibration. In the event of levels considered to be excessive, signals will advise workers to proceed more carefully. This brief report describes the specifically designed monitoring system, its electronic parts and how they operate. Two different applications are described. Firstly, at laboratory level, the vibrations of a scaled section, with well identified dynamic behaviour, are tracked from its original vertical position to its horizontal one. Subsequently (not shown in this abstract), it is applied to the case of an actual large section, correlating the recordings with the different on-site works and the corresponding alarms generated for each case.*

The acquisition system [1] is based on the ADXL355 digital MEMS triaxial accelerometers from Analog Devices, with a noise density of 25 μ_g/ √ (Hz) and sensitivity set to 3.9 μ_g/LSB in the range ±2g, bandwidth from 0 Hz (can measure the acceleration due to gravity) to 1500 Hz and capable to sample up to 4 kHz with 20 bit per sample. Up to six of them are connected to a microcontroller and microprocessor unit based on a myRIO device (hardware based on a Xilinx Zynq 7010 chip, incorporating a FPGA and a dual-core ARM® Cortex™-A9 processor) from National Instruments. Once a certain time increment is selected (set to 10 s), the recordings are processed in order to extract physical parameters such as acceleration amplitudes, prevalent frequencies and rate of change of the Euler angles. If the adjusted thresholds are exceeded, the system generates different codified alarm outputs ranging from light signals of different colours to sounds with different tones and intensities.

In order to understand the conceptual records shown in figure 1, the typical process of detachment of a façade section is described below. In the case under study, sections up to 10 x 20 m^2 are identified to be separated from the rest of the façade by means of straight cuts. As the sections are fragile, they must be reinforced by steel structures on both sides, connected to each other through holes bored in the façade itself. The section, together with its protective steel structure, forming a rigid sandwich, is still connected to the rest of the building through the heads of the floor slabs. On-site works are required to release the sandwich assembly from the building structure. During these works, for safety reasons, the sandwich is held in place by the slings of the autocrane. The works consist of cutting (using wire saws), demolition (using jackhammers and air breakers) and the use of flame-cutting systems for the metal parts. This kind of equipment induces vibrations (area highlighted in yellow). Once the section has been released, it is hung from the crane, which then moves it away from the building by means of translation and rotation movements. Assuming that the façade is in the X (vertical) Y (horizontal) plane, figure shows a 90º turn with respect to the X-axis (area indicated in green). The work continues with the tilt (90° turn with respect to the Y-axis) after which the section will lie flat on the ground. The tilting is carried out with the help of a second crane and is shown in the band indicated in blue. Vibrations may occur during all the process due to the necessary movements of the cranes, possible impacts with the building, the ground support manoeuvre or the readjustment of the slings during the tilting.

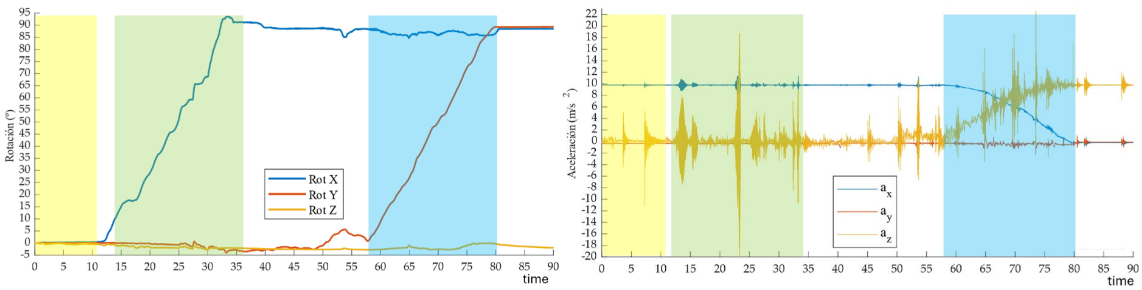

Figure 1: Euler angles (left) and accelerations (right)

Figure 1 shows the rotation and acceleration recordings of the conceptual test carried out at laboratory scale (1:10), where the whole process was carried out in 90 s and vibrations up to 2 g were intentionally induced. The case study to be shown consists of a section of 20 x 10 m^2 and 136 t, handled by 2 cranes of 700 t and 500 t, where 26 hours were used for its releasing and overturning, where the maximum acceleration did not exceed 3.8 m/s^2.

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