Some aspects of the the monitoring of Incheon grand bridge in a permanent quasi-static regime

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***Abstract**: The analysis of a building's construction must also include a good knowing of the characteristic environmental factors in the location area, but in order to optimize the design solutions, the behavior models provided by the data banks (future) become a must. In setting up these data banks the main information is provided by the topo-geodesical activity, which must coordinate the entire monitoring process for the tracking of the behavior after the action of environmental and exploitation factors. The case study, in continuous quasi-static condition, was performed on Incheon Grand Bridge South Korea. At 12.3km long with a main cable stayed span of 800m the new Incheon Bridge will be one of the five longest of its type in the world.*

***Keywords:** monitoring, permanent quasi-static regime, Incheon grand bridge, one of the five longest of its type in the world*

1. Introduction

Development of completion of special constructions of more and more performing dimensions and constructive features, experienced an unprecedented expansion in history, during the last 30 years. In a process of competition among big investors, municipalities, developers and large construction companies, structures with aesthetic, architectural but also functional feature resulted, real sights on the world map. Against this background, the monitoring activity of the time behavior of the constructions became a stage in the life of these structures, started since the completion of foundations, and running their entire life cycle. In this context, techniques and instruments that are considered classics have been partially replaced, appearing new methods, new equipment and also genuine monitoring manager systems of land and constructions. In most cases, new technologies have emerged from specific needs, monitoring the execution and then the time behavior of a very high bridge or construction, but many of them may become universal in so far as they are known, tested and validated. Lack of systematization of information on specified topics at national and global level, makes that this latter goal to be practically impossible to fulfill. Measurement and instrumentation techniques for strains monitoring under static and quasi-static conditions, have been traditionally categorized into two groups, according to the field of the professionals who use these techniques:

- Topographic-geodetic measurements, which include the conventional methods (Land surveying leveling technology or planimetry), photogrammetric methods, some unconventional techniques (laser instrumentation, hydrostatic leveling, alignment method), and satellite methods of the GPS category.
- Structural and geological methods of investigation, which particularly aim the mechanics of land and the destructive processes produced over time upon the strength structure of the monitored constructions; these do not fall within the theme of this paper.

2. Conditions imposed to monitoring methods for building structures in kinematic regime: quasi-static, quasi dynamic and dynamic

We consider that to be useful to direct beneficiaries (engineers of monitored structures), the methods of kinematic monitoring must meet the following conditions:

1. Entries must be either continuous (dynamic regime), or with a constant frequency of reading (quasi-static regime), in various combinations of stress conditions,

2. Parameters of causes that produce movement of the structure, monitored phenomenon, must be accurately defined,

3. Accurately determine the ratio between features of loads, their effects - movements in three-dimensional space,

4. Accuracy of measurement must meet the requirements given in the specifications for monitoring the structure in static regime, i.e. kinematic, quasi-static and / or dynamic,

5. Make possible the overall presentation of the cumulative effects that stress the monitored structure,

6. Make possible to detect possible influences for each of the stress factors,

7. Reducing, as much as possible, environmental effects on measurement methods.

The data provided by the surveyor to the engineer of the measured structure should allow the defining of general and particular behavioral elements for a particular type of structure, such as a cone type structure, features such as height, volume, environment, soil, location, terrain, climate, neighborhood, and the incidence of extraordinary stress factors.

It is considered necessary to approach the possible coupling of stress factors with caution.

3. Incheon grand bridge South Korea

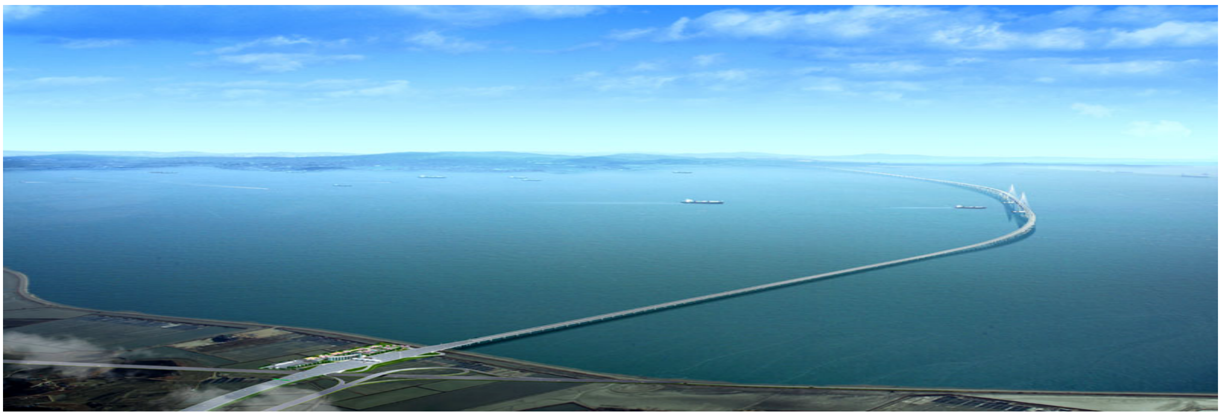

Figure 1. General view 1, Incheon grand bridge South Korea

The Incheon Bridge (also called the Incheon Grand Bridge) is a newly-constructed reinforced concrete bridge in South Korea. At its opening in October 2009, it became the second connection between Yeongjong Island and the mainland of Incheon. The Incheon Bridge is South Korea's longest spanning cable-stayed bridge. In comparison, the Incheon Bridge is the world's seventh longest cable-stayed bridge as of October 2010. (19). At 12.3km long with a main cable stayed span of 800m the new Incheon Bridge will be one of the five longest of its type in the world. Its 33.4m wide steel/concrete composite deck will carry six lanes of traffic 74m above the main shipping route in and out of Incheon port and link the new Incheon International Airport on Yongjing Island to the international business district of New Songdo City and the metropolitan districts of South Korea's capital, Seoul. The cable stayed section of the crossing is 1,480m long, made up of five spans measuring 80m, 260m, 800m, 260m and 80m respectively, and the height of the "inverted Y" main towers is 230.5m(19). The sea crossing bridge section, whose concessionaire is Incheon Bridge Corporation, is funded by the private sector. Korea Expressway Corporation and the Korean Ministry of Land, Transport and Maritime Affairs (MLTM) managed the project(19).

Figure 2. General view 2, Incheon grand bridge South Korea

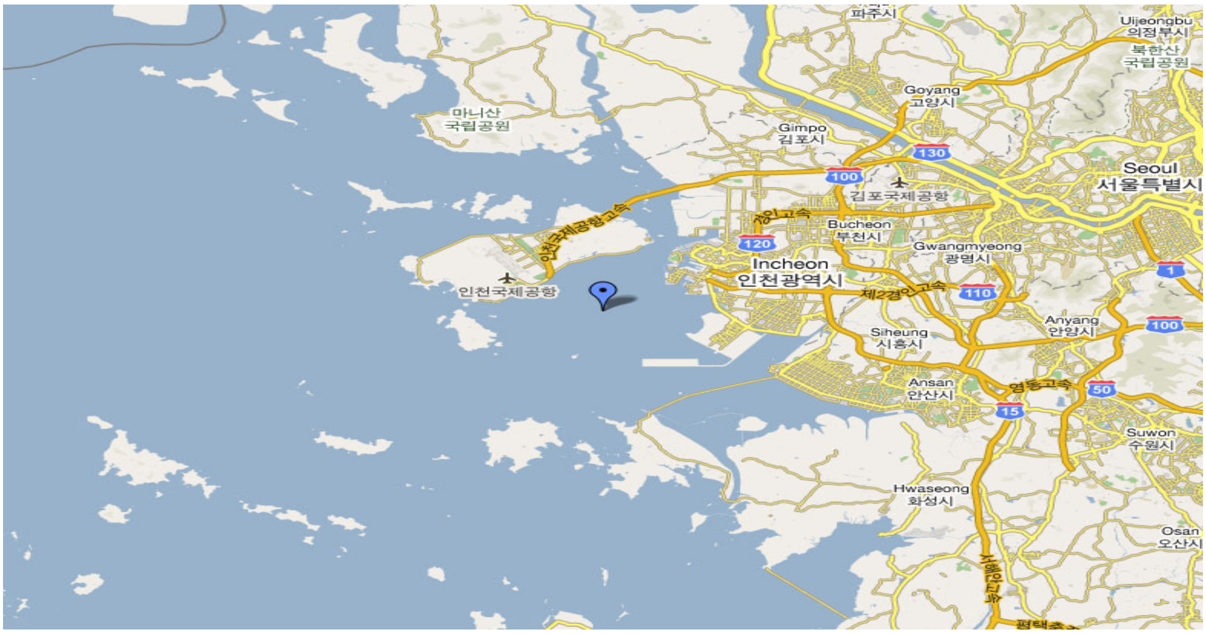

Figure 3. Incheon grand bridge South Korea map

4. Monitoring a structure in quasi static continuous regime, Incheon grand bridge South Korea

As an example of monitoring in quasi static regime, the Incheon Grand Bridge, South Korea (Figures 1 and 2) was chosen, work performed by Vienna Consulting Engineers in Vienna, Austria. From the presentation site we quote: " In order to measure the movement of the cable stayed bridge section and the performance of the modular expansion joints of type LR24, a ROBO®CONTROL remote monitoring system was installed at one at the expansion joint locations. This serves to measure the movements of the first, second and last lamella beams of the joint, as well as the entire gap width and air and structure temperatures. "(Brimos, VCE 2009-2012).

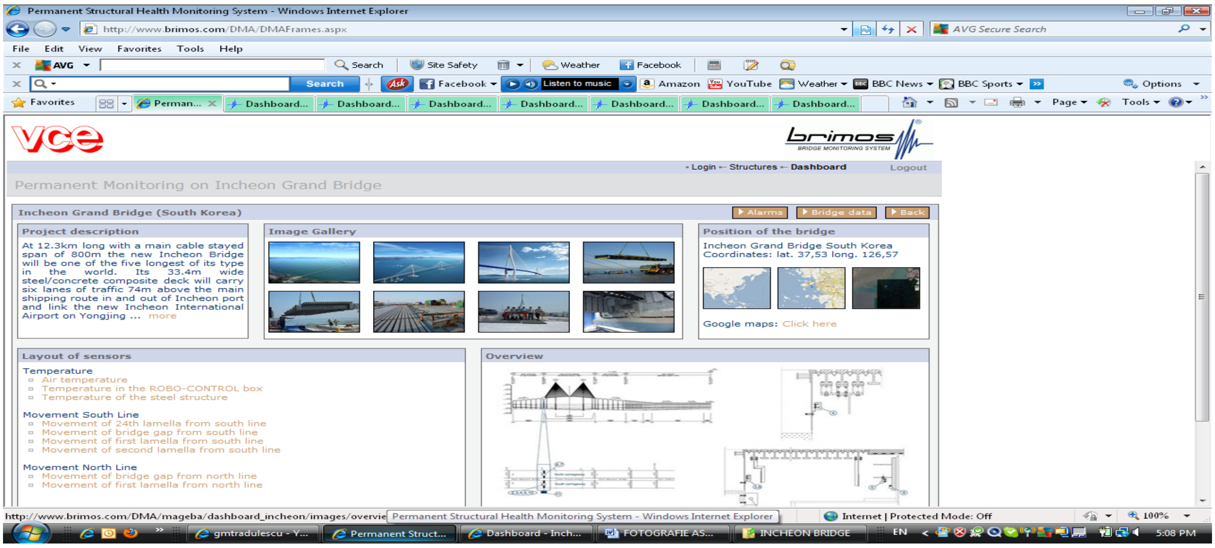

Figure 4. Print screen of the recordings, Incheon grand bridge South Korea

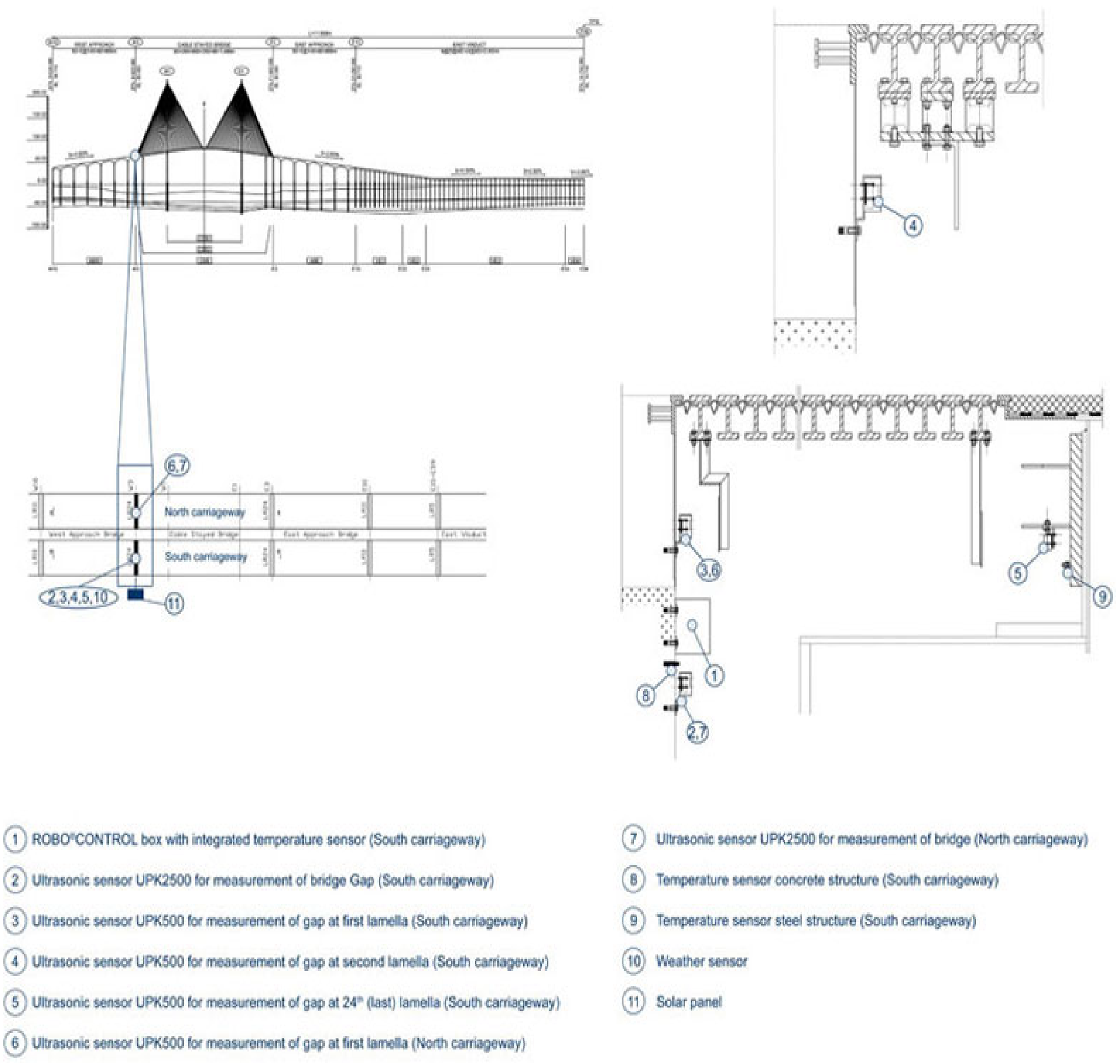

Figure 5. The position of sensors on the backbone of the bridge, RoboControl box, ultrasonic and temperature sensors mounted on the structure

The homepage of the work's presentation site (Figure 4) shows the monitored structure, and the position of the points tracked on the structure. Records were made every five minutes for weather factors and hourly for determining the current position of prisms. Figure 5 shows the sensor location on the backbone of the bridge, RoboControl box, ultrasonic and temperature sensors mounted on the structure and figure 6 shows the position of the RoboControl box, mounted on the structure

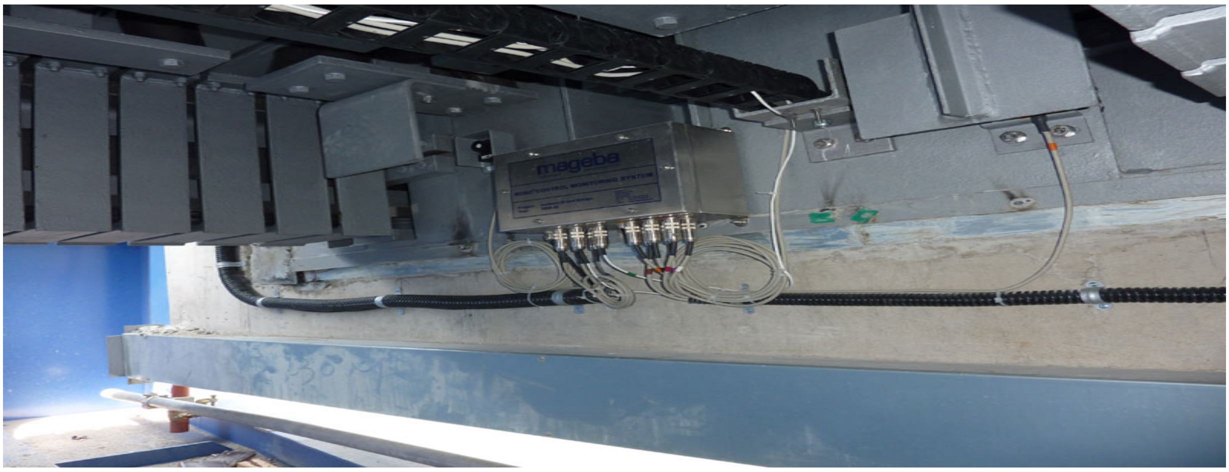

Figure 6. The position of the RoboControl box, mounted on the structure

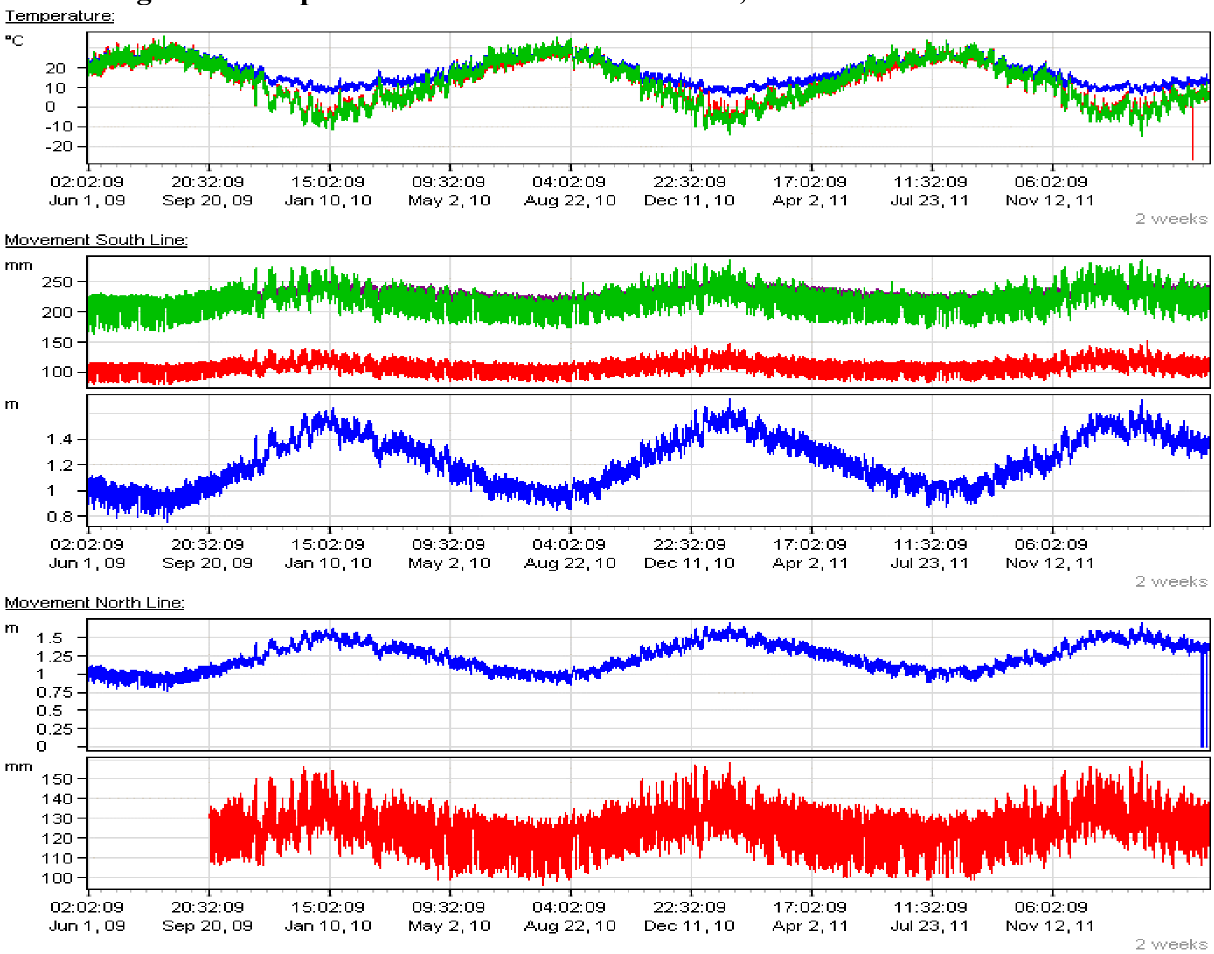

Figure 7. The relationship between atmospheric factors-temperature and the movement of the bridge for all monitoring period 23.06.2009-07.05.2012

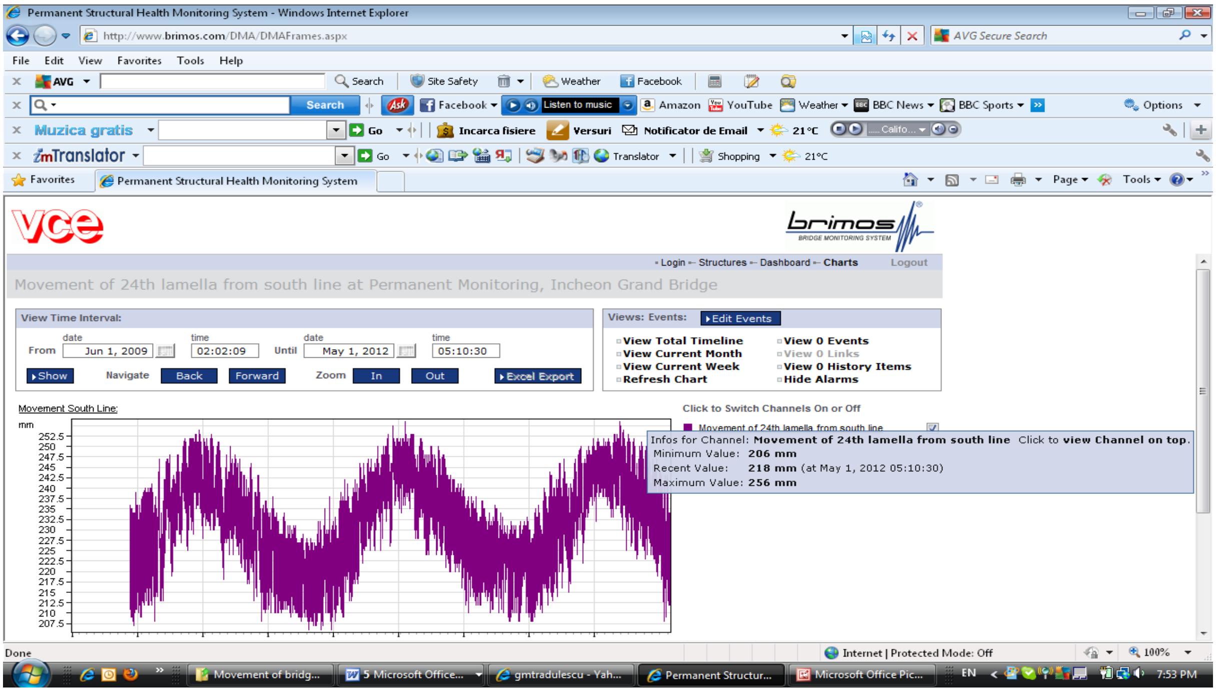

Figure 8. Movement of 24th lamella from south line for the all monitoring period 23.06.2009-07.05.2012

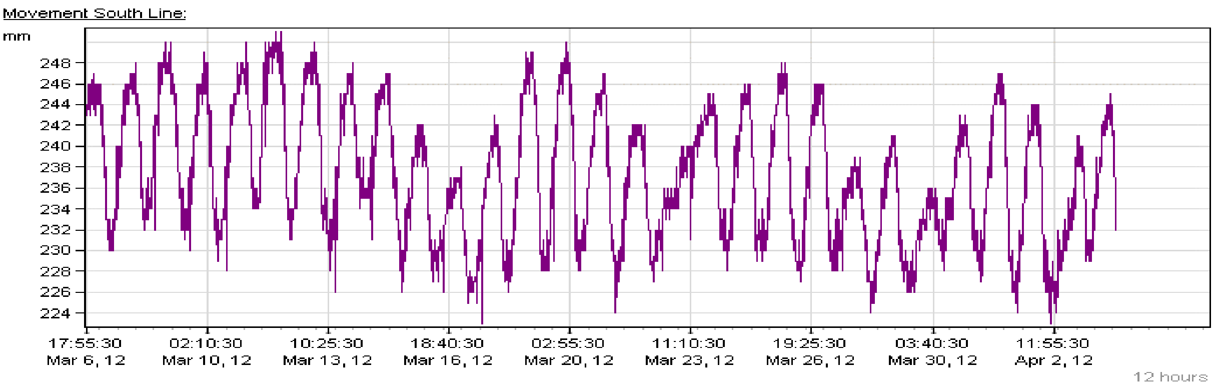

Figure 9. Movement of 24th lamella from south line in the interval 06.03.2012-06.04.2012, one month of the monitoring

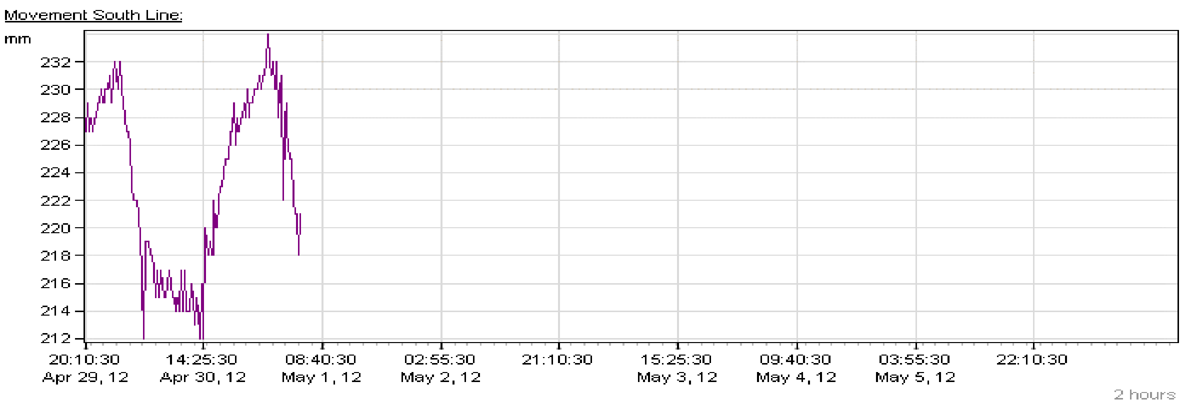

Figure 10. Movement of 24th lamella from south line in the interval 29.04.2012-06.05.2012, one week of the monitoring

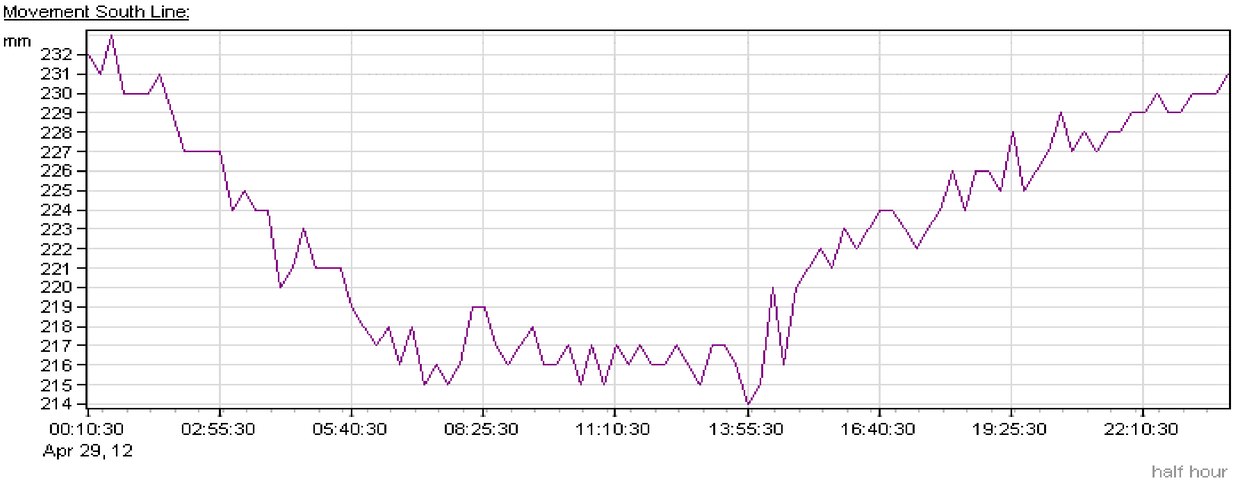

Figure 11. Movement of 24th lamella from south line in the interval 29.04.2012-30.04.2012, one day of the monitoring

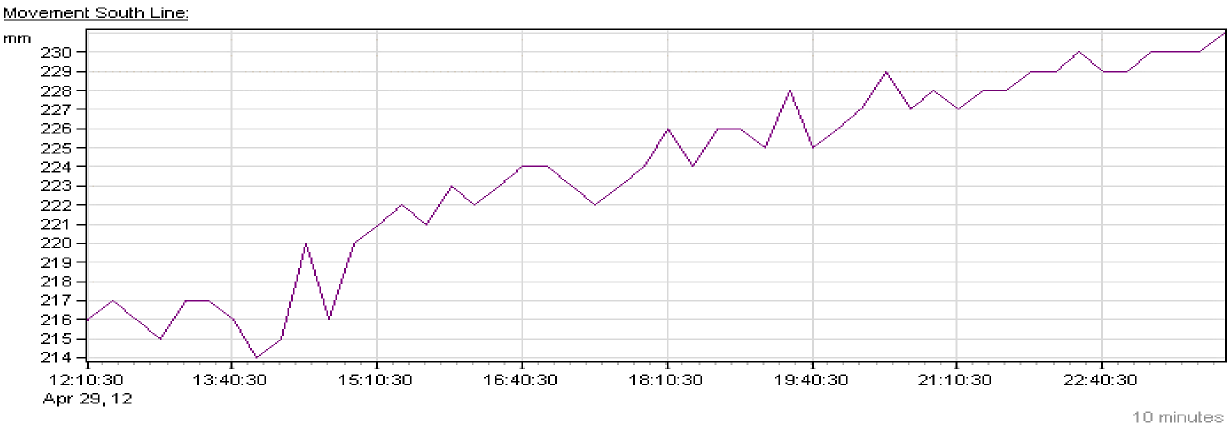

Figure 12. Movement of 24th lamella from south line in the interval 29.04.2012, 12.00.00-29.04.2012, 24.00.00, 12 hours of the monitoring

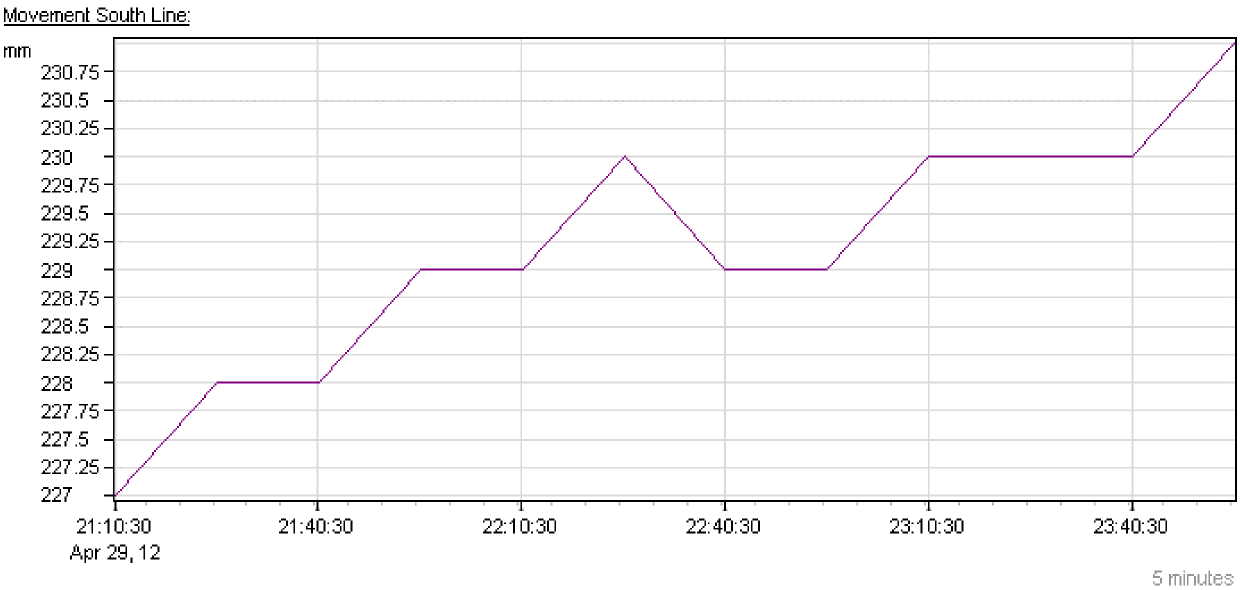

Figure 13. Movement of 24th lamella from south line in the interval 29.04.2012, 21.00.00-29.04.2012, 24.00.00, 3 hours of the monitoring

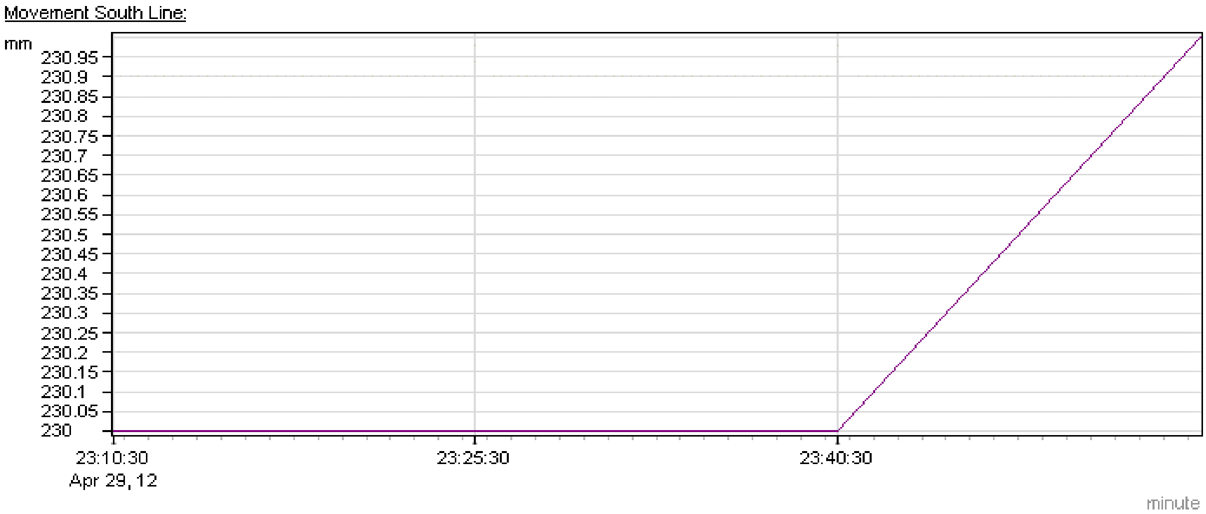

Figure 14. Movement of 24th lamella from south line in the interval 23.04.2012, 23.00.00-23.04.2012, 24.00.00, 1 hours of the monitoring

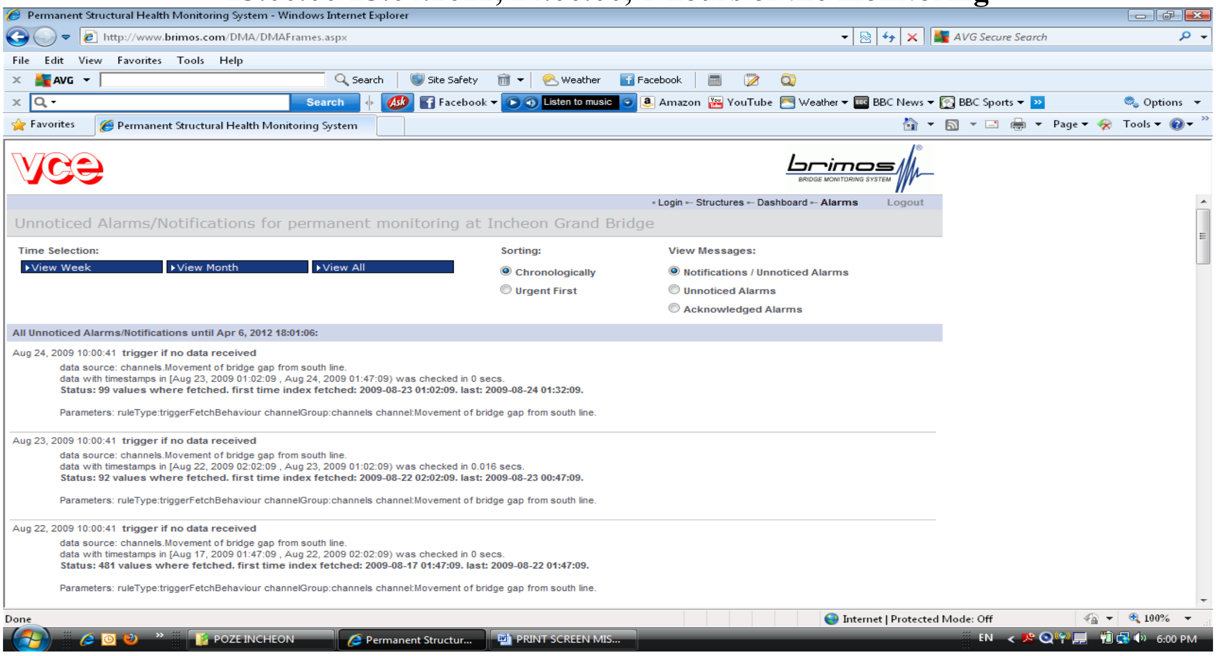

Figure 15. Print screen of the Allarm notifications, Incheon grand bridge

The figure 8-14 shows the movement of 24th lamella from south line in the various interval, for the all monitoring period 23.06.2009-07.05.2012(figure 8), in the interval 06.03.2012-06.04.2012, one month of the monitoring(figure 9), in the interval 29.04.2012-06.05.2012, one week of the monitoring(figure 10), in the interval 29.04.2012-30.04.2012, one day of the monitoring(figure 11), in the interval 29.04.2012, 12.00.00-29.04.2012, 24.00.00, 12 hours of the monitoring(figure 12), in the interval 29.04.2012, 21.00.00-29.04.2012, 24.00.00, 3 hours of the monitoring(figure 13) and in the interval 23.04.2012, 23.00.00-23.04.2012, 24.00.00, 1 hours of the monitoring(figure 14). The Structural monitoring analist have the posibility to analisys the Allarm notifications(figure 15) for the all monitoring period. From the data link provided by the company for each job/structure monitoring we can produce tables, graphs or representations of structure behavior over time in Structural monitoring curent activity.

5. Conclusions

Monitoring structures in quasi static regime requires reliable equipment and rigor. It is very important that the engineer of the monitored structure defines the specifications on this very important stage in the life of the building. The development of methods, technologies and tools for monitoring the behavior in time of structures of any type, buildings or land in static or kinematic regime is spectacular, offering the expert solutions to any such requirement. But the surveyor's mission ends here. He has monitored the structure at the request of the engineer, has recorded the behavioral values of the structure for the intervals required and also the size of loads by category: atmospheric pressure, air temperature, atmospheric humidity. Next, the engineer will analyze and interpret the data by confronting them with project values.

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