Autonomous systems for strain and vibration measurements

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Summary

When studying the long-term behaviour of structures, it often becomes necessary to resort to monitoring of certain structural parameters. This research paper discusses two such applications. A first prototype was used to monitor strains in a concrete fly-over with CFRP-reinforcements. The second prototype was used recently to monitor the vibrations in a continuous fashion during four weeks of speed tests on a new section of the European High Speed Train network.

This article gives an overview of these experiences and on the lessons learned concerning power supply and possible electromagnetic interference in harsh construction site condition. In addition, it describes the intentions to build, a new completely autonomous third prototype for thermal strain monitoring. Furthermore, the most important results of both test cases are discussed in short, including the effectiveness off the CFRP-reinforcement and the natural frequencies of a massive concrete fly-over.

Keywords: bridges, strain gauges, accelerometers, non-destructive testing, monitoring, wireless, concrete creep

1. Introduction

In Belgium, a large number of bridges were built in recent years as part of the European High Speed Train network. A considerable percentage of them were subjected to test loading before completion, during which strains and or accelerations were measured for comparison with design premises.

When studying the long-term behaviour of structures, it often becomes necessary to resort to monitoring of certain structural parameters, such as strains, temperatures, accelerations, etc. Especially when the nature of the structures necessitates the use of an independent power source for the measurement system and restricts the use of wireless connections, a fully autonomous measurement system becomes necessary. This research paper discusses two such applications and the possible pitfall in developing such a system.

2. Measuring concrete creep on the "Luchtbal" fly-over

A first prototype was used to monitor the strains in a concrete fly-over with CFRP-reinforcements. A total of 20 measurement units were developed which could each measure the strains of 4 strain gauges, for a period of two weeks. After that period, the data needed to be downloaded. The total length of the measurement period was more than 6 months, which resulted in a lot of complications.

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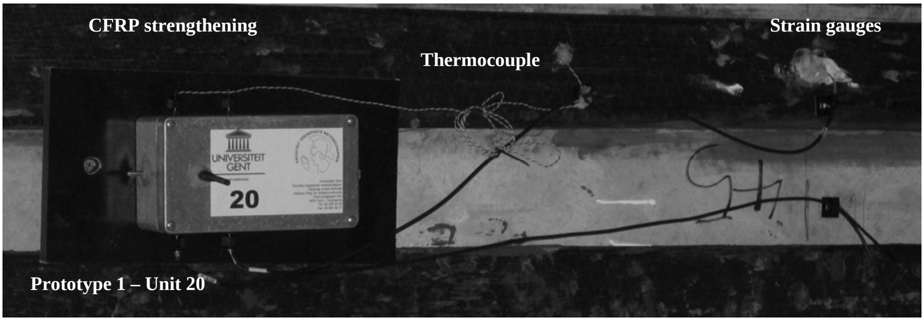

Fig. 1: Placement of the measurement units on the deck of the fly-over.

3. Acceleration measurements on bridges for HST

The second prototype was used more recently to monitor the vibrations in a continuous fashion during four weeks of speed tests on a new section of the European High Speed Train network in Belgium. Due to the nature of the testing, the system needed to act independently for the entire period, necessitating several independent backup systems to ensure redundancy. A total of three of these more robust units were built, each responsible for 4 seismic accelerometers. The overall performance was much more reliable.

Table 1: Comparison of the basis features of both prototypes

	Prototype I	Prototype II
Measurement type	Strains & temperatures	Accelerations
Storage capacity	2 Mb	2000 Mb
Power supply	2 lithium-ion D-cells	3 accumulators
Autonomy	2 weeks	5 weeks
Size	$3\ 10^3$ cm^3	$96\ 10^3$ cm^3
Number of units	20	3
Measurement period	6 months	1 month

4. Lessons learned

Based on the experience of both measurement projects, a number of guidelines can be put forward for all future attempts to create autonomous monitoring systems. First and foremost is the importance of power supply. When working outdoors and in construction site conditions it is better to invest in a dependable and over-dimensioned power supply instead of trying to minimise the size of the unit.

In addition, it is important to emphasize the importance of backup systems. When monitoring for longer periods at locations where it is not possible to perform maintenance, backups must be in place for all parts of the monitoring unit that are imperative for keeping the unit in action. Furthermore, it pays to avoid more high-tech gadgets such as wireless transmission of results when working close to railway lines, where the influence of the overhead wires will reduce the efficiency of such systems to almost non existent.

The main conclusion of the experiences to date is that the development of such a system is certainly possible, but that, given the external circumstances, the design should be as robust as possible and include backup systems for all vital components.