Use of Wireless Sensors in the Building Industry - SensoByg

Dr. Henrik Erndahl Sørensen
Danish Technological Institute
2630 Taastrup, Denmark
henrik.erndahl.sorensen@teknologisk.dk
Sensors in building industry

Introduction

Why use sensors?
- Offers both technical and economical advantages
- Built-in sensors can supply data from otherwise non-accessible parts
- Can form a warning system in combination with decision-making tools
- Helps to minimise production time and costs
Sensors in building industry

Introduction

Current use of sensors
The use of sensors for monitoring in buildings and infrastructural constructions is already known technology. Some examples are:

- Monitoring and controlling indoor climate
- Monitoring moisture content in concrete flooring
- Monitoring corrosion risk on reinforcement in large tunnels and bridges
- Monitoring and controlling concrete temperature during hardening
- Monitoring and controlling cathodic protection of reinforcement in concrete
Sensors in building industry

Wireless sensors

Examples of existing wireless sensors and readers
Sensors in building industry

Wireless sensors

Example of a wireless monitoring system

Wireless sensors (1), Local readers (2), Central datalogging unit (3), Decision-making system (4)
Sensors in building industry

Wireless sensors

Example of a passive, wireless sensor
A passive, wireless sensor do not need its own energy source to make measurements and send data.

The SAW-sensor uses the energy in the request signal to return a response signal with the measured data. (SAW: Surface Acoustic Wave)
SensoByg
- a Danish innovation consortium

Facts
● 3-year national project - started March 2007
● Approx. 4 million EURO budget
● Financial support from the Danish Ministry of Science, Technology and Innovation

Object
To develop and to demonstrate the advantages of low-cost, reliable monitoring systems for the building industry based on wireless sensor technology and intelligent decision-making tools.
SensoByg
- a Danish innovation consortium

Partners

● 6 R&D performers
  - including building physics, wireless technology, sensor technology, software architecture, computer science and concrete technology

● 12 industrial partners
  - including building owners, concrete manufacturers, software developers, consulting engineers and sensor producers
Content

- Main focus: Wireless monitoring of moisture and temperature
- Monitoring systems will be general and flexible
- Fitting to sensors for monitoring of other relevant properties in the building industry will be possible

Photo: Prototype of wireless sensor system for measuring moisture and temperature
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Activities
4 demonstration projects
5 technical focus areas

- Moisture in the construction phase
- Concrete elements
- Large structures
- Moisture in housings

- Coupling & interaction
- Encapsulation & embedment
- Decision support system
- System architecture
- Wireless sensor
D1: Moisture in Housings
D2: Large Structures
D4: Moisture in the Construction Phase
Flat boxshaped wireless sensor
- The wireless sensor is encapsulated in a small plastic casing (2x3x5 cm)
- The wireless sensor is based on a capacitive sensor from Sensirion
- The sensor is separated from the moisture sensitive components by a rubber ring
- The moisture and temperature sensor is connected to a microcomputer, a radio transmitter and an antenna working at 433MHz
- The hardware is supplied with power from a battery
SensoByg

Design of wireless sensor

Cylindershaped wireless sensor
- The sensor is easily postmounted by pressing it into a drilled hole
- Size is minimised to a diameter of 42 mm and a height of 35 mm
- A rubber gasket on the outside gives a well-defined measurement depth
- In-situ testing of this sensor type has not yet been performed
Indkapsling
Design of wireless sensor

Cylindershaped wireless sensor

Exploded view

Cross-sectional view

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Application in D2
Sensor embedment in a highway bridge

**Monitoring a new waterproofing membrane on highway bridge**
- Highway bridge close to the Danish Technological Institute
- Waterproof membrane under the asphalt pavement is leaking
- Rehabilitation of damaged concrete bridge deck
- Concrete deck is renewed followed by application of a new waterproofing membrane and layers of asphalt pavement
- Embedment of wireless moisture and temperature sensors
- Monitoring of possible leaking in waterproofing membrane
Application in D2
Sensor embedment in a highway bridge

Choice of wireless sensors
- Boxshaped sensor type is used
- A supplementary box with extra batteries is used to extent the lifetime
- Total energy of batteries is enough for 30 years use
- The shell life of batteries is approx. 10 years
Wireless transceiver

- The wireless transceiver-unit is powered from a solar panel coupled to a 12V car battery.
- Sensor data is transferred via a GSM modem to an internet server on The Danish Technological Institute.
- The monitoring system on the highway bridge is independent of the public electricity supply.
- So far the transceiver-unit has been running without recharging since October 2007.
Application in D2
Sensor embedment in a highway bridge

Installation of sensors
- The wireless sensors are placed in small box outs made by pressing pieces of wood into the fresh concrete
- Sensors are protected with a lid on top and sealed with flexible mortar
- Filling of box outs with rain water is avoided
- Severe heat from hot bitumen during application is avoided
Application in D2

Sensor embedment in a highway bridge

Position of sensors
- 5 nos. of moisture and temperature sensors
- Placed in gutter line approx. 1 m from northern edge beam
- Sensors are distributed over a length of approx. 30 m:

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Distance to transceiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>4C</td>
<td>3,95 m</td>
</tr>
<tr>
<td>5C</td>
<td>10,05 m</td>
</tr>
<tr>
<td>5A</td>
<td>13,72 m</td>
</tr>
<tr>
<td>59</td>
<td>20,96 m</td>
</tr>
<tr>
<td>5B</td>
<td>30,12 m</td>
</tr>
</tbody>
</table>
Application in D2
Sensor embedment in a highway bridge

Dataopsamling

- Sensor data are transmitted wireless to the transceiver system
- Transmission is rather unstable – especially in wet conditions
- Measurements in January 2008:

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Distance to transceiver</th>
<th>Nos. of measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>4C</td>
<td>3.95 m</td>
<td>30</td>
</tr>
<tr>
<td>5C</td>
<td>10.05 m</td>
<td>80</td>
</tr>
<tr>
<td>5A</td>
<td>13.72 m</td>
<td>11</td>
</tr>
<tr>
<td>59</td>
<td>20.96 m</td>
<td>4</td>
</tr>
<tr>
<td>5B</td>
<td>30.12 m</td>
<td>74</td>
</tr>
</tbody>
</table>
Application in D2
Sensor embedment in a highway bridge

Wireless communication between sensors and transceiver

Highway bridge - January 2008

Graph showing time and position data for sensors E7E7E74C, E7E7E759, E7E7E75A, E7E7E75B, and E7E7E75C.
Application in D2
Sensor data from highway bridge

Highway Bridge - October 2007

Time

Temperature [deg. C]


E7E7E74C
E7E7E759
E7E7E75A
E7E7E75B
E7E7E75C
Application in D2
Sensor data from highway bridge

Highway Bridge - October 2007

Moisture [%RH] vs Time

- E7E7E74C
- E7E7E759
- E7E7E75A
- E7E7E75B
- E7E7E75C
Application in D2
Sensor data from highway bridge

Temperature in highway bridge

Temperature [°C]

Time


E7E7E75C
Application in D2
Sensor data from highway bridge

Moisture in highway bridge

Moisture [%RH]

Time

More information

www.sensobyg.dk

Pamphlet with further information is available