Multifunctional cementitious composite with carbon black for traffic monitoring

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Societies increasingly search for more efficient and resilient structures and infrastructures. These infrastructures are commonly part of networks, where an adequate management can only be achieved with the existence of data regarding their use. Development of these concepts in the last years lead to the advent of the so-called smart infrastructures. Traffic logistics has been one of the fields which has benefited the most of such advances, with the implementation of the so-called Intelligent Transportation Systems. During the last years, advances in materials science enabled the development of a wide range of "smart" construction materials capable of autonomous tasks. An example of these are the piezoresistive cementitious composites, some of which may be used as monitoring systems, due to their self-sensing properties.

The present research aims to bridge the concept of multifunctional cement-based materials to the traffic monitoring discipline, through the use of stress-sensitive cementitious composites, based on the addition of carbon black (CB) particles. These materials, working under the piezoresistive concept, were developed for application in pavement aiming to perform permanent real-time evaluation of traffic data. Using cementitous composites with CB has some advantages compared to traditional monitoring devices and solutions, due to their relative low cost, structural strength, durability and simplicity of implementation.

Different CB percentages and concrete compositions were tested in order to determine the most favourable piezoresistive response for the mixture. Measurement setup was optimized towards traffic monitoring requirements. Quasi-static and dynamic compressive load cycles showed very good gauge factors and a response linearity inaffected by temperature variations, despite registered reductions in sensitivity. Overall, results demonstrated that embedding conductive CB-based concrete elements in pavement surfaces may become a prospective alternative to conventional traffic monitoring solutions given their numerous advantages.

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FIGURE 1
Working principle of the Piezoresistive Cement-based Self-Sensor (PCSS).

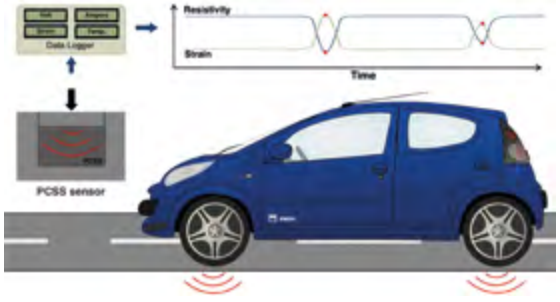
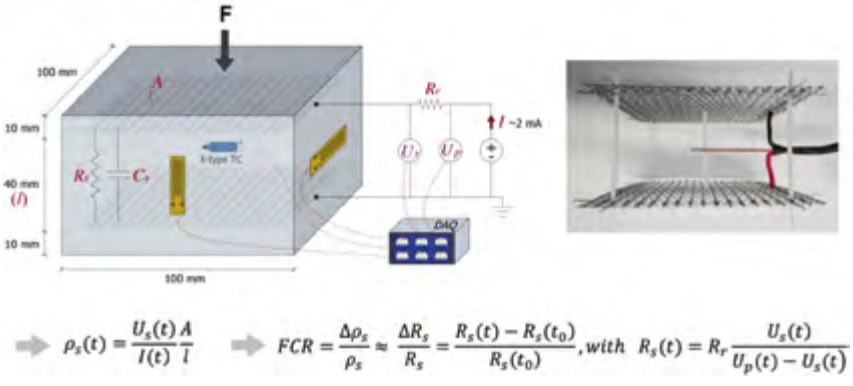


FIGURE 2
Scheme of the piezoresistivity concrete sensor.



$$\rho_s(t) = \frac{U_s(t)}{I(t)}\frac{A}{l} \quad FCR = \frac{\Delta\rho_s}{\rho_s} \approx \frac{\Delta R_s}{R_s} = \frac{R_s(t) - R_s(t_0)}{R_s(t_0)}, \text{with } R_s(t) = R_r \frac{U_s(t)}{U_p(t) - U_s(t)}$$