A PROCEDURE FOR DEFECT IDENTIFICATION OF SUSPENSION BRIDGES CABLES BY MEANS OF OPTICAL-FIBRE STRAIN MEASUREMENTS

L. Nunziante*, M. Fraldi

Department of Structural Engineering, University of Napoli "Federico II", via Claudio 21, 80125 Napoli, Italy.
* Corresponding Author. E-mail: nunsci@unina.it ; mob.+39 338 8211 918

ABSTRACT

Recently, the use of Optical Fibre Sensors (OFS) utilising Brillouin scattering effect for reading distributed measurements of temperature and strains has been addressed. Moreover for the strain readings, a few of technical devices were proposed for connecting the optical fibre sensor to the structure, in order to obtain better results in terms of accuracy of measurements.

Recently, several authors have shown that, by means of distributed experimental strain readings, it is easy the safety monitoring and assessment of large structures as bridges, pipes, tall buildings, dams and tunnels. Moreover, the great utility of this new sensors were demonstrated by the authors for detection of defects rising in large structures, and accuracy and reliability of measurements were discussed. In foregoing papers some of the authors furnished the mechanical response of optical fibre, when this is embedded in a bearing support beam-like element, where OFSs are treated in the framework of elastic Functionally Graded Material Cylinders (FGMCs), under symmetrical load conditions. In this framework they obtained the complete set of the so called no-decaying solutions, which present axial strain in the system core-jacket not varying with the radius, and hence equal to the value assumed in the supporting element. Laboratory tests carried out on aluminium large rods in extension, and on wires for cables for suspended bridges, equipped with embedded-type optic fibre sensors showed the optimal accuracy of the distributed strains carried out by this new OF sensor. These results allow to facing a few of new applications, among which one of the most important is represented by the monitoring and identification of defects occurring in large structures such as trusses, suspension, or cable-stayed bridges. Namely, the problem of the identification of defects occurring in the wires constituting the cables for suspended or cable stayed bridges is one of the unsolved concern of the modern maintenance and monitoring bridge technology. As matter of fact, most part of these bridges suffers the corrosive action and the damage due to both natural and pullution agents present in the athmosphere. As already shown in several technical papers, several aggressive agents are able of strongly reducing the stiffness of the suspension cable system, and the corrosion processes are very fast being able of significant reductions af stiffness also in a few of months. The stiffness of the cables is usually due by that of thousands of wires. The reduction of cable stiffness is usually related to effects of corrosion of wires related to their cross section reduction, as well as to the decrease of the Young modulus E due to chemical agents that modify the material. In the present paper the problem of detection of corrosion or other damage effect, acting on wires for cables suspension or cable-stayed bridges, will be addressed by using structural analisys methods coupled with the results of on field experimental tests on cables.

The proposed identification procedure is based on a program of on-field test's , in which the distributed strains are measured on all the cables by means of Optical Fibre sensors. Eachone of the planned statical tests must be developed in the same conditions of temperature, without any noise effect (wind, vibration,..), and requests the application of the load distribution q over the bridge beam. The paper shows that the structural problem can be solved theoretically by means of a modified Finite Element strategy, based on a linear system of equations expressing the stationarity conditions of Total Potential Energy, in presence of the initial cable stiffnesses .

* Corresponding author: e-mail: nunsci@unina.it; Tel.: +39-081-7683727 (Office); Fax: +39-081-575 6147

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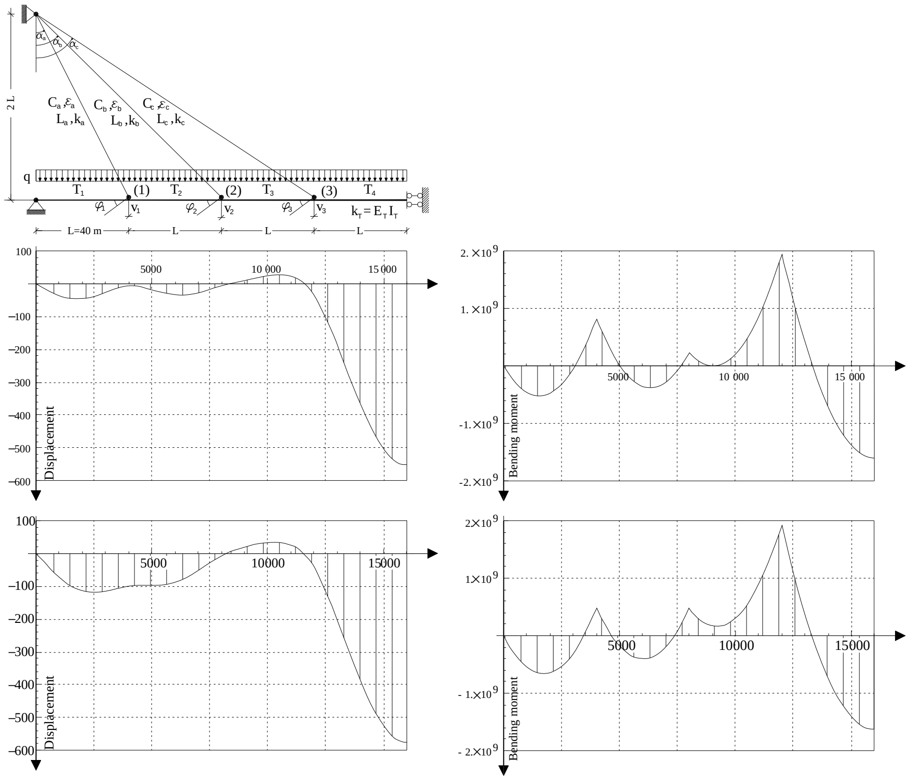
After the occurrence of corrosion or other damage effects able of significantly reducing the cable stiffnesses, the experimental distributed cable’s strain readings can be utilised in the same equation system, where the actual unknown cable stiffnesses are left as unknown parameters to determine. The outlined inverse procedure, by locking the cables's degrees of freedom to the values compatible with the measured cable’s strains, allows to obtaining both the actual reduced values of the cable stiffnesses and the free part of the degrees of freedom. As an example, a case study of identification of corroding effects appearing in a cable stayed bridge structure is also presented.

Keywords: structural damage, defect identification, non-destructive tests, inverse structural problems, optical fibre sensor, distributed strain, rod structures, suspension bridge, cable-stayed bridge, Brillouin Scattering Effect.



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