# Report for One-Year Research on "*FIBER OPTIC MONITORING SYSTEM FOR PREFABRICATED PRODUCTS (PREFOS)*"

**Period of Research:** 01.10.2021 - 30.09.2022

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**Abstract:** Nowadays, fiber optic sensors technology is widely used in structural health monitoring (SHM) of civil engineering structures and the fiber optic sensors based on the fiber Bragg grating (FBG) technology are using in various prestressed concrete structures. FBG sensors are produced in the core of the fiber, as a short length (a few mm) diffraction grating. The principle of operation of the FBG sensors is based on the diffraction occurring at the grating: if broadband light propagates, a quasi-monochromatic counter propagating light originates. The wavelength of the diffracted light depends on the thermoelastic parameters of the core at the grating so that, by performing spectral analysis of the counter propagating light, information about the strain and the temperature variation can be obtained.

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This research proposes an industrial solution for producing self-monitoring of a seven-wire prestressed precast RC beams, instrumenting rebars with optical fibers, solving technological restrictions and simplifying productive processes. Self – monitoring beams will be already instrumented by Fiber Bragg Grating (FBG) optical sensors in the production site, for a quality control and to monitor the structure when the implementation in the construction site will be done. During this research, the steel strands have been instrumented with optical sensors embedding them into fiberglass saddles manufactured for easy positioning and fixing optical sensors during the pre-cast production site. Then different tests have done for comparing and validating FBG monitoring results to traditional measurement systems.

**Project experiments**

**Fiberglass saddle producing procedure with FBG sensors:**

Fiberglass saddles were proposed and produced in the Enea Laboratory. The fiberglass paper was saturated by epoxy resin and half of the length of the fiberglass has been rolled around the strand. Then, FBG sensor

has been put on the fiberglass and the remaining part of the fiberglass has been rolled around the strand. In order to keep epoxy glue homogeneous, the saddle was covered by a film waiting for the curing (about 12 hours); after that, it was cut in two longitudinal directions, just to remove it from the mold and for letting the saddle fix on the strand to be monitored. Finally, the instrumented saddle was glued on the strand with epoxy resin.

The above-mentioned process has been used to produce saddles with two different width of 30 and 110 mm, and two different diameters of 12.5 and 15.2 mm. The length of fiberglass for producing saddles with 110 mm width was 240 mm and also for saddles with 30 mm width was 200 mm.

**Cyclic thermal test on instrumented strand:**

In this step of research, in order to verify the behavior of instrumented strands, two different diameter steel strands with fiberglass saddle and FBG sensors have been inserted in a thermal machine. For monitoring the temperature variations, a temperature sensor was combined to the Fiber Bragg Grating sensors, during the thermal test. In this test, several increasing temperature steps was configured from the machine, between 20°C and 70°C.

**Cyclic thermal tests on chains of instrumented saddles:**

In order to verify the behavior of several instrumented saddles, a number of cyclic thermal tests have performed in Enea laboratory. Four chains consist of saddles have jointed through a fusion splicer. Each chain was connected to a single interrogator's channel for monitoring the wavelength shift of the FBG sensors, during the test.

**Cyclic thermal tests on chains of instrumented saddles:**

With the purpose of monitoring the development of wavelength shift (FBG) during applying load, two bending tests have been carried on. In these tests, the bending machine could apply maximum force about 1000N with the speed of 0.5 mm/min. The force has been applied during 30 cycles during the tests.

**Conclusions:**

The experiments show that preliminary results of this research project still in development. According to first results, it appears as the proposed monitoring solution, that includes the manufacturing of fiberglass saddles in which incorporate optical Fiber Bragg Grating sensors, is able to return data comparable with the traditional sensors monitoring. Fiberglass saddles would also solve difficulties related to the instrumenting of pre-compression cables during the industrial production of pre-cast beams: in this way it will be possible to place the chain of saddles instrumented with optical sensors on the steel strand, before their pre-tension process. During future steps, tensile tests on strands will be conducted, instrumenting cables with saddles, calibrating system by comparing tensile tests results with traditional monitoring systems (extensometers) and Digital Image Correlation.

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**Publications:**

**1-** M. Capasso, R. Darban, D. Lavorato, C. Nuti, M.A. Caponero, C. Mazzotta, A. Polimadei, G. Terranova, P. Clemente, C. Failla, S. Signorini, F. Sonzogni. ***Self – monitoring steel strands with FBG sensors technology for industrial production***. Poster in the third edition of the scientific conference LIMS 2022 - Light, Imaging, Microscopy, Application spectra. ENEA , Frascati, on 19 and 20 May 2022.

**2-** A. Castaldo1, M.A. Caponero, P. Clemente, C. Mazzotta, A. Polimadei, G. Terranova, M. Capasso, R. Darban, D. Lavorato, C. Nuti, S. Signorini, F. Sonzogni, C. Failla. ***Strain and vibration measurements by FBG sensors for engineering applications*.** Submitted poster in 6-th ICFDT conference, ENEA, Frascati for 19/10/2022 to 21/10/2022.

**3-** M. Capasso, D. Lavorato, C. Nuti, R. Darban, M.A. Caponero, C. Contiguglia, P. Clemente, C. Failla, S. Signorini, F. Sonzogni. ***Self – monitoring precast RC beams industrial production with FBG sensors for quality control and real – time monitoring***. Submitted paper in Aicap ICC 2022 conference, 12-15 October 2022 in Naples.