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RADIO FREQUENCY TRANSPARENT BARRIERS FOR AIRPORT STRUCTURES: THE SAS PROJECT

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ABSTRACT

Recently structural design of particular infrastructures has to account for high dynamic load conditions, which could be induced by man-made actions as explosions or impacts. This issue is surely important in airport structures design, like barriers protecting radio communication facilities. Moreover, these particular structures are required to be transparent to radio frequency to avoid disturbing or preventing communications. In December 2006 AMRA, an Italian research centre of excellence, and ENAV, the Italian agency for air traffic control, with the cooperation of University "Federico II" of Naples and other technical partners, started the SAS (Security of Airport Structures) project, focused on this critical topic. The project has the financial support of European Commission – Directorate General Justice, Freedom and Security, through EPCIP 2006 (European Programme for Critical Infrastructures Protection). The objective of the project is to study structural systems like barriers or fences to protect critical airport infrastructures, as VOR stations, against man-made disruptions. To obtain satisfactory structural performance without interfering with RF airport communications, GFRP pipe elements are used. Structural models have been built to simulate the conditions induced by malicious external actions and the results will be validated by blast tests performed on real elements. In the present paper the outcomes of the preliminary static characterization of GFRP elements are outlined. In particular, the results of four point bending tests are discussed.

KEYWORDS

Security, airport structures, dynamic loads, blast, radiofrequency transparency.

INTRODUCTION

Recent terrible events have obliged designers of particular infrastructures to consider high dynamic load conditions in their structural models. Malicious disruptions, blast or impact unfortunately nowadays cannot be ignored and become part of the structural computations. The approach to engineering design of infrastructures has surely changed, mainly for those characterized by particular criticalities. The preservation of their functionality and the protection of the safety of their occupants, in case of malicious man-made events, have become a priority which is influencing every design step of such structures.

In the presented paper the first phase of the SAS (Security of Airport Structures) project is outlined. The project started in November 2006, funded as a pilot project by European Commission – Directorate General Justice, Freedom and Security, through European Programme for Critical Infrastructures Protection 2006 (EPCIP 2006, Green Paper on EPCIP 2005). The main objective is the deployment of a barrier system that could protect particular airport structures against man made malicious disruptions, without interfering with air traffic radio communications. Project will be last one year.

The main partner of the team is the Italian research center AMRA (Analysis and Monitoring of Environmental Risk), based in Campania region, held by several universities and research agencies of Naples area and involved in many research projects on environmental risks. Department of Structural Engineering of University "Federico II" of Naples is one of the AMRA members carrying out SAS project activities from a structural point of view. The end user partner of the project is ENAV, the Italian agency for air traffic control. Many facilities owned by ENAV, essential to manage air traffic, have surely a strategic role and need to be protected as critical infrastructures. Other partners of the project are Weidlinger Associates, a British consulting engineering company, skillful in blast assessment of civil infrastructures, Saint-Gobain Vetrotex España, a company producing glass components and ATP, an Italian company producing Fiber Reinforced Polymer (FRP) components for civil structures.

THE SAS PROJECT

The activities of the project were focused on protection design of VOR (VHR omni directional range) stations, particular radio communications facilities, wide spread in territory. The function of VOR stations is to communicate to aircrafts their courses, providing their distance and their angle from the VOR and allowing them identifying their position on a chart. VOR stations represent a very diffuse technology in air traffic management and their protection is then absolutely fundamental.

Figure 1. VOR station

Recently ENAV started changing the protection system of its facilities and planned to redesign the barriers of VOR stations, taking into account for detailed requirements from redefined standards. Mainly, anti intrusion properties and radio frequency transparency were indicated. The latter is a fundamental property to be provided, in order to avoid that the fence could disturb the communications between aircrafts and VOR stations. Moreover environmental sustainability and low cost of installation and maintenance are required.
The fundamental purpose of the research project is then to verify and validate the adopted solutions. In order to achieve such objectives numerical analyses and lab tests are being performed, investigating mechanical and electromagnetic properties of used elements. Structural static tests and blast tests will be then conducted in order to validate the final outcomes of the project.

THE BARRIER

The barrier is based on GFRP pipes installed on a concrete base to form a continuous gate. Figure 2 depicts a rendering of the barrier in a real site configuration. Structural design was carried out considering service loads, impact loads and blast loads. The former were evaluated according to Italian code (DM 1996, TU 2005) taking into account dead loads and wind loads. The load due to the impact of a vehicle, which could occur as an accidental event or a disruption attempt, was considered. Finally, blast loads were defined from the design charge in equivalent TNT weight, according to the expected risk for the specific area and facility to be protected. The action produced by the explosion of such charge was evaluated in terms of overpressure acting on the surfaces of the barrier. Existing relationships were used to calculate these loads (Henrych 1979). The properties of materials under such dynamic loads were estimated from static properties, according to existing codes (CEB 1988 TM5-1300 1990).
The conducted design evaluations will be validated by mechanical tests on different specimens of the barrier. Static characterization of materials is being carried out in order to estimate their Young modulus, ultimate strength and strain. Static tests on single elements are being also performed, with the purpose of verifying the failure mechanisms of the elements. Blast tests will be finally carried out on parts of the barrier system. These tests will verify that the analysis process performed for the dynamic conditions is sufficiently reliable and drives effectively to good design solutions.
Finally it is underlined that GFRP components were also used as internal reinforcement of the base concrete, in order to guarantee sufficient radio frequency transparency and high durability.

Figure 2. Rendering of the barrier in a VOR site on the hill

STRUCTURAL STATIC TESTS ON GFRP ELEMENTS

In order to investigate mechanical properties of GFRP pipes, a test campaign was designed. In particular the following tests were planned:

- four point bending tests on pipe elements, in order to examine the global mechanical behavior of such elements;
- tensile failure tests on plate specimens, in order to assess the tensile constitutive law of the composite material.

The former will be described in this section.
GFRP pipe elements are composed by an internal core in polyester resin, reinforced with unidirectional fibers and two external layers reinforced with randomly distributed fibers, as depicted in Figure 3. The volumetric percentage of glass in the core is 60%.

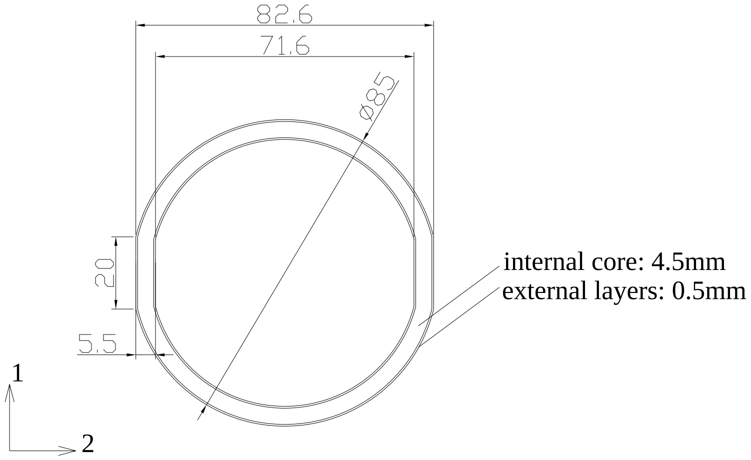

Figure 3: Geometry of the section (dimensions in mm)

The tests were carried out using the setup shown in Figure 4.

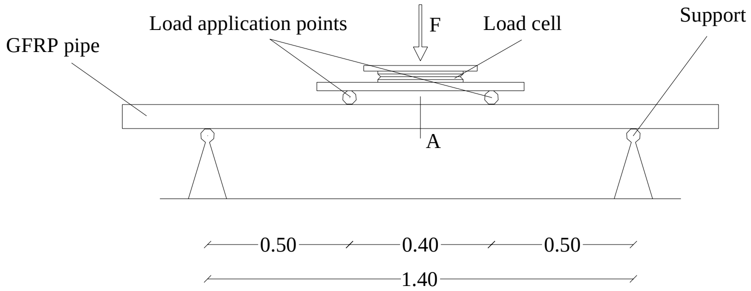

Figure 4a: Test setup (dimensions in m)

Figure 4b: Pipe specimen during test

Midspan cross section A was instrumented with Linear Variable Displacements Transducers (LVDT) and with strain gauges on top and bottom of the section. A load cell, as Figure 4a shows, was used in order to record the applied load.

Five tests were performed using the set-up described above. Experimental data acquired during tests were processed in order to obtain moment – curvature relationships for the midspan cross section, depicted in Figure 5.

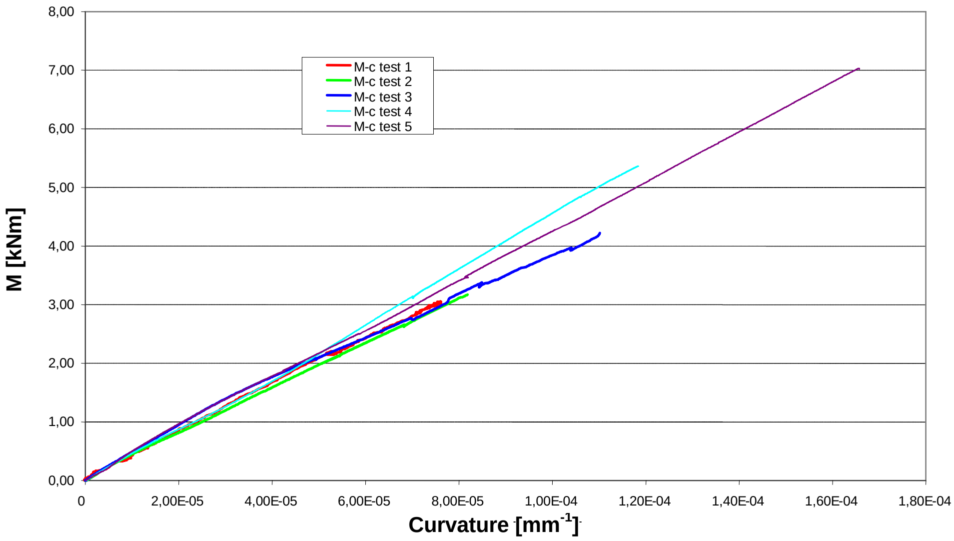

Figure 5: Experimental moment – curvature relationships for midspan cross section

In test 1 and test 2 a local punching mechanism occurred, as Figure 6 shows. Maximum bending moment value was about 3.0 kNm. Instead, in test 3 and 4 a higher value of maximum bending moment was obtained, since a wider surface for the support and a semicylindrical surface for application of load were used, as shown in Figure 7.

Figure 6: Local punching failure in test 1

Figure 7: Set-up for test 4

In particular in test 4 a maximum bending moment of 5.3 kNm was achieved, but a shear failure occurred close to support (Figure 8).

Figure 8: Shear failure in test 4

In test 5 a semicylindrical surface was arranged also for supports (Figure 9) and a maximum bending moment of 7.0 kNm was then obtained. However, also in this case, a shear failure occurred close to load application point (Figure 10).

Figure 9: Support in test 5

Figure 10: Shear failure in test 5

In Figure 5 it can be noticed that slopes in the different moment-curvature relationships are almost similar. This allows easily evaluating an average Young modulus of the pipe equal to about 40 GPa, which is close to expected Young modulus for similar GFRP elements. It is to outline that even if the static configuration used in the performed tests does not represent the service load condition of the barrier, it was helpful in order to evaluate mechanical properties of the elements.

CONCLUSIONS

The present paper describes the main activities that are being performed within the SAS project. It is focused on the design and characterization of a barrier system to protect airport infrastructures against malicious disruptions. In particular in this paper the results of the static characterization of GFRP pipe elements are described. The project will be concluded in November 2007 and will carry to a complete validation of the protection system. Several requirements will be taken into account, from mechanical to electromagnetic point of view, analyzing numerical models and performing lab tests. A cost optimization will be also conducted. Finally, at the end of the project the whole results will provide useful indications, made available to other european air traffic agencies, in order to install effective protection system for airport infrastructures.

AKNOWLEDGMENTS

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