ARCHITECTURAL MODELLING OF COMPONENTS IN COMPOSITE MATERIALS FOR TEMPORARY SHELTER FACILITIES

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ABSTRACT

This work resulted from a multidisciplinary project (PP nº 97) supported by the University of Porto, concerning the areas of architecture, engineering and design. It was established in two phases, “project” and “manufacture”. The “project” includes the modelling of components (design) for architectural proposes, while the “manufacture” deals with different composite materials (engineering) for expeditious construction solutions. Both phases allowed the creating of temporary shelter facilities, executed with few resources and with residual local materials, appropriated for situations of natural catastrophes or other social action’s needs.

Keywords: architecture, composite materials, Ecodesign, shelters, modular construction

INTRODUCTION

This work tried to introduce some different types of solutions for actual needs in temporary shelter facilities, especially those concerning with catastrophes, as has been continuously occurring in our contemporary world. According to that needs, a research was made about typologies, considering case-study examples, products available in the market and in nature and other information related to the shelter’s theme. In the “project” phase one studied the design and architectural solution for the temporary shelter facilities. The “manufacture” phase searches different engineering materials and technology processes concerning viable solutions for local low cost composite materials.

This work was a multidisciplinary project that includes competences from students, professors and engineers from four institutions; INEGI (Instituto de Engenharia Mecânica e Gestão Industrial), where several experiments involving the manufacture of composite materials were performed, the FAUP (Faculdade de Arquitectura da Universidade do Porto), where the architectural design and composites where explored in more detail, the FBAUP (Faculdade de Belas Artes da Universidade do Porto) where printing techniques, to explore a graphic treatment of components and installation and imagining means of appropriation by the user where evaluated, and the FEUP (Faculdade de Engenharia da Universidade do Porto) with collaboration on the coordination and management of the experimental tasks. The preliminary results were presented in a poster (Chaves, 2010) and in an exhibition in “Galeria dos Leões”, of University of Oporto, between 17 and 29 July 2011.

METHODOLOGY

In terms of methodology, the work was divided into three parts: a) theoretical research related to the themes of this study, mainly based on design theories of space systems for shelters; b) “gathering” data for the “project” and “manufacture” of components, able for a design
solution settled in a operable taxonomic language; and c) “experimental” part of the “project” with the “manufacture” of components (resulted from the previous parts), consisting on tests of the operable taxonomic language for defining and optimizing the design and manufacture of the space system of the shelter, in the context of social action and emergence situations. The relation between theoretical/practical was emphasized by systematization themes, especially the ones related to the recent studies of grammar form (Stiny, 2006). Those theoretical themes were combined with a practical “bricolage” experience. The general defined concepts and theories (with interest to reflect, before it was passed to the design itself, on the concept and types of "shelter" and idea of "architectural space") were used in the "gathering" part and in the "experimental" part. In each of these parts it was established two subparts, “project” and “manufacture”. In the “gathering” part, systematized information was processed in diagrams (Fig. 1), incorporating a graphic nature. This information came from consulted literature, software program (CES Edupack 2009, from Granta, UK), used and processed in computer spread sheets. Discussions were made based on posters, to more easily conduct the research process. Those particular graphic diagrams were intended to orient the information gathered, together with the theories of systematization referred. Apart from performing in diagrams, the text served as a thread of research, writing up brief descriptions of the items gathered and the choices made. This textual description included occasional numerical information, trying to argue the selections made for the system design of shelter space, and considering dimensional, functional and aesthetic aspects. At the level of "project", two aspects were addressed, one relating to the spatial “components” of the system and the other concerning the “modelling”. The definition of “components” allows the design of objects, for being combined and applied as a system of shelter space defined as “modeling”. At the level of "manufacturing", two aspects were considered, one relating to possible “materials”, and the other to possible “production technologies” in contemporary engineering market.

The “experimental” part emphasizes the synthesis of diagrams and forms in order to: a) “project” design of system “modelling” of shelters, based on their architectural “components”, according to assumptions in the “gathering” part; b) “manufacturing” through the development of practical samples obtained in 10x10x2cm³ moulds of selected “materials”, and “production technologies” based on the selection achieved in “gathering” part. The architectural design of the “components” was influenced on the idea of a jigsaw puzzle, where such solution allows universal combinations using a unique same piece. Various “modelling” configurations were possible, resulting from the combination of the components for the desired shelter architecture. The determination of “manufacture” of this “experimental” part was based on the definition of material quantities (weight, volume and price) through
proportional calculation in spreadsheets of materials density, to achieve an optimized solution.

RESULTS
In terms of “project” the investigation resulted in a modular solution (Fig. 2). This module was dimensioned in terms of spatial usability, universality and ergonomic construction connections (Fig. 3).

![Axonometric result of the component “project”](image1)

![Dimensional details of the module](image2)
In terms of “manufacture”, the investigation resulted in several potential composite materials defined by the performance of the test pieces 10x10x2cm³ elaborated in the “experimental” part. Fig. 4 shows the details of the more promising solutions.

To cast the composites to make the real scale panels, a prototype was produced (Fig. 5) using a polystyrene mould, which would allow a fast cure, easy processing and affordable price to any potential user. On this basis, it was intended that the production of the composite panel (matrix + binder) for the temporary shelter can be performed on-site in any weather conditions. At a structural level, the proposed solution includes four tubular metallic profiles of 4cm diameter in the middle of each tooth that are placed in place during its manufacture (thereby avoiding any perforation). Another tubular metallic profile, with smaller diameter (3 cm) and 1m length runs inside each external profile, allowing the assembly between components. This metallic solution can be adapted to other local materials, like wood.
Fig. 5 Mould with its components; a) composite (matrix + binder); b) connection tubes with 3cm diameter; c) polystyrene mould

As conclusion, a simulation illustrating two possible shelters solution are presented in Fig. 6.

Fig. 6 Two examples of temporary shelter facilities in simulated situations of natural catastrophes or other social action’s needs.

CONCLUSION
This work proposes a system that can be sent anywhere in the world as a code, using contemporary information and communication technologies, to solve humanitarian problems related to people shelters. It is a process presented as a simplified procedure for local people of any age, to be applied on site in the elaboration of temporary shelters, with local resources, using artisanal low-tech procedures that can offer multiple solutions, according to particular needs.

The entire study was conducted in the fields of architecture, industrial design and engineering, to reach a thread system that can offer a fast, cheap and effective way to solve basic human needs to decent life.

As a final reflection of this work it is important to note that today’s tasks of “project” and “manufacture” are relied on heavily costs and processes, lack of flexibility and adaptability to people needs. The study aimed to systematize a basic process that can lead to a product that serves social needs. This process was based on systematized information, constituting itself as a manual of instructions, based on the idea of using local people and natural goods, obtaining architectural components that make up an emergency shelter, flexible and easily accessible to all, independently of the location in the world.

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REFERENCES