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REFLECTION ON USE OF POLYVINYL CHLORIDE CONSTRUCTION COMPONENTS AS ALTERNATIVE TO BUILDINGS IN ANTARCTICA

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1- ABSTRACT

The need for establishing buildings in areas of difficult access and environmental interest, such as Antarctica and Brazilian oceanic islands, induces to search adequate technologies to both local conditions and potential of the domestic market. This research is focused on evaluation of the potentiality of the polyvinyl chloride for have requirements or be able to met the established conditions, as well as for has good cost-benefit, low maintenance, adaptation to the available logistics, weathering and corrosion strength, acoustic and thermal insulation, among others. The adequacy of the polyvinyl chloride was evaluated by the analysis of its properties and characteristics in relation to the environmental conditioning factors of interest, either in the technical aspects or the analysis of possible environmental impacts. The methodology was based on mainly the analysis of data and intended information, and it was supplemented with specific technical documentation related to use of the polyvinyl chloride in Antarctica. The results suggest the technical adequacy of the material in relation to environmental conditioning factors, however still there is no enough information allowing a position on the adequacy in terms of environmental aspects.

Key-words: polyvinyl chloride (PVC), Antarctica, construction technologies, areas of environmental interest.

2- INTRODUCTION

The construction in areas of scientific and environmental interest, such as Antarctica or oceanic islands, faces limitations due to single climatic characteristics and logistical constraints imposed by those places due to their location and conditions of access.

Previous research pointed the polyvinyl chloride (PVC) as material of interest for application in components for the construction of buildings in those areas, given the characteristics of the final products in relation to preliminary results obtained from previous experiments.

Although very used in civil construction, mainly because of its versatility, this material has not been sufficiently tested under the most adverse conditions and, as other polymers, has specific properties that, many times, constraint its use due to either chemical and physical stability or environmental impacts resulting from its production and use.

3- MATERIAL AND METHODS

The methodology used for obtaining the results was conducted through the following steps: (1) literature review (text-books, theses, search in web sites and specific papers from reliable source); (2) document analysis (material available in Planning and Design Laboratory in the Federal University of Espírito Santo – UFES); (3) analysis of the case studies where the application of the PVC resembles the present research; (4) project testing. In addition to the technical aspects inherent to condition of adequacy and feasibility of the material in relation to conditioning factors predicted to a Brazilian building on Antarctica, emphasis was placed on studies on inherent aspects in the concept of sustainability in civil construction, as well as the toxicity of the PVC during its life cycle.

4- RESULTS

The PVC, manufactured from the sodium chloride (NaCl) and mainly the petroleum, is one of the most used currently because of its versatility, generating products with numerous characteristics, such as stiffness (e.g., tubes and frames) and flexibility (e.g., hoses and plastic films for food packing), as well as range of colour (Rodolfo Jr. *et al.*, 2006).

Among the main characteristics of the product stand durability, flame resistance, chemical stability or inertia, good ability to recycle and recover energy, and good cost-benefit relationship in the most applications (Rodolfo Jr. *et al.*, 2006; Borges, 2004).

The interest in using PVC to make up elements with structural properties in the construction (panels, coverage pieces, structures, etc) is increasing, but there are few conclusions about its use in broader applications, taking into account the need for improvement of mechanical resistance and molding of larger and more complete prefabricated systems.

Some studies, such as that conducted by Parente (2006), have highlighted notes on the possibilities and constraints of this category of materials, for example, improvement of low stiffness with the application of materials to reinforce the PVC mixture, prestressed reinforcements and development of optimum geometries, taking advantage of relationship strength/density of those compounds. It is also emphasized the possibility of the plastic to be molded into several shapes and into single piece avoiding welds, being this an important differential compared with the traditional materials when combining the need for aerodynamic shaper to face strong winds characteristic of Antarctica. Even though the PVC has the property of being self-extinguishing by incorporating additives, Parente (2006) have warns about the behavior of the plastics against the fire, since it is not only concerning the spread of flame should be attention but also the heat, which can harm the stiffness of the structure. Furthermore, that author also has mentioned the environmental consequences, particularly with respect to emission of pollutants gases into the atmosphere.

As a construction material, its application is still scarce and the knowledge of its behavior in more adverse conditions, mainly the access conditions, lead to investment in research in order to develop adequate technologies for each situation. Accordingly, it is highlighted the construction of scientific stations on Brazilian oceanic islands, such as St. Peter St. Paul Archipelago, the Rocas Atoll, and the Trindade Island, whose difficult access, inhospitable climate and conservation interest make those places important laboratories to the innovative constructive techniques.

The main Brazilian building on Antarctica, the Comandante Ferraz Brazilian Antartic Base (EACF, acronym in Portuguese), by means a revitalization program (Alvarez *et al.*, 2007) adopted the use of PVC miter in much of the building. The material is also present in other parts of the building such as water and sewage pipes, insulation of cables, among others where they are less subject to weather. The preliminary findings indicate satisfactory indices as regard the resistance and conservation of integrity of the material over its use. Recently have been built a building on the Trindade Island, the Trindade Island Scientific Base (ECIT, acronym in Portuguese), in its most part made from PVC prefabricated elements, aiming to establish the evaluation of the behavior of the material.

The system used in that island contains profiles for mounting walls, ceilings and accessories for finishing. The profiles may be filled with several materials, providing mechanical strength, thermal and acoustic insulation. Both the internal and external walls do not coatings or paints, even though the latter may be used, and assure 20 years of integrity. The electric and hydraulic installations are attached to inside the panels, whose thick ranges from 100 to 150 mm, being able to reach up to five floors without independent structures (beam and pillar) only with the structural concrete. In the preliminary evaluation from the ECIT construction step, could be found that as regard the transportation logistics the PVC profiles has advantages because of the fact to be lights and easy handling and maintenance. The problems in relation to the construction technique were due to the lack of planning and the inexperience of the supplier, concerning the construction in areas of difficult access and the need for environmental care. However, it is noteworthy that in the Trindade Island, the main obstacle of the PVC constructive system was filling the wall components with light concrete, since that method use large amounts of materials and appropriate equipment, including mixers. To the case of Antarctica, has been evaluated the possibility of replacing the concrete for other material, being that the technique provides the transportation of the entire PVC panels, with the insulation already encapsulated. Thus, it is expected greater agility during the construction and low production of waste, which both are desired factors in situations of high environmental sensibility.

One essential source of information for evaluating the feasibility of use of the PVC in Antarctica was through the analysis of a window in the old Father Balduíno Rambo Refuge, belonging to Brazil, built in 1985 on King George Island, South Shetlands Archipelago, and dismounted in 2004 (Alvarez & Casagrande, 2005). It was found that, even without any maintenance activity, the mitre kept intact its functional and aesthetic characteristics. The exposure to weather is quite relevant in an environment such as Antarctic, since the environmental and economic consequences associated with the maintenance procedures. The PVC shows a good behavior to the impermeability so that are insignificant the effects produced by the weather on the building. Nevertheless, the ultraviolet radiation can compromise the resistance through the degradation during the process called dehydrochlorination. In this case, the possibility of using stabilizers aids to stop the degradation of the material over time.

However, the most used stabilizers are lead-based and causes great problem for the environment, and studies are needed before its adoption in the mentioned areas. As to the marine corrosion, the PVC has increased strength, as well as to a wide range of chemical products (Rodolfo Jr. *et al.*, 2006).

The plastics still has other essential virtues for Antarctic, such as characteristics to be poor thermal conductors – reaching 300 to 2,500 times less than the metals -, and they are a good option in situations demanding qualities of thermal insulation. Moreover, the plastics are poor electrical and sound conductors (Parente, 2006).

The Chart 1 shows the summary of the preliminary analyses carried out in relation to use of the PVC in locations inhospitable and difficult to access.

CHART 1 - Properties of the PVC against the imposed conditioning factors for construction in locations inhospitable.

Conditioning factors		Characteristics of the PVC
Logistical	Transportation	Light material and able to be distributed by pieces making easy its transportation.
	Investiment	Cost-benefit adequate relationship, mainly taking into account the need for maintenance and the lifetime of the building.
	Workforce - Construction	Construction system easy to perform, able to be performed by trained personnel.
	Workforce – Maintenance	Material easy to clean and maintain.
	Time required to perform the activities	The PVC-prefabricated construction system requires reduced assembly time when compared with the traditional techniques.
Environmental	Placement in the landscape	Harmonious relationship with the landscape. It can be produced with different scores and finishing. Possibility of constructions with more traditional vernacular aspects (type “home”), which can provide a more direct feeling of identification with the housing.
	Lifetime	Recyclable and/or recycled material with need for less energy incorporated into its production when compared with other materials, particularly metal ones.
Physical	Exposure to the weather	Material resistant to thermal variation and showing great evolution concernig the thermal degradation and the ultraviolet radiation (UV).
	Exposure to salt fog	Material does not undergo process of corrosion by salinity.

Concerning the sustainability criteria, studies has pointed that the industrial process of the PVC is able to generate waste which might contain high concentrations of heavy metals, in addition to a great organochlorine mixture, including polychlorinated dioxins and furans, which are classified as highly toxic e appear as sub-product released into the PVC production chain, even as either in its combustion or in case of fire. The study conducted by Borges (2004) on the lifetime of the PVC has proved the presence of waste from production of PVC, particularly dioxins, and it was concluded that although certain studies has demonstrated that the presence of polychlorinated dioxins and furans occurs in very low amounts – which probably would not affect the cradle-to-grave studies of environmental impacts -, there is no denying that the emissions do exist. Moreover, it was noted that large concentration of emission of the pollutants occurs at early stage of lifetime of the material, particularly in the final arrangement and/or incineration of the products.

Borges (2004) also points that, in Brazil, studies has found considerable concentrations of dioxins and furans, in addition to high concentrations of mercury, close to the installations of manufactures of PVC, noting that there is no conclusive study on the effective impact and extents of the emissions generated by the production of the PVC.

From another perspective, Oliveira (2009) has reported that the emissions of toxics occurs throughout the lifetime of the PVC and has warned of the risk of its use in the construction field, mainly due to the release of toxic substances generated by combustions of the material exposed to situations of fire. In addition to has exposed other data demonstrating the toxicity of the PVC, the author has cited examples of countries that have banned the production of that material: Sweden, the first country to ban the sale of PVC in 1995; Denmark, which introduced a sales tax of PVC in 1999; and since 1997 the PVC toys have been banned in Austria, France, Greek, Mexico, Norway and Sweden.

5- DISCUSSION

The issue under consideration suggests the need for more debates and deep studies in order to inventory a broader set of application to the development of the prefabricated building, the development of production process and control of the environmental impacts generated.

It appears that the use of PVC in the production of components to build buildings, although interrupted by environmental factors, shows viable possibilities of using and deserve be considered in future research, as well as performing practical experiments aiming to develop technical-construction solutions and improve the process for obtaining and processing that material, which should be more safe and less threatening to the environment.

However, even considering the constraints, the potential demonstrated by the material lead to search of greater knowledge, being on curse research related to Standard Antarctic Module (SAM), designed with internal metallic profiles (protected) according to the concept of steel frame and seals with type sandwich panels composed of PVC in external portion, polyurethane in the core in the filling and wood in internal portion.

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