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PULTRUDED COMPOSITES
The Case Against Extrusions for Energy Conservation

Abstract:
Pultruded composite profiles provide the best energy conservation of any material when used to make window and door components. Composite profiles have the lowest coefficient of thermal expansion of any window framing material. This feature means that windows and doors made from composites have the lowest air and water infiltration, making them the most energy efficient windows on the market.

Aluminum extrusions consume large amounts of energy during their processing. Composite profiles are showing signs of increased competition with aluminum because of its lighter weight and the fact that designers can consolidate parts more readily with pultruded profiles.

This paper will explore applications like windows, where composite profiles are providing better energy conservation when compared to extruded materials.

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Weight and Strength Advantages from Pultruded Fiber Architecture

Abstract:
The earliest pultrusion machine from the world's founder of the process, W. Brandt Goldsworthy, ran solid rod profiles using 100% fiberglass rovings. These, of course, were the natural reinforcements to start out with, given the times. When Brandt received the first roll of rovings on the West Coast of the US from Owens Corning, circa 1938, he started to think right away, that there must be a way to process this with resin in an automatic machine. Later, he made that vision come true.

But then as the industry evolved, it became obvious that the low interlaminar strength of the solid, unidirectional profiles needed cross directional reinforcement. Thus evolved the material of choice: continuous strand mat. It is easy to work with, has great forgiveness, and many pultruders today still use this tried and true combination. However, as has been shown, there really is no reason to not pultrude with even a broader array of fabrics, from stitched, to woven, and even 3-dimensional.

As the fiber architecture is expanded, there is an efficiency gain in the composite. This means there can be less material required to meet the loading requirements; this efficiency gain means the composite can weigh less and in the transportation industry, lower weight translates to improved fuel consumption. In today's reality of high oil costs; materials, products, and transportation systems as a whole need to shed the extra weight to conserve energy. In our current energy and weight conscious time, W. Brant Goldsworthy, would want the industry to understand that reinforced laminate material choice must be dictated by the end-product need to reduce weight and increase strength in the most efficient methods available to the pultruder. Thus the easiest materials to pultrude---roving and continuous strand mat---may not be the best from an energy-consumption viewpoint.

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Polyurethane Pultrusion Application Successes with Large Profiles

Abstract:
Polyurethane resin technology for pultrusion was first introduced in the late 1990's as an option that promoted elimination of continuous strand mat due to the exceptional strength and toughness of the resin matrix. All-roving reinforced pultrusions using low pressure injection or low volume wet out boxes was the initial focus for most pultruders pursuing this opportunity. With moderate effort and guidance of the raw material supplier's, success could be realized in fairly short order for small scale profiles. However, the challenges of reactive polyurethane processing of large heavy wall profiles of considerable complexity required considerably more development effort. This paper describes commercial successes at Creative Pultrusions with applications enabled by the superior performance of polyurethane composites.

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Pulcat, 10 Years Later

Abstract:
Norac introduced a new organic peroxide cure initiator to the Pultrusion industry 10 years ago. I will review case histories of the products used. The major advantages Pulcat has proven to offer include: faster line speeds, better surface profile, more safety in storage and handling, while actually being less expensive. In an era when our industry needs to be concerned about emissions Pulcat is a readily soluble liquid that lends itself easily to direct dye injection. Pulcat is best used for increasing line speeds while producing "Class A" surface finishes. In combination with BPO it is an effective initiator for thick cross sectional profiles. Pulcat has also become the main product in Norac's package of products designed to be used where refrigeration equipment is required to handle conventional products may not be available, or economically feasible.

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Evolution of Innovative Snap-Fit Connection for Pultruded 'Delta Deck'

Abstract:
Among many applications of composites to civil infrastructures, the one to bridge decks seems to be most notable. Compared with conventional concrete deck, the composite bridge deck is significantly lighter, much longer serviceable and more rapidly installable. Due to such notable advantages, increasing number of composite-deck bridges, including world largest one of 300m long and 35m wide, called 'Noolcha Bridge', are recently being built in Korea. It is believed that this composite-deck bridge will set another milestone for the earnest use of composites to the civil infrastructure. The composite deck incorporated in the above bridges is pultruded deck, called 'Delta Deck', with tongue-and-groove connections. Based on such construction experiences of many composite-deck bridges, a truly innovative composite deck profile of multi-cell polygonal shape with vertical snap-fit connection is newly developed. Compared with conventional composite deck of tongue-and-groove connection, it significantly improves construction workability and quality. This deck can be connected by mechanical snap-fit with or without adhesive bonding. It is also applicable to deck of curved bridges. It provides very easy assembly and disassembly if it is only mechanically snap-fit connected without adhesive bonding. Thus, applications of snap-fit deck can further be extended not only to bridges, but also to road-mats for oil and gas development, disaster relief, military operation and construction.

In this paper, development history of ‘Delta Deck’ with connection of snap-fit and tongue-and-groove is presented together with some analytical and experimental results. It also describes some applications of ‘Delta Deck’ to vehicular and pedestrian bridges.

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The effectiveness of use of the carbonglassfiber material in bridge engineering

Abstract:
The present day composite materials appear to be one of the most serious competitors of traditional materials: steel and concrete. Pedestrian bridges of glass-fiber profiles have found wide application all over the world. But development of engineering solutions is restrained by the fact that the glass-fiber material has the low modulus of elasticity. Carbon fibers allow to eliminate these limitations.
Theoretical and experimental researches confirming the effectiveness of use of relatively inexpensive carbon fibers with modulus of elasticity 160 GPa for producing of bearing pultrusion profiles for the bridge engineering are presented in this paper. Carbonglassfiber channel-shaped profiles 400x120x12 mm and reinforcing bars that allow to raise the rigidity of bridge construction by 30-50% have been calculated and produced.

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Damping effect in structural pultruded profiles

Abstract:
This research shows the first results on natural frequencies and modal shapes analysis vibration of structural elements GFRP (Glass Fiber Reinforced Polymer) pultruded profiles with different cross section. The goal is to know and to examine the behavior of this kind of elements in terms of free vibration.
In the first phase were investigated the natural vibrations of the flexural plane of two profile with different section, closed box and symmetric open section, with different length and different boundary condition, hinge-hinge and fully clamped. For the clamped-clamped configuration we considered the influence of axial load, applied on profile to realized the restrain condition. For every profile and for every static scheme was analyzed the dynamic behavior for both principal stiffness axis, I_{xx} and I_{yy}.
The experimental results were verified with the values obtained by numerical and FEM analysis and subsequently compared with the traditional materials behavior, which wood and steel, that were analyzed with the same static scheme but with the optimized section. These first results show a negligible difference between the experimental and theoretic values, Ref. [1]; the comparison with the traditional material, instead, highlights a better dynamic answer of wood for the higher deformability of material and an interesting behavior of pultruded structural element considering the real performance characteristics.

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Pultrusion of Uniquely Damage-Resistant Tubes with >100% Strain to Failure Polyurethane Matrix Materials

Abstract:
KaZaK Composites has developed pultrusion-based technology capable of producing tubular structures from a combination of extremely high strain to failure polyurethane and conventional composite stiffeners. These tubes can cost-effectively replace steel in many damage-sensitive applications. These novel pultruded tubes display a uniquely small tip deflection up to some pre-determined activation load. Once this design load is exceeded, the tube elastically buckles from round to a nearly flat section. In its post-buckled state, the tube dramatically changes its bending stiffness and becomes capable of undergoing multiple 90-degree flexures. When the load is removed, the tube returns undamaged to its original stiff, vertical position. This paper will describe some features of design, materials selection, and pultrusion processing, along with descriptions of use of these high performance pultruded structures on military ships and commercial applications.

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Applying of composite materials in bridge construction of Moscow city megapolis.

Abstract:
The problems, which exist nowadays in bridge management of Moscow city megapolis have been described. The ways of solving of these problems with help of applying of composite materials have been proposed. Realized and planned objects, including small pedestrian bridges, collapsible bridges, pedestrian decks, motor-car bridges, drainage elements and others. Cost-effectiveness of FRP applying in megapolis conditions. Creation of normative base for FRP applying in bridge construction. Experimental determination of parameters of static, fatigue and timeproof durability, parameters of crack growth resistance of material of pultrusion profiles taking into account the climatic factors and also static and fatigue resistance of bolted connections.

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Full pultruded FRP profile structures

Abstract:
Over the last decade there has been significant growth in the use of FRP composite materials as construction materials in structural engineering. These materials have proven themselves to be valuable for use in the construction of new buildings and bridges and for the upgrading of existing structures thanks to its lightness, minimum maintenance costs, execution easiness, corrosion resistance, durability, high specific strength, no magnetic interaction, etc.
In the paper, several full pultruded FRP structures are presented: ***two pedestrian bridges*** located in Spain -one of them (Lérida footbridge) was built to cross a railway line and the new projected high-speed railway line between Madrid and Barcelona and the other one is located inside a cave-; ***the Façade of the Conference Center of Badajoz***, also in Spain, an outstanding example of an elegant public building integrated into a consolidated urban area, where the main building has a circular layout and is surrounded by an external façade – like a big fence- made of GFRP

profiles; ***a truck truss bridge*** in Colombia for emergency situations (under design) and a number of ***bridges strengthened*** using FRP laminates.
General description, requirements, design criteria, analysis structural, construction and conclusions of all the structures will be described in the full paper.

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