16 GRC POLES MADE BY THE FILAMENT WINDING PROCESS - PERFORMANCE, INDUSTRIAL PRODUCTION AND MARKET OPPORTUNITY

P. Ridd[1], E. Prudhon[2], Saint-Gobain Reinforcements
[1]Saint-Gobain Vetrotex España, Ctra. Nacional II. Km. 34,500 Aptdo. 60, 28800 Alcalá de Henares, Spain; www.cem-fil.com
[2]Saint-Gobain Vetrotex America, 750 E. Swedesford Road, Valley Forge, PA 19482 USA

SUMMARY: Filament winding is a process extensively used in the fiber reinforced polymer industry. It involves the wrapping of a resin-impregnated glass fiber strand around a rotating mandrel, and is normally used to produce hollow elements such as tubes, pipes, tanks and vessels. The process enables a high reinforcement/matrix ratio and therefore produces elements with a very high strength-to-weight ratio. Composite Materials Technology (CMT), in partnership with Saint-Gobain Reinforcements (Cem-FIL®), has developed a proprietary method for filament winding GRC in the production of poles for the lighting and electrical distribution market.

This paper reminds readers firstly of the excellent technical characteristics of these GRC poles, which benefit from the advantages of concrete poles, but not the drawbacks. We then present the ease of the industrial production of these products. Finally we highlight a great business opportunity. As the pole market is shifting progressively from wood to alternative materials, these GRC poles may be the blockbuster of the next few years.
KEYWORDS: Cem-FIL® alkali-resistant glass fibers, cement-based matrix, filament winding, GRC, industrial production, lighting poles, transmission poles, utility poles.

HISTORY

Work has been performed on the filament winding of GRC since the 1980s, and a paper was presented by Niels Clauson-Kaas from Denmark at the GRCA Congress in 1987. This method applied a cement paste onto a mandrel before wrapping the glass rovings, so it was a difficult process to operate consistently, and at that time did not have practical applications.

CMT, in partnership with Saint-Gobain Reinforcements, has addressed these problems with CMT's Titan line of GFRC poles, which are currently marketed and sold in the USA.

GENERAL DESCRIPTION OF THE FILAMENT-WINDING PROCESS

This process consists of wrapping a matrix-impregnated glassfiber reinforcement around a suitable mandrel. The mandrel produces the shape of the final item. The filament-winding machine wraps the mandrel with the required number of matrix-impregnated strands at the specified orientation to build the designed reinforced structure, generally producing hollow items such as tubes, pipes, elbows, tanks and vessels with a high fiber content.

The glassfiber reinforcement is generally in the form of a single-end roving with a number of rovings being placed on a creel. The strands are unwound through the guiding and tensioning system under controlled conditions throughout. 'Full bath' or 'transfer roller' systems impregnate and control the amount of matrix on the strands. Impregnated strands are then accurately wound in several layers onto the rotating mandrel of an automated filament-winding machine. Once set the mandrel is removed. The mandrel may sometimes be retained in the final composite item as a liner.

GRC: AN EXCELLENT COMPOSITE MATERIAL FOR POLES

- **Electrically non-conductive and transparent to electromagnetic waves.** This property is very important for safety and to prevent waste by leakage of electric current in poles carrying electric cables. This is also very much appreciated by the telecoms market since no perturbations are created by the pole to the signal emission. And it prevents inductive currents from appearing in the poles holding electric cables.
- **Does not rust** and does not contain rebar or any reinforcement which may possibly corrode or expand in volume and make the matrix crack.
- **Non-flammable.**
- **Extremely resistant to freeze/thaw cycles** due to a very little water absorption.
- **UV resistant.**
- **Lightweight.** The mechanical properties of the filament-wound GRC enables a very thin hollow design and therefore a very lightweight product compared with a regular concrete pole.
- **Flexural strength.** This strength is achieved without any rebar in contrast to regular concrete poles.
- **Long-term price stability** of the key ingredient, the AR glassfiber, which price is not correlated to the price of oil.
- **All materials are widely available** in any country.

PERFORMANCE

A product ready to market

After several years of development in collaboration with Saint-Gobain Reinforcements, CMT has fixed the design of a very good product by reaching:

- a matrix recipe which optimises its hardened mechanical properties, its weathering and aging resistance, finish and production flow
- a winding configuration which optimises the mechanical properties of the poles.

Deflection

Table 1 shows the results of the deflection test as per ANSI C136. The test method was certified by Engineering Data Management, USA.

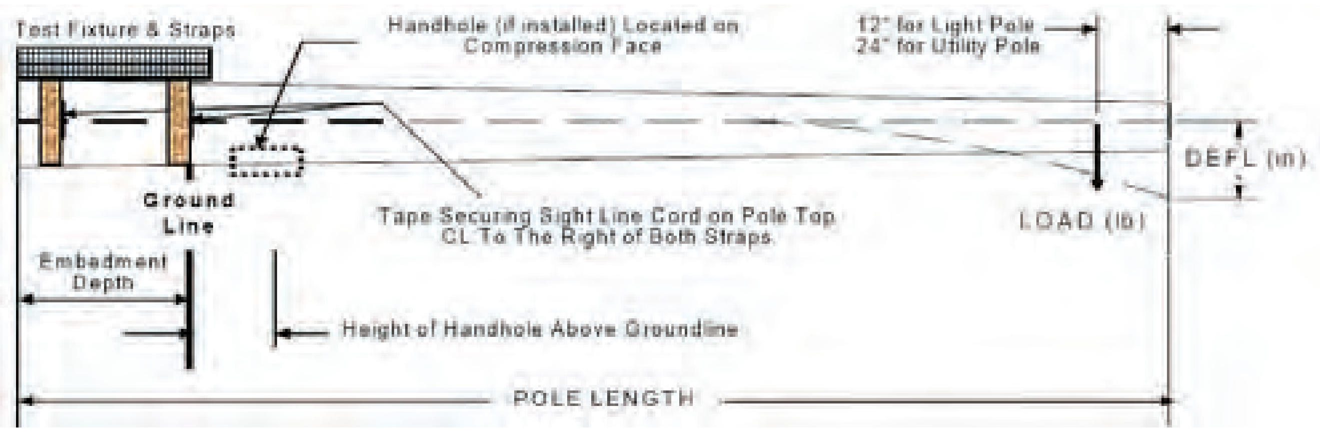


Table 1 - Deflection comparison – GRC vs. FRP poles

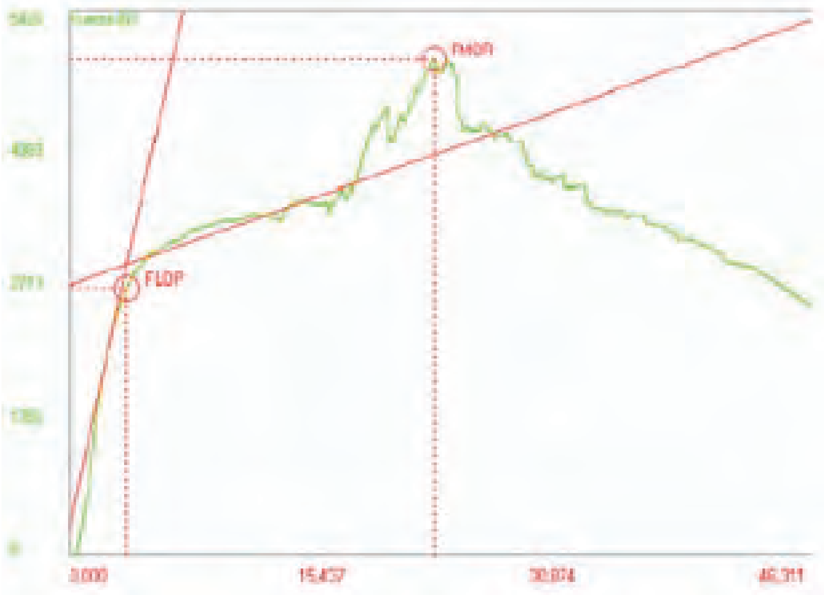
Working load applied (lbf)	50	100	150	200	250	300	350	400
CMT Titan (GRC) pole Sample average – Deflection %	0.4%	0.7%	1.1%	1.4%	1.8%	2.2%	2.6%	3.1%
Competing FRP pole Sample average – Deflection %	2.1%	3.6%	5.2%	6.8%	8.4%	10.0%	11.4%	13.1%

Competing pole meets AASHTO standard of 15% but does not meet ANSI standard of 10%.

Radial compression

This test has been performed in an internal Saint-Gobain laboratory to study the resistance of GRC poles to crushing. A pole may undergo this kind of stress during a shock, for example, like that caused by a vehicle impact. The coupons used are prototypes and do not necessarily feature the accurate characteristics of commercial poles. Specifically the coupons were thinner than commercial poles. One can then extrapolate an even better performance of poles produced and sold by CMT.

The length of the coupon was 60cm and the diameter was 10cm. The coupon did not collapse, and it returned partially to its initial shape. The maximum strain was 24mm and the maximum force applied was about 4900N.



Leakage of electrical current
This characteristic is, for example, critical for the electrified commuter rail industry. This market has a long-standing problem with 'stray' electric current degrading the physical structures on and around rail systems. The inherent extremely low-conductivity properties of the GRC poles may save this industry millions of dollars of replacement costs. The tubular non-conductive design may also be of great value in protecting structures for utility substations where electric arcing is a serious safety issue.

Tests were performed by NEETRAC (National Electric Energy Testing Research & Applications Center) for the Georgia Institute of Technology and the results are shown in Tables 2 and 3.

Table 2 - AC leakage current measurements for a regular commercial wood pole

System voltage (phase to phase) (kV)	Equivalent phase to ground voltage (kV)	Applied V_{rms} in (kV)	I_{rms} (mA)	I_{res} in (mA)	I_{cap} (mA)[a]	Watt loss (W)
4	2.3	2.3	91.1	90.6	9.6	210.2
5.5	3.2	3.2	273.9	272.9	23.1	866.2
12	7.2	~6.0	No measurement recorded. Pole caught fire.			

[a]Capacitive current valid only for sine waves 60Hz

Table 3 - AC leakage current measurements for a CMT pole in filament wound GRC

System voltage (phase to phase) (kV)	Equivalent phase to ground voltage (kV)	Applied V_{rms} (kV)	I_{rms} (mA)	I_{res} in mA	I_{cap} (mA)[a]	Watt loss (W)
4	2.3	2.3	0.3	0.3	0.1	0.7
12	7.2	7.2	1.1	1.1	0.2	8.0
15	8.7	8.7	1.4	1.4	0.2	12.3
20	11.55	11.5	2.0	2.0	0.3	22.8
25	15.6	15.6	2.9	2.8	0.3	44.4
27	14.4	14.4	2.6	2.6	0.4	37.1

[a]Capacitive current valid only for sine waves 60Hz

Standards require GRC poles to show a watt-loss at least as high as for a wood pole. One sees that CMT GRC poles far outperform wood poles.

Critical impulse flashover
This is a characteristic describing the ability of the pole to resist lightning. The usual accepted limit to reach in the pole industry is 300kV2 in dry conditions. CMT poles meet by far this value (see Table 4).

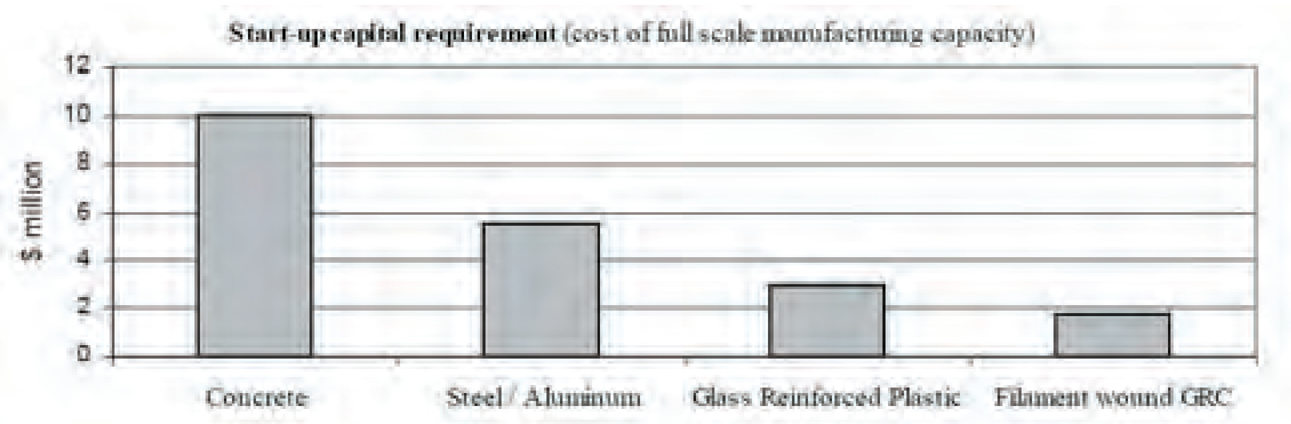
Table 4 - Results of critical impulse flashover text

	Test	Positive CFO (kV^2)
CMT pole	Critical impulse flashover	771
Wood pole		597

INDUSTRIAL PRODUCTION

At the same time that the product has been in development, effective industrial production equipment has also been created and patented.

- This new production system is largely automated. It is computer controlled for high-speed winding and even tensioning of the fiber strands. Eventually it will not be labour intensive.
- This technology is very flexible. The production planning can be adapted very quickly in response to incoming customer orders. The production capacity can be scaled up easily by building additional production modules progressively as the business takes off.
- The production flow is also designed to ease dramatically the logistics of progressing from raw materials to shipping of the finished poles.
- Overall the system is not capital intensive.



This technology can currently manufacture poles of up to 50ft or 15m high. And even higher poles will be produced in the near future (see Table 5 for details).

Table 5 - Pole details

	Street & area lighting	Utility distribution	Transmission, cellular, & specialties
Height	11 to 40ft 3 to 12m	35 to 55ft 11 to 17m	55ft and above 17m and above

MARKET OPPORTUNITIES

The utility structures industry is experiencing a dramatic shift towards the use of alternative materials for any type of installation. Historically this industry has been dominated by treated wood products, but is now moving to a broad range of alternative materials. This trend has emerged over the past 20–25 years.

Alternative materials such as steel, concrete and glassfiber are becoming the materials of choice. The alternative materials market now commands over 40% of the total market. Indications are that over the next 5–7 years the trend will dramatically increase. The shift is on.

Benefits

Obviously filament-wound GRC poles as well as all marketed poles meet industry standards requirements (such as AAHSTO LTS) with regard to mechanical resistance and behaviour. Table 6 outlines the different criteria.

Table 6 - Criteria of various poles available on the market

	Price	Weight/ease of shipping & handling	Aging/weathering/ corrosion/UV resistance	Electric isolator/ electromagnetic transparent	Environmental aspects
Filament-wound GRC poles	$$	**	***	***	***** (can be crushed to get aggregates)**
Regular spun concrete pole	$$$	*	* (rebars rust/concrete cracks)	*	** (steel reinforced concrete not recyclable)
Steel poles	$$	**	* (rust)	*	*** (can be melted again)
FRP poles	$$	***	* (poor UV resistance)	***	** (not recyclable)
Aluminium poles	$$$	***	***	*	*** (can be melted again)
Wood poles	$	**	**	***	* (releases harmful chemicals in the ground)

As shown in Table 6, it would appear that filament-wound GRC poles present the best overall advantages/drawbacks ratio.

Two examples:

- CMT class-3 pole that weighs less than 40% of a comparable wood pole and yet achieves a stress break point of over 3000 pounds or 1360Kg and a deflection greater than 0.67in/ft or 5.6cm/m.
- CMT class-4 distribution pole, 40ft or 14m, weighs 800 pounds or 360Kg compared with the same pole made of spun concrete which weighs 2715lb or 1232Kg and costs twice as much.

ABOUT CMT

Composite Materials Technology (CMT), headquartered in Atlanta, GA, USA, is a leading developer and manufacturer of innovative, high-quality FRP (glassfiber reinforced plastic) and FRC (fiber reinforced concrete) poles. CMT serves three markets with engineered products:

- Lighter duty structures to lighting markets
- Heavy-duty poles to the T&D utility market
- Multipurpose products to the security and wireless networking markets.

CMT is the largest producer of centrifugally cast reinforced FRP poles in the United States and delivers a full line of the highest quality lighting structure products in the market with its Marathon™ and Legacy™ poles. Legacy™ is a line of decorative poles serving the architectural needs of lighting customers. The centrifugal manufacturing process provides a superior, durable finish and makes for a uniform wall thickness over the product's entire length. CMT's South Carolina facility has delivered over 500,000 poles to 5000 customers throughout the United States and internationally over its 25-year history.

Langdale Industries, Inc. joined CMT to develop the next-generation pole for the engineered distribution pole market. CMT's patented Titan™ line of poles is manufactured from high-performance lightweight concrete. The result is an incredibly strong pole with excellent weight-to-strength qualities. John Langdale, CEO of Langdale Industries said, 'Innovations in the utility pole market have always been incremental. Titan™ is the first truly new product to come to the distribution pole market in many years.' Langdale has been a leading provider of wooden utility poles for over half a century. Langdale saw the need to bring an engineered product to the distribution marketplace that has a price and performance that compliments the ubiquitous wooden utility pole. Jim Langdale, Vice President of Langdale Forest Products said, 'We recognized the advantages of the composite technology. Many of our customers need engineered materials to remain competitive in their markets. We are now in a great position to provide a range of options, including engineered products to serve our clients' specific applications.' Langdale invested in CMT to combine its skills and resources to deliver engineered composite products to the market. Allen Sells, President of CMT said, 'Langdale has a great tradition of manufacturing excellence. We are pleased to partner with a respected company with a long tradition of satisfied customers.'

Industrial products giant Saint-Gobain also joined CMT and Langdale in the development and expansion of CMT's patented technology to a worldwide market. Saint-Gobain spends some 345 million Euros in research and development at 15 research laboratories around the world with a staff of nearly 3000 scientists. Under a strategic agreement, Saint-Gobain operates a prototype of CMT's production facility at its Alcala, Spain laboratory, dedicated to developing innovative applications from CMT's technology. Stephan Liozu, General Manager of the Business Unit Specialty Reinforcements, said 'CMT has developed exciting and revolutionary processes and we at Saint-Gobain are very excited to join the engineering and market development effort to deploy CMT's technology worldwide.'

FURTHER READING

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