# TECHNOLOGY AND MARKET CONSIDERATIONS FOR FIBER CEMENT COMPOSITES

AL MOSLEMI
*Professor Emeritus*
*University of Idaho*

Fiber cement composites have gained an increasing foothold in the North American markets over the last twenty years. The penetration in the housing and construction markets has been steady. Over those years, there has been a substantially increased acceptance of fiber cement in applications that were traditionally supplied by wood and other materials.

This presentation is intended to provide an overview of the technologies that are currently in use in general and point out some of the market considerations particularly as it relates to the US market..

## THE TECHNOLOGY

It is clear that addition of fibers to fiber cement imparts a number of attributes that are important to the application and serviceability of the composite. Some of these attributes include resistance to cracking, a lighter weight and a degree of flexibility that are important to the market place. **Fig 1** schematically depicts how fibers impede crack development. In this figure, it is noted that fibers that bridge the crack without slipping out or breaking slow or block crack development.

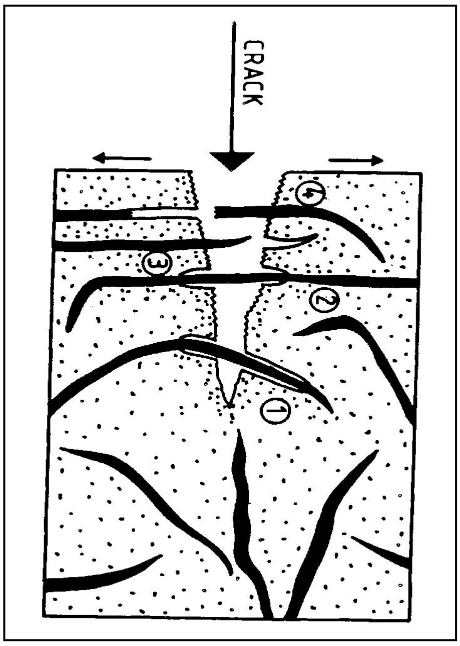


**Fig 1. Fibers in fiber cement showing fiber bridging (1 ) and (2) and slippage (3) and rupture (4).**

The question now centers on the type of fibers that can be used. These fibers not only must be technically viable, they must also clearly be economically acceptable. For many years asbestos has been the fiber of choice. Asbestos fibers created fiber cement products that met a variety of market requirements at a competitive price. This option, of course, has become unacceptable due to the health impact of asbestos. Internationally, company after company is looking for a viable alternative to asbestos in the production of fiber cement.

**Table 1** lists a variety of fibers and a number of attributes that are important to fiber cement manufacturing and product marketing.

**Table 1. A comparison of fibers as various attributes are considered (1 = high, 2 = medium, 3 = low).**

| Fiber | Alkali resist. | Temp. resist. | Process ability | Strength | Toughness | Price |
|---|---|---|---|---|---|---|
| Wood pulp (chem) | 1 | 1 | 1 | 1 | 1 | 3 |
| Wood pulp (mech) | 2 | 2 | 2 | 2 | 3 | 3 |
| Polypropylene | 1 | 3 | 3 | 3 | 3 | 2 |
| PVA | 1 | 3 | 3 | 3 | 3 | 2 |
| Kevlar | 1 | 1 | 2 | 1 | 1 | 1 |
| Steel | 1 | 1 | 3 | 3 | 3 | 2 |
| Glass | 3 | 1 | 3 | 3 | 3 | 2 |
| Mineral fiber | 3 | 1 | 3 | 3 | 3 | 3 |
| Carbon | 1 | 1 | 3 | 1 | 1 | 1 |

Due to the highly alkaline nature of the cement matrix, it is essential that the fibers used are capable of withstanding an alkaline environment over the service life of the product. In addition, the fibers used need to offer other attributes such as temperature resistance to which they are exposed during the manufacturing process. Compatibility with the process of manufacturing, fiber strength and toughness is also important. Obviously, economics is a key consideration. As seen in **Table 1,** lignocellusic fibers, noted as chemical wood pulp offer an advantage over other fibers listed. Clearly such fibers as Kevlar and carbon fibers offer exceptional qualities. However, the economics of those fibers makes their use prohibitive.

**Table 2** shows a different yet very important comparison of some of the fibers shown in **Table 1**.

**Table 2. A comparison of relative cost for a variety of fibers**

| Fiber | Rel. cost per unit weight | Specific gravity ($S_G$) | Tensile strength ($f_t$, MPa) | $f_t$ / $S_G$ | Rel. cost per unit weight / ($f_t$ / $S_G$) |
|---|---|---|---|---|---|
| Wood (Kraft pulp) | 1 | 1.5 | 500 | 333 | 1 |
| Glass rovings | 4 | 2.5 | 1400 | 560 | 2.2 |
| Steel | 1.4 | 7.9 | 2100 | 267 | 1.6 |
| Kevlar | 20 | 1.5 | 2800 | 1867 | 3.3 |
| Asbestos (JM 5R) | 1.2 | 2.6 | 700 | 269 | 1.3 |

In this table, a particular fiber's specific gravity and tensile strength as well as the relative cost per unit weight are shown. If the cost per unit weight for Kraft pulp fibers is assumed to be one, then the cost of glass fibers, steel, Kevlar and asbestos are higher. Clearly, asbestos fiber compares favorably with any other type of fiber shown and is very close to Kraft pulp fibers. It is important to note that costs can vary, sometimes over short period of time. But the comparisons here should still be quite useful in understanding relative economic position of each fiber.

**Fiber Impact:**

Examining wood fiber, a key issue on fiber cement is "how much fiber?". What are the influences of the amount of fiber on composite's properties?

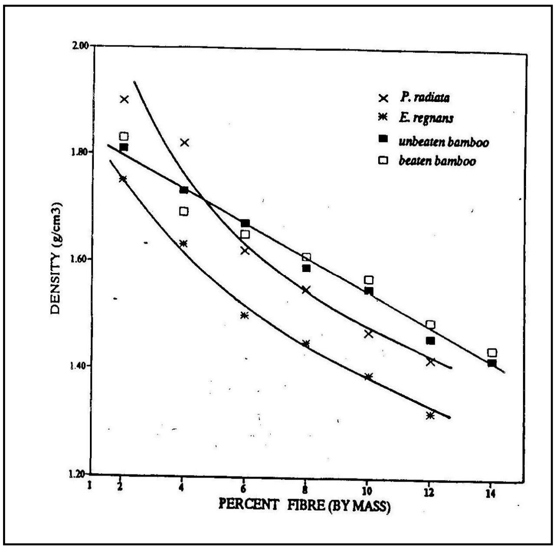


Figure 2. Density-fiber relationship

**Figure 2** presents the influence of the percentage of fiber on the resulting board density. This figure examines two types of fibers; one of radiata pine (*Pinus radiata*) and the other, eucalyptus (*E. regnans*). It also presents two types of fibers from bamboo, one unbeaten bamboo and the other beaten bamboo. One characteristic that is common for both fibers and process types is that as the amount of fiber increases in the composite, there will be a resulting decline in fiber cement density. This should not come as unexpected as the density of the fibers in the composite is lower than that of the cement matrix.

**Figure 2** also shows that the type of fiber does make a difference in the pattern of density decline. Both beaten and unbeaten bamboo fibers follow a straight line decline in density and beating the fibers in this case did not materially change the density-fiber percentage relationship.

The amount of fibers used in the composite also significantly affects strength. This is to be expected since it was just noted that the amount of fiber in the mix significantly affects composite density. **Figure 3** points out this relationship as it involves flexural strength and as a function of the percentage of fiber. Again examining the same types of fibers, in the case of radiata pine, the point of diminishing returns arrives at about 8 percent while for eucalyptus it is about 6 percent. For bamboo, however, the flexural strength continues to increase over the range of 2 to 14 percent shown. Although the exact reasons for this difference on bamboo are not known, it is conjectured that bamboo fibers are better distributed in the matrix and do not form "clumps" of fibers that constitute the weak spots in the mix that cause lower strength in the overall composite.

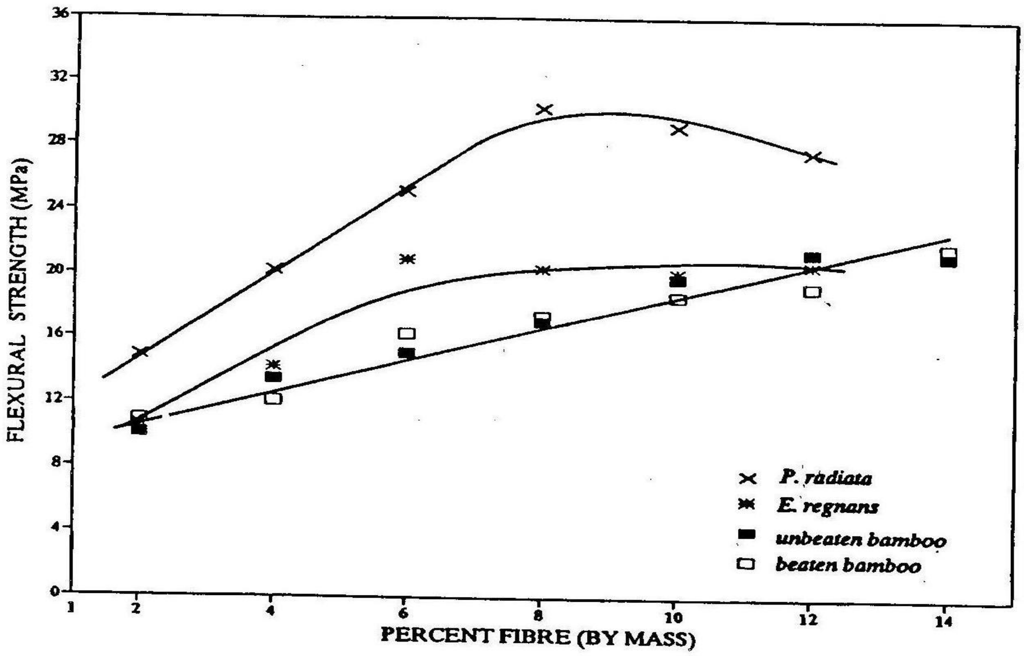


Figure 3. Flexural strength and fiber content

It is well understood that fiber length plays an important role in the properties of fiber cement. **Figure 4** presents the impact of the percentage of fibers on fracture toughness for the resulting fiber cement for five different fiber lengths.

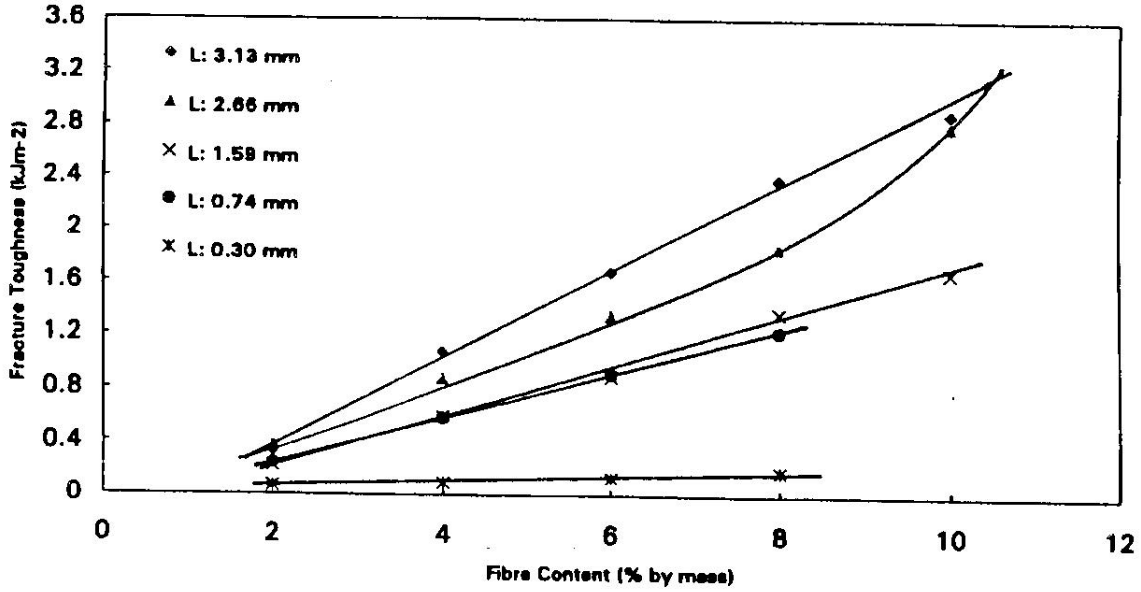


**Figure 4. The effect of fiber length on fracture toughness**

Fracture toughness is an important parameter as it signifies the resistance of the fiber cement to fracture development and ultimately the failure of the product. As it is clear from this figure, longer fibers impart higher fracture toughness to fiber cement. Fibers with a length of 3.12 mm clearly continue to exhibit higher strength over the range of 2-10 percent fiber content. On the other hand, fiber length of 0.30mm provides virtually no improvement in fracture toughness over the range tested. It is believed that short fibers do not provide any significant bridging properties upon micro-crack development and generally act more as fillers.

The issue of fiber length is an important issue from the environmental as well as economic points of view. The industry generally would like to utilize recycled fibers rather than virgin fibers. I also noted earlier that short fibers generally act more as fillers and do not materially add to the fracture toughness (and probably other strength properties) of the fiber cement. **Table 3** shows the challenge we face in using recycled fibers.

**Table 3. The length distribution for virgin cellulose and two sources of recycled fibers.**

| Length (mm ) | Virgin cellulose | Recycled source 1 | Recycled source 2 |
|---|---|---|---|
| < 0.2 | 4.16 | 12.47 | 1.96 |
| 0.2-1.0 | 16.72 | 44.43 | 49.86 |
| 1.0-2.0 | 20.63 | 27.96 | 29.63 |
| 2.0-3.0 | 16.56 | 12.12 | 15.28 |
| 3.0-4.0 | 12.38 | 2.62 | 2.66 |
| 4.0-5.0 | 10.9 | 0.38 | 0.51 |
| 5.0-6.0 | 7.55 | - | - |
| 6.0-7.0 | 4.11 | - | - |
| > 7.0 | 6.95 | - | - |

This table compares the fiber length distribution of virgin cellulose with those of two types of recycled fibers. It is noted that in virgin cellulose the longer fibers predominate with nearly 80% of fibers being 1 mm and longer. Furthermore, nearly 30 percent of the fibers are 3mm or longer. On the other hand for recycled fibers of the same species and a similar species most of the fibers are less than 3mm and a high percentage is one mm or less. Although we can expect to see differences in the various sources of virgin cellulose and recycled fibers of the same fiber source, the basic relationships presented in this table is likely to apply.

**Product Manufacture**

The manufacture of fiber cement involves using both organic and inorganic raw materials. The inorganics can include:

Portland cement
Water
Silica
Silica fume
Limestone flour
Metakaolin
Fly ash
Cacium silicate

The organic components can include:

Cellulose pulp (Kraft)
Recycled fibers
Synthetic fibers
Flocculants
Defoamers

The major components involve cement, water, silica, limestone flour and fibers. The others mentioned, if utilized, are used in minor quantities

Fiber-cement products into which lignocellulosic fibers are incorporated have emerged in certain markets and are becoming increasingly accepted as we attempt to replace asbestos in these composites. As noted in this presentation, the research and industrial communities have been examining a variety of fibers some of which were noted earlier. Lignocellulosic fibers, however, continue to be the fibers of choice for many manufacturers due to the advantages they offer including economics which is critical in making these products price competitive. To be sure, none of the fibers have yet to quite match asbestos in properties and cost effectiveness as well as ease of processing.

Many fiber-cement operations around the world offer a variety of products for the construction and industrial markets. These operations still use asbestos mostly in the less developed nations which are also increasingly becoming aware of the health danger of using this fiber. Therefore number of plants using asbestos is likely to decline over the next decade or two. Meanwhile as the industrial nations develop other viable fiber options for fiber cement, these technologies are likely to be examined globally and adopted by each operation depending on local circumstances.

Although no survey of the exact number of fiber cement operations is available, it is estimated that some 1100 to possibly 1500 manufacturing facilities are producing fiber cement. Many of these operations are relatively small addressing local markets.

The most popular technology used in fiber-cement manufacturing is the Hatschek process dating back to 1911. It is named after its developer Ludwig Hatschek of Austria who based it on the pulp and paper manufacturing process.

In this process, an aqueous slurry of fiber and cement plus some additives, about 7-10 percent solids by weight, is supplied to a holding tank which has a number of rotating screen cylinders **(Figure 5)**.

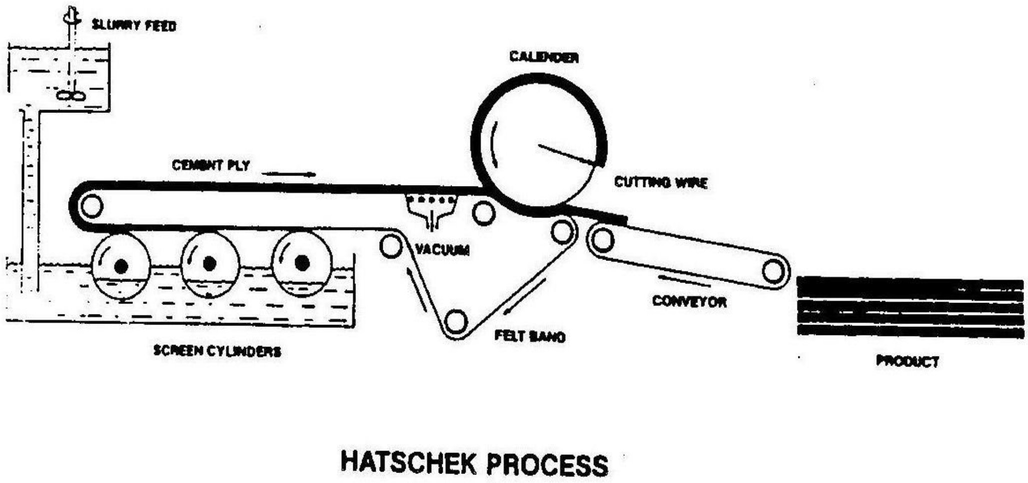


**Figure 5. The basic elements of a Hatschek machine**

These cylinders pick up the solid matter removing some of the water in the operation. An endless felt band travels over the top surfaces of the cylinders and picks up a thin layer of fiber-cement formulation from each cylinder. The built-up laminated ply then travels over vacuum dewatering devices which remove most of the water. The sheet product thus formed subsequently wraps around an accumulation roll and continues to build additional thickness until the desired thickness is obtained. The fiber-cement sheet thus formed is further subjected to pressure by pressure rolls which are in contact with the accumulation roll. These pressure bars play an important role not only in consolidating the boards but are also important in imparting surface profiling (i.e. wood grain, etc) into the sheet.

Once the desired sheet thickness has been obtained, an automatic cutting knife built into the accumulation roll is activated and the "green" sheet with the desired thickness and length is dropped onto a conveyor which subsequently transfers it to a stack or to a filter press depending on the process design.

**Figure 6** shows the schematics of a plant lay-out for a Hatschek process operation.

In this figure, cement, fibers and additives are measured and directed to a mixer which, in turn, mixes the raw material and sends it to a stock reservoir. From this reservoir, the material is sent to the Hatschek machine pointed out in the previous figure. Once "green" sheets are produced, they are stacked and sent to a stacking press. The stacks thus formed are then sent to a hardening chamber involving heat and humidity. The hardened boards are further subjected to an autoclave. Once the boards emerge from the autoclave, they have attained much of their final strength. At this stage, these boards are ready for priming and finishing, cutting and other preparations needed for shipping to various market destinations.

In many parts of the world, in addition to flat sheets, corrugated products are also produced usually for roofing applications. To manufacture corrugated products, flat green sheets-- once they have exited the accumulation roll-- are directed to oiled steel caul molds for shaping in a filter press.

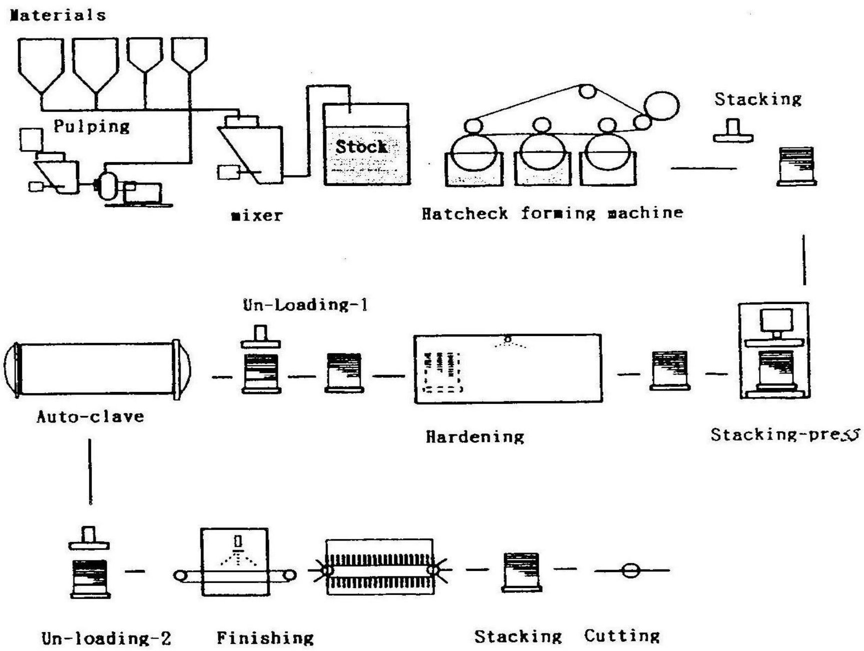


**Figure 6. Schematic plant lay-out of autoclaved fiber cement production plant using a Hatschek machine.**

In addition to the Hatschek process, interest also has been expressed in the manufacture of fiber cement by the extrusion technology. **Figure 7** presents a schematic view of this technology by which kneaded material enters a screw conveyer, passing through a vacuum pump and exiting the conveyer. The extruded material then is deposited onto the moving conveyer belt.

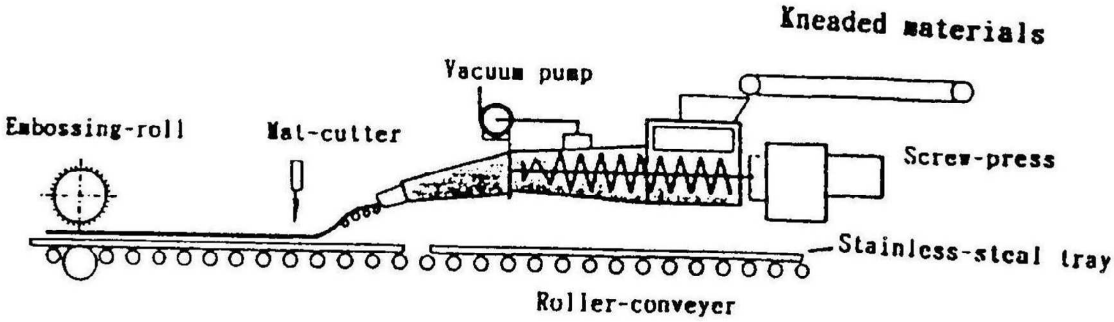


**Figure 7. Schematics of an extrusion machine.**

Embossing rolls can then impart the desired patterns onto the sheet which subsequently is processed similar to other processes.

In the Fourdrinier Forming Machine **(Fig 8),** fiber and cement slurry is pumped from the machine stock tank to the Fourdrinier headbox.

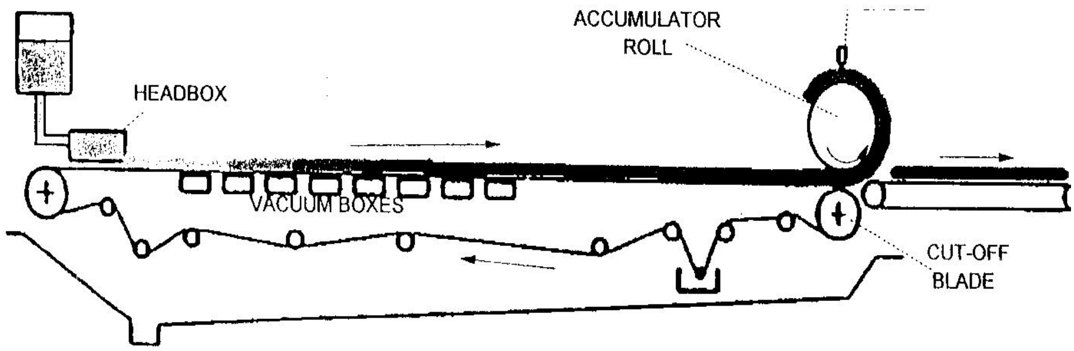


**Figure 8. Fourdrinier forming machine.**

Slurry is poured from headbox onto a moving forming wire. It is then dewatered over a sequence of vacuum boxes. The wet lap thus formed is taken up by an accumulator roll until the desired mat thickness is reached. Mat thicknesses from 3 mm to 25mm can be manufactured. Once the target thickness is reached, a cut-off blade is activated to trim the mat to its final length. The circumference of the accumulator roll determines sheet length.

The pour-on technology simply deposits the slurry onto a conveyor belt which dewaters it and sends it to a section applying pressure as it moves forward. Once it exits the pressure belt, it is cut and stacked for further processed **(Fig 9).**

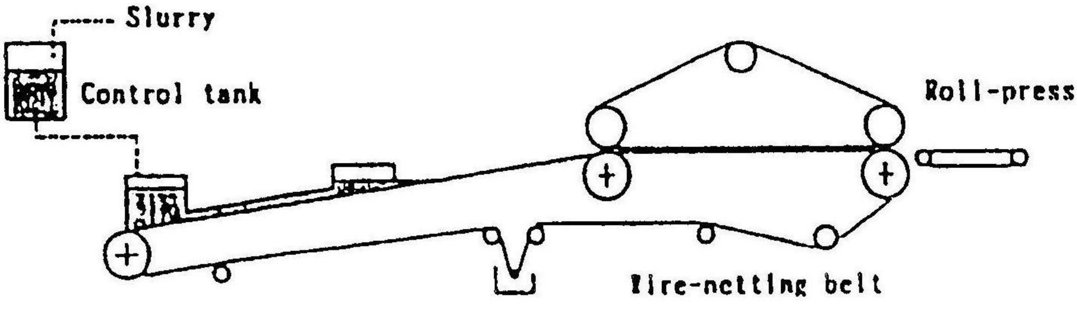


**Figure 9. The pour-on lay-out.**

In the US market, there are other types of products that are used in various applications such as tile backer boards. One such product is called WonderBoard (also Durock). This product incorporates a fiberglass mesh which reinforces the board and is embedded in a matrix **(Fig 10**). The board has a cementitious paste on the top and bottom surfaces and a fiberglass mesh (see Figure 10).

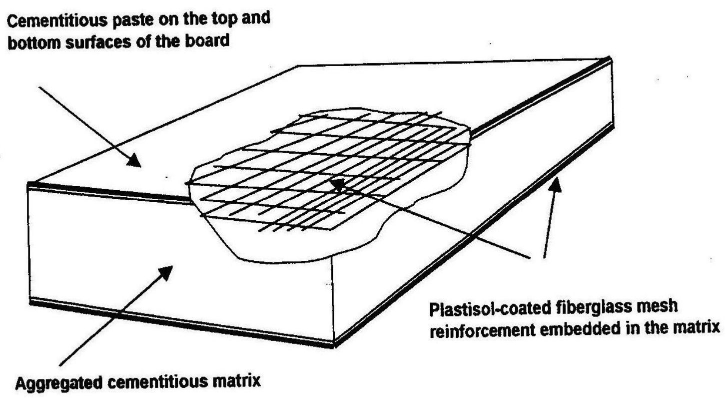


**Figure 10. The basic structure of WonderBoard**

**Figure 11** presents the schematics of the production process for this t

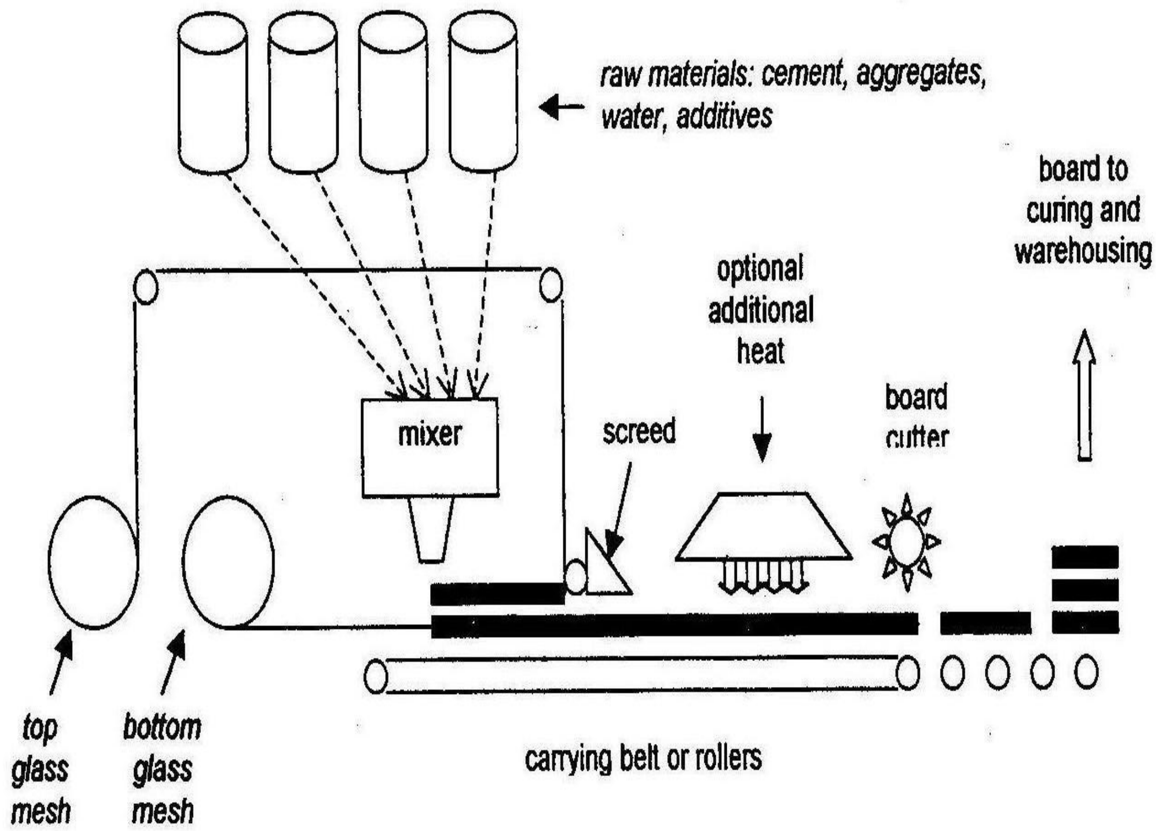


**Figure 11. The basic lay-out of the WonderBoard Process.**

WonderBoard offers high strength and fire resistance. In addition, it offers high dimensional stability and acceptable pull-through resistance.

**Cement-Bonded Particleboard**

In this technology, instead of fibers, wood particles are used in much higher proportions than that used for fiber cement. The technology borrows much from resin-bonded particleboard with the plant lay-out being quite similar. **Figure 12** schematically presents the process which in this case also includes an autoclave. Autoclaving accelerates curing the board quickly thereby, among other gains, reducing the negative impact of tannins and other constituents of wood on the cement binder.

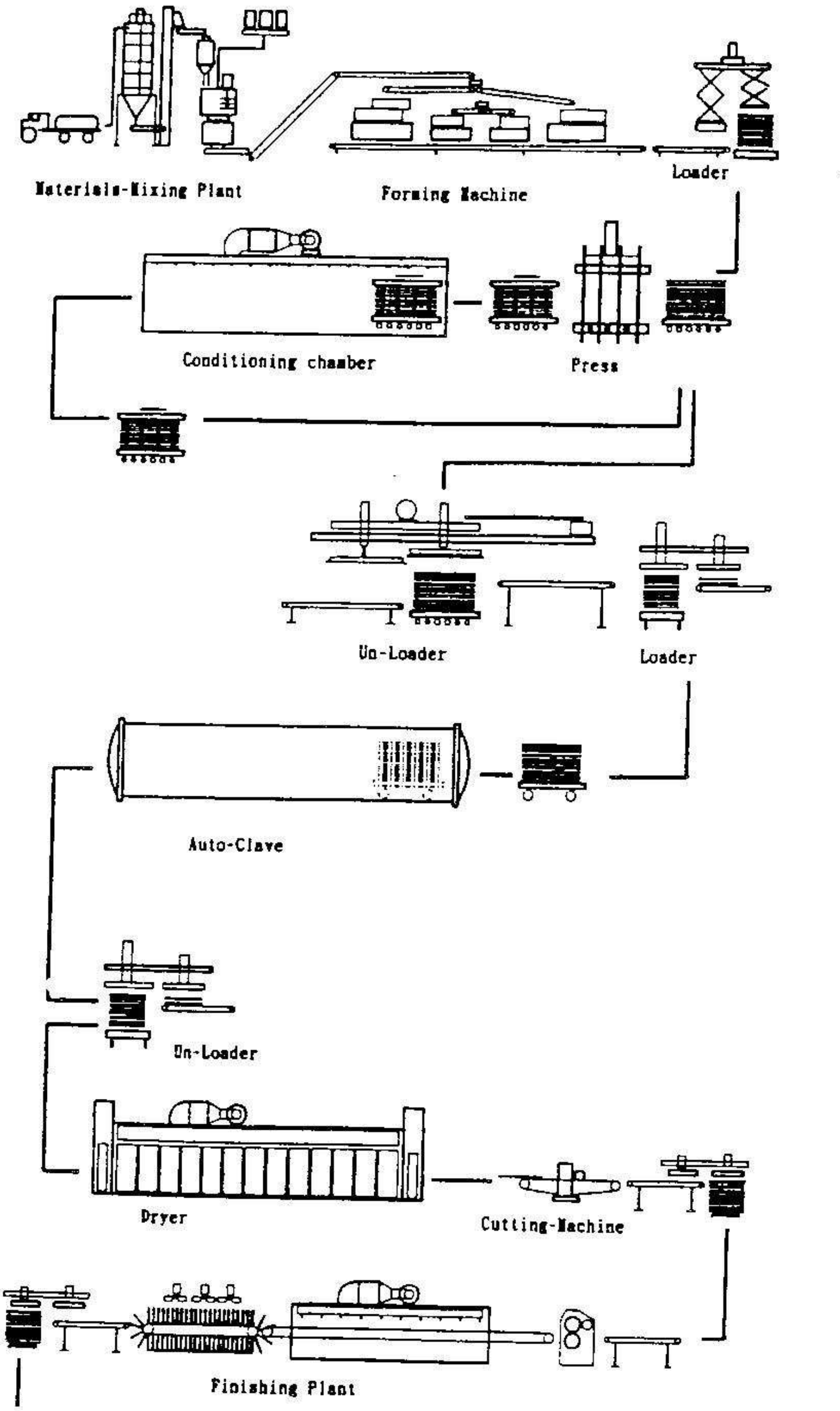


**Figure 12. Lay-out of a cement-bonded particleboard**

In **Figure 12,** wood particles are first processed into the sizes that are similar, in most cases, as those used for resin-bonded particleboard. Once these particles are ready and screened for fines, they are mixed with cement. Water is added to commence cement hydration. Due to the fact that cement is slow-setting, there is no concern about pre-set with the subsequent steps in the manufacturing process which follow within a few hours.

The "blended" particles then are directed to a forming machine which can deposit these particles on a moving conveyor belt generally in a multiple layer process. In some of the operations, this machine is designed to deposit the smaller particles in the core layers while the larger particles are deposited on the surfaces. This board configuration is intended to provide a greater bending strength to the board. In other operations, the particle deposition can be the opposite with larger particles placed in the center of the board and smaller particles positioned on the surfaces. This type of board will have a smoother surface desired in some of the board applications.

Once the mats are formed, they are moved on caul plates to a stacker. Such boards, at this stage, can not be handled without the support caul plates provide. The stacker therefore receives the intended number of such boards before sending the stack to a consolidation press. The press then performs consolidation and wraps the stack tightly to keep the pressure on the stack until the cement binder has achieved a certain amount of hardening allowing the board to be handled individually. That initial hardening takes place in a conditioning chamber where the stack is subjected to heat and humidity for a period of time. The stack in the chamber slowly moves on a wheeled base which rolls slowly in the conditioning chamber and resides in the chamber for the length of time designed to give the boards its initial hardening (see **Figure 12**)..

After the stacks go through some reloading and placed on another loader designed for entry into an autoclave, the restructured stack is directed to an autoclave. It should be noted that autoclaving may or may not be used in this process. After trimming the boards, they can be placed in the yard for curing or be directed to an autoclave.

Once substantially cured, the boards are further processed by sizing and finishing, if desired, and shipped to customers.

Technology has also been examined that subjects the boards to carbon dioxide gas. The exposure of cement paste to carbon dioxide gas substantially accelerates setting of Portland cement. In this case carbon dioxide dissolves in water and forms an acid which, in turn, reacts with calcium silicates to form calcium carbonate. The exposure of cement-bonded particleboard to carbon dioxide consumes as much calcium in a few minutes as the normal curing does in several weeks. The second major advantage of the $CO_2$ exposure is that the reaction produces calcium carbonates and calcium hydrates which contribute to the board's desirable properties. This process would allow the production of cement-bonded particleboard in a manner similar to resin-bonded particleboard when rapid production through a press does not require additional curing which in the case of cement-bonded particleboard can take weeks.

Cement-bonded particleboard panels are manufactured in relatively small plants under current technology. Plant capacities for cement-bonded particleboard are normally much smaller than resin-bonded particleboard. The smaller capacities for cement-bonded particleboard is due to the slow curing requirements for cement. With the successful application of carbon dioxide in the production of cement-bonded particleboard, plant capacities could be substantially increased.

The addition of autoclaves eliminates the need for yard curing and without the application of carbon dioxide which requires very precise application of the gas and therefore is highly sensitive to variations in the application of the gas.

Cement-bonded particleboard has not been as successful in the US markets compared with fiber cement. A major reason is the fact that, due to substantial volume of wood particles in the product, dimensional stability has not been acceptable for the intended applications. Smaller plant capacities have also been a problem although with the inclusion of autoclaves, plant capacities could be increased.

**Wood Wool (Excelsior) Boards**

These boards are composed of long strands of wood and Portland cement. The strands are generally 1-5mm wide and 0.2 to 0.5mm thick and can vary from these dimensions depending on the application of these boards. For acoustical and decorative applications the strands are relatively narrow but thick. For insulating applications, the strands are wider but thinner.

The strands are produced from round bolts on special machines and subsequently doused with cement and other chemicals such as calcium chloride and others to improve wood-cement bonding. Forming machines shape the mix into boards that are subsequently cured before shipping.

In Europe and the US, these boards are generally used for decorative and insulating applications. In less developed parts of the world it is used in the construction of inexpensive housing due to their lower costs.

Innovations in the production of sandwich panels combining wood-wood cement board and Styrofoam, for example, further improves insulation and lower weight per square meter of the board.

**Blocks and Slabs**

These technologies are not really new: they have been in existance in Switzerland since the 1940's. Blocks and slabs have also been manufactured in Canada since the 1950's.
In these technologies, the composite is basically made of wood and cement and shaped into blocks and stay-in-place wall forms for concrete structures, free-standing sound barriers and other applications. They have open texture and immune to rot while offering high fire resistance.

In addition to their application in housing, blocks and slabs have also been applied to highway construction as a noise barrier.

## MARKET CONSIDERATIONS

Fiber cement and related products, as we have seen in this presentation, have found a niche in the market place. One of the important reasons for their acceptance has been product attributes.

**Table 4** lists some of these attributes that are important in their acceptance by the market. Fiber cement has high fire resistance and will not be attacked by insects or rot fungi. They are generally highly durable (some manufacturers now routinely offer 50 year warranties). They also offer paint stability on finished products. Resistance to high winds and to impacts are also important market considerations. **Table 4** also lists other attributes that have been important in the acceptance of fiber cement especially in the North America markets.

**Table 4. Product attributes for fiber cement.**

## <u>PRODUCT ATTRIBUTES</u>

- HIGH FIRE RESISTANCE.
- DURABILITY
- NO ROT, INSECT ATTACK
- PAINT STABILITY ON FINISHED PRODUCTS
- RESISTANCE TO IMPACTS (HIGH TOUGHNESS VALUES)
- RESISTANCE TO HIGH WINDS.
- RELATIVELY LIGHT WEIGHT (ESPECIALLY IN LOWER THICKNESSES)
- REDUCED WASTE ON JOB SITE
- FREEZE-THAW RESISTANCE IN PRESSED BOARDS
- CAPABILITY FOR AESTHETICALLY PLEASING PRODUCTS (SIMULATE WOOD, SLATE, ETC.)
- CODE APPROVALS
- RESISTANCE TO ULTRAVIOLET LIGHT
- GOOD STRENGTH PROPERTIES
- NAILABLE, SAWABLE, CUTS WITH WOODWORKING TOOLS.
- INCREASINGLY WELL ACCEPTED BY ARCHITECTS, BUILDERS
- WIDER DISTRIBUTION AND RECOGNITION ACROSS THE U.S.

One item of importance has been to secure building code approvals which are a key in marketing fiber cement. Fiber cement especially in certain applications in North America now has those approvals and is very well accepted by the building contractors, architects and the general public.

Fiber cement underlayment, trim--- especially in laminated thicknesses of ½ inch or more ---and tile backer boards are currently being marketed. Others such as wall board, roofing shingles and slates, roofing panels, flooring for specialized uses, water coolant slats, lattice panels, laboratory counter tops, fence posts, corrugated roofing are just some of the examples of applications for fiber cement. **Table 5** lists many product opportunities many of which await market development. The fact remains that, at least in the US, companies have been quite busy supplying the existing markets in a limited number of products and have not taken up the opportunities that are presented to them to develop and expand new products.

**Table 5. Fiber Cement Product List.**

***FIBER CEMENT PRODUCT LIST***

**Numerous Opportunities/Markets**

* Lap/Panel Siding (embossed, smooth,etc.)
* Soffit
* Fascia
* Underlayment
* Trimboard
* Extra-Strength “Tough” Wallboard
* Utility Panels (Tile backer, Storage House Siding)
* Roofing Shingles ans Slates
* Roofing Panels (large Sheets)
* Computer Room Flooring
* Water Coolant Slats
* Lattice Panels
* Decorative Fence Panels
* Corrugated Roofing
* “Spanish” Tile Roofing
* Patio Decking
* Molded Door Core
* Trim Moldings
* Light Commercial Construction Panels
* Industrial Roofing Applications
* Exterior Cladding
* Preformed Slabs
* Highway Sound Barriers
* Highway Advertisement signs
* Applications with Direct Contact with Water
* Suspended Ceilings
* High Traffic Flooring
* Demountable Walls
* Roof Decks
* Fire-Resistant Structures
* Thermal Barrier Walls and Floors
* Kitchen Countertops
* DIY Applications
* Sound Prooofing Walls
* Swimming Pool Sorroundings
* Multiple Applications in Gymnasiums and Auditoriums
* Suspended Ceilings
* All Types of Displays
* Reception Desks
* Airline Ticket Counters
* Counters for Restaurants, Shops
* Decorative Applications

Table 5. continued

- Decorative Wall Carvings
- Fire protection for Steel Columns
- Modular Building Systems
- Flat Roof Decks
- Sound Studios
- Welding and Shop Areas
- Fumigation Chambers
- Storage for Combustible Materials
- Ventilation Ducts
- Table Tops for Laboratories
- Storage for Chemical Materials
- Cooling Towers Covers
- Industrial Flooring
- Webs for I-Beams
- Pharmaceutical Rooms
- Meat Smoking Rooms
- Drying Towers
- Cooling Towers
- Ducts
- Fumehood Liners
- Curved Partitions
- Melamine Faced Substrate
- Edge Profiled Products
- Animal Breeding Rooms (Chicken, Hogs, Cattle)
- Incubators
- Greenhouse Panels and Bench Surfaces
- Silos
- Other Agricultural Structures
- Prefab Buildings
- Containers
- Flower and Shrub Containers
- Mobile Home Floors
- Pallet Faces
- Base for Pool Tables
- Marine Applications
- Playgrounds
- Burial Vault Liners
- Boiler Enclosures
- Sport Arenas
- Multiple Applications is Shopping Malls
- Gas Stations
- Off-Shore Oil Platforms
- Multiple Applications in Airports

In the US, the current manufacturers of fiber cement are listed in **Table 6.**

**Table 6. Current fiber cement manufacturers in North America**.

| |
|---|
| • James Hardie Building Products |
| • CertainTeed |
| • GAF Materials |
| • Cemplank |
| • MaxiTile |
| • Nichiha |

Among these, James Hardie Building Products has the major share of the market especially in house siding and tile backer boards. However, others such as, for example, GAF Materials market other types of building products and fiber cement is simply an element in their total product offerings.

James Hardie Building Products utilizes the Hatschek process in the production of a family of its current products. The company now has ten manufacturing facilities in the following location:

Fontana, California
Reno, Nevada
Tacoma, Washington
Cleburne, Texax
Waxahachie, Texas
Plant City, Florida
Summerville, South Carolina
Pulaski, Virginia
Blandon, Pennsylvania
Peru, Iliinois

These plants have mostly been constructed over the last fifteen years and are designed to supply growing market areas in the south, west and eastern US.

Fiber cement continues to be considered a profitable business with respectable margins although it is encountering a soft market at this time. The prices for fiber cement have been strengthening in the past number of years but currently are leveling due to the market conditions**. (See Figure 13).**

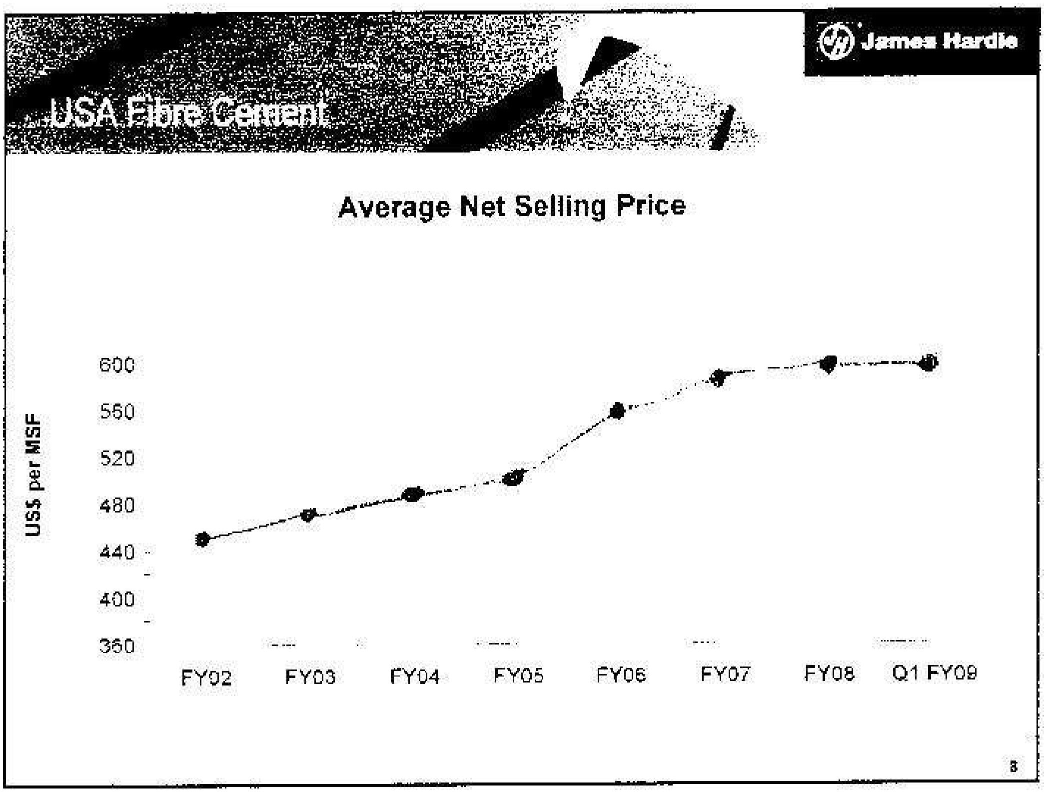


**Figure 13. Fiber cement prices as obtained from James Hardie report to shareholders**

Other fiber cement manufacturers in the US, as noted earlier include CertainTeed . This company is a leading manufacturer of a family of building products in addition to fiber cement. Its main office is in Valley Forge, Pennsylvania with some 70 manufacturing facilities in the US. Although CertainTeed began operation in 1904 as a roofing manufacturer, it became a wholly owned subsidiary of Saint-Gobain of France in 1988.

Nichiha Corp of Japan is a relatively recent entrant as a manufacturer to the US market with its first plant constructed in the state of Georgia. Nichiha began as a hardboard manufacturer in Japan in 1956 but later entered fiber cement manufacturing. The US operation is headquartered in Atlanta with the plant located in Macon, GA. It uses recycled pulp and cement in making its products. It offers a variety of embossed products and is currently largely concentrating on the southeastern markets.

Cemplank is a company with nearly a century of fiber cement history. Sand, cement and cellulose fibers constitute the raw material using the Hatschek process to produce planks, panel and trim products. Products are autoclaved to insure curing prior to shipment.

GAF, founded in 1886, is one of the largest building products manufacturers in North America. Roofing, decking, railings, decorative stones, ductwork and specialty fabrics are among some of the products that are produced by GAF in addition to fiber cement.

Maxi-Tile also offers fiber cement products in both roofing and siding applications. Roofing include both corrugated panels and slates. Smooth and embossed siding and roofing are made available similar to products offered by other fiber cement manufacturers. The company, Mexalit Industrial has it main operations in Mexico with an increasing presence in the US..

The fiber cement industry has experienced significant growth since 2002. This slow-down in the current market, however, is expected to be temporary and growth should resume in 2010 or 2011.

What has constituted an effective marketing and sales strategies for fiber-cement products?

Generally tapping into an existing sales/distribution network permits fiber cement to be sold along with other building materials. With an increasing environmental awareness, some have argued that the use of recycled fibers and other positive environmental features should be highlighted in sales literature (Green labeling). Although this approach could be helpful, it is not a major factor in the fiber cement's market acceptance. Product qualities continue to be the most important as they are considered key elements by architects, contractors and homeowners.

## A CONCLUDING THOUGHT

In conclusion, fiber cement continues to be a successful business. It is likely that product diversification will continue in the years ahead in addressing market opportunities that are likely to emerge. With wood products, the quality and supply will be of concern. Fiber cement composites are poised to offer product replacement as well as new applications as we move into the next decade and beyond.