



9 February 2006

Mr Scott Gregson  
General Manager, Adjudication Branch  
Australian Competition and Consumer Commission  
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Dickson ACT 2602

**By email and courier**

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Dear Mr Gregson

**James Hardie Australia Pty Ltd: Exclusive dealing notification N31496**

We refer to your letter to Fiona Crosbie dated 16 January 2006.

We confirm that your understanding of the notified conduct is correct. However, as discussed with Jessica Stewart, our client, James Hardie Australia Pty Ltd (**James Hardie**) wishes to clarify aspects of the notification.

**(a) Clarification and developments**

**(i) Trim products**

The reference to Linea™ Trim in the definition of the new technology differentiated products is a reference to 'Trim' products generally, which includes Linea™-branded trim. Like Linea™ Trim, all James Hardie Trim products comprise external window and corner trim, and are made of fibre cement. The only difference between James Hardie's Trim products is that their dimensions, namely their width, length and depth, vary.

The Linea™ Trim product is currently available from James Hardie in the following dimensions: 2600mm x 84mm x 16mm; and 2600mm x 100mm x 16mm.

Early this year, James Hardie proposes to launch throughout Australia a new 'Trim' product with the following dimensions: 4200mm x 84mm x 38mm; and 4200mm x 45mm x 38mm. James Hardie has launched this product in a small region of Queensland.

James Hardie submits that the same market considerations apply to Linea™ Trim as to other variations of Trim products, and that substitution possibilities for all Trim products are identical.



Our Ref FVCS:205523670

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Sydney  
Melbourne  
Brisbane  
Perth  
Bangkok  
Beijing  
Hong Kong  
Jakarta  
Phnom Penh  
Port Moresby  
Shanghai  
Singapore



(ii) Colorbond fencing

Colorbond fencing products are important substitutes for James Hardie's HardiFence® Sheets. James Hardie intended to include colorbond fencing products in the list of non-fibre cement alternatives to HardiFence® Sheets in Attachment B, Table 2 of the notification.

(iii) BGC NuLine Weatherboard External Cladding System

James Hardie has become aware that the Buckridge Group of Companies (**BGC**) has recently developed and launched a technology differentiated product: NuLine Weatherboard External Cladding System (**NuLine**) (please see the attached brochure). NuLine is substitutable for Linea™ Weatherboard. The main aesthetic difference between NuLine and Linea™ Weatherboard is thickness: NuLine has a 14mm profile, whereas Linea™ Weatherboard has a 16mm profile. Traditional fibre cement weatherboard products have a 9mm profile. NuLine accessories are similar to Linea™ Weatherboard accessories.

For completeness, we mention that NuLine is also substitutable for James Hardie's PrimeLine® Weatherboard, as well as the other products set out in paragraph 4.1(a) of the notification.

We set out below our client's responses to your requests for further information, using your numbering.

1. **Please provide a list of James Hardie's distributors, their location (on a state basis) and the proportion of James Hardie's sales they account for. Please advise if any of James Hardie's distributors currently stock James Hardie products exclusively.**

Set out at Attachment A to this letter is a confidential spreadsheet listing James Hardie's distributors, their location on a state basis, the proportion of James Hardie's sales attributable to each distributor, and whether each distributor stocks James Hardie's products exclusively. By 'exclusively', James Hardie understands the Commission to mean that the distributor chooses, whether for reasons of price, purchase terms or quality of service, only to stock James Hardie fibre cement products.

In the notification, James Hardie stated that the distribution policy would, as at the date of the notification, relate to 210 distributors. This figure comprised all distributors who had current written supply agreements with James Hardie, and James Hardie classified distributors with multiple outlets (such as, for example, Bunnings) as one distributor. James Hardie has other customers who are not parties to a written supply agreement, most of which are listed in confidential Attachment A.

We make the following comments in relation to the spreadsheet:

- (b) Column 5 headed 'Likely exclusive stockists': James Hardie is unable to identify with certainty whether a distributor supplies its fibre cement products on an exclusive basis. Therefore, James Hardie has based the information in this column on:
- (i) the distributor's current and historical purchasing patterns;
  - (ii) the terms of the distributor's current trading arrangements with James Hardie; and
  - (iii) whether the distributor is listed on CSR Ltd's (**CSR**) website as supplying CSR's fibre cement products.

James Hardie reiterates that it is unable to warrant the correctness of Column 5 of Attachment A and it may be that a distributor identified as stocking James Hardie products exclusively also stocks competitors' fibre cement products.

**What proportion of James Hardie's distributors currently stock the new technology differentiated products?**

For the period 1 April 2005 to 18 January 2006, \_\_\_\_\_ of James Hardie's distributors have purchased more than \_\_\_\_\_ worth of the new technology differentiated products from James Hardie. James Hardie does not know however which of its distributors currently physically stock the new technology differentiated products.

The new technology differentiated products have been launched on a limited basis.

The Commission should also know that James Hardie has not yet put its new policy into operation. Therefore, it is not able to say whether these distributors will continue to stock the new technology differentiated products.

**What proportion of James Hardie's sales do the distributors which currently stock the new technology differentiated products represent?**

For the period 1 April 2005 to 18 January 2006, \_\_\_\_\_ of James Hardie's total sales are attributable to the distributors who have purchased more than \_\_\_\_\_ worth of the new technology products. James Hardie does not know however which of its distributors currently physically stock the new technology differentiated products (see answer to question above).

2. **Please provide a list of James Hardie's manufacturing plants, their location and an explanation of how products are transported from these plants to distributors.**

Set out below are 2 confidential tables:



3. **On the basis of the information contained within the notification and particularly paragraph 1.2 of Attachment A, I understand that it is likely that part (a) of the notified conduct will apply to distributors which currently account for less than 5% of James Hardie's total sales. Is this correct?**

Your understanding is correct.

James Hardie intends that part (a) of the distribution policy will apply to all James Hardie distributors. However in practice, James Hardie understands that currently, distributors who on-sell James Hardie's fibre cement products to other fibre cement manufacturers and/or distributors described in paragraph (a)(ii) and (iii) of the distribution policy account for less than 5% of James Hardie's total sales.

4. **I note that part (a)(i) of the notified conduct, concerns fibre cement manufacturers. Please identify all relevant fibre cement manufacturers and provide their market shares.**

James Hardie is aware that the following Australian companies manufacture fibre cement products:

- CSR; and
- BGC.

Fibre cement products are also imported into Australia by Hume Doors & Timber (Aust) Pty Ltd from Hume Cemboard Industries Sdn Bhd, Malaysia and by Dindas Lew, Victoria from Everite Limited, South Africa.

James Hardie does not have official share data in respect of the fibre cement product category. It notes that CSR and BGC have made the following statements:

- (a) CSR: "We are Australia's second largest producer of fibre cement products, used for external cladding, wet area wall linings, flooring and high impact partitions. In Queensland, NSW and Victoria, our market share is more than 15%"<sup>2</sup>

"CSR Fibre Cement is supplied to eastern seaboard markets, where our market share is over 15%."<sup>3</sup>

Until recently, James Hardie understands that CSR's website stated that CSR Fibre Cement had 24.5% market share on the east coast, excluding columns and pipes.

- (b) BGC: "BGC Fibre Cement's Canning Vale plant was established in 1994, and today employs more than 130 people in production, engineering and support services. We supply 15 per cent of the construction industry's needs Australia-wide, including products such as sheet lining, external cladding, lattice, and vinyl and cork underlay sheets".<sup>4</sup>

James Hardie is able to estimate its share of the fibre cement product category in various ways:

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<sup>2</sup> CSR annual report March 2004 p 8

<sup>3</sup> CSR annual report March 2005 p 11

<sup>4</sup> <http://www.bgc.com.au/fibreceement/>

- (ii) **using ABS statistics:** ABS identifies the dominant external cladding material used in new building approvals submitted to local councils.<sup>5</sup> In most cases, fibre cement is not the dominant material and is therefore not recorded. ABS uses this information to publish sales volumes for external cladding and internal lining products, and attributes a certain percentage to fibre cement products. James Hardie could estimate its share of ABS share data. However in the usual course it does not do so, as it believes the ABS statistics are unreliable, principally because they do not capture all usages of fibre cement.

**5. What percentage of James Hardie's total sales concern core products (as defined in Attachment A to the notification)?**

Sales of James Hardie's core products comprise \_\_\_\_\_ of its total sales for the period 1 April 2005 to 18 January 2006.

**6. What percentage of James Hardie's total sales concern technology differentiated products (as defined in Attachment A to the notification)?**

Sales of James Hardie's technology differentiated products comprise \_\_\_\_\_ of its total sales for the period 1 April 2005 to 18 January 2006.

<sup>5</sup> James Hardie understands that only 50% of councils provide information to the ABS.



7. **What percentage of James Hardie's total sales concern the new technology differentiated products?**

Sales of the new technology differentiated products comprise \_\_\_\_\_ of James Hardie's total sales for the period 1 April 2005 to 18 January 2006.

8. **I note that under the notified conduct, James Hardie may provide a distributor with written consent to on-sell James Hardie products and/or to purchase the new technology differentiated products without acquiring 100% of their fibre cement products from James Hardie. Under what circumstances would James Hardie provide such written consent?**

James Hardie will not provide written consent to a distributor to exempt it from paragraph (a) of the distribution policy. Where a distributor seeks exemption from paragraph (b) of the distribution policy, James Hardie encourages that distributor to engage in discussions with James Hardie. As a guide, James Hardie will consider providing written consent to a distributor, exempting it from paragraph (b) of the distribution policy where:

- (a) the distributor can reasonably demonstrate that a builder customer has requested to purchase fibre cement products that are not manufactured by James Hardie, and the distributor is unable to influence the builder's choice because, for example, an alternative fibre cement product has been specified in architectural plans; and
- (b) the distributor's overall sales of competitor fibre cement products made pursuant to (a) above from the commencement of its agreement with James Hardie up to and including the time it supplies the competitor's fibre cement products comprise a minor percentage of that distributor's total sales of James Hardie fibre cement products for that period, which percentage will be agreed on a confidential basis with James Hardie; or
- (c) the distributor acquires a competitor's fibre cement products immediately after entering into a supply agreement with James Hardie in order to meet existing obligations to its customers, and it ceases to do so as soon as possible, or in any event by the expiration of a period to be agreed on a confidential basis with James Hardie.

Where distributors acquire products from other distributors (**two stepper distributors**), rather than from James Hardie direct, James Hardie will:

- (d) request two stepper distributors to inform it prior to supplying another distributor, so that James Hardie can ensure the other distributor is not a distributor who comes within paragraph (a) of the distribution policy; and
- (e) in the case of paragraph (b) of the distribution policy, provide two stepper distributors with a list of distributors who acquire 100% of their fibre cement products from James Hardie. Two stepper distributors will be free to supply the new technology differentiated products to distributors on that list. For any distributor not on that list, two stepper distributors must seek the consent of James Hardie prior to supplying the distributor with James Hardie products. James Hardie will only grant consent if it can identify that the acquiring distributor purchases



100% of its fibre cement products from James Hardie, or falls into one of the exceptions at (a)-(c) above.

9. **I understand that under its former distribution policy, James Hardie could also provide distributors with written consent to engage in activities in contradiction to the policy. Did James Hardie receive any requests from distributors for such written consent? If so, how many such requests and what number of requests were granted or denied? In what circumstances were such requests granted or denied?**

James Hardie did not receive any requests from distributors for consent to engage in activities in contradiction to the former distribution policy. Having said that, James Hardie has not taken steps to enforce actively the terms of the former distribution policy.

10. **I note that paragraph 4.1 of Attachment A to the notification suggests that there are no significant technical, legal, or financial impediments to creating technology differentiated products and paragraph 5.1(a) describes the cost of research and development in fibre cement products as relatively modest. However, paragraph 5.1(c) of Attachment A suggests that the development of technology differentiated products involves considerable sunk development costs. Please clarify the situation with respect to the barriers to entry to manufacturing technology differentiated products, providing supporting information where possible.**

James Hardie understands that barriers to entry to developing fibre cement products are relatively low. Both CSR and BGC have enjoyed rapid growth in the fibre cement product category since they commenced manufacturing fibre cement products. James Hardie understands that CSR and BGC commenced manufacturing fibre cement products approximately 11 and 12 years ago respectively. Over that period, the presence of each in the fibre cement product category has grown significantly and quickly. One commentator estimated that by about the year 2000, 5% of fibre cement sales in Australia were attributable to BGC, and 25% were attributable to CSR.<sup>6</sup> This growth demonstrates the relative ease with which CSR and BGC commenced manufacturing and selling fibre cement products, despite the investment required.

James Hardie was the first company to develop technology differentiated products. James Hardie has invested significant resources into developing these products, and endeavours to stay at the forefront of innovation. As set out in the notification and at paragraph (a)(iii) above, James Hardie's principal competitors, CSR and BGC have now followed James Hardie's lead and developed some of their own technology differentiated products. On this basis, James Hardie assumed and included in its notification, its belief that there are no significant technical, legal or financial impediments to CSR and BGC creating their own technology differentiated products.

James Hardie manufactures only fibre cement products, and not the full range of building products. A core focus of James Hardie's business is therefore in product innovation and development. Much of James Hardie's investment in research and development is not profitable, as not all products it develops are marketed and sold. James Hardie invests

<sup>6</sup> Coutts R, Australian Centre for International Agricultural Research: *Natural Fibre-cement Composites: An Australian Perspective* see: [www.aciar.gov.au/web.nsf/doc/JFRN-5J47AH/\\$file/Chapter1.pdf](http://www.aciar.gov.au/web.nsf/doc/JFRN-5J47AH/$file/Chapter1.pdf)

substantial resources in identifying new products that may be successful in the market and in promoting those products when developed. James Hardie also explores various ways of developing one particular product before arriving at the best method and best quality outcome. It then undertakes significant testing and analysis of the product. Therefore, many of James Hardie's costs in developing technology differentiated products are sunk, as it cannot recoup all of its research and development costs through sales of the products it chooses to launch.

James Hardie assumes that research and development of innovative fibre cement products is a less significant business focus for CSR and BGC. It believes that CSR and BGC invest in technology differentiated products once they have assessed the success of new products launched by James Hardie. In doing so, CSR and BGC operate with the distinct advantage of hindsight which is not open to James Hardie<sup>7</sup>. For example, CSR's ExpressWall™ product mentioned at paragraph 4.1 of the notification was launched after James Hardie's substitutable product, as was BGC's NuLine product.

As a leader in developing technology differentiated products, James Hardie would spend considerably more than a manufacturer who developed a similar technology differentiated product later in time. The second to manufacture such a product can build on the technological innovations of the first manufacturer to do so, and can, in many instances, reverse engineer a successful product in order to build its own. In doing so, the intellectual and financial investment required is significantly less. For this reason, James Hardie submits that it is likely to incur significantly greater sunk costs in relation to these products than any of its competitors.

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<sup>7</sup> This advantage has been recognised by the High Court in the context of patent litigation. In the case of *Minnesota Mining and Manufacturing Co v Beiersdorf (Australia) Ltd* 144 CLR 253, Justice Aickin recognised that "the opening of a safe is easy when the combination has already been provided" (at 293).

Please let us know if you have any queries in relation to the responses above.

Yours sincerely



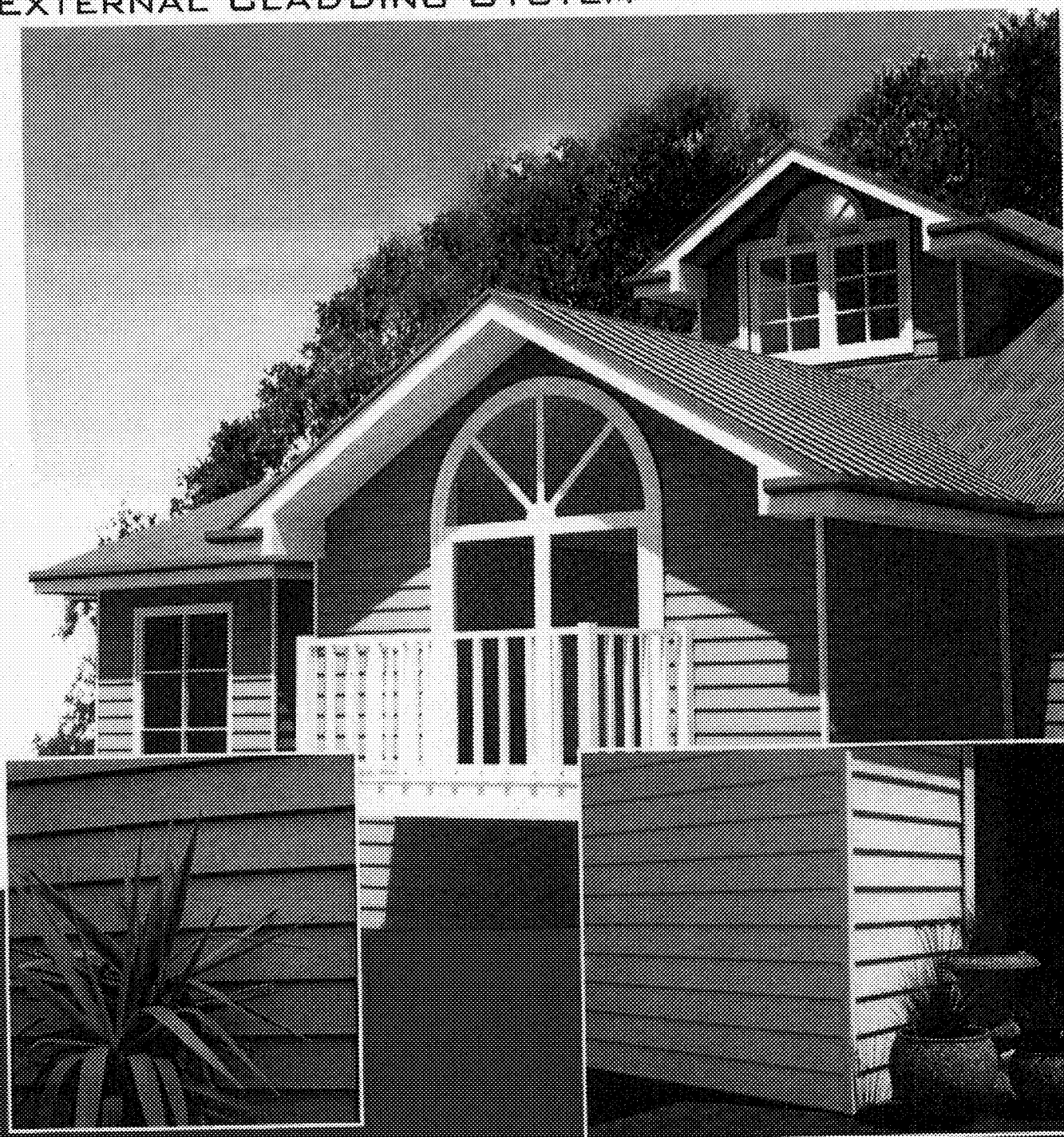
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# NULINE

WEATHERBOARD  
EXTERNAL CLADDING SYSTEM



Strength, elegance, and durability  
in design. NuLine.



Austlians buy best and choose for best

**BGC**

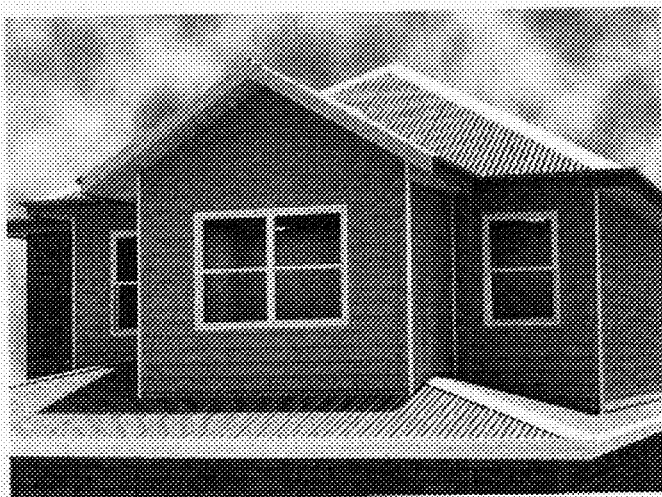
Fibre Cement

# NULine

## WEATHERBOARD

EXTERNAL CLADDING SYSTEM

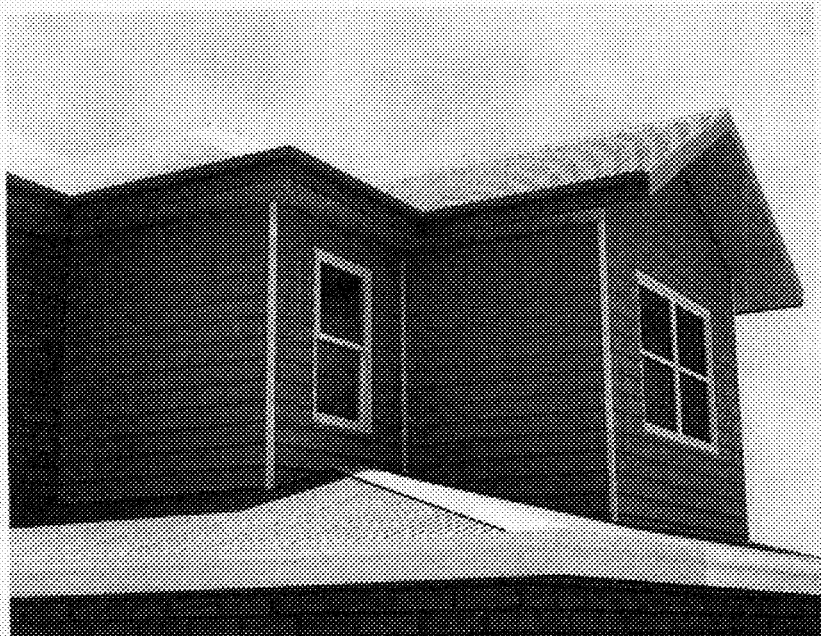
Simple Timeless Lines,  
Classic Proportions  
and Fine Timber  
or is it NuLine?



Traditional timber weatherboarding is great for enhancing the appearance of a building, but it needs continual maintenance to prevent rot.

NuLine Weatherboard is the ideal alternative. It has all the visual appeal of timber weatherboard yet is simple to install, doesn't rot and is an attractive low maintenance alternative to other existing weatherboards.

NuLine Weatherboard is constructed using advanced Fibre Cement Technology and is far more durable than natural timber and much better looking offering a range of sizes and profiles.



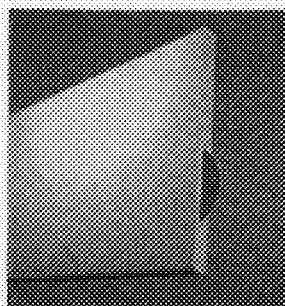
- New 14 mm profile for enhanced character
- Ease of installation
- Maintains a straighter line because of density and innovative fixing system.
- A variety of corner options to suit your taste
- Ease of fastening via nails or screws
- Minimal waste with new innovative Butt join system.
- Easy to cut and handle
- Versatile range of uses
- Square, Bullnose and Bevel profiles available for your choice
- Fire and termite resistant

If you are looking for a new product to enhance your building design that offers old world aesthetics with a combination of today's technology, then look no further.

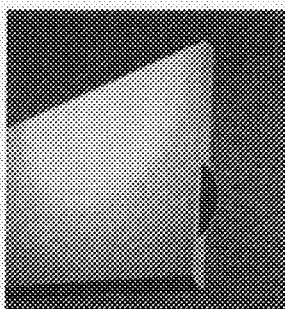
BGC NuLine offers not only good looks but offers a complete installation system to the installer that allows for fast and easy installation in all areas.

**BGC** Fibre Cement

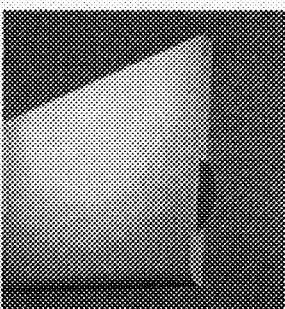
# **NULINE** **WEATHERBOARD** **EXTERNAL CLADDING SYSTEM**



**Square**



**Bevel**



**Bullnose**

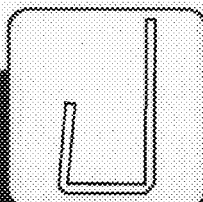


## **PLANK SIZES**

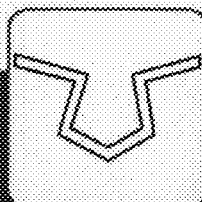
NULINE IS AVAILABLE IN THE FOLLOWING SIZES

Width (mm)	Length (mm)	Thickness (mm)
175	4200	14
205	4200	14

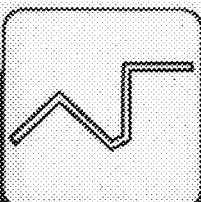
## **Accessories Range**



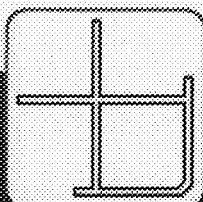
**Starter Strip**



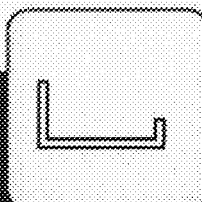
**External  
Obtuse**



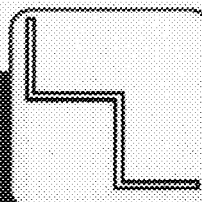
**Internal  
Obtuse**



**External**



**'J' Mould  
Window Mould**



**Internal**

### **Recommended Safe Working Practices**

Maintain your usual O.H &S guidelines whilst working with NuLine and adopt use of P1 or P2 type masks and safety goggles (approved to AS/NZS1337) also known as 'eye protectors for industrial applications'. These precautions are required only during cutting and installation of NuLine. It is safe to handle NuLine during unloading and or stacking without the above precautions.

### **Clean up guidelines**

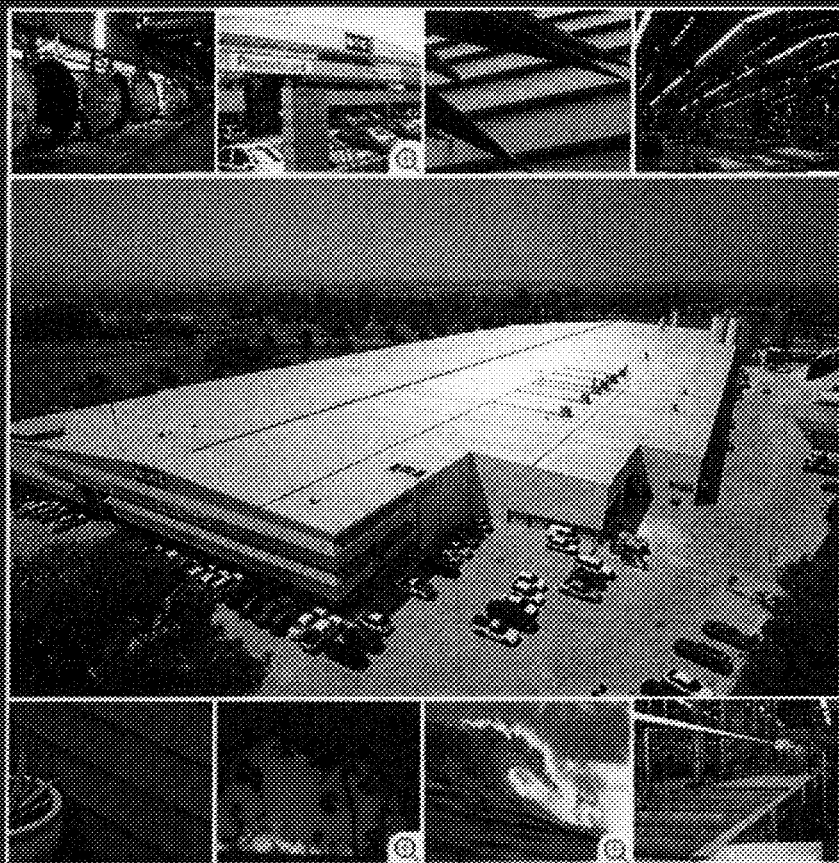
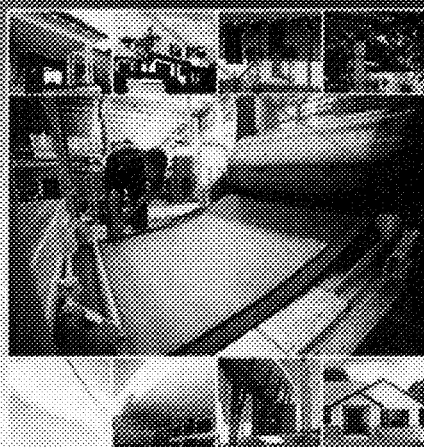
To ensure safe clean up always wet down work area. Alternatively, vacuum, dust, and dispose of dust using containment procedures for dust collected.



## **BGC** Fibre Cement

**BGC Fibre Cement is an Australian owned and operated Company.**

**BGC continually demonstrates that one of its major objectives is to supply products to the building industry and public with a high level of integrity and responsibility to you.**



### **OTHER FIBRE CEMENT PRODUCTS**

- |                                  |   |
|----------------------------------|---|
| <b>DURASHEET</b>                 | For use on external applications. It is ideal for cladding of gables and the lining of eaves, carports and verandahs. |
|                                  | For commercial soffits and external cladding on non impact areas.   |
| <b>DURATEX</b>                   | A base sheet for textured coatings on external wall applications.   |
| <b>COMPRESSED</b>                | Domestic, commercial sheet for wet areas, flooring, partitions, external decking, fascia and facade cladding.         |
| <b>DURAPLANK</b>                 | Smooth finish, Woodgrain finish, Weatherboard.  |
| <b>DURALATTICE</b>               | Square or Diamond patterned lattice.  |
| <b>DURALINER</b>                 | An internal lining board, ideal for wet areas.  |
| <b>DURALUX</b>                   | A square edge internal lining board.  |
| <b>CERAMIC TILE UNDERLAY</b>     | "CTU" - for laying ceramic tiles.   |
| <b>VINYL &amp; CORK UNDERLAY</b> | "VCU" - for laying vinyl & cork floor coverings.  |

For your nearest BGC stockist call:

Adelaide  
Telephone: (08) 8293 4166

Brisbane  
Telephone: (07) 3711 4744

Melbourne  
Telephone: (03) 8392 8444

Perth  
Telephone: (08) 9374 2500

Sydney  
Telephone: (02) 9632 2100

## Natural Fibre-cement Composites: An Australian Perspective

Robert S.P. Coutts<sup>1</sup>

### *Abstract*

Over the last three decades considerable research has been undertaken to find an alternative fibre to replace asbestos in asbestos-cement products. Australian research focused on natural fibres and ultimately it was a natural fibre — wood pulp fibre — that proved to be a suitable replacement for asbestos fibres. This paper reports on some of the Australian research that led to the commercial exploitation of natural fibres as reinforcement for cement products. The preparation and properties of the fibres are discussed, as well as their compatibility with existing processing technology. Some explanation of the bonding and microstructural behaviour (under load) within these composite materials is presented and related to their performance in service. The spread of the Australian wood fibre-cement technology and the range of applications for which the natural fibre-cement composites are used are discussed briefly, particularly with reference to activities in the USA and Asia.

In the early 1970s a global effort was initiated to legislate for the removal of asbestos reinforcement from a wide range of products. Fibre-cement composites were a major consumer of asbestos and therefore new reinforcing fibres were sought as alternatives to asbestos.

### **Legislation Against the Use of Asbestos**

Those countries that recognised the need to legislate against the use of asbestos on health grounds have proved to be the ones that have achieved the most significant advances with respect to asbestos substitution.

In 1982 the German Government and industry agreed to reduce asbestos content by 30–50% before 1986. In 1984 they revised the agreement so that it stated that all building construction materials would be free of asbestos by 1990. Since 1988, two producers of fibre-cement products in Germany, Eternit and Fulgurit, have received approval to produce large-size pressed and air-cured asbestos-free corrugated sheets. Unfortu-

nately, in Germany the Government subsidises metal roofing to the detriment of the fibre-cement industry, and this has caused Fulgurit to close down its Wunstorf plant that had been manufacturing air-cured wood-fibre-reinforced cement composites.

By 1987, Sweden, Norway and Denmark had prohibited the use of asbestos. After 1989, with the easing of trade barriers in Europe, Italy, Belgium, the Netherlands, Austria and Switzerland introduced relevant bills that proposed to partly or completely prohibit the use of asbestos within 10 years. Countries such as France and Spain have been slower in changing to non-asbestos formulations, but with the advent of investments in new plant a transition to asbestos-free products can be expected.

Eastern European countries such as the former Yugoslavia and Czechoslovakia, which have been exporting fibre-cement products to Western Europe, will also be changing to asbestos-free products in an attempt to retain their market share of fibre-reinforced cement composites.

Russia and China, which produce more than half the world's asbestos, are obvious users of asbestos fibre in cement products and are expected to

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<sup>1</sup>Assedo Pty Ltd, Melbourne, Australia.



continue to be so for some time into the future. Although some research is being conducted into non-asbestos fibre-cement composites, there is no obvious strong drive towards legislation against the use of asbestos in those countries at the present time.

Although there is no legislation banning asbestos in fibre-cement composites in Australia, it was still the first country in the world to produce asbestos-free fibre-reinforced cement composites (New Zealand adopted this technology immediately afterwards). James Hardie Industries has been manufacturing asbestos-free cement sheeting since 1981 (Anon. 1981), and all products, including moulded products and non-pressure pipes, have been free of asbestos since 1987. The success of James Hardie's technology encouraged two more producers of natural fibre-reinforced cement products—BGC Fibre Cements and CSR Fibre Cements—to commence operations in Australia in 1994 and 1996, respectively. James Hardie Industries has since taken its asbestos-free technology overseas to New Zealand, Asia and North America.

The situation is different in developing countries. Older technology is much more prevalent there because of less stringent rules about occupational health and safety. Hence, high levels of production of asbestos-containing fibre-cements composites in Asia and South America are expected to continue for some time.

At the other end of the spectrum there exist many cottage-industry-type operations. The products of such enterprises are usually corrugated roofing, roofing tiles and flat sheet products that depend on a cheap fibre source and labour intensive production methods (IUTRLMS 1983, 1985; Swamy 1992). It is unfortunate that, even though millions of dollars have gone into this area of research in the form of foreign aid, the success of such activities has been somewhat limited by product failure (Lola 1992). However, the picture is not as bleak in this area as some have painted it. Efforts are being made to control the performance of low-cost building materials for use in developing countries. For example, in 1987 Gambia was the first country in Africa to adopt regulations supporting the use of indigenous, low-cost building materials suited to the needs and financial capabilities of its inhabitants (Anon. 1987).

There remains a great need to study new cheaper methods of fibre production, low-cost production processes, and the all-important question of durability of fibre-reinforced cement composites. Durability is related to matrix formulations, processing methods and curing regimes, and if natural fibre-reinforced cement products are to be readily available for low-cost housing much research still remains to be conducted.

### Research in Australia

#### James Hardie research

The history of fibre-cement composites in Australia starts long before the 1970s. James Hardie and Coy Pty Ltd, hereafter referred to as James Hardie, began manufacturing asbestos-cement products in Australia in 1917. After establishing manufacturing plants around Australia, the company extended production to New Zealand in 1938. International expansion continued in the 1960s with the formation in 1966 in Malaysia of United Asbestos Cement Berhad, a joint venture (51% Malaysian ownership) with James Hardie, Turner and Newall and the European Eternit Company. In 1970, Indonesian production started with P.T. Harflex Asbes Semen. By 1977 James Hardie had 29 plants in Australia, New Zealand, Indonesia and Malaysia employing 6500 people.

James Hardie took an active interest in the use of cellulose as an economic asbestos substitute in fibre-reinforced cement in the early to mid-1940s. This work was intensified during the post-World War II years when there was a worldwide shortage of asbestos fibre. An investigation was conducted at Camellia, NSW, by Heath and Hackworthy (JHI 1947) to discover whether paper pulp could be used to replace asbestos completely or partially in asbestos-cement sheets. Fibres studied included bagasse, groundwood, wheat straw, cement bags and brown paper. The experimental autoclaved sheets showed that brown paper (kraft) was the best of the pulp sources, giving greatest strength to the composite material. However, when abundant supplies of asbestos became available, this work was discontinued.

Renewed interest in wood fibres began almost inadvertently in 1960 (Greenwood 1983; Seach, B.G. pers. comm. 1987). In those days, the asbestos fibreboard, containing 15% asbestos,

was made between steel interleaves. James Hardie's was believed to be the only group in the world to be steam-curing its sheets at that time. To make a cheap board as an alternative interleaf, a composite was made in which half the asbestos was replaced by wood fibres. Surprisingly, this material was found to be better than James Hardie's commercial product. This board became the first generation Hardiflex, and full production started in 1964. From the 1960s onwards James Hardie products contained no more than 8% asbestos, which was about half the amount their competitors were using.

Attempts to further reduce the asbestos content by adding more wood fibre were unsuccessful because these fibres were not as effective as asbestos in trapping the cement particles during formation of the sheet in a conventional Hatschek machine. It was in the 1970s, following health concerns about asbestos, that James Hardie made a strong commitment to the total replacement of asbestos reinforcement in their products.

#### CSIRO and industry research

CSIRO in the early 1970s had active research programs studying ways of using wood fibres as reinforcement in a broad range of composite materials. They were also testing modification of the surface of wood pulp fibres to make them more compatible with various organic and inorganic matrices.

In 1977 James Hardie approached CSIRO Division of Chemical Technology (currently, CSIRO Forestry and Forest Products) about the possible use of natural fibres in their Indonesian subsidiary. After several meetings the organisations entered into a collaborative project to study the reinforcement of cement products with wood fibres. This project continued over the period 1978-82 (Anon. 1981).

After over 50 years of research into the science and application of wood and paper pulp CSIRO was well equipped to study, among other things, the refining of wood fibres. This was examined in an attempt to overcome the major problem of retaining the cement particles during the production of the wood-fibre-reinforced cement sheet. The project proved successful and it was later demonstrated by scanning electron microscopy (SEM) that refining opened up the

structure of the individual fibres resulting in a fibrillated ('hairy') surface. During sheet production these refined fibres acted as a net, retaining the matrix material, similar to the situation occurring when asbestos was used (Courtts and Kightly 1982). By May 1981 a new generation of asbestos-free cement products, Hardiflex II, was being commercially manufactured. This autoclaved product was asbestos-free and totally reinforced by refined kraft wood fibres (Courtts and Ridikas 1982; Australian Patent No. 515 151).

#### Refining of fibres

Refining and beating are both defined as the mechanical treatment of pulp carried out in the presence of water, usually by passing a suspension of pulp fibres through a relatively narrow gap between a revolving rotor and a stationary stator. The term 'beating' is usually applied to a batch treatment of pulp suspension, whereas 'refining' is used when the stock is passed continuously through one or more refiners in series (Britt 1970; Clark 1987).

It should be pointed out that refining does not produce the same effects on chemical pulp as it does on mechanical pulp. Chemical pulps contain less lignin, and hydroxyl groups are much more accessible. In mechanical pulps, hydroxyl groups are blocked by the presence of lignin. The refining of mechanical pulp is necessary to defibrate the fibre bundles that are produced by thermo-mechanical pulping.

Changes in fibre structure resulting from refining depend on the type of refiner, the refining conditions used, the fibre type (hardwood or softwood) and the pulp (mechanical or chemical). The main effects that are observed can be classified into four areas:

- (i) internal fibrillation or delamination,
- (ii) external fibrillation of the fibre surface,
- (iii) fines formation,
- (iv) fibre shortening.

Internal fibrillation effects, (i), are difficult to observe under a microscope, but they can be understood by considering a piece of rope. Rope is a helical wrap of strands that are themselves helical wraps of fibres. If a rope is twisted in the direction of the helical wrap the rope becomes 'stiffer'; likewise, if the twist is in the opposite

direction the rope unwinds (or delaminates) to open up the structure, and becomes 'floppy'; this is the case with internal fibrillation. The main effect of internal fibrillation is to increase fibre flexibility and swelling. The fibres may also undergo excessive curling and twisting.

External fibrillation, (ii), is easily observed by scanning electron microscopy. The fibrils or fibrillar lamellae attached to the fibre surface can vary widely in size and shape (but the process is again similar to the unravelling of a piece of rope at its surface).

The last stage, (iii), of external fibrillation is the peeling off of the fibrils from the fibre surface, with the formation of fines. The latter depends on the forces acting on the fibres during refining, and the duration of refining.

Fibre shortening, (iv), is the other primary effect attributed to refining. An indication that fibre shortening has occurred is the change observed in particle size distribution, which is a result of the cutting action of the blades or discs in the machinery on single fibres.

Refining plays an important role in producing a large surface area for fibre-to-fibre or fibre-to-matrix (in the case of composites) bonding and, more importantly, can assist in controlling the drainage rates of processing liquids during the manufacture of products. This is one of the main advantages of wood fibre compared to synthetic fibres such as glass, steel, etc., and a key factor in the success of kraft pulp as a replacement for asbestos when existing processes are used to manufacture wood fibre-cement composites.

#### *Chemical modification of fibres*

During this same period of time it was believed that modification of the fibre surfaces by chemical means might assist in the bonding to inorganic matrices. This complemented earlier studies at CSIRO on the use of coupling agents for composite products, and surface treatments of pulp for paper production. A collaborative research project with Australian Chemical Holdings was carried out during 1979-81. Although many novel polymeric systems were studied and certain benefits were achieved, the mechanical approach of refining fibres proved far superior with respect to performance and cost.

#### *Fibre selection*

The choice of wood pulp fibre as the preferred replacement for asbestos in fibre-cement occurred in spite of strong competition from other fibre types. During the 1970s and '80s, glass-fibre-reinforced cement was being acclaimed as the prime alternative to asbestos reinforcement (Hannant 1978). Also, steel fibres and a wide range of synthetic polymeric fibres as well as other natural fibres were actively under research in various countries around the world (Hodgson 1985). Although kraft wood pulp fibres were suitable they were reasonably expensive. Considerable research was conducted into alternative methods of producing fibres, and into extending the range of natural fibres suitable for reinforcing cement products.

The search for a replacement for asbestos fibres resulted in many natural fibres being examined in numerous laboratories around the globe as well as by Australian researchers. Obviously the fibre-cement industry has considerable in-house data, the results of which have not been made available to the general scientific community. At CSIRO a wide range of natural fibres, prepared by several pulping methods, was studied in various cement systems. Some representative published results are summarised in Table 1.

Some of the research at CSIRO on fibre selection was done in collaboration with overseas scientists who were evaluating the potential of local fibres to reinforce cement composites.

#### *University research*

Sydney University was involved with James Hardie Industries in the 1970s through Professor Snow Barlow who was investigating plant structure. The identification of plant fibres as substitutes for asbestos was also a priority in his laboratory.

Sydney University had a strong interest in the mechanical performance of a wide range of materials, and, under Professor Mai, extensive testing of wood-fibre-reinforced sheeting was carried out to establish the products' performance under slow crack growth (Mai and Hakeem 1984a,b) and the generation of fracture toughness (Mai et al. 1982).

Research by Victoria University of Technology (Courtts et al. 1994; Zhu et al. 1994; Courtts and Ni 1995) was carried out in collaboration with CSIRO

**Table 1.** Natural fibres examined at CSIRO for their potential to reinforce cement composites

Fibre	Pulping <sup>1</sup>	Refining <sup>2</sup>	Matrix <sup>3</sup>	Cure <sup>4</sup>	Reference
<i>Pinus radiata</i> (softwood)	K, TMP, CTMP	R/NR	C, M	A, AC	Campbell and Coutts 1980; Coutts and Ridikas 1982; Coutts 1984, 1986, 1987b; Coutts and Warden 1985
<i>Eucalyptus regnans</i> , <i>E. grandis</i> , <i>E. saligna</i> , <i>E. pellita</i> (hardwoods)	K, CTMP	R/NR	C, M, GFS	A, AC	Coutts and Michell 1983; Coutts 1987a; Evans et al. 2000; Savastano et al. 2000a,b
<i>Acacia mangium</i>	K, CTMP	NR	C, M	A, AC	Eusebio et al. 1998a,b
Waste paper	—	NR	M	AC	Coutts 1989
New Zealand flax	NaAQ	R/NR	M	A	Coutts 1983
Abaca	K	R	C	AC	Coutts and Warden 1987
Banana	K	NR	C	AC	Coutts 1990; Zhu et al. 1994; Savastano et al. 2000b
Sisal	K, S	NR	C, GFS	AC	Morrissey et al. 1985; Coutts and Warden 1992; Savastano et al. 2000a
Bamboo	K	R	C, M	A, AC	Coutts et al. 1995; Coutts and Ni 1995

<sup>1</sup>K = Kraft pulp, TMP = Thermomechanical pulp, CTMP = Chemithermomechanical pulp, S = Soda pulp, NaAQ = Soda anthraquinone pulp

<sup>2</sup>R = refined, NR = not refined

<sup>3</sup>C = Cement, M = Cement and sand/silica mix, GFS = Ground furnace slag matrix

<sup>4</sup>A = Autoclaved, AC = Air-cured

at the Division of Forestry and Forest Products and was focused on non-wood pulp fibres.

More recently, The Australian National University, in collaboration with CSIRO and the Forestry and Forest Products Research and Development Institute in the Philippines, has become involved with wood-cement products and some of this work has involved wood fibre-cement composites (Eusebio et al. 1998a,b; Evans et al. 2000).

#### Other manufacturers within Australia

After the initial success of James Hardie, other Australian companies became interested in wood fibre-cement products. Pulp manufacturers from both Australia and New Zealand carried out considerable research on the suitability of their range of pulps as replacements for asbestos. Cement companies also looked at the opportunities for manufacturing products from cement and natural fibres. However, the main thrust of

research in Australia remained with wood fibre-cement panel products.

Early in 1991 Atlas-Chemtech (now BGC Fibre Cement) asked CSIRO to assist them in establishing a plant to manufacture wood-fibre-reinforced-cement composites. They had acquired a second-hand Hatschek machine from Toschi in West Germany. This company, which had no prior experience in fibre-cement production, began constructing its factory in 1993. Its location, adjacent to the Aerated Autoclaved Cement (AAC) plant, was selected to take advantage of a silica ball mill and a gas-fired boiler for autoclaves. This enterprise enabled the parent company to supply their extensive building empire in Western Australia with fibre-reinforced-cement sheeting. At the same time, due to cheap (backload) freight (from west to east), they could compete with James Hardie, selling their excess capacity to the east coast market of Australia. It is believed they have about 5% of the local market.

The original formulation for wood fibre-cement composites was based on that of Supradur (Canada) which had a high cement content and 10% bleached cellulose fibre. This mix produced a high strength sheet that did not suit certain applications in Australia, because it lacked flexibility and nailability and there was excessive sheet movement. After much research and development, BGC developed a new formulation using New Zealand fibre-cement-grade cellulose pulp. This produced a better product that could be used as a building material in a greater range of applications. The quality and production efficiency of BGC was recognised by USA building products manufacturer Temple-Inland when it decided to enter the US fibre-cement siding market. In 1996, Temple-Inland signed an agreement with BGC for its technology and assistance in constructing a fibre-cement plant in Texas, USA.

BGC is currently operating one line with a capacity of 5 million Standard Metres, and has plans to increase production. Sales and warehouse facilities exist in Perth, Adelaide, Melbourne, Sydney, Brisbane and Auckland. As well as having Australian and New Zealand markets the company exports to Singapore and New Caledonia.

In 1994 CSR also asked CSIRO to assist it in producing fibre-cement composites. CSR is one of the world's largest building and construction materials companies, with operations in Australia, New Zealand, USA and Asia. At that time it employed about 20 000 people in nine countries with sales worth over A\$6 billion per annum. Its entry into the market was a little less demanding in that it had built a turn-key plant for about A\$6 million. The big advantage that this company had was that it already had large distribution centres in Australia that could guarantee its entry into the market — a feature lacking for James Hardie, which in many cases had been supplier to CSR-owned outlets! CSR currently has about 25% of the domestic market in Australia with distribution outlets in all Australian States and in New Zealand. Their product is also exported to several Asia-Pacific countries.

In 1998, Applied Technology and Planning Pty Ltd (ATP) developed a patented manufacturing process called Micro Internal Compaction. This injection moulding style process allows the rapid production of two- and three-dimensional aerated

fibrous cement products. Ultimate Masonry Australia Pty Ltd (UMA), from its factory in Brisbane, is using this technology to produce what it claims to be the world's first commercial, hollow aerated concrete block. Production is currently limited to the full range of 400 mm x 400 mm x 200 mm hollow 'SmartBlocks'. These blocks have compression strength superior to that of conventional concrete blocks at half the weight (see also Klatt and Spiers, these Proceedings).

In 1999 Assedo Pty Ltd advised ATP on the use of wood pulp fibres as reinforcement in cement products. The UMA SmartBlock is currently made from an aerated slurry of cement, fly-ash, cellulose fibre and water. In this application, compression strength is of primary importance. A low fibre content is used to stabilise the rheology of the three-phase air, water, powder mix during the vacuum dewatering stage of the Micro Internal Compaction moulding process. SmartBlocks are autoclaved after moulding. The density of this product is 1100 kg m<sup>-3</sup> while the hollow product with a 50% void ratio has a gross density of 550 kg m<sup>-3</sup>. There is no significant alignment of fibres and the process produces an essentially isotropic material.

UMA claims a wide range of advantages for its product, including environmental and occupational health and safety benefits, reduced construction costs and improved thermal and other functional characteristics. The fine-grained high precision surface of the SmartBlock can be sanded and painted to achieve a plaster style finish for both internal and external applications. By January 2001 a new three-head moulding machine will have allowed production to increase from the current 5000 blocks per week to 50 000 blocks per week. In the longer term UMA plans to establish a series of plants adjacent to coal-fired power stations to take full advantage of the benefits of industrial ecology. The first of these is planned to commence production in 2002 and will have a capacity of 10 million blocks per annum. Negotiations are underway regarding the development of plants in both India and China.

ATP continues research directed towards exploring other applications of its Micro Internal Compaction technology. In particular, it is working with high cellulose fibre mixes on a variety of linear, sheet and decorative products where flexural strength becomes significant. It

aims to use the unique characteristics of its production technology, including the ability to mould aerated low-density products, to open up new applications for fibre-cement products.

Australian research led the world in finding an alternative to asbestos in fibre-cement products. That revolution in relation to the material was not matched by any significant change to production processes. Cellulose fibre-cement sheeting and pipe products continue to make use of the old Hatschek process originally developed nearly 100 years ago for use with asbestos-based products. The Australian-developed Micro Internal Compaction process, together with developments in cellulose material technology, opens up possibilities for new environmentally sustainable products that could transform the building industry.

#### **Further Global Expansion: James Hardie Industries**

In 1983 James Hardie and Cape Industries of the UK formed a joint venture, Fibre Cement Technology (JHI 1984). The objective was to market the new technology they had developed, to manufacture asbestos-free fibre-cement building products to interested companies throughout the world.

It was stated in 1985 that the UK manufacturers had replaced asbestos in about 50% of fibre-cement sheeting products (Crabtree 1986). James Hardie by this time had totally replaced asbestos fibre in its range of building products, which included flat sheet, corrugated roofing and moulded products, throughout Australia and New Zealand. Part of the Malaysian production by the company was also free of asbestos. The Indonesian interests had been sold in 1986 for financial reasons. The Malaysian operation also ceased about this time.

As well as flat-sheet products, James Hardie had become a world leader in injection moulded fibre-cement products and non-pressure fibre-cement pipes, all based on wood fibre as the reinforcing material. The first experimental production of wood-fibre-reinforced cement pipe was undertaken at the Brooklyn factory in September 1980. Commercial production began in Western Australia at the Welshpool factory in July 1984. The last asbestos pipes made by James Hardie were manufactured in March 1987.

In the late 1980s James Hardie introduced imported wood-fibre-reinforced cement products into the USA market. At that time fibre-cement composites represented less than 1% of the large sidings market. The market comprised wood-based materials (~51%), vinyl (~28%) and inorganic products (~20%). By 1999, fibre-cement could claim more than 9% of the sidings market in the USA.

In 1990 James Hardie built its first plant at Fontana, California, to start manufacturing in the USA. Although the product was initially slow to be accepted by the building industry, the superior durability, fire resistance and value for money resulted in increasing market share, and by 1994 the company started to build its second plant at Plant City, Florida. It was not until 1995 that demand for the product suggested that the technology had been fully accepted. In 1997 a third plant at Cleburne, Texas, was opened followed by a fourth plant at Tacoma, Washington (1999). In November 1999 James Hardie announced that a fifth plant would be constructed at Peru, Illinois.

The in-house research that James Hardie has undertaken over many years has provided it with proprietary product and process technology that enables it to offer the widest product range and to benefit from significantly lower capital and operating costs, compared to competing fibre-cement technologies.

Recent research by James Hardie, involving a team of staff from the Sydney and Perth laboratories in Australia and the Fontana laboratory in USA, has resulted in the development of 'Harditrim'. This innovative material is a low-density product that can be made thicker than normal panel products and therefore can be used on corners, columns, windows and gables where current products are unsuitable. James Hardie commits some A\$25 million per annum to continuing research into wood-fibre-reinforced cement products and process technology and estimates the potential long-term fibre-cement market in the USA, in areas such as sidings, roofing and trim products, to be worth up to A\$4.8 billion a year. At the moment James Hardie has ~A\$400 million sales — 85% of the fibre-cement market in USA.

The global market could be as large as A\$15 billion when it is noted that more than two-thirds

of the fibre-cement industry still uses asbestos; global pressure will drastically change this situation in the near future. The European Union has declared that it will ban asbestos-cement products by 2005. South American countries are also starting to move against asbestos.

A joint venture with Jardine Davies, Inc., resulted in the development of a \$50 million plant in the Philippines. This plant was commissioned in 1998. James Hardie has recently further expanded its manufacturing capability in Asia. Once again it has formed a joint venture with Malaysia's UAC Berhad. This 50/50 venture will link the James Hardie Philippines plant with the UAC plant in Malaysia, giving the combined group a capacity of 220 million square feet a year. James Hardie has estimated that within five years its Asian business could be as big as its billion square feet a year USA business. James Hardie is confident that fibre-cement composites will replace traditional materials such as plywood in house construction in Indonesia, Malaysia and the Philippines, and masonry products in Taiwan and Hong Kong.

### Conclusions

Australian research groups have been major contributors to the global success of wood-fibre-reinforced cement composites, products totally free of asbestos fibres.

James Hardie Industries deserves the position it holds in the global marketplace due to its commitment and perseverance, especially during the early years in the USA when it experienced a period of operation without profit.

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