Cement boards are made of mixtures of cement, water and either reinforcing fibres or particles. The resulting mix is formed into sheets or continuous mats, stacked (and/or pressed), dried and trimmed to size. There are four distinct categories:

- Fibre Cement Board (FCB) 48.0%
- Cement Bonded Particle Board (CBPB) 18.0%
- Wood Strand Cement Board (WSCB) 6.0%
- Wood Wool Cement Board (WWCB) 28.0%

Each type of board has its own manufacturing process, which will be covered in more detail later.

**Why use cement board?**

The use of cement board in the construction industry is increasing due to its advantages over traditional building materials. A brief summary of the advantages and disadvantages are detailed below:

**Advantages:**
- Savings in cost, space, time, convenience,
- Environmentally-friendly,
- Highly-durable, impact-resistant,
- Resistant to fire, water, vermin and fungus.

**Disadvantages:**
- High initial cost,
- CBPB and FCB are around twice as heavy as gypsum-based board systems, so are expensive and awkward to transport and handle.

Significant savings can be gained through the use of cement board despite the initially higher cost when compared to gypsum wallboard due to its increased longevity.

Figure 1 shows the division of cement board types being produced worldwide by 90 global manufacturers. Fibre cement board, the oldest board type, has 43 global producers, while wood strand cement board (also known as EltoBoard) has only six.

Typical cement board applications vary widely between the different board types due to the variable properties of each, but commonly include:

- Tile substrates, flooring and underlay,
- Kitchen counters, backsplashes,
- Roofing, shingles and shales,
- Weatherboard, façade, cladding,
- Prefabricated houses,
- Exterior and partition walls,
- Acoustic and thermal insulation,
- Soffits, ceilings and architraves.
Fibre Cement Board (FCB)

Fibre cement board (FCB) has been used since the 1900s when Ludwig Hatschek first combined 90% cement and 10% asbestos fibres with water. The mixture was run through a cardboard machine to produce asbestos cement board. This board was widely used for residential construction until the 1970s discovery that asbestos cement board causes mesothelioma (a rare form of lung cancer), at which time many countries strictly prohibited its use. FCB is not only the oldest type of cement board, but also the most widely used and produced. It is manufactured by 43 companies worldwide, 48% of cement board producers.

Fibre cement board consists of cement, water, silica, limestone flour and fibres, be they recycled, synthetic or cellulose pulp. Optional additives, including silica fume, metakaolin ($\text{Al}_2\text{Si}_2\text{O}_5$), fly ash, calcium silicate, flocculants (chemicals that promote coagulation) and defoamers may also be used.

The strength of FCB is dependent upon the composite fibres in several ways. Synthetic fibres such as Kevlar or carbon produce the strongest board, which is both moisture resistant and very expensive. Cellulose fibres can contain high levels of sugars and other organics that increase cement setting time and reduce the board’s water resistance, although the use of kraft pulps, which release only very low amounts of sugar, can help to combat this. They can also contribute to an increased saturated mass, poor wet-to-dry dimensional stability and lower saturated strength, which can lead to freeze/thaw damage. The latter can, however, be controlled by appropriate board formulation. Recycled cellulose fibres are both environmentally friendly and economical, but are shorter than virgin fibres and as such produce weaker boards.

Fibre cement board is fire, moisture, impact and decay resistant and also lightweight, rendering it easy to handle and transport. It is also possible to print wood or brick effects directly onto it with a texture imitating plate, rendering it highly decorative. FCB is suitable for both internal and external applications, including weatherboard and façade, roofing, cladding, external and partition walls, underlay, flooring and tile-backing. Prefabricated housing projects using FCB can be seen in New Zealand, Spain and much of Africa, while in 2007 James Hardie constructed the Denny Park Appartments in Seattle, USA. The complexes are owned by the Low Income Housing Institute and are made from a combination of metal, Hardieplank and HardiePanel, which are sustainable FCB products with a 50 year guarantee.

There are three processing methods employed for the production of fibre cement board, namely the Hatschek process, the Extrusion process and the Perlite process.

Hatschek process production of FCB

The most common production method used is the Hatschek process, during which unbleached cellulose fibres are re-pulped in water and then refined before being mixed with cement, silica and various additives. The mixture is deposited onto a wire substrate, vacuum de-watered and cured to form a cement board sheet. This air cured process is well suited to the production of roofing products and all applications where the sheets are directly exposed to harsh weather conditions. The main disadvantages of the Hatschek process are the large quantity of waste water produced and the fact that it can only produce fibre board in sheet form. Efforts to reduce the amount of water wasted have included installing filtration systems or adjusting the water pH for re-use.

Extrusion process production of FCB

An alternative manufacturing method that enables the production of three-dimensional blocks of fibre cement with less wasted water is the Extrusion process, taken from the plastics industry. It involves forcing a highly viscous mixture through a shaped die. Achieving the right viscosity requires multiple additives, including binders, dispersants and surfactants, which increases the production cost.

Perlite process of FCB

Both Knauf and USG’s Durock apply a different methodology that requires the inclusion of perlite,
a naturally-occurring volcanic glass material with a high water content. Knauf adds expanded perlite to cement, silica solution, thickener and a hydrophobing agent. This combination is then pressed in a mould, shaped and left to harden. The product is then finished in a dryer.

**Wood Wool Cement Board (WWCB)**

Wood Wool Cement Board (WWCB) was initially developed in 1920 by Josef Oberleitner in Austria. It is manufactured by 25 companies worldwide, which is 28% of all of the cement board companies. European producers alone produce in excess of 20Mm²/yr of WWCB.

WWCB comprises wood ‘wool’ fibres, cement, water, a salt solution and (optional) additives for property enhancements. Although individual recipes vary between companies, a general proportion of wood wool (by dry weight), cement and water of 1:2:1 is typical. The wood wool itself is made from softwood, usually industrially grown FSC pine, spruce, eucalyptus or poplar. The logs are felled, debarked and dried for several months to reduce the moisture and sugar content by natural fermentation. A high sugar content inhibits the cement curing during manufacture. The wood is then shredded into fibres that measure 25cm long, approximately 0.35mm thick and 1-5mm wide depending on the application of the finished board. In the USA wood wool is known as Excelsior.

WWCB is characterised by an open matrix and a very low density (350-570kg/m³). The low weight of WWCB enables easier handling and reduced-cost transport. WWCB is resistant to fire, moisture, wet and dry rot, vermin, termites and fungus.

WWCB is primarily used internally for decoration, underlay and insulation (thermal and acoustic), but also finds application in permanent shuttering and roofing. The construction of low-cost housing in developing countries is a major application of WWCB. One such example is the ‘Climatex Project,’ which was undertaken in 1980-1982 in Porto Alegre, Brazil. More than 7000 affordable houses were constructed and reported to be highly versatile due to their relatively easy extension and renovation at a later date. They were also judged to be impressively long-lasting upon follow-up inspections in 2010.

WWCB production was originally relatively basic, with large workforces performing most of the work by hand. In some countries, including the Philippines, WWCB is still manufactured on a relatively small scale this way. In 1960 Braun and Schneider (Germany) developed a reliable wood wool shredding machine for use in larger plants, which was the start of safe semi-automated production. Also in 1960, Holland’s Gerry van Elten, founder of plant manufacturer Eltomation, streamlined the WWCB production process to enable the even distribution of the mix using continuous moving moulds, which rendered huge improvements to the quality of the cement board product. Van Elten might be considered the ‘fire-starter’ behind the entire wood-based cement board industry. Most recently Eltomation reinvented the shredding process with its fully automated Eltomatic CVS-16 wood wool machine, which has a wood wool production capacity of around 4000kg/hr. There are approximately 30 Eltomatic CVS-16 wood wool machines currently in operation in WWCB plants throughout the world.

The modern production process begins with the shredding of the dry wood into wood wool, which is then dipped in a 2-4% sodium silicate solution. The wood wool, cement and water is mixed and then distributed into moulds. A stacking press applies pressure, followed by the application of a concrete weight for 24 hours to promote bonding, which also acts to partially petrify the wood fibres, increasing moisture resistance. The resulting board is left for 10 days to allow the cement to fully cure and finally trimmed and finished to specification.

**Cement Bonded Particle Board (CBPB)**

Cement Bonded Particle Board (CBPB) was first produced by Switzerland-based Durisol in 1970 under the trade name Duripanel. It was initially an extremely popular product due to the race to replace asbestos boards. While Durisol was originally one entity, it is now divided into region-specific companies, such as Durisol UK. Durisol is now a brand-name product that is sold world-wide by independent companies. CBPB is currently produced by 16 manufacturers around the world, which is 18% of world-wide cement board producers. Demand has not changed
much since its initial entry onto the market.

CBPB is made from cement (60%), wood chip particulate (20% by dry weight) and water (20%). Small quantities of additives may also be added to improve cement setting times. The previous percentages are approximates only, as the actual recipe varies widely between companies. For example, Versaroc cement bonded particle board (produced by the Mayapple Corporation) contains 71% Portland Cement, 19% wood particles, 9% water and 1% bonding agent.

CBPB has a typical density of 1250-1400kg/m³. The relatively high density reduces the board flexibility and requires the pre-drilling of holes for fixture. This type of board possesses relatively high expansion and shrinkage properties when exposed to moisture due to its high wood content. A high pH (11) makes it extremely durable and resistant to wood-boring insects and fungi. CBPB also has a high level of fire-resistance.

The applications of cement bonded particle board vary widely between countries due to differences in cultures and building codes. In Western Europe and Russia it is used to produce large hollow prefabricated housing components which are shipped to the construction site and filled with concrete once assembled. In Japan, which boasts a very advanced CBPB industry, a trend towards using CBPB to replace traditional wooden exterior cladding has received full government backing following a series of city fires. The board is painted and embossed with a variety of decorative finishes to produce attractive buildings. In the USA popular CBPB applications include soffits (supportive understructures e.g. under arches, architraves, eaves and cornices), ceilings, roofs and modular building construction. Global applications include the production of fire and moisture resistant furniture and permanent shuttering for concrete floors and walls.

There are two manufacturing processes, Bison and Eltoman, for cement bonded particle board, each of which produces a different type of board. The production plants typically produce their own supply of wood particles in-house, either by the refinement of purchased paper mill chips with hammer mills, knife ring flakers, refiners and screens, or directly from wood logs using a drum flaker and refiner for processing.

**Bison plant production of CBPB**

The Bison process produces CBPB that comprises one or two thick board layers made with coarse particles, sandwiched by two thinner layers of board made with fine particles. As such, Bison plants use two separate mixers. The fine particle layers are distributed by airflow and the coarse layers are mechanically distributed.

Bison plants may become increasingly scarce in the cement board industry since Bison was taken over in 1996 by Kvaerner AS of Oslo and production was halted. Bison board is still produced by several companies, including India’s NCL Industries Ltd. In 1999 the Greten family, who originally owned Bison, founded Binos GmbH. Binos produces MDF/HDF, OSB and OPB lines, in addition to new and improved Combi-System CBPB plants. The new plants have improved capacities and enhanced product quality over dated Bison plants, which it also provides upgrades and modifications for.

**Eltoman plant production of CBPB**

The Eltoman process produces CBPB that is typified by fine surface particles that gradually change to coarse particles in the centre and fine particles on the other side. Eltoman plants use one large mixer and two mechanical distributing machines that are positioned opposite each other. They distribute a combination of fine and coarse particles throughout the distribution process, separating the fine from the coarse in accordance to current board position.

Eltoman no longer produces CBPB plants, although it does upgrade existing plants. Sources at Eltoman state that this is due to the improved alternatives provided by the combination of WWCB and WSCB, in terms of plant cost and flexibility in product range.
Wood Strand Cement Board (WSCB)

Wood Strand Cement Board (WSCB) was developed in 2000 by Eltomation and is marketed under the trade name EltoBoard. While non-EltoBoard WSCB does exist, such as that made by hand in the Philippines for housing projects (also known as high density wood wool cement board, HDWWCB), the board is more comparable to WWCB in terms of its impact resistance and strength. References to WSCB herein should therefore be taken to refer to EltoBoard-type WSCB only.

WSCB is the least common type of cement board, with only six manufacturers at the time of publication. While two companies in China possess plants that are capable of producing WSCB, to date they have been used primarily for the production of low-density WWCB since their construction. Given that WSCB is still relatively new to the market, more manufacturers may add WSCB to their repertoires in years to come.

The basic mixture needed to produce WSCB is much the same as WWCB, namely a mixture of wood fibres, cement and water in a 1:2:1 ratio (by dry weight). The use of additives during the production of WSCB is also common. Wood strand cement board differs from wood wool cement board mainly by density, which results from alterations to the manufacturing process and the wood fibres. Significantly, the wood fibres in WSCB are thinner and wider than those used in WWCB production.

WSCB possesses fire, moisture, fungal, impact and insect resistance. As a medium density board (1100kg/m³) it has a remarkably high strength. Great scrutiny has been placed upon WSCB, with extensive scientific analysis performed to assess its properties. Terry Brady, Alaskan consultant on natural resource development and conservation issues, performed in-depth tests on the durability and resistance of WSCB:

“The samples were virtually indestructible under ordinary severe environmental conditions (snow, rain, wind, freeze, solar UV, boiling and exposure to flame).”

The production process of WSCB is almost identical to that of WWCB, but requires the use of an additional clamping press to apply a greater pressure to produce the higher density board product. As such, a WSCB plant can also be used to produce low density WWCB.
Global cement board companies

Figure 2 shows the global distribution of the 90 cement board producers. Europe has 38 producers, six of which are located in Germany and three are in Denmark. Significantly, a remarkably high number (15) are UK-based which is surprising given the low number of UK-based cement manufacturers. The Americas also have a large number (20) of cement board producers, most of which are located in North America, although Brazil and Chile do both have one producer each. In contrast, Asia, the Middle East and Africa have 22 producers between them. That China has only five cement board companies is quite surprising given its dominance in the cement industry. However, this quantity may increase rapidly over the next few years given that Eltomation has installed six new WWCB/WSCB plants in China since 2010.

There are sure to be several companies around the globe which do not possess individual websites and as such are not represented in Figure 2. Additionally, smaller privately-owned companies which supply cement board exclusively to domestic customers may also not be featured.

The cement board industry

Opportunity for expansion in the industry is substantial since the raw materials are available locally to most nations. There is also a strong need for durable building products given the ever-increasing population sizes of most countries, especially those prone to severe natural disasters.

The slow recovery of the global economy, as reported in the IMF’s World Economic Outlook Database (see Table 2), is reflected in the gradual improvement of the global construction industry since the financial crisis of 2008. International cement producers have corroborated these findings. Housing start-ups in the US are growing at a healthy rate compared with recent years, while several companies, including James Hardie, are increasing board production capacities in the ASEAN nations in anticipation of an improvement in the Asian construction industry.

Most of the major cement board producers are privately owned companies that do not publish financial reports, limiting the analysis of company progress. However, by many accounts the businesses continue to expand into new markets and increase production capacity, which is indicative of a recovering market. Those companies that do publish annual reports describe very promising results. For example, James Hardie reported a 12% year-on-year increase in sales volumes of FCB in the US and Europe in fiscal 2013 and a marginal increase (0.004%) in Asia.

<table>
<thead>
<tr>
<th>Cement Board Type</th>
<th>Properties</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre cement board (FCB)</td>
<td>• Durable and impact resistant.</td>
<td>• Façades, weatherboard and cladding.</td>
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<td></td>
<td>• Resistant to fire, moisture and decay.</td>
<td>• Roofing, shingles and shales.</td>
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<tr>
<td></td>
<td>• Can be printed on.</td>
<td>• Exterior and partition walls.</td>
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<tr>
<td></td>
<td>• Can be expensive.</td>
<td>• Flooring, underlay and tile-backing.</td>
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<tr>
<td></td>
<td>• Relatively easy to handle due to low weight.</td>
<td>• Prefabricated houses.</td>
</tr>
<tr>
<td>Wood wool cement board (WWCB)</td>
<td>• Low bending strength and elasticity.</td>
<td>• Flooring, underlay and tile-backing.</td>
</tr>
<tr>
<td></td>
<td>• Resistant to fire, moisture, fungus, vermin and freeze-thaw.</td>
<td>• Roofing, shingles and shales.</td>
</tr>
<tr>
<td></td>
<td>• Easy to handle and transport due to very low weight.</td>
<td>• Permanent shuttering.</td>
</tr>
<tr>
<td></td>
<td>• Low cost.</td>
<td>• Prefabricated houses.</td>
</tr>
<tr>
<td>Cement bonded particle board (CBPB)</td>
<td>• High expansion/shrinkage properties when exposed to moisture.</td>
<td>• Acoustic and thermal insulation.</td>
</tr>
<tr>
<td></td>
<td>• Durable and impact resistant.</td>
<td>• Fire resistant construction.</td>
</tr>
<tr>
<td></td>
<td>• Resistant to fire, wood-boring insects and fungi.</td>
<td>• Ceilings and architraves.</td>
</tr>
<tr>
<td></td>
<td>• Prefabricated houses.</td>
<td></td>
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<tr>
<td></td>
<td>• Exterior and partition walls.</td>
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<tr>
<td></td>
<td>• Soffits, ceilings and architraves.</td>
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</tr>
<tr>
<td></td>
<td>• Production of fire and moisture resistant furniture.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Façades, weatherboard and cladding.</td>
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</tr>
<tr>
<td>Wood strand cement board (WSCB)</td>
<td>• High bending strength and elasticity.</td>
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Environmental concerns

Additional incentives that may increase the use of cement board include the increasingly stringent environmental policies being implemented globally. Reductions in CO₂ emissions and increases in the use of low-carbon cement products are being urged by organisations such as The Cement Sustainability Initiative (CSI). The 24 companies that participate in the CSI have reported the CO₂ emissions from cement production have fallen by 17% from 756kg/t in 1990 to 629kg/t in 2011. However, multiple sources state that in the absence of a large technological advance, CO₂ emissions from cement production will remain relatively high. This is further evidenced by Cembureau’s recent statement that a 75% ‘gap closure’ in emissions reductions by 2025 is unobtainable.¹³

As cement board contains reduced levels of cement and potentially hazardous chemicals when compared with concrete, it is an excellent environmentally-friendly low-carbon cement product alternative.

References