Innovation in the Production of Cement-Bonded Particleboard and Wood-Wool Cement Board

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INTRODUCTION

Eltomation supplies modern state-of-the-art plants for the manufacture of various mineral bonded boards and elements. This lecture will give an overview of the most common known mineral (inorganic) bonded wood fiber products. Special attention will be paid to Wood Wool Cement Board (WWCB), EltoBoard and Cement Bonded Particle Board (CBPB) where new technologies, equipment and products recently developed by Eltomation and others will be highlighted.

BACKGROUND (Figure 1)

In the early fifties the undersigned Gerry J. van Elten, practising mechanical engineering as a student in a wood wool cement board factory in Holland, learned about the need for automatic equipment for mass production and consistent quality of wood wool cement boards. In 1956 Elten Engineering was founded and the following years over 10 patents were obtained on new machinery, technology and board types.

Until 1989 more than 140 automatic plants for the manufacture of Wood Wool Cement Boards, Cement Bonded Particle Boards and Gypsum Bonded Fiber Boards (GBFB) were exported worldwide, including 29 plants to Germany.

In 1989 Elten Engineering was devided between me and my partners. The partners remained owners of the office, the factory buildings and the other activities (cheese storage systems and automated warehouses). I obtained all the patents and pending patents on wood processing and wood wool (excelsior) production machinery and, together with my sons, founded the new company Eltomation in Voorthuizen. Since then several new technologies were developed and patented by Eltomation. Nowadays, Eltomation is the world's most experienced plant supplier dedicated solely to the Mineral Bonded Board industry.

Durisol of Switzerland was a company producing various wood residue cement products. They took the first licence from US researchers to produce high density oriented Wood Wool Cement Boards. Durisol developed this board into high density CBPB with fine wood particles and the first CBPB plant was built in Switzerland under supervision of the Durisol engineer Hans Knöpfel who therefore can be considered as the pioneer of CBPB. The production started in 1969. At the same time others installed a plant in Japan for the production of lower density CBPB using coarser wood particles. After Durisol was taken over by another company, Mr. Knöpfel worked for the company Versatec and continued engineering CBPB plants.

In 1992 Mr. Knöpfel joined Eltomation as a team member, thereby combining the know-how and experience gained from the design and supply of 10 complete CBPB plants, approx. 150 WWCB plants, 2 GBFB plants and various other wood residue cement board plants.

OVERVIEW OF MINERAL BONDED BOARDS

The main mineral bonded wood fiber boards are listed in Figure 2, grouped according to binder type and wood fiber size. Of these board types, WWCB and CBPB are the main types. The following sections deal mainly with these two type of boards.
1. Wood Wool Cement Board (WWCB)

The production of WWCB had already spread over Europe in the thirties, several years after wood wool gypsum boards and wood wool magnesite boards were successfully produced and applied in Austria. After 1950 WWCB has spread world-wide. In industrialised countries automatic plants were installed, in developing countries usually only certain essential sections to reduce the investment and to employ people.

Until recently no fully automatic WWCB plant could be supplied, since all wood wool shredding machines were manually operated. Besides being unhealthy and dangerous for the operators these machines produce wood wool of an inconsistent quality, while the capacity is relatively low.

For the production of special WWCB boards special plants were built, such as having two distributing machines for the production of reinforced or sandwich boards, or plants with a cement screeder for the manufacture of boards with a finish.

WWCB Applications

Traditionally wood wool cement boards have been applied in Europe as a base for gypsum plaster or cement stucco and for permanent shuttering and insulation of concrete. Later in some countries (Scandinavia, Holland) non stuccoed, spray painted acoustic ceiling boards have proven to be very successful and are now increasingly being used in several other countries as well.

In the sixties so called Sandwich or Composite Boards were introduced, offering higher insulation values. These boards consist of one or two outer layers of WWCB with a core of a rigid foam of polystyrene or polyurethane. To further improve the fire resistance also composite panels with mineral wool are produced.

For an increased span of roofing boards, wooden laths (Holland) or poles (Sweden) embedded in the boards allow for a free span of up to 1, respectively 2 meters and with steel channels at the edges.

Figure 2: Overview of Mineral Bonded Wood Fiber, Particle and Strand Boards (not including Cellulose Fiber Cement Boards)
(UK) up to 4 meters. In case of a special shape of the board and channels according to our UK Patent 1,094,689 a free span of up to 6 meters is obtained.

In developing countries various systems were developed for mass production of low income houses. For the description of these systems I refer to my earlier lectures for the Food and Agriculture Organisation of the United Nations (FAO) and the World Association for Element-Building and Prefabrication (WAEP). Copies are available on request.

**What is new on Wood Wool Cement Boards?**

*Eltomatic Rotating Wood Wool Shredding Machine*

Safe and fully automatic production of wood wool is now possible by using the Eltomatic Rotating Wood Wool Machine (Figure 3). This machine has 16 'Slot Knives' in a rotating horizontal disc. Attached to the machine is an automatic saw which cuts 50 cm long wood blocks, coming from the automatic logging saw, into halves. The 25 cm long blocks are automatically placed between feedrolls at two opposite stations above the rotating disk. During cutting the blocks are firmly held and in a controlled way pushed down by hydraulic rams. The new and patented Eltomatic Slot Knives cut the wood blocks into high quality wood wool strands of controlled shape ranging from very narrow to very wide strands including clean cut strands for OSB boards.

The capacity (up to 80,000 strands per second) is very high, replacing up to 10 traditional wood wool machines. The rotation speed is adapted to the demand of wood wool and the diameter of the blocks. The hydraulic rams allow virtually 100% use of the wood, which means that the common special planing machines for rest pieces can be omitted too.

*New Eltomatic Slot Knives*

For the new Eltomatic a new type of knife was developed: the Eltomatic Slot Knife. Slot Knives cut with the grooves and not with the teeth and because there is no free space in front of the teeth, chips and whiskers can not occur anymore as illustrated in Figure 4, which shows the position of the Slot Knives in the disc. The knives are placed in alternating even and odd positions so that the knives in even positions cut 50% of the wood to strands and the knives in odd positions cut the other 50% of the strands in between.

The cutting edges are situated in such a way that heat, generated during shredding, is easily passed on to the body of the knife. This increases the cycle time of each knife to more than 8 hours between grinding.

A special quick-lock system reduces down-time for changing knives. The knives can be precisely set up in knife holders outside the disc. With a hydraulic tool the 16 knife holders in the disc can be exchanged within 15 minutes. As a result of the Slot Knives the otherwise necessary extra labor to pick chips and whiskers from the surface of the fresh boards is not needed any more.
**New acoustic ceiling boards**

Narrow wood wool strands give acoustic ceiling boards a very attractive texture. With the new Slot Knives chip free wood wool with a width of only 0.75 mm can be produced, thus considerably improving the appearance of acoustic ceiling boards. It is expected that these new ceiling boards, combining fire resistance with very good acoustic properties and attractive appearance, will contribute positively to the sale of WWCB.

**Expandable WWCB plant**

Eltomation introduced the ELTOMATION EXPANDABLE WWCB PLANT especially for use in developing countries and for companies that are operating in an expanding market. The Expandable Plant can be installed in Phases according to Figure 5. Essential is that already in Phase I the dosing and distributing processes (which determine the final board quality) are automated and heavy equipment like wood wool machines, mixer and press are already positioned in place for the Phases II, III and IV. Depending on labor costs and the required production capacity several functions can initially be performed manually and be further automated at a later stage. Figure 5 lists the main production equipment and recommended level of automation for the respective Phases and capacities.

<table>
<thead>
<tr>
<th>Capacity (m³/shift)</th>
<th>Phase I 25-50</th>
<th>Phase II 75-100</th>
<th>Phase III 100-150</th>
<th>Phase IV 150-175</th>
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<tbody>
<tr>
<td><strong>Process</strong> (● = automatic, □ = manual)</td>
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<td><strong>Wood Wool Production</strong></td>
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<td>Logging Saw</td>
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<td>Wood Wool Shredders (350mm knives)</td>
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<td>6-8 or Eltomatic</td>
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<td><strong>Dosing and mixing</strong></td>
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<td>Wood Wool Submersion</td>
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<td>Wood Wool dosing</td>
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<td>Cement supply</td>
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<td>Cement dosing</td>
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<td>Mixing</td>
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<td><strong>Mat forming</strong></td>
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<tr>
<td>Distribution of mixture</td>
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<td>Mould transfer</td>
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<td>Separating Saw</td>
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<td>Stacking Press</td>
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<td>Mould stripping</td>
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<td>Mould cleaning &amp; oiling</td>
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<td>Board Trimming</td>
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*Figure 5: Production capacities and levels of automation at expandable Eltomation WWCB plants*

**Enlarged scope of raw materials**

Various new processes are now available to bind the cement with previously unsuitable kinds of fast growing (tropical) wood and agricultural waste like bagasse, bamboo and palm oil fibres. According to some new processes the cement setting inhibitors can be removed by washing and/or can be neutralized by chemical treatment.

Eltomation now avails of a new development (patents pending) enabling the immediate use of several kinds of freshly cut wood for binding with cement, even if cut in summer.
2. **EltoBoard and EltoPlank**

When with the production of WWCB (approx. 400 kg/m\(^3\)) a too dense WWCB board is produced it is dumped as waste. However, in the Philippines I discovered this purposely produced board with a density of approximately 900 kg/m\(^3\), being very successfully used for normal and low cost housing. This board in the Philippines is called High Density Wood Wool Cement Board (HD-WWCB). It is getting very popular due to its favorable price and excellent properties such as its resistance to moisture and termites.

Until recently these boards were produced in simple hand operated plants of low capacity having no controls for equal quality and thickness. However the first fully automatic high capacity Eltomanation production plant has been put in operation in April 1999. Automatic plants to produce these boards are identical to WWCB plants, but after the piling press one extra press with much more pressure is needed to close the bundle of wooden moulds with rims. Then clamps hold the bundles tight for at least 8 hours of setting. Stripping of the moulds and sizing of the boards are the same as for WWCB.

Eltomanation has developed this board further into embossed and painted board with a closed surface. These and all other by Eltomanation equipment produced dense wood wool and - wood strand - cement boards are called EltoBoard and EltoPlank.

The low income house in Manila, shown in Figure 6, is made of EltoBoard. It withstanded the force of a 250 km/hr hurricane. Not only the walls but also the floors, doors, certain furniture and shingles on the roof are made of EltoBoard. The frame of the house consists of a few concrete beams which are filled in with thick boards or wooden battens to which on both sides thin EltoBoard boards are fixed. The ceiling consists of wooden beams with 25 mm thick EltoBoard panels on which a 3 cm meshwire reinforced concrete floor is poured for the sleeping rooms upstairs. Sometimes the boards are painted or stuccoed at the ground floor level.

Due to its excellent properties, and in comparison to CBPB the high production capacity and relative low investment needed for a plant, I predict a great future for this product.

We are now testing the lighter and relatively stronger EltoBoard to be used for permanent shuttering elements instead of the heavier and more expensive CBPB.

The decisive factor for companies considering to start a production of Fiber Cement, CBPB or EltoBoard may be that the investment for a plant to produce EltoBoard is less than 40% of the investment for a CBPB plant with the same capacity and board dimensions and less than 20% of a Fiber Cement Board plant.
3. Cement Bonded Particle Board (CBPB)

In 1977 my company built its first plant for the production of CBPB. However, this concerned a relative low density board with a brickwork-like embossed and painted surface, used for external applications. The plant was installed near Dortmund, Germany. The embossing was obtained by pressing or milling.

Mainly for the reason that these panels, produced in wooden moulds, were to small and the public in Germany disliked the sometimes visible joints between the boards, no further plants for this type of boards were built again. The panels at the houses built at that time however are still in perfect shape after more than 20 years, being repainted with synthetic paint only once.

In the eighties, when the high density and larger size CBPB panels, developed in Switzerland, got accepted in the market, my company built and supplied some large CBPB plants to the former Soviet Union. These plants were already equipped with the very successful mechanical distributing machines instead of the usual air supported distributing machines.

**CBPB Applications**

Being suitable for all climatic conditions, highly fire resistant and impervious to termites, vermin and mold, CBPB is a very versatile building material.

In Europe on the continent it is mainly applied as fire resistant partitioning, outside wall cladding, floor units and for permanent shuttering systems. In Hungary also for wall and roofing shingles and prefabricated housing. In the UK mainly for internal wall claddings as ceiling boards and for flooring with built-in heating systems. In Japan several plants are producing embossed and painted panels for cladding of outside walls.

**What is new on CBPB boards?**

New technology for extremely even mat distribution

In 1992 the owner of the Amroc/Zehoma CBPB plant in Magdeburg, Germany, demanded quotes for renovation of his CBPB plant because of complaints about board quality and thickness tolerances. Eltomanation developed and built a new mechanical distributing machine to produce CBPB boards with extremely low thickness variations.

This development is so successful that due to the very even distribution also thin boards of 4 mm thickness can be produced. The first stack of 6 mm boards produced in Magdeburg was so precisely formed that all boards were within a thickness tolerance of ± 0.2 mm. Such narrow tolerances make costly sanding unnecessary. Further the boards have smooth surfaces of very fine particles while the particle size gradually increases toward the centre of the board, as illustrated in Figure 7.

As a consequence of the very even distribution also very high density boards can be produced up to 1500 kg/m³, which results in very high bending strengths of up to 17 N/mm² while the CEN norm for CBPB requires only 9 N/mm². Of the boards produced with this new distributing technology at Amroc/Zehoma in Magdeburg 98.4% meet the tolerances guaranteed by Eltomanation, which are more stringent than the CEN Norm and the British Standard.

To maintain a high capacity in m³ also with thin boards, thin boards can be produced at nearly double speed and processed in a special way.

![Figure 7: Cross-cut of 40mm CBPB panel](image-url)
Waste Management
To reduce the amount of wasted material several steps are taken to prevent and re-use waste materials. Fresh material from the ends of the cauls at the caul accelerating station, from the fresh board weight checking station and from the board lengthening machine is fed back to the mixing area and re-used. Pretrimmed material from 8 hours cured board is also re-used after refining, storing and dosing. Up to 5% of this relatively fresh material may be added to the fresh mixture in the mixer without harm to the quality of the boards. Only a little amount of final trimmed-off material after drying has to be dumped.

Embossed surfaces
Not new, but still not widely known are CBPB boards with embossed and coated surfaces in various configurations like brickwork, wood grain or natural stone. Especially in Japan these boards are very successful. More than 90% of the Japanese CBPB boards have an embossed and coated surface and are used for exterior wall claddings (Figure 8). Based upon the success in Japan, several companies in various other countries are now testing the market for these boards. The surfaces are usually rolled or spray painted in the desired colours for which nowadays various suitable paints and coatings are available. The profiled moulds (cauls) of fiber reinforced hard plastics with embossed surfaces are so stiff and strong that they can replace the normal steel caul, however once in every 5 to 10 boards an extra steel caul may be added for extra stiffness.

Shingles
Also not new but very interesting is the development of CBPB shingles. In Hungary applications of painted and unpainted shingles on walls and roofs are common, but of special interest are the roof and wall shingles developed in some states in western USA. No doubt the notorious bush fires in California and Sidney, Australia and the influence of insurance companies help to promote these nice looking and inflammable shingles in the market. In Figure 9 wood grain structured CBPB shingles are stapled to a roof construction in California.
**Prefabricated wall and floor panels**

Eltomation is involved in the development of a plant for the production of large hollow CBPB wall and floor panels with an overall thickness of 15 to 30 cm, a wall height up to 280 cm and a length up to 600 cm. Figure 10 shows part of such a panel. Given the complicated moulds with expandable hydraulic retractable bodies and the very special press a CO₂ hardening process is applied. With this process only a few moulds are required. About every ten minutes one large panel can be produced.

The system will be developed in such a way that also large size sheet panels e.g. for shuttering of monolithic concrete can be produced. A pilot plant for the production of 120 x 300 cm panels is currently being installed at the Amroc/Zehoma CBPB plant in Magdeburg, Germany.

**Permanent shuttering of concrete**

Very interesting is the successful application of large size prefabricated wall and floor elements assembled of CBPB panels on the computer operated DUO-TEC assembly line. The computer programme is simultaneously created by the architect while designing the building. At the same time all calculation work is done by computer. The elements consist of CBPB panels, spaced with metal or high tensile plastic spacers and have the required internal reinforcements installed. Each element is precisely cut to the exact dimensions at the factory, including openings for cables, pipes, ducts, doors and windows. On site the prefab elements only have to be installed and filled with concrete, creating a monolithic construction. Before the concrete is poured, piping for water, gas and electricity can easily be installed in the hollow walls.

After the construction of the building the outer walls are insulated with 7 cm thick sheets of styrofoam which are finished with a thin layer of elastic stucco or finish. Figure 11 shows the front of such an apartment building under construction in Vienna, Austria. Three labourers only were needed to install all walls and floors for one storey each week. Due to the prefab system, this fast and highly efficient building method causes no dust, waste or the usual noise on the building site and provides for a quick return on investment. Figure 12 shows the preparation at the CBPB floor units before being filled with concrete.

**Figure 10:** CBPB hollow wall panel

**Figure 11:** Permanent shuttering with CBPB prefab elements

**Figure 12:** Installation the CBPB prefab floor units.
Figure 14 shows a picture of a complex of apartments built with the DUO-MASSIV permanent shuttering system in Osterweddingen near Magdeburg, Germany. Figure 13 shows the apartments during construction. For the assembly of the elements Eltomanation supplies small hand operated equipment as well as the fully automatic computer operated DUO-TEC assembly line.

Figure 13: Complex of apartments in Osterweddingen under construction.

Figure 14: Complex of apartments in Osterweddingen build with the DUO-MASSIV system.

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