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NEW DEVELOPMENTS IN THE FIELD OF WOOD CEMENT PRODUCTS, APPLICATIONS AND PRODUCTION TECHNOLOGIES

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ABSTRACT

This paper reports the further development of advanced production technologies for the manufacture of various types of wood cement boards and their applications. Due to the general awareness for healthy and comfortable living conditions with reduced energy costs, the demand for various types of wood cement boards, both for renovations and new buildings, has grown significantly over the last years. As a result, the demand for automated production lines for these energy-saving boards has also increased.

During the last years Eltomation BV has further developed and sold several new plant types which allow the production of Wood Wool Cement Boards (WWCB), Wood Strand Cement Boards (WSCB – EltoBoard) and the newly developed Large WWCB Wall Elements. In several cases multiple product types are combined in one plant for a wide range of products.

KEYWORDS:

Eltomation; Wood Wool Cement Board (WWCB); Wood Strand Cement Board (WSCB - EltoBoard); Large WWC Wall Elements; WWCB Production Technologies and applications.

INTRODUCTION

Eltomation BV of Barneveld, The Netherlands, is specialized in the development and supply of turn-key plants and equipment for the production of various Wood Cement Boards. The main products produced in these plants include: - Wood Wool Cement Board (WWCB); - Wood Strand Cement Boards (WSCB - EltoBoard) and - Large WWC Wall Elements. Clients in (Western) Europe include renowned producers such as Knauf Insulation, (incl. formerly Heraklith), Fibrolith – Germany, Celenit – Italy, Troldtekt (former Hammerich) – Denmark, Träullit – Sweden and others. During the last few years a highly increased interest for durable, environmentally friendly and energy-saving building materials has come from the large Russian and Chinese markets and other markets. In view of the high demand for various wood-cement boards, Eltomation has obtained orders for large wood-cement board plants, where the clients demand flexible production of multiple product types at a high output of up to 1.000 m^3 of finished product per day. This range of products will either be marketed and used as general building material or be used as intermediate product for pre-fab housing, in which case the output of the plant will be complete pre-fab houses. The demand for these combined plants required innovative and new technologies to be developed by Eltomation. One such new technology is the Large WWC Wall Elements system, which allows for quick and cost-effective construction, high thermal insulation and comfortable living conditions.

OVERVIEW OF MAIN WOOD CEMENT PRODUCTS

In general the following Wood Cement Boards are considered to be the main products which are on the market today:

1. Wood Wool Cement Board (WWCB);
2. Wood Strand Cement Board (WSCB/ EltoBoard);
3. Large WWC Wall Elements;
4. Wood Residue Cement Board (WRCB);
5. Cement Bonded Particle Board (CBPB).

This paper will mainly deal with the production technology for the first three mentioned product types. Each of these 3 product types require small diameter logs (mostly soft wood species such as pine, spruce, poplar, eucalyptus, etc.) as raw material, to enable the production of long thin wood wool or wood strands.

PROPERTIES OF WOOD WOOL CEMENT BOARD

Of the above described main Wood Cement Products, Wood Wool Cement Board (WWCB) is by far the most common product with a large number of plants in operation. To ensure its excellent properties in view of thermal insulation and sound absorption, WWCB is produced at a low density of only approx. 400 kg/m^3.

The main features of WWCB are:

- High fire resistance
- Wet and dry rot resistance
- Freeze-thaw resistance
- Termite and vermin resistance
- Excellent workability
- Exceptional insulation and acoustic performance
- Low cost and ease of manufacture

For increased thermal insulation, WWCB is also often produced as a (2 or) 3 layer sandwich board with a core of EPS/Polystyrene, Rockwool or PU-foam.

Figure 1 - Standard WWC Board

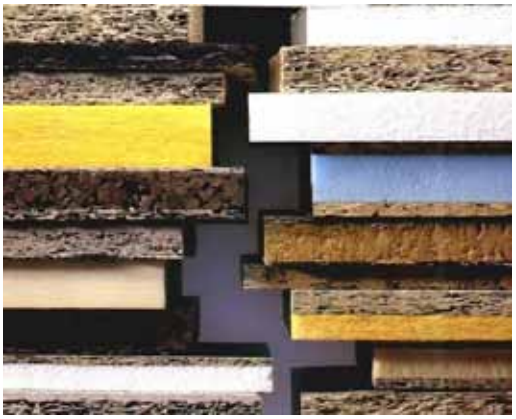

Figure 2 - Composite WWCB

APPLICATIONS OF WOOD WOOL CEMENT BOARD

Standard applications of WWCB include:

- Insulation board for external walls (and floors) as permanent shuttering;
- Roofing boards (reinforced);
- Acoustic ceiling applications;
- General board for insulation / renovation / fire protection.

Figure 3 - Permanent shuttering (WWCB)

Figure 4 - Reinforced roofing boards (WWCB)

Figure 5 - Acoustic ceiling panels (WWCB)

Figure 6 – Renovation (WWCB)

PRODUCTION LINE FOR WWCB

The (summarized) video shown during the presentation will show a typical Eltomation WWCB production line in full operation. Boards are typically 60/61 cm (2') wide and 240 – 300 cm (approx. 8'- 10') long. Thicknesses range from 15 to 150 mm. The capacity of a standard WWCB Plant is up to 465 m^3 per day with production speeds of the main line of up to 20 m/min. (in average one board per 7 seconds). Nowadays WWCB is produced in accordance with EN 13168 (formerly DIN 1101). Besides upgrading of such plants at the existing customer base in Europe, new similar turnkey WWCB plants have during the last years been supplied to South Korea, China (3) and Russia (2). Additional lines are currently under construction.

Figure 7 - Fully-automated Phase IV WWCB Plant

Figure 8 - Eltomatic CVS-16 Rotating Wood Wool Machine (cap.: 3.000 kg/hr.)

WOOD STRAND CEMENT BOARD (WSCB – ELTOBOARD)

The production of medium-density Wood Strand Cement Board (WSCB – EltoBoard) is accomplished on a standard WWCB Plant to which a special EltoBoard Press has been added, which will compress the fresh wood-cement mat to a much higher density. The result is a medium density board with structural strength (bending strength of up to approx. 20 MPa). Board dimensions are typically 60 cm wide and 240-300 cm long. Board thicknesses range from 8 to 25 mm. Eltomation is currently also developing a production line to produce WSCB - EltoBoard as 120 cm (4') wide boards, which will allow the client to cover a broader market-range, e.g. for replacing other structural boards such as Cement Bonded Particle Board (CBPB) and Oriented Strand Board (OSB), for reasons of moisture-, fire- or insect resistance. For a detailed description of the production process of WSCB, reference is made to the IIBCC 2006 (Sao Paulo) paper of Mr. G.J. (Gerry) van Elten. This Publication is available on the website of Eltomation (www.eltomation.com) under "Publications".

Figure 9 - EltoBoard Press

Figure 10 - EltoBoard applied in walls, floors and roof

LARGE WWC WALL ELEMENT BUILDING SYSTEM

During the last few years, a new revolutionary large-size wall system has been developed by one of Eltomation's clients, the company Träullit in Sweden. These large wall elements are made out of solid (although light-weight) WWC with dimensions of up to 6 m (20') in length, 2,7 - 3 m (9'- 10') in wall height and up to 40 -50 cm (1' - 4" to 1' – 8") thickness, subject to the local climatic conditions.

In addition to the excellent thermal insulation (0,19 W/m^2 ºC when 40cm thick), these elements also provide a high thermal storage capacity (250 kJ/m^2 ºC).

During the first years of production of the large WWC wall elements, Träullit has further optimised its product using semi-automated production facilities, such as for forming, demoulding, storage, cutting/finishing, etc. Eltomation has now developed a production line for the fully-automated production of such large elements at high capacity and reduced labour requirements.

Figure 11 – LE's ready for shipment

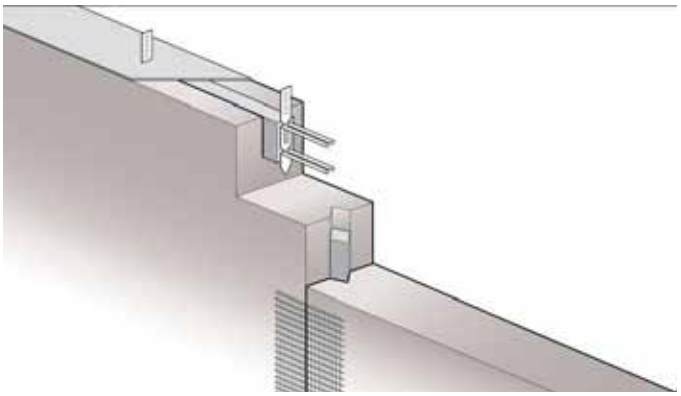

Figure 12 – Principle of construction

CONSTRUCTION WITH LARGE WWC WALL ELEMENTS

Due to the low weight of the wall elements one can transport up to 108 metres of large wall elements on a truck with a trailer. The elements are loaded into open containers, e.g. one container on the truck and two on the trailer.

Figure 13 – Economic (Just-in-time) transport

Figure 14 /15 – Placement of LE's

The Traullit large wall element system consists of a column/beam system of reinforced concrete that is cast on site after the elements have been mounted onto the foundation. In the joints between the large wall elements vertical V-shaped slits form a square cavity (approx. 70 x 70 mm) when the elements are mounted next to each other (Figure 12). At the crest of the large wall element the U-shaped groove (approx. 100 x 160 mm) forms the carrying (ring) beam that runs along the top of the element around the entire outer wall crest. The vertical and horizontal cavities and grooves are reinforced with steel bars and are cast on site after the elements have been stabilised with buttresses. During the mounting the corners can be stabilised with sharpened corner braces. These ensure stability for the casting process.

To get the correct cover layer of concrete around the reinforcement, rafter fastening irons are used. This is an arrow-shaped, 3 mm thick piece of sheet metal that has punched gaps for fixing the reinforcement bars and the fastening of the rafters. It is struck into the U-shaped groove of the large wall element crest. The walls are mounted with a mortar levelling on the foundation. A reinforcement bar in the joint between the large wall elements is anchored into the foundation and can be bound to the carrying (ring) beam. The load-bearing structures are the joint columns and the carrying (ring) beam. These are reinforced in order to be able to carry the appropriate loads. The large wall element itself has a compression resistance factor of 27kN per running metre. A possible bending down of the concrete beam is prevented by the large wall element that works together with the concrete ring beam. Once the wall elements have been mounted and the beams and cavities have been cast on site, the walls have to be air tightened so that no wood wool cement remains visible. This is particularly important around windows and the crest of the building where it will be impossible to plaster after the windows and the rafters have been mounted. Beams and struts that are placed in direct contact with the outside wall must also be plastered before they are mounted. The diffusion barrier on the inside of the roof is folded double and squeezed against the exterior wall with an L-shaped sheet metal profile. Between the wall and the diffusion barrier an EPDM-rubber is fitted.

Figure 16 -
Open Ring- beam

Figure 17 -
Anchors in ring beam for floor

Figure 18 -
Pouring of concrete

The rafters are anchored to the large wall elements by the arrow-shaped sheet metal pieces that were cast into the carrying (ring) beam. The actual amount of nails/screws needed for the anchoring of the rafters is determined by the wind load on the roof. Under each rafter a moisture proofing sheet must be placed to ensure no moisture is carried to the wood rafters. The gable walls are anchored to the roofing with screws and plugs all the way to the concrete beam in the large wall element joints to ensure a tight fastening of the gable. If the building is more than one level, the large wall elements are placed on top of each other and the

joint column runs all the way to the top of the upper carrying (ring) beam. The elements on the ground level must be mounted, reinforced and cast first before the large wall elements of the upper level can be mounted. Depending on the wind load the building must withstand (depending on location), the columns may have to be cast larger and be better reinforced to be able to ensure stability. The beam layout of a multilevel building can be made of wood or concrete. If wood is the chosen material, a strut with a cast-in threaded stainless steel bar is anchored onto the wall which the rafter can be hung into with an iron joist hanger. Concrete based rafters can be made of lightweight concrete or similar. All rafters, regardless of material, are mounted onto the inner crest of the large wall elements (Figure 17).

The elements are always lifted and handled by a crane and two or three construction workers that fit the elements together, buttress them, and manage the concrete casting on site. Such a work team can manage to lift down 5-6 large wall elements from the truck, fit them, and buttress them in an hour. A complete mounting with reinforcing, caulking the joints and casting on site naturally takes a longer time. On average one can complete a mounting of about two elements per hour.

Electricity fittings are simply milled into the wall since the large wall element is very easy to work with. (note: in the new fully-automated Large Element Line, an integrated CNC Centre can optionally provide all such openings for cables and piping in the plant). When all the fittings are finished the milled fittings are plastered over. After that the entire surface of the interior wall can be plastered.

Figure 19 – Inner walls prior to stuccoing

Figure 20 - Ready villa (215 m^2 living space)

Fastenings for e.g. kitchen cupboards and fittings are usually made with screws and plugs. The hole for the plug should be drilled a couple of millimetres smaller than what is recommended for the selected plugs. The drilling hole should be cleaned and air-proofed with e.g. mounting glue before the plug is mounted. After this the interior fittings can be mounted into place. A normal 10 millimetre plug has a vertical pulling load of 165 kilos per mounted screw. Stiffer plugs of the type that is used for lightweight concrete have a vertical pulling load of 300 kilos per mounted screw.

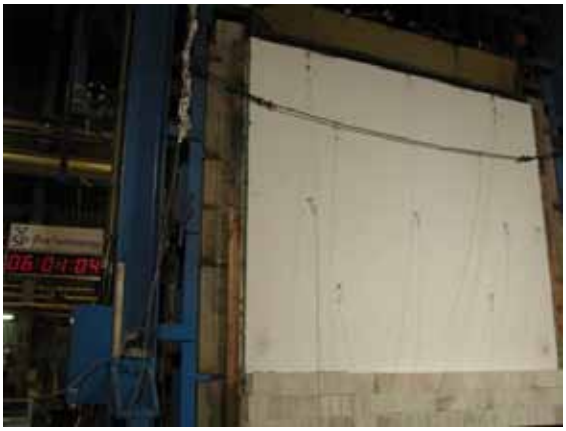

Figure 21 – Fire tests on LE, showing 6 hour fire resistance.

Träullit Large Wall Element, Thickness 400 mm	
Technical Data	
U-value	0,19 w/m² ºC
Fire rating	REI360
Heat storage capacity	250 kJ/ m² ºC
Critical RH (preliminary tests)	90 %
Air permeability	20 m³/mhPa
Bending strength	27 kPa
Load carrying strength	27 kN per running metre of wall
Density	Approx. 300 kg/m³

Table A – Main Technical Specifications of Large Element.

The Traullit large wall elements have obtained the highest fire-rating in Sweden. When tested the large wall element was subjected to a continuous fire during six hours. The temperature of the fire was 1200 degrees centigrade on the fire side of the wall, while the other side of the wall held a temperature of only 45 degrees centigrade.

COST ANALYSIS OF LARGE WWC WALL ELEMENTS

The Large WWC Wall Element System has proven to be very competitive in view of its relative low production costs, efficient installation and durability. The (ex. Works) sell price of the Large WWC Wall Element in Western Europe is up to approx. EUR 100,-- per square meter (subject to quantity and complexity per Element). The cost for the Elements for all outer walls of a typical single story house of 100 m2 living space will therefore be approx. EUR 12.000,- to 15.000,-- only. Considerable savings apply in the reduced construction time. For example 3 persons can install all such Elements for a 100 m^2 single story house within one working day. During construction no heavy cranes are required. In addition to the quick and easy installation, the Elements are easy to be worked on for e.g. cutting slots for electrical wiring (when not already done in the work-shop) and applying stucco.

PRODUCTION LINE FOR LARGE WWC WALL ELEMENTS

Eltomation has recently obtained an order for a plant for the fully-automated production of large wall elements. Dimensions for these large elements will be: 6 m (approx. 20‘) length x 2,7 meters (approx. 9’) height. The wall thickness will standard be based on 40 cm (approx. 1’ – 4”) subject to the climatic conditions. Initial calculations have shown that for the extreme cold climate in Siberia, Russia (temperature in winter at minus 40 ºC, being minus 40 ºF), a wall thickness of 35 cm will be sufficient. However, due to

specific wishes of the client for special applications, it was decided to determine the range for the wall thickness from 30-60 cm.

The capacity of the large wall element Line is designed to be approx. 500 m3 of finished product per day (based on a 3 shift production). This capacity is based on a standard production capacity of wood wool with one Eltomatic CVS-16 wood wool machine and the use of standard dosing and mixing units (similar equipment as currently used in the Phase IV 60 cm WWCB Plant). Based on an average element thickness of 40 cm, the plant capacity is therefore approx. 1.250 m^2 of large wall elements per day.

For the continuous forming of the mixture over the full 2,7 – 3 m width, Eltomation has developed a new large-size forming station, which will distribute the fresh mixture (over the full width) into continuously moving moulds as one long mat. The long (continuous) mat is separated at the next station by means of a so-called flying saw. Moulds are initially filled only half-full, which will allow the insertion of lifting-straps or reinforcements in the centre of the Elements. Hereafter, an automatic loop conveying system returns the half-filled moulds again to the forming station for filling the remainder of the mould.

Individual full moulds are thereafter placed into a first setting area for initial curing for approx. 24 hours. After curing, full moulds are automatically "stripped" / "demoulded" by means of a demoulding station to release the cured elements from the mould. Each element is thereafter transferred to a 90 ^{o} lifting unit, which will place the ready elements in an upright position. Ready Elements are thereafter taken to storage by means of the overhead crane system (or fork lift truck) for further curing. Empty moulds are cleaned and oiled and automatically returned to the forming station to again be filled with WWC mixture.

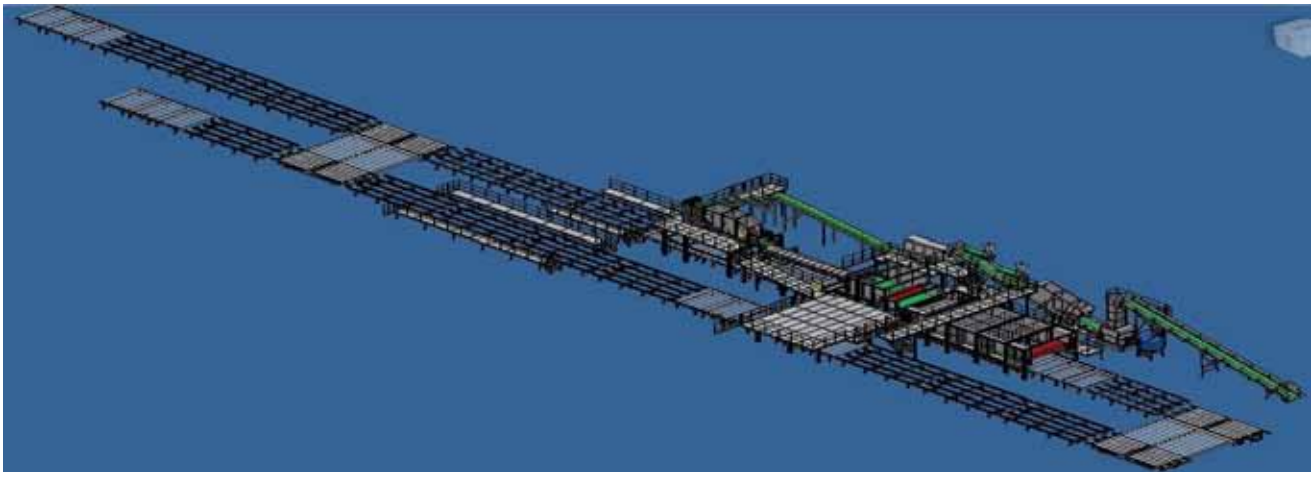

Figure 22 – Large Element Line, Loop and Forming System

PRODUCTION LINE FOR LARGE WWC WALL ELEMENTS IN COMBINATION WITH A STANDARD 60 CM WWCB/ELTOBOARD PLANT

To enable a client to produce the full range of WWCB products, being WWCB, WSCB-EltoBoard and large elements (LE), a plant concept was designed which would meet the following starting points:

- Total product mix of WWCB, WSCB and LE, which serves as basis for a complete pre-fab housing line;
- Capacity: up to 1000 m^3 per day of finished products;
- Both lines can either run independently from each other, or (optionally and at wish) the wood-cement mixture can be shared;

The following pictures show such Combined Phase IV WWCB - EltoBoard Plant (with a capacity of 12.000 m^2 per day or up to 465 m^3/day of WWCB) with a full-size large element line (with a capacity of up to 500 m^3 per day).

Such combined plant is currently under construction for supply to a client in China. Similar combined Plants will be supplied to clients in Russia and other regions.

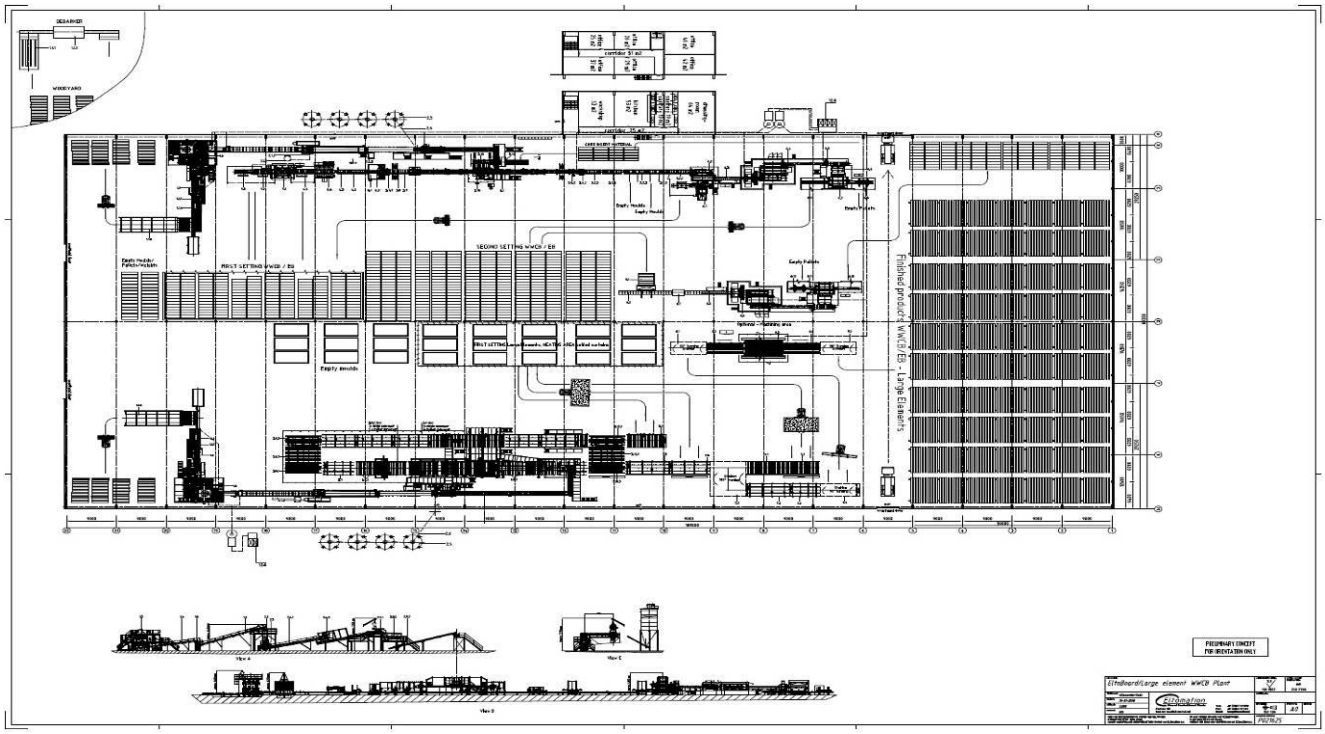

Figure 23 – Combined plant for 60 cm WWCB / EB and large elements with independent mixing groups, currently under construction for a client in China.

DURABILITY AND SUSTAINABILITY.

At the end of the life cycle (of over one hundred years) the WWC material can be re-used. Recently a Heidelberg Cement spokesman explained that the material can be ground to form basic ingredients for new cement production, thereby reducing the need for fresh limestone and clay. A leading Dutch architect has commented that WWCB is one of the few building products with a neutral Life Cycle Analyses (LCA) and complies with Cradle to Cradle principles.

Both scientific tests, initiated by customers of Eltomation, as well as open air application of WWCB have shown that WWCB is unaffected by over 70 years of open air exposure to the elements (even in countries with a high number of freeze-thaw cycles, such as Sweden). This property is further improved when the WWCB is stuccoed as is customary done for applications where the material is exposed to the elements.

SUMMARY (CONCLUSION)

Summarizing one can say that in recent years, worldwide there is a strongly increased demand to construct more energy efficient houses, combined with a high standard of living comfort. In addition home-owners require a durable product, which include properties such as fire-resistance, resistance against termites, fungi, etc. As a result there is a world-wide increase in demand for products such as Wood Wool Cement Board. This demand resulted in the development of the large WWC wall system. In view of the excellent properties of WWCB and the very efficient building system using these Large WWC wall elements, Eltomation expects a further demand for the "Combined Plant" concept. Such first fully automated combined lines will become operational in the summer of 2011 and may set a new standard for large-scale, durable and affordable, economic housing. Eltomation will continue its engineering and design activities to meet the demands of its client now and in the future.

ACKNOWLEDGEMENTS

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REFERENCES

E. J. (Bert) van Elten, Eltomation BV, The Netherlands. 2006. Cement Bonded Particle Board (CBPB) and Wood Strand Cement Board (EltoBoard): Production, Properties and Applications. 10th International Inorganic Bonded Composite Materials Conference. Sao Paulo, Brazil, 2006. Proceedings published by IIBCC.

G. J. (Gerry) van Elten, Eltomation BV, The Netherlands. 2004. History, present and future of Wood Cement Products. 9th International Inorganic Bonded Composite Materials Conference. Vancouver, Canada, 2004. Proceedings published by IIBCC.

G. J. (Gerry) van Elten, Eltomation BV, The Netherlands. 2006. Production of Wood Wool Cement Board and Wood Strand Cement Board (EltoBoard) on One Plant and Applications of the Products. 10th International Inorganic Bonded Composite Materials Conference. Sao Paulo, Brazil, 2006. Proceedings published by IIBCC.

Mattias Rückert, Nike Arkitektur AB, Sweden. 2008. Träullit Large Wall Elements. 11th International Inorganic Bonded Composite Materials Conference. Madrid, Spain, 2006. Proceedings published by IIBCC.

(Note: The above publications can also be found on the website of Eltomation under "Publications").