RECYCLING OF CCA-TREATED WOOD AND OPPORTUNITIES FOR WOOD-BASED COMPOSITES

for

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EXECUTIVE SUMMARY

Solutions are required to the problem of CCA-treated wood waste disposal or reuse in Canada. This issue will become more important in the coming decades as the volumes of CCA-treated wood currently in use are taken out of service. Incorporation of wastes as furnish in composites is one option and there is already industrial interest in the use of wastes from the "urban forest" in such products. While markets for many of the existing "commodity" composites are buoyant with increases in future demand anticipated and a literature review has indicated considerable research activity in the field, the use of CCA-treated wastes in composites currently presents a lot of questions and not many clear cut answers. A literature review, in combination with information on treated wood waste quantities and a study of market feasibility/consumer acceptance issues, suggests that use of CCA-treated wastes in wood/cement composites might be feasible and could be compatible with existing exterior applications for these products. Apart from the need to understand the practical impact of such wastes on the wood/cement composite process and product, key questions concerning market acceptance and effect on process cost need to be addressed. A feasibility study in cooperation with industry would establish whether specific details of technical viability should be investigated as a next step.
Au Canada, il est temps de trouver des solutions au problème de l’élimination et de la réutilisation des résidus de bois traités au CCA. Ce problème va s’amplifier au cours des prochaines décennies alors que les bois traités au CCA seront remplacés. L’une des options consiste à les utiliser dans la production des produits composites car l’industrie a déjà démontré son intérêt à recycler les résidus de la "forêt urbaine" dans la fabrication de tels produits. Alors que les marchés pour les produits composites de base sont soutenus, que l’on prévoit un accroissement dans l’avenir, et qu’une revue de littérature démontre qu’il y a beaucoup de recherches dans ce domaine, l’utilisation des résidus de bois traités au CCA dans les produits composites suscite bien des questions qui demeurent sans réponses précises.

À partir d’une revue de littérature, des renseignements sur les volumes disponibles et d’une étude de marché sur l’attitude des consommateurs à cet égard, on peut penser que la fabrication de produits composites bois-ciment, à partir de résidus de bois traités au CCA, pourrait être possible et compatible avec les emplois à l’extérieur de ces produits.

Mis à part le besoin de mieux connaître les problèmes d’utilisation de ces résidus au niveau du procédé de fabrication et du produit même, il faut s’interroger sur l’attitude des consommateurs et l’effet sur les coûts de production. Une étude de faisabilité réalisée avec l’industrie permettrait de savoir s’il faut examiner la rentabilité technique lors d’une prochaine étape.
ACKNOWLEDGEMENTS

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1.0 OBJECTIVE

This review of opportunities for use of CCA-treated wood wastes in composites arose as a result of a workshop on recycling of preservative-treated wood held in Vancouver on November 4, 1993 and a subsequent call for research proposals on related topics. The objectives of the study were to:

- Review scientific literature on past research relevant to the potential use of CCA-treated wood wastes in composites.
- Describe the location and characteristics of CCA-treated wood wastes in Canada.
- Comment on production and market feasibility issues associated with composites incorporating CCA-treated wood materials.
- Summarize the relevant product opportunities and recommend appropriate future research directions.
Disposal of waste wood products and materials from the manufacture and use of wood products is an issue that is now well recognised and is of international concern. Disposal of wastes through burning raises the possibility of toxic emissions and is not a choice in most cases for preservative-treated wood. The reduced availability of landfill sites for waste disposal and the higher costs of disposal in situations where sites are available has also led to an increased interest in alternative methods for dealing with the issue of recycling or reuse of preservative-treated wood. Given the likelihood that copper chrome arsenate (CCA)-treated wood wastes will increase in volume in the future as current structures are taken out of service, new methods for "recycling" CCA-treated wood wastes are clearly of interest. Options include remanufacturing (e.g., recycling of the above-ground portions of treated poles), remediation through biological or chemical means, or conversion of wastes into completely different products. Each of these options has its strengths and weaknesses and needs to be assessed on both technical and economic grounds.

In Canada, the estimates of the volume of construction and demolition wastes vary widely from 11% up to as much as 50% of the total solid waste stream [Kalin et al., 1993]. A recent report indicated that Canada's annual solid waste stream, excluding hazardous waste, is 30 million metric tonnes and that about 30% of this is generated by the construction industry [Environment Canada, 1992]. Unfortunately, as demolition waste is not tracked separately, it is very difficult to say how much of the waste stream comes specifically from demolition activities.

CCA treatment has increased in significance in recent years as a method of wood preservation. The reasons for this increase include a considerable history of proven performance for CCA and environmental concerns around the manufacture and use of oil-borne preservatives such as creosote and pentachlorophenol (PCP). Of the 60 wood preserving plants currently operating in Canada, 45 use CCA only, nine use CCA and PCP, four use CCA, creosote, and PCP, and one uses ammoniacal copper arsenate (ACA), CCA, creosote and PCP [Stephens et al., 1994]. Given the increase in use of CCA-treated wood, especially in residential construction and landscaping, it is likely that disposal of CCA-treated wood as a problem will increase in significance in the coming years.

A workshop on options for reuse or remediation of CCA-treated wood wastes was held in Vancouver in November 1993. This workshop addressed remanufacturing, biological or chemical remediation, incorporation of wastes in composites, combustion/incineration, and disposal of waste materials as soil amendments. Each of these options has its own advantages and disadvantages and a few general comments are made in the following sub-sections of this report.

2.1 Reuse

Poles offer a high potential for reuse and reprocessing is a possibility for poles, posts, lumber, timbers and shingles (cedar). In a study of poles removed from service in Ontario and Quebec [Coomarasamy and Cooper, 1994], almost 40% of the volume could be used for lumber manufacture with good grade and volume recovery.
Reuse of treated wood may be considered environmentally responsible because CCA is well fixed in wood. However, markets for used materials may not be large and the disposer may need to ensure that proper handling techniques are employed by the purchaser [Webb and Davis, 1993].

### 2.2 Combustion/Incineration

Conventional combustion of CCA-treated wood presents special problems due to the volatilization of arsenic and the concentration of all three elements in the grate and flue ashes [McMahon et al., 1986; Conradie, 1984; Dobbs and Grant, 1976]. Conditions have been identified that minimize volatilization of arsenic during the heat treatment of CCA-contaminated wood [Pasek, 1994]. However, furnaces will require elaborate flue precipitators and scrubbers and a safe procedure for removal and treatment of ashes.

One thermal disposal process that merits study is the use of CCA-contaminated wood as fuel in cement kilns. Not only would the CCA contaminants be controlled, but the process would benefit from the fuel value of the wood. Existing standards permit defined levels of contaminants in the cement clinker and if the CCA components can be deposited in the clinker or effectively precipitated or scrubbed from the flue gas, some CCA-treated wood may be processed in this way. Bernardin [1994] defines the limits of copper, chromium and arsenic in treated wood for use in cement kilns based on expected wood retentions and the specified limits. Chromium content of the wood is the limiting factor, since it is retained in wood removed from service at a higher level than copper or arsenic and the permitted level in cement clinker is lowest of the three elements (0.10 kg/tonne clinker vs. 0.27 kg/tonne for arsenic and 1.0 kg/tonne for copper). At an estimated 7.5 kg of chromium per tonne of dry treated wood, only 13 kg of CCA-treated wood could be used per tonne of cement clinker produced which accounts for only about 5 % of the total energy requirements [Bernardin, 1994]. In theory, a maximum of 188 thousand tonnes (about 470 thousand cubic meters) or about 25 % of the annual Canadian production of CCA-treated wood could be consumed in the production of the 14.5 million tonnes of cement produced annually in Canada. However, this disposal option should probably only be considered as an outlet for relatively minor amounts of CCA-contaminated wastes mixed with other wood wastes.

Another potential recycling option is to process CCA-treated wood at a copper smelter. The copper and often the arsenic components of CCA come from these smelters originally, and they can be recovered by the flash smelting process [Nurmi and Lindroos, 1994]. The chromium component is stabilized in the slag residue. The greatest hindrance to this potential solution is the logistics of getting the bulky wood to a suitable smelter.

### 2.3 Chemical Extraction/Biological Extraction

There have been several attempts to chemically or biologically extract CCA components from treated wood. Kim and Kim [1993] extracted much of the CCA with hot concentrated sulphuric and nitric acids. CCA components can also be efficiently extracted from contaminated soil and sludge by aqueous ammonia solutions containing metal chelating components such as citric or tartaric acid [Pasek, 1994]. However, the extraction is not complete and, if applied to wood, it is likely that more than trace amounts would remain in the wood. Several organic acids such as acetic and formic acids are relatively effective at extracting CCA from treated wood [Stephan et al.,
but again significant quantities are left in the wood. Chemicals extracted in this way can be recovered and, with some treatment, could presumably be recycled as wood preservative.

Some copper-tolerant brown rot fungi such as *Postia placenta* and *Antrodia vaillantii* are known to form low solubility copper oxalate in CCA-treated wood. Exposure of treated wood to these fungi results in increased water solubility of the chromium and arsenic components. However, the copper and significant amounts (5 - 25 %) of the other two components remain in the wood. One other disadvantage of this approach is that the fungus degrades the wood resulting in loss of the wood for fibre or fuel [Ruddick, 1994].

2.4 Dispersal as Soil Amendments

Based on results of phytotoxicity and plant uptake trials, several investigators have concluded that quantities of CCA-treated waste wood could be added to soil for agricultural uses without significant adverse effects [Homan and Militz, 1993; Speir *et al.*, 1992a, 1992b]. While it is encouraging that CCA-treated sawdust does not adversely affect growing plants, for overall environmental reasons it is doubtful whether this could be considered as a viable option for managing waste CCA-treated wood.

2.5 Composites

As indicated in the original project proposal, this report is designed to specifically address the feasibility of recycling CCA-treated wood wastes into composite products. As also mentioned at the 1993 workshop, it is possible to foresee some problems with this approach including transportation issues, materials handling difficulties, the need to define the acceptable frequency of recycling back into composites, and the whole question of consumer and market acceptance of such products. However, advantages can also be seen in terms of generating value-added products from wastes and, in some cases, perhaps even improving the properties of composite products.

This report was therefore structured to deal with the major issues identified above. By way of introduction, the next section provides a current assessment of wood composites and market directions, section four consists of a review of the literature on past research deemed relevant to use of CCA-treated wastes in composites and this is followed by a description of CCA-treated wood wastes and their location in Canada. Section six provides a summary of consumer and market feasibility issues around use of CCA-treated wastes in composites and the final report section provides a summary including recommendations for the future.
3.0 MARKETS FOR WOOD-BASED COMPOSITE PRODUCTS

Worldwide production of wood-based composite panels and composite lumber products is growing at a dramatic rate. New products or combinations of products are introduced frequently and modifications of existing products are occurring continuously. This section of the report will briefly examine production of and markets for a variety of wood-based composites. Information will be presented on structural panels (plywood and oriented strand board (OSB)), non-structural panels (particleboard and medium-density fibreboard (MDF)), engineered lumber composites (e.g. laminated veneer lumber (LVL), parallel strand lumber (PSL) and oriented strand lumber (OSL)) and wood/cement products. Current and future production and markets will be briefly examined from a global, a continental, and a national perspective.

3.1 Structural Panels

In North America wood construction using the platform frame technique dominates the residential construction market while in regions such as Europe, Central and South America, and parts of Asia residential construction is dominated by materials other than wood and construction techniques other than platform frame. As a result, North America dominates the world production of structural panels in construction grade softwood plywood and OSB. Since 1980 the wood-based structural panel market has evolved from a market dominated by plywood to one where other wood composite panels (initially waferboard and currently OSB) have captured significant market share. Figure 1 shows these trends for plywood and OSB in both Canada and the United States. Data from 1984 to 1993 are actual production volumes while data for 1994 to 1998 are estimates from Pease [1994] and are based on announced mill expansions.

![Figure 1: North American Structural Panel Production](image-url)
Much of the impetus for the shift from plywood to OSB has resulted from a scarcity of supplies and a corresponding escalation in price for the high quality logs necessary to create veneer for plywood. In contrast, the cost of material furnish (often aspen) for OSB is relatively low [Constantino et al., 1989]. Timber shortages in North America are expected to intensify as sustainable forestry, ecosystem management, and biodiversity objectives become incorporated into short and long-term harvesting scenarios.

The growth of OSB production is expected to continue with 28 new plants already announced for construction in North America in the near future. While not all of the intended facilities may be built, a substantial increase in production of wood composite structural panels over the next five years is inevitable [Wood-based Panels International, 1994c]. Market share projections, graphically illustrated in Figure 2, indicate increasing market share for OSB in the North American structural panel market.

![North American Market Share](image)

**Figure 2: North American Structural Panel Market Share: Plywood vs. OSB**

OSB was first introduced as a low cost alternative to plywood for construction purposes. Initially its use was restricted to wall sheathing. With time and product development OSB has replaced construction grade plywood for more and more uses. For example, OSB is now used for roof sheathing and webs in wood I-beams. Technology and knowledge has pushed the development of OSB to expand both its product characteristics and its quality so that many of the uses for OSB in the future will be at the expense of plywood. Product and market development occur concurrently and at a rapid pace during the initial growth phase of new product development. OSB production in Canada is expected to continue to grow at an extremely high rate in the short to medium-term future.
In Canada the shift from using softwood construction plywood to OSB has been more rapid than in the United States due to a variety of structural, social and political reasons [Constantino et al., 1989]. Continued market share gains for OSB are expected as shown in Figure 3. There are currently 14 OSB plants scheduled to be built and in production between 1994 and 1996 in all regions of Canada from New Brunswick to British Columbia. The majority are clustered in Quebec and Ontario [Wood Based Panels International, 1994c]

3.1.1 Markets for Structural Panels

Product and market development for OSB is entering a new and exciting phase. As capacity expands and research and development expands product properties, the markets and uses for OSB products should develop further. There are several new market areas that OSB has already entered or is about to enter.

One of these new areas is the export market in the Asian countries of the Pacific Rim, particularly Japan. Asian countries could be replacing expensive hardwood plywood with OSB in the construction industry for sheathing, for industrial use, as a packaging material for international shipments, and as walls, floors and tops for transport containers. Japan currently relies heavily on its own plywood industry which uses increasingly expensive imported hardwood and softwood logs and decreasing supplies of Indonesian lauan plywood. The industry in Japan expects to replace some of this demand with OSB from Canada [Japan Lumber Journal, 1994; Sorensen, 1994]. Japan has a large market potential since almost 50% of existing residential construction of over 1.3 million units per year is of wood. Since the Japanese do not consider OSB to be a low-grade plywood but a totally different material they also have developed some unique non-building uses for this product.
[Cohen et al., 1994]. Initial product development in Japan has seen OSB used as interior, finished wall panelling, as flooring (called ActiveFloor) and as ceiling tiles. Pent-up demand in Japan is substantial. Imports of OSB from North America increased from 34,000 cubic meters in 1992 to 58,000 cubic meters in 1993 (over 80% from Canada) and imports could expand by magnitudes annually for many years [Japan Lumber Journal, 1994].

As the production of OSB has increased in North America, processing technologies and product sophistication has also grown. OSB is now used to produce lap and panel exterior siding for residential construction, furniture frames, packaging, crating, and manufactured house components. Some examples of these include InnerSeal by Louisiana-Pacific Corp. (siding), Omniform by Masonite Division of International Paper (siding), Structureframe and Ultraspan by Weyerhaeuser Co. (furniture parts). In the construction industry new structural products include panels used for subfloors, roof sheathing, webs for I-beams, floor joists and roof trusses. Some examples of these include Stabilized Strand Board by Grant Forest Products (Ontario) and Oxboard by Potlatch Corp.

OSB is expected to continue its dynamic growth in use both in taking market share from plywood as a structural building material and also in developing new markets that will replace both solid lumber and non-wood materials. Whether the growth in markets will keep pace with the announced growth in production capacity is questionable and some oversupply of commodity OSB is expected in 1996-98 [Columbia Engineering International Ltd., 1993].

The production and markets for plywood are very different in the United States and Canada. In the United States, plywood production has almost disappeared from the Pacific Northwest and increased in the Southeastern US. The US industry has competed with OSB in commodity markets by lowering cost of production and price. Limited raw material supplies combined with increasing uses for both peeler logs and veneer will limit increased production. In Canada, plywood production (based predominantly in British Columbia) is in the process of shifting from high volume commodity production to lower volume, higher value specialty panels. Raw material costs influence direct competition with OSB in commodity markets. Currently some plywood production goes to specialty markets such as concrete forms (high strength plywood with a high or medium-density overlay), transport decking (such as TransDeck by Ainsworth Lumber Company), and furniture parts. Future markets for plywood are expected to continue to evolve from providing generic commodities for mass markets into developing proprietary specialty products for specific market segments.

3.2 Non-Structural Panels

Non-structural panels predominantly consist of particleboard and medium-density fibreboard (MDF). The major difference between these two products is that particleboard is made from small flakes (discrete pieces or particles) while MDF is made from wood fibres produced by a mechanical refining process. Both particleboard and MDF are manufactured by bonding together substrate material with resin using heat and pressure.

The production and use of particleboard expanded through the 1950s and 1960s. During the past decade its growth has been slowed by the growth of MDF in North America. Figure 4 illustrates the production levels of both particleboard and MDF in North America.
3.2.1 Particleboard

In response to competition for industrial markets by MDF, particleboard manufacturers have developed improved surface quality and edge machining capabilities. Almost 80% of US shipments of particleboard are used for industrial purposes such as components for furniture, cabinets, toys and games. Other market uses include floor underlayment in construction, mobile home decking, shelving, and door cores. The ready-to-assemble (RTA) furniture industry uses large quantities of particleboard.

There are two new process/product/market developments which may provide impetus to continued growth of the North American particleboard sector. The first involves changes in wood furnish. Most North American plants rely heavily on waste from sawmill and plywood plants. However, increased efficiency of sawmills combined with decreasing numbers of plywood plants has led particleboard manufacturers into developing production from post-consumer recycled wood wastes. Low quality particleboard products are now being produced at a Willamette Industries' Oregon plant where 70% of the furnish is supplied by recycled construction waste. This opens the door to developing specific products for the "green" consumer [Wood-based Panels International, 1994d]. Using post-consumer wood wastes as furnish is becoming increasingly common in Germany and South Africa where collection systems are more highly developed than in North America. The manufacture of particleboard from demolition wastes has also been investigated in Japan [Suzuki, 1994]. The second process which may alter or expand markets for particleboard also includes changes in furnish. Initial work is underway to replace wood particles with other lignocellulosic-based furnish. Currently flax and hemp (used in Belgium), bagasse (sugar cane stalks which are used in China), straw (development underway in the United States), jute (in India) and cotton stalks.
(in China) are being examined as potential furnish for particleboard. Wood may in the future be considered as a high quality added furnish in these new products.

3.2.2 MDF

In Europe, MDF has dramatically increased in production and sales. From 1984 to 1993 production of MDF in Europe increased from less than half a million cubic meters to over 2.5 million cubic meters. Increases in production of MDF in North America have lagged behind increases in the rest of the world, particularly Asia and Europe (see Figure 5). In 1984 North America was responsible for almost half of the global production but by 1993 it was responsible for less than 30%.

![Graph showing world production of MDF by region](image)

Figure 5: World Production of MDF by Region

There are currently four MDF plants in Canada and 15 in the United States. Many of these plants are small and use older equipment. By 1996 there will be at least two new large plants in Canada and seven new plants in the United States [Wood-based Panels International, 1994e]. In addition, several older plants will be rebuilt resulting in increased capacity. Thus production of MDF is expected to grow quite rapidly during the next few years in North America.

3.3 Markets for Non-structural Panels

MDF produces a high quality, homogeneous panel with a flat smooth surface ideal for finishing. Because this fibreboard is very suitable for painting, printing, and laminating and can produce a tight edge suitable for intricate machining there are a multitude of expanding markets. MDF is typically overlaid with veneer or decorative foils and papers. Most markets are industrial in nature and MDF is heavily used in factory-assembled and ready-to-assemble furniture. It is also used for
cabinets, underlay, drawer fronts, molding, and counter tops. Finishes and overlays can be used to provide a grain pattern typical of lumber and many wood finishing components such as door edgings, decorative trim, frames and cornices are being replaced by MDF. In addition, MDF is replacing thin plywood and wet process hardboard in the production of molded and flush doorskins.

New products include a super-refined board by Plum Creek Timber Co. with fine fibres throughout to facilitate deep routing and machining. Board is also being produced in some countries which use non-wood-based lignocellulosics such as bagasse and cotton stalks. Such processing is most common in Asia where wood fibre is in short supply.

Particleboard competes directly with MDF in many lower quality markets. These include previously mentioned industrial markets such as ready-to-assemble furniture and underlay. Due to a surface which is more difficult to finish, particleboard is predominantly used in applications where appearance is relatively unimportant or where only flat surfaces require finishing. New technologies are facilitating the development of particleboard which can compete in the higher value, finished product markets currently served by MDF.

### 3.4 Engineered Lumber Composites

As sources of lumber produced in North America have shifted from predominantly large-diameter old-growth timber to second-growth, plantation-grown trees, there has been a reduction in the availability of large-sized dimension lumber. Adjustments to this shortage of supply and a corresponding increase in prices has resulted in the development and rapid spread of engineered wood products. The growth of engineered lumber composites has mirrored this growth of engineered building components.

One of the key areas of substitution has been in residential construction and several examples of substitution follow:

1. Roof rafters traditionally composed of solid wood members (2 by 10 or 2 by 12 on 16 inch centres) have been replaced in over three quarters of all new houses built in the United States by roof trusses [McKeever and Anderson, 1992]. These trusses are made of combinations of short pieces of solid wood (2 by 4s), engineered lumber composites and metal nailing plates.

2. Many solid wood members used for floor joists (usually 2 by 8, 2 by 10 or 2 by 12 on 16 inch centres) have been replaced by wood I-joists (for example in the TrusJoist MacMillan Silent Floor System). I-joists often use engineered composite lumber (either laminated veneer lumber (LVL) or parallel strand lumber (PSL)) as flanges.

3. Large structural supporting members whether used for door or window headers or as main structural supports have traditionally been produced by nailing together many pieces of 2 by 8 or 2 by 10 lumber to produce large dimension built-up nailed beams. Today these beams produced on site are frequently replaced by LVL or PSL to reduce construction time, minimize the potential for carpenter error, and to facilitate the design of engineered homes.
Recently, TrusJoist MacMillan has developed a system they have named the “FrameWorks System” which replaces the majority of solid wood in residential construction with wood composite products including PSL, LVL and oriented strand lumber (OSL). Promotional materials stress both the environmental benefit of using material from plantation forests and non-contentious forest lands and the strength and dependability of engineered structures made from designed materials. These two attributes will continue to drive the switch from solid wood to engineered lumber composites.

The use of engineered lumber composites has also grown in non-residential construction where LVL and PSL are replacing steel for support in some new construction. Smaller commercial buildings (less than five storeys) have already started using engineered lumber composites with a high acceptance in western North America but less acceptance in eastern and southern Canada and the United States. Expectations for the continued growth of some engineered lumber composites are shown in Table 1.

Table 1: Expected Growth of Selected Engineered Wood Products

<table>
<thead>
<tr>
<th>Product</th>
<th>1990</th>
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<tr>
<td>PSL</td>
<td>0.9</td>
<td>7</td>
</tr>
<tr>
<td>I-Joists</td>
<td>150.0</td>
<td>318</td>
</tr>
<tr>
<td>Glulam</td>
<td>141.0</td>
<td>339</td>
</tr>
<tr>
<td>LVL</td>
<td>100.0</td>
<td>372</td>
</tr>
<tr>
<td>Trusses</td>
<td>200.0</td>
<td>435</td>
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Market growth is expected to continue not only in Canada and the United States but also in Asia. Currently, demand for both imported and locally produced structural composite products is growing in Japan [Taniguchi, 1995]. Changes in codes and standards are now underway which should encourage the introduction and growth of engineered lumber composites.

3.5 Wood/Cement Products

Three classes of wood/cement composite are in significant use worldwide. These are wood wool boards, particleboards, and fibreboards.

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<thead>
<tr>
<th>Product</th>
<th>Typical Density</th>
<th>Ratio of Water / Cement / Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood wool boards</td>
<td>360 - 570 kg/m³</td>
<td>0.4/1.0/0.7</td>
</tr>
<tr>
<td>Particleboards</td>
<td>1000-1350 kg/m³</td>
<td>0.4/1.0/0.35</td>
</tr>
<tr>
<td>Fibreboards</td>
<td>1350 kg/m³</td>
<td>0.4/1.0/0.1</td>
</tr>
</tbody>
</table>

In Australia and Asia, products made from a combination of wood and cement are commonly used as exterior siding and roof products. In Japan, surface technologies have been developed which produce a deep embossed brick and block or wood grain finish to wood/cement siding.
While the material properties of wood/cement panel products had always been acceptable to Japanese customers, market research had shown that the surface needed to look like more traditional finishing materials. Now that the finish can appear like brick or wood grain the popularity of wood/cement siding is growing. Australian production has focused on developing an exterior finish similar to Cape Cod shingles.

Commercial wood/cement board is typically composed of about 60% cement, 20% wood and 20% water. It produces a product which has some very good working capabilities. It has excellent machinability and can be screwed, nailed, riveted, and drilled. Other important product attributes include high fire resistance, exterior durability, moisture resistance, soundproofing and rot resistance. Boards made from wood and cement are used in prefabricated housing, as cladding, balcony parapets, sound barriers, fence walls and as a replacement panel for asbestos. Some countries are constructing buildings by using flanged wood/cement panels to erect walls without studs but with interlocking panels. Interior applications include wall partitions, non-flammable walls and ceilings, shielding for steel supports, lining for high-humidity rooms such as bathrooms, and underlayment for wood, vinyl or other laminates.

In North America, wood/cement board embossed with a wood shake texture has become an acceptable substitute for cedar shakes and shingles as a response to more restrictive fire regulations regarding flammable roofing materials. Louisiana-Pacific Corp. has scheduled two plants for completion in the next year to produce textured cement-based roof shakes in competition with existing products manufactured by MacMillan Bloedel and other companies.

Markets for wood/cement composites are expected to grow, particularly for exterior use. Since these composites contain no hazardous chemicals and can withstand outdoor exposure exterior siding and roofing markets are expected to grow significantly as technology currently in use in Asia and Australia is transplanted and adapted for use in North America.
4.0 CCA-TREATED WOOD IN COMPOSITES: A LITERATURE REVIEW

4.1 Compatibility of Adhesives with CCA-Treated Wood

Much of the past research involving preservatives and composites has been oriented towards obtaining a treated composite product. Treatment of finished composites with waterborne preservatives detracts from the appearance of the product. There is therefore a great deal of interest in pre-treating the furnish prior to the panel manufacture. This has generally resulted in poor wood to adhesive bonds and substandard strength properties [Hutchinson et al., 1977; Rakness, 1962]. A number of researchers have attempted to explain the bond degradation by different theories. Kumar and Jain [1976] found that CCA treatment increased the water repellency of the wood surface which could affect the penetration of adhesive into the wood cells. Rakness [1962] found greater strength reductions with increasing arsenic levels of the preservative used and suggested that arsenic could be the limiting factor. Others questioned the preservative acidity. Hutchinson et al. [1977] reported pre-cure with urea adhesive, Boggio and Gertjejansen [1982] and Winandy and River [1986] noted even better bonding with pentachlorophenol than with CCA or ACA. Reducing the physical amount of CCA on the bonding surface has been shown to improve strength properties. Choong and Attarzadeh [1970] found that veneers momentarily dipped in CCA produced acceptable bonds with phenol formaldehyde resin. These studies found that veneers with higher arsenic retention from prolonged dipping or pressure treatment showed increasingly poorer bonds. Hutchnison et al. [1977] also noted decreasing resin penetration into the wood with increasing arsenic levels. Vick reported that if bonding surfaces were treated with sodium hydroxide prior to adhesive application then structural quality bonds were obtainable. Similar results were reported by Janowiak et al. [1992] by planing the wood surface to remove excessive CCA prior to applying the adhesive.

While many experiments have brought into question the compatibility of CCA preservative with exterior adhesives, successful bonding of CCA-treated surfaces with exterior adhesives has been reported by Selbo [1959], Rakness [1962] and Vick and Christiansen [1993]. These studies reported adequate wood failures but reduced bond strengths and some decrease in cure rate was noted.

4.2 Use of CCA-Treated Wood in Particleboard and Flakeboard Products

In considering the potential for using waste CCA-treated wood in particleboard and flakeboard products, there are several issues of concern. The effect of CCA preservatives on adhesion and the resultant physical and mechanical properties and the biological resistance of these products must be addressed. Also, the implications of using material at variable but generally low moisture content, often contaminated with nails and other metal fasteners, is also a concern.

In those products where resistance to decay or insect attack is an advantage these properties are normally imparted to wood composites in one of five ways [Deppe, 1987]:

(i) Treat the chips before drying and gluing.
(ii) Mix the preservative with the resin or add simultaneously with the resin into the blender.
(iii) Spray on the preservative after application of the resin.
(iv) Apply the preservative as a powder before, during or after gluing.
(v) Treat the finished boards.

Apparently, only (ii) and (iv) were being used on a large scale in 1987 [Deppe, 1987]. However, for the application considered here, (i) is the most relevant as the furnish contains the preservative already. If the treatment must be fortified, any of the above approaches could be considered.

Most wood particle products have interior or protected uses and there is therefore usually no need for a wood preservative. However, several products such as Parallam™, Timberstrand™ and OSB bonded with water resistant and durable thermosetting resins find application where resistance to decay would be an asset. In such products, the incorporation of CCA-treated flakes or strands is a possibility, although at this time furnish for these products is derived from green round wood, as veneer clippings (Parallam), or is directly obtained from logs. As a result, only out-of-service poles and piling would be appropriate for such products, and the problems of processing low moisture content wood contaminated with metal fasteners would have to be addressed.

Heimingsson [1980] discussed the use of waste CCA-treated wood to produce particleboard in Sweden. CCA-treated telephone poles and other CCA-treated wood wastes were hammer milled into particleboard furnish and panels were produced at a density of 650 kg/m³ using 12% melamine urea resin based on dry wood. The main difficulties were the collection, separation and efficient chipping of treated material. Despite the fact that much of the board cross-section remained untreated, Heimingsson reported improved termite resistance compared to untreated board. Round scots pine, a thick sapwood species, was used in this study, so the proportion of the furnish containing preservative was higher than would be expected with furnish made, for example, from residential lumber. Thus, decay and insect resistance tests on particleboard products made from less well treated wood would be necessary under some circumstances. Panels made from treated wood exhibited strength properties equal to those of untreated pine.

In the same study, panels made from wood which had been treated after chipping failed to meet minimum bond requirements.

There have been several attempts to produce commercial/industrial exterior grade products such as poles and railway ties from treated wood particles. Examples are the "COMPOLE" and "COMARM" products developed by Michigan Technological University (MTU) for the Electric Power Research Institute (EPRI). Researchers at MTU used preservative-treated flakes bonded with isocyanate-type resins. Initial analysis by MTU indicated these poles were competitive with solid wood poles. Flakes pretreated with CCA, then glued into a flakeboard product and subjected to accelerated weathering tests suffered significant strength losses, whereas those treated with pentachlorophenol did not [MTU, 1981]. As a result, preservatives other than CCA were used for full-scale tests. For the initial studies, flakes were treated by spraying to 1.5 % of dry wood mass followed by equilibration in plastic overnight then drying. Under these conditions, CCA-C will not be fixed [Kaldas and Cooper, in preparation]. Thus, there is a need to investigate the physical and mechanical properties of composites prepared with well-
fixed and weathered CCA-treated wood. If CCA-treated wood waste is to be used for such products, concerns about potential long-term weathering deterioration must be overcome and flakes will probably have to be retreated to ensure adequate biological resistance, if that is a desired product attribute. The researchers also found that roundwood flakers provided a stronger product. Therefore, it is likely that the best products would have to be made from recycled poles, piling and other round stock. Treated lumber would have to be flaked with a ring flaker, resulting in lower quality furnish.

There have also been attempts to manufacture composite railway ties using recycled creosote-treated ties [e.g., Geimer, 1982]. Cedrite Technologies Incorporated has patented a process for making reconstituted ties and has manufactured and placed in service a large number of composite ties. Since the Cedrite product is proprietary, few details of the technology have been disclosed. Old ties are chipped, mixed with a resin, pressed in a mould and baked in an oven [Anon, 1988]. The plant was designed for high production capacity (50,000 ties per month or about 5,000 m³). The Cedrite process evolved somewhat as earlier versions had problems with bond durability and lateral spike resistance. The process was uneconomical and the operation has since gone out of business. However, the process did produce a durable product containing a preservative which generally is incompatible with adhesives and with large amounts of dirt and ballast contamination. A similar process might be feasible for manufacturing other products from CCA-treated wood, although physical performance of the product on weathering could be a concern.

4.3 Use of CCA-Treated Wood in Fibreboard Products

Fibre building boards could benefit from enhanced biological resistance for such products as simulated shingles and fibreboard siding. Products manufactured by a wet process are more difficult to protect by the above treatment methods since the process water will be contaminated with the preservative and the finished board is difficult to treat. Dry process fibreboard (e.g. MDF) would be more amenable to incorporation of CCA-treated wood. However, there are two major considerations that would limit such development. These are, first, the unknown and potentially negative impacts of treated wood fibre on fibreboard process equipment and, second, the need for dimensional stability as well as biological resistance in wood fibre-based composites exposed to high humidity or exterior conditions.

4.4 Incorporation of CCA-Treated Wood in Wood/Cement Products

As discussed earlier, the manufacture of composite products that use cement as an inorganic binder for wood is technically and commercially feasible and yields products with improved sound-insulating properties (high sound transmission loss), fire resistance properties and biological resistance compared to conventional wood-based composites. The composite is also dimensionally stable and durable outdoors. Incorporation of CCA-treated wood removed from service in these products is an attractive concept, as it has the potential to provide a product with good durability and could be a real opportunity to divert some waste material from landfills and other disposal options.
Technical concerns with the incorporation of CCA-treated wood in wood/cement composites include the effect of treatment on wood/cement compatibility and the resulting effects on physical and mechanical properties, the potential for leaching losses of CCA components from product in service with possible environmental impact, and the recyclability of the composite at the end of its life cycle.

4.4.1 Wood/Cement Compatibility

One of the main problems with wood/cement composites is that wood extractives interfere with cement setting by inhibiting crystallization reactions. This retards the cure rate and results in reduced adhesion between the cement binder and the wood particles. The longer setting times (6-8 hours) for Portland cement particleboard require long pressing or clamping times for moulded products, adding to production costs. There have been a number of technological advances to overcome these problems [e.g., Simatupang and Geimer, 1990]. For example, extraction of wood extractives by water soaking the furnish increases the wood/cement compatibility. The rate of curing can be increased with the use of accelerators such as calcium chloride and sodium silicate. Also, exposure of the cement to carbon dioxide (as gas or released from ammonium bicarbonate) during the curing process reduces the required press time to several minutes [ibid, 1990].

The effect of CCA components on cure rate and bond quality in wood/cement products is controversial. Shukla [1977] found that treatment of Chir wood dust with CCA, chromated zinc chloride (CZC) and acid copper chromate (ACC) inhibited cement curing and reduced the strength of the composites. Similarly, Shively et al. [1986] in studies on stabilization of inorganic wastes in cement matrices found that high concentrations of chromium arsenite resulted in a decrease in the compressive strength of the material.

In contrast, Schmidt et al. [1994] found that the compatibility of several pine species with cement was increased by treatment with CCA-C or chromic acid. This resulted in enhanced compressive and flexural toughness properties in wood/cement composites made with CCA- or chromic acid-treated particles. Zamorani et al. [1988] in their studies on encapsulation of inorganic wastes in cement also found that chromium enhanced the strength of Portland cement. It is not clear from the Shukla study if the treatments were allowed to fix after treatment. It is probable that the chromium component was still in the hexavalent state during the curing in this study. In contrast, in other studies, chromium was completely reduced to the trivalent state before the composite was produced. In consideration of using CCA-treated waste wood in wood/cement composites, it may therefore be desirable to retreat particles with chromic salts to ensure a uniform effect and improved decay resistance.

4.4.2 Leaching of CCA from Wood/Cement Composites

Several technologies have been developed to encapsulate toxic inorganics in cement [Daniali 1990, Mitchell 1990, Shively et al., 1986]. Encapsulation of inorganic wastes reduced the leaching characteristics by several orders of magnitude, allowing the treated waste to pass leachate extraction procedure tests and facilitating disposal in normal landfills. Thus, incorporation of wood waste in these composites may also reduce leachability significantly,
provided compatibility is good. For example, Mitchell [1990] describes a system capable of reducing CCA sludge leachate hazard by 10,000 times through encapsulation in cementitious materials.

The high pH of cement is presumed to result in hydrolysis of metal salts such as chromates to highly insoluble hydroxides [Zamorani et al., 1988] and contaminants released from treated wood might therefore be immobilized by the cement matrix. Evaluation of CCA component leaching from these materials would be needed if this disposal option was pursued.

Portland cement is normally relatively porous and more leaching of encapsulated material might be expected in this type of material. To reduce this, latex compounds at 15-20% polymer to cement could be incorporated in the mix to plug the capillaries.

4.4.3. Disposal of CCA-Containing Wood/Cement Composites

Once wood/cement composites complete their life cycle, it is unlikely that they could be recycled in new wood/cement composites. Thus, at this time, landfill disposal or use as fill is the most likely disposal option. It will be necessary to evaluate the CCA leaching characteristics of this material as it is taken out of service by standard Leachate Extraction Procedures [CGSB, 1987] to establish its suitability for normal landfill disposal.

4.4.4. Commercial Applications of Wood/Cement Composites

There are several exterior wood/cement composite products in production which could benefit from inclusion of CCA-treated wood.

Simulated Roof Tiles and Wood/Cement "Shakes"

Wood fibre/Portland cement composite simulated roof tiles (e.g., MacMillan Bloedel division American Cemwood Corp., Albany, Oregon, "Trieste Tile™") are lighter than clay or concrete tiles (450#/square vs 900 - 1200 for cement tile), have better thermal insulation and meet the most stringent Class A fire retardant rating for roofs. Manufacturers provide a 50-year warranty even without preservative treatment, so the benefits of incorporating treated wood are questionable, except if justified by increased wood/cement compatibility.

Chips are refined and sodium silicate added to increase the wood to cement compatibility. The product is 60% wood fibre by volume/ 60% Portland cement by weight. The shakes are consolidated by cold pressing and the cure accelerated by gas heat. The cured product is sealed and finished.

Wood/cement shakes (e.g., MacMillan Bloedel division American Cemwood Corp., Albany, Oregon, "Cemwood Shakes") are made by a similar process. They have good commercial potential, especially for exports. Current production is about 200,000 squares/year. The manufacturer originally used Douglas fir planer shavings but a shortage of this material led to the use of beetle-killed lodgepole pine. This material has the advantage that sugars and other extractives that interfere with cement cure have been lost. Under other circumstances wood had
to be "cured" for nine months to avoid this problem [Keil, 1994]. Residential CCA-treated wood removed from service will likely have the same advantage.

**Highway Sound Barriers**

The "Durasol™" product produced by Tapecrete in Mitchell, Ontario is based on patented Swiss technology. It is currently used in Ontario for highway sound barriers. The combination of high mass, roughness and incorporation of fibrous material results in excellent sound absorption properties. While there is little information on biological deterioration of this material, incorporation of wood containing CCA contaminants could be justified on the basis of better composite properties as well as decay resistance. This manufacturing facility is strategically located to use waste residential construction material.

**Wood Residue Concrete Blocks**

Construction blocks incorporating wood sawdust have better insulating properties than concrete blocks. Rashwan et al., [1992] describe such a wood residue concrete block which was manufactured at a foundry in Alberta. Calcium chloride was the most effective accelerator tested. This may have application as a use for sawdust from re-sawn CCA-treated poles.

**Wood wool boards**

Wood wool boards are finding increased application in tropical and sub-tropical areas for low cost and prefabricated housing and for thermal insulating and sound insulating construction [Shukla, 1977]. These boards are not resistant to biological deterioration and the wood component must be treated if there is a risk of biological attack [ibid, 1977]. The main potential for such products containing CCA-treated wood is for export markets.
5.0 CCA-TREATED WOOD WASTES IN CANADA

5.1 CCA-Treated Wood Wastes in Canada - Location and Quantities

The chromated copper arsenate (CCA) preservative system was developed about 60 years ago. Until about 1975, CCA was used mainly for commercial products such as poles (limited use), marine piling (limited use) and commercial decking. Production was low compared to that of creosote and pentachlorophenol over this time period (Figure 6). These products were treated under high quality control conditions to retentions of 6.4 - 9.6 kg/m³ for poles and timbers and to 32 kg/m³ for marine piling. As a consequence the wood could be expected to have an average service life of 30 - 50 years unless it failed mechanically. Studies on leaching characteristics of this material [Ruddick, 1990; Cooper, 1993] suggest that poles and presumably other products treated in this time period retain most of the originally applied preservative.

With subsequent changes in marketing strategies by CCA chemical suppliers and greater consumer acceptance of the treatment for residential construction, production of CCA-treated wood increased exponentially after 1975 (Figure 6, Table 2). The production of CCA-treated wood exceeded that of creosote and pentachlorophenol by about 1980 and currently makes up almost 80% of the total volume of treated wood [Stephens et al., 1994]. Consumer demand for CCA-treated wood for residential uses such as fences, decks and retaining walls was accompanied by increased substitution of CCA for creosote- and penta-treated commercial products such as poles, piling, posts and timbers. The only large volume commercial product that has not been supplanted significantly by CCA-treated wood is creosote/petroleum oil-treated railway ties. To a lesser extent, other building materials have also been replaced by CCA-treated wood, for example preserved wood foundations replacing the use of concrete foundations. Reliable information on the relative amounts used for different products is available only for 1992 (Table 2). However, it can be assumed that residential construction uses, including preserved wood foundations, have dominated since 1975.

CCA-treated poles, piling and other commercial products treated before 1970 and currently coming out of service are of low volume and scattered throughout the country. The quantities are relatively insignificant and reuse or disposal in landfills or by burying or abandonment are unlikely to raise any concerns or even be noted. Because of the difficulties of recovering and transporting this material to a central location, it is unlikely that any significant quantities would be available for centralized reprocessing. The use of CCA treatment for poles has increased significantly since the mid 1980s. Bell Canada made a strong commitment to the use of CCA-treated poles and has used this treatment for non-joint use poles since about 1984. Both Ontario Hydro and B.C. Hydro have switched a significant proportion of their new pole installations to CCA treatment in the past two years. Thus, the current rate of installation of CCA-treated poles of about 180,000 m³ per year results from recent changes in pole specifications by the major utilities. There will be a relatively sustained source of Bell Canada poles available for reuse and recycling in eastern Canada in 15 to 20 years as the earliest installed ones approach their service life. The higher quantity of used poles resulting from the most recent uses of CCA-treated poles will not be reflected in higher quantities available for about 40 years.
Volumes of Wood Treated with Different Preservatives in Canada

(million of cubic metres)

- Creosote
- Pentachlorophenol
- Waterborne (i.e. CCA)

Year


Figure 6

21
Table 2: Quantity and Characteristics of CCA-Treated Wood Production in Canada

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume</th>
<th>Volume</th>
<th>Consumer Lumber</th>
<th>Poles</th>
<th>Marine Piling</th>
<th>Industrial Sawn &amp; Round Timbers</th>
<th>Others *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10^6 ft^3</td>
<td>10^6 m^3</td>
<td>10^6 m^3</td>
<td>10^6 m^3</td>
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<td>10^6 m^3</td>
<td>10^6 m^3</td>
</tr>
<tr>
<td>1975</td>
<td>6.0</td>
<td>0.17*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>4.9</td>
<td>0.14*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1977</td>
<td>6.0</td>
<td>0.17*</td>
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<tr>
<td>1978</td>
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<td>0.18*</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1979</td>
<td>9.9</td>
<td>0.28*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>12.7</td>
<td>0.36*</td>
<td></td>
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<td>1981</td>
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<td>15.2</td>
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<td>1983</td>
<td>17.3</td>
<td>0.49*</td>
<td></td>
<td></td>
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<tr>
<td>1984</td>
<td>20.1</td>
<td>0.57*</td>
<td></td>
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<td>1986</td>
<td>26.4</td>
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<td>1987</td>
<td>30.3</td>
<td>0.86*</td>
<td></td>
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<td></td>
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<tr>
<td>1988</td>
<td>55.0</td>
<td>1.56@</td>
<td></td>
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<tr>
<td>1989</td>
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<td>1.49@</td>
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<tr>
<td>1990</td>
<td>60.5</td>
<td>1.72@</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1991</td>
<td>56.8</td>
<td>1.61@</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1992</td>
<td>55.1</td>
<td>1.56@</td>
<td>1.02</td>
<td>0.18</td>
<td>0.0003</td>
<td>0.32</td>
<td>0.05</td>
</tr>
</tbody>
</table>

* Cooper and Ung 1989
@ Stephens et al., 1994
** PWF, plywood, shakes and shingles
It is most probable, based on the current approaches of the utilities, that CCA-treated poles removed from service will be graded for reuse and reprocessing as solid wood products and that only a fraction of the recovered poles (e.g., sawdust, slabs and edgings, trim ends and planer shavings will be available for composite manufacture). This material will be characterized by high CCA retention since most is derived from the well treated sapwood. It will be transferred to a few central locations for reprocessing and collection and transport to recycling plants will be facilitated.

With the increased use of CCA in residential construction, the volumes of waste wood available as off-cuts, cull or damaged wood, or structures taken out prematurely because of aesthetic or home owner preferences has increased significantly. Because of the anticipated shorter life of this material, significant volumes will be made available in the near future. However, the volumes have far from peaked. Using the production information shown in Table 2 and assumptions of average service lives for different commodities in Table 3 the anticipated future volumes of waste CCA-treated wood in Canada are as shown in Figure 7.

<table>
<thead>
<tr>
<th>Product</th>
<th>Estimated service life*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential decks, fences etc.</td>
<td>15</td>
</tr>
<tr>
<td>Round fence posts</td>
<td>35</td>
</tr>
<tr>
<td>Poles</td>
<td>40</td>
</tr>
<tr>
<td>Piling</td>
<td>25+</td>
</tr>
<tr>
<td>PWF</td>
<td>50</td>
</tr>
</tbody>
</table>

* Accounts for biological life + estimates for removal for other reasons.

This consumer wood is characterized by lower treatment quality (lower penetration and retention of preservative). This results from inadequate quality control (wood moisture content, temperature, processing length) and the use of refractory species such as spruce, jack pine and Douglas fir. This means that when the wood comes out of service, it is less heavily contaminated compared to commercial products and a smaller fraction of its volume is penetrated. It is estimated that the residual CCA level in residential structures when removed from service is about 3 kg/m³. This raises the possibility of removing the contaminated portions of CCA-treated lumber for recycling and using the remainder for alternative products. However, if this consumer wood is to be used in its entirety in composites with the aim of enhancing its durability, it may be necessary to supplement the treatment by treating the particles with a wood preservative. As discussed earlier, this may reduce the bond quality.
Estimates of Future Volumes of Treated Wood Removed from Service in Canada

(million of cubic metres)

- Creosote
- Pentachlorophenol
- CCA

Year

Figure 7
CCA-treated waste wood material is generally concentrated in urban areas. According to Statistics Canada demographic data, approximately 17 million (of 29 million Canadians) live in 25 major metropolitan areas. The major concentrations are metropolitan Toronto (4.1 million), metropolitan Montreal (3.3 million), and metropolitan Vancouver (1.7 million). Based on population only, it is estimated that over the past five years and for the foreseeable future, about 0.23, 0.18 and 0.10 million m$^3$ of treated wood are being placed in residential use annually in the greater Toronto, Montreal and Vancouver regions respectively. Similar quantities should become available for recycling within 10 years. The dispersal of the wastes among individual residences means that its collection is amenable to a "blue box" type program, or voluntary delivery by owners to a designated collection area. Material used in residential applications does not have the advantage of involving several large owners as in the case, for example, of CCA-treated poles and guiderail posts.

In addition to the figures mentioned above, about 0.04 million m$^3$ of consumer CCA-treated wood is installed each year in residential and light industrial buildings as "permanent wood foundations" (PWF). However, the distribution of these buildings is generally not the same as consumer lumber since PWF construction is typically used in more remote or rural areas. PWF material is generally better treated than consumer lumber, but is more difficult to recover and collect and is unlikely to be available in significant quantities for recycling.

Superimposed on this heavy residential construction use of CCA-treated wood is the increased use for other commercial products such as piling, commercial construction, guiderail and sign posts. These products, which now make up an estimated 24% of total production in Canada are extensively dispersed over Canada’s infrastructure network, creating difficulties in collection and transport to a central collection site, but having the potential advantage of few owners who tend to be good "corporate citizens" concerned about the fate of their waste material. As an example, marine piling, currently comprising only about 0.02% of CCA-treated wood production, will not be available in significant amounts for recycling.
6.0 COMPOSITES CONTAINING CCA-TREATED WASTES: MARKET FEASIBILITY AND CONSUMER ACCEPTANCE ISSUES

Exploring the potential for recycling CCA-treated wood into composites requires an evaluation of some of the market forces which will impact the acceptance of products made from this material. Consumer behaviour regarding environmental or ecological considerations is a recent and relatively unexplored field of study. Specific information which might link consumer attitudes on these issues and their purchasing and life style decisions is sparse. However, environmental considerations are growing and many of these ecological issues will evolve from infancy to impact mature purchasing decisions. Some of the environmental issues addressed in this section are societal shifts towards more environmental or ecological construction and consumer concerns regarding long-term, low-risk health issues. The synergy between raw material supply and market access issues is also discussed.

6.1 General Trends in Consumer Behaviour regarding Environmental Issues

Few doubt the emergence of environmental issues as a strong societal force. However, debate still exists as to whether this force is a temporary fad or an enduring shift in public awareness. Ottman [1992] makes a compelling argument that links the maturing of the baby boomer population in Europe and North America with "a permanent shift in values toward more environmentally sound products and companies". Trends in Oceania, North America and Europe indicate growing public concern about the environment, increased offerings of products which make "green promises", a growth in "green advertising" and an increase in the impact of environmental considerations on general purchasing decisions [Ottman, 1992]. The fact that environmental concern is stronger among youth than middle-aged adults indicates the likelihood that environmental considerations will continue to grow in importance.

Studies have indicated that over half of the consumers surveyed had avoided and/or selected certain products based solely on environmental considerations [Winterhalter and Cassens, 1994]. This is a shift from previous behaviour whereby avoidance or boycotts of products due to environmental concerns dominated consumer reaction to environmental campaigns. Respondents also indicated a willingness to pay more for products made from "sustainable" forests. Environmentalism is evolving from "ringing an ecological fire alarm" to cooperatively developing solutions to environmental problems [Moore, 1994].

The growth of societal concerns regarding the environment may be considered a two-edged sword when examining future markets for recycled CCA-treated wood. One edge creates favourable public perception regarding the re-use or recycling of treated wood. The other edge raises concerns about the long-term impact on the health of individuals who reside in an environment in which they come in contact with CCA-treated wood products. Before examining these two factors this section of the report explores the growth of sustainable construction which provides the foundation for re-use of building materials including CCA-treated wood.
6.2 Sustainable Construction

Sustainable or "green" construction is a rapidly emerging area of construction industry concern and activity throughout the world [Kilbert, 1994]. An important tool in selecting materials for sustainable construction is the use of Life Cycle Analysis or LCA. This technique evaluates materials based on their environmental impact. It includes the effects from resource extraction and material production through building construction to use and dismantling, including recycling and/or disposal. LCA has also been called "a cradle to grave" environmental audit. Results indicate that carbon dioxide emissions and energy use are two of the most critical environmental concerns. Initial results record that wood, as a material, has significant advantages compared to other building materials when viewed in LCA terms. [Arima, 1993; Koch, 1992; Marcea and Lau, 1992].

Two of the most important considerations in creating sustainable construction are recycling and serviceability [Wyatt, 1994]. Recycling ensures that the life of a material becomes multi-generational while serviceability ensures that during each life the material provides maximum benefit for minimal ecological cost. CCA-treated wood is currently considered very serviceable. The CCA treatment extends the life of the wood and facilitates the ability to replace non-renewable materials (such as plastic, steel and concrete) with renewable materials. However, CCA-treated wood does not fare as well in terms of recycling. A recent US study of the National Association of Home Builders (NAHB) indicated that 71% of builders surveyed recycled clean lumber while only 41% recycled treated lumber [EBN, 1995]. One of the objectives of this report is to identify and explore opportunities to utilize CCA-treated wood to help create a renewable, multi-generation (i.e. recyclable) material. Growing interest in sustainable construction provides a climate which would embrace practical construction materials created from recycled CCA-treated wood products. The "other edge of the sword" of growing environmental concern is society's escalating anxiety regarding health and safety issues.

6.3 Public Health Concerns

There is a growing concern about the long-term health impacts of a variety of construction materials. As discussed by Dr. Steve Hrudy, Chair in Risk Management at the Medical School of the University of Alberta during a recent presentation at UBC, one of the most widely known examples is the lengthy, expensive and perhaps questionable removal of asbestos from buildings. While small risks do exist, the risks created by the removal process are considered by some to outweigh the benefits. In some cases the least health risk would be to leave the asbestos in place. However, society requires more and more assurances of safety. Standards approach the impossible to ensure that risk is eradicated. The concept of acceptable risk levels is out of favour while zero tolerance has gained credibility.

Education has often been touted as an alternative to restriction or regulation for materials that could cause health problems. However, product information sheets and industry-run seminars on the proper use of CCA-treated lumber in the United States have had little impact in educating professional or do-it-yourself builders [Sinclair and Smith, 1990]. In fact, concerns about health and quality issues have retarded the acceptance of permanent wood foundations which use CCA-treated lumber and plywood [Hain, 1989].
Consumers will perceive a risk, regardless of whether this perception has a basis in scientific reality, that materials containing chromium and arsenic will slowly leach harmful material into their living environment. If this dispersal cannot be measured it will be considered a fault of the measuring devices and not proof that there is minimal risk. It is necessary to consider the perceived health and safety issues at the product design stage. The following recommendations should help avoid direct conflict and position products to be most easily defended from a consumer safety perspective. Products made from recycled CCA-treated wood should meet the following criteria:

1. products should not come in regular contact with the consumer (e.g. exterior windows or roofing materials but not furniture, flooring, doors, etc.)
2. products should be used in well-ventilated areas (e.g. exterior wall panels, garages, and roofing but not interior studs, floor joists, etc.)
3. products should be assembled or ready-to-assemble to avoid do-it-yourself construction and the corresponding improper waste disposal issues (e.g., it would be better to have pre-cut roofing tiles rather than roofing panels that would be cut to size on the building site)

6.4 Geographical Concerns

In the future, CCA-treated wood wastes will predominantly come from the demolition of existing construction in the urban environment. In a similar way to waste paper, the "urban forest" provides unique opportunities and constraints. Given the toxicity of CCA-treated wood, removal of this material from building sites may produce a hazardous waste [Abraham et al., 1994]. Therefore this material may have to be separated at the building site and treated as a unique material. Fortunately, the majority of treated wood use is for decks, gazebos and other outdoor buildings which facilitates separate demolition, handling and on-site separation.

One advantage of reusing CCA-treated wood for consumer products such as building materials is that the source of raw material and the market are in close proximity, (i.e., the large urban centres). This could reduce transportation costs and minimize raw material inventory needs and suggests that the products examined might be produced on a relatively small scale. This, in turn, would encourage many small production facilities located near the urban centres of raw material supply. Thus, it would be preferable to use recycled CCA-treated wood in a product such as wood/cement roof tiles (which can be produced in a facility with a relatively small minimum efficient size) rather than in OSB (which has a very large minimum efficient size, typically requiring 600,000 cubic meters of raw material each year and location near the rural forest).

Currently there are 10 plants in North America producing wood/cement products. Worldwide there are 33 plants. In some parts of North America wood/cement board embossed with a wood shake texture is replacing cedar shakes and shingles. Advantages for these roof tiles include high fire resistance, exterior durability, moisture resistance, and soundproofing. These characteristics along with dimensional stability and the ability to withstand outdoor exposure indicate a growing market for wood/cement roof tiles. Louisiana Pacific expects to have two plants in operation by the end of 1995 and several plants are already in operation in British Columbia and Oregon.
An additional advantage to developing products which could be produced in many urban centres throughout North America would be the creation of geographically dispersed sites for using recycled CCA-treated material. Since the second largest source of CCA-treated wood will be telephone poles, and these poles are scattered geographically throughout the region, multiple processing facilities could lead to the most efficient transportation of this dispersed material.
7.0 SUMMARY

This report has provided an introduction to some of the possible uses for CCA-treated wood wastes in Canada as alternatives to landflling or burning. Particular emphasis has been placed on the potential incorporation of CCA-treated wastes in composites and the markets for wood composites have been reviewed. In general, it is apparent that composites are the products of the future with strong demand fuelling increased production capacity for MDF and OSB in particular. A review of the scientific literature has shown that use of CCA-treated wood in a wide variety of composites is technically feasible although compatibility of the preservative with synthetic adhesives remains an issue. From a practical standpoint, the incorporation of CCA-treated wood wastes in furnish for "commodity" composites such as plywood, MDF and OSB presents some daunting technical obstacles and, even if appropriate materials handling could be developed, it is arguable that there are probably better ways to produce durable products if that is the objective. Although there is considerable industry interest in use of the "urban forest" (e.g., Canfibre Inc, in Canada, Willamette Industries in the U.S.) to provide a fibre stream, there is no indication at this stage that preservative treated wastes are needed or could be handled in plants currently in operation or planned. For composites which are widely used in interior applications there is also the issue of contact during use and this in itself would mitigate against use of treated waste material during manufacture. For products which are typically used in exterior applications, the literature review as well as the study on market feasibility/consumer acceptance issues suggest that wood/cement composites might be a viable option for disposal of some waste materials. Apart from their current accepted use in exterior applications such as roofing and sheathing, research to date in this area suggests that CCA-treated material might even provide better wood/cement bonding and therefore might also provide some improvement in product properties. However, as with the other composite materials, there are some major issues which would need to be studied. First, wood/cement composite plants are currently few and far between and the transportation costs of collection and getting CCA-treated wastes to such plants would be a critical issue. Second, the impact of CCA-treated waste fibre or particle type on product properties remains largely unknown from a commercial perspective. Third, any development in this direction would require market analysis to determine whether wood/cement composites containing encapsulated CCA-treated wastes would find acceptance in the marketplace. In addition to these questions, consideration would have to be given to leaching of CCA from wood/cement composites and its potential reduction through the use of additives.

Although it has been suggested that CCA-treated material could improve product durability, this is not proven and, in addition, existing wood/cement composites are deemed to be durable and are promoted as such. Recent contacts with the U.S. Forest Products Laboratory (FPL), in Madison, Wisconsin indicate that researchers in wood composites at FPL believe the idea has some merit and are examining use of spent CCA-treated wood wastes as fiber reinforcement in a low-density wood particle/cement composite suitable for use in housing components. There may therefore be some opportunities to collaborate with FPL in this area in the future.

Apart from the questions raised above, uncertainty may also arise as to the sort of applications in which such a composite might be permitted and whether warning labels might be required. Furthermore, it is possible that the wood material might require re-treating prior to incorporation
to ensure durability. Finally, new options for further use or disposal of the CCA-treated wood/cement composite at the end of its useful life would likely require development.

This overview of the options for use of CCA-treated wastes in composites suggests with possibly one exception, that CCA-treated waste inclusion in composites will provide formidable and possibly insurmountable technical challenges. The one exception is use in wood/cement composites and even in this case much market, economic and technical research would be required to bring this concept to fruition. A specific feasibility study focusing on this particular product type would be a necessary next step if this option were to be pursued. The study should ideally examine market acceptance, transportation and manufacturing costs, and the likelihood that CCA-treated fibres or particles could produce a technically acceptable composite. Such a study would of necessity require the close involvement of a wood/cement composite company or companies.
8.0 APPENDIX: DEFINITIONS

Engineered Lumber Composites

This family of products is composed of structural members produced from veneers, flakes or chips which replace existing structural materials such as solid wood, steel or concrete. Included in this family of products are parallel strand lumber (PSL), laminated veneer lumber (LVL), glue laminated beams (glulam) and oriented strand lumber (OSL).

Engineered Wood Assemblies

This family of products is made from combining engineered lumber composites, lumber and/or panels with adhesives and/or metal plates to produce building sub-assemblies. These products include roof trusses, I-beams, and parallel chord trusses.

Fibreboard

Fibreboard is made from the fibres of lignocellulosic material, typically wood. It is produced by interfelting the fibres and consolidating the fibrous mat under heat and pressure in a hot press. Fibreboards are classified according to density and method of manufacture and are not considered a structural panel. Some common fibreboards are:

- **Hardboard**: a fibreboard of 0.5 - 1.2 g/cm³ to which other materials may be added to improve properties. It is commonly used for interior and exterior construction purposes.
- **Medium-density fibreboard (MDF)**: a fibreboard compressed to between 0.5 and 0.8 g/cm³ normally using urea-formaldehyde as a bonding agent. MDF is commonly used in furniture, moldings and other products requiring a smooth surface.

Particleboard

Panels are manufactured from wood particles bonded with resins using heat and pressure. Low-quality particleboard is used as underlayment for floors and in mobile home decking. Higher quality particleboard is used primarily as core stock for furniture and cabinets. Particleboards are not considered structural panels. Densities range from 0.6 g/cm³ (low density) to 0.8 g/cm³ (high density).

Plywood

Structural panels are produced by gluing layers of veneer together with the grain direction of adjoining layers perpendicular to each other. Plywood is often used as exterior and interior wall and roof sheathing for residential construction.

Oriented Strand Board (OSB)

Structural panels are produced by forming mats of wood flakes oriented in layers which are perpendicular to each other. Mats are bonded under heat and pressure using adhesives such as
isocyanate or phenolic resins. Strands for surface layers are often 10 cm or more in length. OSB is used as sheathing in residential construction, packaging and for other industrial purposes.
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