UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into Sustainable Building Materials – Laminate Wood

Sam (Sang Han), Cho

Jimme, Huang

University of British Columbia

APSC 262

April 2010

An Investigation into Sustainable Building Materials – Laminate Wood

Utilizing Mountain Pine Beetle Infested Wood

Sam (Sang Han), Cho
Jimme, Huang April 6th, 2010

APSC 262 - Technology and Society II - Section 201
Course Coordinator: Dr. Carla Paterson

Tutorial T2A: Pat Cramond

TABLE OF CONTENTS

3.0 LIST OF ILLUSTRATIONS

4.0 GLOSSARY

Yonung's Modulus: quantitative measure of stiffness of the elastic material.

Safety Factor: indicator of the structural capacity of a system under the applied loads.

Rotary kiln: an instrument that heat the material to high temperature in the continuous process.

Lignin: is a complex chemical compound most commonly derived from wood, and an integral part of the secondary cell walls of plants[1] and some algae.

Vessel: Wood vessels are the thin "tubes / pipes" that transport the water in the stem (trunk) of a woody plant. They consist of many linked empty cells, the wood vessel members. These have perforations in the ends and link toghether to form long tubes, the wood vessels. Wood vessels carry water and minerals from the roots of a woody plant (a tree, for instance) to the leaves.

Laminated Wood (Engineered wood): also called *composite wood*, *man-made wood* includes a range of derivative wood products which are manufactured by binding together the strands, particles, fibers, or veneers of wood, together with adhesives, to form composite materials. These products are engineered to precise design specifications, which are tested to meet national or international standards.

5.0 LIST OF ABBREVIATIONS

MPB: Mountain Pine Beetle

SPF: spruce-pine-fir

SUB: Student Union Building

LCA: Life Cycle Assessment

ISO: International Organization for Standardization

6.1 SOCIAL IMPACT

The most important evaluation criterion for laminate wood is to look at the social aspect. To assess the laminate wood in terms of the social perspectives, we have compared and listed the advantages and disadvantages of the using the laminate wood against the conventional reinforced concrete as the primary building materials. The evaluation of the laminate wood starts from the origin raw material of the wood, which is the mountain pine beetle wood. The primary benefit of using the mountain pine beetle wood is to demonstrate the application of sustainable design. The rejection of the mountain pine beetle due to the blue stain on the surface, which is caused by micro-fungi, isolates the materials in using in any building applications (Lum, Byrne & Casilla, 2006). According to Ministry of Forest and Range, the mountain pine beetle has affected more than 400 million cubic meters of wood, which is approximately 22% of the British Columbia's merchantable lodgepole pine, since mid 1990. It has also been estimated that more than 80% of the pine will be affected in year 2013 (*Mountain Pine Beetle in B.C.,* 2005). Despite of the blue stain caused by the beetle, the mechanical properties of material do not change at all (Lum et al., 2006). Instead of wasting the material, we should apply the mountain pine beetle wood in the form of laminate and utilize them in the building structure. The second advantage of using the wood over the reinforced concrete is more general acceptable natural design and form of the wood. Statistic has shown that people love the appearance of wood more than the monochromic concrete. The third benefit of using laminate wood over the conventional concrete is the creations of more job opportunity for small communities who rely their living on extraction and processing of wood materials. It has been reported that more than 800 B.C.

forestry workers lost their jobs due to the impacts of mountain pine beetles in the beginning of 2010 (“Pine Beetle Blamed,” 2010). The initiation of applying the mountain pine beetle timbers on the building structure in the laminate form will create more job opportunities especially for those small communities who depend their living on forestry works.

Figure 1: Mountain Pine Beetle infected pine stands in interior B.C.. The red- colored Region indicates that the “Red-attack” (recently infected pine)

Source: www.shim.bc.ca/atlases/fbc/ss3/Forest.html

Despite the benefits of the wood structure against the reinforced concrete as discussed above, the disadvantages of using the wood to replace the concrete are also evaluated in terms of social perspectives. The primary disadvantage of the wood structure comparing to the reinforced concrete is the physical properties of the materials. The young’s

modulus, which is defined as the stiffness of the material for both laminate wood and reinforced concrete, are illustrated in the figure 2 on next page.

As shown in figure 2, the young's modulus of steel reinforced concrete is measured 2x higher than modulus of the wood (*Data Table for: Miscellaneous Materials: Concrete: Steel Reinforced Concrete*, n.d.). In addition to the less promising physical properties of wood, the varied range of safety factors of wood materials is considered as the disadvantage of laminated wood. The varied range of safety factor is due to the random hole and moisture content inside the wood structure, which also reduces the material properties of the materials. As a result, people's life might be in risk due to the varied range of the safety factor and less promising material properties of wooden frame structure.

Materials	Young's Modulus (GPa)
Steel Reinforced Concrete	26.0
Laminate wood	8.0-18.5

Table 1: Material Properties for Steel Reinforced concrete and Wood

Source: (*Data Table for: Miscellaneous Materials: Concrete: Steel Reinforced Concrete*, n.d.) and (Lynnelle, 2004)

6.2 ENVIRONMENTAL IMPACT

In terms of the environmental aspect, one of the most significant and distinctive advantages of using the wood is less emission of carbon dioxide (European Commission DG ENV, 2006). The cement is produced by grinding and intimately mixing clay and

lime-bearing in the proper composition and heating the mixture about 1400ºC in the rotary kiln (Callister, 2007). In the heating process, carbon dioxides are liberated. Although the drying process of the wood in the kiln heating system involves the consumption of oil and natural gas (Ruddick, 2008), the production of carbon dioxide is much less than that of concrete. Swedish and Finnish scientist has compared the net carbon dioxide emission and energy consumption of concrete and wood frame building. The result shows that the wood-based building material reduces the carbon dioxide emission and energy consumption relative to the concrete building material (Gustavsson, & Sathre, 2006). Figure 3 and 4 demonstrates the carbon dioxide emission and energy consumption in production of materials for both wood-based building frame and concrete-based building frame.

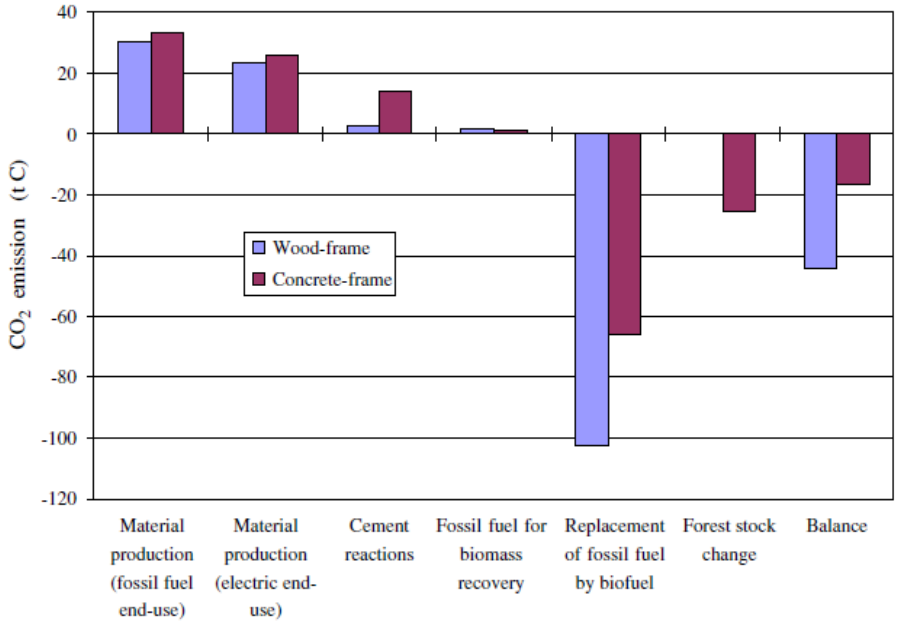


Figure 2: CO_2 Emission in Production of Materials for Wood and Concrete Frame

Source: (Gustavsson, & Sathre, 2006)

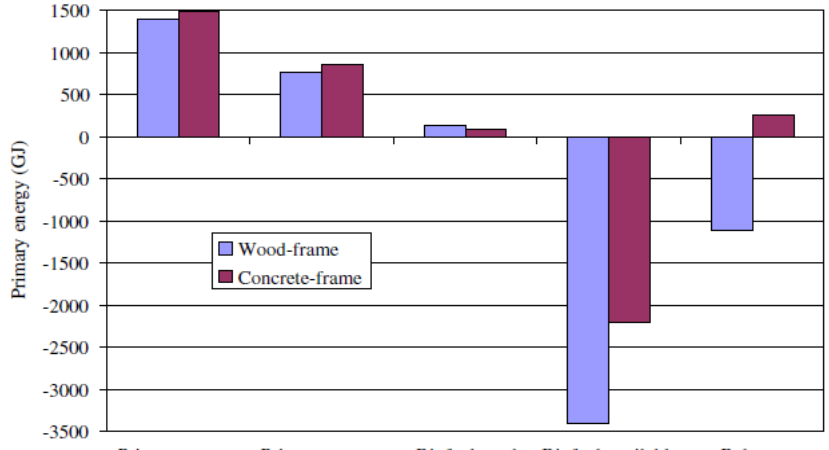


Figure 3: Energy Consumption in Production of Material for Wood and Concrete Frame

Source: (Gustavsson, & Sathre, 2006)

Another very important parameter to determine whether the material is environmental-friendly or not is recyclability. Wood is much easy to recycle comparing to concrete. The waste wood or demolition wood can be crushed, grinded and used in the pulp and paper industry. In addition, the waste wood can also be used in the heating system for residential house (*The Eco-cycle of Wood and Wood-based Products*, 2006). In fact, the laminate wood can be made from the waste and demolition wood. With the innovative technology, there is a growing trend of recovered wood in the global. Figure 5 shows the growth of the recovered wood market in Spain.

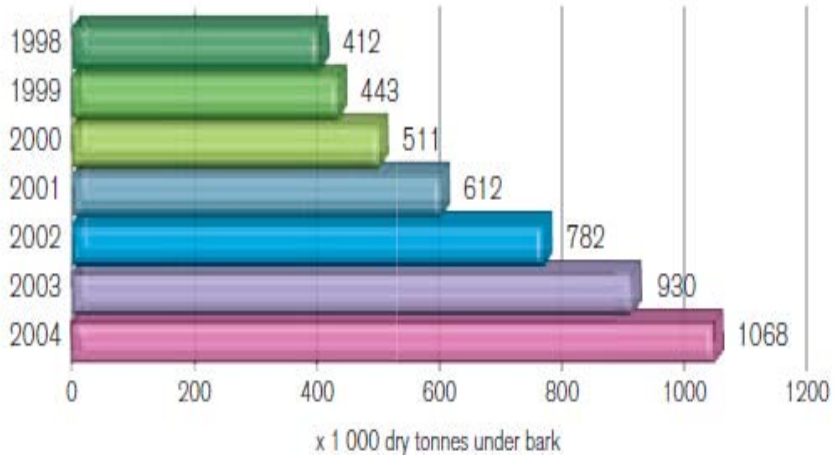


Figure 4: Growth of the Recovered Wood Market in Spain

Source: (*The Eco-cycle of Wood and Wood-based Products*, 2006)

Although wood material is much more environmental friendly relative to the concrete, the manufacturing process of laminated wood involving binding the layer or chopped wood contains toxic chemical substance. The adhesive, either synthetic or natural in assembling layers of wood contains toxic solvents (Black, 2003). When contacting with flame, the adhesive releases solvent in the air and pollute the environment and health of the staff (Black, 2003).

6.2.1 New SUB Building

The material selection becomes critical in terms of social, environmental and economical impacts. The laminate-glued wood is proposed in the choice of the materials. In terms of social perspective, the application of the mountain pine beetle wood fully demonstrates the application of sustainable design. Furthermore, the utilization of the wood materials creates more job opportunities for the forestry dependent communities. However, the less promising mechanical properties of the laminate wood comparing to the conventional reinforced concrete should be considered since students and staff walks frequently into the SUB building. Since wood is much flammable than the concrete, the safety factor of using the laminate wood has also to be considered. In terms of environment impact, manufacturing concrete building frame produces much more CO_2 emission and consumes more energy than those of laminate wood. In addition, laminate wood can be easily recycled where as concrete cannot.

6.3 ECONOMIC IMPACT

There are substantial economic advantages in using Mountain Pine Beetle (MPB) infested laminate woods for the Student Union Building (SUB). Carefully engineered laminate wood frames are as durable as concrete and steels but also at a

fraction of cost of the conventional building materials (Lam et al, 2005). The "Life Cycle Assessment" (LCA) of a wood products and conventional building materials show comparable costs and economic value of wood structures versus concrete and steels. Utilizing the MPB infested laminate woods in SUB building can also provide economic benefits to many of the forestry dependent communities in British Columbia.

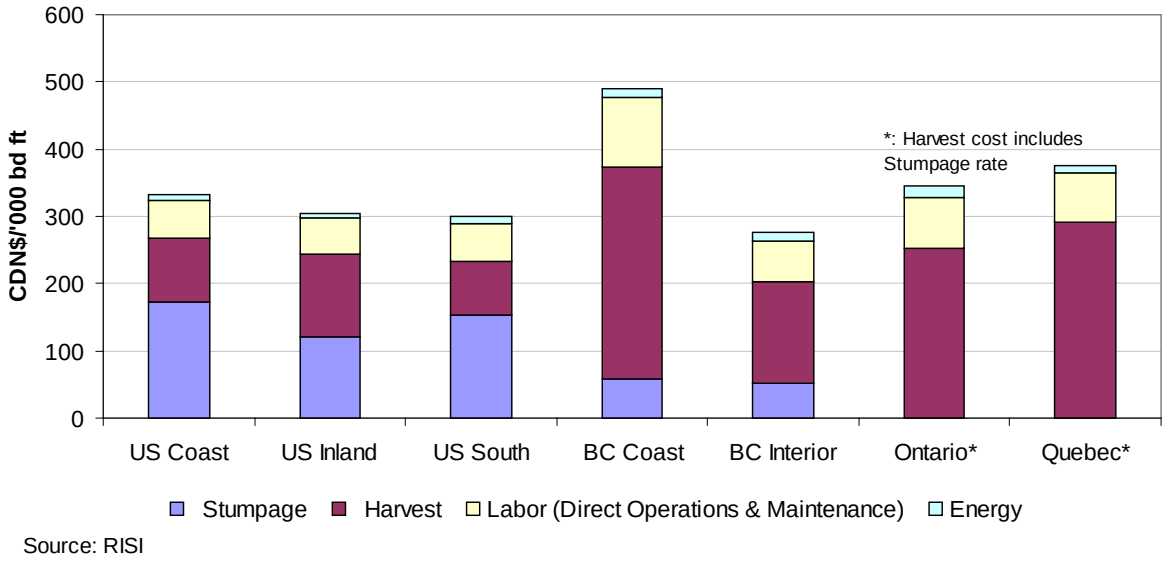
6.3.1 Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is based on ISO 14040, which analyzes the environmental impacts of a material, product or service through its entire life cycle, from raw resource or material acquisition through manufacture and use to waste disposal (Canadian Wood Council, 2001). The LCA not only provides green building standards but also the rough estimates of the cost of resource extraction, manufacturing, onsite construction, occupancy/maintenance, demolition, and recycling/ Reuse/disposal of various raw materials. Compared to conventional building materials (Concrete and steel), the full life cycle of wood tend to have substantially lower costs and less overall environment impacts. For example, there are abundant sources of standing MPB infested pines in central and interior B.C.. Acquiring raw materials (i.e. MPB infested pines) and processing them locally reduces transportation cost and ecological footprint. Many sawmills in B.C. are capable of processing various sizes of lumbers at an efficient rate at reasonable prices (refer to Figure 2b) (Economics and Trade Branch, 2009). The usage of MPB infested laminate wood products could increase productivity of on-site construction due to its lightweight and familiarity of laminate wood materials as one of a typical building materials in B.C.. Efficient productivity could also mean short labor periods, which is directly related to the cost of the construction.

Unlike the conventional building materials, the occupancy and maintenance cost is

dramatically less in wood structured buildings (Canfor, 2007). Wood is a better insulator than the concrete and steel material. Wood's cellular structures such as lignin and vessels, limits heat transfer, which makes the indoor cooler during the summer and warmer during the winter, thus reducing energy consumption. According to Canfor, average wood panel of same thickness traps heat 15 times better than concrete and 400 times better than steel (Canfor, 2007). Furthermore, indoor implications (walls, ceiling, post, truss beams, and etc) of MPB Infested laminate wood can be easily replaced at lower cost and less effort compared to the conventional steel framed concrete indoor/internal structures. Lightweight of wood material requires less effort when demolishing while providing sustainable recycle and disposal processes compared to the heavy concrete and steels that contain various toxins. However, when exposed to outdoor weather, the laminate wood requires more frequent replacement compared to concrete/steel structures.

North American Lumber Mills Variable Cost Structure in 2007
B.C. VS North American Competitors



Source: RISI

Figure 5: Comparison between Canadian lumber mills and other North American competitors. Notice that B.C. Coast has the highest variable cost in North America, whereas the B.C. Interior has the lowest.

Source: Economics and Trade branch (July 2009)

6.3.2 Local economic benefit

B.C.'s rural community is feeling the direct impact of the U.S. recession; especially the central and interior where the majority of small communities are solely dependent on Forestry (refer to Figure 1b)(Economics and Trade Branch, 2009). The majority of B.C. central and interior forest products are exported into the U.S. lumber market, mill dependent communities are having difficulties due to mill production curtailments.

The U.S. housing market collapse and the shifting Canadian/U.S. currency exchange rates are severely limiting sales into the U.S. market (Economics and Trade Branch, 2009). The fibre supply in the B.C. Interior region has dropped significantly due to the Mountain Pine beetle epidemic. According to the Natural Resources Canada, 80 per cent of the mature pine will be dead by year 2013 (Natural Resources Canada, 2009). Utilizing the MPB infested laminate woods will produce jobs in forestry dependent communities in central and interior B.C..

7.0 Works Cited

Canadian Wood Council. (2001). *Energyand the Environment In Residential Construction.* Retrieved April 2, 2010, from Canadian Wood Council: http://www.cwc.ca/Publications/PDF+Publications/index.htm#Sustainability

Canfor. (2007, August 27). *Products Lumber and Building Materials.* Retrieved April 2, 2010, from Canfor: www.canfor.com/_resources/products/Wood_Green_building.pdf

Lam et al, F. (2005, May). *CFS Bookstore* . Retrieved April 1, 2010, from Natural Resources Canada - Canadian Forest service: http://bookstore.cfs.nrcan.gc.ca/pdf.php?CatalogNumber=25430

Wood Works! (2009, April 19). *What's New*. Retrieved April 2, 2010, from Wood Works!: http://www.wood-works.org/

Natural Resources Canada. (2009, September 1). *Canadian Forest Service*. Retrieved September 6, 2009, from Forest. Forward. moving beyond the pine beetle: http://mpb.cfs.nrcan.gc.ca/index_e.html

Natural Resources Canada. (2008, February 4). *Wood Markets: Annual Report 2005-2006*. Retrieved June 2, 2009, from Canadian Forest Service: http://cfs.nrcan.gc.ca/subsite/canada-wood/report2006/12

Economics and Trade Branch. (2009, July). *BC Forest Sector Economic Issues.* Retrieved July 30, 2009, from Ministry of Forest and Range: https://gww.for.gov.bc.ca/het/Economic%20Situation--July%202009%20(with%20Notes).pdf

Lum, C., Byrne, T., & Casilla R. (2006). Mechanical Properties of Lodgepole Pine Containing Beetle-Transmitted Blue Stain. *Forest Products Journal.* Retrieved from http://www.entrepreneur.com/tradejournals/article/148008073_1.html

Mountain Pine Beetle in B.C. (n.d.). Retrieved from http://www.for.gov.bc.ca/HFP/mountain_pine_beetle/bbbrochure.htm

Pine Beetle Blamed for B.C forestry Layoffs. (2010. January 7). *CBC News*. Retrieved from http://www.cbc.ca/canada/british-columbia/story/2010/01/07/bc-forestry-layoffs-pine-beetle.html?ref=rss

Data Table For: Miscellaneous Materials: Concrete: Steel Reinforced Concrete. (n.d.). Retrieved from http://www.matbase.com/material/other/concrete/steel-reinforced-concrete/properties

Lynnelle. (2004). Glued Laminated Timber (Glulam). *Engineered Wood Products*. Retrieved from http://www.timber.org.au/NTEP/resources/Glulam%20text.pdf

William D. Callister, Jr. (2007). *Materials Science and Engineering An Introduction.*7th Edition. New York, NY: John Wiley & Sons, Inc.

European Commission DG ENV. (2006). *Wood-framed Construction Requires Less Energy and Emit less CO_2,* Retrieved from http://ec.europa.eu/environment/integration/research/newsalert/pdf/40na1.pdf

Ruddick, J, N.R. (2008). *Wood Drying*. Retrieved from University of British Columbia

Gustavsson, L., & Sathre, R. (2006) Variability in Energy and Carbon Dioxide Balances of Wood and Concrete Building Materials. *Building and Environment, 41*, 940-951. Retrieved from http://www.sciencedirect.com/

The Eco-cycle of Wood and Wood-based Products. (2006). Retrieved from http://www.roadmap2010.eu/wisd/pdfs/46-57.pdf

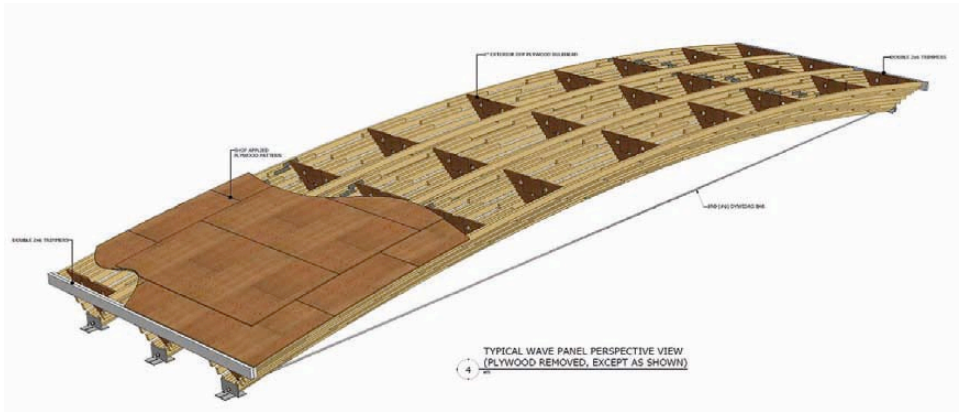
Black, S. (2003). Getting to the Core of Composite Laminate. *Composite Technology*. Retrieved from http://www.compositesworld.com/articles/getting-to-the-core-of-composite-laminates

Young's Modulus. (n.d.). In Wikipedia. Retrieved April 5, 2010, from http://en.wikipedia.org/wiki/Young's_modulus

Factor of Safety. (n.d.). In Wikipedia. Retrieved April 5, 2010, from http://en.wikipedia.org/wiki/Safety_factor

Rotary Kiln. (n.d.). In WiKipedia. Retrieved April 5, 2010, from http://en.wikipedia.org/wiki/Rotary_kiln

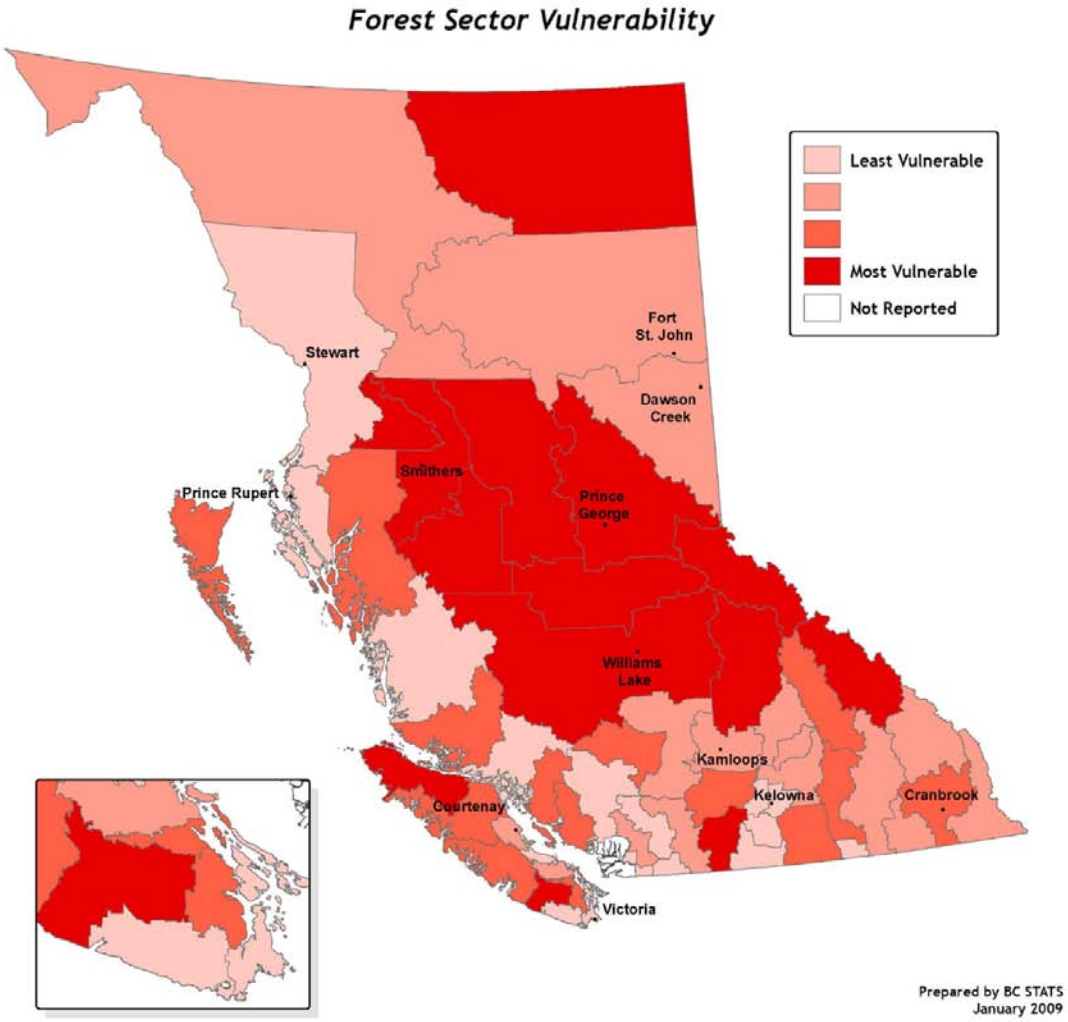
APPENDIX A


TYPICAL WAVE PANEL PERSPECTIVE VIEW
(PLYWOOD REMOVED, EXCEPT AS SHOWN)

Appendix A: Richmond Olympic Oval Building. Example of utilizing MPB infested pine throughout the building.

Source: (Wood Works!, 2009)

APPENDIX B



Appendix B: Forestry Sector Vulnerability in B.C.. Dark red represents high economic dependency on forestry sector. Notice that Northern Interior communities have greater vulnerability than the Lower Mainland regions.

Source: Economics and Trade branch (July 2009)