THE USE OF ENGINEERED WOOD PRODUCTS IN TRADITIONAL JAPANESE WOOD HOUSE CONSTRUCTION

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ABSTRACT

In Japan 42%–48% (425,000–600,000) of all new housing construction is made from wood. The majority (>75%) are built using traditional post and beam construction. During the nineties, much of the cutting and notching of components has shifted from the construction site to what is called a precut factory. Structural and nonstructural components are manufactured and stored at the factory and taken to the construction site for assembly. This has resulted in a shift in material preference from large green timbers for posts and beams to dry, more stable, solid and engineered wood products. Results from surveying both builders and precutters indicate that the use of engineered wood products will continue to grow, capturing significant market share from solid wood structural members.

Keywords: Japan, engineered wood products, markets.

INTRODUCTION

During the nineties in North America, there has been a shift towards using more engineered structural wood products. For example, the production of I-joists, and laminated veneer lumber in North America has increased by over 12% each year from 1992–2000 (compounded annually) (adapted from Adair 2001). In Japan, the house construction sector and the use of engineered wood products are different than in North America. Some of these differences in the construction sector include an industry structure dominated by small (<10 houses) traditional construction firms that build post and beam wood houses using non-specialized crews (Cohen and Gaston 2001; Lampert and Ikehata 2000). These differences have contributed to a different adoption curve for engineered wood products.

Wood construction in Japan accounts for 40–50% of the more than 1.2 million housing starts per year (JAWIC 2001b). Each year, Japan builds the second highest number of wood houses in the world. The predominant form of wood construction is post and beam, with 2 by 4 (also called platform frame construction) accounting for less than 15% of all wood housing starts in 2000 (JAWIC 2001b). With imported logs and lumber accounting for over 75% and 25% (respectively) of Japan's construction needs (JLJ, 1998a), changes and op-

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portunities in this sector are important to all exporters of wood products. The size of this market and the reliance on imports suggest increased opportunities for the adoption of engineered structural products.

Results pertaining to the Japanese market for engineered structural products (ESP) form the basis of this report. This was part of a large multifaceted industrial and consumer research project completed in 1998 cooperatively by the University of British Columbia and Forintek Canada Corp., with all data collected between March and June 1998.

BACKGROUND

There have been two key trends in residential construction in Japan during the past two decades.[1] The first has been a shift from wood single-family dwellings to nonwood high-rise apartments in an urban setting (called mansions in Japan). The share of new wood single-family housing starts has fallen from 70–80% in the 1970s to 40–50% in the 1990s (JAWIC 2001a).

The second trend has been a shift away from traditional post and beam construction to two alternatives. The first alternative is the adoption of North American (N.A.) platform-frame construction (called 2 by 4 in Japan) first introduced in 1972 (Cohen 1994). The second is the shift from the construction of post and beam wood houses from green timbers cut, notched, and assembled on site by traditional carpenters, to factory cut structural components that are assembled on site. A driving force behind this change has been the shortage of skilled carpenters, the labor savings from the use of computer-assisted design and cutting and the lack of adequate building regulations for traditional Japanese housing facilitating a rapid technological change (Gaston et al. 2000). These changes have opened the opportunity for structural building material that is sufficiently stable to have intricate joints produced in a factory, stored for a week or more in an open air setting with variable relative humidity, and then transported to the building site for assembly. These factories are referred to as precut facilities. This has led to increased use of kiln-dried and engineered wood products in the Japanese market (Anonymous 1998; Gaston et al. 2000; Cohen and Gaston 2001; JLJ 2001b; Lampert and Ikehata 2000). As Japan does not have adequate kiln capacity to meet its needs, demand for kiln-dried lumber imports (predominantly from the European Community—EC) has increased dramatically.

TABLE 1. *Japanese laminated lumber production and imports.*

Year	Domestic prod. of structural laminated lumber (,000 m3)	Percent change from previous year	Vol. of imported structural laminated lumber	Percent change from previous year
1990	127		10	
1991	127	0	18	80
1992	127	0	21	17
1993	140	10	59	181
1994	174	24	89	51
1995	208	20	148	66
1996	340	63	231	56
1997	385	13	267	16
1998	374	−3	148	−45
1999	484	29	271	83
2000	622	29	446	65

Source: JLJ 2001a 42(7):1–2 and JLJ 1998b 39(8):11–12.

The trend towards increased use of engineered wood products is illustrated in Table 1, which highlights the growth in both domestic Japanese production and imports of laminated lumber for structural use. Most lamstock used in producing domestic glulam production is imported. The use and also the imports of both lamstock and engineered wood products have grown dramatically during the nineties. To explore trends in the use of ESP made from wood, both small builders and precutters were interviewed in 1998.

METHODOLOGY

From March–June 1998, personal interviews were conducted with 170 small builders

[1] This excludes changes in house design such as increased westernization of rooms, larger houses, and more two- and three-story houses.

and 135 precutters located in one of the three major metropolitan Japanese areas (Tokyo, Osaka, and Nagoya). Small builders were defined as those that build fewer than 100 houses per year. There are over 100,000 of these builders (called kumoten), and they were responsible for over 70% of all single-family housing (JLJ 1999). They have kept traditional post and beam construction alive in Japan. Builders were randomly selected from a stratified population to reflect the 80:20 split between traditional post and beam and 2 by 4 builders in the three major urban centers on the main island of Honshu. The list used was a combination of the members of the appropriate Japanese association and lists developed by Canadian associations with offices in Japan. Precutters were also selected from the appropriate Japanese association membership lists and interviewed since in 1997 they were responsible for between 40 and 45 percent of all lumber used in housing in 1997 (JLJ 1998c). One hundred and seventy managers of the estimated 860 precut mills in Japan were interviewed for a representative sample of 19.8%.

The researchers recognized that there might be some double counting as some of the builders could be using material from precutters. The possibility of double counting prohibits projecting any volumes to the sector at large.

Survey questions were written in English, translated into Japanese, evaluated by a team of bilingual experts, and then pilot tested with bilingual Japanese experts involved in the building sector. This ensured that the meaning was translated and not just the words.

LIMITATIONS

Because of the geographical limitation of the research (restricted to the three largest urban centers in Japan) and the inability to ensure a lack of nonresponse bias, the reader is cautioned regarding the inferential analysis. In September of the same year, a series of personal interviews were conducted with medium and larger builders, and qualitative results confirmed the results of this survey, providing an empirical check on nonresponse bias. While unorthodox, this is a useful process particularly for international research. The results do provide insights into the trends in use of ESP in Japanese residential construction in the three largest urban centers in Japan.

RESULTS

General results for builders

The 170 builders interviewed built an average of between 11 and 20 houses per year (the category selected most frequently in the appropriate survey question). The proportion of respondents that built wood post and beam was 70%; the proportion that built 2 by 4 houses was 22%, with 4% building each of steel and prefabricated houses. Respondents indicated that by 2001 they expected the proportion of post and beam to decline and the proportion of 2 by 4 to increase, while steel would increase slightly and prefabricated would decrease slightly.[2] Over 96% of builders were concerned with formaldehyde emissions but only 44% were willing to pay a small premium for products with greatly reduced emissions.

Eighty-five builders responded to questions about preferences for structural material. On a scale of 1–7, with 1 being very low preference and 7 being very high preference, solid wood has an average of 6.24, followed by engineered wood products (5.16), steel (3.64), and lastly concrete (3.54). An ANOVA analysis compared the means for all four materials and found significant differences between all possible comparisons except for between steel and concrete.[3] This indicates that builders have significant preferences for wood as a structural building and prefer solid wood over engineered wood.

[2] It appears that these results were accurate predictions of housing starts for the first nine months of 2001 (JAWIC 2001b)

[3] SPSS was used to run an ANOVA with a Scheffe post hoc comparison at mean difference significance set at 0.05.

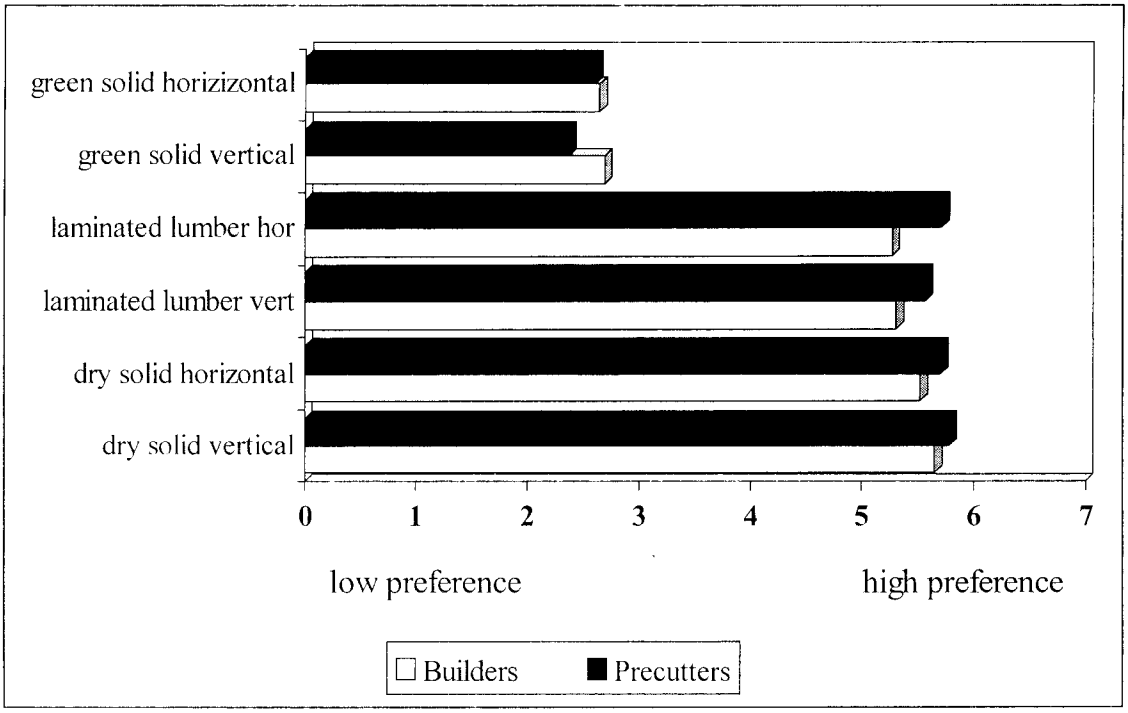

FIG. 1. Preference of builders and precutters for types of wood structural member.

Builders also indicated their preference among wood products used as structural members for both horizontal and vertical purposes. Figure 1 clearly illustrates that builders (and precutters) consider laminated lumber and dry solid wood members as superior to green members. An ANOVA analysis indicated significant differences between green and dry products (both solid and laminated) for both vertical and horizontal structural members.[4] There were no significant differences between laminated or dry solid lumber for posts (vertical members) or beams (horizontal). This supports the clear trend toward kiln-dried material in Japanese construction but indicates increased opportunities for dried solid members as competition for engineered structural components.

Builders ranked the five most important attributes in selecting a building system.[5] An arbitrarily adjusted score was created by weighting the ranks as follows: 5 points for a first place ranking, 4 points for a second, 3 points for a third, 2 points for a fourth, 1 point for a fifth, and 0 points if the attribute was not ranked. The values were then summed to create the scores shown in Table 2. Although the scores are statistically meaningless, they do serve a practical purpose in highlighting the relative importance of these attributes to builders.

Ease of "treating" and "country of origin" attributes had scores of less than 25. The low ranking for country of origin seems consistent regardless of product group or market segment. It is interesting to note the importance of performance factors such as strength and

[4] SPSS was used to run an ANOVA with a Scheffe post hoc comparison at mean difference significance set at .05.

[5] A building system was defined as both the location of construction and method, that is site built or factory-built and either 2 by 4 method, post and beam or hybrid.

TABLE 2. *Most important attributes of house system for builders.*

Attribute	Score
durability (how long the house will last)	268
strength (earthquake preparedness)	265
method of construction (e.g., factory built, 2 by 4, P & B)	177
design (e.g., western, traditional Japanese, mixed)	162
structural material (wood, steel, or concrete)	122
green versus dry wood	103
house is detached	81
house size	37
size of structural members	26
country of origin	23
ease of treating	17

TABLE 3. *Most important attributes for engineered structural products for builders and precutters.*

Attribute	Builders' score (rank) n = 85	Precutters' score (rank) n = 130
strength	304 (1)	489 (1)
durability	261 (2)	327 (3)
price stability	228 (3)	456 (2)
connections	139 (4)	48 (7)
security of supply	108 (5)	297 (4)
species	88 (6)	137 (6)
supply reliability	71 (7)	168 (5)
treatability	45 (8)	33 (8)
source of material	9 (9)	12 (9)
country of manufacture	7 (10)	11 (10)

durability.[6] Despite defining durability as longevity, follow up interviews indicated that there is a wide variety of opinions as to what durability means, ranging from termite-resistant, decay-resistant, earthquake-resistant or long-lived. The scores for design and construction method indicate that builders have a relatively firm commitment to the building method they are most familiar with and will be resistant to change. The issue of dry versus green building materials is moderately important with a score of 81 and a mid-point ranking. Note that this has to do with the selection of a building system and not a construction material.

General results for precutters

Each of the 130 precutters manufactured precut posts, beams, and lumber for an average of 598 houses per year. Of these, 78% were post and beam, 16% were 2 by 4, and 3% each of concrete and prefabricated houses. Respondents indicated that by 2001 they expected the proportion of 2 by 4 and hybrid houses (which use both post and beam and 2 by 4 techniques) to increase while the other types were to decrease. Over 85% of precutters were concerned with formaldehyde emissions, but only 46% were willing to pay a small premium for products with greatly reduced emissions.

Builders and engineered structural products

Eighty-five builders answered questions concerning ESP made from wood. They ranked the five most important attributes in an ESP, and an adjusted score was created as discussed previously. Table 3 summarizes the results and shows the evaluation score.

It is very interesting to note that the countries of origin of material and source of material are of little importance to builders. Their primary concerns are with performance characteristics (strength, durability, and connections). Service characteristics are also very important and include price stability and security of supply.

Builders indicated the specific location in a post and beam house where they used, considered using, and expected to use ESP. Table 4 shows the responses with the "do not expect to use" column calculated by subtracting the "have used" and "expect to use" from the total number of respondents. Figure 2 illustrates the location of the structural members referred to in this question. It is clear that builders expect wood ESP to increase market share to 85% for the upper level beam, the one requiring the greatest strength, where they have already captured a majority share (62%). For joist beams and floor joists where ESP represented less than a 20% share, builders ex-

[6] The conjoint analysis indicated that while these two attributes were ranked the highest, respondents were not willing to pay a premium for increased performance.

TABLE 4. *Builders use of engineered structural products (n = 79).*

	Have used	Have considered	Expect to use	Do not expect to use
foundation itself	12.7%	19.0%	22.8%	64.6%
hari (upper level beams)	62.0%	24.1%	24.1%	13.9%
keta (beam)	46.8%	22.8%	15.2%	38.0%
obiki (joist beam)	15.2%	32.9%	19.0%	65.8%
neda (joist)	13.9%	29.1%	19.0%	67.1%
kanbashira (posts)	54.4%	20.3%	12.7%	32.9%
toshibashira (long posts)	36.7%	25.3%	10.1%	53.2%
taruki (roof rafters)	10.1%	25.3%	16.5%	73.4%
mabashira (stud)	30.4%	25.3%	16.5%	53.2%

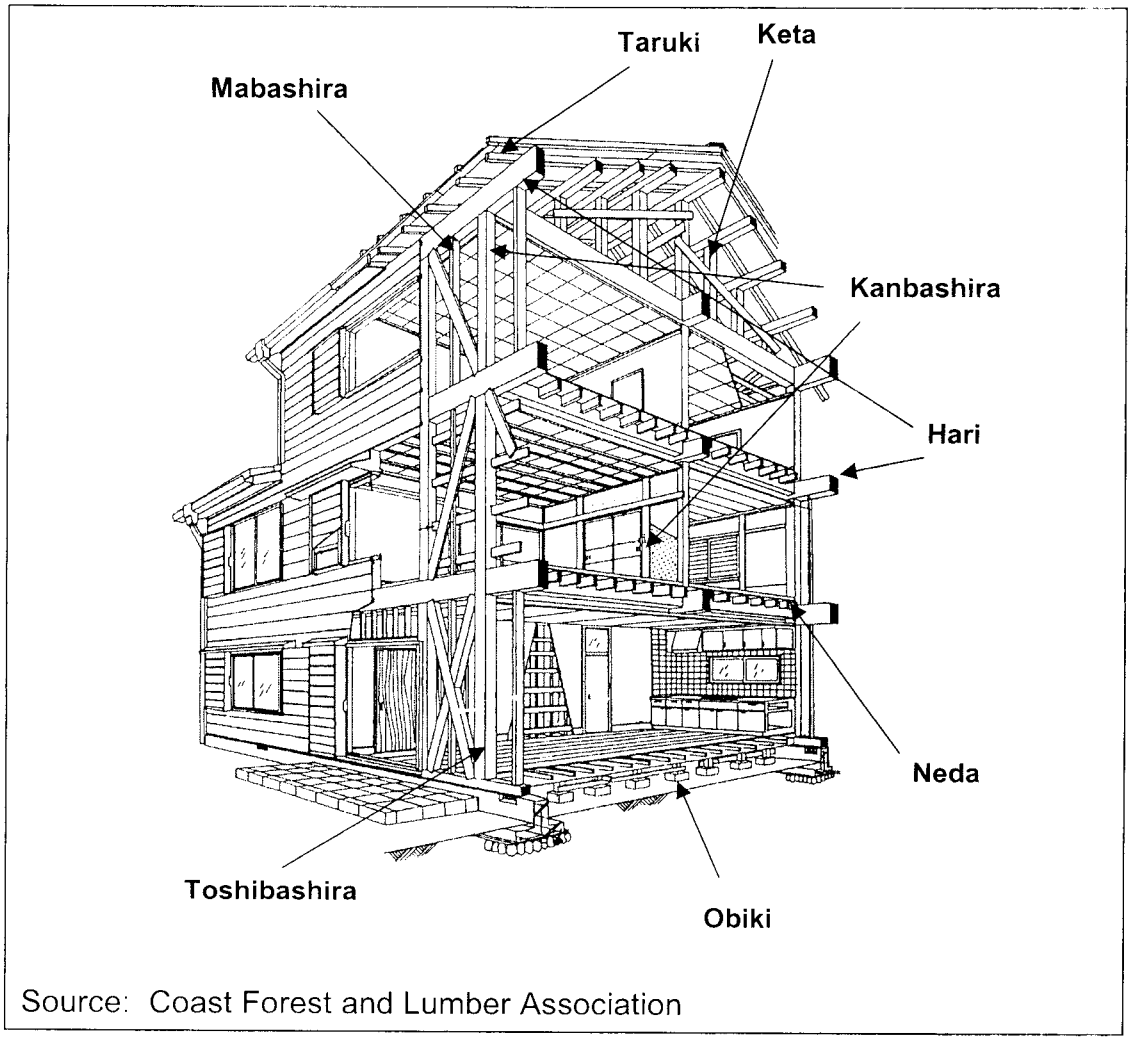

FIG. 2. Location of structural components for Japanese post and beam house.

TABLE 5. *Precutters' use of engineered structural products (n = 111).*

	Have used	Have considered	Expect to use	Do not expect to use
foundation itself	29.7%	25.2%	25.2%	45.0%
hari (upper level beams)	91.9%	4.5%	4.5%	3.6%
keta (beam)	84.7%	6.3%	5.4%	9.9%
obiki (joist beam)	22.5%	26.1%	25.2%	52.3%
neda (joist)	21.6%	29.7%	23.4%	55.0%
kanbashira (posts)	93.7%	3.6%	1.8%	4.5%
toshibashira (long posts)	92.8%	5.4%	0.9%	6.3%
taruki (roof rafters)	15.3%	32.4%	22.5%	62.2%
mabashira (stud)	76.6%	9.9%	4.5%	18.9%

pect this to increase to over 65%, indicating an opportunity for domestic and foreign producers of ESP.

Builders expect ESP to capture over 50% market share for posts, beams, and upper level beams. Builders expect increased use of ESP in all types of structural members in traditional post and beam houses. The builders expect to use a greater proportion of solid wood for taruki, neda (joist), obiki (joist beams), foundations, and mabashira (studs) despite growth in overall use for ESP.

Precutters and engineered structural products

The 130 precutters who responded to these questions also ranked the five most important attributes in wood ESP. Results (shown in Table 3) are similar to those of the builders. Precutters considered connections less important than builders (ranked 7 versus 4), while builders considered reliability of supply more important than precutters did (5 versus 7); and precutters ranked price stability slightly higher than did builders (2 versus 3). However overall, there was good consensus among builders and precutters as to the most and least important attributes for ESP previously discussed in the builders' section.

Respondents indicated the specific location in a traditional post and beam house where they used, considering using, and expected to use ESP. Table 5 shows the responses with the "do not expect to use" column calculated by subtracting the "have used" and "expect to use" from the total number of respondents. Precutters indicated that the greatest use of ESP is for upper level beams (hari), beams (keta), and posts (kanbashira) the same as builders.[7] Precutters expected ESP to capture a higher market share for all components compared to builders. However over 80% of precutters have already used ESP in these applications indicating that they have adopted ESP faster than traditional builders; and for some applications, there is less room for growth than among traditional builders. The greatest growth in the use of ESP for precutters is for obiki (joist beams, foundations, neda (posts), and taruki (roof rafter).

DISCUSSION AND CONCLUSIONS

There is dramatic potential for increased use of ESP in single family wood house construction in Japan. The shift of cutting and notching from on site to the factory where elements are precut will continue accelerating the substitution of green solid members with engineered structural members. It is expected that this trend will accelerate and evolve into those factories developing building systems (walls, floors, and roofs). Already some precut facilities, such as Precut 21, are grouping together and expanding into branded systems (JLJ 2000).

With the adoption of the new Building Stan-

[7] See Fig. 2 for a graphical explanation of the Japanese terms for members of the superstructure in a traditional Japanese post and beam house.

dards Law in Japan, the introduction of the mandatory ten-year warranty, and the voluntary adoption of the "nine performance indicators" for new single family home construction, it is expected that the trends toward increased use of kiln-dried lumber and ESP will be even further accelerated.

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