C I N T R A F O R

Working Paper

70

A TECHNICAL ASSESSMENT OF THE NORTH AMERICAN-STYLE 2X4 RESIDENTIAL CONSTRUCTION SYSTEM IN JAPAN

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The excessive use of framing lumber was routinely observed.
It is estimated to increase framing material costs by 30-35 %.

EXECUTIVE SUMMARY

Anecdotal information from US architects and contractors with experience in residential construction projects in Japan indicates that Japanese construction professionals often do not fully understand the North American-style 2x4 construction system and often employ construction techniques that can compromise the structural integrity and/or long-term performance of these homes. A recent study by CINTRAFOR estimates that 2x4 construction costs in Japan range from 2 to 2.5 times higher than in the US (Eastin *et al.* 1995), partly due to differences in the way that the technology and construction management practices are implemented in Japan. The CINTRAFOR study suggested that Japanese construction professionals could improve their cost effectiveness and improve the quality of 2x4 homes built in Japan by increasing their understanding of North American-style 2x4 construction technology and construction management practices.

This research project was designed to provide specific information about how North American-style 2x4 homes are built in Japan. The specific objectives of this research project were to:

1. provide information to help Japanese construction professionals rationalize and reduce 2x4 construction costs through a more efficient transfer of North American-style 2x4 construction technology;
2. identify areas where a more efficient transfer of North American-style 2x4 construction technology could help improve the structural integrity and long-term performance of 2x4 homes in Japan; and
3. provide information to support the development and implementation of the 2x4 technology transfer program administered by the Washington State Department of Community, Trade and Economic Development.

While the tone of this report might appear to be negative, this is not the intention. The reader should keep in mind that the primary purpose of this project was to identify construction practices that negatively impact the structural integrity and long-term performance of North American-style 2x4 homes in Japan. Given the emphasis of this project, it is unavoidable that the tone of the discussion could easily be construed as being overly negative. However, it is important to emphasize that in many of the projects visited, particularly those being built by large construction companies, the technical team observed that the quality of construction was very good. While it is always dangerous to generalize, the technical team found that larger home builders, and the home builders with more experience with the 2x4 construction technology, generally were building good quality North American-style 2x4 homes. In contrast, the team observed that the projects with the lowest quality ratings were managed by smaller construction companies or companies with little or no experience in building North American-style 2x4 homes.

The results of the construction cost assessment and the technical assessment indicate that technical training seminars should focus on the following areas:

- rough framing techniques and lumber specification
- construction detailing
- specification of imported building materials
- exterior finish details
- interior finish details
- insulation and energy efficiency details
- construction management and planning
- architectural design and details

Another important consideration in the design of a technology transfer program relates to the long-term maintenance of 2x4 homes in Japan. In order to ensure that North American-style 2x4 homes built in Japan provide the long-term performance that is expected of them, a strategy must be developed to ensure that they receive routine maintenance. It is critical that routine maintenance services be provided, whether by the homeowner, the building contractor, or an independent maintenance contractor.

Finally, some sort of independent certification of North American-style 2x4 homes built in Japan should be considered. The certification process could focus on the structural components of the home or could be extended to include the routine maintenance of the home as well. A certification program would not only ensure that North

American-style 2x4 homes are built using the correct construction techniques but it could provide a forum to facilitate the provision of technical training programs in Japan.

It is critically important, from the US perspective, that the structural integrity of North American-style 2x4 homes in Japan is not compromised by the incorrect application of North American-style 2x4 construction technology. From a long-term strategic market development perspective, it is imperative that Japanese builders and carpenters be properly trained in 2x4 construction technology in order that the growth of this important segment of the Japanese housing market not be jeopardized by substandard product performance.

Given the Japanese expectation of high quality, the long-term growth potential of the 2x4 market is dependent on maintaining the quality of the North American-style 2x4 houses being built in Japan. From a marketing perspective, the role of quality is more important than low price in Japan and every effort should be made to ensure that the North American-style 2x4 construction technology is implemented correctly by Japanese contractors and carpenters. Failure to ensure the correct transfer of North American-style 2x4 construction technology would contribute to a perception by Japanese home buyers that 2x4 housing is poor quality, and would undermine efforts by North American companies and industry associations to further develop this growing segment of the Japanese housing market.

Over the long-term it is equally important that US value-added manufacturers and exporters work to gain greater acceptance of US wooden building materials in the other segments of the Japanese housing industry: post-and-beam and pre-fabricated housing. This includes learning how building materials are specified, by whom, what factors affect the specification process, and how to influence the specification process effectively to increase the use of US building materials in these segments of the Japanese residential construction industry. Similarly, it is equally important that US exporters better understand the role of maintenance and product support factors (*e.g.*, local inventory, product installation instructions and support services, and product maintenance literature) on the competitiveness of US building materials in Japan. Other factors such as product distribution and product support affect the overall success and acceptance of North American-style 2x4 projects, although these were not a part of the terms of reference of this project.

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LITERATURE REVIEW

Forest Products Trade Flow Between North America and Japan

Japan is the single largest importer of forest products in the world (Sedjo *et al.* 1994). Japan is also an important trade partner to the United States and is the single largest market for US primary and secondary forest products exports. In 1997, 31% of the $8.2 billion of total US forest products exports went to Japan (Table 1). More forest products were exported to Japan than to the NAFTA trade partners of Canada and Mexico combined.

Table 1. US forest products export destinations in 1997.

Country	Value ($US)	Percentage
Japan	2,587,254,123	31.6
Canada	1,984,749,576	24.2
Mexico	379,273,284	4.6
Germany	349,252,238	4.3
UK	325,417,915	4.0
Korea	299,822,123	3.7
Italy	229,081,406	2.8
Other	2,042,427,051	24.9
Total	**8,197,277,716**	**100.0**

The Japanese market is also a major export destination for Canadian wood products (Table 2). The US market takes the greatest share of Canadian exports by value at 78%. However, Japan is the largest market among all non-US export destinations. Exports to the Japanese market make up 67% of all wood products exports by value going to countries outside the US. In addition, it has been estimated that Canadian wood is consumed in over half of the wooden housing starts in Japan (Jahraus and Cohen 1997).

Table 2. Canadian forest products export destinations in 1997.

Country	Value ($Can)	Percentage
US	13,694,132,000	77.4
Japan	2,682,257,000	15.2
UK	198,258,000	1.1
Germany	183,732,000	1.0
Other	941,977,000	5.3
Total	**17,700,356,000**	**100.0**

Japan is heavily dependent on forest products imports because their forest resource is unable to meet domestic demand. The domestic forest resource is generally considered to be too poor in quality or too expensive to harvest due to severe site conditions (Gaston 1997). Jahraus and Cohen (1997) also suggest that Japan is heavily reliant on imported forest resources due primarily to the high cost of domestic production relative to imports, and the labor shortages faced by the wood processing industry.

Japan has been dependent on imports since 1923 when large volumes of lumber were imported to rebuild after the Great Kanto Earthquake destroyed much of Tokyo. At that time, the domestic supply of lumber was inadequate and North American lumber imports were required (WWPA 1994). In 1961, the Japanese government officially implemented a policy of promoting the import of softwood lumber from North America to meet their surging housing and pulp demand (Pesonen 1993). The Japanese government has recently introduced new policies to promote the import of houses as a way to reduce housing costs by 33% by the year 2000 (Yamakoshi 1994).

The US lobbied Japan from May 1989 under the Super 301 provision of the 1988 Omnibus Trade Act to open up its forest products market to foreign competition, putting forest products in the same league as supercomputers and satellites as major areas of trade friction (Coaldrake 1990). In 1996 the American Forest and Paper Association (AF&PA) recommended that Japan be removed from the Super 301 trade protection watch list (Washington State CTED 1997). AF&PA noted that Japan had removed substantial barriers to US forest products exporters and would continue to do so. The US is now Japan's largest supplier of forest products (Table 3): Japan sourced 22% of its $15.1 billion worth of forest products imports from the US in 1997 (*Japan Lumber Journal* 1998b).

Table 3. Sources of timber imports into Japan by value in 1997

Country	Value ($US)	Percentage
US	3,317,000,000	22.0
Canada	2,369,000,000	15.7
Indonesia	2,116,000,000	14.0
Malaysia	1,880,000,000	12.5
China	836,000,000	5.5
Russia	792,000,000	5.2
Australia	608,000,000	4.0
New Zealand	486,000,000	3.2
Chile	393,000,000	2.6
Others	2,292,000,000	15.2
Total	**15,089,000,000**	**100.0**

Japan's Residential Housing Market

The largest single end use for imported wood in Japan is residential construction (JAWIC undated). In 1992, it was estimated that 79% of lumber imports went into housing construction (Gaston 1997). Japan's residential housing market has consistently been one of the largest and most dynamic in the world. Since 1987, Japan's housing starts have been approximately equal to those in the United States, even though Japan has only 46.9% of the population and 3.9% of the land mass of the US (Table 4). The population density is thus very high in Japan. This has an impact on the type of housing built, especially in the cities.

Table 4. Comparison of key demographic factors between Japan and US.

Demographic factor	Japan	US
Total area (sq. km)	377,835	9,629,091
Population (July 1997 est.)	125,732,794	267,954,764
Housing starts 1997	1,387,014	1,474,000

Source: *Japan Lumber Journal* 1998a; and Stat-USA 1998

Japan's housing starts experienced a dramatic decline as the "Bubble Economy" came to an end in 1991 and again in response to the recession caused by the Asian Economic Crisis in 1997. Japanese housing starts were very high during the late 1980's and again in 1996, which was the first year since 1987 when housing starts increased by double digits over the previous year (Figure 1). The high number of housing starts in 1996 can be attributed in part to the rebuilding following the Great Hanshin Earthquake in Kobe in 1995. The earthquake damaged 147,600 houses (*Japan Lumber Reports* 1995) and displaced 400,000 households (*Pacific Rim Wood Market Report* 1996). Housing starts were also high in 1996 because homebuyers moved quickly to purchase homes before the Ministry of Finance increased the national consumption tax from 3 to 5% on April 1, 1997 (the start of the fiscal year).

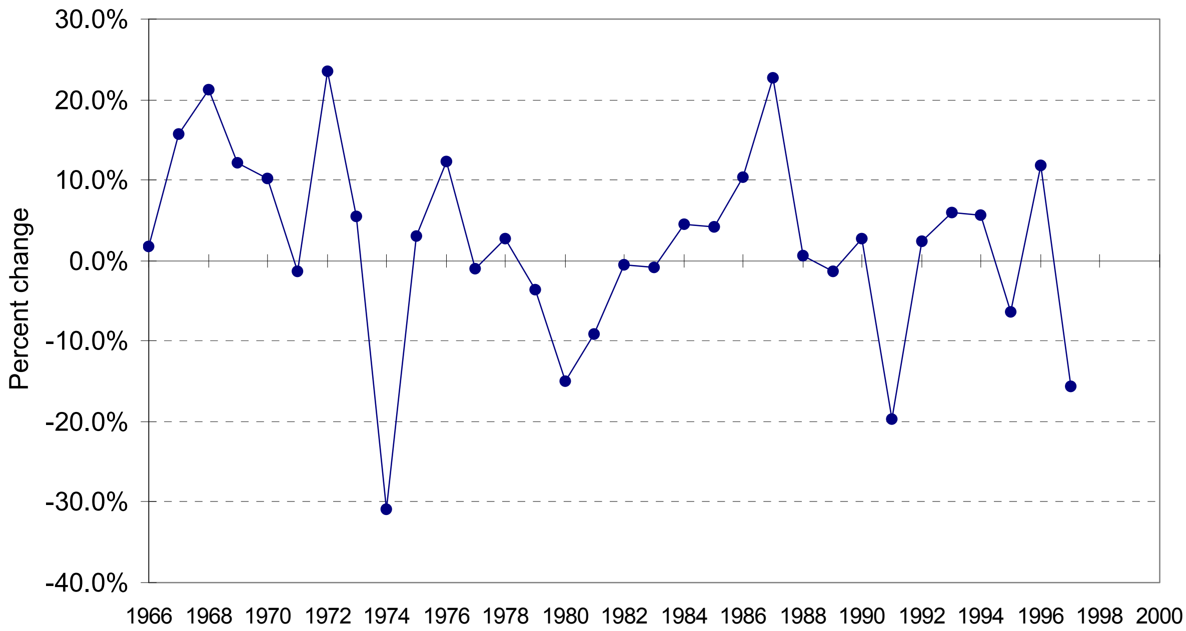

Figure 1. Annual percent growth rate in total Japanese 2x4 residential housing construction

The dramatic decrease in housing starts in 1997 can be attributed to three factors: 1) the increase in the consumption tax from 3% to 5%, 2) the cost of living increase caused by the removal of the income tax reduction and increases in the costs of medical care, and 3) funds for large public works by the government not readily available due to anxiety over the troubled banking system and an overall slump in the economy (*Japan Lumber Reports* 1998a). The government's implementation of various fiscal policies were expected to knock a full point off private spending in 1997 (Bremner and Takahashi 1996). Late 1997 was also a time of currency devaluations and economic instability in many Asian countries.

A combination of factors has spurred the consistently high levels of housing starts, including: active construction of rental housing, extremely low interest rates, active government support for providing affordable housing, sustained growth of per capita income, rapid turnover of existing housing stock, large migration to urban centers, large volumes of existing low quality housing in need of replacement, improved tax benefits for housing, and stable land prices (JETRO 1995; Robertson and Waggener 1995). While the population in Japan has increased by 50% since 1950, the average household size has fallen from 5.02 to 3.01 indicating a trend away from large extended families (Robertson and Waggener 1995).

Increases in population and the number of nuclear family households have raised the demand for housing. In addition, Japanese homeowners perform very little routine maintenance on their homes. As a result, Japanese houses are typically replaced every 20-25 years and housing is viewed more as a disposable commodity than a long-term investment as in the US (Jahraus and Cohen 1997). Most new housing starts are on building sites where the existing home has been demolished. Given the poor quality of the older housing stock in Japan, it is more efficient and cost-effective to demolish older homes than it is to repair or remodel them (Eastin 1994).

Types of Residential Housing

Although there are many ways to classify residential housing in Japan, all houses must meet the requirements of the Building Standards Act (JETRO 1993). The Building Standards Act covers all aspects of the construction industry in Japan and ensures that the building site and structure are constructed in a manner that does not endanger the occupant's life, health, and property from preventable disasters. All housing and exterior building materials must also meet the strict fire prevention and flammability guidelines of the Fire Laws. Fire prevention requirements are strict because of a past history of devastating fires in Japan's residential areas. Major fires burned down numerous houses during the Great Kanto Earthquake in 1923, which was centered in Tokyo, and the Hanshin Earthquake in Kobe in 1996. Fires in urban areas have historically resulted in many fatalities, causing the government to implement strict guidelines regarding the construction of new fire-proof houses to reduce the liklihood of catastrophic fires in the future. In urban Japan, residential lots are typically small in size and the house occupies most of the lot area, resulting in houses being very close together, further increasing concern about fire prevention.

One way that residential housing can be classified is by occupancy type: single-family detached versus multiple-family collective housing residences (including apartments and Nagoya style townhouses) (JETRO 1996a). JETRO (1996a) determined that multiple-family residences comprised the majority of total housing starts in 1994 at 52.9% of the total. There is a clear trend towards building multiple-family residences as a strategy to provide housing in the densely populated urban areas. In Tokyo for example, 65.3% of all residences are multiple-family units, although within Japan in general, detached single-family units comprise the majority of the existing housing stock (58.2%).

JETRO (1996a) and the *Japan Lumber Journal* (1998a) also segment housing starts based on whether the houses are constructed from wood or non-wood materials such as concrete and steel (Figure 2). There are two main types of wooden housing built in Japan: traditional Japanese post-and-beam houses and 2x4 houses. The 2x4 housing industry has experienced healthy growth within the wooden house segment.

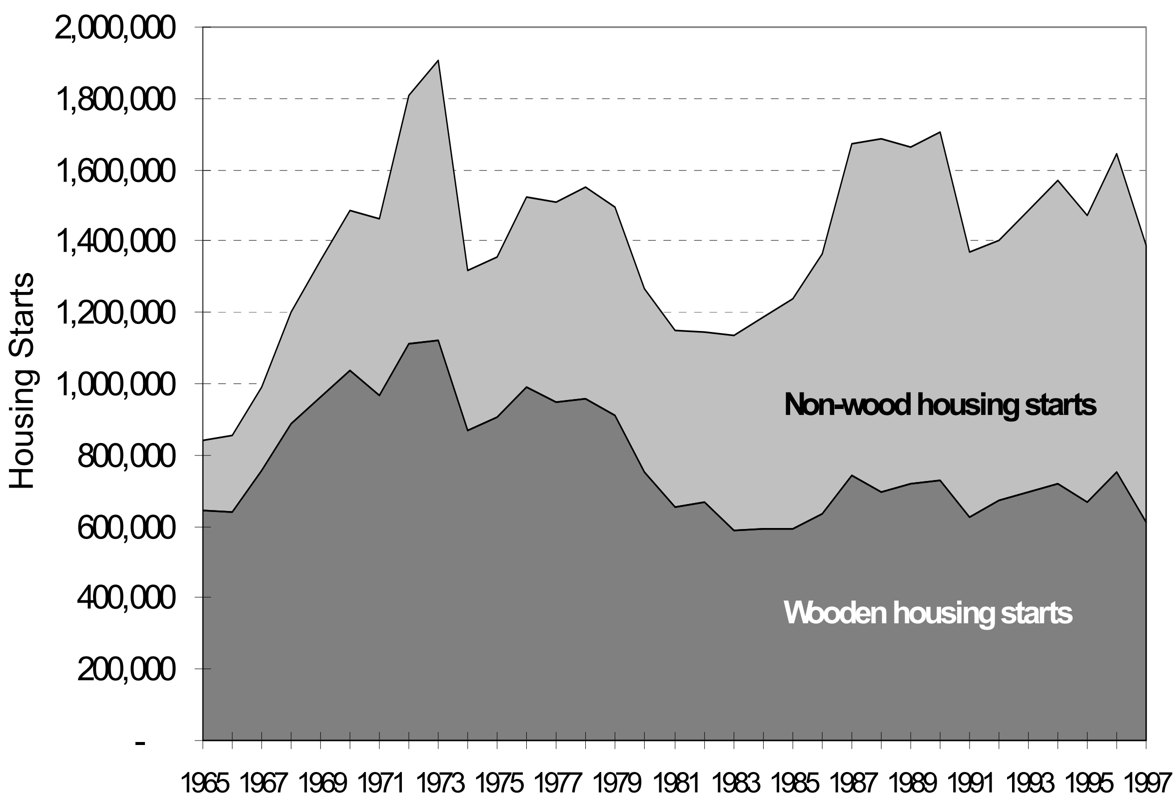

Figure 2. Japanese housing starts since 1965 based on structural material used.

Wood has always been an important part of Japanese culture. Trees were traditionally thought to be the places where the native gods first descended to earth. As a result, wood has had a strong religious meaning to the Japanese. Most temples and shrines are constructed with wood and the Japanese are deeply drawn to the aesthetic beauty, strength, and aroma of wood. Wood's attractiveness as a material is also demonstrated by the high value placed on using wood in Japanese homes. A survey conducted by the Japanese Prime Minister's Office showed that nearly 80% of Japanese would prefer to live in a wooden house if given a choice (Coaldrake 1990).

In 1965, 76.7% of all new residential housing starts were constructed of wood. Wooden houses comprised the majority of residential housing starts until 1984. Since then, the wooden house market share has been consistently below 50%, reaching a low in 1988 at only 41.4%. In 1997, roughly 490,000 units were constructed using the traditional post-and-beam system (*Japan Lumber Reports* 1998a). Wooden housing experienced a decline in market share in 1997 (44%) due mostly to the drop in starts of post-and-beam houses.

Housing starts can also be segmented by the type of utilization by the resident: owner-occupied units, rental housing units, company-owned houses, and units built for speculative sales (Figure 3) (*Japan Lumber Journal* 1998a). In 1997, the majority of the houses were rental units (38%), followed by houses occupied by the owner (25%).

The type of financing used for new houses is another way of that government and industry associations classify the residential housing industry (*Japan Lumber Journal* 1998a; Pesonen 1993). The two main sources of financing are private and public (Figure 4). In 1997, the majority of residential house financing (61.1%) was through private sources. The remaining mortgage financing was through public mortgage lenders, in particular the Government Home Loan Corporation (GHLC). The GHLC was established by the government in 1950 in order to assist middle-class home buyers with low interest loans (JETRO 1995). The interest rate for GHLC mortgage loans is well below market interest rates. In 1995, the GHLC interest rate was 3.1% compared with a commercial interest rate of 4.4% set by the private financial institutions (*Japan Lumber Journal* 1996). The GHLC has strict rules regarding eligibility criteria for potential borrowers. In 1993, the personal income ceiling was raised to ¥13.225 million to allow a larger proportion of the population to qualify for the mortgage loans. Financing was also expanded to include houses up to 240 m^2 floorspace from 220 m^2. This resulted in a record 667,118 mortgages being granted by GHLC in 1994, although in 1997 GHLC loans dropped to 245,497.

Residential Housing Industry Structure

Residential housing is mainly developed using one of two methods: subdivision developments and owner built housing (JETRO 1996a). Subdivision developments describe a situation where a developer sells both the house and land in a new residential development. Larger subdivision developments are sometimes referred to as "new towns." Owner-constructed housing is usually built by a contractor on land belonging to the owner. In many cases, the landowner tears down an older house and builds a new house in its place. These types of houses are mostly custom built to fit the shape and size of the lot (McKellar 1995). Owners have very strict specifications for the new house and their input is constantly listened to throughout the design and construction process. As the owner usually desires a home with a unique appearance, "cookie-cutter" house designs would not do well in this market segment.

The companies involved in large subdivision developments do most of the tasks involved ranging from developing the land tracts, providing architectural designs, performing the construction, and marketing the completed house. Smaller companies acquire small tracts of land to develop and sell houses. These are the "Tateuri" (Build and Sell) or "Mansion" (Condominium) companies. Despite the connotation of the term "mansion" in the US, in Japan the term "mansion" is commonly used to refer to high rise apartments or condominiums, even though they usually have a smaller floor space than single-family, detached houses.

JETRO (1996a) describes the three main groups of Japanese single-family house builders as:
1. large, national housing manufacturers
2. medium-sized, regional housing companies
3. small, local home builders (*kohmuten*) and/or carpenters.

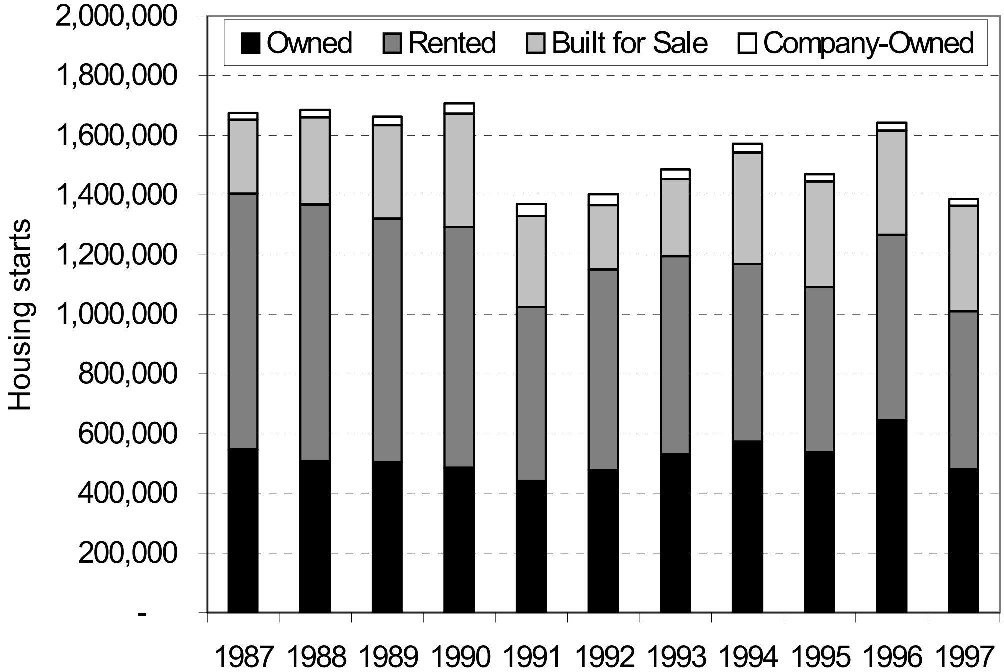

Figure 3. Total housing starts segmented by utilization type.

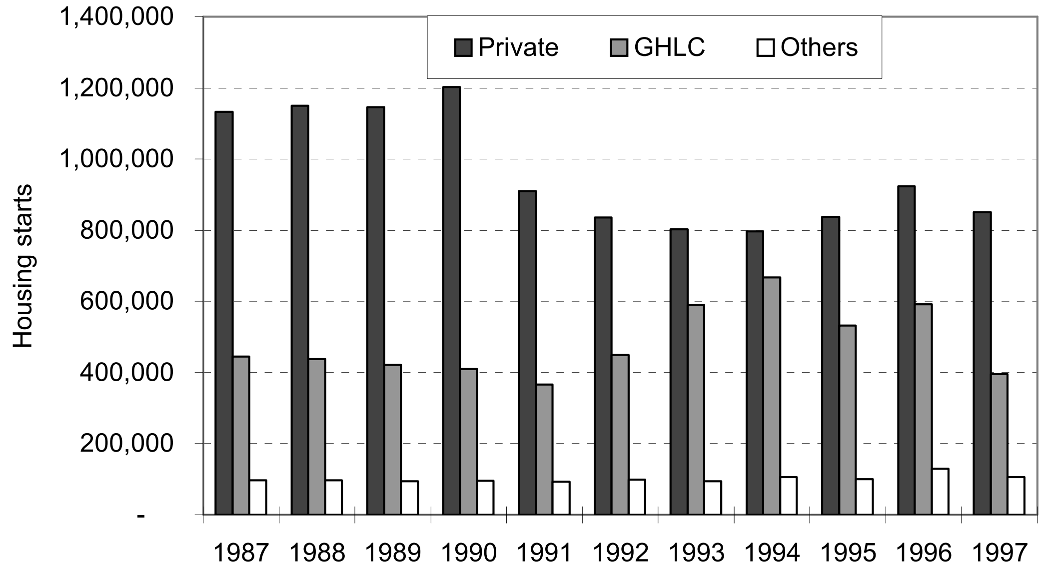

Figure 4. Number of total housing starts segmented by source of mortgage funding.

The large housing manufacturers have powerful nation-wide sales networks. In 1994 there were eight large housing manufacturers, each of which had annual sales of 10,000 units or more. They supply materials that are manufactured in their own factories even though the actual construction process may be subcontracted to smaller companies.

The regional housing companies are based in local communities and usually provide design, sales, and construction services. The medium-sized companies typically build roughly 50 or more houses annually. These companies are expecting high potential growth because they construct most of the 2x4 houses in Japan and this market segment is expected to grow steadily in the future (*Pacific Rim Wood Market Report* 1996). It is not unusual for medium-size companies to subcontract the construction work to small local builders.

The small housing companies do most of the construction work for both themselves and for the larger companies. The small companies, a category which includes self-employed carpenters who work as labor subcontractors, generally build three to five houses annually. Historically, the small companies have controlled the largest market share within the residential construction industry. The Japan 2x4 Homebuilders Association has reported that most of the North American-style 2x4 houses in Japan are constructed by small and medium-sized companies, while large companies focus primarily on building Japanese-style 2x4 houses that are based on the 3x6 module (Roos and Eastin 1998). In recent years the large national companies have seen their market share increase to roughly 25% of the single-family housing market, primarily because they offer steel and concrete multiple-family units whose market share have grown very rapidly.

Pesonen (1993) alternatively describes five main types of house builders and building contractors:

1. large building contractors
2. local builders and carpenters
3. builders of post-and-beam houses
4. prefabricated housing companies
5. platform-frame construction companies

The large building contractors consist of 6-8 major contractors who account for 15% of total residential construction. These companies deal primarily with concrete- and steel-based multi-family projects. The local builders and carpenters include nearly 50,000 small companies who account for about 60% of total residential construction. These companies are primarily involved in the construction of wooden post-and-beam houses. The builders of pre-fabricated houses consist of approximately 240 companies. These companies have "industrialized" the production of building components and construct about 60,000 units annually. The prefabricated housing companies are capital-intensive and oligopolistic. The 10 largest companies produce over 90% of total units. The platform-frame or 2x4 construction companies are comprised of 750 companies with the five largest accounting for over 50% of total 2x4 housing units.

A survey by the Management and Coordination Agency found there were 92,500 companies directly involved in wooden house construction in Japan (JETRO 1996a). In addition, there were about 62,000 firms acting mainly as subcontractors. The average number of employees per housing company was 5.1 while it was 2.9 per carpentry business. These figures suggest that the majority of companies in the housing industry are small enterprises.

The process of building a house in Japan is different than in the US and partially explains why construction costs are higher in Japan than in the US. When a large housing company signs a contract to build a house, it typically subcontracts the work to a construction company, which in turn subcontracts to companies which specialize in various jobs such as foundation, framing, roofing and electrical work. After this level of subcontractors, there is usually another layer of subcontractors who do the construction. Levy (1990) has suggested there are potentially seven layers of subcontractors between the consumer and the actual workers who construct the house. This complex system is referred to as the "multi-layered" or "multi-tiered" subcontracting structure (JETRO 1996a). This system makes building a house in Japan more complex and costly than in the US.

In addition, it is common practice to include labor costs when invoicing material costs in Japan. This practice is called the "Total Material and Labor" system (JETRO 1996a). This system makes it difficult to calculate the actual construction cost of building a house.

Changing Nature of the Residential Housing Market

Historically, post-and-beam wooden housing dominated the residential housing market. In 1963, 86.2% of all new residential houses starts were post-and-beam houses (Coaldrake 1990). However, by 1996, they represented just 39.3% of new residential starts (JETRO 1996a). Great inroads have been made by the steel and ferro-concrete industries as the market share of multiple-family housing units increased by 16.6% since 1968. Multiple-family housing units are characterized by high-rise, high-density condominium or "mansion" buildings where steel and concrete must be used for structural integrity as specified in the Japanese building codes. In large cities such as Tokyo and Osaka, they are an absolute requirement for providing affordable housing. Japan would be one of the most densely populated countries in the world at 857.1 people per square mile overall. However, the population density is actually 2571.3 people per square mile because only 33% of Japan is habitable. The other 67% is made up of mountains and other uninhabitable terrain. In addition, for many people, mansions are more affordable than a detached single-family house (WWPA 1994). The only drawback to mansions is that their floor space is usually smaller. On average, the floor space of detached single-family residence is 2.7 times greater than multiple-family residences (JETRO 1996a).

Competition from prefabricated houses and 2x4 houses have also taken market share away from the post-and-beam industry. Prefabricated housing units comprised about 15% of residential housing starts in 1997 while 2x4 units comprised about 6% of residential housing starts (*Japan Lumber Journal* 1998a). Post-and-beam housing starts have also decreased because of an aging labor force. Many young people dislike entering the construction workforce because of the harsh and dirty work involved. Also, the construction industry has not been viewed favorably because of its poor safety record in past years. In addition, it takes approximately seven years as an apprentice to become a post-and-beam carpenter, another factor which discourages young workers from entering the carpentry profession (Cohen *et al.* 1996). As a result, the average age of the on-site construction worker is almost 44 years (Levy 1990). In addition, the number of post-and-beam housing construction workers is decreasing. It is estimated that the number of construction workers will decrease by 45% during the 1990's (Pesonen 1993).

Japan has traditionally isolated itself from outside ideas and people. However, the strong yen and the bubble economy of the 1980's allowed many Japanese to travel overseas and experience other cultures and lifestyles (JETRO 1996a). In addition, a substantial number of Japanese have lived overseas as a result of business activities, overseas study, and foreign home stays. As a result, many Japanese, who have had the opportunity to see and experience the quality of housing in other cultures now demand this same high quality for their own houses in Japan.

There is strong dissatisfaction among the Japanese regarding the quality of their houses. A 1993 MOC survey found that 49.4% of Japanese families are not satisfied with their current housing condition. Among the more commonly cited reasons for this dissatisfaction were: inadequate living space, inferior layout of rooms and facilities, excessive noise transmission, inadequate thermal insulation, and the overall poor quality of older homes due to poor maintenance and poor quality materials (JETRO 1996a). Survey respondents indicated strong interest in raising the quality of housing in Japan to reflect the country's increased level of affluence.

Differences in Residential Construction Costs between Japan and US

Construction Requirements

In a study conducted at Stanford University, Okimoto *et al*. (1996) suggest that Japan's non-traded sectors such as agriculture, housing, construction and others tend to be high-priced, inefficient, and non-competitive vis-à-vis foreign firms. These non-traded sectors, which account for over 70% of Japan's GDP, have long benefited from the negative effects of protectionism, political patronage, industry cartels, bid rigging, and excessive regulation. They suggest that the onerous weight of government regulatory controls must be lifted and international competition be embraced in order to increase the performance and efficiency of firms operating in these sectors.

Many sources have noted that residential construction costs in Japan are much higher than in the US. In May 1994, the MOC's North America Housing Cost Study Group determined that a two-story 2x4 house built in Japan was 1.82 to 1.98 times more expensive than comparable houses built in the US on an exchange rate basis of ¥111 to $1 (JETRO 1996a). The MOC Study Group also found that the cost of an average 164 square meter house in Seattle was about $139,000 compared to $255,000 (exclusive of land costs) for a comparable house in the Sendai region (Magnier 1994).

The reasons residential construction costs are higher in Japan include: complex and hard to use distribution channels, non-standardized construction methods, limited competition, higher overhead, more cumbersome regulations, higher material costs, the high cost of certifying US wood products, and the fact that 2x4 houses are built using the same management system employed in the post-and-beam industry. The MOC Study Group acknowledged that extended distribution channels are typical in Japan and that the residential construction industry has a long history where material supply channels have become well established (JETRO 1996b). They conclude, however, that it would be very difficult to modify this system without causing severe disruptions in the supply of residential building materials.

The MOC Study Group also found that labor comprised approximately two-thirds (65%) of the total construction cost in Japan compared to 35% in the US (EP 1992). The various factors that contribute to higher labor costs in Japan include: little specialization of labor in the residential construction trades, high carpenter wages, and low labor productivity. Tokyu Home Corporation estimates that US carpenters can complete work on one tsubo (a common Japanese construction measurement equivalent to 3.3 square meters) in 6.72 hours while the most efficient Japanese carpenter requires 9.6 hours to complete the same amount of work (Nakamae 1994). Thus, these researchers conclude that labor productivity of carpenters in Japan is substantially lower than in the US. Similarly, the Ministry of International Trade and Industry (MITI) estimated that the labor requirement for building a residential house in the US was approximately 700 hours compared with 2,500 hours to build a traditional Japanese house of equivalent size (Briggs and Dickens 1984). Japanese researchers estimate that the overall cost savings resulting from using the North American-style 2x4 construction technology is in the range of 20-50% of total construction costs as compared to the traditional post-and-beam method of construction.

These cost measures do not include land costs. If land were included, the Japanese price would increase substantially. *The Economist* (1997) conducted a study that showed that if the cost of land were set at 100 in Japan (on a m^2 basis), then land costs in the US would be 8 and UK would be 4. On the basis of this analysis, the cost of land in Japan is roughly 12.5 times higher than in the US.

Consumer Requirements and Expectations

For many Japanese consumers, purchasing a house is a once in a lifetime decision (JETRO 1996a). In contrast to the US, where on average a family will move once every five years, Japanese families often live in the same house for several generations. As a result, homebuyers are extremely sensitive to small defects in a new house. Consumers care deeply about the appearance and finish of new homes, and as a result, the cost of new homes increases as builders strive to meet homebuyers' quality expectations.

Consumers also expect a high degree of after-sales service. Most Japanese builders provide warranties and regular inspections for 10 years (JETRO 1996c). However, Japanese homeowners rarely perform routine maintenance or repair activities on their homes, relying instead on the contractor to perform these tasks. As a result, construction companies generally increase the price of their houses to reflect the additional costs associated with after-sales maintenance and repair activities.

Although most cost comparisons are based on comparable houses built in Japan and the US, significant design modifications are frequently incorporated in Japanese homes which substantially increase construction costs. In general, Japanese homes require an entrance space or *genkan* where street shoes can be exchanged for house slippers before entering the living area of the home. Bathing, toilet and washing facilities are almost always separated from each other and most homes have a traditional "tatami" room. Finally, central heating is not common in Japan and individual heating/cooling units are typically located in each room (JETRO 1996c).

Imported Housing in Japan

Import housing has been defined by the Imported Housing Industry Council as a house designed using foreign design concepts that incorporates more than 50% of foreign building materials in its construction (JETRO 1996a). The imported housing classification specifically excludes housing that imitates foreign design or housing that uses only small quantities of foreign components and building materials such as Japanese-style 2x4 houses (based on the 3x6 construction module) and log houses. Imported houses have been sold in Japan since 1909 when an American businessman sold a prefabricated 2x4 style house in Tokyo (JETRO 1996c). However, it was not until recently that the Japanese government and other related organizations have focused increasing attention on imported housing.

Imported housing starts have risen rapidly since 1993 when there were only 1,500 units constructed, representing just 0.1% of the total housing market (*Pacific Rim Wood Market Report* 1996). The Japanese Ministry of Construction (MOC) reported that a total of 10,672 units were imported in 1997, a 30.6% increase over 1996 (*Japan Lumber Reports* 1998b). MOC also found that the majority of imported houses were prefabricated homes using the 2x4 construction method (Table 5).

Since 1993, the Japanese government has actively promoted imported houses as a component of their effort to reduce the cost of housing in Japan. MITI plans to facilitate the import of 50,000 houses over a seven year period starting in 1993 (Nakamae 1993). MITI has also reduced the 4% import tariff to 3% for imported housing units. Furthermore, the Export-Import Bank of Japan will increase the amount of low-interest loans that are made available to companies that import houses. As a result, the Imported Housing Industry Council expects the number of imported houses to reach 30,000 units annually by the year 2000.

Table 5. Import housing by type of construction method FY 1996.

Housing Type	Value	Percentage
2x4	4,517,000	39.1
2x4 panelized	3,273,000	28.4
Log house	1,295,000	11.2
Post-and-beam	178,000	1.5
Unknown	121,000	1.0
Others	2,154,000	18.7
Total	**11,538,000**	**100.0**

Note: "2x4" represents stick-built houses built on site while "2x4 panelized" represents prefabricated, panelized 2x4 houses. Source: *Japan Lumber Reports* 1997.

2x4 Housing Industry in Japan

2x4 housing product life cycle

2x4 housing is in the growth stage in Japan. 2x4 housing was first introduced into the Japanese market in 1974. Sales experienced very slow growth during the introductory phase of the product life cycle (Figure 5) (JETRO 1993). This has been attributed to the many barriers, both tariff and non-tariff, that limited sales and market growth. As a result, it was not until 1995 that 2x4 houses surpassed a 5% share of the residential construction market for the first time. Surprisingly, while the percentage of wooden housing starts has declined, the 2x4 market share has consistently increased since 1974. The market share of 2x4 housing has risen from 0.01% in 1974, when it was first introduced, to 5.7% in 1997 (Figure 6).

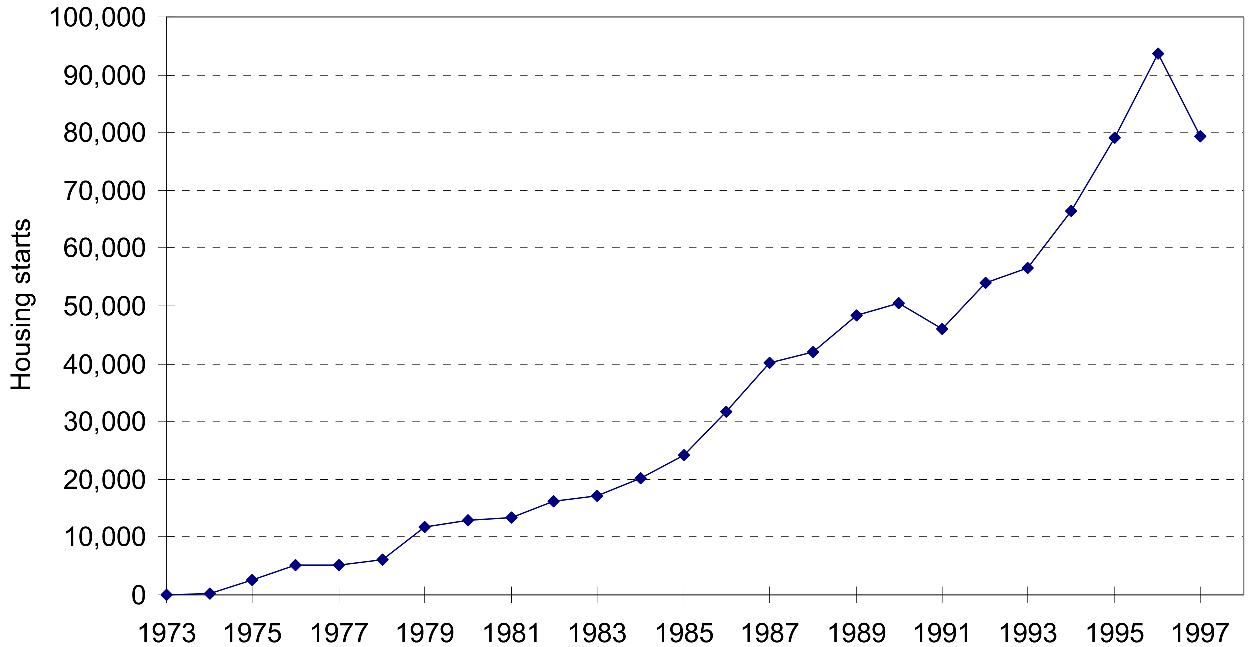

Figure 5. 2x4 housing starts since introduction into Japan. Source: *Japan Lumber Journal*.

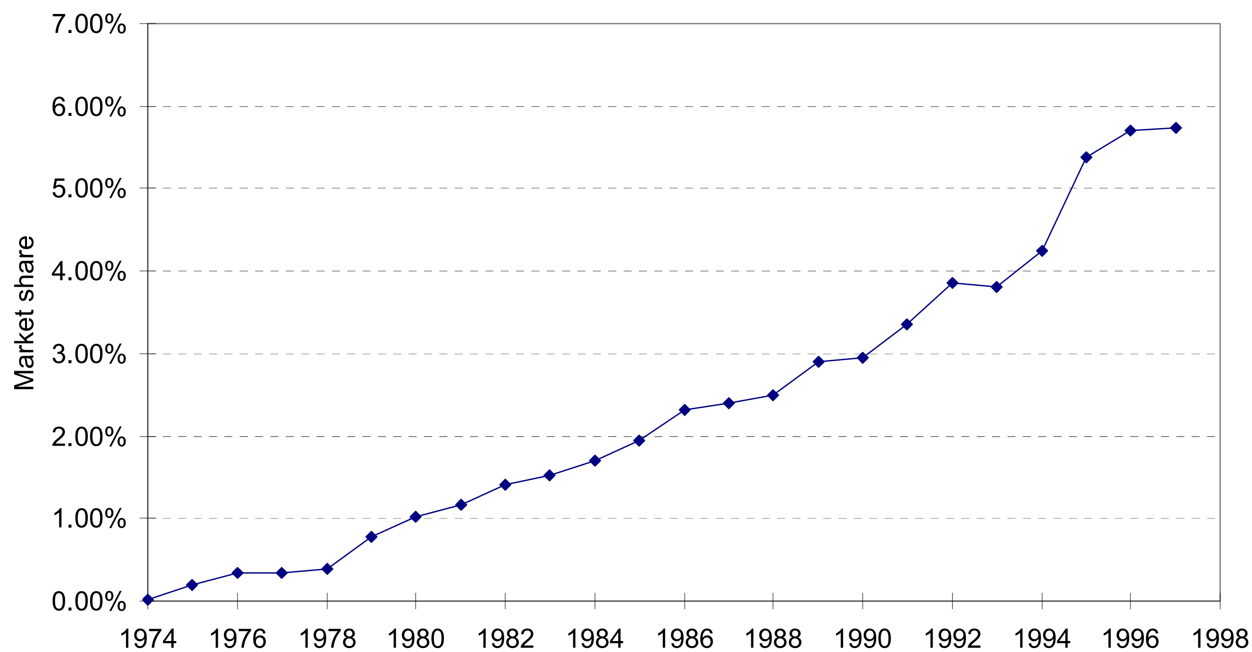

Figure 6. The market share of 2x4 housing starts as a percentage of total housing starts.

Over the past five years, the market share of 2x4 homes has grown at a rate of 5% annually (Figure 7). This makes 2x4 houses one of the fastest growing segments within the Japanese residential construction industry. In addition,

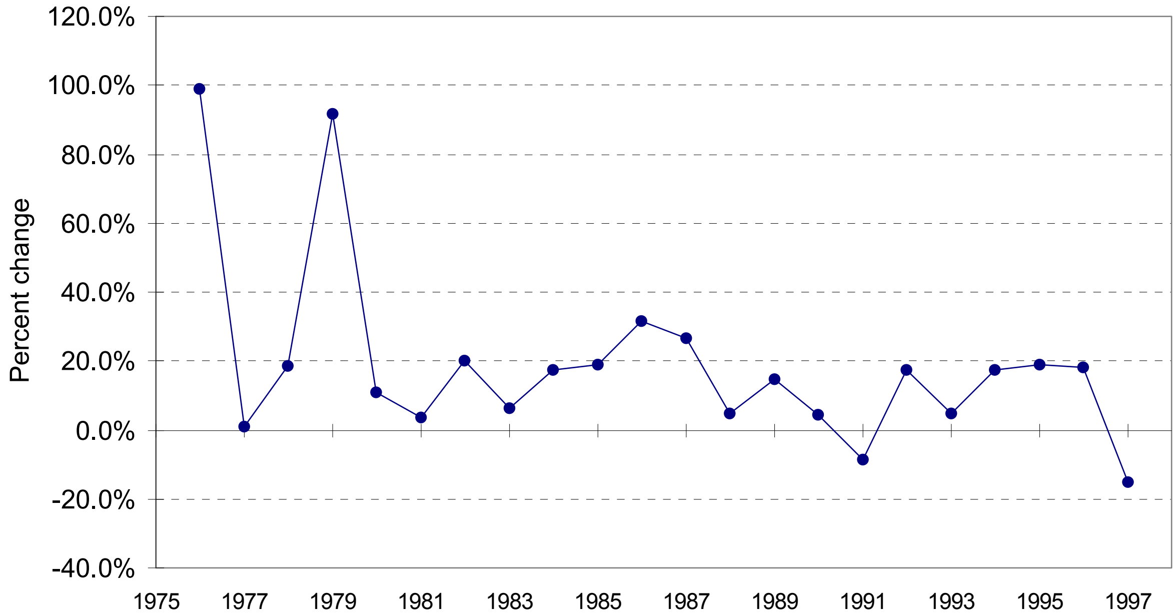

Figure 7. Annual percentage growth rate in 2x4 housing starts in Japan.

the 2x4 segment of the industry has the potential for continued growth because of the favorable market environment. The number of 2x4 houses built in 1997 totaled 79,458 units, down substantially from 93,693 starts in 1996 (Figure 5). Despite the substantial drop in total starts, the overall market share for 2x4 housing remained constant, a reflection of the fact that this segment of the residential construction industry performed better than all other segments despite the poor performance of the Japanese economy in 1997 (Figure 6).

In a study conducted by the Japan 2x4 Homebuilders Association it was determined that nearly 50% of their members began building 2x4 houses within 6 years of the introduction of the 2x4 technology in 1974 (Roos and Eastin 1998). Therefore, many companies have had time to develop their construction techniques and learn the intricacies of the North American-style 2x4 construction technology. The Japan 2x4 Homebuilders Association, as one of the major industry associations promoting 2x4 housing in Japan, is supported by MOC and is composed of 978 members including homebuilders, general contractors, developers, trading companies, building material suppliers, and other related organizations (WWPA 1994).

The rapid growth in the construction of three-story wooden houses represents another market opportunity for the 2x4 construction industry (Tables 6 and 7). Although the overall growth rate of three-story buildings lags that of post-and-beam houses, 2x4 housing starts have been growing at approximately 18% annually over the past 5 years.

Table 6. Market shares of three-story wooden single-family houses, by type of structure.

Year	Total Stars	Prefab	2x4	Mixed structure	Post & beam
1990	10,753	650	2,533	2,459	5,109
1991	11,014	708	2,462	2,963	4,880
1992	15,579	855	3,007	4,124	7,593
1993	21,804	1,024	3,615	5,285	11,880
1994	25,313	1,043	4,193	6,349	13,728
1995	31,648	1,406	5,621	9,153	15,359
1996	40,352	1,519	6,605	10,272	21,892

In addition, the proportion of three-story houses being built in quasi-fire prevention areas has increased from 23.1% in 1990 to 48.2% in 1996 (*Japan Lumber Journal* 1997d). 2x4 houses have become the market leaders in the three-story wooden apartment market, with over 50% (Table 7).

Table 7. Market shares of three-story wooden apartments, by type of structure.

Year	Total Starts	Prefab	2x4	Mixed structure	Post & beam
1992	46	6	20	0	20
1993	134	1	93	1	38
1994	115	4	53	19	39
1995	140	7	60	31	42
1996	126	1	63	27	35

Factors restricting the growth of 2x4 housing starts

One of the main factors restricting the market development of 2x4 houses in Japan is the lack of carpenters who possess adequate training in 2x4 construction techniques (Eastin *et al.* 1995). North American-style 2x4 construction technology is relatively new to Japan and carpenters are still adjusting to it. In contrast, traditional post-and-beam houses have been built for hundreds of years and post-and-beam remains the dominant method of building single-family wooden homes. Older carpenters, who dominate the carpentry trade, are reluctant to switch from the post-and-beam method because it requires learning an entirely new technology.

Another factor has been the failure of many builders to realize the substantial construction cost reductions expected. There are a variety of reasons for this. Many have to do with the construction practices that exist in Japan (Eastin *et al* 1995). In addition, many single-family homes are built individually rather than in the large, multi-unit subdivision developments that are common in the US.

Japanese product codes are complex and difficult. The Japanese Agricultural Standards (JAS) are applied to lumber and plywood products while the Japanese Industrial Standard (JIS) specifies acceptable types of nails, gypsum board and related products for use in residential construction. In the past all building materials, both domestic and imported, required these standards stamps before they could be used in the construction of Japanese homes. For example, the JAS standards required that all imported lumber and plywood had to be graded or perhaps re-graded to meet building code approval. This was particularly a problem for imported packaged housing because every item within the package had to be inspected and individually marked. In a related barrier, the Japanese government did not recognize the grade marks of foreign lumber and plywood grading associations such as the American Plywood Association and the Western Wood Products Association. Thus, even though a product might be acceptable for use in a 2x4 house in the US, it had to be re-graded using JAS grading rules before it could be imported into Japan for use in the residential construction industry.

Government Promotion of Imported Housing in Japan

The Japanese government has developed several programs to increase the supply of low cost, good quality, affordable housing, including imported housing. Over the past five years, 2x4 imported housing promotion programs have been initiated by the MITI, MOC, and the Government Housing and Loan Corporation (GHLC).

MOC introduced an Action Plan with the stated objective of reducing housing costs to roughly five times the average annual salary of a Japanese salaried worker (Yamakoshi 1994). This would be equivalent to reducing housing costs by approximately 33%. MOC wants to achieve this goal by fiscal year 2000. This plan was introduced by then Prime Minister Miyazawa in the “Five-Year Economic Plan: Sharing A Better Quality of Life.” The plan aims to provide good quality, affordable housing that would be commensurate with Japan’s economic power. The plan also calls for the importation of low cost building materials (*Pacific Rim Wood Market Report* 1996).

The Hashimoto administration implemented widespread deregulation by revising the MOC's 2x4 standards on March 30, 1997. Building standards are now less restrictive in order to reduce housing construction costs (CTED 1997). Some of the issues included in the deregulations include:

1. reducing the time required to issue work visas for US carpenters entering Japan
2. providing wider acceptance of US lumber grade marks
3. transitioning from prescriptive building codes to performance-based building codes

Reducing the time of issuing work visas will enable US workers to enter Japan more easily to build houses and educate Japanese construction workers on North American-style 2x4 construction techniques. Wider acceptance of US lumber grades will reduce the non-tariff barriers imposed on US lumber and plywood. A performance-based Construction Standard Law will facilitate the use of new construction designs and allow a wider range of building materials to be used (*Japan Lumber Journal* 1997c). The MOC anticipates that new products will be developed, new technologies will be used, and foreign products will be introduced to the marketplace. These factors should help to reduce the construction time of wooden homes, which is currently hampered by cumbersome construction regulations. The current Construction Standard Law is considered to be cumbersome mostly because of the prescriptive nature of the specifications related to engineering methods, building materials, and material sizes.

The MOC has made many revisions to the Buildings Standards Law that should facilitate market access for imported housing companies. In 1987, the MOC allowed the construction of a three-story wooden house which met the technical standards specified for the quasi-fire prevention area. In 1992, the MOC allowed the construction of three-story wooden apartment buildings outside the fire prevention area and the quasi-fire prevention area (*Japan Lumber Journal* 1995). In 1993, the Building Standards Law was again modified to increase the maximum allowable floor space for wooden houses from 2,000 m^2 to 3,000 m^2. These changes have encouraged the building of three-story, multi-family wooden houses and apartments. Three story houses are very attractive to Japan's aging population because they allow elderly parents to live with their children and grandchildren in an inexpensive and convenient manner. This is important because it is predicted that the percentage of people over age 65 will increase from 14.5% of the population in 1995 to 20% in 2010 (Kodansha International 1995).

Another action taken by MOC in 1997 allows all imported lumber products carrying an accepted foreign grade stamp to be used in 2x4 residential construction without meeting JAS specifications (*Japan Lumber Journal* 1997a). This means that all lumber that has been graded by members of associations certified by either the American Lumber Standards Committee or the Canadian Standards Accreditation Board will be recognized for use in 2x4 housing projects in Japan. This action, which covers the products graded by organizations such as APA, WWPA, SFPA, and NLGA, will help to reduce the cost of imported softwood lumber and plywood in Japan and increase the speed of delivery.

RESEARCH OBJECTIVES

Anecdotal information from US architects and contractors with experience in residential construction projects in Japan indicates that Japanese construction professionals often do not fully understand the North American-style 2x4 construction system and often employ construction techniques that can compromise the structural integrity and/or long-term performance of 2x4 homes. In addition, a recent study by CINTRAFOR estimates that 2x4 construction costs in Japan range from 2 to 2.5 times higher than in the US (Eastin *et. al.* 1995). This is partly due to differences in the way that North American-style 2x4 technology and construction management practices are implemented in Japan. The CINTRAFOR study suggested that Japanese construction professionals could improve their cost effectiveness and improve the quality of 2x4 homes built in Japan by increasing their understanding of North American-style 2x4 construction technology and construction management practices.

This research project was designed to provide specific information about how North American-style 2x4 homes are built in Japan. The specific objectives of this research project were to:

1. provide information to help Japanese construction professionals rationalize and reduce 2x4 construction costs through a more efficient transfer of North American-style 2x4 construction technology,

2. identify areas where a more efficient transfer of North American-style 2x4 construction technology could help improve the structural integrity and/or long-term performance of 2x4 homes in Japan, and
3. provide information to support the development and implementation of the 2x4 technology transfer program administered by the Washington State Department of Community, Trade and Economic Development.

RESEARCH METHODOLOGY

This project was carried out in two phases. The first phase consisted of the collection of construction cost data from North American-style houses built in Japan. Construction cost data was obtained from a small residential construction project located in Kitakyushu. The project involved the construction of sixteen North American-style 2x4 homes. The company responsible for supplying the building materials for the project collected the material cost data. This same company was responsible for collecting construction cost data (*e.g.*, labor, overhead and marketing costs) from the contractors involved in the project. This demonstration project was sponsored by the city government of Kitakyushu and was intended to provide an accurate and objective assessment of the potential cost savings that might be derived from utilizing North American-style 2x4 construction techniques and imported building materials. As a result, the five contractors involved in the project agreed to provide detailed construction data to facilitate the assessment of the construction costs.

The construction cost team visited the Kitakyushu project in February, 1997, and toured the development. The raw construction cost data for this project was translated in consultation with the project manager and City of Kitakyushu building officials involved in the project. The construction cost data was then analyzed and categorized using the construction cost classification system developed by the Construction Specifications Institute.

The second phase of the project involved a technical assessment of North American-style 2x4 construction techniques and construction practices in Japan. To assess how North American-style 2x4 construction technology is practiced in Japan, a team of Washington State construction experts visited 21 North American-style 2x4 residential construction projects in various stages of completion between Tokyo and Osaka in March, 1997 (Appendix C). Team members completed a construction evaluation survey for each project visited. The construction site evaluation form is presented in Appendix A, while a summary of the technical evaluation for each of the projects visited is provided in Appendix D. In most cases the quality of the 2x4 projects visited was found to be quite good. However, the construction team identified a number of areas where differences between the Japanese and US application of 2x4 construction technology could adversely impact the structural integrity and/or long-term performance of 2x4 homes in Japan. A detailed summary of evaluator comments, technical observations and a short discussion of technical implications is presented in Appendix B. The team also made recommendations for improving the cost efficiency of building North American-style 2x4 homes in Japan.

RESULTS AND DISCUSSION

Results of the Cost Assessment

The construction cost data for this analysis was derived from a residential development project located in Kitakyushu called Evergreen Chiyo. Mr. Hitoyoshi Kondou, the Executive Director of the Kitakyushu Municipal Housing Corporation, described the Evergreen Chiyo project in the following way:

> *Pioneering the effort to examine the economic advantages associated with the highly integrated American building system, the Kitakyushu Municipal Housing Corporation commissioned the design, import, and construction of 36 American-style 2x4 homes. The first project of its kind undertaken by a municipal housing corporation in Kyushu, phase one, consisting of 16 homes, was built in a joint construction and sales venture with 5 local homebuilders.*
>
> *Designed to introduce Japanese homebuilders to the high productivity of the American-style construction system, this project was the site of several import housing seminars as well as on-going, hands-on,*

technical workshops for interested industry professionals. In addition, the project was effective in showcasing the added creature comforts of the American lifestyle as well as emphasizing the significant economy inherent in American-style import housing.

In recognition of our sister city relationship, primary American-made building materials were imported from our sister city of Tacoma. Also, from the Tacoma area, a team of highly skilled professionals was brought in to train Japanese crews during the construction of this project.

Unique in many ways, the homes offer features such as central climate control systems, generously proportioned lots, and comfortably spacious floor plans. In an effort to recreate the atmosphere of an American-style neighborhood, all utilities were put in-ground and the use of partitions between lots was minimized to give the community a spacious, open feeling.

We hope this pioneering project will serve as a benchmark and set in motion the expansion of American-style import housing throughout Japan.

As described, Phase I of Evergreen Chiyo consisted of 16 North American-style 2x4 houses and involved the participation of a US construction team and five Japanese homebuilders with experience building Japanese-style 2x4 homes from the Kitakyushu area. The project was designed so that the US construction built the model home while the Japanese carpenters and contractors observed the construction techniques employed. During the construction of the model home, seminars and lectures by the US construction professionals were held to provide information on North American-style 2x4 construction techniques, imported building materials, US construction tools, and US construction management techniques.

The five Japanese contractors then built three houses apiece. Japanese carpenters built one of the three houses in each group using Japanese building materials. Japanese carpenters built the second house using the maximum amount of imported building materials allowed by the Construction Standards Law. Japanese and US carpenters built the final house using North American construction technology and the maximum amount of imported building materials allowed by the Construction Standards Law.

Detailed labor and material costs were recorded for each of the houses built and the averages for each of the cases are summarized in Tables 8-10. The construction cost data was summarized using the construction categories outlined by the Construction Specifications Institute (CSI). The construction cost data is graphically presented for Cases 1-3 based on the total construction costs (Figures 8 and 9), total material costs (Figure 10), and total labor costs (Figure 11). The construction costs presented in Figures 8-11 are reported in yen and do not include the cost of the land.

Figure 8 demonstrates that the total construction costs for Case 2 are 2.4 times higher than in Case 1 and Case 3 is twice as high as Case 1. Assuming that all of the regulatory reforms scheduled to be implemented by the year 2000 were approved and enacted (Case 4), the construction costs for building a North American-style 2x4 home in Japan would decline substantially but would still be approximately 1.53 times higher than in the US.

A comparison between Case 1 and Case 2 illustrates those areas with the greatest disparity in construction costs between the US and Japan. Differences in material costs were found to be extremely high in the categories of framing (¥2,103,139), interior doors (¥1,117,713), finish carpentry (¥970,124), exterior doors and windows (¥962,104), HVAC (¥861,000), floor and wall coverings (¥466,112), and exterior siding (¥433,465). In most cases, the higher material costs can be attributed to the fact that the price of domestically sourced materials is considerably higher than the price of similar imported products. However, in some cases there are additional factors that contribute to higher material costs. For example, the practice of using excess lumber when framing a house (*e.g.*, doubled studs and tripled headers), or specifying J grade lumber, add significantly to material costs. Similarly, in the case of interior doors, Japanese carpenters typically do not frame interior rough openings using a standard set of dimensions. As a result, each interior door must be custom made to fit the specific opening where it will be used.

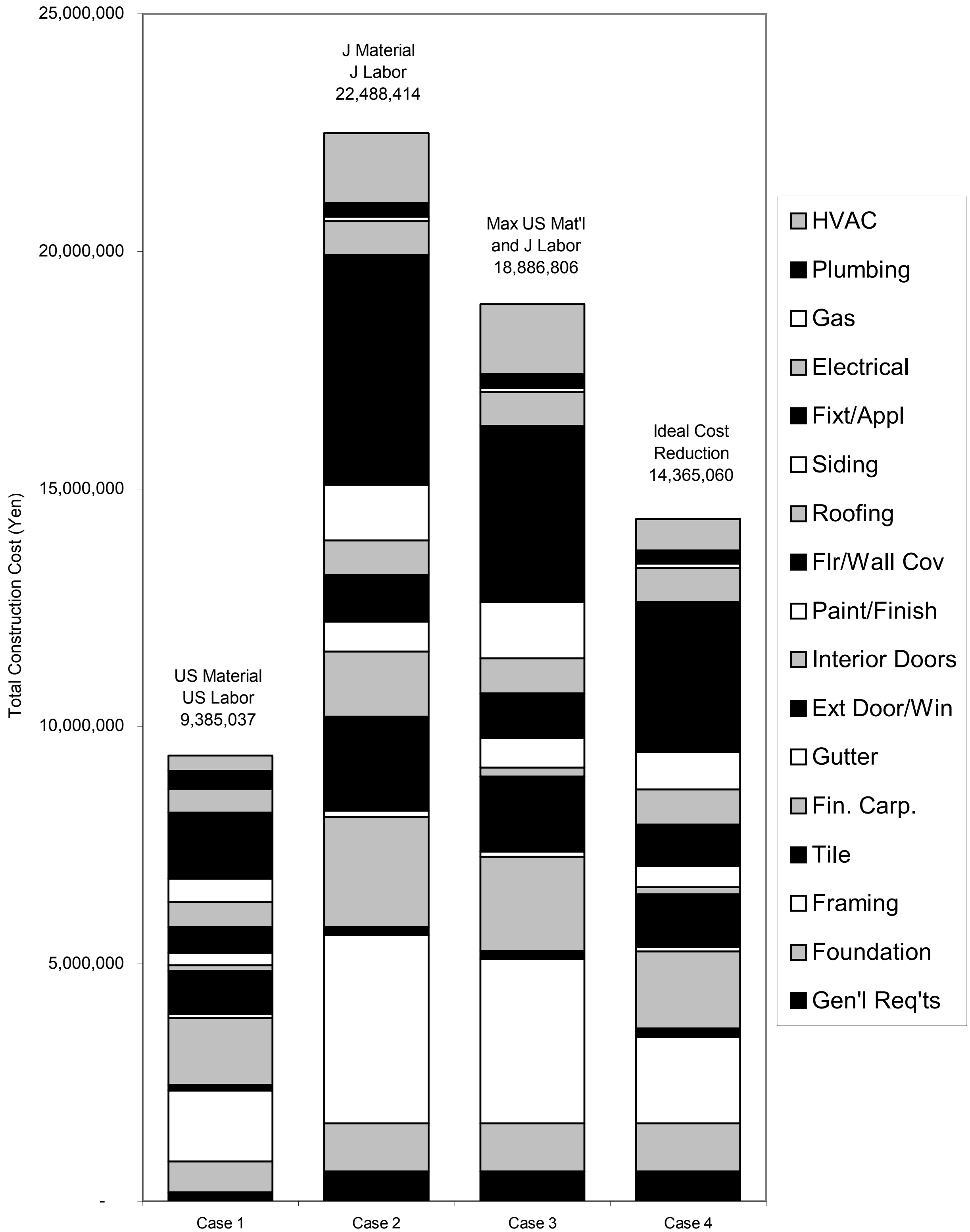

Figure 8. Total construction costs broken down by construction category for Cases 1-4.

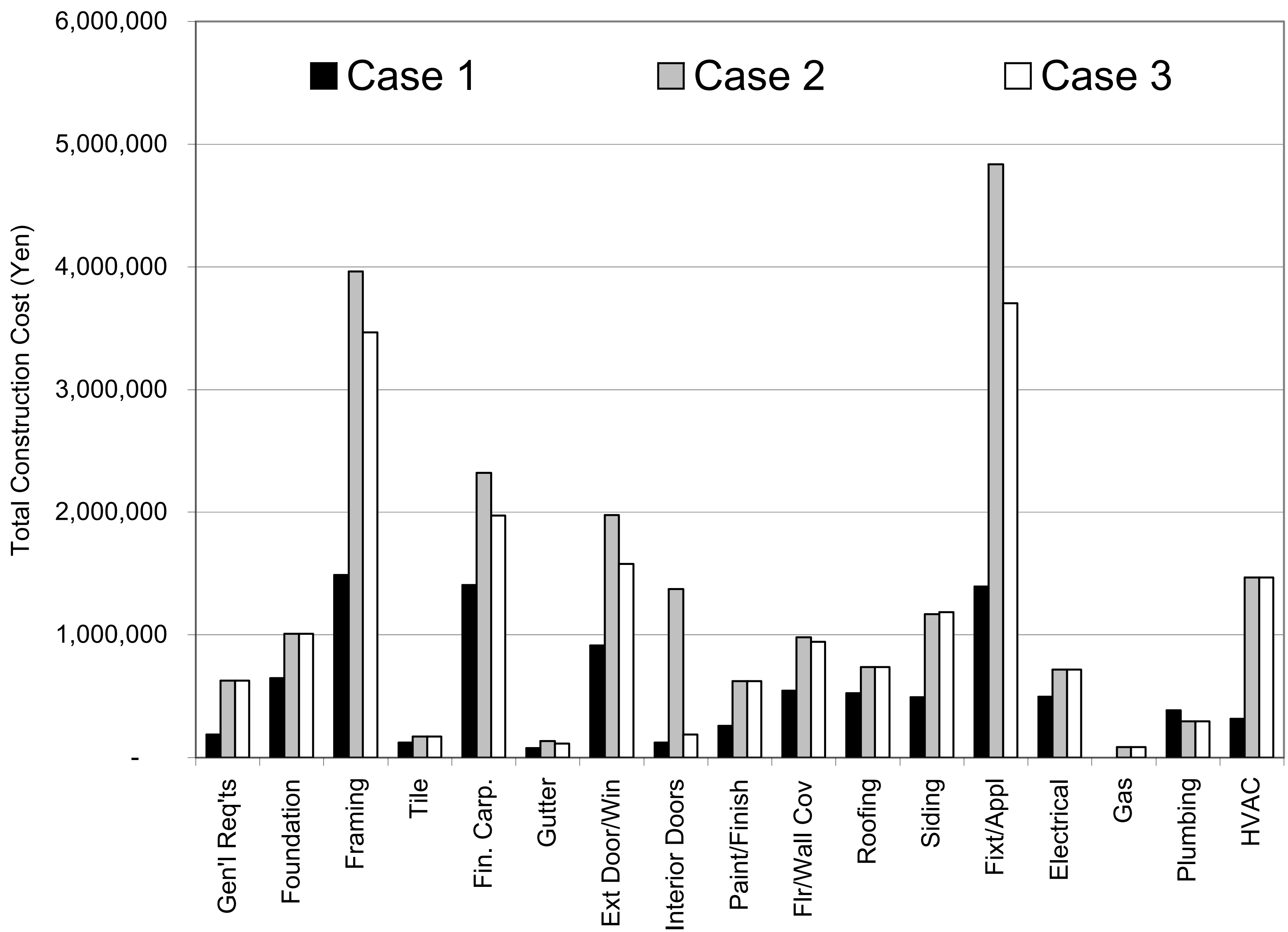

Figure 9. Total construction costs broken down by construction category for Cases 1-3.

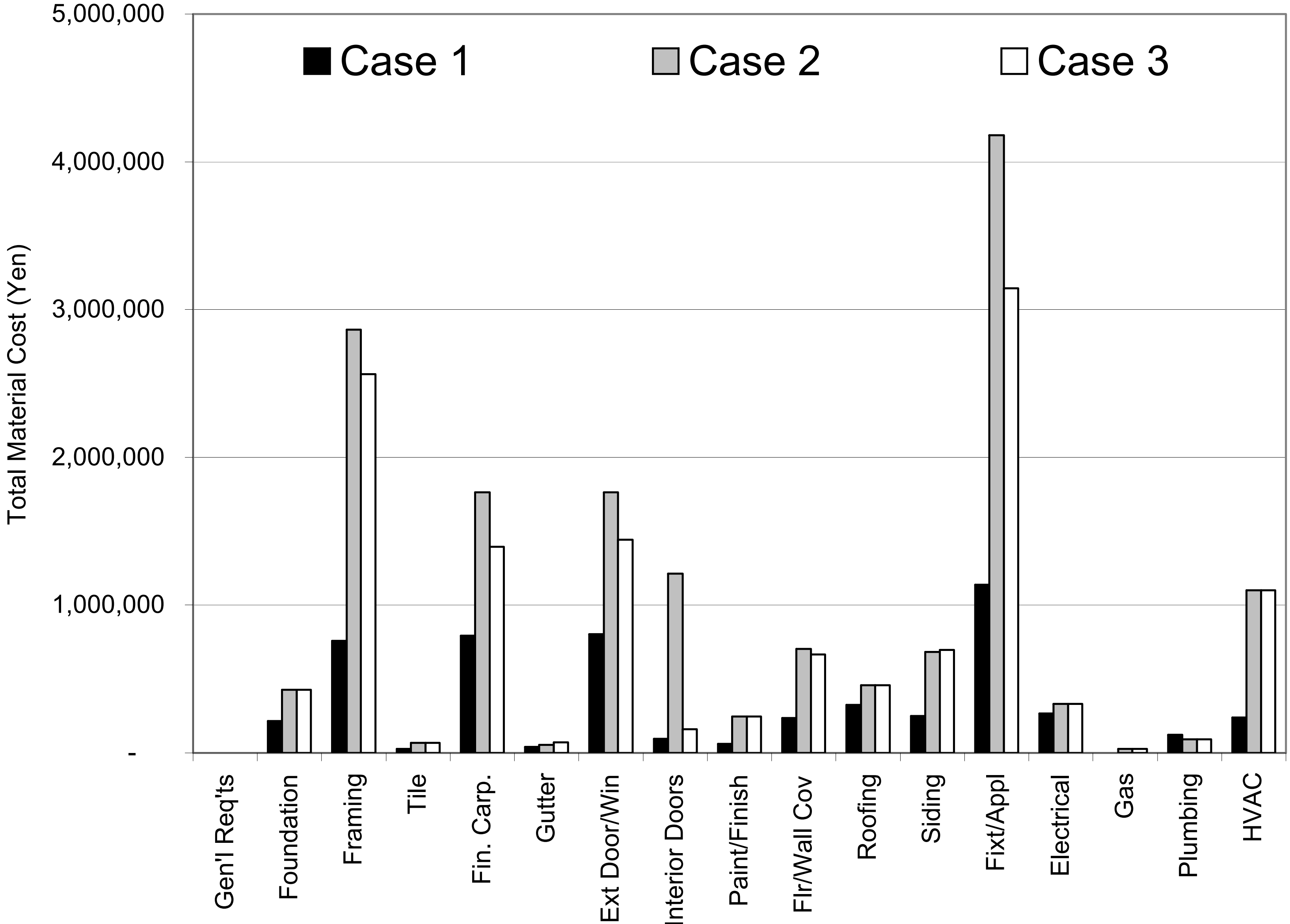

Figure 10. Total material costs broken down by construction category for Cases 1-3.

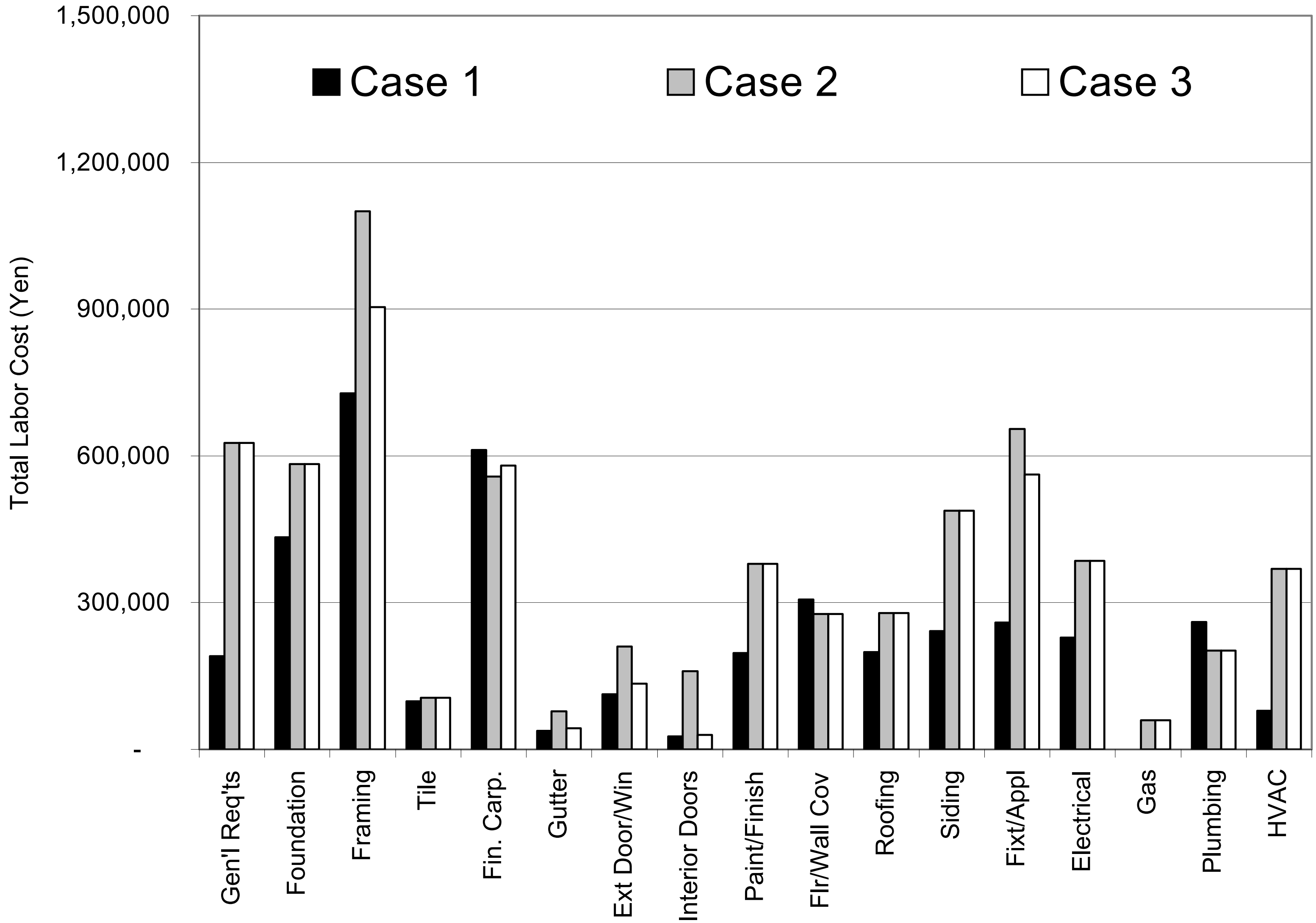

Figure 11. Total labor costs broken down by construction category for Cases 1-3.

Table 8. Comparison of 2x4 construction costs for different construction scenarios, by construction category.

	Case 1 US Carpenters/US Materials			Case 2 J. Carpenters/J. Materials			Case 3 J. Carpenters/Max. US Mat'l			Case 4 Ideal Cost Reduction		
Construction Category	**Material**	**Labor**	**Total**	**Material**	**Labor**	**Total**	**Material**	**Labor**	**Total**	**Material**	**Labor**	**Total**
General Requirements	0	190,200	190,200	0	626,519	626,519	0	626,519	626,519	0	626,519	626,519
Foundation	216,700	433,300	650,000	425,934	583,794	1,009,728	425,934	583,794	1,009,728	425,934	583,794	1,009,728
Framing	760,100	727,917	1,488,017	2,863,239	1,100,077	3,963,316	2,562,383	904,508	3,466,891	925,148	904,503	1,829,651
Tile	26,870	98,100	124,970	58,902	97,279	156,181	58,902	97,279	156,181	58,902	97,279	156,181
Finish Carpentry	794,313	612,576	1,406,889	1,764,437	557,536	2,321,973	1,394,262	579,996	1,974,258	1,040,705	579,990	1,620,695
Gutter	39,943	38,271	78,214	56,040	77,450	133,490	70,483	43,560	114,043	48,616	43,560	92,176
Exterior Doors/Windows	802,571	112,424	914,995	1,764,675	210,300	1,974,975	1,442,363	134,582	1,576,945	976,841	134,579	1,111,420
Interior Doors	96,947	26,263	123,210	1,214,660	159,480	1,374,140	160,101	29,610	189,711	117,998	29,607	147,605
Paint/Finish	60,371	196,377	256,748	244,393	379,295	623,688	244,393	379,295	623,688	73,480	379,294	452,774
Floor/Wall Covering	236,772	306,810	543,582	702,884	277,120	980,004	665,297	277,120	942,417	596,939	277,120	874,059
Roofing	324,316	198,888	523,204	458,740	278,860	737,600	458,740	278,860	737,600	458,740	278,860	737,600
Siding	249,135	242,456	491,591	682,600	487,574	1,170,174	696,220	487,570	1,183,790	303,232	487,570	790,802
Fixtures/Appliances	1,136,421	259,359	1,395,780	4,180,075	655,650	4,835,725	3,142,719	561,416	3,704,135	2,594,546	561,406	3,155,952
Electrical	266,875	228,900	495,775	331,075	385,575	716,650	331,075	385,575	716,650	331,075	385,575	716,650
Plumbing	123,790	260,673	384,463	91,527	201,895	293,422	91,527	201,895	293,422	79,845	201,895	281,740
HVAC	238,000	79,400	317,400	1,099,000	369,000	1,468,000	1,098,999	369,000	1,467,999	289,679	369,000	658,679
Total	5,373,124	4,011,913	9,385,037	15,936,916	6,551,498	22,488,414	12,842,132	6,044,674	18,886,806	8,320,415	6,044,645	14,365,060

Case 1. The construction cost data for this case were derived from a construction bid submitted by a US construction company for building the model home in the Seattle area. The costs for this case were based on using standard materials and construction methods in the US. The major difference with the other cases was the interior drywall method with a painted surface.

Case 2. Using the same design and grade of materials as in Case 1, but built to Japanese standards with standard construction techniques and Japanese building materials. Interior wall surfaces were wall papered.

Case 3. This case is a combination of Cases 1 and 2. However, the maximum amount of US building materials allowed by the building codes and mortgage financing guidelines were used. In addition, US construction supervisors worked with Japanese carpenters and contractors to build these houses. Interior wall surfaces on these homes were wall paper.

Case 4. This case is hypothetical, assuming that all deregulation measures scheduled for the year 2000 were implemented. These assumptions are based on using primarily imported building materials and the North American-style 2x4 construction technology. As a result, this case assumes that the efficiency and productivity of Japanese carpenters will be increased substantially and reduce total construction costs closer to those observed in Case 1.

Table 9. Summary of total 2x4 construction costs for different construction scenarios, by construction category.

Construction Category	Case 1 US Labor and US Materials	Case 2 J. Labor and J. Materials	Case 3 J. Labor and Max US Materials	Case 4 Ideal Cost Reduction
General Requirements	190,200	626,519	626,519	626,519
Foundation	650,000	1,009,728	1,009,728	1,009,728
Framing	1,488,017	3,963,316	3,466,891	1,829,651
Tile	124,970	172,452	172,452	172,452
Finish Carpentry	1,406,889	2,321,973	1,974,258	1,620,695
Gutter	78,214	133,490	114,043	92,176
Exterior Doors/Windows	914,995	1,974,975	1,576,945	1,111,420
Interior Doors	123,210	1,374,140	189,711	147,605
Paint/Finish	256,748	623,688	623,688	452,774
Floor/Wall Covering	543,582	980,004	942,417	874,059
Roofing	523,204	737,600	737,600	737,600
Siding	491,591	1,170,174	1,183,790	790,802
Fixtures/Appliances	1,395,780	4,835,725	3,704,135	3,155,952
Electrical	495,775	716,650	716,650	716,650
Plumbing	384,463	293,422	293,422	281,740
HVAC	317,400	1,468,000	1,467,999	658,679
Total	**9,385,037**	**22,488,414**	**18,886,806**	**14,365,060**

Table 10. Comparison of 2x4 construction costs for similar US and Japanese project, by construction category.

Construction Category	Case 1 US Carpenters/US Materials			Case 2 J. Carpenters/J. Materials			Ratio of Case 2/Case 1		
	Material	Labor	Total	Material	Labor	Total	Material	Labor	Total
Gen'l Requirements	0	190,200	190,200	0	626,519	626,519	n/a	3.29	3.29
Foundation	216,700	433,300	650,000	425,934	583,794	1,009,728	1.97	1.35	1.55
Framing	760,100	727,917	1,488,017	2,863,239	1,100,077	3,963,316	3.77	1.51	2.66
Tile	26,870	98,100	124,970	58,902	97,279	156,181	2.19	0.99	1.25
Finish Carpentry	794,313	612,576	1,406,889	1,764,437	557,536	2,321,973	2.22	0.91	1.65
Gutter	39,943	38,271	78,214	56,040	77,450	133,490	1.40	2.02	1.71
Ext Doors/Windows	802,571	112,424	914,995	1,764,675	210,300	1,974,975	2.20	1.87	2.16
Interior Doors	96,947	26,263	123,210	1,214,660	159,480	1,374,140	12.53	6.07	11.15
Paint/Finish	60,371	196,377	256,748	244,393	379,295	623,688	4.05	1.93	2.43
Floor/Wall Covering	236,772	306,810	543,582	702,884	277,120	980,004	2.97	0.90	1.80
Roofing	324,316	198,888	523,204	458,740	278,860	737,600	1.41	1.40	1.41
Siding	249,135	242,456	491,591	682,600	487,574	1,170,174	4.58	2.01	2.38
Fixtures/Appliances	1,136,421	259,359	1,395,780	4,180,075	655,650	4,835,725	3.68	2.53	3.46
Electrical	266,875	228,900	495,775	331,075	385,575	716,650	1.24	1.68	1.45
Plumbing	123,790	260,673	384,463	91,527	201,895	293,422	0.74	0.77	0.76
HVAC	238,000	79,400	317,400	1,099,000	369,000	1,468,000	4.62	4.65	4.63
Total	5,373,124	4,011,913	9,385,037	15,936,916	6,551,498	22,488,414	2.97	1.63	2.40

An analysis of the construction cost data between Cases 1, 2, and 4 provides some interesting insights into where the greatest reductions in construction costs could be obtained assuming that all regulatory reforms being considered were to be enacted, allowing the maximum use of imported building materials. The cost data suggests that a Japanese builder can reduce total construction costs by 16% simply by replacing domestic building materials by imported building materials in those applications that are currently allowed by existing building codes and mortgage lenders. With the regulatory reforms scheduled for implementation by the year 2000, Japanese builders would be able to increase their use of imported building materials substantially and could reduce their construction costs by up to 36% over Case 2. The areas where the greatest cost savings could be realized are in framing (¥2,133,665), interior doors (¥1,226,535), exterior doors and windows (¥863,555), finish carpentry (¥701,278), and HVAC (¥809,321). Taken together, these five categories represent 71% of the total cost savings that could be achieved by implementing the regulatory reforms scheduled for the year 2000.

While the data analysis suggests that there are other areas where substantial cost savings could be realized (*e.g.*, foundations and electrical), implementing changes in these areas would be difficult for several reasons. First, many of the practices and techniques employed by Japanese builders are specified in the building codes, which are prescriptive in nature. Secondly, certain techniques are favored by Japanese construction professionals and past experience has shown that they are extremely reluctant to change these techniques despite the fact that lower cost alternative techniques have been shown to be equally effective.

The construction cost analysis clearly demonstrates that 2x4 construction costs could be substantially reduced in Japan by substituting imported building materials for domestic building materials. In addition, the use of imported building materials would facilitate a 7.7% reduction in labor costs from Case 2 to Case 3. The areas where the greatest cost reductions could be achieved are: framing, interior doors, exterior doors and windows, and finish carpentry. Substantial cost savings would also be derived using imported HVAC equipment in place of domestically-produced equipment. Finally, it should be noted that, while the fixtures/appliances category was not included in this discussion, substantial cost savings could be realized by using imported fixtures and appliances in place of higher priced domestic products.

Results of the Technical Assessment

The technical assessment identified a number of areas where a better understanding of the North American style-2x4 construction technology could contribute to improved cost efficiencies while increasing the aesthetic appeal, structural integrity, and long-term performance of North American-style 2x4 homes in Japan. However, two factors, architectural design and construction site management practices, were identified as having the greatest potential to increase performance in these areas. The following section provide further discussion on the important roles of architectural design and construction site management in rationalizing and integrating North American-style 2x4 construction technology in Japan.

It should be noted that there is a Japanese version of 2x4 construction technology that co-exists with the North American-style. The primary difference between the two systems relates to the size of the basic wall panel used in the construction process. The Japanese 2x4 system utilizes a 3’x6’ panel size, which is based on the size of a traditional tatami mat, while the North American style 2x4 system uses 4’x8’ panels in the construction process. Other differences between the two systems include the stud spacing (17.8 inches versus 16 inches on center) and the greater integration of domestic building materials into the Japanese system. Finally, the Japanese system tends to use more wood in the construction process and thus is less cost effective. This research project was focused exclusively on projects utilizing the North American-style 2x4 construction system.

It should also be noted that, while the tone of the following discussion on 2x4 construction practices in Japan might appear to be overly negative, this is not the intention of this report. The reader should keep in mind that the primary purpose of this project was to identify construction practices that negatively impact the structural integrity and long-term performance of North American-style 2x4 homes in Japan. Given these objectives, it is unavoidable that the tone of the discussion might be construed as being negative. However, it is important to note that in many of the projects visited, particularly those being built by large construction companies, the technical team observed that the quality of construction was very good. While it is always dangerous to generalize, the technical team found that larger home builders, and home builders with more experience using the 2x4 construction technology, generally were building good quality North American-style 2x4 homes. In contrast, the team observed that the projects with the lowest quality ratings tended to be managed by smaller construction companies or companies with little or no experience building North American-style 2x4 homes.

In the sections that follow, this report will present a discussion of the role of architectural design concepts and architectural details and their application in Japan. A member of the technical assessment team who is a noted architect and who has extensive experience designing residential projects in Japan wrote this section. The second section will discuss the role of construction management in the construction process and comment on the differences in how construction site management is practiced in the US and Japan. This section was also written by a member of the technical assessment team who has a strong background in construction management and who has managed a large number of construction projects in Japan and who has taught construction management and 2x4 technology transfer courses and seminars to Japanese construction professionals in both Japan and the US. The final section will present a discussion of the technical problems observed by the technical assessment team during the course of their visit to a large number of North American-style 2x4 construction projects.

Architectural Design Concepts and Details

Architectural design and construction are interconnected processes that assemble a collection of manufactured products into a house. This study tour provides a comparison between American and Japanese imported houses in the results of this assembly. The most noticeable characteristic observed with imported houses is the uniformity of design style (or type). The design of the houses visited during this study displayed little variation in the architectural design elements employed, missing an opportunity to adapt the wide variety of US designs and details to Japanese culture and taste. This relative homogeneity of architectural design can be attributed to three factors:

- The uniformity of dimension and shape of house lots.
- The limited selection of interior and exterior finish products used.
- Unimaginative and standardized design forms and details.

Standardization, of both design elements and construction details, has proven to be an effective strategy for achieving construction cost economies. This concept is one of the primary benefits of the North American 2x4 residential construction system. However, the US experience has shown that cost efficiencies can still be derived from the 2x4 system even when design concepts differ from project to project. The challenge is for the architect to provide a combination of imagination and experience when designing a house that incorporates construction costs efficiencies with unique and culturally appropriate concepts.

It appears that the concept of the North American imported house has been assimilated into Japanese consciousness as a style rather than a structural system or assembly of imported building materials. This is demonstrated by the widespread use of the American style. The American Colonial/Traditional architectural design has been incorporated into the design of most imported houses to varying degrees. The architectural style of a house is determined by the form of the house, roof shape and slope, exterior finishes, and design details. In many houses observed in Japan, different architectural elements were applied in designs in a manner that appeared to be random, non-functional, and disjointed. Design quality results from uniformity that creates order, or from variety that creates differences within an overall architectural concept. In only a few of the Japanese projects did the architect succeed in achieving design quality by changing plans, forms, and orientation within a neighborhood, while maintaining design consistency through roof shape and pitch, color schemes, detailing, and landscape.

The standard architectural design observed in Japan does not represent the broad variety of architectural design options available in the US. Unfortunately, neither do these designs relate well to the qualities of traditional Japanese architectural design. Often the imported houses observed represented a contrast to the scale and character of the community as a whole.

It is difficult to ascertain why this inappropriate utilization of American architectural designs exists in Japan. One cause may be the residual perception of Japanese real estate marketers/developers regarding the image of large American/European estates. These image-oriented homes were built for the upper middle class in Japan during the

Bubble era as being symbolic of taste and image. Another cause may be the economic necessity of building material consolidators to standardize the product selections they offer to their Japanese customers. Unfortunately, this economic "filter" not only discourages variety within the range of products offered by individual consolidators but, in order to meet the current low cost criteria required by many Japanese customers, it tends to promote uniformity of product selection across a range of material consolidators. In the future, as the market for imported 2x4 homes expands, the range of home prices will broaden and allow consolidators to offer their Japanese customers a more varied selection of building materials, both in terms of cost and style.

In contrast to the uniformity of architectural design observed, floor plan development in imported housing varies widely. The most experienced architects and builders are designing floor plans that are well suited to Japanese homeowners and lifestyles, adapting the best features and spatial arrangements from both cultures. For example, many houses have western features that enhance social interaction such as larger, open kitchens; open living rooms and dining rooms (sometimes open to the kitchen), and added storage space. Similarly, stairs are often more western in their proportions. Although this type of stair uses more space, the increased width, shallower rise, handrail and carpet add comfort and safety compared to the typical Japanese stair design.

The western concept of openness to the outside environment has also been adapted, although ironically the flexible and transparent exterior wall is originally Japanese. Standard American design elements such as large windows, French doors, patio doors, and exterior wood decks help to create the extension of space and promote an open character.

Many imported floor plans lack order and organization as Japanese builders adapt stock floor plans from the US, resulting in dysfunctional spaces, problem dimensions, conflicting traffic circulation patterns, and unusable spaces/functions. Clear concepts for floor plans that incorporate the best of US and Japanese cultures and lifestyles will help to increase consumer demand for imported housing. Japanese architectural elements that are strong cultural imperatives, such as *tatami* rooms, *genkan*, and unit baths, are easily accommodated into the best floor plans. Flexibility and the ability to easily change room layouts in floor plan will also increase the livability of imported homes. For example, larger, more functional, family oriented open kitchen/dining room combinations will more effectively respond to changes in cultural behavior. Likewise, creative integration of *ofuro* into western-style bathrooms acknowledges a fixed Japanese cultural preference.

The quality of construction details varied widely among the projects visited. This study provides evidence of the highest quality and lowest quality applications. Successful details, from both a functional and aesthetic perspective, occur when the architect thoughtfully designs them and/or the builder implements or invents them during construction. Stock house plans from the US that do not provide construction details and are subsequently used by inexperience builders or carpenters in Japan can result in disaster. Appearance aside, missing or incorrectly constructed details can result in leaks, dry rot, excessive wear, and/or unacceptable maintenance requirements.

Another design issue that is usually not within the control of the architect or builder is site planning. The unimaginative layout of neighborhoods eliminates the variety that can increase the attractiveness and livability of a development. Landscaping is used around western homes as an aesthetic device and to provide a privacy screen, while imparting a unique natural character to the community. Recognizing that space is limited in residential developments in Japan, a new creative design strategy should be developed for residential developments.

Usually the difference between strong and weak architectural design is the designer. As more Japanese architects become familiar with the potential of imported designs and concepts, and they begin to master the functional details, the condition of imported housing will improve. Builders and consumers will begin to rely on architects who design comprehensively rather than simply engineer the structure. Similarly, specifiers will learn to understand the unique design performance of a wide range of imported building materials and products. An example of this development is window design. As Japanese building codes change to become performance based, the design of residential windows will become more varied. In turn, larger windows or groups of windows can be used to achieve a specific design effect. As a result, window manufacturers who now provide only a limited selection of products to their Japanese customers will be required to increase their product offerings in order to better meet more varied design expectations for aesthetics, functionality, and energy conservation.

Construction Management in the US versus Japan

The Japanese and American homebuilding industries have taken divergent approaches to construction management during the past thirty years, resulting in differences in site productivity and construction costs. Whereas most Japanese builders have adopted a system relying on the experience of the individual carpenter and utilizing site supervisors with minimal field experience and little formal project management training, US builders employ site supervisors and project managers with both training and experience in all aspects of residential construction.

This difference has resulted from each country's respective approach to the education of construction managers. Over the past thirty years, over one hundred universities in the US have developed construction management degree programs, preparing thousands of skilled managers for the construction industry each year. Combined with graduates from the two-year programs offered at community colleges and technical schools, the skill level of construction managers has been constantly rising. In contrast, formal Japanese education and training programs in construction management do not exist and most companies employ graduates of engineering and architecture programs who lack coursework in specialized construction management practices. Therefore, the development of construction management skills is done informally on a company-by-company basis. This training process has resulted in significant differences in the responsibilities and authority of construction managers in each country, and in many cases influences the decisions that determine how residential construction projects are managed.

The difference in training programs for construction management professionals leads to construction projects being managed in significantly different ways in the US and Japan. For the purposes of this discussion, these differences have been broken down into six overlapping topics: (1) the authority and responsibility of the on-site supervisor, (2) specialization of trades, (3) material handling and storage, (4) scheduling and sequencing of work, (5) cost control strategies, and (6) quality control.

Authority and Responsibility of the On-site Supervisor

The site supervisor and project manager in the US are accorded a great deal of respect, both by their employer and the construction crews they manage. The basis for this respect is not a reflection of their title, but rather their technical and managerial knowledge of residential construction practices. It is common for the typical US site supervisor to have more than ten years practical trade experience as well as some formal construction management training. Similarly, the typical project manager in the US tends to have at least five years field experience and a degree from a program in construction management. As a result, most US construction companies confer a high level of responsibility and authority to construction site supervisors and project managers, as well as providing appropriate financial compensation.

In contrast, this does not appear to be the case with most Japanese residential construction firms. In general, site supervisors are often junior or entry-level employees, and while many have a formal education in engineering or architecture, most have little or no training in residential construction technology or management. In addition, most have little practical field experience, and therefor have no basis for evaluating the work being performed by the construction crews they supervise.

This problem is further compounded by the fact that due to their youth and minimal experience level, few site construction supervisors are able to command the respect of their construction crews, who often have thirty or more years of construction experience. This lack of respect places young site supervisors at a disadvantage from the management standpoint and often relegates them to a position of simply recording work progress and even performing clean-up and other menial tasks. This practice adds to the cost of construction without increasing efficiency and in some cases can be counter-productive. Innovation, which in the US often results from the interaction between construction workers and site supervisors working to resolve a problem, tends not to occur to the same degree in Japan. The net result is that more efficient construction methods are not developed to help offset rising labor rates and material costs.

Specialization of Trades

In the US, site supervisors rely heavily upon the specialization of trades to increase efficiency and lower construction costs. The typical construction project involves an average of 20-25 subcontractors and this can run as high as 40 with nearly 90% of the work in the residential construction project being performed by subcontractors. Although this process requires greater coordination and scheduling between jobs and construction crews, the US experience has demonstrated that specialized subcontractors can complete the work at less cost and with a higher level of quality than a single carpenter or subcontractor who is required to perform many tasks.

Traditionally, the Japanese carpenter has been viewed as a master craftsman and is expected to perform, and excel at, many different functions. Achieving this level of performance takes many years of training and experience, and often results in cases where the individual is not as skilled or efficient in a specific task as a specialized worker who performs the task on a daily basis.

The key role of Japanese carpenters has given them a great deal of power in the residential construction industry and many people have argued that it is very difficult to take tasks away from, or reduce the scope of responsibility of, the carpenter. There are recent instances, however, where this relationship has begun to change, and work tasks are being subcontracted to specialized workers that were previously thought to be the sole domain of the carpenter. Examples include drywall, insulation work, and the division of rough framing and finish carpentry. Specialized labor, while thought to be more cost and quality effective in the US, may produce different results in Japan unless effective construction management systems are developed and site supervisors are trained to deal with the coordination and quality control issues which arise from the specialization of trades.

Material Handling and Storage

One of the site supervisor's responsibilities in the US is to ensure that the building materials delivered to the job site arrive in good condition and that they are properly handled and stored on the job site. Many instances were observed in Japan where proper material handling and storage practices had not been implemented. This may either result from a lack of understanding of the requirements, or from not possessing or exercising the authority to make sure that workers and subcontractors comply with proper handling and storage practices.

The consequence of this deficiency is damaged products that either must be replaced before installation or that fail prematurely. Both situations are detrimental to the reputation of North American-style 2x4 housing when they involve imported products. An often observed example was window units that were either stacked flat on top of each other or were leaned against walls at such an angle as to cause breakage of the glass, failure of the seal on the insulated glass unit, or air or water leakage of the assembly after installation.

Early delivery of finish building materials to construction sites is another problem. Many of the building materials used on these projects are sourced from US consolidators and delivered in container loads, requiring contractors in Japan to store these materials on the job site. This is particularly true for small to medium-sized builders who are unable to warehouse building materials off-site until they are needed at the project. Many times these materials must be moved several times within the job site prior to installation in order to make room as the work process progresses. Repetitive moving of these materials not only increases the risk of damage but also increases the amount of labor dedicated to a non-productive activity and can substantially reduce labor productivity in a project. While it goes without saying that Japanese construction sites are smaller and more restricted in terms of storage area than sites in the US, this is all the more reason for careful material management, including just-in-time scheduling of deliveries from off-site storage areas.

Scheduling and Sequencing of Work

The Critical Path Method (CPM) for scheduling construction projects has been utilized in the US since the 1960's, but has not been understood or used in Japan until recently. The main features of this system involve the careful placement and linking of construction tasks into their proper sequence, allowing the construction manager to determine the duration of the project as well as identify the most critical tasks prior to the start of actual construction. By monitoring these tasks, the manager is able to maintain better control of a project, placing resources (labor, equipment and supervision) where they are most needed to meet the scheduled project completion date. This method also facilitates the modification of the construction schedule should that become necessary due to delays, a process that is made even easier by existing computer software that incorporate CPM methods.

Imported housing projects in Japan are often attempted in unrealistic time frames, a result of too much time being spent on pre-construction activities (*e.g.*, design and negotiation of contracts). This leaves a shortened period available for construction, as companies aim to complete projects for specific "selling seasons." While homes in the US have been built in as few as 17 days (start to finish), this involves huge amounts of labor and is not economically feasible. The normal construction period in the US for site-built homes ranges from three to five months, depending on the size and complexity of the project. It should be noted that these construction times are achieved when materials are available locally and do not have to be procured and shipped across the ocean.

In contrast, Japanese imported housing projects rarely allow more than 90 days for construction and have very rigid completion dates. The short duration of projects requires very exacting schedules and experienced supervision, without which there is an inevitable loss of efficiency as work crews compete for the same space within a house, or must work overtime to complete their tasks. As pointed out previously, this level of construction management has typically not been available on Japanese residential construction sites, so the workers are left to work out many of these scheduling conflicts themselves.

One of the cost efficiencies of the US system is in allowing the specialized subcontractors to have as full access to the house as possible, making it possible for them to complete their work in the least amount of time and achieve the highest level of productivity. Coupled with this is "just-in-time" delivery of the materials needed for each function. This is accomplished either by having the subcontractor supply and bring his own materials to the job site or by coordinating the delivery of materials prior to installation. In Japan, many of the materials are delivered weeks ahead of schedule, adding confusion and inefficiency to an already crowded construction site. Considerable labor is wasted by repetitively moving materials out of the way so work can be completed, particularly in the later stages of a project. As would be expected, the more often that building materials must be moved within the site, the higher the likelihood that they will be damaged as a result of mishandling or improper storage.

On Japanese construction sites specific tasks appeared to be scheduled with little consideration being given to their relationship with other tasks occurring in the construction process. Poor scheduling means that critical tasks are not staged in the proper order and contributes to a lack of overall coordination that adversely impacts construction efficiency and increases total project costs. For example, because stairways in Japan are often considered to be a finished system, they are not installed until late in the project. This forces workers to use ladders to move between floors, generally hindering their movement and the movement of construction materials within the job site. In addition to reducing the efficiency of the carpenters, this practice creates a safety hazard as it was often observed that makeshift ladders were used.

In most of the projects observed that were under construction, hardwood flooring and finish trim work were installed after drywall installation but before taping, texturing and painting of the walls. This slows down these subsequent activities, as extra time must be taken to ensure that the flooring and moulding are not damaged. Perhaps more importantly, the moisture introduced into the interior of the house during the mudding and painting process could very well damage the interior flooring, doors and trim.

Cost Control

In the US, cost control has come to mean much more than simply comparing the actual construction costs with the budgeted costs. While this comparison is certainly important, it does not provide the cost control necessary to keep projects within budget. All of the best pre-planning is of limited value if an effective system is not implemented to facilitate the careful monitoring and control of construction costs as they occur during the construction project, as this is where the majority of a project's cost overruns will occur. With a good cost control system in place, a builder can analyze the productivity of the workers, the performance and cost effectiveness of the equipment being used, and the job site overhead costs. This analysis can be done on an ongoing, "real-time" basis, so that deviations can be identified and corrected while the project is still in progress.

In Japan, construction cost estimates often combine material and labor, making it difficult to know the true budget for each. Unlike in the US where many builders use the Construction Specification Institute (CSI) numbering system for categorizing costs, no such standardized system exists in Japan. This makes it difficult for a builder to compare their costs with national or regional averages to determine if their crews and subcontractors are cost-efficient.

There are other essential elements of the American builder's cost control system which appear to be missing in Japan. One of these is the delegation of the responsibility for cost control to a qualified site supervisor. In the US, supervisors are provided with all of the information related to the project budget and then given the authority (and responsibility) to monitor and control all project costs that are under their control. Weekly cost reports are provided to site supervisors and strategies are discussed to help keep the project on budget.

Another element missing in most of the Japanese projects observed was a written cost improvement program. While not all US companies use such a plan, the majority of US builders have developed such a program. Thus, value engineering is constantly performed to assure that the best possible product is delivered to the customer within the targeted price range.

It should be noted here that true cost improvement does not occur by lowering product specifications, changing design details, or eliminating features. While all of these methods have been used to reduce housing prices in Japan during past three years, they do not truly constitute cost improvements. This must be accomplished by reducing material costs, increasing labor efficiency, or reducing overhead costs. None of this can be accomplished overnight and the process involves a long-term commitment to cost improvement.

Quality Control

In the US construction industry the inspection and quality assurance systems are interrelated. Although the goal of producing a safe, high quality house is the same in both the US and Japan, the methodology for achieving this goal is quite different. The result is that many of the construction deficiencies that are discovered and corrected under the US construction inspection system go undetected in the Japanese system. In the case of imported housing, this is creating homes that have built-in problems that can (and most likely will) affect the long-term performance and durability of the home.

To ensure compliance with US building codes and safety regulations, eight to fourteen site inspections are required during various phases of construction. Impartial "third party" inspectors who are employed by the government municipality where the work is being performed conduct these inspections. In addition, municipal building departments in the US prior to issuance of building permits require detailed structural and architectural plan reviews. A brief discussion of the US building inspection process is presented in Appendix C.

This comprehensive system of site inspections is in sharp contrast to Japan, where the plan check process involves more of the site coverage of the structure rather than a detailed structural and code analysis. Also, the inspections are for the most part done by each company on an honor system, with government inspectors making at most one or two visits to the project during the construction process. While this self-policing policy probably works much better in Japan than it would in the US, it is still open to both abuse and honest mistakes.

Of even greater significance to the overall quality of the completed project is the fact that US site supervisors are given the responsibility and authority for monitoring quality control. At each stage of construction, the site supervisor does a walk-through with the subcontractor and prepares a list of corrections that must be completed. This list is given to the subcontractor with a time schedule for completion, and the site supervisor has contractual remedies if the work is not done in a timely manner. The key to this system is a strong supervisor who possesses a good knowledge of all phases of construction, something which, as noted earlier in the discussion, is not usually present in the Japanese system.

While the quality of the finished workmanship is usually very high in Japan, it is the "hidden" defects that pose the greatest threat to the long-term performance and durability of, and ultimately the customers satisfaction with, imported housing.

Discussion of the Technical Assessment

The differences between the traditional post-and-beam construction method and the North American style 2x4 construction method are partly a reflection of the cultural differences that exist between the countries (Photos 1 and 2). The Japanese interest in North American-style 2x4 homes is in part a reflection of the increased standard of living associated with the Bubble Economy of the mid to late 1980s and partly due to an increased interest in the US lifestyle on the part of many Japanese. Only after the collapse of the Bubble Economy did Japanese builders and contractors look to imported housing to provide a combination of affordability and value as an answer to the high cost of housing in Japan. The relatively short history of 2x4 housing in Japan means that Japanese architects have had little opportunity to learn the design details that have contributed to the success of 2x4 construction in North America. Perhaps more importantly, the emphasis of builders and contractors during the 1980s was on building 2x4 homes based on their concept of "Americana" and the American life style, an emphasis that often provided an interesting contrast with traditional architectural styles (Photos 3and 4).

During the technical assessment of North American-style 2x4 housing projects in Japan it often appeared that architectural design was driven by product selection, availability, and western image rather than by design concepts, functions, and details. As a result, the link between architectural design and construction technology was often lacking, contributing to a loss of design continuity within the home and reducing the inherent cost efficiencies of the North American-style 2x4 construction technology. In addition, it appeared that some Japanese architects and builders lack an understanding of imported building materials and the process of specifying these products. Not only does this adversely impact the aesthetics of many projects (Photos 6 and 10), but it also affects the functionality of the design (Photos 6-8).

Photos 9-12 illustrate how poor product specification and placement can adversely impact the aesthetics of a house. For example, the lack of coordination between design, product selection and exterior finishing can significantly reduce the aesthetic appeal of a housing development (Photo 9). Similarly, unfamiliarity with North American building materials can result in unusual combinations of functional and non-functional products (Photo 10) as well as the mis-specification of products (Photo 11). Note that the shutters are a different height than the windows.

An important area of concern noted by the technical assessment team was the lack of understanding of the North American 2x4 construction management process. Building lot sizes are typically quite small in urban Japan (Photos 12 and 13). As a result, most material storage and preparation occurs on the work platform, contributing to congestion and adversely affecting worker productivity (Photos 14-16). In addition, cultural norms in Japan require that builders and contractors erect intricate and expensive scaffolding and tarp systems to minimize the visual and noise impacts of the construction process on nearby neighbors (Photo 17). These scaffolding systems impede workers' movement around the construction site, restrict their access to the work platform during the construction process, and complicate the handling and movement of building materials on site.

Specific construction tasks appeared to be scheduled with little consideration of their relationship with other tasks occurring in the construction process. This poor scheduling of jobs means that critical tasks are not staged in the proper order, contributing to a lack of overall coordination that adversely impacts production efficiency and increases total construction time and cost. In most of the projects under construction it was observed that hardwood floors and interior moulding were installed after the installation of wallboard but prior to the mudding, taping and finishing of the wall board (Photo 19). This means that extra time and care must be taken when finishing the interior walls in order to ensure that the flooring and interior trim are not damaged.

Finally, there appeared to be little coordination of tasks between the different trades (*e.g.*, framers, finish carpenters, plumbers, electricians, roofers, and sheet rockers), resulting in delays between jobs and extended construction times. For example, gypsum wall board was often installed over electrical switches and outlets without cutouts being made by the sheet rock crews (Photo 20). It became the job of the electrician to locate electrical switches and outlets and cut out the receptacles. Not only is this a time consuming and inefficient use of expensive skilled workers, but it means that construction costs are increased substantially. This problem in scheduling has been attributed to the fact that the network of Japanese skilled workers who normally perform these tasks are reluctant to work with imported products with which they have little experience. Thus carpenters on the job site are often required to perform tasks on which they are not particularly proficient (*e.g.*, hanging and taping wallboard, installing flooring, putting up moulding, and hanging doors and windows).

The typical process employed in building a foundation in Japan (Photos 21 and 22) involves six steps: soil preparation, spreading of a rock base, pouring concrete for the perimeter and interior foundation walls to a sub-grade level, pouring a mud or "rat" slab, pouring a thin mortar cap on top of the foundation walls to bring them to final grade level, and applying a smooth mortar finish to the exterior walls. One problem noted is related to the fact that foundation walls are not initially poured to the finished grade level. In order to bring the foundation to the finished grade level, concrete forms are nailed to the foundation walls and a thin mortar cap (15-30 mm. thick) is poured (Photo 23). This practice results in poor adhesion between the thin mortar cap and the foundation wall, often resulting in the separation and cracking of the mortar cap (Photo 24). Given the frequency with which this defect was observed, the instability of the mortar cap can adversely impact the structural performance of the house and could result in wall cracks as the house shifts and settles. Also, on several occasions it was observed that uneven and/or out of level foundations were corrected using structurally unsound practices. Over time the concrete shims used to level walls will crack, causing the corner of the building to settle (Photo 25).

Foundation walls are generally placed under interior walls, both load bearing and non-load bearing (Photos 21-23). Alternatively, foundation piers are placed under long floor spans and adjustable support columns, placed on the foundation piers, used to provide intermediate support for floor joists, ostensibly to reduce sag and stiffen floors (Photo 26 and 27). The adjustable support columns observed were not fastened to either the floor joist or the foundation piers, thus were subject to failure if a lateral or uplifting force were to be applied to the house, as in the case of an earthquake. While these adjustable columns are unnecessary, expensive, and most likely ineffective, they also compromise the structural integrity of the floor system.

Many carpenters and contractors have a poor understanding of the technical details of North American-style 2x4 construction technology. This was observed to some degree on almost all of the construction sites visited. In most cases this lack of understanding probably contributed to higher construction costs without adversely affecting the structural integrity and/or long-term performance of the home, although in some cases it could very well adversely impact structural integrity. For example, on several projects the exterior sheathing on the shear wall did not extend to the sill plate on the foundation (Photo 28). In the absence of adequately engineered and installed tie-downs, failure to tie the shear walls to the foundation means that the house has minimal resistance to applied lateral force and is subject to shifting on the foundation.

The excessive use of lumber during the rough framing of a 2x4 house was also frequently observed in wall, floor, ceiling, and roof construction (Photos 29-31). For example, wall studs were often doubled in an apparent effort to simulate the 4x4 posts used in traditional post-and-beam construction. Floor joists were doubled to increase the stiffness of the floor and dropped ceilings were employed to reduce noise transmission from upper floors to lower floors. These practices require an increased use of lumber, resulting in both higher material and labor costs without substantially increasing the structural performance of the system.

Blocking in walls in areas outside of shear wall applications where it served no structural purpose and was not required by local building codes was often observed. Blocking refers to the use of small pieces of wood placed between and perpendicular to wall or ceiling studs. For example, blocking was often located behind the ends of adjacent sheets of plywood and drywall to facilitate nailing the ends of the sheets, behind wall-mounted cabinets in kitchens and bathrooms, and inside closets where shelving was to be installed. The installation of blocking is very labor and time intensive, does not increase structural performance, and results in increased labor costs while slowing down the construction process. The grade of lumber specified for rough framing was often much higher than required, further increasing material costs during the rough framing process (Photo 32). A number of US contractors involved in 2x4 projects in Japan have estimated that the increased use of lumber, and specification of higher grades of lumber, during the framing process results in a 20-35% increase in framing material costs.

Another area of concern was related to exterior finish details that influence the ability of exterior walls to resist air and water infiltration (Photos 33 and 34). In many instances, gaps were observed in the areas where exterior siding butted up to doors and windows as well as at the interior and exterior corners of the house. In addition, flashing above doors and windows was frequently deficient or missing completely. These deficiencies provide an opportunity for water to penetrate into the walls of the house, establishing an opportunity for decay and degradation of the wall system, windows, and doors to occur in the future.

One of the advantages of the 2x4 construction system is improved energy efficiency, a feature that makes 2x4 homes attractive to Japanese consumers given the temperature and humidity extremes experienced in winter and summer. The evaluation team observed a general lack of understanding regarding the installation of insulation (Photos 35-37). They observed cases where undersized batts of insulation were used as well as instances where oversized batts of insulation were compressed into walls and ceilings, reducing the loft of the insulation as well as its insulating ability. In general, they found that walls and ceilings were under insulated (*e.g.*, R11 and R19 insulation was often used in walls and ceilings when US building codes generally specify R19 and R30 insulation in these applications, respectively). In addition, the team reported that many of the houses visited did not have adequate ventilation in the soffits and attics. Non-functional vents were often located on the peaks of homes solely for aesthetic purposes (Photo 38). Failure to provide adequate roof ventilation can result in moisture buildup which, when combined with high humidity and high temperatures, can lead to the degradation and premature failure of the roof system.

In many cases, Japanese contractors recognize that technology transfer is important to increasing the quality and performance of the homes that they build. This is discussed in greater detail in the following section. A much more detailed discussion of the technical assessments, including specific examples of the technical problems that were observed and their impact on the structural integrity and long-term performance of North American-style 2x4 homes, is provided in Appendix B.

Results of a 2x4 Housing Survey of Japanese Construction Professionals

In 1996 a survey was conducted by the Japan 2x4 Housing Association regarding 2x4 housing construction in Japan. Part of the survey focused on the amount and method of 2x4 technical training conducted by member companies. The survey was sent out to 390 member companies of the Japan 2x4 Housing Association; 145 companies responded. Companies with no 2x4 building experience were not included in the survey analysis. The final number of respondents was 138 companies, or 35.4%.

The survey defined two types of 2x4 construction technologies in Japan: North American-style 2x4, defined as using the 4’x8’ module with stud spacing at 16” on center; and Japanese-style 2x4, defined as using the 3’x6’ module with stud spacing at 17.5” (445 mm) on center. A majority of the 2x4 houses built in Japan use the Japanese-style 2x4 method. The respondent companies were segmented based on the amount of experience they had in each category (Tables 11 and 13).

Table 11. Type of segmentation used for survey respondents.

		North American-style 2x4 Construction Experience		Japanese-style 2x4 Construction Experience
T	**A**	Over 51 Houses	**A**	Over 201 Houses
Y	**B**	6 - 50 Houses	**B**	21 - 200 Houses
P	**C**	1 - 5 Houses	**C**	1 – 20 Houses
E	**O**	0 Houses	**O**	0 Houses

Table 12. Amount of experience reported by respondents with each type of building technology.

North American Style	Japanese Style	Type	Number Of Respondents		
A	A	AA	3	9 (6.5%)	56 (40.6%)
	B	AB	2		
	C	AC	1		
	O	AO	3		
B	A	BA	11	33 (23.9%)	
	B	BB	14		
	C	BC	3		
	O	BO	5		
C	A	CA	2	14 (10.1%)	
	B	CB	8		
	C	CC	2		
	O	CO	2		
O	A	OA	40	82 (59.4%)	
	B	OB	36		
	C	OC	6		
TOTAL			**138 (100%)**		

More than half (61.1%) of companies building Japanese-style 2x4 homes have worker training programs while only 39.6% of the companies building North American-style homes have worker training programs (Tables 13 and 14. This may reflect the larger size of companies building Japanese-style 2x4 homes compared with those building North American-style 2x4 homes. Among the companies that did not provide training, over 80% in both groups reported that their workers already possess sufficient technical skills and additional training was not required.

Table 13. Japanese-style 2x4 construction companies and their use of worker training programs.

	Japanese Style A	Japanese Style B	Japanese Style C
Have Worker Training	41 Companies	29 Companies	7 Companies
Do Not Have Worker Training	14 Companies	30 Companies	5 Companies

Table 14. North American-style 2x4 construction companies and their use of worker training programs.

	North American Style A	North American Style B	North American Style C
Have Worker Training	5 Companies	12 Companies	4 Companies
Do Not Have Worker Training	4 Companies	19 Companies	9 Companies

The methods of training utilized within the two groups are listed in Tables 15 and 16. Companies building Japanese-style 2x4 houses appear to be more likely to rely on in-house training programs than companies building North American-style 2x4 homes. Another contrast is that companies building North American-style 2x4 homes often employ experts from abroad for training, while companies building Japanese-style 2x4 homes more often employ domestic experts. Very few companies in either group send their employees abroad for technical training.

Table 15. Types of technical training employed by respondents building Japanese-style 2x4 houses.

Training Method	Number of respondents #	%
We conduct training using our company's in-house training program.	37	48.1
We hire domestic experts to conduct training.	33	42.9
We conduct training independently using literature, videos, and seminars.	30	40.3
We invite experts from abroad to conduct training.	21	27.3
We go abroad to receive training from N. American organizations.	5	6.5

Table 16. Types of technical training employed by respondents building N. American-style 2x4 houses.

Training Method	Number of respondents #	%
We conduct training independently using literature, videos, and seminars.	11	52.4
We invite experts over from abroad to conduct training.	10	47.6
We hire domestic experts to conduct training.	7	33.3
We conduct training using our company's in-house training program.	7	33.3
We go abroad to receive training from N. American organizations.	2	9.5

The top three problems encountered by companies building North American-style houses that arise from a lack of worker training (Table 17) were: increases in material costs, labor costs, and construction time. Each of these problems contributes directly to the increased cost of 2x4 construction in Japan relative to the US. In addition, a substantial number of respondents recognized that inadequate training contributes to poor quality construction. Workers who have completed 2x4 construction training programs do not receive bonuses or increased wages as might be expected. This lack of recognition and acknowledgement of worker training might act as a disincentive to workers in seeking training in 2x4 construction techniques.

Only a small percentage (5.9%) of the respondents have adopted the critical path method of construction management utilized in North America (Table 18), although they all reported that they have derived positive results. Over 70% of the respondents reported that they are either looking into using the CPM or would like to look into it but are not sure how. This high percentage indicates that there is a substantial amount of potential demand for learning the CPM method of construction management. Overall, the respondents reported that there has not been much effort made to provide 2x4 training programs for building professionals involved in the construction of either North American-style 2x4 homes or Japanese-style 2x4 homes.

Table 17. Summary of the types of problems that respondents attribute to insufficient technical training in North American-style 2x4 construction techniques.

Training Method	Number of respondents #	%
Increased labor costs.	32	86.5
Higher amounts of materials are wasted.	27	73.0
Increased construction time.	24	64.9
Poor quality finishing.	18	48.6
Problems (*i.e.*, squeaky floors) from improper installation.	7	18.9
Water leaks.	6	16.2

Table 18. Respondent opinions regarding their use and potential adoption of the critical path method used by construction professionals in North America.

Reason	Respondents #	Respondents %
The method we have been using is sufficient and we do not intend to adopt new methods.	7	13.7
We would like to look into these methods but are not sure how.	11	21.6
We are currently looking into these methods.	25	49.0
We looked into adopting these methods and decided not to use them.	1	2.0
We adopted these methods and had positive results.	3	5.9
We adopted these methods and then stopped using them.	0	0.0
Other	4	7.8

CONCLUSIONS AND RECOMMENDATIONS

In order to increase the competitiveness of North American-style 2x4 homes and building materials in Japan, it is important to ensure that the quality, value, and long-term performance of 2x4 homes in Japan is not compromised by incorrect construction techniques. Some Japanese construction professionals, particularly small to medium-sized builders, do not fully understand North American-style 2x4 construction technology and, as a result, employ construction techniques that could compromise the structural integrity and/or long-term performance of 2x4 homes. From a long-term strategic market development perspective, it is imperative that Japanese construction professionals be introduced to US construction management techniques and be properly trained in the technology in order that the growth of this important segment of the Japanese housing market not be jeopardized by substandard product performance. The successful transfer of the North American construction technology will ensure that the quality and value of these homes meet the high expectations of Japanese home buyers while enabling US and Japanese companies to work together to increase the competitiveness of 2x4 homes and imported building materials in Japan.

Better integration is required between the marketing and sales of North American building materials and training programs on the installation and maintenance of North American building materials. Since entering the Japanese market in the mid-1970s, North American building materials manufacturers have taken a fairly passive stance regarding the training of Japanese 2x4 construction professionals. According to the results of the Japan 2x4 Association survey, most Japanese companies prefer to conduct their training in Japan rather than sending their carpenters abroad. This represents an opportunity for North American manufacturers to gain a competitive advantage by aggressively establishing technology training programs in Japan. While this might be a fairly costly endeavor, it could be made more cost effective by forming cooperative training programs between non-competing manufacturers. For example, a cooperative training program could be developed by a consortium of non-competing companies such as manufacturers of windows, doors, cabinets, hardwood flooring, and molding and millwork. Technical training programs could also be established by industry associations or by public agencies (*e.g.*, the 2x4 technical transfer seminar series in Japan established by the Washington State Department of Community, Trade and Economic Development). Given the interest of Japanese contractors in CPM, an expert in this area should be included in the training seminars in order to integrate the CPM method with the use of North American building materials.

These technical training programs could be promoted directly in the Japanese industry print media and through direct mailings. One magazine that reaches the Japanese 2x4 builder is “Yunyuu Jutaku” or “Imported House.” This is a Japanese language publication that targets 2x4 builders. Advertising a technical training program in this magazine would be an extremely effective way to reach the target market. In addition, the State of Washington publishes a quarterly Japanese language newsletter that has been used to promote the CTED technical training seminars. Mailing lists could also be obtained from these magazines or by joining Japanese industry associations such as the Japan Housing Round Table.

The construction and technical assessments indicate that there is a lack of understanding of North American-style 2x4 construction technology, particularly on the part of small and medium-sized builders. Technical training programs and seminars in Japan should be in-depth and focused on specific components of the 2x4 construction technology rather than be general overviews or introductory in nature, and should focus on the following areas:

- rough framing techniques,
- construction detailing,
- specification of imported building materials,
- exterior finish details,
- interior finish details,
- insulation and energy efficiency details,
- construction management and planning, and
- architectural design and details.

Technical training programs should be designed with the specific target audience in mind. For example, a seminar on 2x4 design should be targeted for architects and designers while a seminar on rough framing techniques should be targeted to the builder and carpenter. Further, while a classroom seminar might be most appropriate for a discussion of architectural design concepts, a seminar on rough framing techniques might be most effective if designed to be a hands-on experience, where the participants can be actively involved. The target audience for these seminars should be small to medium-sized builders and builders who are relatively new to the North American-style 2x4 construction technology. Based on the results of the Japan 2x4 Association survey, technical training seminars should take place in Japan and should be held throughout the country rather than in a single location. In addition, it might be useful to perform a geographical analysis of where the largest number of 2x4 homes are being built within Japan and target these areas for technical training seminars. Obviously, given the fact that the target audience is small to medium-sized home builders and their carpenters, technical seminars should be conducted in Japanese. Also, given the interest expressed by Japanese builders in learning more about the critical path method of construction planning and management, it might be timely to develop a separate seminar on this topic.

Another important area that needs to be considered in the design of a technology transfer program is the long-term maintenance of 2x4 homes in Japan. The superior long-term performance of 2x4 housing in North America can to a large degree be attributed to the fact that home owners in North America perform regular maintenance on them. In contrast, Japanese homeowners have traditionally regarded housing as disposable, with homes receiving little, if any, regular maintenance. As a result, the life span of a wooden home in Japan is estimated to be approximately 30 years. Home maintenance is also a cultural issue and where North American homeowners are willing to undertake routine maintenance (*e.g.*, exterior painting and caulking around exterior doors and windows), few Japanese homeowners are currently willing to do this. In order to ensure that North American-style 2x4 homes built in Japan provide the long-term performance that is expected of them, a strategy must be developed to ensure that they receive routine maintenance. While this maintenance can be provided by the homeowner, the building contractor or by an independent maintenance contractor, it is critical that routine maintenance services are provided.

Finally, independent certification of North American-style 2x4 homes built in Japan should be investigated. The certification process could focus on the structural components of the home or could be extended to include other aspects of the home as well (*e.g.*, thermal efficiency or noise transmission). A certification program would not only ensure that North American-style 2x4 homes are built using the correct construction techniques but could provide a forum to facilitate the provision of technical training programs in Japan. For example, a small to medium-sized contractor might be certified to build North American-style 2x4 homes after demonstrating their ability to build 2x4 homes using the appropriate construction techniques. Those contractors who would like to be certified but do not possess the technical skills to receive certification could attend a series of technical transfer seminars and arrange for an on-site trainer or site supervisor to provide hands-on training in North American-style 2x4 construction techniques to their carpenters and site supervisors.

It is critically important, from the US perspective, that the structural integrity of North American-style 2x4 homes in Japan is not compromised by the incorrect application of the technology. From a long-term strategic market development perspective, it is imperative that Japanese builders and carpenters be properly trained in 2x4 construction technology in order that the growth of this important segment of the Japanese housing market not be jeopardized by substandard product performance.

Given the Japanese expectation of high quality, and the marketing emphasis on the North American aspect of 2x4 housing in Japan, the long-term growth potential of the 2x4 market is dependent on maintaining the quality of the North American-style 2x4 houses being built (Photos 39-41). From a marketing perspective, the role of quality is frequently more important than low price in Japan. Every effort should be made to ensure that the North American-style 2x4 construction technology is implemented correctly by Japanese contractors and carpenters. Failure to ensure the effective transfer of the technology will contribute to a perception by Japanese home buyers that this housing is poor quality, and would undermine efforts by North American companies and industry associations to further develop this growing segment of the Japanese housing market.

Over the long term it is equally important that US value-added manufacturers and exporters work to gain greater acceptance of US wooden building materials in the other segments of the Japanese housing industry: post-and-beam and pre-fabricated housing. This includes learning how building materials are specified in these industries, identifying who at the company is responsible for specifying product options, what factors affect the specification process, and how the specification process can effectively be influenced to facilitate the use of US building materials. Similarly, it is equally important that US exporters better understand the role of maintenance and product support factors (*e.g.*, local inventory, product installation instructions and support services, and product maintenance literature) on the competitiveness of US building materials in Japan.

BIBLIOGRAPHY

Bremner, Brian and Tomoko Takahashi. 1996. Is Japan Headed for Another Recession? Business Week. Dec. 16: 48-49.

Briggs, D. G. and N. Dickens. 1984. An Evaluation of Japanese Softwood Construction Lumber Grading Systems and Their Implications for North American Export Lumber Producers. Working Paper 2. CINTRAFOR, University of Washington, Seattle, WA.

CIA (Central Intelligence Agency). 1997. 1996 World Factbook. electronic source.

Coaldrake, W. H. 1990. The Culture of Market Penetration-Timber Products and the Japanese Housing Industry. The Australia-Japan Research Center, Canberra, Australia.

Cohen, D. Forest Products Journal

Eastin, I. L. 1994. Import Distribution Channel Considerations for Value-Added Wood Products in Japan. CINTRAFOR News 9(1):1-5.

Eastin, I. L., K. Bentil, and G. Beltran. 1995. A Comparative Assessment of North American and Japanese 2x4 Residential Construction Systems. Working Paper 53. CINTRAFOR, University of Washington, Seattle, WA.

FAO (Food and Agriculture Organization of the United Nations). 1994. Forest Products Yarbook. Rome, Italy.

Japan Lumber Journal. 1995. No Damage on House Built Under New Earthquake Proof Standards. Vol. 36(9):1,19.

Japan Lumber Journal. 1996. Applications for GHLC's Loan Favorable with 150,100 Units. Vol. 37(14):10.

Japan Lumber Journal. 1997. Housing Starts for 1996 Highest Level Since "Bubble Economy" to 1.64 Million Units. Vol. 38(3):1-2.

Japan Lumber Reports. 1995. Disaster would not disturb wood supply. Feb. 10. No. 207:1.

Japan Lumber Reports. 1996. Revision of construction standards in wide range. Mar. 15. No. 231:1.

Japan Lumber Reports. 1997. Import housing doubles. Jan. 24. No. 250: 7.

JETRO (Japan External Trade Organization). 1990. Your Market in Japan: Prefabricated Houses. Mini-Report No. 9.

JETRO. 1995. Your Market in Japan: Housing. No. 101.

JETRO. 1996a. Your Market in Japan: Housing. No. 101.

JETRO. 1996b. Your Market in Japan: Wooden Construction Materials. Mar. No. 103.

JETRO. 1996c. Report on Japanese House Design. Mar.

Kellar, James. 1985. Industrialized Housing: The Japanese Experience. Alberta Municipal Affairs. December.

Leonard Guss Associates, Inc. 1992. Export Market Opportunity for Pre-Manufactured Housing in Canada and the Pacific Rim. October 13.

Levy, S. 1990. Japanese Construction: An American Perspective.

Magnier, Mark. 1994. Homebuilders in Japan cut costs by ordering materials from US. The Seattle Times. Aug. 16: D2.

Ministry of Construction. 1994. Action Program for the Reduction of Housing Construction Costs. Mar. 18.

Nakamae, Hiroshi. 1993. Import houses? Unassembled, of course. Nikkei Weekly. Sept. 20.

Nakamae, Hiroshi. 1994. US-style housing cheaper, but riskier. Nikkei Weekly. Sept. 12. 32(1637):2.

Pacific Rim Wood Market Report. 1996. Millions of New Houses: A Good Year for Wood? No. 104:1-4.

Pesonen, Miikka. 1993. Japanese Market for Scandinavian Wood Products. Department of Forest Economics Reports No. 1. University of Helsinki, Finland.

Robertson, Guy and T.R. Waggener. 1995. The Japanese Market for Softwood Sawnwood and Changing Pacific Rim Wood Supply Conditions: Implications for US Pacific Northwest Producers. CINTRAFOR Working Paper No. 52.

Roos, J. and I. L. Eastin. 1998. Japan 2x4 Housing Survey Study: A Survey of Japanese 2x4 Builders Conducted by the Japanese 2x4 Construction Association. Working Paper. CINTRAFOR, University of Washington, Seattle, WA.

The Evergreen Partnership Japan Update. 1992. Japanese Housing Construction Costs Twice as Expensive as American Costs. July 8.

U.S. Bureau of the Census. 1996. Statistical Abstract of the United States: 1996. 116th edition. Washington, DC.

Washington State Community, Trade and Economic Development. 1997. Japan Housing and Building Materials Market News. Jan:1-2.

WWPA (Western Wood Products Association). 1994. Softwood Lumber Markets in Japan. Apr. 1.

Yamakoshi, Atsushi. 1994. Housing Problems in Japan: Policy Review and Perspectives. Japan Economic Institute Report. Dec. 16, No. 47A.

Yorimitsu, Ryozo. 1992. Thriving Housing Construction in Japan and the Factors Contributing to it. The Current State of Japanese Forestry VIII. The Japanese Forest Economic Society, January. p.1-16.

Youngquist, W. G. and H. O. Fleischer. 1977. Wood in American Life 1776-2076.

PHOTOGRAPHS

Photo 1. A dramatic contrast between a traditional post and beam home and a 2x4 home in Japan.

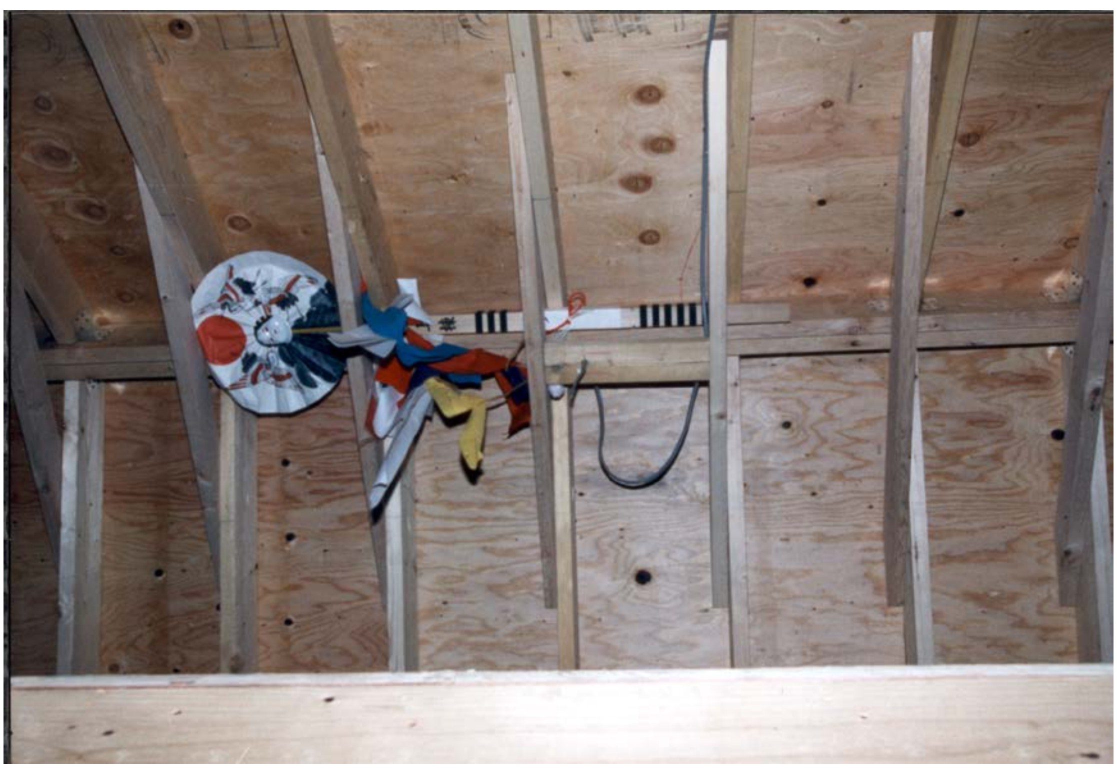

Photo 2. In a tradition derived from traditional post and beam construction, ceremonial items are often placed in the roof of 2x4 houses to bring the owner good luck and fortune.

Photo 3. Entrance of a traditional post and beam house.

Photo 4. Entrance of a North American-style 2x4 home where the architect has gone to great lengths to produce an Americana motif.

Photo 5. Lack of familiarity with North American architectural designs and building materials can adversely impact the aesthetics of a home.

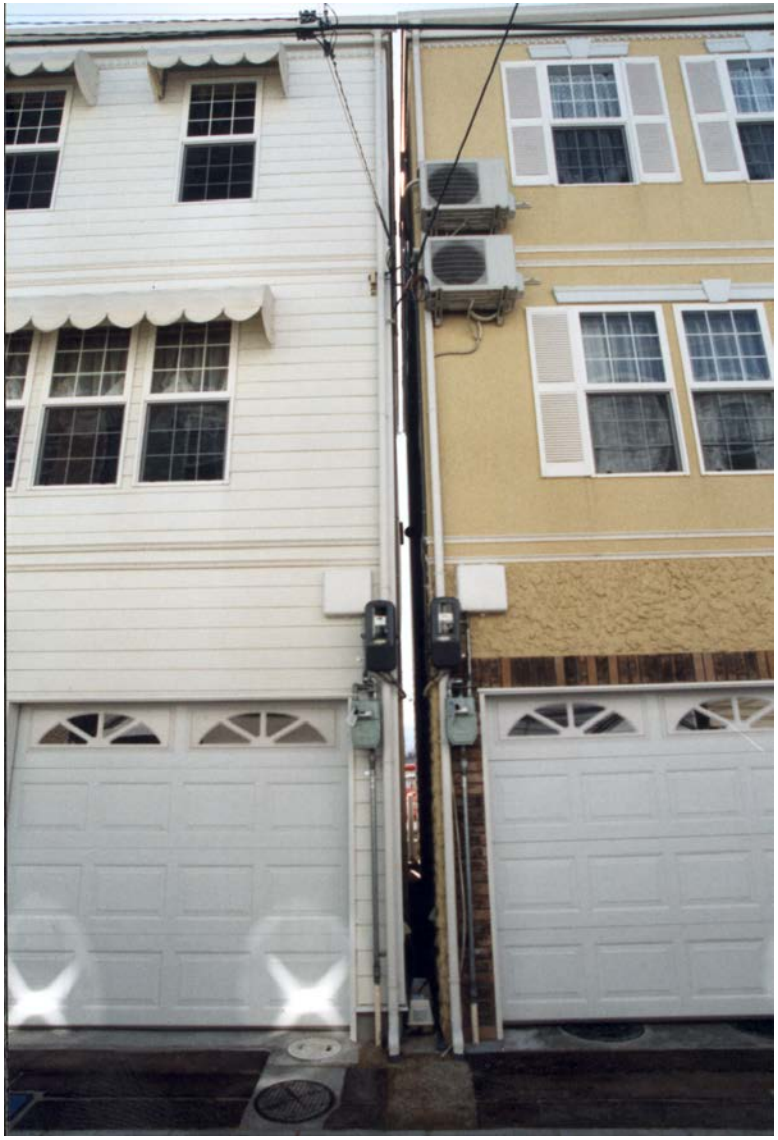

Photo 6. Poor design means that the garage doors at right must be raised before the septic tank covers can be accessed.

Photo 7. This fragmented and compartmentalized floor plan results in wasted hall space that is too narrow for a usable room and too wide for a corridor.

Photo 8. The conspicuous placement of service equipment is unsightly. Also, the height of the door above the landing poses a safety hazard.

Photo 9. Lack of familiarity with North American architectural designs and single family housing developments can adversely impact the aesthetics of housing projects in Japan.

Photo 10. Lack of familiarity with North American building materials can adversely impact the aesthetics of 2x4 homes.

Photo 11. Lack of familiarity with specifying imported building materials resulted in a mismatch between the length of windows and shutters.

Photo 12. Another example of poor product specification. This picture also highlights the small size of building lots in urban Japan.

Photo 13. Narrow building lots in Japan increase the importance of employing efficient construction management practices in residential construction.

Photo 14. Small lot sizes lead to material storage on work platforms, contribute to crowded and unsafe working conditions, and result in excessive material handling.

Photo 15. Small lot sizes mean that both material storage and material preparation operations occur on the work platform.

Photo 16. Storage of building materials on the construction site results in excessive material handling, contributes to reduced worker productivity, and can potentially lead to increased damage of finished products (e.g., windows).

Photo 17. The extensive use of intricate and expensive scaffolding systems in Japan can hinder the movement of both carpenters and building materials on the job site.

Photo 18. Insulation on this exterior wall has been incorrectly installed. Note the use of an unsafe makeshift ladder well into the construction process.

Photo 19. Installation of mouldings, millwork and flooring often occurs before wall surfaces have been finished.

Photo 20. Wall board is often installed over electrical outlets and electricians waste time locating outlets and cutting outlet openings in the wallboard.

Photo 21. View of Japanese foundation showing foundation walls located under all interior walls and pier blocks at the middle of longer spans.

Photo 22. In many cases foundation walls do not provide adequate ventilation for the crawl space.

Photo 23. Foundation walls are not poured to the final grade level and form work must be added, and a thin topping layer of mortar poured, to reach final grade level. This practice substantially increases both material and labor costs and greatly extends the total construction time of the project.

Photo 24. Poor adhesion by the thin mortar layer used to level foundation walls often results in separation.

Photo 25. A structurally unsound effort to level an uneven foundation.

Photo 26. Expensive and potentially unsound support columns are not connected to the pier blocks or floor joists and can kick out during an earthquake. Note the end notch where adjacent joists are butted is not located above a support column.

Photo 27. Support columns have not been secured to the foundation or floor joists and a structurally unsound system of wires has been used to prevent the columns from kicking out during a seismic event.

Photo 28. Exterior sheathing on this shear wall is not nailed to the sill plate and thus does not tie the house to the foundation.

Photo 29. The excessive use of framing lumber was routinely observed and is estimated to increase framing material costs by 30-35 percent.

Photo 30. An example where triple top plates have been used.


Photo 31. All window and door headers were tripled in this project, resulting in excess material and labor costs.

Photo 32. Specification of high grade lumber can add significantly to framing material costs without significantly improving structural performance.

Photo 33. Failure to install flashing or apply caulk around exterior doors and windows allows moisture to penetrate exterior walls.


Photo 34. Failure to caulk exterior joints allows water to infiltrate into exterior walls and eventually results in their deterioration.

Photo 35. Incorrect installation of insulation reduces the loft of the batts and results in reduced thermal performance.

Photo 36. Insulation was often under specified and improperly installed, adversely impacting the thermal performance of the home.

Photo 37. Insulation laid directly on top of recessed lighting fixtures poses a fire danger.

Photo 38. Use of non-functional vents for aesthetic purposes eliminates air flow in attic spaces and under roofs and contributes to moisture buildup.

Photo 39. The relationship between North American style housing and imported building materials is often emphasized at housing developments in Japan. As a result, it is critical that these products perform well in order to maintain their competitiveness.

Photo 40. Promotional brochure from Phase 1 of the Evergreen Chiyo demonstration housing project emphasizing the connection between 2x4 housing and the US.

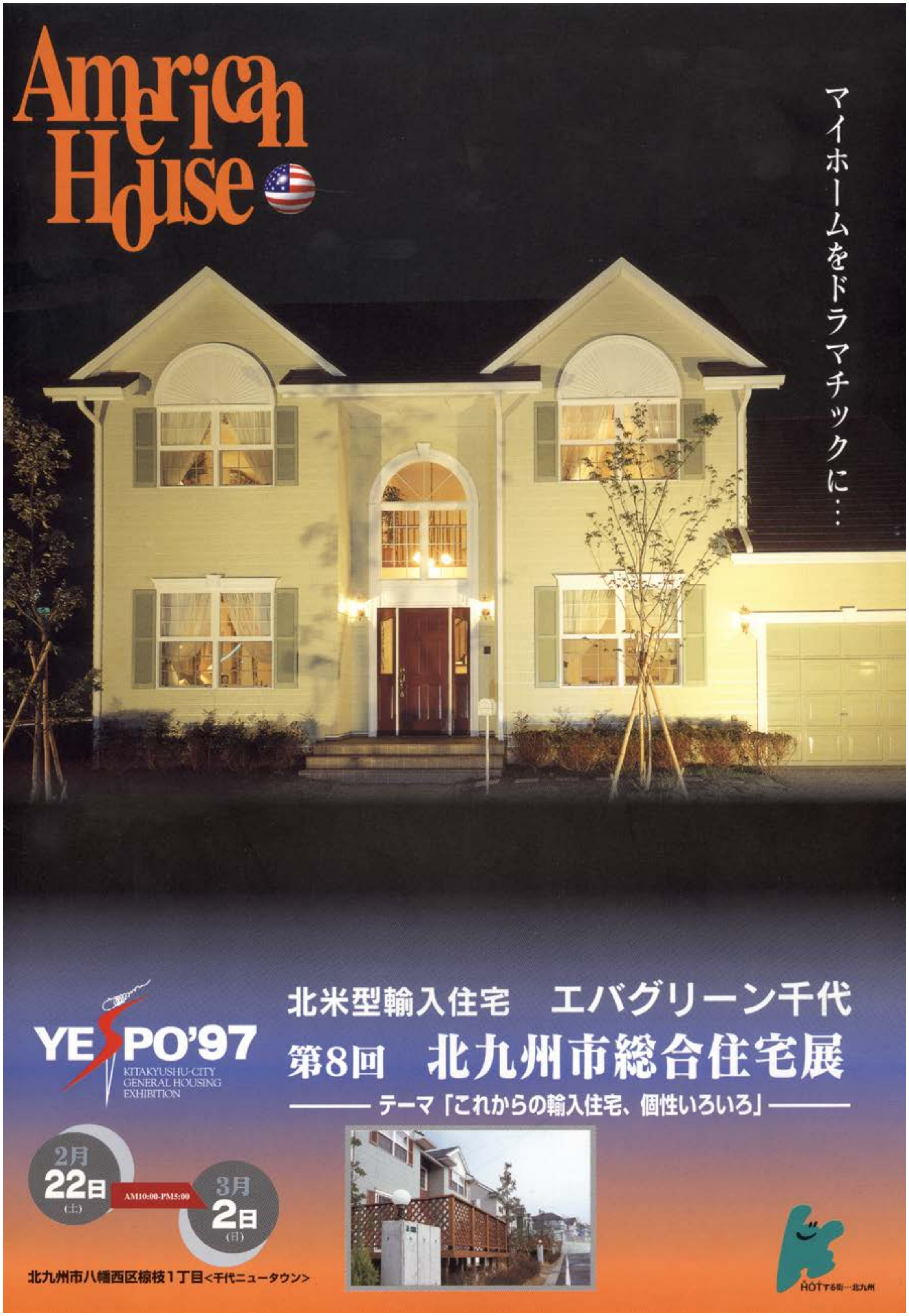

Photo 41. Promotional brochure from Phase 2 of the Evergreen Chiyo demonstration housing project emphasizing the connection between 2x4 housing and the US.

APPENDIX A

TECHNICAL ASSESSMENT SUMMARY

SUMMARY OF TECHNICAL ASSESSMENTS

A team of Washington State construction experts, each with 5-10 years experience in wood frame housing in Japan, visited 21 2x4 residential construction projects in various stages of completion between Tokyo and Kobe in March, 1997. Team members completed a construction evaluation survey for each project visited, rating each project on formulated by the Construction Specification Institute (see Appendix A for survey):

1. Design concept and development
2. Construction detailing
3. Structural characteristics
4. Framing quality
5. Product specification
6. Exterior finish details
7. Interior finish details
8. Construction management and process
9. Ventilation
10. Insulation and energy efficiency
11. Maintenance
12. Marketing and sales strategy
13. Factors that impact affordability

There was a broad range in quality of the projects visited, which appeared to be a function of company size and amount of experience building 2x4 homes. Larger companies with resources to administer in-house training programs have developed organizational structures and project management personnel similar to those of US firms. Most of the construction deficiencies observed were on projects constructed by small to medium-sized companies that had been using this technology for a relatively short time. Support systems or programs to help smaller builders foster the development (or obtain the services) of adequately-trained construction management personnel are not available.

The following pages summarize the team's observations in each category for all sites visited. Individual site ratings are provided in Appendix C.

1. DESIGN CONCEPT AND DEVELOPMENT

A. Evaluators' Comments

Planning and Site Development

- House not well oriented to site
- Poor use of terrain

Design Aesthetics

- Too much focus on American style (Photos 4, 9, 11)
- Exterior architectural design boxy (Photos 9, 10, 12)
- Inconsistent quality between model homes and other homes within a project
- Incompatible variety of architectural styles/elements used within a single house (Photos 5 and 10)
- Fencing and decking material doesn't match exterior finish materials
- Use of fencing around homes with small lots creates a dense cluttered feel
- Conspicuous placement of electrical and mechanical equipment adversely impacts aesthetics of the home (Photo 8)

Design Functionality

- Dysfunctional floor plans (Photo 7)
- Poor use (location and/or size) of windows (Photos 5, 9, 10, 11)
- Non-functional architectural elements used indiscriminately (Photos 10 and 38)
- Interior floor plans fragmented and compartmentalized (Photo 7)

- Lines for exterior HVAC units and electrical equipment not integrated into wall systems
- Roof pitch too low for shingles considering occurrence of typhoons
- No handrail on stairs
- Lack of weather protection over out-swinging doors (*e.g.*, no overhangs above doors)
- Inadequate drainage on waterproof decks
- Stairways too steep by US standards
- Houses are poorly adapted to accessibility and safety requirements (Photo 8).

B. Observations

The observations noted in this section can be summarized into three factors: 1. Planning and Site Development, 2. Design Aesthetics, and 3. Design Functionality.

1. With respect to the first factor, it appears that site development in the 2x4 projects visited is unchanged from traditional Japanese practices. In order to improve the process of locating a house on the building site, there needs to be more flexibility in how building sites are developed in Japan. Many of the homes observed did not take advantage of natural light through a thoughtful orientation of the house on the building site. In addition, it appeared that the house design did not provide for the most efficient use of the natural terrain of the site. The density of communities creates no solution for adequate, or designed parking.

2. Concern about the second factor, design aesthetics, was focused primarily on the fact that many of the projects incorporated architectural elements, both functional and non-functional, whose sole purpose was to maximize the "Americana" aspect of the home. The translation of architectural designs from North America to Japan is often too literal with little effort to adapt the designs to incorporate local culture, tradition, and materials. Exterior designs were often eclectic and discordant with little effort being taken to integrate the designs into a single design concept. The overall impact of these factors will be to likely reduce the value of the home by reducing the long-term aesthetic appeal of the home.

3. Finally, the area of architectural design functionality was identified as a concern. An example of this factor was the practice of taking stock house plans from North America and, with only minimal adaptations, using the same plans in Japan. The strategies generally employed to adapt North American house plans included shrinking the house to fit onto a smaller lot and designing steeper stairs to reduce the area required for stairwells. The results of this shrinking process are disjointed floor plans that become boxy and compartmentalized. Another area, the specification and location of windows, resulted in the poor utilization of windows both in terms of their ability to provide interior light and their impact on the exterior aesthetics of the home.

C. Implications/Comments

1. Unless designs are more sensitive to varied needs and tastes, the depth of the market for import housing will be limited.

2. Assuming that import houses, given proper maintenance, will last 100 years, the current limited "American" designs and styles being used will become dated. The simplicity of shape, form and materials that is prevalent in traditional Japanese architecture is more timeless. This design can easily be constructed from US wood products. Deregulation allows the design of wooden multi-story/multi-family housing and townhomes which can further diversify the market and lower unit costs.

3. More sensitive site planning, neighborhood planning, and landscaping can reinforce community identity.

4. Incorporating the same US "standards" or code requirements such as stair dimensions, kitchen layout and handrails will make Japanese homes safer - particularly for senior citizens.

5. Varied ceiling heights and open ceilings create an increased perceptions of space – a particular advantage in smaller homes.

6. Flexible spaces create an opportunity to accommodate changing family lifestyles and sizes. This common American design characteristic provides a unique opportunity for Japanese 2 and 3 generation homes.

2 CONSTRUCTION DETAILING

A. Evaluators' Comments

- Poor venting of soffits
- Fireblocking inadequate or missing
- Inconsistent insulation detailing (Photo 37)
- No fire separation between housing units
- Inconsistent door heights
- Rafter tails not blocked
- Lack of flashing above exterior doors and windows
- Inadequate venting (Photo 38)
- Stair treads not glued
- Insulation laid directly on top of recessed lights (Photo 37)

B. Observations

1. Drawings of many construction details are not generally included in the architectural drawings used for residential housing. This practice does not usually present a problem in the US because carpenters, contractors, and site supervisors can rely on their extensive knowledge of 2x4 construction techniques to address many of the technical issues that arise during the construction process. However, when the 2x4 system is used in Japan, this informal process breaks down because Japanese construction professionals often lack the extensive background of experiential knowledge that US construction professionals possess.

2. The lack of familiarity with the 2x4 system in Japan has its greatest impact in those areas where hands-on construction experience allows a carpenter to complete construction details that are essential to the long-term performance of the home, but which may not have been specified or detailed in the construction drawings. The inclusion of architectural drawings that clearly illustrate these construction details for projects being undertaken in Japan is important for ensuring that Japanese construction professionals understand the correct construction techniques for completing those details that significantly impact the long-term performance of the home. The architectural drawings need to be left on-site and made accessible to the carpenters and site supervisors at all times.

3. There was some concern indicated about the fact that some carpenters were unable to understand the technical information contained in the architectural drawings. It should be noted that this problem should also be attributed to North American designers and manufacturers who fail to adapt their drawings for Japan. These drawings are often sent to Japan in English with measurements being specified in feet and inches rather than in the metric system that Japanese carpenters are more familiar with.

4. The prevalent shortcoming of detailing is related to improper ventilation of the wood structure in unheated locations (*e.g.*, closed soffits, attics, enclosed fences/deck walls).

5. Spun fiberglass thermal insulation is installed incorrectly-presumably due to lack of detail or lack of knowledge on the part of the installer.

C. Implications

1. Details improperly constructed can result in structural degradation.

2. Inadequate or missing ventilation details will result in wood decay (dry rot). Details that allow water penetration; flashing, shingles, overlapping exterior finishes, *etc.*; will cause water damage to the interior finishes and/or allow dry rot. Without complete accurate details on the construction drawings, there is a risk of overlooking these critical elements in construction.

3. Even in those cases where structural detailing is included in the project documents, however, misuse of materials and incorrect detailing of structural design often results in over-design and increased material. Therefore, the cost of the structure increases needlessly. Problems with details arise from any or all of these issues:
   a. Architect doesn't understand detail
   b. Supervision doesn't teach or know the detail
   c. Carpenter has no experience with the connection
   d. Inspection system fails to notice-or is nonexistent

4) Japanese and U.S. structural detailing are different. Japanese architectural drawings show each member on the plans at a small scale while in the US it is traditional to enlarge connection details for clarity and references to plans.

5) The style and content of the construction documents for imported housing (specifications and drawings) will have to change to accommodate US standards. Otherwise, technical and material decisions made by inexperienced carpenters on the site will continue to add unnecessary costs, or worse, cause structural and maintenance problems over the life of the house..

3 STRUCTURAL CHARACTERISTICS

A. Evaluators' Comments

Structural

- Over designed columns
- Over designed headers (Photo 31)
- Hip rafters not doubled and roof loads not posted to load bearing walls
- Inadequate support of beams, joists, or walls (Photos 26-27)
- No rafter tie-downs (hurricane clips)
- Missing or inadequate seismic tie-downs at the foundation (Photos 27-28)
- Rafter and joist hangers not used where needed
- Inadequate nailing in shear walls
- Floor joist spans too long and cause excessive deflection in floors

Foundation

- Foundation walls not poured to final grade level or not level (Photos 23 and 25)
- Foundation walls often located under interior walls
- Thin mortar cap on top of foundation walls often raised and separated (Photo 24)
- Floor jacks under floor joists not structurally sound (can tip over during seismic activity) (Photos 26-27)

Framing

- Mix of 2x4 and 2x6 in exterior walls
- 2x4 sill plate used for 2x6 wall
- Wall studs are located under each floor joist, even when double top plates are used

- Redundant framing members (Photos 14, 29-31)
- Misplaced rim joists

B. Observations

1. There is a common tendency for Japanese carpenters to use excessive lumber in the framing of a house, leading to higher material and labor costs. (This was observed at many of the sites and is further corroborated by the experience of the evaluators.)

2. The doubling of wall studs where a single stud is structurally adequate is the most common example of the overuse of materials. (This may result from the fact that Japanese carpenters have extensive experience working with the traditional post-and-beam system and relatively little experience with 2x4 construction. Thus, the small cross-sectional size of a 2x4 stud versus that of a 4x4 post gives the appearance of being structurally inadequate.) Another item is the tripling of members in headers where two are structurally adequate, resulting in nearly 50% more lumber usage in the header.

3. Over-specification of lumber grades also contributes to higher lumber costs, and may be a reflection of a lack of understanding on the part of Japanese contractors regarding the structural performance characteristics and capabilities of North American 2x4 wood frame construction. Virtually all lumber in a 2x4 home is covered by drywall and finishes, making it unnecessary to use lumber graded for better visual appearance which always carry a price premium.

4. Seismic tie-down of the structure to the foundation was either missing or inadequate in many cases, and is of particular concern given the regular incidence of earthquakes in Japan. There appears to be a lack of understanding of how lateral and vertical forces of an earthquake are transferred to the foundation, either by the engineers or those doing the framing (or both).

5. Roof structures are often inadequately secured to the walls, creating concern for both wind uplift and lateral stability of the house. It was noted that rafter tails were improperly blocked on the top plate of exterior walls, and in some cases hurricane clips were not used to tie the roof rafters to the exterior wall.

6. The process used to pour foundations is inefficient and overly complicated and results in poor structural performance and high construction costs. For example, the thin mortar layer used to level foundations was often observed to crack and separate from the foundation. This can rsult in differential settling of the walls and lead to cracking of interior walls.

C. Implications

1. An overly complicated system of pouring foundations, use of excessive lumber, and specification of higher lumber grades all contribute to driving up the cost of labor and materials of North American-style 2x4 homes built in Japan.

2. Inadequate or improperly constructed structural details reduce the quality of the home and can adversely impact its long-term structural performance.

3. The fact that so many structural-related errors are being made on the framing of North American 2x4 homes in Japan indicates a need for additional technical transfer programs for Japanese construction professionals.

4. Additional training is also indicated in the area of specifying lumber grades in order to maximize the cost efficiency of the North American-style 2x4 system in Japan.

5. A more efficient and effective system of site inspection by trained, third-party inspectors is necessary in order to identify mistakes and require corrective action and re-inspection prior to covering with drywall and finishes.

4 FRAMING QUALITY

A. Evaluators Comments

- Framing work being done in a very precise and workmanlike manner
- Tools being used for framing were of high quality
- Carpenters demonstrated pride in their work
- Work appears to be plumb, square & level

B. Observations

1. The quality of workmanship displayed by Japanese carpenters when framing in a 2x4 house is extremely high.

2. Attention to detail characterizes many of the projects that were visited, and can likely be attributed to Japanese carpenters experience building traditional post-and-beam homes where most of structural lumber is high quality and is left exposed in the completed home.

3. The framing connections are often done with a precision more appropriate for finish carpentry. Unfortunately, the economic trade-off involved in using excessively high quality during the framing process is increased labor costs with no attendant increase in the structural performance or aesthetic appeal of the house.

C. Implications

1. The precision of the framing done by Japanese carpenters is very visually pleasing, but contributes very little to the structural or aesthetic appeal of the finished product. Thus, it results in higher labor costs, while not increasing the value received by the homebuyer.

2. Additional training (or re-training) is needed for carpenters in order to learn efficient framing techniques.

3. Japanese construction managers need to gain a better understanding of the 2x4 system so that they can properly train, supervise, and inspect a house during the critical framing process.

5. PRODUCT SPECIFICATION

A. Evaluators' Comments

General specification issues

- Inconsistent product specification (*e.g.*, deluxe product on a low cost home)
- Lack of awareness of imported products on the part of Japanese construction professionals
- Lack of understanding of specification process
- Limited product variety supplied by US and/or selected by Japan

Incorrect specification of materials

- Non pressure treated product used in moisture susceptible application (*e.g.*, untreated hemlock 2x4's used as sill plates)
- Common nails used on decking instead of casing nails or screws
- Misunderstanding of proper use of imported products

- Brass plated steel door hinges susceptible to rust in exterior applications
- Incorrect specification of lumber grades and species

Consideration of price vs. quality

- Product selections often based on low initial price at expense of long-term durability (*e.g.*, poor quality windows and doors used)

B. Observations

1. Product specifications often appear to be based on a low initial purchase price rather than the long-term performance characteristics of the product (*e.g.*, durability and maintenance requirements).

2. Mismatched combinations of products created detailing, construction, and durability problems (*i.e.*, window shutters were often observed to be of different lengths from the windows with which they were used.

3. On a number of projects, the focus on an American style or theme resulted in the specification of glitzy products at the expense of quality, performance, and aesthetics.

4. Based on preliminary discussions with Japanese home builders and US exporters and distributors of building materials it would appear that Japanese contractors and architects have only a minimal understanding of imported building materials and the process of specifying imported building materials. For example, paint finishes and chemistry are often inconsistent with flat latex being applied in "wet" areas (*e.g.*, bath, kitchen, and laundry) and gloss enamel being applied in other areas.

5. The range of products offered within a specific product category (*e.g.*, doors or finish hardware) is often limited by the distributor. While there may be good reasons why product selections are limited, the net result is that Japanese contractors and architects may find it difficult to specify a range of products that provide the best combination of functionality, quality, and price.

C. Implications

1. Incorrect specification of imported building materials will most likely have significant implications for the long-term performance of North American-style 2x4 homes. This is illustrated by the fact that untreated wood was often used in exterior applications that are susceptible to moisture exposure or penetration.

2. The market for imported housing may be limited if the consumer is not provided with a reasonable variety of products and materials to choose from.

3. Striving to achieve a low initial cost of production may result in an image of "cheap" and "shoddy," thus undermining the value and quality image of imported housing.

6. EXTERIOR FINISH DETAILS

A. Evaluators' Comments

- Missing or improperly applied caulking at exterior doors, windows, and finishes (Photos 33-34)
- Missing or inadequately applied grout on exterior wall stonework
- Flashing missing or improperly installed around doors and windows (Photo 33)
- Siding butted too tight against doors and windows
- Window trim set on top of siding.
- Poor installation of exterior siding and trim (Photo 33)

B. Observations

1. On many of the projects visited there were problems related to the installation of the exterior siding that resulted in the house not being properly sealed against weather. In most cases improper installation of the exterior siding compromised the ability of the exterior siding to prevent moisture penetration into the walls as well as the movement of cold and hot air into and out of the structure.

   US manufacturers and suppliers might consider providing a product selection adapted to Japanese cultural requirements (*e.g.*, more durable exterior finishes, greater selection of pre-finished materials, out swinging doors with water barriers, lower kitchen cabinets with door seals).

2. The detailing of weatherproofing and waterproofing elements also indicated a misunderstanding of basic details. Flashing at heads of door and window, flashing at exterior horizontal trim and cap flashing was inconsistent or missing.

3. Wood exterior trim, caps and sills were often applied without details resolved. Connections and splices were inconsistent and separated.

C. Implications

1. Moisture penetration into the structure can have an adverse impact on both the structural framing elements of the structure as well as the performance characteristics of doors and windows. Moisture penetration into wall cavities can cause degradation and dry rot of framing members, floor joists, rim boards and, if the moisture penetration is severe enough, to interior wall surfaces.

2. Moisture penetration around doors and windows can adversely impact their performance and inevitably lead to premature failure of these elements. Most importantly, problems attributable to moisture penetration can be minimized or avoided altogether simply by ensuring that the exterior walls of the house are properly covered and sealed.

3. Improperly sealed exterior walls allow increased infiltration of air through the exterior wall, thereby reducing the thermal performance of the home and potentially resulting in moisture build-up on interior wall surfaces and within wall cavities.

4. The appearance of exterior trim details greater influence the initial perception that potential home buyers have of a house. The craftsmanship, fit, and finish of exterior details must project an image of quality. Unresolved details can undermine the image or perception of quality.

7 INTERIOR FINISH DETAILS

A. Evaluators' Comments

Floors

- Wood floors installed early and not adequately protected during subsequent work
- Hardwood floors inadequately nailed
- No expansion space between edge of hardwood flooring and wall
- Base molding set too high above carpet
- Carpeting not installed well (*e.g.*, edges not properly fastened or finished, uneven seams)
- No padding under carpet on second floor or on stairs

Gypsum Wallboard (GWB)

- Poor quality wallboard installation (*e.g.*, inconsistent nailing and screwing, joints not properly located)
- Inconsistent mudding and taping (*e.g.*, too much or too little tape compound used, not enough sanding or too much, tape not properly bedded)
- Preparation of GWB surface inconsistent with finish

- Cutouts in GWB for electrical switch boxes and outlets usually left for electricians to do

Paint

- Wall surface not properly protected by paint (*e.g.*, only one coat applied)
- Uneven paint application (*e.g.*, debris in paint, brush marks in paint, uneven paint application, mix flat with glossy paint)
- Enamel paint not used in kitchens and baths

Wood Finishes

- Final finish work inconsistent (*e.g.*, inadequate puttying, caulking or sanding of trim work)
- Poor quality railing installation (*e.g.*, not properly fastened or too wide baluster spacing)
- Poor quality casing installation (*e.g.*, miter joints not tight or nailing inconsistent)

B. Observations

1. Hardwood flooring and interior molding and millwork are generally installed after gypsum wall board (GWB) has been hung but prior to its being mudded and taped.

2. In general, the quality of paint application on interior walls, molding, and finish trim work was the least professional element in the houses. To a large degree, this can be attributed to the fact that carpenters, with little experience or skill in painting, are doing the painting. Closer observation of interior paint finishes revealed that in many cases there was debris in the paint finish. This debris can most likely be attributed to the fact that interior moldings and trim work is installed early in the construction process and is left exposed to the dust and debris generated during the general construction process.

3. Another point of concern relates to the installation and specification of stairway railings and handrails. On a number of projects it was observed that railings and hand rails were under specified and/or improperly attached to walls and stair treads. It was also noted on several occasions that the spacing between the railing balusters was too wide.

4. Gypsum wallboard finish is well below U.S. quality standards. The substrate taping, compound application (mudding) and sanding is often incomplete, leaving ridges, mars, ripples, and craters. Paint fails to cover these blemishes.

5. Finish nailing on visible wood components is incomplete, spaced unevenly or head recesses left unfilled.

6. Few details are included in the construction drawings resulting in random installation by carpenters. (**See Exterior Finish Detailing and Construction Detailing**)

7. Framing carpenters are sometimes responsible for the interior finish details - as they install finishes. For example: Different materials finishes and colors are installed in the same areas. A problem usually caused by on-site decisions rather than designed details.

C. Implications

1. Potential problems result from the fact that a tremendous amount of moisture is introduced into interior rooms as a result of drying the GWB mud used to cover nail heads, wallboard joints, and corner joints. Because most wooden interior trim work is kiln dried, prolonged periods of exposure to conditions of high humidity can result in swelling and increases in moisture content, conditions which can have an adverse impact on finish quality.

2. Failure to remove dust and debris from interior finish trim significantly reduces the quality of the final paint finish and contributes to an overall reduction in the perceived quality of the home.

3. The primary problem is a perception of quality (or lack of) by the consumer. The "perfection" quotient is more obtainable than currently demonstrated.

4. Additional experience and training should help the Japanese craftsman to learn the acceptable standard of finish for site finished interior materials.

5. Design details will respond to the installer's expertise and recognize the difference compared with Japanese pre-finished materials.

6. Advantage of carpet for comfort, safety, health and acoustical control may become familiar to Japanese homeowners, as it is in other industrialized nations.

8. CONSTRUCTION MANAGEMENT AND PROCESS

A. Evaluators' Comments

- Interior trim and flooring installed before GWB is taped and mudded (Photo 19)
- Building sites used for material storage and material preparation (Photos 14-16)
- Stairs installed late in the project, workers use ladders to move between floors (Photo 18)
- Little coordination between trades (*e.g.*, interior trim goes up before GWB mudded and taped)
- Carpenters use miter boxes to cut framing lumber is slow and causes extra material handling
- Excessive material handling of materials on site (*e.g.*, materials moved and re-stacked repetitively)
- Carpenters perform tasks where they lack experience
- Electrical splices not made in electrical boxes and therefore not accessible for future repairs
- Carpenters inexperienced with 2x4 construction technology (*e.g.*, carpenters rarely have access to vocational training in 2x4 construction technology)
- Improper material storage (*e.g.*, unprotected lumber and plywood stacks left exposed to elements; windows stored improperly on the construction site) (Photo 16)
- Temporary handrails not installed around stairwells (unsafe)
- Work platform crowded, disorganized, and potentially dangerous (Photos 14-15)
- Consensus decision-making process reduces productivity
- Site supervisors lack construction knowledge and experience
- Poor understanding of 2x4 construction management (*e.g.*, sequencing of tasks, scheduling of workers, lack of quality control checks and formal inspections) (Photos 14, 16, 19)
- Temporary makeshift ladders are unsafe (Photo 18)
- Extensive use of scaffolding and tarps
- Heat not used during GWB taping and painting

B. Observations

1. The concept of construction site productivity differs in Japan where historically carpenters and the houses they built were oriented towards craftsmanship and detail. This concept of craftsmanship has not transferred well into an era where residential housing developments and affordability of housing are important criteria.

2. Visits to numerous projects throughout Japan indicate that management practices on most residential construction sites is both inefficient and ineffectual.

3. Poor management practices adversely affect the flow of the project and result in substantial budget overruns. In addition, they often adversely impact worker safety on the job site.

4. The reduced labor productivity and loss of efficiency which result from poor construction management practices contribute to increased labor costs and construction time.

5. The poor storage and handling of building materials, as well as their repeated movement within the job site, adversely affects their long-term performance as well as greatly increasing the probability of damage before installation. For example, window seat failure and glass breakage due to improper window storage and handling.

6. Both Japanese and US supervisors interviewed on the job sites visited indicated that formal inspections of construction projects are minimal. The lack of a formal inspection process for most portions of the work means that mistakes can go undetected that can adversely affect the quality and long-term performance of North American-style 2x4 homes.

7. Proper sequencing of work is not understood or implemented by many site supervisors, leading to labor inefficiencies and damage to finish materials which are installed too early in the construction sequence.

C. Implications

1. There are many differences in form and style of project supervision and management between Japan and the US which are cultural in nature and may be difficult to overcome in order to produce more cost-efficient housing.

2. Additional training in this area may help to identify the differences and allow Japanese managers to take actions they deem most appropriate.

3. A third party inspection system would force site supervisors to be more responsible for compliance with codes and proper construction practice (see Appendix : Building Code).

4. Without change in this area, it is doubtful that Japan will achieve the maximum cost efficiency that the North American-style 2x4 system can offer.

9. VENTILATION

A. Evaluators' Comments

- Non functional vents used for aesthetic purposes (Photos 10 and 38)
- Inadequate or no ventilation in roof structures (Photo 38)
- Foundations do not have ventilation openings
- Inadequate ventilation at parapet and balcony walls, closed water proof decks, and soffits
- Interior foundation walls have no ventilation openings

B. Observations

1. Inadequate or non-existent venting of closed spaces (attics, crawl spaces, parapet and balcony walls, *etc.*) were observed in many of the homes.

2. Insulation in roof rafters of cathedral ceilings often filled the entire space, allowing no room for ventilation and air flow (minimum 1-1/2 to 2" is desired).

3. Air circulation within the home was often minimal, with no provisions for efficiently bringing in fresh outside air or exhausting inside stale and moisture-laden air.

C. Implications

1. Efficient air flow and air exchange throughout the home is very important, particularly given the tightness of new, energy efficient North American-style 2x4 homes.

2. Poor ventilation can lead to moisture build up and contribute to the deterioration of wood members in roofs and foundations, as well as increasing operating and maintenance costs to the homeowner.

3. Many "healthy house" issues involve ventilation, and a lack of understanding in this area can have detrimental impacts on the occupants of the home.

10. INSULATION AND ENERGY EFFICIENCY

A. Evaluators' Comments

- Floors, walls, and roofs are under insulated relative to climate in Japan
- Heating ductwork in attics and crawlspaces not sufficiently insulated
- Improper insulation at cathedral ceilings (*e.g.*, improper installation or inadequate insulation)
- Vapor barrier installation poor and not tight enough to prevent air infiltration (*e.g.*, mis-lapped and uneven spacing)
- Inconsistent energy products and standards (*e.g.*, insulated glass used with under insulated walls) (Photos 36-37)
- Insulation incorrectly installed (Photos 35-37)
- Lack of central HVAC
- Insulation laid directly on top of recessed lights (Photo 37)

B. Observations

1. High energy efficiency devices and details not used to the same extent as in North America and Europe (*e.g.*, water heating, HVAC, lighting and lighting controls).

2. Energy codes are less stringent in Japan and therefore 2x4 exterior walls are often used when new US homes would typically be built using 2x6's. This limits the insulation in the exterior wall to R-11 rather than the more energy efficient R-19 that is used with 2x6 walls.

3. One of the most frequently observed problems related to insulation was improper installation (*e.g.*, mislapped and uneven spacing).

4. In order to maximize the thermal efficiency of insulation, the loft (or fluff) of the insulation must be maintained after installation. The technical team visited numerous projects where insulation was compressed in wall spaces, thus substantially decreasing its energy-efficiency.

5. Large gaps were observed between pieces of insulation, as were instances where insulation was indiscriminately laid into crawl spaces and attics. Both of these practices reduce the thermal insulating efficiency of the insulation.

6. Several cases were observed where the exterior house wrap was incorrectly installed and unable to effectively prevent air infiltration, resulting in reduced energy efficiency of the home. In some of those cases, water infiltration may also occur, contributing to deterioration of wall and floor framing.

C. Implications

1. The use in Japan of 2x4 exterior walls (with R-11 insulation), along with R-13 or R-19 roof insulation, provides less efficient thermal performance than in the United States. This results in increased energy costs for the homeowner, as well as greater national energy dependency.

2. Deterioration of the structure will occur more rapidly if proper insulation standards are not followed, adding to long-term maintenance costs.

3. Additional technology transfer is required in terms of explaining the benefits of higher insulation levels and showing proper techniques of insulation installation.

4. Absence of central HVAC systems reduces overall comfort, energy efficiency, and durability.

11. MAINTENANCE

A. Evaluators' Comments

- Premature exterior paint failure due to improper surface preparation and/or paint application or specification
- Absence of builder maintenance plans or homeowner maintenance manuals
- Low quality exterior trim products and installation results in increased maintenance
- Absence of product installation and maintenance instructions in Japanese

B. Observations

1. From both physical observation and interviews, it is apparent that Japanese homeowners usually don't perform basic regular maintenance projects on their homes. While there are indications this may be starting to change, it will be some time before homeowner maintenance will be the norm.

2. Some imported building products are being used which are not appropriate for the climatic conditions where they are being installed. Failures of these products can be observed in as little as 2 to 5 years after installation (*e.g.*, caulking and door hardware).

3. Even properly selected materials will require high amounts of maintenance if not installed correctly (*e.g.*, are doors and windows).

4. Maintenance and operating instructions are often not provided to the homebuyer in Japan, or have not been translated if they are furnished.

C. Implications

1. The absence of proper periodic maintenance can have an adverse impact on product durability and performance as well as on the aesthetics of the home.

2. The absence of periodic maintenance will result in the poor performance of North American-style 2x4 housing and contribute to a poor image of imported housing and building materials.

3. Additional technology transfer is needed to help Japanese homebuilders select the products appropriate for their specific locale. In addition, an effort should be made by exporters to understand the climatic conditions of the area where their materials will be used, and provide choices compatible with those conditions.

12. MARKETING AND SALES STRATEGY

A. Evaluators' Comments

- Minimal amount of landscaping on model and within development
- Poor maintenance of model home
- Inconsistent quality between model home and homes for sale
- Model home not furnished or poorly accessorized
- Model home design different than homes being offered for sale

- Ineffective sales brochure (*e.g.*, fails to promote or describe technology, life style, or amenities)
- Lack of home owner manuals (*e.g.*, operation and maintenance guidelines)
- Sales staff lacks knowledge of North American design features, construction technology, and products

B. Observations

1. The technical team observed that there was often a discrepancy between the model home and the other homes in the project being offered for sale. These discrepancies ranged from floor plans to the type of products being used to the overall quality of construction. In addition, the sales people staffing the model homes possessed little technical knowledge about North American-style 2x4 construction or the benefits of this type of house for the potential home buyer.

2. There is a greater opportunity to develop a marketing strategy that more effectively matches consumer needs and interest with house design and product selection. Poor marketing strategies and follow through with potential customers can adversely impact sales of imported houses. Contractors and developers need to define their market segment and then design a product that meets the needs of the consumers in that specific market segment.

C. Implications

1. If import housing can be de-emphasized and replaced with a market strategy that demonstrates the advantages and value of imported products integrated into "Universal" or more international houses. The application of these materials into homes that meet cultural needs and contemporary expectations should find an eager market in Japan. The model home strategy is well engrained into housing market in Japan. Utilizing this method to introduce <u>real</u> value would be effective in achieving:
   - Convenience
   - Environmental Sensitive Products
   - Structural Safety
   - Energy Consciousness
   - Flexible Planning
   - Community Identity
   - Affordability

2. Placing the marketing emphasis on North American-style design, construction technology, and products could have an adverse impact on the market for 2x4 homes if they don't meet homeowner expectations.

13. FACTORS THAT IMPACT AFFORDABILITY

Overall rating 2.8 out of 5; range 1-4

A. Evaluators' Comments

- Home prices being reduced by lowering the quality of many of the building products
- Designs are being simplified to where homes are little more than a box
- Inefficient labor techniques make homes less affordable for consumers.
- Strategy for reducing cost of homes seems counter-productive from durability standpoint

B. Observations

1. Low price was usually not achieved through increased labor productivity and construction efficiencies, but rather through design over-simplification and making standard features optional at additional cost to the home owner.

2. In general, the technical teams observed that affordability was often achieved through the use of low quality materials that adversely impact the quality and long-term performance of the home. This

strategy for achieving affordable housing means that the long-term performance of the house and the products used are often compromised.

3. In those cases where contractors were building affordable houses they often did this by building a house that had poor design aesthetics and provided the home buyer with fewer amenities.

C. Implications

1. A consumer backlash to the strategies being implemented to promote affordability will likely be felt in Japan in the coming years, resulting in decreased sales of both imported and traditional homes.

2. True cost savings from productivity and management improvements will be required to make housing more affordable over the long-term.

APPENDIX B

RESIDENTIAL BUILDING INSPECTION: THE US APPROACH

RESIDENTIAL BUILDING INSPECTION: THE U.S. APPROACH

By David Cordaro
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(Speech given at Kobe Interhome Fair, September 1997, Kobe, Japan

I am honored to be present at the Kobe Interhome Fair to talk about Building Inspection. I would like to extend my sincere appreciation to those who have made it possible for me to be here.

I am currently a Senior Building Inspector for the City of Seattle. Seattle and Kobe have a long established "sister city" relationship. I spend each day performing inspections and working with builders to resolve questions on building projects. I have been with City of Seattle for nearly 12 years. I have been working in the construction industry for around 20 years in various capacities including carpenter, field engineer and inspector.

1. WHY PERFORM INSPECTIONS: RULE OF LAW - CODE AUTHORITY

To begin with, inspections I perform as a part of my occupation as a Building Inspector for the City of Seattle, are performed as a mandatory part of Building Permits required by the City of Seattle, and the Seattle Building Code. The Building Permit is the legal instrument used to regulate buildings and land use. A Building Permit is required for each new home, as well as for all other structures. These permits are issued by the local government. The purpose of the permit is to promote general Health, Safety and Public Welfare through the administration of locally adopted land use and building regulations. The building regulation for Seattle is known as the Seattle Building Code and must be legally adopted by legislative action. A series of inspections are dictated by our Seattle Building Code. I will refer here generally to "Building Codes", but it should be understood that similar codes for Electrical work, Plumbing work and Heating systems are also mandatory minimum standards and are a part of the process herein referred to as building permits and inspections.

Throughout the U. S. there are currently three major code writing bodies. The Building Officials and Code Administrators International (BOCA) in the northeast; Southern Building Code Conference, Inc. (SBCCI) in the southeast and International Conference of Building Officials (ICBO) in the west. Seattle uses the Uniform Building Code published by ICBO as our base building code and modify about one third of it to be more agreeable to local conditions such as Fire Department response time, engineering community input and builder's organization efforts. The nature of the building code development process in the US includes an opportunity for business groups to provide input into the language adopted into the codes. Every year a code revision cycle is initiated. Anyone can propose a code change and include with the change proposal a persuasive reason for the change. Presentations can also be made at code committee meetings where a ruling on each change is developed. Organizations like the American Plywood Association, Gypsum Wallboard Association, Structural Engineers Association and others are very active in the code development process.

Historically Seattle's city fathers became active in development of a strong local building code following a catastrophic fire in 1889. Fire resistive and structural standards were proposed and developed by a civic team of architects, engineers, fire department personnel, builders, building owners and insurance representatives. Today the Uniform Building Code is named by our State government as the required building code. Amendment to the code is allowed at the local level.

Throughout the U.S., cities, counties and states administer the building permit and inspection system in a similar manner. Even with several versions of building codes throughout the U. S., building techniques and materials are quite uniform. Styles vary in different parts of our country due to both architectural preference and geographic conditions. But the basic regulatory framework of requirements is the same. In fact in the year 2000 the three codes are being merged into one. It will be named the International Building Code (IBC).

Permits

The permit is a legal document produced by the city and issued to a property owner. In order to obtain a permit to proceed with a building construction project, the property owner completes a written request known as the permit application. The signed application and copies of design drawings are submitted to the city for review of the technical detail included. Reviews are performed for land use and zoning, fire safety, life safety and structural provisions of the building code. Upon completion of reviews the permit fee is paid and the permit document is issued to the property owner. The owner is now authorized to proceed with the building project.

Inspections are required by specific code language. The basic list of inspections required includes Foundation, Framing, Insulation and Final. Each of these categories may require multiple visits as the complexity of the project increases. Other major categories of routine inspections include Electrical and Plumbing, each of which normally includes a “rough-in” inspection at the time framing is approved to cover and a “final” at completion of the project.

Insurance

The insurance industry in the US provides coverage to homeowners commonly known as “Fire Insurance”. Historically this has been a result of catastrophic losses and the desire of the insurance industry to protect its business interests. In order to provide consistency in an actuarial basis for loss prevention and recovery, Building Codes were developed to set a standard for construction quality and fire resistance. Today the building permit and resulting inspections are a necessary part of successfully insuring any structure. Building inspection approvals must be completed in order to obtain documentation of insurability.

Lending Institution

The Banking industry also has a vested interest in the building permit inspections of structures in order to validate value, durability, uniformity of quality, consistency of design and construction, as well as the inclusion of fire safety and occupant safety standards. Because the lending institution holds the ability to authorize or deny financing for construction of buildings, their interest in the building permit inspection is an important incentive to builders and owners to complete the local government permit and inspection process. Without an approved series of mandatory inspections, the banks will not authorize release of the financing package for new structures. Additionally, certificates of insurance are required by the lending institution to complete this financing.

Customer Satisfaction

Most buyers of constructed homes and other buildings do not possess the experience, expertise or time necessary to monitor the construction process. The building permit inspection process serves as a mandatory set of inspections all owners can rely on to provide a consistent level of inspections on any given building. Although the lending institution usually sends an inspector to projects they finance, the purpose differs in that the bank is looking for percentage of completion to release monthly payments to the builder on the construction loan. Inspections for the building permit are more technical in nature and focus on details of structure, fire safety, occupant safety standards and weather tightness. Citizens rely on the building permit and inspection process to verify that minimum building code standards are incorporated.

Uniformity Of Construction

Architects, Engineers, Builders and Homeowners rely on mandatory building permit inspections to provide a standard of performance throughout the construction process. Even with a wide variety of styles, designs, techniques, products, and materials available the existence of a set series of inspections required by law on all projects results in uniformity of quality within the scope of minimum standards defined by the building codes.

Documentation

The city or county is normally the local jurisdiction responsible and authorized by law to operate as the administrator of the building codes and permits on the local level. Each and every residence or other building has a file of information maintained by the local jurisdiction. This file includes a building plan which has been reviewed and approved by the local jurisdiction, a set of inspection records and a record of the final approval for the project. Record storage, organization and retrieval are necessary components of the documentation process.

2. WHAT INSPECTIONS ARE PERFORMED

The following are details which are all subjects of inspections during the construction process. The process generally exists in four standard inspection steps: foundation, framing, insulation and final. Each of these inspections requires at least one site visit, and sometimes several. The actual time spent on each inspection ranges from a minimum of 15 minutes for the simplest to over an hour for complex framing and some finals. A typical time frame for a fast track simple house would probably run as follows: foundation inspection - 2 to 3 weeks following issuance of a permit and clearing of the site; framing inspection - 4 to 6 weeks after foundation inspection; insulation inspection - 1 to 2 days after framing inspection; sheetrock nailing inspection - 1 to 2 weeks following insulation; interior finish and final inspection - 4 to 6 weeks after sheet rock nailing inspection. This process should be approximately the same in most locations. Large complex house designs will naturally add additional time to the process, as will difficult site conditions and poor weather.

Foundations

One very important aspect of foundation placement is the condition of the ground below the footing and capacity to support the structure without settlement. Undisturbed, firm, clean earth with the bottom of the footing placed below the frost line is essential. Erosion control measures should be in place to prevent damage of either the new foundation cut or adjacent properties from deposits caused by water runoff.

The location of the structure is regulated by local zoning. The setback approval is shown on the set of blueprints reviewed and marked as approved by the local authorities. Setback measurements from the edge of the structure to the property lines must be checked for compliance with approved zoning. This measurement is dependent upon demarcation of the actual property lines. Licensed land surveyors must be hired to place property corner stakes which can be used to pull string-lines for the purpose of locating the building properly. At the inspection for location the string-line is used to check the dimensions from the foundation to the property lines.

The customary style of foundation construction we see is the spread footing and stem wall. The footing size and wall size must be at least that required by the building code or conforming to the specific engineering design provided for in the approved blueprints. The reinforcing steel size and spacing must be within the prescribed design. Seismic hold downs will require large bolts in a specific pattern, seismic framing straps must be located and fastened to the concrete forms. Anchor bolts to fasten the sill plate to the top of the foundation wall may be inserted into the fresh concrete if the builder has the locations necessary clearly in mind. All these details must conform to specific engineering requirements provided for the project.

The Structural Frame

Again, the specific engineering design for the structure will dictate all structural parts of the building. If there is no specific engineering design, the conventional wood frame provisions of the building code set out the parameters for simple wood frames. These conventional framing provisions are prescriptive in nature and have become the customary standard method for wood frame construction in the U.S. Wind loads, Snow loads and earthquake protection all are included in conventional construction prescribed by the building code.

Crawl space and attic ventilation must be examined at the framing inspection to assure minimum required air flow openings are present.

Fire blocks and draft stops are required as fire safety components built into the frame system. Both are effective in lessening the spread of fire through the wood frame structure.

Member size and spacing required by the building code is normally inspected following the erection of the entire frame and after plumbing, electrical and heating systems are in place. The reason this inspection follows installation of these other systems is to examine holes made in framing members and the remaining structural integrity of the frame. Where excessive cutting has occurred corrections will be required to replace structural integrity.

Any sole plate or sill plate that rests against concrete or masonry is required to be treated against moisture decay. Top plates in bearing walls must be doubled and overlapped at corners to provide a connection through the corner. Other structural members included in the structural frame inspection include wall studs, floor and ceiling joists, roof rafters, beams and headers. Notching and boring of holes are allowed within limits. Wall studs may be bored up to 40% the depth of the stud. For floor joists, notches on the ends of joists shall not exceed one fourth the joist depth. Holes bored in joists shall not be within 51 mm (2 inches) of the top or bottom of the joist, and the diameter of any such hole shall not exceed one third the depth of the joist. Notches in the top or bottom of joists shall not exceed one sixth the depth and shall not be located in the middle third of the span. Glu-lam beams may only be drilled with a guideline from the manufacturer's engineer. Manufactured I-joists possess specific limitations on drilled holes.

Exterior sheathing is generally plywood or oriented strand board (OSB) and is fastened by nails or staples as allowed by the building code. Nailing or fastener connections are checked for number, size and spacing of nails. Post to beam connections must always be rigid and often require metal fastening.

Manufactured roof trusses are checked against the specific engineer design for a match between the truss design and the truss installed. Truss ends are fastened to the tops of walls to prevent wind uplift. In high wind exposures each truss will have a metal connector installed at the end. Cross bracing or diagonal bracing must be installed to strengthen the trussed roof system against lateral rolling in a excess load, wind or seismic event.

Glued-laminated beams are checked against engineered drawings for size, structural designation and camber required by the engineer's design. Hangers and heavy steel connectors are an important item to be inspected for correct fabrication and installation. Glu-lams are sometimes used as simple beams and headers due to their smaller size relative to load bearing capacity.

All structural members are checked for size, span, solid bearing and fastening. The load path through the building must be traced to assure that all loads are adequately distributed to the ground at the foundation. All lumber used in the structure must be stamped with the grade and designation by a registered grading agency.

Seismic protection is now incorporated into building systems through combinations of a variety of methods. Plywood shear panels provide lateral stiffness and force distribution between horizontal and vertical shear diaphragms. Distribution occurs through top and bottom wall plate connection to horizontal floor diaphragms above and below. Some specifications include top plate blocking to the floor above toenailed to the top of wall at 15 cm (6 inches) on center or fastened with metal hardware at 30 cm (12 inches) on center. The bottom plate will often be nailed through the plywood floor diaphragm with 2-16d nails 15 cm (6 inches) on center.

Hold down hardware is available to fasten walls to foundations as well as through floors. In the case of fastening to the foundation, the anchor bolt size depends on the hold down specification. All hold down sizes and locations are dependent upon the force concentration determined by the engineer's calculations; therefore, the details of a registered engineer's drawings are very important to proper inspection.

Lateral shear strength is developed in shear panels by addition of nailing patterns, edge blocking and increased stud size as necessary too accommodate developed loads. For example, it is common to see 12.5 mm (1/2 inch) plywood fastened to one or both sides of a shear wall with a nailing specification of10d nails 30, 45 or 60 cm (2, 3, or 4 inches) on center at the edges of each plywood sheet. Normally only 15cm (6 inch) nailing at edges is the basic code requirement. Metal straps are designated where necessary to add to the capacity of wood framing to distribute loads. Exterior wall plywood sheathing often is connected across a building floor line by the use of metal straps.

interior shear walls that stack above each other through the building may be strapped through the floor as well as top and bottom plate fastening to accomplish complete transfer of seismic calculated loads between floor and wall diaphragms, ultimately to the ground.

Modern building codes include prescriptive seismic protection requirements for simple structures, whereas more complex designs must be engineered. In general, rigid fastening of the wood frame to a strong foundation, rigid lateral bracing by use of wall panels, fastening of wall panels to horizontal diaphragm floor panels and bracing of roof truss systems provides a composite load distribution system to resist the forces expected in earthquake events.

The rise and run dimensions of stairways have specific safety related provisions to be checked at the time of rough framing to preclude discovery of a problem at building completion. Identification of defects at the rough framing stage of the building allows for correction in a more cost effective manner.

Bathrooms and kitchens are required to have exhaust fans installed. The fan and duct connection to the outside are inspected at the time of structural framing inspection.

Several other inspections must also be completed for the framing to be released for covering. Electrical wiring, plumbing and heating systems must be complete and approved at the time of the structural frame inspection.

In general failed inspections result in a list of corrections to be accomplished. Usually these are written directly by the inspector to be corrected and re-inspected. Occasionally a correction will require that an engineer provide an engineered solution to a problem. An option to an engineer’s recommendation would be a revised blueprint submitted to the inspectors office for review and approval by the office engineers, also known as plans examiners, at the inspection department. Two re-inspections are allowed before an additional fee is applied.

Insulation

The energy conservation package for residences includes specified insulation levels, window and door thermal transmission values and draft prevention measures. Following the structural framing inspection, the insulation is inspected for compliance with conservation standards.

There are several methods for building in improved energy conservation methods. U.S. energy codes provide for either a prescriptive approach or a calculated heat loss performance method. Within the prescriptive method the code specifies insulation levels required, window and door thermal transmission levels, per cent window area and heat source type. The calculated heat loss method on the other hand allows for flexibility in the design to accommodate large window areas or other creative design elements otherwise limited by the prescriptive requirements.

Typically the prescriptive approach is used for simplicity and uniformity on most housing. Walls and floors require R-19 insulation which is usually accomplished by a 2 X 6 frame wall filled with fiberglass batt rolled material. The product is manufactured in standard dimensions to fit in 406mm (16 inch) on center or 610 mm (24 inch) on center studs spacing. Ceilings or attic spaces require R - 30 insulation if gas heat is used or R - 38 insulation if electric heat is used. Windows must be manufactured under a supervised test procedure and labeled with the U value for thermal transmission. The calculation method is based on a target heat loss factor. The performance of the structure under heating loads must achieve a heat loss at or below the target number.

Drywall Nailing

The common wall and ceiling covering in the U.S. is gypsum wallboard, also known as sheet rock or drywall. Common nailing or screwing patterns are prescribed by the building code. Some shear wall nailing patterns are called out by the engineer in a seismic design and in such a case must be checked for conformance with the engineer’s plan. In some cases fire protection accomplished be additional layering of gypsum wallboard. If this is the case the layering and joint staggering must be verified by inspection.

Final Inspection

The final inspection is performed upon completion of the building. Safety elements include guardrails at elevated decks, handrails at stairs, installation of smoke detectors in each bedroom and each level without bedrooms.

The most common fire separation wall in a residence is the wall between the dwelling unit and the attached garage. This fire separation must be equivalent to one-hour wall construction.

The building should be examined for completion of weather protection elements such as well installed roofing, flashing, caulking, gutters and downspouts.

The perimeter of the building must have a minimum earth to wood separation of 15cm (6 inches). Grading around the site must provide slopes away from the building for rainwater drainage.

Minimum housing standards must also be complete including running water, an operating bathroom, a functional kitchen, operable heating system and minimum security measures such as door locks, deadbolts and view ports in doors. House numbers must be installed in a clearly visible location on the building.

Separate final inspections for electrical and plumbing are also required. Utility connections must all be complete and operating. At the approval of the building final inspection, the building is released for occupancy.

As discussed above, re-inspections are allowed for corrections necessary.

3. ADMINISTRATIVE ISSUES

Customer Service

Due to the ability for each governmental agency to operate within its own chosen level of service, we have varying levels of service in existence from one jurisdiction to the next. For example the City of Seattle offers inspections one day following notification. Most other jurisdictions offer a 2 to 3 day response time.

The City of Seattle has chosen to provide a higher level of service compared to some other cities because the local citizens have demanded it through the locally elected officials.

Another aspect of service relative to inspections is the willingness of inspectors to assist owners and builders in problem solving on the job site. Of course professional builders are expected to exercise a greater level of expertise in performing their work. Homeowners working on their own buildings may ask questions of inspectors and receive answers in a helpful and constructive manner.

In general, development of the customer service ethic depends on the will of the leadership in any given location. A decision must be made concerning how to meet the needs of customers and continue to operate effectively.

Costs

The greatest cost of operating an inspection agency lies in salaries of personnel. Our salaries are known to be comparable to that which could be made as a builder, therefore the positions are attractive to individuals experienced as builders. The number of employees needed is dependent on the number of inspections required and the volume of construction activity. Vehicles are necessary for transportation to individual building sites. Fuel, maintenance, insurance and parking costs contribute to the total.

Office space, telephone, copiers, office supplies, clerical support also must be considered. Inspection forms are costly but necessary for proper documentation. Maintenance of a computerized record keeping system has become a necessity and an important tool for communications is the portable cellular phone.

Fees

In Seattle we are structured to charge permit fees which cover the cost of operating the permit and inspection system as a whole. Some other jurisdictions operate out of a general fund structure where fees for permits are paid directly into the general fund and the cost recovery comes out of general fund to support permit and inspection activity. Each method has advantages. Permit fees for a standard 167 square meters (1800 square feet) house usually run about $2200 US.

Scheduling Inspections

The City of Seattle, Department of Construction and Land Use offers a unique availability of response to inspection requests. We have in place a 24-hour recording phone line where customers may call at any time to leave an inspection request. Their request would include the building address, permit number and inspection type. Each business morning the messages from the previous day are retrieved from the recording system and transmitted to each responsible inspector. Since our inspectors are assigned to geographic districts, the inspection requests are easily sorted for distribution by location.

As I said, each morning the previous days calls are distributed for inspection on the same day. Additionally we will retrieve new messages in the morning until 8:30 AM. At 9:00 AM the inspectors leave the office to complete the days called inspections.

Managing Workload

There is a natural seasonal variation in the volume of residential building activity between winter and summer, and consequently a variation in the volume of building inspections. We have determined a staffing level which allows us to achieve the desired level of service year round. We do not increase staffing levels for the busy season and decrease staffing levels for the slow season. It has become more important to keep well trained, and qualified people even through the slower times.

Our supervisory positions are considered "working supervisors", thereby allowing additional manpower when necessary. We also have two specialized positions known as "structural" building inspectors for highly complex structures which require more time on each inspection. The total for building inspectors is 9 geographic district inspectors, 2 structural specialists, 1 special project inspector and 2 supervisors for a total of 14. In addition one manager oversees this entire group. We perform approximately 25,000 to 26,000 building inspections a year. Seattle is a city of approximately 600,000 people.

Qualifications

The most important criteria we have chosen in determining a persons ability to perform as an inspector is actual field experience and knowledge of the building trades, construction process and technical details of the business. Most of our inspectors have worked as builders, carpenters and in construction management.

It is essential that the inspector be well versed in engineering principles of structures. Educational backgrounds in Architecture and Civil Engineering are helpful. The ability to read and interpret blueprints and building codes is a necessity.

Just as important is the ability of the person to interact with those who become subject to their inspections. It is very important that our inspectors are respectful of the authority granted them. It is also true that we demand high ethical standards in our inspectors so as to prevent accusations of bribery, collusion and favoritism. A successful inspector must speak well, listen well and write well. The ability to work over the telephone is a necessity, and today use of the computer is becoming another necessary skill. A good driving record is essential.

Once an inspector candidate is brought into the work force a period of training will take place to familiarize the individual with the operations of the organization, the methods for making work assignments, familiarization with the specific code in use for inspections, report forms and how paperwork is to be submitted. Each new person will be assigned to accompany other experienced staff to ride along on typical daily tasks for two weeks. At the end of the two week period the new inspector's familiarity should have progressed to the point where they are taking on their new assignments. Supervisors stay closely in touch with the new inspector to respond to questions as they arise. At six months a performance review is done, followed by annual performance reviews.

Record Keeping

Every inspection performed must be documented, maintained and be retrievable. Today in Seattle we use a three-part form for each individual inspection. One copy is left at the jobsite for the builder, one copy is retained by the inspector in the permit file and the third copy is turned into the clerical support staff for data entry into the computerized permit tracking system.

Legal Enforcement

The requirements to obtain building permits and inspections is a legal requirement. When construction is performed without permits it sometimes becomes necessary for the city to initiate a legal process to enforce the requirement. Our legal process is defined by the courts and administered by qualified attorneys.

In addition to the City initiating a legal action, it often becomes necessary for the City to produce records and testimony in an action between citizens. In such a civil action where one private party has filed suit against another private party, the City may be called as a third involved party or even named as a defendant. The result may be discovery of records held by the City, written affidavits, depositions or even testimony in court by inspection staff.

All too often a legal action taken by the City is initiated by a complaint filed by a citizen. This complaint usually has to do with some other citizen building something without approvals by the City. The City now must respond by investigating whether or not there is a violation of the legal requirements. If a violation is in existence a properly written notice is served upon the offending party. A certain amount of time is allowed for the party to respond and resolve the violation. If resolution does not occur within the given time, the legal process moves on to the next level where legal notification is again issued requesting a pre-trial settlement meeting. If no pre-trial settlement is decided upon, the issued is scheduled for trial in a court of law. The court's decision is final and the results become part of the written record for both the individuals involved and the property address.

Legal actions occur only on a small percentage of properties but still become a necessary task for the City administration. Most building projects begin with a good idea, are planned and executed without difficulties and are used to the benefit and enjoyment of their owners. All things considered, life in the community is better for the completion of the building permit and inspection process.