RESEARCH REPORT

External Research Program

"RORO" Modular Home Shipping System

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"RORO" MODULAR HOME SHIPPING SYSTEM

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November 1997

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REPORT

"RORO" MODULAR HOME SHIPPING SYSTEM

November 1997

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Canada Mortgage and Housing Corporation, The Federal Government's housing agency, is responsible for administering the National Housing Act. This legislation is designed to aid in the development of housing and living in Canada. As a result the Corporation has interests in all aspects of housing and urban growth and development. Under Part IX of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available, inform,ation which may be useful in the improvement of housing and living conditions and the development of Canadian housing exports. This publication is one of the many items of information published by CMHC with the assistance of Federal funds.

PURPOSE

Canada is Japan's leading source for imported homes. In 1996 Canada held a commanding 45 percent of the market, an almost 50 percent increase over its share in 1995. Canada's nearest competitor, the United States, holds slightly under 30 percent of that market.

Despite this dominance, Canada's share of the total Japanese imported housing sales amounted to only about $145 Million. The reason for this relatively modest return stems in part from the nature of the housing packages being exported. In general, these packages are comprised of modest assembled stud walls, with or without sheathing as appropriate, pre-cut floor joist and roof rafters plus the additional materials, necessary to complete the home, exclusive of foundations, at the Japanese job site.

This approach incorporates relatively little Canadian labour and consequently limits the opportunities to generate increased revenue through 'value-added' services. Unfortunately, by focusing on the materials, for which it is acknowledged there are a limited range of options, this approach regulates housing packages to the status of *commodities* with the implicit disadvantage of their being subjected to fierce competition wherein the lowest price is the sole determinant for sales. Furthermore, the Japanese contractors' lack of familiarity with our building system and the limited skill of much of its workforce in handling these types of homes has resulted in many homes either being erected late, being erected incorrectly or both. This in turns lowers the perceived value of the Canadian product to the detriment of sales.

This project addresses these issues by proposing the use of modular rather than panelized housing components. Such an approach could significantly increases the percentage of Canadian labour, while allowing greater opportunities for product differentiation and marketing innovation. Further, it would provide, on site in Japan, a unit which requires a minimum of skilled labour to complete. The wide use of modular construction has historically been resisted by the manufactured housing industry due to a belief that the transportation costs for modules, which the industry describes as *shipping air,* would prove prohibitive. However, continuing shifts in Japanese labour conditions and costs plus access to cost-effective ocean transport by way of modern car carriers, known as RORO (Roll-On / Roll-Off) vessels, which return essentially empty to Japan, suggest that a modular housing approach might be possible.

The following report discusses these options by comparing the detailed costs for the manufacture, shipment and site erection of comparable panelized and modular homes. Costs were secured from a Canadian manufactured building producer, various shipping industry representatives and a Canadian contractor currently engaged in residential construction in Japan. These costs are analysed within this report and are then used to define a projected level of market penetration. Those figures are in turn used to suggest the impact that developing and introduction of a modular housing system might have on Canada's manufactured housing industry.

ACKNOWLEDGEMENTS

I wish to thank the following individuals and firms whose contribution made this work possible. While these individuals provided information and insights which were crucial to an understanding of the issues under review and the subsequent completion of the work, any errors in analysis or interpretation are solely the responsibility of the author.

Don Hazleden, MAIBC, MRAIC
Senior Advisor , Research and Technology Transfer, CMHC , VANCOUVER

Mr. Hazleden first raised the concept of using RORO car carriers to transport modular housing during a meeting of housing exporters in Vancouver. His subsequent support and insights regarding the Japanese export housing market were instrumental in initiating and sustaining this work.

Francois Rivest
Second Secretary, Commercial, Canadian Embassy, TOKYO

Mr. Rivest's contribution was critical to the success of this work. In addition to technical input , comments and suggestions, Mr. Rivest contributed an understanding and appreciation of the subtleties of the Japanese housing and construction industries which made the overall issues comprehensible. Further, the quarterly newsletter "Trends - in Housing and Building Products in Japan" which he edits for the Canadian Embassy in Tokyo, was an invaluable source of information.

Paul Baxter
Manager, Marine Operations , NORTEC Marine Agencies Inc. , VANCOUVER

Mr. Baxter provided insights and information regarding the technical operation of RORO ship operations in particular, and the shipping industry in general.

Mr. Peter Ng, Port Superintendent & **Ms. Nana Rouf,** Export Supervisor
Montreal Shipping Inc., VANCOUVER

The two individuals provided additional information on RORO operations, port requirements and shipping costs.

Bill Walker
Operations Manager, Annacis Auto Terminals Ltd. , Annacis Island, NEW WESTMINSTER

Mr. Walker and his staff provided invaluable insight and understanding of the practical operations of a RORO dock facility.

Ross Hodges
Terminal Manager , Cosco Terminals, VANCOUVER

Mr. Hodges provided information and an understanding of the operations of a conventional 'break-bulk' shipping dock and terminal.

Harold Clifford
President, Shelter Industries Inc., ALDERGROVE

Mr. Clifford and his staff at Shelter industries provided considerable assistance in the technical aspects of the proposed Japanese home described in this study. His firm also provided the base costing information for the production of the alternate panelized and modular housing options.

Bill Kirkhoff
President, Canadian Homes International Inc., CHILLIWACK

Mr. Kirkhoff drew upon his experience building homes in Japan to provide information and advise regarding the proposed home designs and construction methods. His company also provided the basic costing information for the erection or assembly of the panelized and modular homes in Japan.

I would also like to thank my many colleagues and friends within the manufactured housing, housing research and housing export industries who contributed advise, insights and information to this study. Without the broad support of the participants in Canada's housing industry, this study would not have been possible.

EXECUTIVE SUMMARY

This report discusses the potential use of RORO vessels as a shipping system for exporting modular housing components to Japan. The work looks at the modular concept, compares its costs to the more traditional panelized housing export [product , estimates a potential market and discusses the system's advantage. These issues are addressed in the following five chapters.

CHAPTER 1- INTRODUCTION

This chapter provides a very brief overview of the Japanese residential construction environment. In particular, it explains the changes being proposed by the Japanese government which will eventually permit the importation of modular homes. It closes by identifying some of the advantages which modular housing offers Canadian manufacturers and Japanese contractors.

CHAPTER 2 - SHIPPING

As one of the core elements in the report, this chapter encompasses four major sections.

Section one discusses the various regulatory, industry and practical size limitations which will impact any proposed module or associated shipping system. Whereas the suggested module width somewhat exceeds the 'normal' permitted shipping width in japan, the report also explains how this issue should be approached with the various authorities having jurisdiction.

Section two looks at various shipping options from modern containerization to traditional break-bulk cargoes. It explains the physical and operational environments one will find at the various port facilities and on the vessels themselves.

The third section integrates the findings arising from the first two parts and proposes alternate methodologies and equipment for transporting modules either from plants within an hour of the port of export or from intermediate distances ranging up to 300-400 km.

The final section compares the costs of shipping two identical homes to a common construction site in Japan. One home is a panelized structure and finishing materials which are loaded into two 40' containers while the other home is a six module residence wherein the modules are equipped to be towed on their own wheel assemblies. The comparison considers two sources of manufacture, one close to the port and the other in the Central Okanagan region of B.C. In Japan, the analysis considers two situations, one in which the containers and modules can be trucked directly to the job site and a second scenario where the length of the containers necessitates their being unloaded and the panels and materials transferred to a smaller truck for subsequent delivery to the job site.

CHAPTER 3 MODULAR DESIGN AND CONSTRUCTION

This chapter's review of modular design, technical requirements and attributes provides a context for the broader shipping discussions and subsequent costing. The chapter looks at a typical example of a mid-range, westernized Japanese imported home. It discusses various functional requirements, cultural attributes and some simple design options whose use can significantly improve on the somewhat boxy appearance which plagues many other modular homes. There is also an extensive discussion of technical issues such as structural anchors, inter-module connectors, joint finishing between modules , fire safety and environmental or envelope integrity.

The chapter closes with a look at some potential developments. These is a brief discussion of some innovative foundation systems and hinged roof trusses. The former can simplify the on-site preparation work while the latter further reduces the contractor's work load at the same time offering consumers a 'bonus room' by way of a 22 sq.m. unfinished attic.

CHAPTER 4 ECONOMIC AND MARKET ANALYSIS.

This fiscally oriented chapter encompasses three elements. The first contains a detailed comparison of the *differences* in the costs associated with producing competing panelized and modular systems in a Canadian plant and then assembling the materials into identical homes in Japan. To these two sets of figures are added the shipping costs generated in Chapter 2 to produce an overall economic comparison of the two construction approaches.

These figures are then used in turn as a basis to estimate high, medium and low potential markets and calculate what resulting direct impact those degrees of market penetration might have on the manufactured housing industry in particular, and on the Canadian economy at large.The reader should note that in all of these analysis, the work adopts a very conservative approach in order to not create an optimistic , or worse false, expectation of the potential success or impact for modular housing exports.

CHAPTER 5- MODULAR ADVANTAGES AND FUTURE POTENTIAL

The closing chapter briefly describes some non-quantifiable or non-monetary advantages which could accrue to the Japanese contractors who adopt a Canadian modular housing approach. It also suggests some modest approaches that competing Canadian manufacturers might cooperatively pursue to improve the performance of this housing form, further expand its markets and solidify its position as the country of choice for housing exports to Japan.

APPENDIX A

The report closes with a copy of the information and costing work sheets which were used to calculate the modular and panelized construction costs in Japan.

RÉSUMÉ

Ce rapport fait état de la possibilité de recourir aux navires rouliers pour expédier des éléments de maisons modulaires au Japon. De plus, on examine le concept de la maison modulaire, on en compare les coûts à ceux des produits d'habitation préfabriqués plus traditionnels destinés à l'exportation, on évalue le marché potentiel et on commente l'avantage d'un tel système. Ces questions sont abordées au sein de cinq chapitres.

CHAPITRE 1 - INTRODUCTION

Ce chapitre donne un bref aperçu du milieu de la construction résidentielle au Japon. Plus précisément, il explique les changements que le gouvernement japonais propose en vue de permettre l'importation de maisons modulaires. Il se termine par l'indication de certains des avantages que revêtent les maisons modulaires pour les fabricants canadiens et les entrepreneurs japonais.

CHAPITRE 2 - EXPÉDITION

L'un des éléments fondamentaux de ce rapport est traité dans ce chapitre, lequel est divisé en quatre grandes sections.

La section un porte sur les diverses contraintes réglementaires, industrielles et dimensionnelles qui influeront sur tout système d'expédition proposé, qu'il soit modulaire ou autre. Bien que la largeur du module proposé excède quelque peu la largeur «normale» permise au Japon, le rapport explique aussi de quelle façon cette question pourrait être traitée auprès des diverses autorités compétentes.

La section deux examine différents modes d'expédition, de la conteneurisation moderne aux méthodes traditionnelles de transport par cargo. Elle explique les milieux physiques et opérationnels qui caractérisent les diverses installations portuaires ainsi que les navires eux-mêmes.

La troisième section intègre les découvertes issues des deux premières parties et propose des méthodes et de l'équipement de rechange pour le transport de modules, que ce soit à partir d'usines situées à moins d'une heure du port d'exportation ou à des distances intermédiaires pouvant atteindre entre 300 et 400 kilomètres.

La dernière section compare ce qu'il en coûte pour expédier deux maisons identiques vers un chantier de construction commun au Japon. L'une de ces maisons est constituée d'une structure préfabriquée et de matériaux de finition chargés dans deux conteneurs de 40 pieds, tandis que l'autre est une habitation composée de six modules équipés de manière à pouvoir être remorqués sur leur propre train de roues. La comparaison a pris en considération deux sources de fabrication : l'une près du port et l'autre dans la région centrale de l'Okanagan, en Colombie-Britannique. Au Japon, l'analyse a tenu compte de deux situations : l'une dans laquelle les conteneurs et les modules peuvent être transportés par camion directement au chantier et l'autre dans laquelle la

longueur des conteneurs exige qu'ils soient déchargés et les panneaux et matériaux transférés sur un plus petit camion pour être ensuite transportés jusqu'au chantier.

CHAPITRE 3 - CONCEPTION ET CONSTRUCTION DE TYPE MODULAIRE

Le chapitre 3 passe en revue la conception modulaire ainsi que ses exigences et attributs techniques. Il fournit ainsi un contexte en vue d'organiser des discussions plus larges sur la question de l'expédition et, par la suite, sur les coûts. Ce chapitre illustre un exemple typique de maison moyenne importée de l'Ouest par le Japon. Il aborde les diverses exigences fonctionnelles, les caractéristiques culturelles ainsi que des adaptations conceptuelles simples qui peuvent contribuer à améliorer considérablement l'aspect carré qui nuit à bien d'autres maisons modulaires. On commente aussi largement des questions techniques comme les dispositifs d'ancrage structural, les connecteurs de modules, la réalisation des joints entre les modules, la sécurité incendie de même que l'intégrité de l'ensemble du point de vue de l'enveloppe et de l'environnement.

Le chapitre se termine par l'étude de certains progrès possibles. On commente brièvement quelques types de fondations innovatrices ainsi que des fermes de toit articulées. Les fondations dont il est question simplifient le travail préparatoire sur le chantier et les fermes de toit articulées diminuent la charge de travail de l'entrepreneur, offrant par la même occasion aux consommateurs une «chambre en prime» grâce à l'attique non fini de 22 pi^2 formé par ces fermes.

CHAPITRE 4 - ANALYSE ÉCONOMIQUE ET ANALYSE DE MARCHÉ

Ce chapitre est axé sur les aspects financiers de la question et couvre trois éléments. Le premier est une comparaison détaillée des *différences* de coût associées à la production de produits modulaires et préfabriqués concurrents dans une usine canadienne et à l'assemblage des matériaux dans des habitations identiques au Japon. À ces deux séries de chiffres s'ajoutent les frais d'expédition donnés au chapitre 2 de manière à produire une comparaison économique globale des deux méthodes de construction.

Ces chiffres servent ensuite de fondement à l'estimation de marchés à potentiel élevé, moyen ou faible ainsi qu'au calcul de l'impact direct que pourraient avoir ces différents degrés de pénétration du marché sur l'économie canadienne en général, mais aussi sur le secteur de l'habitation usinée en particulier. Le lecteur remarquera que dans toutes ces analyses, les auteurs ont adopté une approche très prudente pour éviter de tomber dans l'optimisme exagéré ou, pire, de susciter de faux espoirs quant au succès ou à l'impact éventuel des exportations de maisons modulaires.

CHAPITRE 5 - AVANTAGES ET AVENIR DES MAISONS MODULAIRES

Le dernier chapitre décrit brièvement certains avantages non quantifiables ou non pécuniaires dont pourraient bénéficier les entrepreneurs japonais qui adoptent la technologie canadienne des maisons modulaires. On y suggère également des approches modestes que les fabricants canadiens concurrents pourraient employer ensemble afin de rehausser la performance de cette forme de logement, de développer davantage ses marchés et de consolider la position du Canada comme pays de choix pour les exportations vers le Japon dans le domaine de l'habitation.

ANNEXE A

Le rapport se termine par une copie des feuilles de travail de coûts et d'information qui ont été utilisées pour calculer les coûts de construction des habitations modulaires et préfabriquées au Japon.

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CHAPTER 1 - INTRODUCTION

Background

Despite enjoying possibly the strongest economy in the world, many of Japan's homes would not appear out of place in a Third World setting.

This dichotomy weighs on the Japanese national psyche to the extent that they worry about "Yi Shoku Jyu". While this literally translates to "clothing, food & shelter", it means 'quality of life' or 'standard of living'. The relatively poor overall standard of housing when compared to their high international ranking in other spheres of life led the Japanese government in 1995 to initiate a series of changes which by the year 2000 would see the nation raise its quality of housing, while at the same time lowering the average cost by some 30 percent.

They intend to achieve this goal through a variety of means such as:

- reorganization of their building materials distribution system,
- rationalization of material and construction standards with international counterparts,
- revamping restrictive labour laws and building regulations,
- greater use of evolving western building technology and administrative systems, and
- **the increased use of cost-effective imported housing, raising the level of imports from 1,500 homes to 50,000 homes by the year 2000.**

Proposal

This massive range of proposed changes has created considerable uncertainty and flux within the residential construction industry as contractors and developers seek to understand the new regulatory environment and explore means to capitalize on the opportunities it presents.

Canadian modular housing represents one of those more interesting opportunities.

Traditionally, the various regulations and market conditions have limited Canadian companies to exporting simple open panels or consolidated building materials. However, the evolving regulatory climate, and on-going negotiations between Canadian and Japanese officials should soon permit Japanese customers to import closed, and serviced, building panels. This in turn will permit importation of modular housing components.

This report is intended to provide an understanding of a modular shipping option and allow interested parties to explore the concept and be prepared to benefit from this approach when the required regualtory charges have been implemented.

Advantages

Use of modular components has a number of advantages for both the Canadian exporter, and the Japanese importer. A few of the benefits offered Japanese contractors include:

- the ability to eliminate the added expense and bother of using Japan's complex distribution system,
- opportunity to deal directly with Canadian modular producers,
- direct and continuing access to the latest in Canadian building technology without the need for an extensive learning curve,
- a better product,
- lower costs,
- better schedules, and
- the direct introduction of North American construction efficiencies, via the plants, without major reorganization of their own offices.

This approach also offers Canadian manufacturers a number of advantages:

- higher value-added content and consequently higher profits, raising the Canadian import from a mere 15 percent +/- of the finished home to nearly 58 percent,
- an opportunity to market housing and Canadian technology as a 'system' to the exclusion of foreign competitors, and
- the ability to compete on a higher 'value-added' plane thus locking out competitors who previously competed solely on the basis of a 'lowest cost' commodity-like approach to building materials.

The market for large modular construction components has generally been restricted by travel costs. Modules were limited either to sites close to the place of manufacture where transport costs were modest, or to very remote, or inhospitable sites, where transport costs were offset by what would have been very high construction costs. To date, these conditions were not perceived to exist within the Japanese export housing market, and when combined with stringent, and somewhat restrictive, regulatory conditions, made the use of modules impractical. However, the evolving construction climate and state of flux noted above appear to suggest that it is now appropriate to reconsider this export product.

Shipping

Basic to any reconsideration of modular housing components is development of a viable, and cost-effective, shipping strategy. The following report considers this issue and suggests technical, administrative and cost implications of one such strategy. Based on the use of car carriers or RORO vessels (Roll-On, Roll-Off) which return essentially empty to Japan after delivering vehicles to North American west coast ports, these vessels offer an intriguing , export delivery opportunity.

This report is not an export primer, Japanese marketing advisor, nor textbook on Japanese certifications and Article 38 approvals. The work assumes that the exporting manufacturer or their importing Japanese customer are familiar with the import, general shipping and building regulatory environments.

At a time when the labour component on a Japanese home is some 320 percent that of a comparable North American home, materials are 145 percent as costly and the overall efficiency of the Japanese residential construction industry is estimated at half that of their North American counterparts, it would appear to be an ideal time for Canadian modular housing manufacturers to investigate the potential for their products in the Japanese market.

This report assists in that investigation.

Introduction

Creation of a viable shipping strategy is crucial to the development of any export market for modular housing components. Such a system requires a number of specific attributes. These include:

- **Foremost,** the system must be cost-effective in terms of the overall construction budget,
- it must be readily implementable both in Canada and Japan,
- in Canada it must be compatible with existing manufactured housing shipping strategies and technologies,
- in Japan it should allow the contractor or importer to circumvent the existing, and expensive, transportation industry,
- it should require an absolute minimum of capital investment or trained personnel, and
- it must operate with a minimum of special permits or approvals.

The transportation approach described in this chapter meets these criteria and suggests an approach to shipping modular housing components to Japanese construction sites. The work looks at the transportation regulations which govern any possible system, considers alternate transportation strategies and compares the cost of transporting identical panelized and modularized homes to a common construction site in Japan.

Whereas the Canadian manufactured building industry is capable of producing transportable units up to 5 m wide by some 22-23 m long, it became readily apparent in the initial stages of the study that the size of the modules and the subsequent design of any shipping system or approach would be dependent upon the size limitations established by the transporters themselves or the regulatory authorities which governed the various routes over which the modules would travel.

Given these conditions, the critical initial task was to establish these limitations. To this end, various regulatory authorities and shipping industry representatives were contacted for their regulations or comments. These are reported below.

Shipping Limitations

Permits

During the course of this work it became evident that many jurisdictions operate with established basic shipping limitations and anything outside of those limitations requires a permit. However, many of these permits are not restrictive and are issued on perfunctory basis, what one might think of as an *administrative permit*. Whereas one of the project objectives was to devise a shipping approach which could be readily, and inexpensively, implemented by both manufacturers and contractors, it was taken as a starting point that all shipments must be able to proceed without the requirement for *unique permits*. In terms of this study, this means that while some form of *administrative permit* may be required to facilitate the movement of the proposed modules on a specific roadway, the type of permit involved would be one which would be readily approved by the regulatory authority having jurisdiction, and it is with this understanding that the following analysis of shipping limits was conducted.

Canadian Roads

In terms of hauling the base modules, the British Columbia highway regulations which would govern the modules during their delivery to any of the Vancouver docks or RORO terminals are quite generous. They impose the following limitations:

Width (1)	=	4.4m*
Width (2)	=	3.2m
Length	=	20.5m
Height	=	4.4m

* This dimension assumes the use of a pilot car in addition to the transporter which is pulling or carrying the modules in question. In order to eliminate this added expense, the maximum width is reduced to the 3.2 m noted for Width (2)

Japanese Roads

Comparable limitations for Japanese highways are:

Width	=	3.2 m*
Length	=	15.5 m
Height	=	3.8 m

* The traditionally accepted Japanese roadway width is 2.5m. However, depending upon the condition of neighbourhood roads, permits can be obtained from the local police for the more generous 3.2m allowance, and it is this figure which is used within this report.

Canadian Rail Lines

While it is anticipated that the overwhelming bulk of modules destined for Japan will come from manufacturing plants in the Vancouver, or central Okanagan Valley of B.C., it may prove viable for some firms to ship their modules via rail from more remote facilities. Consequently, the corresponding dimensions for railway use were identified.

The exact limiting dimensions vary somewhat between rail lines and routes in response to applicable track clearances through various tunnels. However, in general, the rail shipping envelope on the rail car is:

Width	=	3.25 m
Length	=	27.10 m
Height	=	3.50 m

While this envelope sets the general clearance parameters for routes from Vancouver to Halifax, it must be understood the that shipping envelope limitation on rail lines is not one fixed set of dimensions . Rather, clearances vary in width according to their location ATR (above top of rail) and curve inward to reflect the traditional rounded top shape of the tunnels which the lines must traverse. Consequently one might find that they can ship a module 6m in height provided it is only 1.5m in width at the top. While rail height limitations are not considered to be problematic, a manufacturer contemplating the use of rail to move modules to either coast should confirm appropriate routings and clearances with the railway before committing to a particular design. For the purposes of this study , rail height limitations, in Canada, are not deemed an influencing factor.

Japanese Rail Lines

During discussions with Canadian rail and transportation authorities , it was very strongly suggested that rail transit for goods was not a viable option within Japan. The size limitations imposed by the rolling stock were deemed restrictive, the availability of lines was limited and the cost of repetitive handling of the modules from the docks to the railheads, loading, transit, unloading and transport from the railhead to the construction sites would be prohibitive. It was noted that , Japan had elected to focus its goods transit on a road rather than a rail distribution system ; consequently , for the purposes of this study , with its diverse end sites and varied load requirements , we have focused exclusively on road transit within Japan.

European Rail & Road Clearances

Preliminary enquiries were made regarding the shipment of modular homes from eastern ports to various European markets. While only very limited specific dimensions were gathered, the general sense of the discussions was that the transport limitations found in Europe are universally more generous both in terms of rail and road regulations than those found in Japan. Consequently, any transportation system which works within the Japanese regulatory environment will more than probably work in its European counterpart; although, specific details must be secured for any particular market or shipping route before contracts are signed and design initiated.

Ocean Vessel Clearances

Dimensional clearances for ocean vessels vary enormously. The suitability of any particular vessel to accommodate the type of modular cargo must be decided during the initial charter discussions. However, the typical modern RORO vessel has decks dimensions of some 30 m in width by 200 m in length, with a widely spaced interior column system. While the average deck clearance is in the range of some 2-2.5 m, many of the newer vessels have one or two interior decks which can be raised or lowered to create clearances in the 4.4 - 5.4 m range. Consequently , the critical dimensions become the width of the ramps and portals by which the modules must be loaded.

Ramp and portal dimensions are among the most variable found in this study with no apparent standardization. However, most small ramps, and portals, were typically found to be in the 4 m range scaling up to 6 m for the major rear ramps of the larger RORO vessels.

Figure #1 illustrates a modern RORO vessel and notes the comparable size of the typical module which is the subject of this discussion.

An alternate ship type is the break-bulk carriers. These are the traditional types of ships one thinks of in terms of ocean vessels. They have large open holds and carry a wide-range of goods from loose bulk wheat to large equipment or crated and containerized materials. These vessels can handle even larger dimensioned goods than the RORO carriers and while the maximum item size they can handle varies by the specific vessel, all limitations exceed those of either the Canadian or Japanese highway regulations ; consequently, their specific size limitations are not pertinent to this work.

Weight Limitations

Despite the apparent large size of the proposed modules, as viewed within the context of one's normal experience, their weight is not an issue within the context of this study. With an average unit weight of some 4000-4200 kg ,these units do not represent an impediment to handing within an industry , where railcars carry 86,000 kgs., fork-lifts manoeuvre loaded 40' containers weighing upwards of some 23,000 kgs., and cranes can lift twice those loads. Further, the RORO vessels tend to have single axel load limitations , on their main expandable decks , in the range of some 30,000 kg. Finally, positioning of the modules at the job site will not be a problem, as they units can be readily handled by the type of small mobile crane which the contractor is expected to rent for the day's lifting and placing activities. Consequently, weight is not considered in this study.

Alternate Shipping Strategies

While the original project concept was predicated upon the use of RORO carriers, alternative shipping methods were evaluated as potential delivery systems. The following section briefly reviews the various optional systems which could be utilized and evaluates them in terms of the ultimate house construction goal.

Containerization

This shipping system is both well understood, cost effective and readily employable. However , the dimensional limits imposed by the standard container sizes create significant impediments when dealing with the scale of component being contemplated. Containers come in two basic lengths, referred to as 20' and 40' containers with a standard width of 2.45 m. There are however two variations in container heights, with the small units possessing an overall height of 2.6 m and the larger ones, called high-cubes, being 2.9 m high.

One must recall however , that for the purposes of this study, the critical dimensions are not the overall container dimensions, but rather the door openings. Despite the difficulty that would be encountered by trying to secure 100 high-cube containers for a major shipment , we will use them as a basis for our analysis in which case their larger door openings are generally in the range of 2.57 m high by some 2.35 m wide. Assuming that one would wish to maintain an absolute minimum 25 mm clearance all round , this still represents a very significant limitation.

Given that the anticipated combined floor and ceiling assemblies of the proposed modules would encompass some 260 mm in depth , we are left with an available interior ceiling height for the module itself of only 2.28 m. Use of such an interior room height would place these units at a significant marketing disadvantage especially at a time when competing 2x4 construction is uniformly offering a traditional 2.44 m ceiling height. Further , the unit width of 2.3 m is significantly below the 3.2 m limit permitted on the highways and represents a major penalty for use of this system.

In addition to dimensional restrictions, it is anticipated that very significant difficulties would be encountered attempting to load and unload modules. Without being able to lift the units and insert them on fork-lift tongs, one would be reduced to pushing the modules into the container. This is not only a difficult process in itself , but it would require the availability of a large, level loading area directly in front of the container of some 12 m in depth to properly align the units prior to their placement. Naturally, this process would be reversed at the job site, many of which are notoriously small and tend not to have large, smooth, clean working surfaces. Or working at an off-site delivery dock , the units could be unloaded from the container and transshipped onto a transporter for subsequent delivery to the job site. Despite the best efforts of both shipping and receiving crews, double handling could damage the units.

Whereas the logical depth for a typical house and consequently the required length of a modules is approximately 9 m-10 m, one would have to use a 40'(12.2 m) container for each module. This ‘wastes’ approximately 1/4 of each container unless a use can be found for this end space to carry loose-shipped materials , such as insulation or lumber.

One final disincentive to the use of containers is their reliance on the involvement of the established shipping ‘system’ with its inherent penalties of inefficiencies and limited competition. Just as contractors are turning increasingly to direct importing of buildings materials and house packages to circumvent the established distribution systems, so too should they benefit from a shipping system which frees them from the artificial restrictions imposed by established shipping strategies. This issue is pursued further in the section on “System Design”, page 18 .

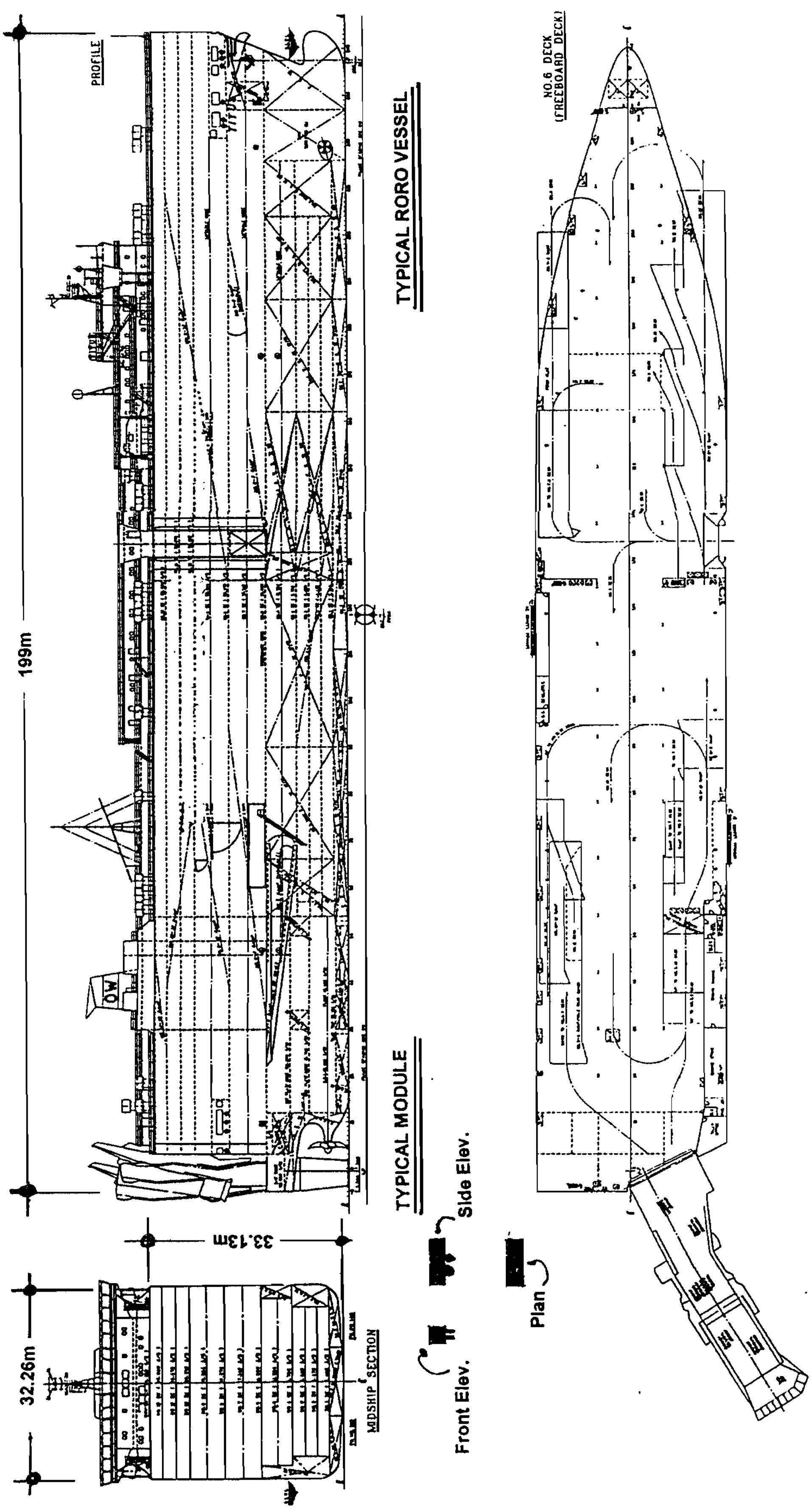


Figure # 1 :
Modern RORO Vessel & Typical Module

Containers are not without some advantages. Obviously they will afford the modules a very high level of structural and environmental protection . However, as modular units are already designed to be self-contained and weatherproof for road transit it is uncertain if this additional level of protection is necessary. Further it is also unclear if containers offer a level of protection beyond that found in RORO carriers which have been designed to transport very expensive and somewhat fragile automobiles between world ports.

Open Top Containers

There is a further option within the container industry which merits discussion and that involves the use of open-top containers . These units, although similar to standard containers , encompasses some basic variations . First , they do not possess a top , coming equipped with a removable tarpaulin like cover. Because of their open top , these containers are not as structurally rigid as conventional containers ; consequently , the floor structure has been deepened to compensate. Thus these open units actually offer less shipping height than conventional units and, there is a premium charged for loading above the unit's top line. These units were designed to accommodate loads which would be difficult to load lengthwise through a door , such as the components for a log home, and not to specifically accommodate over-height units.

Secondly, the units are not available in significant quantities. If one wished to ship 100 modules via open top containers , they would have to schedule their shipment over a three to four month period. Finally , these units are leased at a premium of some 70% above normal rates which makes them prohibitively expensive for the type of use being contemplated , and when taken in concert with the other limitations , this eliminates them from consideration as a transport option.

Container-Like Packaging & Shipping

Because of the basic box shape of the proposed modules ,it is possible to create a 'containerized' unit and equip it with what are known as ISO corner connectors such that the unit might be stacked like , and with , regular containers. In fact , such a system was developed and patented by 'World Homes Inc.' of Fernandina Beach Florida, and is available for licensing.

This approach has the advantage of facilitating a larger unit cross section , now up to 2.44 m overall width by 2.9 m in heigh and thus allows for full 2.44 m interior ceiling heights. However, this is offset in a sense , by the disadvantage that the system is, in some ways, more dimensionally restrictive than containers as the units must now match exactly the height, width and length of the 20' and 40' containers with which they would be stacked. Unfortunately, neither the 20'(6.1 m) nor the 40'(12.2 m) length is a convenient planning dimension. Analysis of 33 Japanese homes and apartment plans indicated that only one project would lend itself to these construction dimensions while a further one or two designs might be forced to these parameters.

As noted , this approach has already been patented , in both Canada and the United States, and as such requires a license to use. With an annual minimum, up-front fee in excess of $28,000, which is charged against a per area fee of some $15/sq.m. this system is not inexpensive, and could prove prohibitive for smaller start-up companies.

As with the containerized approach discussed above, this shipping approach relies upon , and benefits from the use of , established shipping technologies . It also places a burdensome , and expensive, reliance on the existing transportation 'system', and again places the contractor / importer at the mercy of the prevailing distribution channels. Whereas a secondary goal of the RORO approach is to free manufacturers and contractors from the vagaries and constraints of traditional shipping companies, this approach is not deemed a viable option.

Break Bulk

Break Bulk is the general term given to the shipping approach wherein items are loaded individually into a ship. This means everything other than containers or bulk products such as coal, oil and wheat .

Because of its extreme flexibility , this approach offers many advantages to the average customer. Ships are readily available both in terms of numbers and shipping dates. Numerous ports of call may be specified and a variety of item dimensions can be accommodated. On small orders, of one or two houses, break-bulk may be a convenient transport option as vessels can generally be found which will be shipping other goods between the required ports and consequently a special stop, such as might be required for a RORO carrier, is not required.

Generally , the disadvantages of this approach are few, and limited to such issues as the possibility of some additional minor damage due to multiple handling in the yard facility and during loading. However , the units will have to be engineered for lifting , often by slings , in order to place them in the ship's hold , with the lifting points reinforced , as required , and clearly marked . However, the light weight of our modules does not require significant engineering or construction.

A disincentive to using this approach rests with the inability of the modules to be stacked, or to have other cargoes placed on their roofs. This can result in the modules themselves being stacked on top of other cargoes in a deep hold, which might lead to damage during transit, or the modules might be placed at the bottom of a hold and the customer charged for any unused volume above them. These issues need to be examined in detail by the customer when investigating shipping options and accompanying costs.

The one foreseeable major disadvantage of this option involves the organization of a large shipment of say 25+/- modules for a major construction project. While this number of units is readily accommodated on a RORO carrier, it may not be possible to secure sufficient space within any one break-bulk carrier. Consequently additional planning and scheduling may , and probably will, be required if this approach is used. From a cost perspective , break-bulk shipping will generally be more expensive than RORO transport as the modules will be occupying vessel capacity which could be used for other cargoes.

In summary , the shipping industry representatives contributing to this project were unanimous in their belief that if the modules can be equipped with their own wheel assemblies , then the use of RORO carriers is by far the best approach to take both in terms of convenience and projected end costs.

Packaging

Because RORO car carriers provide such a high level of protection to their cargos during the sea voyage, it only remains to provide protection for the modules during their road transits or while standing either at the docks or the job site. This protection falls into two categories. First, protection of any module walls which will become part of the homes exterior and secondly, protection of those walls and or openings which are parts of the home's interior.

Fortunately , we can draw upon the extensive experience the manufactured housing industry, gained from shipping modular homes . For the purposes of this work , it is assumed that those parts of the modules' exterior which are also part of the homes' exteriors will be finished to the degree of including windows, doors and building paper or air barrier . This is comparable to the finish of many modular or mobile homes currently shipped on Canadian highways.

While the current level of finishing provides a demonstrably adequate level of protection, some manufacturers install additional protection by way of disposable lathing which is nailed over the building paper to provide additional mechanical anchorage. They may also caulk any joints in the sheathing on the exterior wall, particularly those which faces the direction of travel, in order to reduces the chance of water penetration due to rain hitting that leading face while it is travelling at up to 100 km/hr.

Some manufacturers may also elect to install sheathing protection to all doors and windows both to provide a supplemental level of impact protection ,and to demonstrate their concern for the delivery of a high-quality protected product. However, either approach is adequate to meet the protection needs which will arise from the handling process envisioned in this study.

A second condition or category of protection exists where part of the modules' exteriors contain large openings and wall elements which will eventually be part of the home's interior. In these instances, it is necessary to provide additional, and subsequently removable protection. Canadian manufacturers have adopted a variety of responses to this problem. A good compromise of economy and protection utilizes temporary shipping walls comprised of relatively widely spaced studding, heavy polyethylene film and an exterior covering of 'crate-grade' OSB. This 5 mm ungraded, often off-square, panelling can sometimes be acquired for as little as $2-$3 for a 4x8 sheet and provides inexpensive, long term impact protection. Other manufacturers rely upon the use of very limited sheathing, providing instead widely spaced triangular plate bracing between some of the studs and plates of the shipping walls to ensure structural integrity. To this they add a covering of heavy, reinforced ,tear resistant plastic, or one of the many air barrier building wraps such as Tyvek. This approach has an added attraction in that the wrap can be economically printed with either a manufacturer's or contractor's logo and thus providing a travelling billboard.

Those interested in a more sophisticated protection approach might consider a product such as Hippwrap, a shrink wrap film which has been designed to withstand air pressures of 2,500 psi and is used to provide weather protection on high rise construction sites. A similar, but recyclable, product is Trans Shield, which comes as a large bag that fits completely over the module. One advantage of this system is that it can be equipped with a zippered door-like opening that would permit access to the unit for various work tasks, such as loading a missing item, or customs inspections. When used to protect just the open mating wall side, or roof of a module, these protection systems cost about $55 per side. While this is more expensive than the $.75-$1.00/sq. m. for installed heavy plastic, the added benefits, and recyclable nature of these products may prove attractive, and as such merit consideration as part of one's comprehensive packaging, shipping and advertising activities.

RORO Terminal Operations

Those wishing to use RORO car carriers in the Vancouver area have two options, the various docks of the Vancouver Port Corporation, what one thinks of as Vancouver Harbour and the docks of the Fraser River Harbour Commission, in particular, the Annacis Terminal and the Fraser Wharfs. However ,it should be noted that, with the exception of some specialty carriers which had been converted for lumber transport. Fewer than a dozen car carriers used Vancouver Harbour docks in 1995 while over 100 carriers used the Fraser River facilities during the same period.

Further , the Vancouver docks are situated essentially in the heart of the City , and access may be somewhat restricted for larger modular loads. Despite this, at least half of the more than 30 docks in Vancouver Harbour can accept RORO carriers with a half dozen specializing in this type of cargo. In addition, these docks regularly handle 40' containers and similar cargos and thus must still be considered as viable shipping points . In light of these conditions, this study investigated both the Vancouver and Fraser facilities.

Casco Terminals Limited - Vancouver Port Commission

This dock is located at the foot of Heatley Ave. in downtown Vancouver. While a large facility , it is sufficiently typical of others in the Harbour so as to be representative of similar operations. Casco Terminals is a combination container , break bulk and general cargo facility. As such, it is equipped to handle the types of modules under consideration. To appreciate the nature and scope of the Casco operation ,one should note the following capacities:

21	hectare	fenced site
5,750	m	rail siding
1,230	m	container rail loading
10		incoming truck lanes
6		RORO simultaneous dockings
8,842	unit	container storage
30,000	sq.m	storage shed
4	cranes	up to 50 tonnes & 42.7 m reach
	forklifts	lifting 20' & 40' containers to 23,580kgs.

Annacis Terminals - Fraser River Harbour Comm.

Annacis Terminals is a custom built transfer facility specifically designed for the transshipment of wheeled and track vehicles between RORO vessels and road or rail carriers. Because of its specialized operation, Annacis does not possess the facilities to handle the container, break bulk and general cargoes which constitute the core of the Casco operation. however, the terminal facilities are equally impressive:

53	hectares	paved site
8		rail sidings for 74 rail cars
5		rail loading ramps
39		truck loading bays
2		RORO simultaneous dockings
1,115	sq.m.	storage shed

Located on Annacis Island between Delta and New Westminster , Annacis is a freshwater port and free of the harmful air borne salt which sometimes affect cargoes at the salt-water Vancouver port. Further , the terminal enjoys modestly better access to major highways ; although , not to the degree that it would be automatically selected over a more centralized Vancouver Harbour dock.

The only significant variation between the Annacis and the Casco terminal operations is the general absence , at the former , of large capacity fork-lift vehicles for unloading any modules which might be delivered by rail car. However, such forklifts are readily available and would be leased if a shipment of modules were schedule for rail delivery.

The Annacis facility's major advantage lies in its greater availability of space and familiarity with RORO operations. Further , although designed to handle over a quarter of a million vehicles annually , significant reductions in auto imports have freed up sufficiently large staging areas that dock-side assembly of a module order is available almost at the base of the loading ramp .

Terminal Operations

The Vancouver and Fraser facilities were found to be rather similar in both their capacities and their operational procedures; consequently, the following discussion of dock and RORO operations can be applied to both facilities.

Facility Config uration

At the beginning of this study, it was anticipated that the volume and scale of the proposed units would necessitate some physical modifications, or adjustments, in either the dock facilities or operations to accommodate the modules being discussed. However, it quickly became evident that the overall existing shipping system could readily handle these modules. As noted above, the docks are quite large; further, their layouts readily accommodate module arrivals and intermodal transfer between any combination of road, rail and vessels. The type of yard receiving, staging and loading of the modules is essentially similar to the normal dock operations as they apply to existing auto cargos; consequently no physical or administrative modifications are required.

Hours of Operation & Receiving

Both facilities tend to work on a 7:30-4:30, five days a week schedule for the receiving of materials and the loading of ships. While the Casco facility is currently experimenting with some evening hours of operation, this is an exploratory effort and should not be considered in one's planning.

When queried about late or weekend deliveries, the facility managers indicated that their experience has shown that when presented with firm operating hours, almost all truckers, without exception, do manage to deliver their shipments during business hours. However, they are not insensitive to the realities of the weather or the trucking industry, and it is possible to arrange to have goods received outside of normal business hours. However, this can prove to be expensive, as the yards are fully unionized and overtime charges are significant.

The one exception to this rigid scheduling involves the staging of rail cars which the railways drop off at their convenience and which are then unloaded during regular business hours by the terminal staff. Whereas this represents an area of operation over which modular manufacturers have neither any input nor control, this was not pursued further.

In summary, one can assume that manufacturers local to the docks will be able to tow their units to the docks during normal business hours, while longer haul, multi-unit transported delivers must be organized to respect the terminals' hours of operations. This standard of operation should not be deemed oppressive as the manufacture and shipment of modules are planned months in advance of actual delivery in order to meet deadlines and connect with tightly orchestrated shipping schedules. Consequently, adhering to operation schedules represents a modest requirement.

Scheduling

When scheduling a modular order for RORO shipment, it is worth noting that it costs approximately $15,000 - $20,000 to have a RORO vessel tie up at a dock. Further , because of the operating cost and value of these vessels, their movements are tightly scheduled and managed. This matter becomes increasingly important when dealing with over-size cargoes whose loading , and subsequent on-board storage must be pre-planned and pre-mapped. Consequently , major cargoes, such as the modules under discussion, are similarly tightly scheduled and planned; often as much as two-three months in advance of any proposed shipping date. For orders in the 100 unit range ,the upper limit of this study, a pre-planning period of three- four months would not be unreasonable.

Given the conditions surrounding the operation of the RORO carriers, most shippers will require that a modular order must be completely present , *on the dock,* at least two days prior to the vessels anticipated arrival. As a result of this requirement, 'Just-in-Time' (JIT), arrival of modules for direct loading onto a ship is not a potential option. This means that even for major orders, such as a 100 unit shipment, all modules must be present, and pre-set 48 hours in advance of the ship's arrival.

In reality, such extensive lead times should not constitute a managerial impediment for the manufacturer. Planning, and costing, of the shipping service, whether done by the buyer, or the manufacturer, will be an important part of the final decision making process and thus must be well in hand, long before any purchase order is placed.

Dock Movement & Storage

Given the pre-load delivery time noted above, it becomes important to consider what effect the staging will have on dock-side space requirements, particularly for a worst case scenario such as a 100 unit modular shipment.

In a RORO marshalling yard, the vehicles, or units, to be loaded are not staged laterally, as they would be in a conventional parking lot; rather, they are parked hood to trunk in a vertical configuration. Not only does this arrangement facilitate very dense staging, but it also allows the vehicles to be driven forward to the loading ramps without undo turning, and possible subsequent damage. The dock facility operators have indicated that any modular homes would be staged in the same configuration; particularly, for larger orders.

In a vertical stack, the typical module will occupy a space envelope, including circulation etcetera., of some 8.5 m x 9.5 m . For a 100 module shipment, this represents a total area requirement of 0.8 hectares. The reader will recall that even the Casco Terminal, the smaller of the two docks being discussed in this project, encompasses some 21 hectares ; consequently, our maximum spatial requirement is only some 4% of available space. This represents an insignificant spatial demand with the implication that once sited at the RORO dock, the modules will not have to be moved.

When specifically queried about a theoretical shipment of 100 modules it was suggested that with a minimum of two weeks advance notice, an adequate a staging space could be provided for a period of two weeks, or more if required , to assemble the shipment prior to the arrival of the ship. At that time , the units would be towed onto the vessel using either fork-lifts or yard trucks.

This situation is reinforced by noting that vehicular traffic, from Japan, is down some 54% since the early nineties. While driven in part by the recent downturn in the economy, this trend is largely a result of the establishment of Japanese automotive plants in North America, and thus is expected to be a continuing situation. This downturn in traffic is one of the reasons that the dock operators and the shipping companies who are seeking to develop new markets have assisted with this project.

Handling

While the evidence suggests that inter-storage movement will not be required, it is advisable to consider how it would be handled if it becomes necessary. The various dock and ship operators had clearly indicated that the RORO shipment of modular homes is only viable if the modules are self-contained in terms of their running gear. They were almost adamant in their 'request' that any module design and shipping strategy be totally independent. That is to say, they would not counsel the use of interim yard dollies, air-glide suspensions, temporary wheels or any, attachable and detachable interim solution which interfered with the smooth handling of the yard.

Neither the traditional shipping docks, nor the RORO facilities, wish to accommodate the significant number of modular units being contemplated, if they have to lift, move or stack the modules. However, given the potential ease of operation, and economy, afforded by the inexpensive, attachable modular wheel system discussed later in the report, no further consideration was given the more exotic options which are available. The key to success for the type of operations envisioned rests in the ability to move the units , **on their own wheel systems** , both around the terminal compound and onto or off of the RORO carriers. Using an attachable wheel system, the modules can be readily moved, staged and relocated, as required, with the use of a yard-truck or fork lift fitted with a ball hitch and this is deemed the most acceptable situation.

Naturally, it should be noted that the reluctance to move modules which are not on wheels, only applies if one wishes to minimize their shipping cost. The docks and shippers are more than capable of handling non-wheeled, non-standard modules, if necessary ; however, there will be a significant increase in handling charges, and as one objective of this work is to devise a 'cost-effective' shipping scenario, custom handling was not pursued.

There is one exceptions to the above. At the Canadian docks, it may be necessary to use equipment to lift units off-of railcars. These are units which have been shipped over such distances that road haulage is not deemed a viable option. Generally, this would mean units from the Prairies or central Canada. In this instance, the RORO dock operators can readily lease heavy-duty industrial forklifts to unload the units. Industry forklifts can hoist 20'-40' containers weighing up to 23 tonnes and manoeuvre them about the yard or stack them up to three containers high. By comparison, it is estimated that the types of modules being considered in this project are but 8.2 m long and weighs 5.2 tonnes . However, once unloaded, the units will be staged using traditional, yard trucks or forklifts fitted with a ball hitch.

Ship Loading and Module Securing

Regardless of the terminal being utilized , the ship loading operations will be similar. Once the ship is ready for loading, 3/4 ton pick-ups or yard trucks, with ball hitches, will tow the individual modules onto the vessel and manoeuvre them into their final resting position. Assuming that the modules are staged on the dock and organized on the ship in such a way that two modules can be loaded at the same time , and that the trucks have a generous half-hour turn-around time , four trucks and work crews could load an entire 100 unit order in 12-14 hours ,which is acceptable to the industry .

As with the docks, the RORO vessels themselves, with their integrated wide loading ramps, high decks and large inter-column spaces do not require any physical reconfiguration to accommodate the modular cargo. Securing the units against movement on the ship is accomplished by way of adjustable, quick-release fabric webbing straps which are rigged between the module frame and numerous, recessed deck tie-down rings. Typically capable of resisting loads in the 1200 kg. range , additional straps are added as required to provide security in all directions. By crossing the straps fore and aft , and side to side, the units will be adequately secured to resist all sea movements. Given the anticipated configuration of the towing hitch and axel assemblies, it is expected that additional tie-down points will be required on the modules. Manufacturers should anticipate bolting up to six , 10 cm. x 20 cm. metal plates c/w with 4cm. dia. holes to the perimeter frame at the four corners and 1/3 points across the back of the modules to provide the requisite securing. This requirement should be reviewed with the shipping company during the planning stages for the shipping arrangements to ensure compatibility with the ship tie-down requirements.

Packaging & Protection

Protection of the units from sea spray and weather is unnecessary, as the units will travel, weather protected, completely enclosed within the body of the ship. If anything, the units will suffer greater potential damage during road shipment in a rain storm. If the modules are protected to withstand that buffeting as described on pages #9 - #10, they will be more than secure on either the docks or in the hold of the ships.

Unloading

Unloading is an extremely simple process requiring only the release of the webbing straps and towing the modules off the vessel onto the dock staging area. Naturally , off-loading is much quicker than loading ; however, some allowance in timing & placement will be required to facilitate turning the units 180 degrees to a hitch forward, unloading, position.

Holding

The import docks are very similar to those described above for the Vancouver and Annacis Terminals; consequently, almost identical general operating conditions prevail. Industry practice in Japan allows the receiving shipper or contractor between 5 and 7 days, after the units have cleared customs, to remove their modules from the receiving dock area where their cargo is being stored. To consider this in context, we can assume a worst case scenario wherein all 100 modules arrive on the same vessel; the intended construction site is 100 km from the dock requiring a four hour round-trip and we have a 12 hour shipping day. To clear the dock within the minimal 5 day time limit, the contractor will have to engage 7 delivery trucks to tow the modules to his site. At this time, this does not appear to be an unrealistic requirement; consequently , it is not currently anticipated that off-dock marshalling areas will be required at the receiving dock and no prevision need be made for such occurrence at this time. While no inter-storage movement will be required, it has been noted that some construction sites may be rather limited for space, and while a crane can lift, and place, the units almost as fast as they are delivered, it may be desirable to 'stack' the units on site. To allow for this eventuality, it is possible to incorporate blocking to the underside of the modules, such that they can be more easily worked with forklifts or cranes after the wheel assemblies are removed. The blocking is shown in Figure # 9 Note however, that such stacking may be impaired or precluded, on some upper floor units, by the use of folding truss roofs which are discussed later in Chapter # 3 .

Summary

The technologies, facilities and operations of the existing RORO shipping industry are more than adequate to accommodate the type of residential, Canadian standard, modules which would be destined for any overseas destination. Given this finding, there is no reason, at this time to contemplate any alternate shipping or unit design.

SHIPPING SYSTEM DESIGN

As noted above, the various shipping industry representatives were rather unequivocal in their promotion of a module shipping system in which the wheel assemblies are attached to the modules. Conversely, they were equally opposed to the use of any interim carriers, dollies or a returnable wheel unit in the dock yard, on the ships or at the receiving port. They indicated that this approach would create administrative problems of collection and return shipment. They noted that the RORO carriers do not follow repetitive scheduled runs. Rather, RORO vessels are allocated varying world routes in response to fluctuating demands and timing , thus there is no guarantee that the interim wheeled assemblies could be conveniently returned to the port of origin.

The shipping representatives emphasized the ease of operation and efficiencies to be gained by working within the conceptual parameters of the existing RORO operations and its focus on the rolled-on, roll-off movement of wheeled vehicles, and urged its adoption for any modular shipping system. It would be fair to suggest that these representatives were enthusiastic about the concept and ventured that such a system should prove both practical and cost-effective. In light of this strong industry position, the following shipping approach was developed to first meet the demands of the typical RORO carriers and secondly to be easily implemented and manageable by both the shipping manufacturer and the receiving buyer, providing each with independence and flexibility.

While in reality the module unit, the preliminary house plan and the towing system were, by necessity, developed concurrently, and interdependently, for the convenience of the reader, these three elements are dealt with somewhat independently. Further, because the Japanese road regulations impose the more limiting criteria they were used in establishing the design parameters for the transport system. Based on the preliminary information, it was estimated that the modules would be approximately 9 m by 2.5 m, with a unit weight estimated at 4,100 kg +/- given an average dead load of 170 kg/sq.m. With this rather light weight, it was determined that these units need not be transported with the help of heavy duty truckers or complex hauling systems, but rather they could be hauled by a heavy duty ½ or $^{3}/_{4}$ ton pick-up truck if it were equipped with the proper heavy duty ball hitch attachments and towing package. This was considered a very important finding as one of the goals of the project was to devise a shipping system which was easy, and inexpensive to use. More importantly, we sought a transport system which could be readily and economically implemented, by Japanese contractors thus freeing them from reliance on major trucking companies with the attendant cost such semi-monopolies entail.

Once the decision was made to base the transportation system on the use of a heavy duty pick-up truck as the towing vehicle, we could maximize the modules' travel dimensions within the overall 12 m. x 2.5 m envelope for transporter and cargo which is common for this type of load. In order to maximize the actual module length, one minimizes the length of the towing vehicle. Investigation showed that we could be shorten the overall length of a typical pick-up, which is around 5.4 m by up to 940 mm by eliminating the rear box. Further, for a modest charge of approximately $1,500 it is possible to shorten the frame and drive shaft by an additional 600 mm. This results in a tractor unit of only 3.86 m in length. By locating the hitch forward, above or below the pick up's own rear axel, we should be able to accommodate the module's towing hitch within the tractor's dimensional limits thus leaving approximately 8.2m in allowable load length.

The 2.5 m limiation imposed by the Japanese highway code was initially accepted. However, with only a modest extension in the unit width, to 2.914 m, one could create a unit that would accommodate a typical 2x4 wall and leave sufficient interior clearance for the placement of three tatami mats. Whereas the inclusion of a tatami room is typical, even within westernized designs, and the 914 mm width of the tatami mat is also a typical Japanese planning module, a three mat module width could be an important marketing tool. The 2.914m module width is comprised of the following :

Window & Door Sill Extensions	40 mm
Exterior Sheathing	15mm
2x4 Stud	89mm
Drywall	13mm
Tatami Mats - 3@914mm	2 742mm
Closure Ply on Mating Wall	15mm
TOTAL Desired Thickness	2 914mm
Permitted Load Width (Nominal)	2 500mm
Desired Over width	414mm

Once it was decided that a three tatami mat unit width should be a project goal, a means to accomplish this under the Japanese shipping regulations was investigated .Belief that this effort could prove successful was driven in part by knowledge that one Canadian company already exports to Japan limited quantities of smallish single unit, modular residences for use as resort facilities and cabins. Known in Canada as 'Park Models', these units have an overall width of some 3.5 m.

Further investigation in Japan disclosed that while the general highway width limitation was indeed 2.5 m , wider permits can be obtained. Detailed regulations and permits must be cleared with three authorities:

Ministry of Transport (MoT)
- vehicle limits and safety standards

Ministry of Construction(MoC) &
Road Law Vehicle Control Regulations
- control of vehicles on public roads

National Police Agency
- vehicle traffic regulations

MoT deals with the safety of the vehicles , MoC covers travel on the major roads and highways and the Police provide approval for Over Width loads in the local neighbourhoods. Those wishing to haul the type of units being discussed need to secure approval from all three agencies to arrange the proposed route and hours of travel.

In summary , the proposed modular units and transportation system not only meet Japanese highway requirements , but are suited for convenient use within Canada. One can envision a manufacturing facility in the lower mainland of BC, producing these units and towing them on a individual basis to the selected shipping terminal. As noted above , the various terminals have suggested that a two week staging period is quite common and acceptable for a project of this nature. Consequently, a manufacturer would only have to transport 10 units per day over a two week , 10 day , working period to assemble a major order in preparation for export, and could do so with just the services of a heavy duty 3./4 ton pick-up.

This system also works for distant manufacturers who elect to ship their modules to the terminals by rail. In those instances, the plants would probably use a 3/4 ton pick-up as the main towing vehicle to haul their modules to a convenient rail siding where they could be staged for a couple of weeks prior to loading with a rented, heavy duty fork lift and subsequent transport to a loading dock where they will be handled as previously discussed.

However, this approach fails to serve those intermediate distanced manufacturers who are too removed for individual unit towing, but too close to use rail delivery. Such is the case for the relatively numerous manufacturers found in central, or northern B.C. and Alberta for whom this market would be attractive if they could move their modules to the Vancouver ports cost-effectively.

These plants require an alternate solution, a transporter which would accommodate more units , for economy of transport , but one which is both economical to manufacture and easy to operate. Fortunately, inspiration for such a system is found in the Canadian transporters currently employed to haul conventional mobile and drywalled modular homes. In the former instance , units up to 4.4 m wide in BC, by some 8-12 m in length are regularly transported on simple , double beam steel frames assemblies. More fragile modular units travel on full support flatbed units called *floats*. With air cushioned support, floats not only provide the smooth supportive ride required by the drywall , but in addition, the air bag suspension system is capable of a degree of vertical movement. This movement greatly simplifies placement of the units onto their foundations at the job site by allowing the driver to raise or lower the units with the air bags.

Combining these two concepts into the transporter illustrated in Figures #'s 2A, 2B & 3 produces a unit which transports of up to three modules at a time , can be operated by a single individual, and automaticly raises and lowers the modules for pick-up and delivery, offers a smooth air suspension ride and can be fabricated in a modest steel shop by those manufacturing plants which produce their own shipping frames.

The reader is reminded that the following transporter is not an 'engineered' proposal, and the discussion only deals with the more visible components of the Department of Highway regulations. Consequently , any firm, or individual, wishing to implement such a transport system MUST secure proper engineering for the system to ensure its structural viability, and conformance to ALL highway regulations.

The transporter is essentially a very elongated 'C' with its mouth opening towards the rear. The transporter is comprised of two basic components. The first component is the primary frame and wheel assembly. Fabricated from either Hollow Steel Sections (HSS) or various rolled steel shapes, the frame constitutes the backbone of the system. To minimize shipping costs, it was advisable to use a transporter which didn't require the use of a 'pilot car' preceding the transporter with a flashing yellow safety light. Consequently, we adopted on a low bed trailer configuration with a maximum width of 3.2 m and a length which can vary between 18.0 m and 20.5 m depending upon the arrangement of the transported modules.

The second major system component involves relocatable elevators mounted on the low bed trailer and which raise or lower the modules for loading and unloading. Combining these two components results in the creation of a transporter which allows a single operator/driver to load, transport and unload, up to three modules, *without* assistance.

The transport process begins with the manufacturer aligning the modules ready for loading. The driver removes the rear cross-bar, and then backs up to encompass the modules between the two arms of the transporter. During the course of various discussions, there were divergent views expressed on the typical driver's ability to accomplish such a fine degree of backing; consequently, if necessary, the modules can be hauled up between the shipping arms by a cable winch mounted on the tractor (truck) itself. Regardless of the loading approach taken, as the modules move the lowered elevators pass under the modules, clearing them by some 4-5 cm. With the modules properly positioned, within the transporter, the cross braces are reinstalled and the transporter readied for lifting.

In order to carry the modules, it has been necessary to eliminate the conventional axels on the transporter relying instead upon a spindle and shock absorber assembly which is mounted directly to the heavy steel plating which makes up the triple axel wheel housing assembly.

Figure # 2A :
Transporter Plan & Elevations

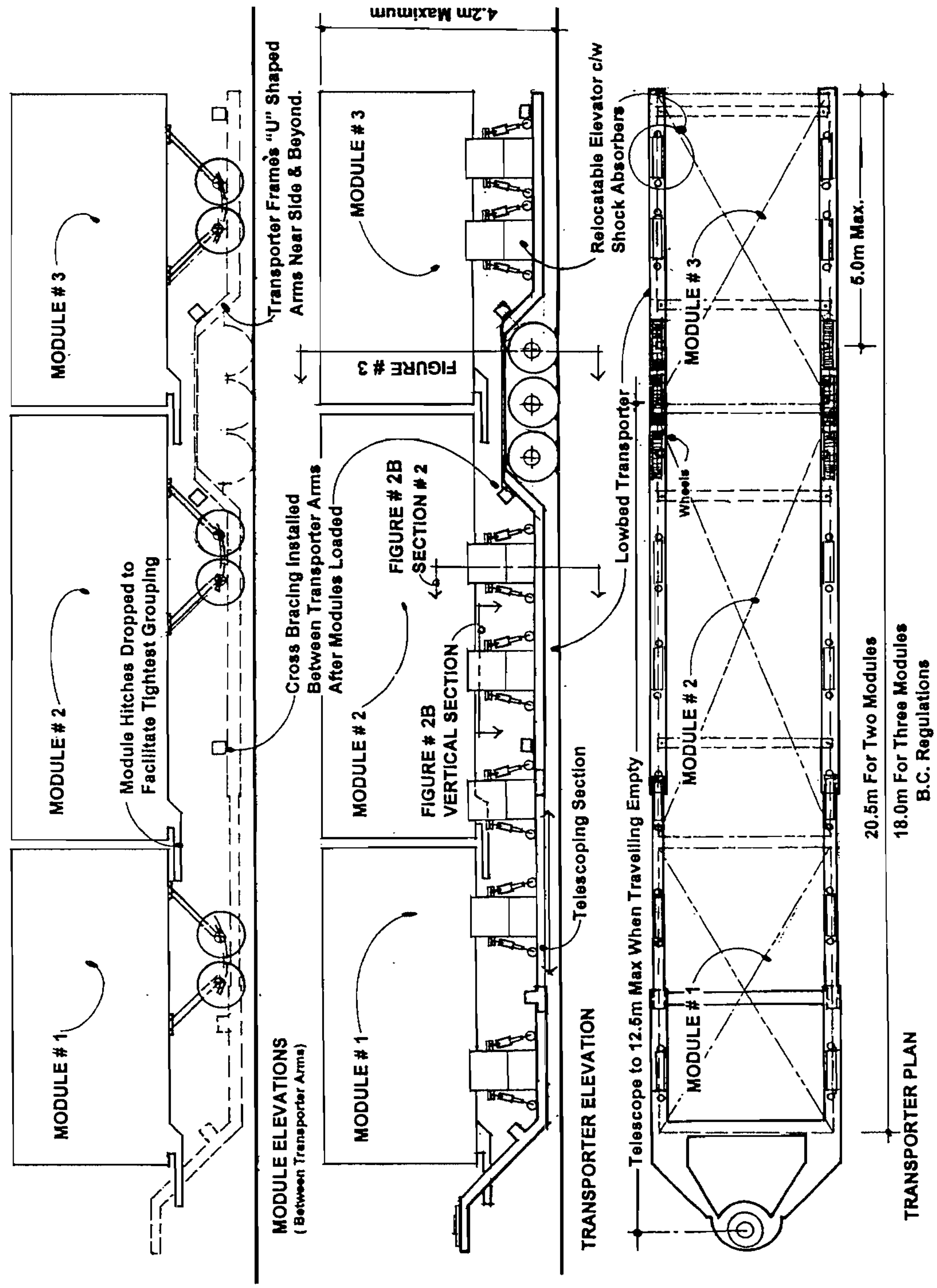
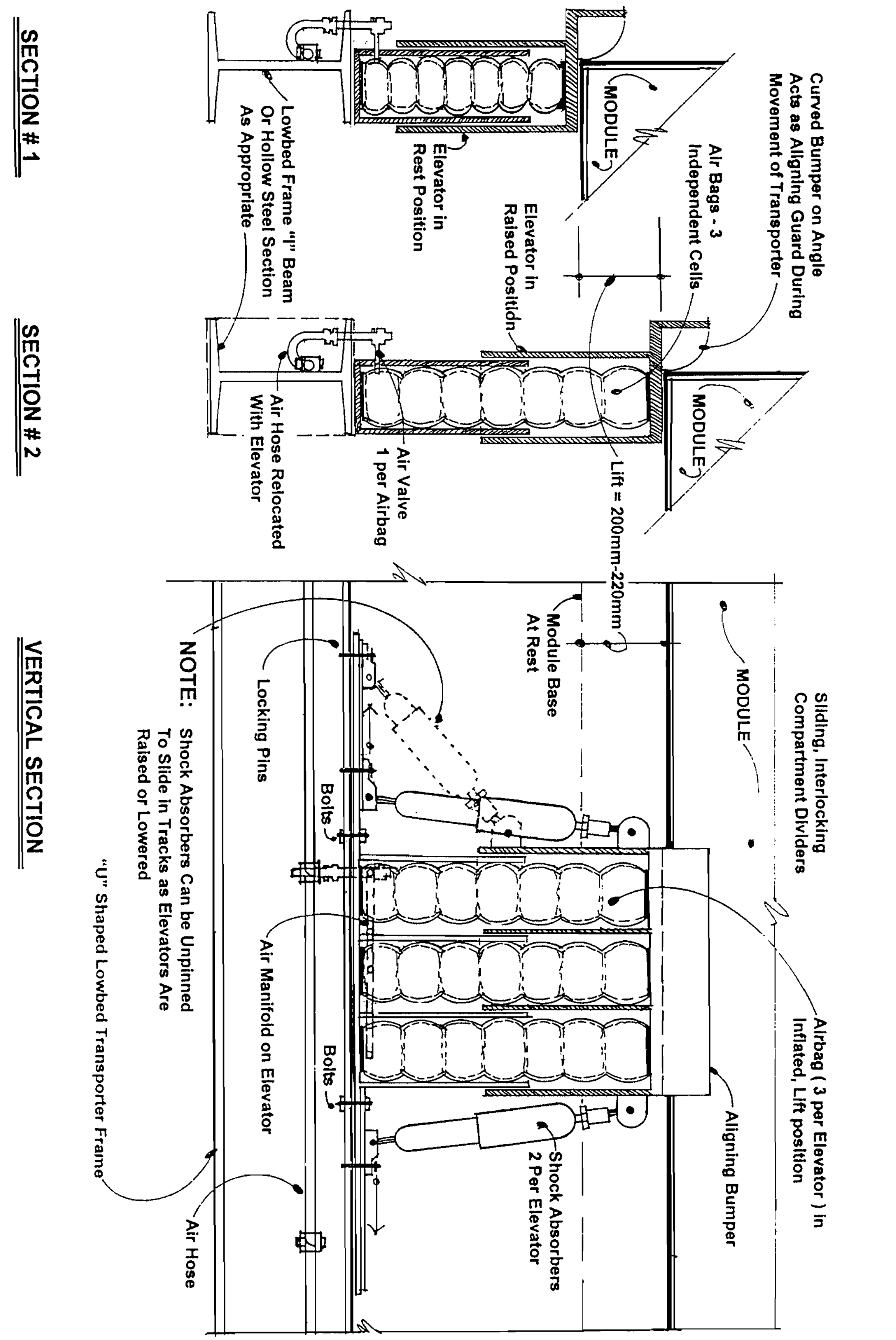


Figure # 2B : Transporter Elevators : Various Sections



As illustrated in Figure #3 this arrangement leaves sufficient clear space for the passage of the modules and yet can be accommodated within the dimensional limits of the transporter frame. Consequently, the wheels do not detract from the overall 3.2 m width which is available to the transporter.

The actual loading or lifting process is accomplished by inflating the air bags within the individual elevators. Whereas the modules are separate units themselves, they can be raised as independently thus reducing the necessary capacity of any truck mounted compressor. The elevators themselves are relocatable along the transporter frame, and while their individual weight will probably be such that the aid of a small fork lift during their relocation would be beneficial, it will probably not be mandatory. However, as any relocations will be undertaken to meet the specific dimensional requirements of the plant's production, their participation during the elevator relocation and set up is a reasonable expectation. To assist in the aligning the modules during their placement between the transporter arms, the elevators have curved bumpers along the outside face of their lifting plates. Not only do these bumpers align the modules, but they also resist lateral movement.

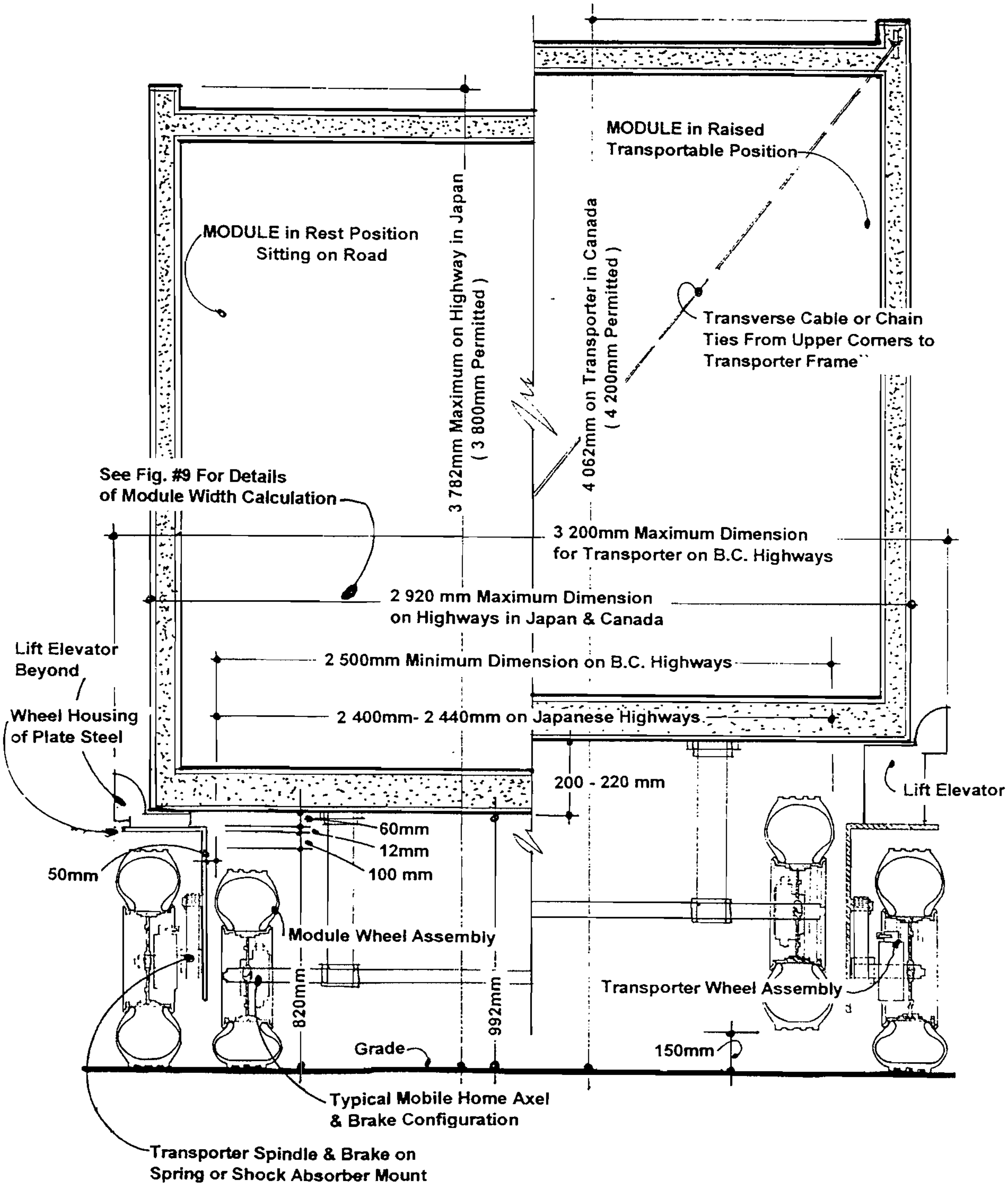
Each elevator is equipped with at least two shock absorbers as part of a hold-down mechanism. Unlike the air-bags which cushion the modules against downward movement, the shock absorbers act as restraining devices and prevent their too rapid upward movement in the cradles. This combination of air-bag and shock-absorbers creates the essentially flat ride which is essential to the crack-free shipment of the finished modules. The shock absorbers serve a minor secondary function which is to help pull the modules down onto the ground as the air bags are deflated at the unloading point. While one might assume that the module weight alone will compress the bags and lower the modules, such things as dirt and ice , along with a slow air release can cause the elevators to 'hang-up'. The shock absorberseliminate this problem.

The transport system contains a number of minor features. First, the removable cross braces, provide rigidity to the transporter frame, and prevent spreading of the long arms during movement. Whereas these braces work primarily in tension, they can be quite light, and possibly even be replaced with cables; however, the small additional compressive load they can carry may justify their retention as light weight HSS. In addition to the cross bracing, the modules will require cross ties. The ties can be cable or chains running from the upper corners of the modules down and across to the opposite frame. These ties can be connected to very simple holed plates which are attached to the header of the modules ceiling joists.

Finally, low bed trailers must be reduced in length when travelling empty in B.C. This is generally handled with a built-in telescoping section. While this is often accomplished in the overhang behind the triple axel, the transporter designer engaged for the project recommended moving the telescoping section forward between the hitch and th axels as this was considered easier, and less expensive to build.

There is one final element of the overall transport system which requires discussion and that involves the running gear which are attached to the modules themselves. B.C. highway regulations require that the minimum dimension from outside of tire to outside of tire can **not** be less than 2.5 m. While this is easy to implement on any modules which are hauled directly on their own running gear in B.C., this does present something of a minor problem when one attempts to accommodate both that dimension and the transporter wheel assemblies within the maximum transporter width of 3.2 m.

Figure # 3:
Transporter & Module: Cross Section in Pre-Load & Transport Position



This is illustrated in Figure #3 . Fortunately, the Japanese have no similar corresponding regulation. Therefore , one can have special axels for those modules which are to be shipped on transporters, and another for those modules which run directly on B.C. highways.

We have two options when selecting a module axel system,. We may elect to use disposable axels , which are often referred to as 'one-way axels' ,and discarded them at the job site or if we can find a means to economically return the axels to the plants, we might consider using a sturdier conventional axel.

Disposable axels cost approximately $300 for each CSA approved , 2540 kg. rated set. Consequently , for the modules in question we would require 2 axels at a total cost of $600 per module or $3,600 per typical home. Reusable axels are significantly more expensive at an estimated absolute minimum of $550 per axel or $1,100 per module and $6,600 per home. Given these figures, a manufacturer can determine at what point it becomes economical to utilize reusable axels and organize their return from the job site.

Assuming that the most efficient means of returning the axels is containerization , it would appear that the break point for the decision to return or not return axels occurs in the 42 axel range. This represents 21 modules or 3-4 homes, and constitutes the basic load of a 20' container. The decision will be based on the following analysis of detailed and estimated costs:

Load container in Japan	$ 500.
Container shipment in Japan	1,500.
Ocean shipment	2,500.
Trucking Vancouver-Kelowna (Worst Case)	750
Unload container	250
Total Cost	$ 5,500
Cost Per Returned Axel	**$ 130**

As the scale of the project approaches the 100 axel range one can use 40' containers wherein costs drop quite precipitously as the ocean shipping rates are only slightly higher for better than double the load , and the loading / unloading cost vary little, as shown in the following analysis:

Load container in Japan	$ 1,000
Container shipment in Japan	1,500
Ocean shipment	2,900
Trucking Vancouver-Kelowna (Worst Case)	750
Unload container	500
Total Cost	$ 6,650
Cost Per Returned Axel	**$ 70**

Based on these figures, one assumes that with the exception of limited one to three home orders, the manufacturer and Japanese buyer will cooperate to return reusable axels to the plant.

NOTE: The above discussion does not involve participation by any of the shipping companies or RORO vessel operators, being strictly a matter between the manufacturer and the Japanese contractor.

The proposed transporter system has a number of advantages. First, the system only requires one vehicle and one operator. Air-bags enable the operator to both load and unload the modules without any additional help, and the air-bags provide the cushioned ride necessary for shipping finished modules. Finally, the proposed transporter is consistent with current shipping practices within the manufactured building industry and as such, it can be readily produced and integrated without requiring changes to existing procedure, skills or towing vehicles.

Shipping Costs

Utilizing the above information, it is possible to prepare comparative estimated costs for shipping either a panelized or modularized home to a construction site in Japan. The panels would be shipped in standard containers while the modular units would use the RORO approach.. As with the other components of this study, this exercise adopts a conservative approach to the pricing, and utilizes the home illustrated in Figures #'s 4A-4C of Chapter #3 as the basis for comparison.

Shipping costs will vary greatly depending upon the distance of the manufacturing plant from the port, the chosen shipper, the port of destination , the distance to the construction site from the port of delivery, and the final delivery system adopted by the Japanese contractor. Despite these variables, the analysis in Table # 1 provides a sense of these costs, and is based on the following assumptions:

- The panels and consolidated materials can be fitted into two 40' containers.
- The modular homes encompasses six modules, each 2.9 m x 8.2 m x 3.7 m high
- The containers will be professionally hauled from the dock to the construction site.
- The Japanese contractor will haul the modules from the receiving dock to his construction site, using his own vehicles.
- The construction site is 100 km from the port.
- Costs such as dock receiving, handling ,port authority charges and insurance are included in the base prices given in the analysis.
- When appropriate, costs are averaged across a number of modules.

Based on these assumptions, costs are derived for the following shipping combinations:

In Canada

1. Modular units produced in the Vancouver area are towed to the dock by the manufacturer using a 3/4 Ton pick-up. or

2. Modules produced in the Central Okanagan region of B.C. are professionally towed to the dock using the transporter described above, and

3. Traditional 40' containers shipped from both Vancouver area and Central Okanagan plants

In Japan

4. Traditional 40' containers shipped to the construction site from the receiving dock or

5 Due to road conditions, the containers must be stripped and the materials loaded on smaller trucks for delivery to the construction site.

6. Modules are shipped from the dock to the site.

The details of the shipping costs analysis are shown in Table # 1 on the following page. This analysis indicates that shipping a six unit modular home to a typical construction site within 100 km of a major port will cost between and **$9,654** and **$11,156** more than it would cost to ship two 40' containers filled with the panels and pre-cut materials necessary to site assemble the same home.

If this approach to exporting modular homes to Japan is to be successful, the transportation difference must be offset through reduced site work charges , or in perceived extra value that arises from using a modular construction approach. These costs and issues are addressed in the following Chapter.

Table #1
Comparative Modular & Panelized Home Shipping Costs ($/Can.)

		Vancouver Plant	Okanagan Plant	Vancouver Plant	Okanagan Plant
CONTAINERS					
Load Container		$/Can. 555	555	555	555
Transport to Dock		200	580	200	580
Shipping Costs		2770	2770	2770	2770
Japanese Transport		1875*	1875*		
Transship to Truck				3063	3063
Unload Container		1752	1752		
Unload truck				1095	1095
Total - 1 Container		7152	7532	7683	8063
Total - 2 Containers		14,304	15,064	15,366	16,216
MODULES					
Hitches & Axels		450	450	450	450
Load Finish Mat's		40	40	40	40
Transport to Dock		100	300	100	300
RORO Shipping		3240	3240	3240	3240
Transport to Site		300	300	300	300
Unload Items		40	40	40	40
Total - 1 Module		4170	4370	4170	4370
Total - 6 Modules		25,020	26,,220	25,020	26,220
Minus - 2 Containers		14,304	15,064	15,266	16,126
Module Shipping Premium		**$10,716**	**$11,156**	**$9,654**	**$10,094**

* This is a relatively conservative figure. Container shipping costs of $3,700-$8,600/CAN. from the dock in Japan to the construction site are not unheard of. Obviously, if such costs were applied, the Modular Shipping Premium is significantly reduced. Typically, the cost of shipping a 40' container from Tokyo or Yokohama docks to a construction site 90 km distant is 1.5 times the cost of shipping that same container to Japan from North America.

CHAPTER 3 - MODULE DESIGN AND CONSTRUCTION

Introduction

While the focus of this project is the development of the RORO shipping system, it is useful to illustrate how those same modules can be organized into a home. This exercise facilitates a number of discussions. First, a specific house design allows one to view the modules in context and demonstrate how modules, with their relatively fixed dimensions, can be organized and augmented to meet the same diverse range of consumer demands and construction needs currently being met by Canada's alternate , and leading, export housing system of panelized homes.

Secondly, the following review also looks at the technical questions, designs and issues which must be addressed in a modular context.

The third points deals with the potential for future design initiatives or current options which could be incorporated to make modular homes more conventional in appearance.

Finally, a specific design is necessary for a detailed cost comparison. The cost analysis , which is presented in Chapter # 4 , compares the panelized and modular approaches to housing as they affect the production, site assembly and finishing of two identical homes. This comparison also incorporates the shipping cost analysis discussed in above. This chapter addresses these various issues through discussion of the home described below.

Today's typical middle-class Japanese home averages about 112 sq.m. , an area and volume of housing which can readily be accommodated in about 4½ of the2.9 m x 8.3 m modules which were the product of the shipping system analysis in Chapter 2.

However, in order to accommodate the typical inefficiencies of design, to recognize a sustained trend in Japan towards larger residences, and to offer the most rigorous comparison between the panelized and modular systems, the study adopted , as a basis for comparison, the six module house plan illustrated in Figures #'s 4A to 4C. An alternate five module home plan and elevations are illustrated in Figures #'s 4D & 4E.

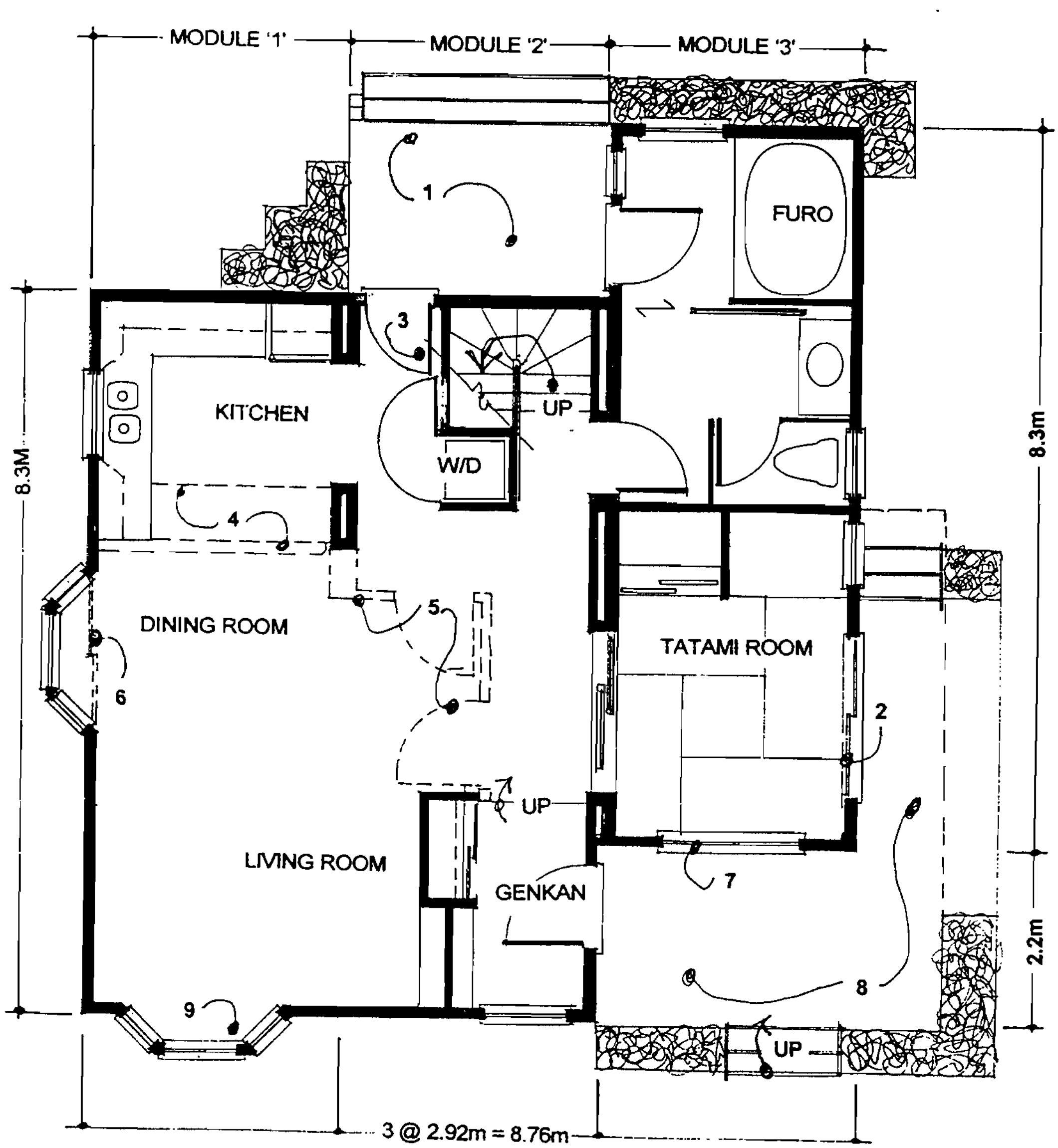
A technically oriented study such as this can not consider every market niche or potential family lifestyle. However, it is felt that the study home is sufficiently responsive to those markets that it reflects the prevailing range of home designs and lifestyle choices. Further, the arrangement of the modules and the home's internal layout attempt a compromise which optimizes the organization of the modules, while illustrating options which homeowners can economically include to customize the home to their unique requirements and desires.

Layout

The study home utilizes a somewhat traditional, and compact, rectangular floor plan. This layout is both an attribute of the modular approach, and a reflection of the relatively compact properties which are typical of most Japanese sites. However, within the constraints of site and system, the design attempts to incorporate a number of design features which expand the sense of home, respect traditional Japanese housing requirements and provide the opportunity for layout options and design excitement.

By recessing the right hand modules by 2.2 m, Figure #4A, we create variety in the home's somewhat simple facade, while at the same time

Figure # 4A:
Demonstration House: Main Floor - Six Module Style



ELEVATION - FIG. # 4C

OPTIONS:

1 Field supplied and installed rear deck and roof over.

2 Patio doors

3 Door c/w large glass panel

4 Eating counter

5 Dividing walls and doors.

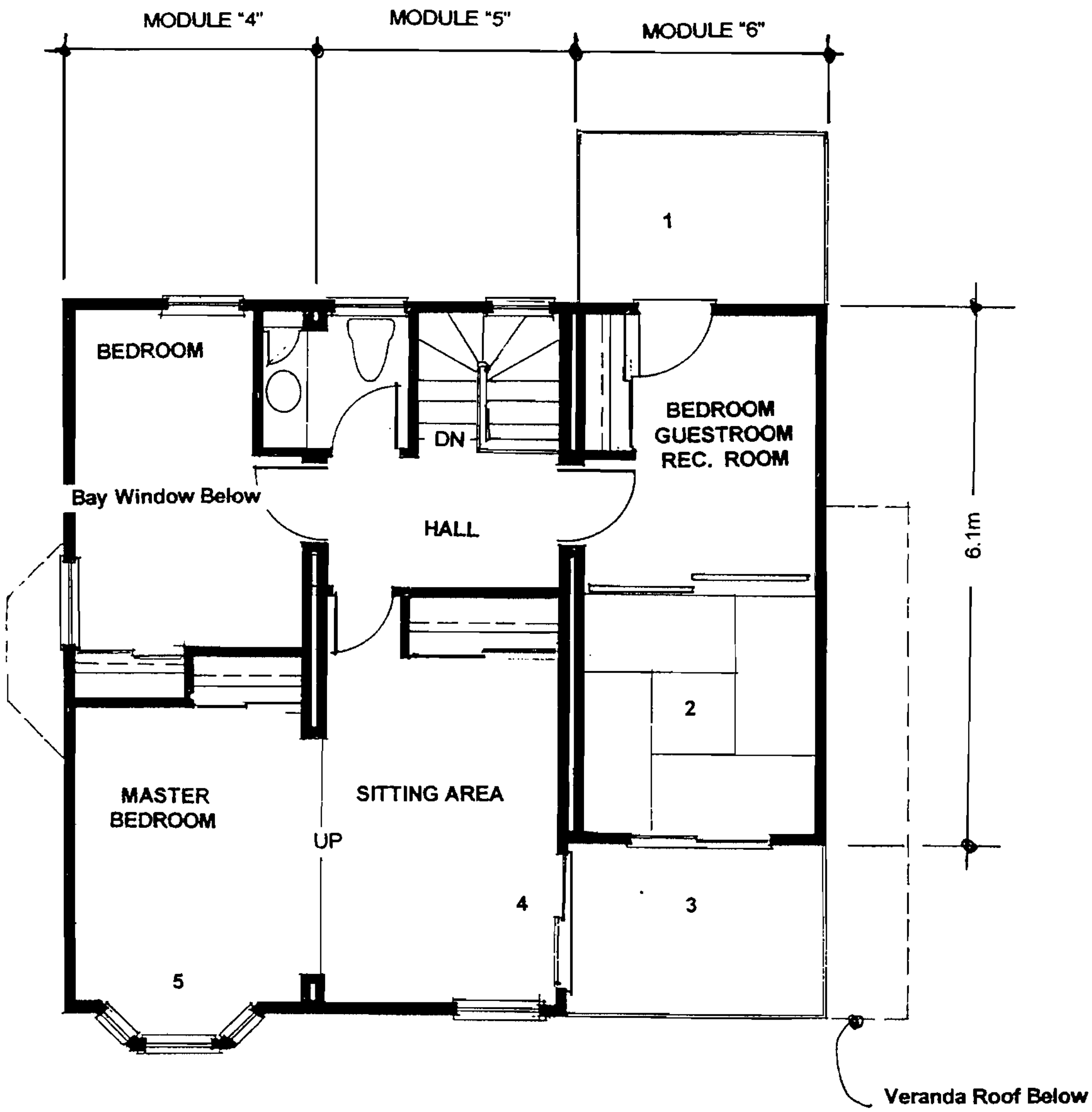
6 Patio door or window

7 Optional window location

8 Entry deck, roof and planters field supplied and installed

9 Field installed, surface mounted bay window.

Figure # 4B:
Demonstration Home: Second Floor - Six Module Style



OPTIONS:

1 Roof patio off of bedroom or roof.

2 Tatami area or room

3 Roof patio for master suite and tatami room or porch roof

4 Patio doors or windows.

5 Field installed, surface mounted bay window.

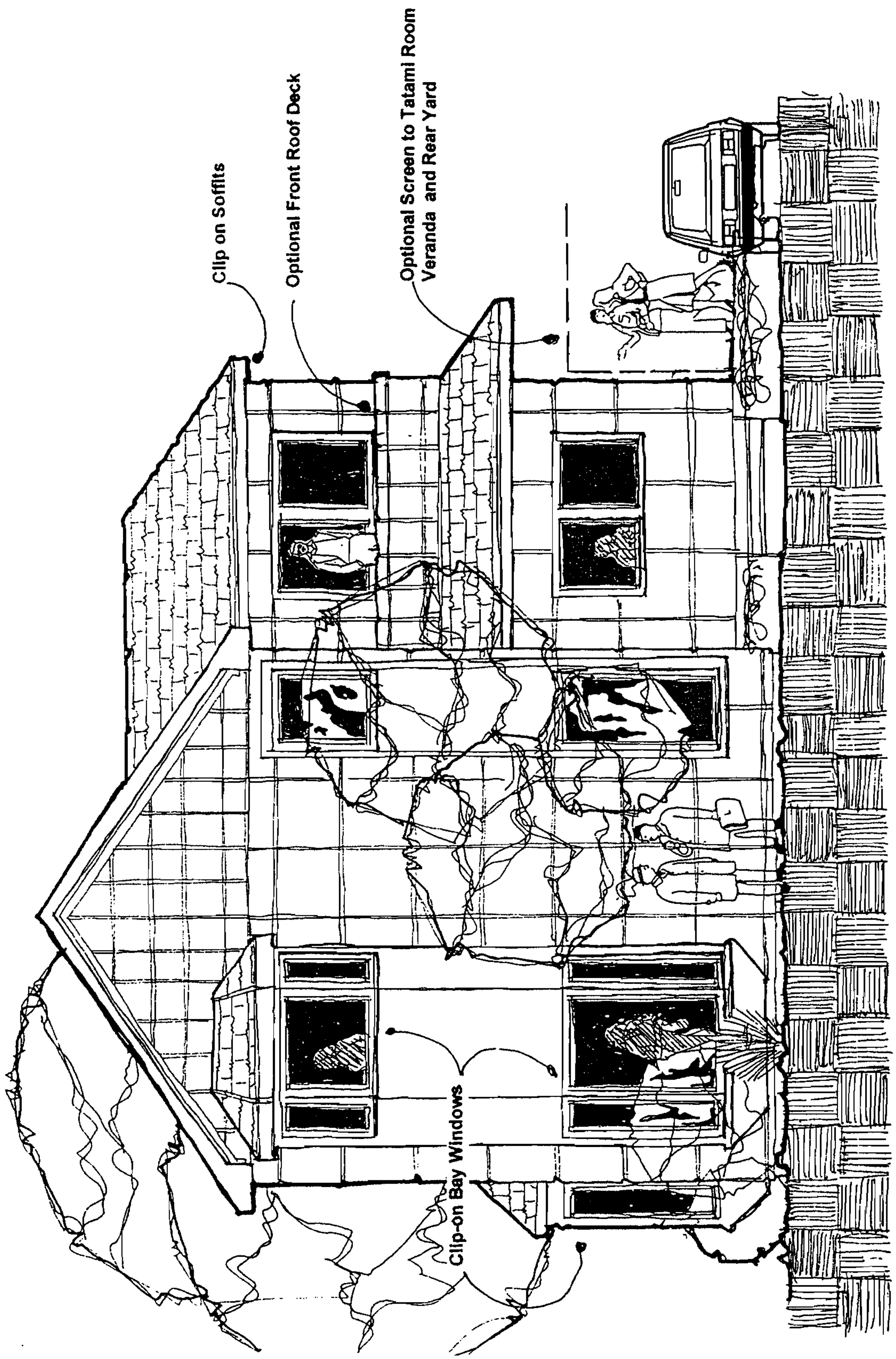


Figure # 4C:
Demonstration Home: Main Elevation - Six Module Style

Figure # 4D:
Demonstration Home: Second Floor - Five Module Style

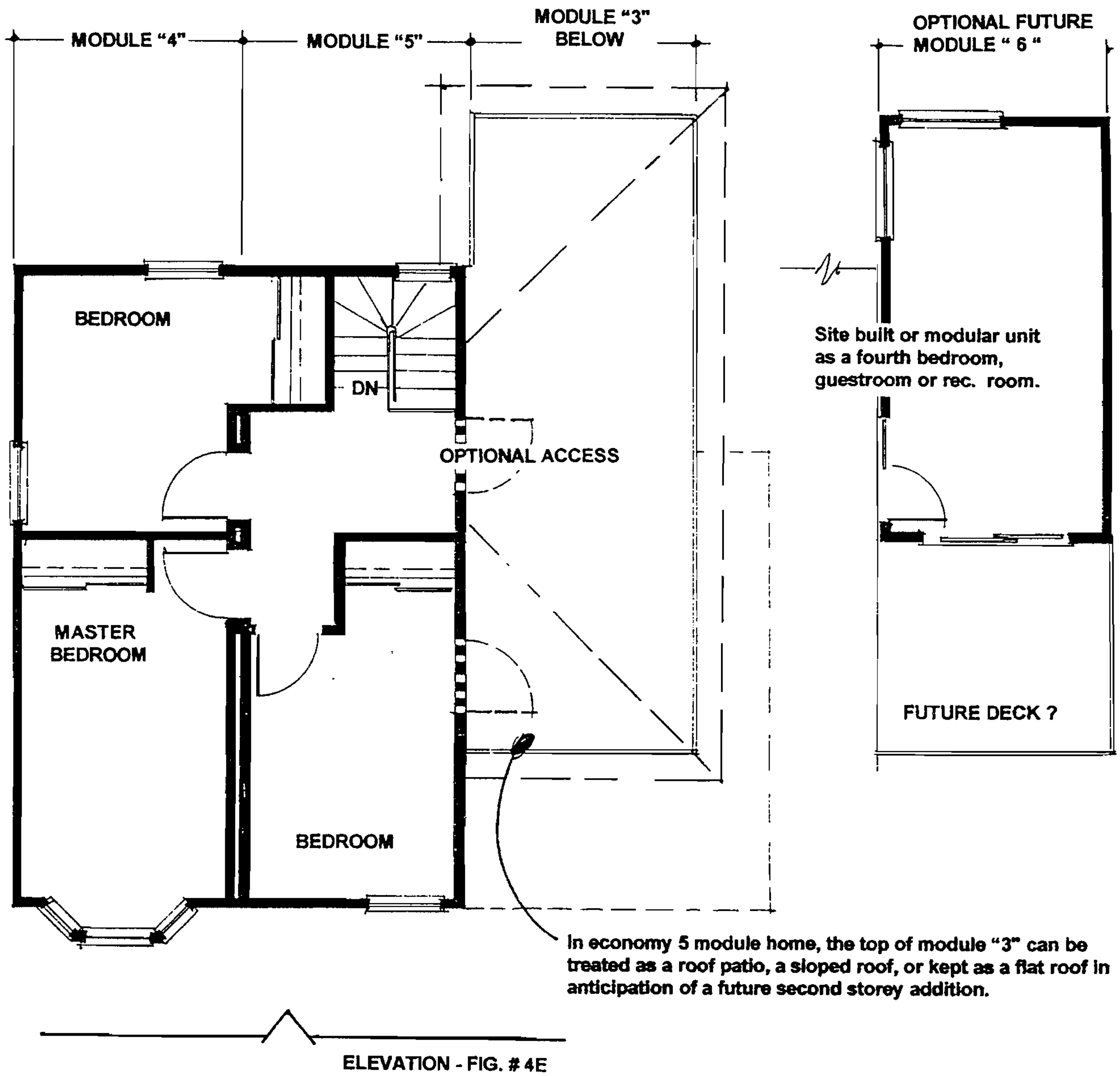
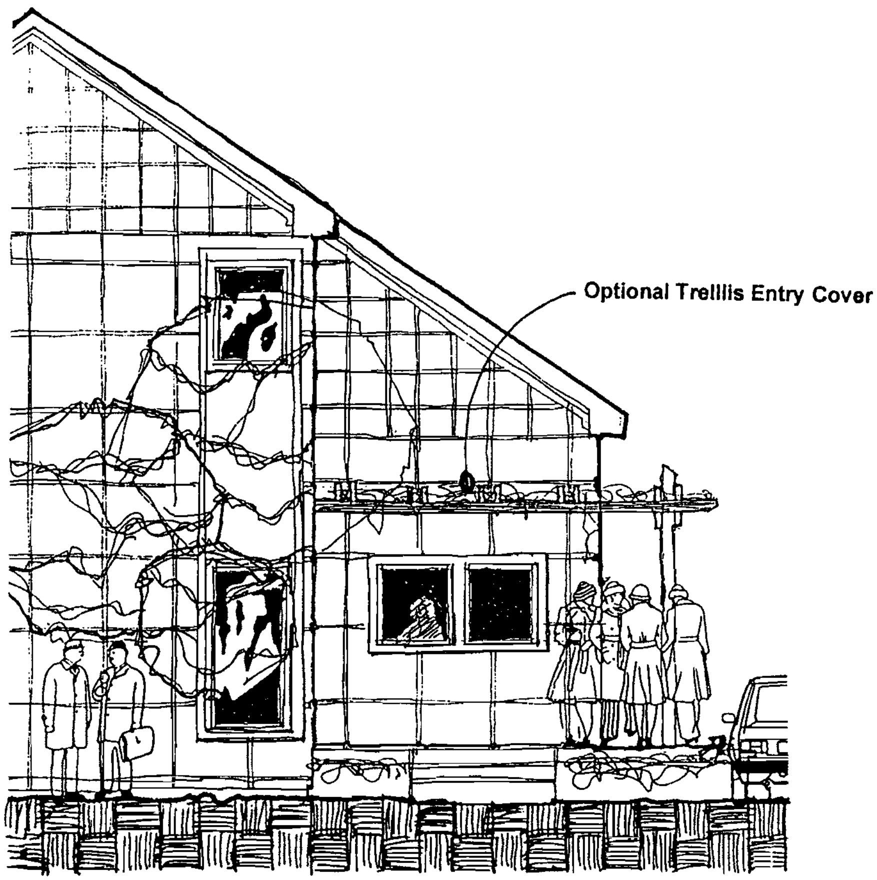
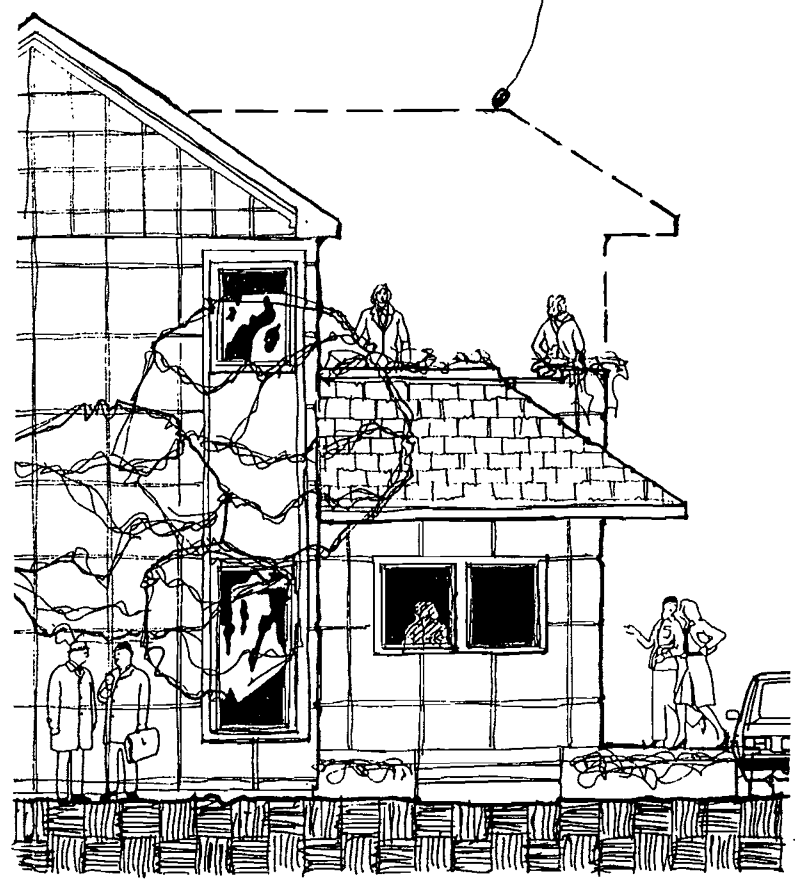


Figure # 4E:
Demonstration Home: Main Elevation - Five Module Style

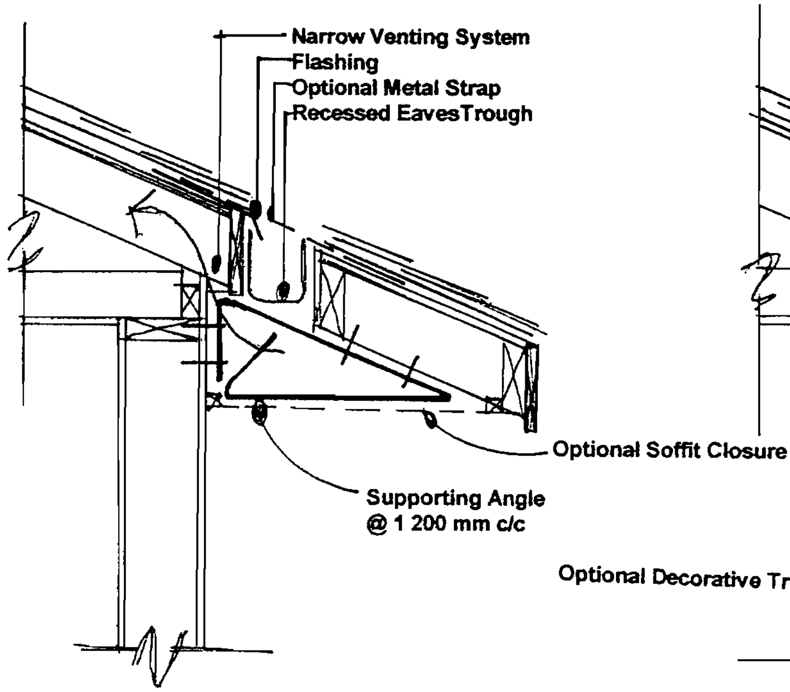


SHED ROOF OPTION ON MODULE # 3

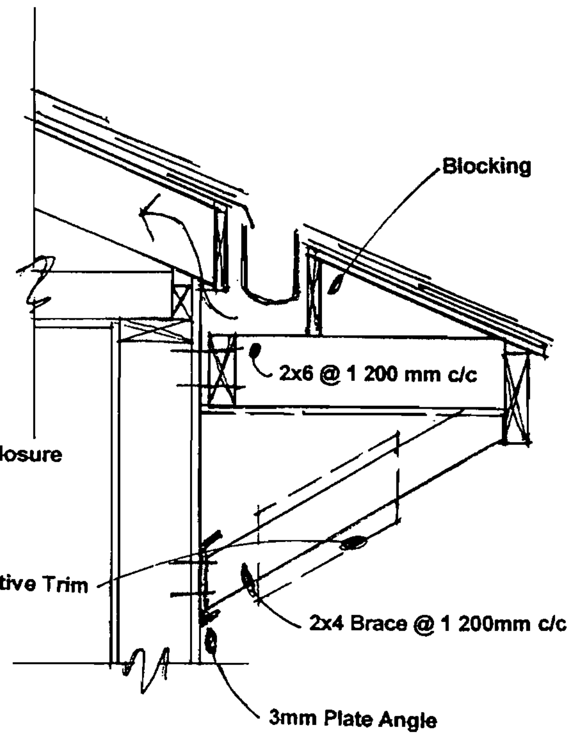


ROOF DECK OPTION ON MODULE # 3

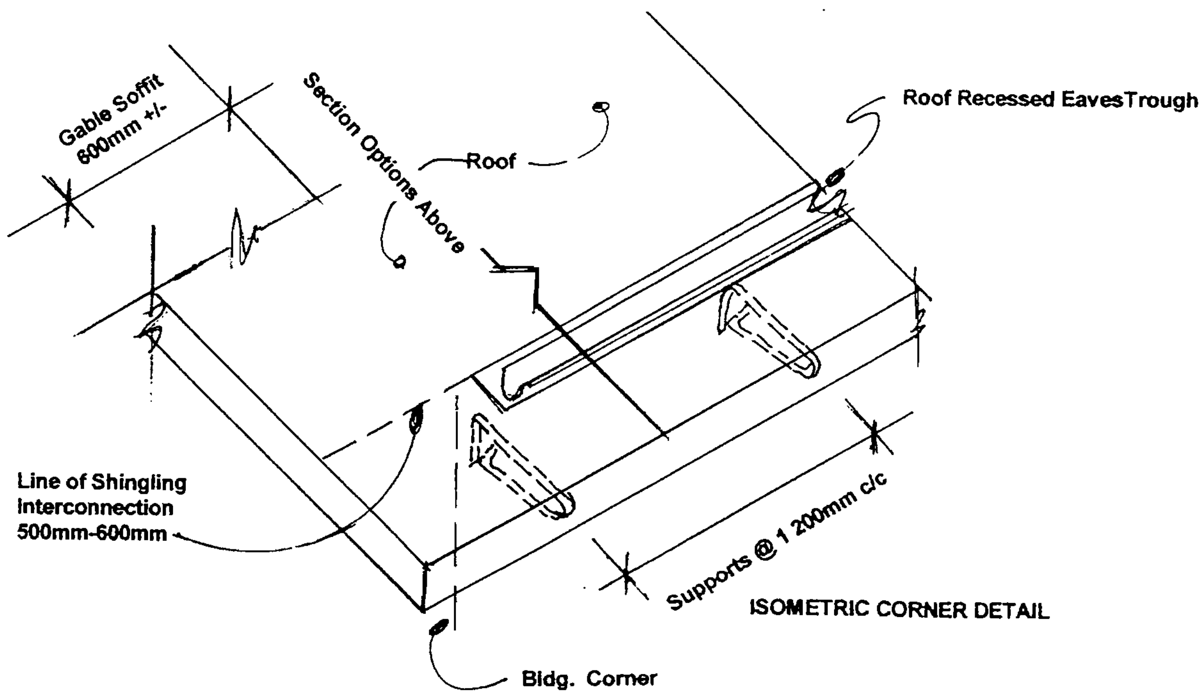
Figure # 5:
Clip-On Soffit Option



OPTION "A"
Soffit Extension - Metal Bracket



OPTION " B"
Soffit Extension - Decorative Wood Bracket



ISOMETRIC CORNER DETAIL

creating the potential for a sheltered covered entry porch. This will prove a welcome feature during Japan's often inclement weather. The home itself opens with a stepped-down and somewhat secluded *genkan* This hard-surfaced, and sheltered, spaces provides a measure of privacy to the main living areas while respecting the traditional entry.

From the *genkan,* visitors enter into a general circulation area which skirts the open living area on the left, and opens on the right into a traditional room of some 4½ tatami mats. The tatami room in turn opens onto an equally traditional site-built, roofed veranda. Depending upon the specific site, this can become an area of contemplative retreat from which to enjoy nature, or possibly an alternate access from the living area to the backyard. An optional patio door , of off the dining room, on the opposite side of the home serves the same function.

Those families wishing a more typical Japanese house plan with its set of formal rooms, rather than the greater sense of openness afforded by the great room concept, can elect to have the optional hallway walls and doors installed at the plant. Any modest up charge for this work should be largely offset by the savings from the additional work in floor finishing, in the hallway areas, which can now be included during manufacturing.

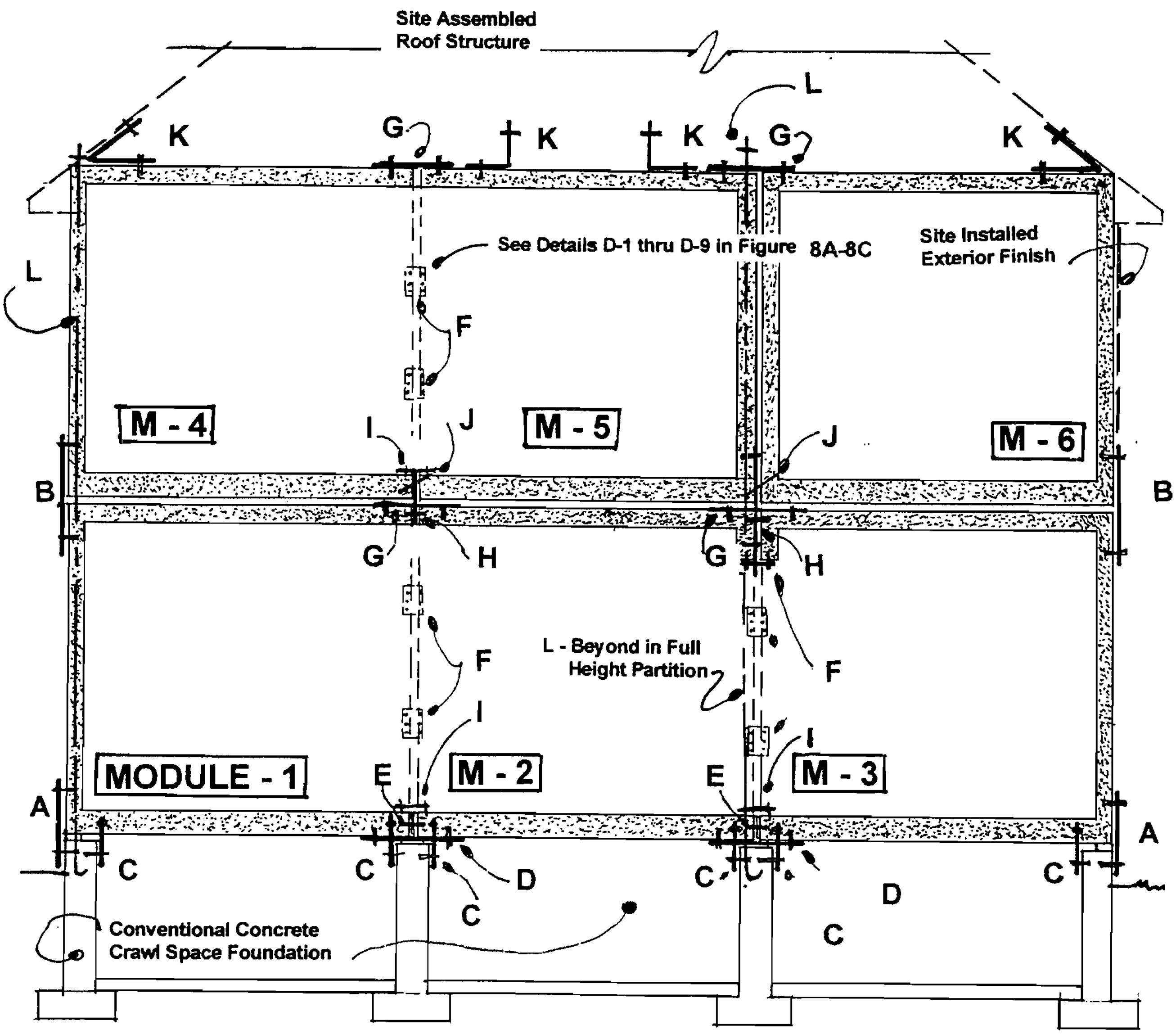
Entry to the bathroom or *furo*, the Japanese soaking tub, is discretely recessed at the bottom of the stairs for easy access from the second storey bedroom floor. By taking advantage of the module offset, the *furo* itself can be designed with an extra degree of openness or natural connection to reflect the family's lifestyle or to take advantage of the site.

As noted in Figures # 4B, this level of variety and options continues on the second floor . An optional western, half-bath can be included for convenience, or in a tighter five module plan, Figure #4D, this space can be incorporated into the adjacent bedroom. Obviously, spatial organization and uses can be readily rearranged to meet specific consumer needs. However, the illustrated plan suggests a one or two child family wherein the master bedroom has been enlarged for the comfort of the parents, while the combined areas, rooms #'s 13 & 14 can be utilized for a diverse range of activities ranging from playroom to guestroom. The value of these combined spaces is further enhanced by the module offset, and the truncation of Module #6. The resulting external second floor spaces at either end of Module #6 can , if desired, be developed as roof decks, a valuable feature given the comparatively smaller Japanese lots. Should greater privacy be desired for the master suite and its adjacent deck, the patio doors or windows in Room # 14 can either be eliminated , in favour of the rear-facing windows, or they can be replaced with clear storey units which admit light and a far view, but whose high aspect leave the master suite deck secluded.

Figure #4D illustrates further options. In the five module arrangement, the roof of Module # 3 offers a variety of choices. It can be finished as an extension of the main roof, see illustration Figure #4E, or left flat for use as a major outdoor space. This latter choice is not only useful in the short term, but presents the possibility of a modular or site built addition at some future date.

Because of its reliance on box structures, modular construction can, and often does, appear plain and oppressively two dimensional. In response, consider such inexpensive design options as the site-mounted bay windows, or the attachable prefabricated soffits illustrated in Figure #5. Additionally, site veranda and porch roofs can enhance the surface modelling and perceived texture of the homes. Furthermore, in terms of this project, the decision to utilize locally supplied, site installed, exterior finishes allows the contractor to customize the homes' appearances while producing units which reflect the surrounding community. For further discussion of exterior finishes see page # 44,

Figure # 6:
Structural Connectors: Optional Styles & Locations



POTENTIAL CONNECTORS - TYPICAL ALL BUILDINGS

A. Exterior Foundation Tie
B. Module - Module Tie
C. Foundation - Floor Tie
D. Horizontal , Joist - Joist Tie
E. Lag Bolt Floor Headers
F. Sub-Drywall Plate Connectors
G. Horizontal, Ceiling Joist Ties
H. Vertical, Module - Module Tie
I. Sub-Finish Floor Tie
J. Angled Lag Bolt
K. Module - Roof Ties
L. Continuous Hold Down Rod or Strap

Assembly Techniques

Design advantages are of little value if they are not parallelled by technical advances in terms of home assembly, structural integrity, safety and construction quality. Fortunately, given their method of manufacture and their basic shape, modules can readily meet these challenges.

Unit Placement

It is assumed that most manufacturers will design their module floor systems in such a way that they will be able to ship the units without using a supporting steel frame preferring to connect the axels directly to the floor structure. Consequently, the modules will have sufficient rigidity within their box structures to be craned, at the job site, or during ship loading and unloading, using only a spreader bar and web harness.

In the rare event that an underfloor steel frame is employed during transit, reinforced lifting points will have to be built into the module to facilitate hoisting once the module is removed from its shipping assembly at the construction sites. One option would be to use the supplemental tie-down points, which are bolted to various points on the floor's perimeter frame to secure the units during RORO transit. A worst case, and highly improbable scenario might see the addition of full height steel rods, with detachable top eyes being built into the modules' walls expressly for the purpose of lifting the modules on site. Regardless of the chosen method of lifting, the modest scale of the units will present little, if any, impediment to handling or placement of the modules.

Structural Integrity

Because modules are built as boxes, and by necessity encompass double mating walls and floors, they are exceptionally strong when combined into a home. Further, modules are engineered, not for normal construction loads, but to withstand the rigours and extended dynamic loads experienced during long distance transport. The strength of the individual boxes is augmented when the units are assembled into larger structures on site and connected by various structural straps and tie plates.

As noted in Figure # 6 there exist numerous opportunities to utilize structural connectors both to tie the individual modules together, and to secure them to the foundations against seismic movement. An exception occurs when one attempts to locate a finished module, such as Module #5, into a corner position with three other modules such as units numbers 1,2 and 4. While the other three units can be extensively tied together, the finished nature of the modules precludes access to any easily installed external links on mating line planes between the modules 2-5 and 4-5. See Figure # 6 on page # 34.

However, this is not to suggest that modules in similar situations to Modules #'s 5 & 6 are without connection capabilities. These modules can still be integrated into the overall structure with a diverse and overlapping series of ties.

Options include:

- vertical and horizontal strap ties between the modules, such as tie 'B', on their exposed external ends,
- seismic tie plates, such as 'F' in doorways and stub walls which span the module joints,
- angled lag bolts, installed behind the site installed baseboards, bolted into the adjacent floor headers
- steel rod connectors, see item 'L' which run from the foundation up through plastic conduit in the finished walls to securing plates and nuts in the attic.

When used in combination, these engineered connectors can provide any desired level of seismic, typhoon or structural stability.

Finishing Details

Once the modules are structurally secured, it is necessary to finish the gaps between them. The nature and design of the finishing details should reflect a compromise between the manufacturer's production process and the site contractor's finishing preferences and abilities. However, regardless of the exact design of the finishing details ultimately utilized, they should be developed to require the absolute minimum of site work. This approach is illustrated in Detail D-1 of Figure #7A which demonstrates how the finishing of a stub wall on the module mating lines can be organized to minimize the required patching and subsequent painting.

Traditionally, modular manufacturers terminate their work flush with the face of the studs at the edge of any opening. This leaves the site contactor to finish both the face of the two studs and the corners leading to the adjacent flat wall surfaces. Not only does that approach leave the additional, and difficult, corner work for site completion, but this approach means that the work must be carefully feathered into the superior plant produced large wall finishes, and additional care must be exercised to ensure that any paint or wall paper matches the broader wall surface.

Alternatively, as noted in Detail D-1, site work can be limited to patching the smaller flat gap, and painting is only taken to the corners where a change in wall plane, and the subsequent change in light, will mask any minor variances with the larger adjacent flat wall surfaces.

Variations of this approach are illustrated in Details #'s 2 thru 9, in Figures #'s 7A-7C, which cover the range of finishing requirements to be anticipated in a typical modular structure. The locations where the various details will be utilized in a typical home are illustrated in Figures #'s 8A & 8B.

The reader should note that the finishing details do not fully account for all of the potential interior finishes which might be requested by the future owner. The most extreme example of this involves the use of wallpaper. A finish used extensively in Japan . Consequently, the selection and design of particular finishing details should make allowances for its use. One example of an accommodation would occur in the living room where one might wallpaper the front wall of Module # 1 to a point near the joint with Module # 2. Following the assembly and patching of the Module #1-#2 joint the remainder of the wallpaper on the front wall, from its termination in Module # 1 to the edge of the bookcase behind the genkan in Module # 2 would be completed on site.

Because of the extreme variety of wallpapering options available , this finishing technique was not costed in the comparative analysis. However, one contributor to the report has suggested that none of the wallpaper be done in Canada as its use makes the repair of any potential drywall cracks both bothersome and expensive. Not all technical advisors shared this view, feeling that the small scale of the units and the proposed shipping scenario would almost totally eliminate any cracking. One production manager was so confident about the structural rigidity of these small sized modules that he would be willing to even grouted, ceramic tiled floors.

While no definitive conclusion was reached concerning the use or elimination of wallpaper, it should be noted that this work item will only entail about 9-10 man-hours on the construction site. Consequently, this is a relatively minor item which those wishing to pursue this market should investigate thoroughly with both the manufacturer and the on-site contractor. However, it was felt that this issue would have only a limited impact on any costing scenario. For demonstration purposes, it might be prudent to ship any initial test units

Figure # 7A:
Finishing Details - Main Floor: Locating Sheet #1

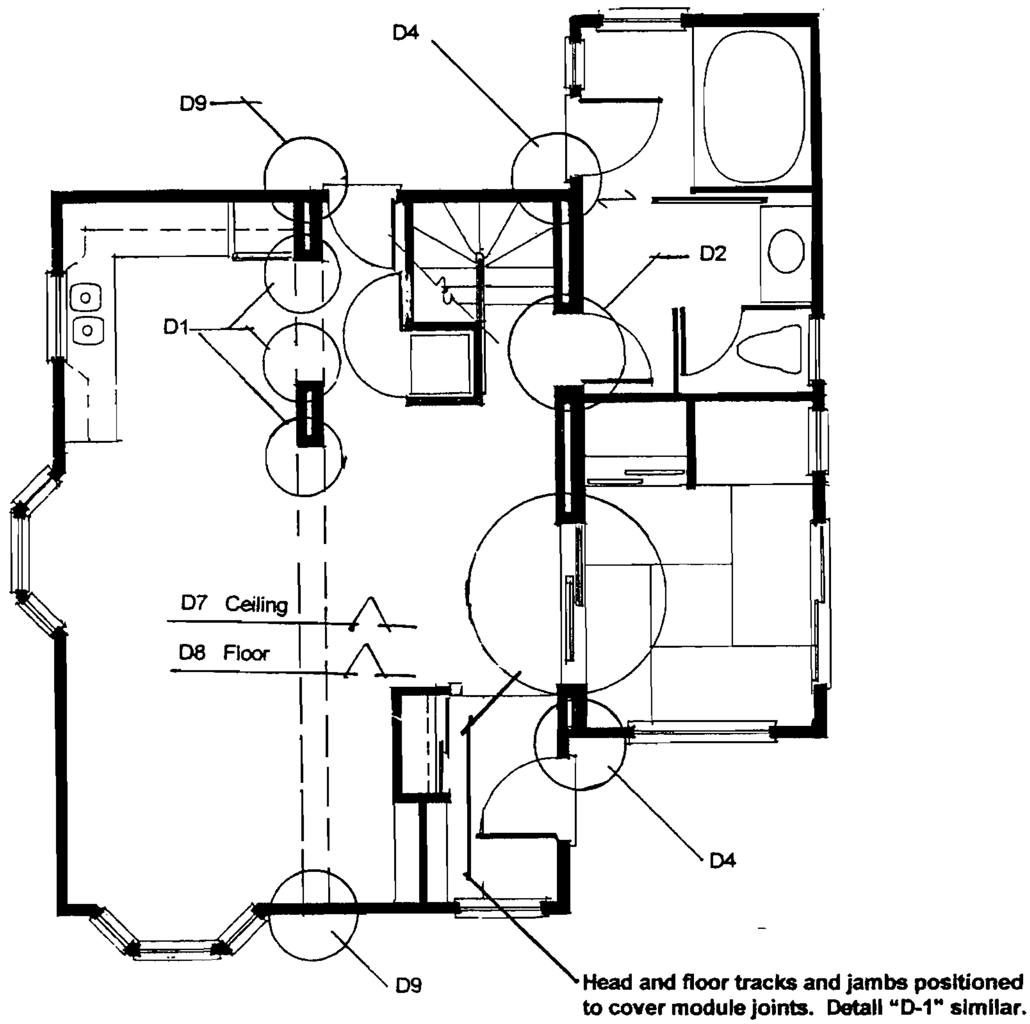


Figure # 7B:
Finishing Details - Second Floor : Locating Sheet # 2

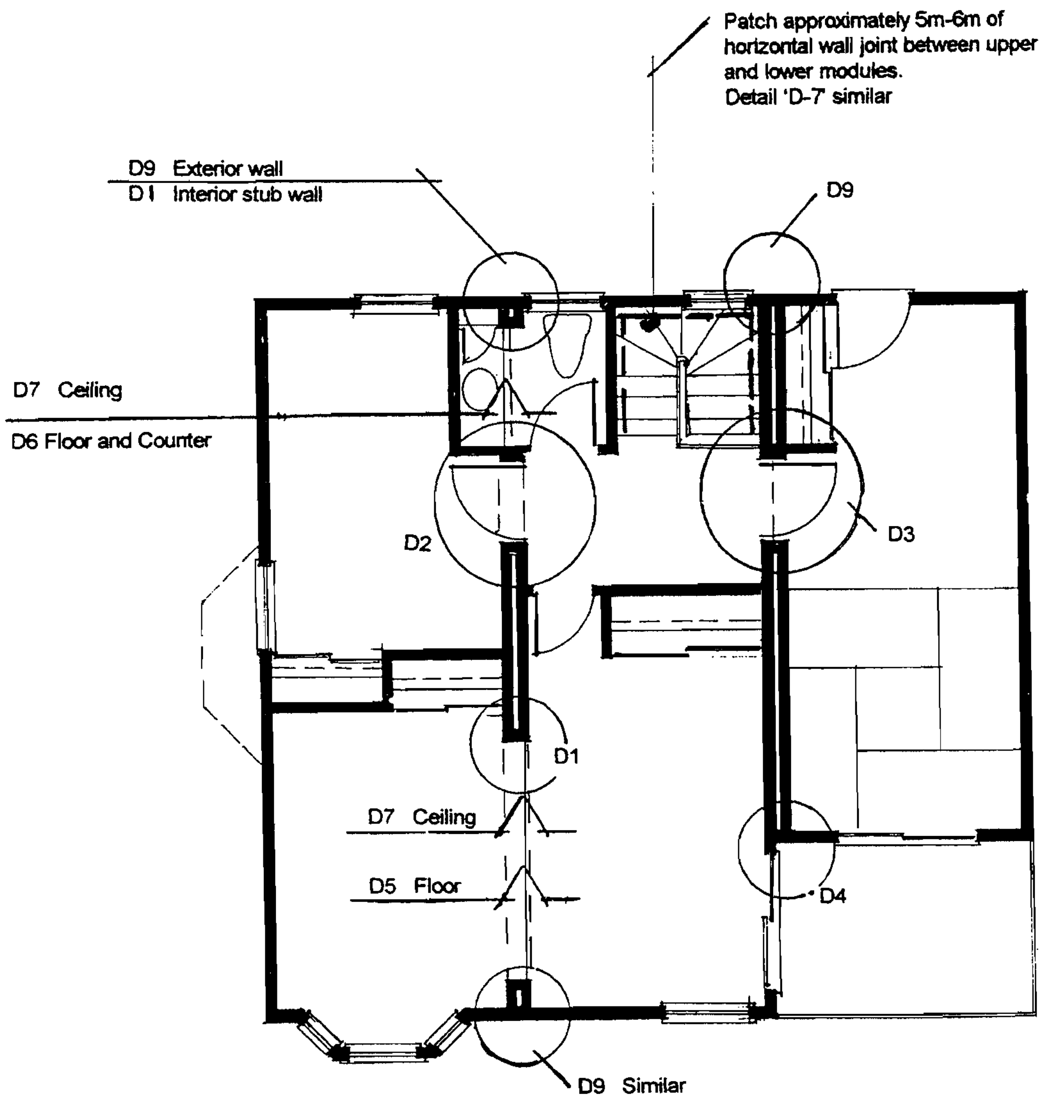
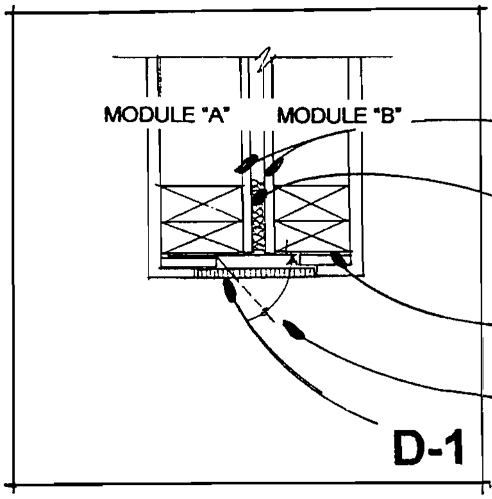


Figure # 8A:
Inter-Module Finishing Details: Sheet # 1

(S) = Work done on site (P) = Work done in plant



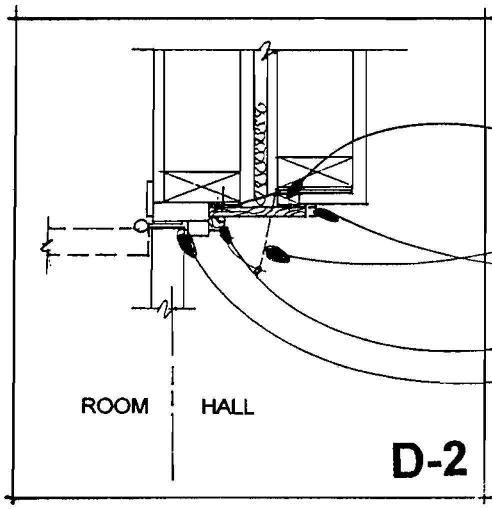
(S) Retention of sheathing used to protect mating wall during shipping recommended for additional racking strength while not mandatory. - TYPICAL

(S) Foam or fiberglas batt used to reduce air movement in cavaties. - TYPICAL

(P) 13mm nailer provides solid backing for drywall joint and allows some room for adjustment.

(S) Fold over and nail seismic strapping

(S) Patch with supplied drywall, mud, and paint to corner.



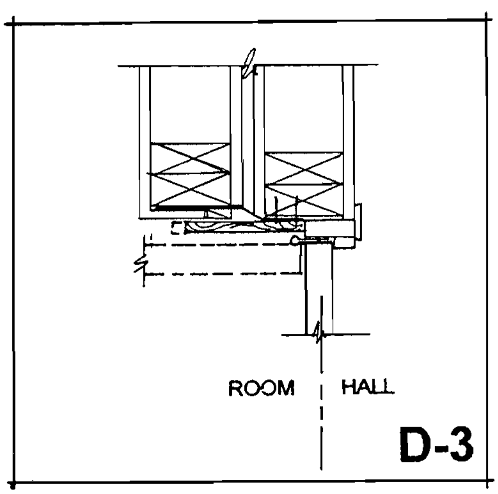
(P) Nail blocking

(S) Fold down and nail seismic strapping.

(S) Trim to length as required.

(S) Install finish trim

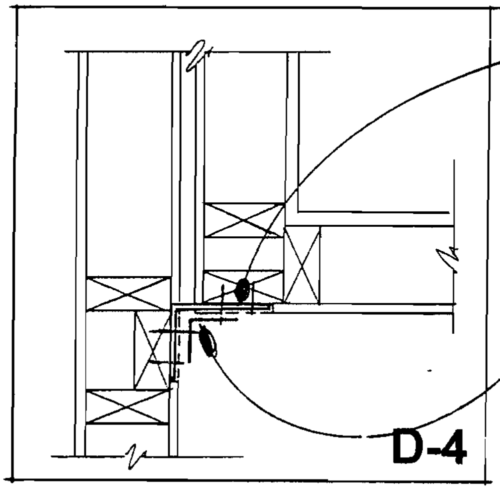
(P) Trim, jamb, stop and door.



NOTE: As per detail "D2" - showing arrangement when door is flush with walls of hall and opens into room.

Figure # 8B:
Inter-Module Finishing Details : Sheet # 2

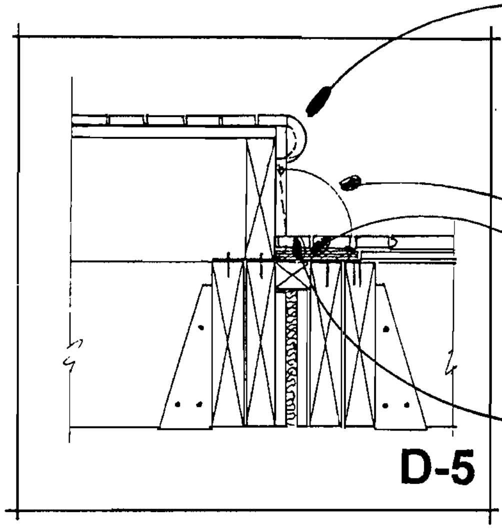
(S) = Work done on site **(P) = Work done in plant**



(S) Cut out shipping sheathing to recess seismic plates which are connected to studs as shown.

(S) Install continuous vertical flashing

NOTE: Detail for seismic plates on flat adjacent walls at the ends of abutting modules similar.



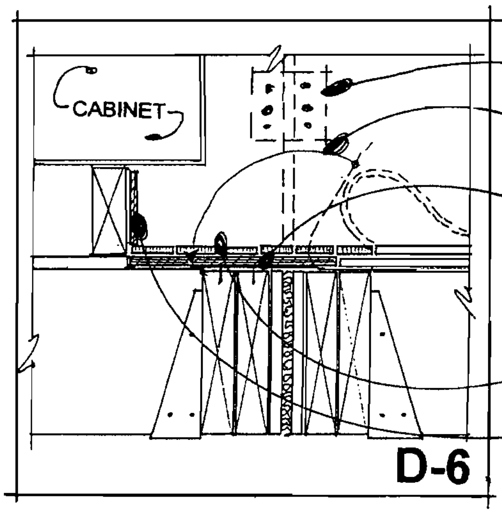
(S) Install small bullnose and roll carpet over and attach to fase of riser covering the joint of floor and riser below.

NOTE; If upper floor level is hardwood:
(P) Plant wood flooring installed to near face of step.
(S) Field install last strip of flooring , wood bullnose or edger trim and wood riser trim.

(S) Fold down seismic strip and nail to sub-floor.

(S) Blocking and sub-floor as required.

(S) Finish wood flooring into face of riser, cover joint with baseboard along face of carpet..



(S) Seismic plate connector under site finished drywall beyond

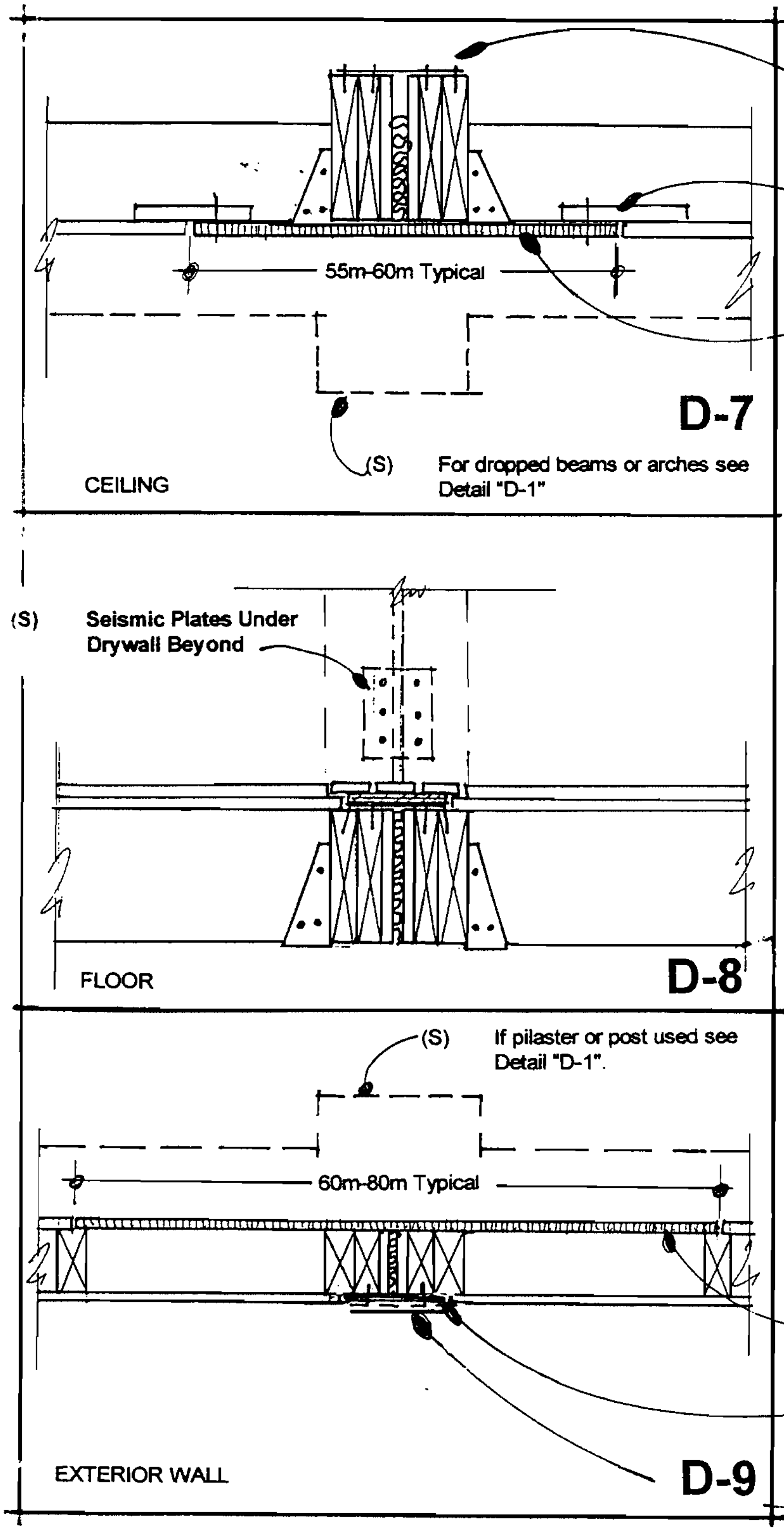
(S) Fold down seismic plate and nail to rim-joists.

(S) install sub-floor filler as required.

(S) Install ceramic tile and grout, or fold down and secure sheet vinyl.

(S) Install toe kick trim to hide floor-cabinet joint.

Figure # 8C: Inter-Module Finishing Details: Sheet # 3



(S) = Work done on site

(P) = Work done in plant

(S) Install seismic straps as required. In multi-family structures these double as fire-stops.

(P) 2x-ply-or drywall backing secured to joists or glued and screwed to plant installed drywall sheeting.

(S) Install drywall and secure to joists and backer.Mud joints and paint to match.

FLOORING OPTIONS:

Carpet & Sheet vinyl
Both materials can be plant installed and folded down over the module joints after the sub-floor is installed on site

Ceramic Tile
Can be plant installed in individual rooms. Hoqwever, if it crosses module joints in large areas, it should be installed on site. minor areas can be a combination as per Detail "D-6".

Hardwood Flooring
Option # 1
Do one module in plant and finish adjacent major area on site as per Modules #1 & #2.
Option # 2
Use random width flooring and install most of the flooring in the plant, but adjust on site for 300mm on either side of joint.
Option # 3
Install matched flooring in plant, but treat the joint on site as an architectural detail and use a board of varying width, grain or colour

(S) Install drywall and patch to match adjacent.

(S) Cut out sheathing to recess seismic plates and secure to studs.

(S) Install continuous vertical flashing.

without the wallpaper installed in order to gauge the degree of drywall cracking.

Environmental Envelope

Because of the varying climates one find's in Canada's export markets, this report can not offer a full range of alternative sealing details. However, given the flexibility of the system and ease of access to all joints, users will be able to readily integrate their own required details whether they range from additional lengths of vapour barrier which can be lapped and sealed on either interior or exterior joints, supplemental air barrier gaskets and seals, or taped patches to exterior air barriers such as TYVEK. The reader will note however that the illustrated details do suggest the use of either packed batt insulation or sprayed foam sealant at all joints. This small effort will greatly reduce, or entirely eliminate, drafts resulting from air movement within any interconnected wall cavities.

In summary, the illustrated modular approach can incorporate the latest in Canadian building theory, technology and products, and can be readily upgraded to reflect new advances or modified to meet the peculiarities of site specific conditions.

Fire Safety

NOTE: The following section does not purport to be a professional interpretation of the Japanese building code as it relates to fire safety, fire separations and fire stops. Rather, it is an effort to illustrate how modular construction can be adapted to meet the general requirements implicit in this form of construction. Designers , manufacturers and contractors wishing to work in the Japanese building environment are urged to familiarize themselves with both the local requirements for the use of architectural services, and the regulations contained in *The Building Standard Law of Japan*, and *The Building Standard Law Enforcement Order*.

Interconnected, hidden wall spaces are a concern from the perspective of potential fire spread. While this topic has greater application in the wood framed multi-family residential sphere, it is also as a concern in single family residences and as such must be addressed. This is particularly true of modular construction wherein stacked units, if not properly designed and assembled, could create a chimney-like cavity extending upwards of four floors from the foundation crawl space to the attic.

Fortunately, the detailing required to preclude such a draft chimney is as easy to achieve in modular construction as it is in conventional site framed structures. Various articles of the Japanese building codes stipulate differing floor to floor fire separations depending upon the type, and scale, of building in question. Generally however, these can be thought of as 1 hour separations similar in nature to Canadian requirements. This level of separation is readily achieved between floors through a combination of fire rated drywall, wood joist ,and floor sheathing. However, the double ceiling-floor construction which is typical of modular construction should be reviewed with the *authority having jurisdiction* during the preliminary stages.

The remaining area of concern involves dividing the inter-module spaces into acceptably sized fire containment areas. Despite the potential complexity and arrangement of the inter-module spaces, the required separation can be readily achieved by utilizing an appropriate combination of metal strip fire stops at the locations noted for ties 'F' , 'G' and 'I' as previously illustrated in Figure # 6.Generally fire stops, in Canada, are in the range of .38 mm thick and as such, can not act in a structural capacity; however, where engineering calculations demonstrate suitability, plus material and labour costs permit, the two roles may be served by one product with one installation procedure. Consequently, this approach merits consideration.

In summary, there appears to be nothing inherent in a wood-framed modular construction system, in terms of its structural reliability, environmental integrity or fire safety which would preclude its use in single family and low-rise multi-family residential construction. One might even suggest that the superior work environment of a manufacturing facility , when combined with the simplicity of the on-site assembly will facilitate superior construction and building integrity.

Future Additions

In order to allow the RORO shipping proposal to be considered in an existing and plausible context, it has been necessary to somewhat limit the basic discussion to conventional construction materials, designs and techniques. However, once the market begins to accept Canadian wood-framed modular units, manufacturers , exporters and contractors should begin to fully exploit the potential of the manufactured housing approach.

In addition to constantly innovative design, improving quality and minimizing job-site activities, consideration should be given to further manufactured input. Two of the areas for consideration are found at opposite ends of the construction spectrum and schedule. They are foundations, both the pressure-treated wood foundations (PWF's) and Insulated Shallow Footings (ISF's) and hinged roof trusses.

Preserved Wood Foundations

There are no engineering or environmental; reasons why a PWF foundation system can not be used throughout Japan. Full height and crawlspace PWF systems have been full explored, refined and utilized in Canada for decades. With proper engineering, a wood framed structure need not be limited to use above grade. Employing similar details to those currently used to tie the building to the foundation. we can , more than adequately, tie either a full height or a crawl space, pre-fabricated , wood foundation wall to conventional concrete footings. Appropriately engineered panels can be manufactured in the Canadian plants along with the modules, and then shipped in those modules, for subsequent erection on the Japanese, site-prepared footings as the underpinning for a modular home.

While it is recognized that PWF foundations and pads can bear directly on the ground, it is suggested that given Canadian consumers' historic resistance to PWF foundations, the concrete footings should be retained and marketed noting that it is the footing, not the foundation wall, which supports the home and ties it to the ground. The new PWF foundations walls merely bridge the gap between the footing and the first floor, just as the main floor walls bridge the gap to the second floor.

Insulated Shallow Foundations

Manufacturers might also wish to introduce their Japanese customers to Insulated Shallow Foundations (ISF). ISF's have been used successfully in Scandinavia for decades and are currently gaining acceptance in the North American residential market. Developed for use in colder climates where footings must be placed below the frost line, ISF's can significantly reduce the depth at which such footings must be placed and yet still protect the home against frost heave.

While the ISF approach is not a 'product' which the manufacturer can sell, its promotion has a number of advantages. First, by proposing a new construction system, the manufacturer establishes themselves as a primary source for information on evolving technologies. Secondly, because the system is cost-effective, its proposal demonstrates a concern for the contractor's bottom line. Finally, use of ISF's as part of a broad, Canadian based modular housing system greatly simplifies the requisite site work which enables more contractors to pursue modular housing ,or existing participants to undertake more homes. At the same time it creates a 'total' housing system which identifies Canada's modular housing as the system of choice.

At the upper end of the construction process, the roof, we find one of the most innovative and exciting of the manufactured housing techniques, the hinged truss. As illustrated in Figure # 9, the upper modular unit can produced with the roof system already attached, largely complete with shingles, and shipped in a folded-down position.

Hinged Trusses

Hinged trusses are available in the widest range of configurations. They can have optional soffits or peak closure panels. They are also available for all roof slopes from the conventional 5:12 pitch to the much steeper 12:12 model. As noted in Figure # 9, this later pitch readily accommodates an accessible attic, however, the module ceiling must be upgraded to accommodate the increased attic floor loads.

One will note that the overall shipping height exceeds most highway regulations. This is true for both the high axel approach , illustrated on the left and intended for use with the previously described transporter, or the road ready , low axel configuration shown on the right. While one can pursue a number of options to redress this problem, such as redesigned axel attachments, smaller tires, lower second floor ceiling heights or new truss designs, the market information and design criteria necessary to select the appropriate combination of remedial actions was beyond the scope of this project. Consequently, it is left for future clients, contractors and manufacturers to address this matter when a real-world option presents itself.

Steel Framing

Other areas for consideration include new materials such as light-weight, steel framing where advances in steel frame construction and commercial modular work can be transferred to the traditional, and export, modular markets. This will prove particularly marketable in Japan where concerns about fire safety are a continuing concern and which see manifestation in such regulatory responses as the establishment of fire and quasi-fire zones wherein combustible construction is either prohibited or significantly restricted thus reducing the market for Canada's traditional *wood* based 2x4 construction.

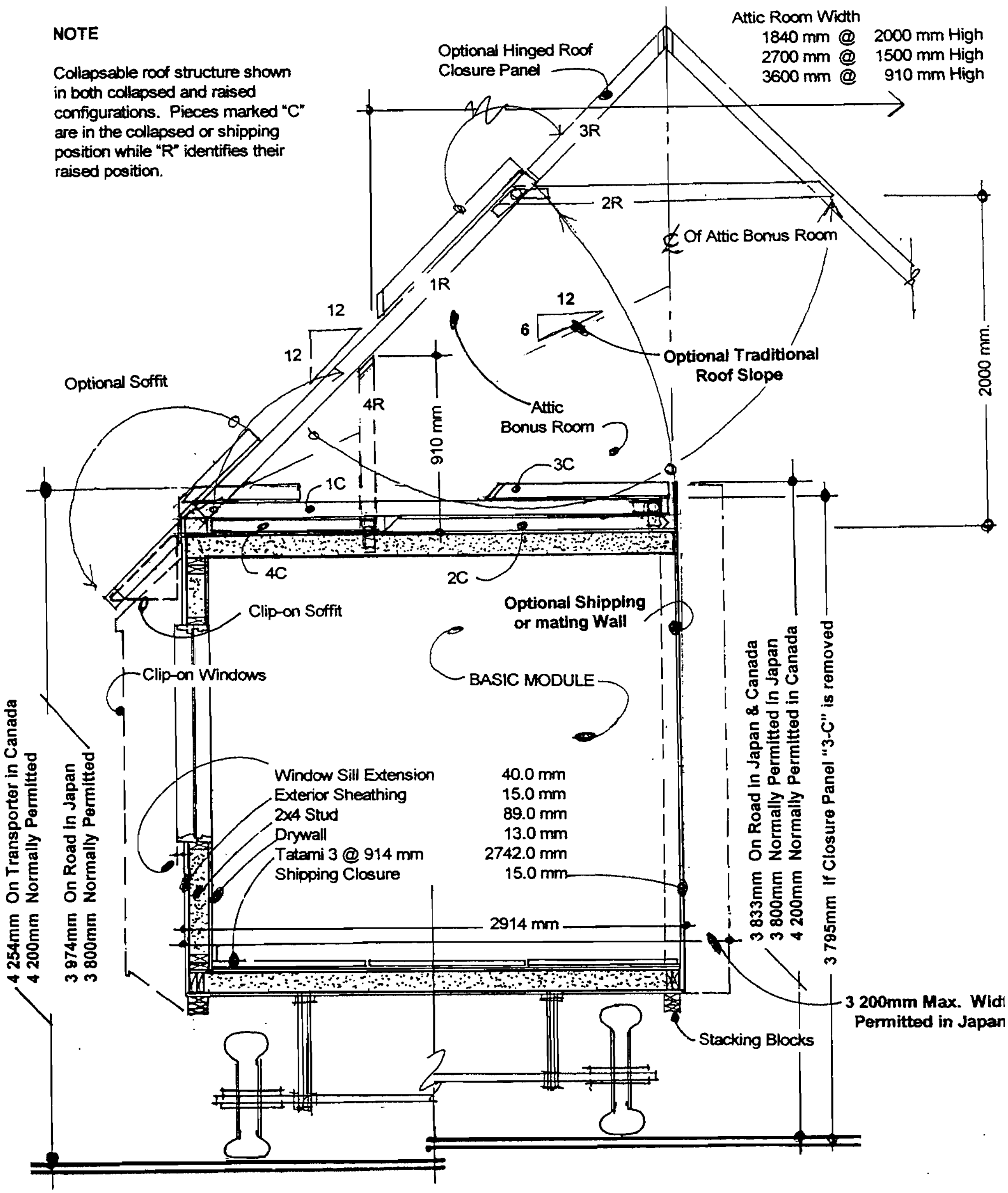
Exterior Siding

Finally, one could consider offering modules with fully finished, fire-proof exterior sidings. It should be possible to introduce a variety of the metal, ceramic composite, and synthetic panel type sidings which are currently employed in North American commercial and retail construction. While these finishes have not found a broad application within our own residential sphere because of their non-traditional appearance, they will fare better in Japan where single-family residences currently utilize a much broader range of synthetic, non-wood siding type finishes.

This report excluded the installation of exterior siding as part of the plant work in order to focus on a basic and readily implementable modular strategy which utilized readily applicable techniques and materials. However, a review of the house plans, Figures #'4A, 4B, and 4D show that 70% of the exterior could be installed at the plant. The only wall areas which are excluded from a 100 percent installation are both levels of the front and rear , flat, abutting end faces of Modules # 1 and #2 where a vertical seam might be difficult to hide in any horizontally patterned siding.

Areas such as the front end of Module # 3, which abuts the entry porch, can be finished to the point where it intersects with the exposed portion of the right sidewall of Module # 2. Any uneven joint will be covered by the corner trim which will also cover

Figure # 9:
Innovative Modular Concepts



Maximum Height Configuration Using High Transporter Running Gear in Canada

Minimal Possible Height Configuration With Legal Canadian Direct Road Running Gear

the joint detail. This also applies to the joint between Modules #2 & #3 at the back porch. Being able to take the exterior finish of Module#3 into the corners means that the plant can install all of the exterior finish for that module . In this discussion, it is assumed that the unit's facade design and detailing allows for the extension of the exterior siding, or a trim piece, across the horizontal joint between the flors.

In summary, the degree of plant work incorporated into the modules will only be limited by the units' designs and the willingness of the manufacturers to explore, and exploit, new materials and new opportunities. Manufacturers are encouraged to develop the concept of manufactured housing to its fullest potential and to think of modules as but one part of a broad *system* and to consider the fullest range of options, components and products which they can manufacture in Canada for world export.

CHAPTER 4 - ECONOMIC & MARKET ANALYSIS

Introduction

This Chapter looks at the economic and market implications of introducing the proposed RORO modular housing approach. The work opens with a comparison of the difference in costs between building two identical homes in either a modular or panelized approach. This is followed by a brief analysis which suggests the scale of market share modular units might be able to capture in both an initial and a mature market. The Chapter concludes with a discussion of what impact the introduction of this export housing product might have within the manufactured housing industry.

Comparative Costing

Because the cost comparison was conducted on two identical homes which differed only in their mode of construction, the work was significantly simplified as it was only necessary to look at the *differences* between the two approaches. This meant that common items are not included in the following calculations. A detailed list of inclusions and exclusions is provided below.

It is very important to note that we are **not** discussing the cost of the homes, but rather the differences in the costs to produce, ship, erect, and finish the two different sets of components to a common standard.

Comparative costs were gathered from three industry sources. Trucking and shipping companies provided estimates for the transportation component of the work. These were reported at the end of Chapter 2. A Canadian modular building manufacturer provided costs for producing, and preparing for shipping, both a modular and panelized home. Finally, a Canadian contractor, who is currently building in Japan, provided estimates for erecting the two different homes and finishing them to comparable levels.

Exclusions

It is easiest to understand what was included in the two cost comparisons by first looking at what was excluded. Essentially all common elements were eliminated from the comparison,exclusions entailed:

- land costs
- all construction and finishing materials
- permits or development fees and taxes
- land preparation, clearing or demolition
- site services, installation and hook-up
- excavations and foundations
- tieing the first floor to the foundations
- insertion of bay windows
- exterior finishes
- roof construction, tie-downs and finishing
- installed mechanical systems
- porches, porch roofs, external steps
- landscaping
- driveways or walkways

Profit Margin

The costing also excluded any references to a profit margin. This was done because the level of profit taking on exports has been known to vary very considerably between suppliers. It was felt that the inclusion of a profit margin might unduly skew the figures and that by its exclusion, other manufacturers will be able to use the costing information as base data and include their own profit ratios. From the consumer's perspective, it is irrelevant whether the profit of assembly is taken by the manufacturer or the site contractor.

Manufacturing Costs

A manufacturer of modular structures provided costs for both a modular and panelized approach to providing the homes. In the panelized scenario, this work included the supply and organization of what is know as a 'consolidated home package'. Within the export housing industry this means the collection and packaging of all of the components, excepting the exterior finish, necessary to produce a complete home. However, as this work component is similar in nature and scale to providing the same materials in a modular home, this work item is considered as a common element and consequently, was not costed separately.

Inclusions

Panelized home costs included:

- manufacture all wall components
- pre-cut floor and roof materials
- load materials into two 40' containers.

Modular home costs included:

- produce and finish six modules
- manufacture and attach towing hitches
- attach wheel assemblies
- load into modules and secure for shipping the finishing and roofing materials

Shipping Costs

Elements of the panelized and modular processes which had *shipping* aspects such as loading or unloading containers or attaching axels were disaggregated and reported in the shipping cost analysis reported in Chpater 3. This was done to clarify the impact of shipping related activities or attributes versus the more conventional manufacturing activities.

Site Construction Costs

The contractor provided comparative prices for the erection of the home in both panelized and modular formats. The contractor was provided with itemized worksheets to aid in the pricing. The information package contained details about room finishes and potential approaches to servicing. This information package and blank pricing sheets can be found in the Appendix for those wishing to replicate this element of the costing exercise. Recall that the following prices do **not** represent the cost of erecting the types of homes in question. Rather, these costs cover only that portion of work between the top of the foundation, and the underside of the roof structure, and exclude the exterior finish.

Further, it should be noted that the comparison is based on using labour rates such as might be secured by employing an imported Canadian workcrew. This was done to maintain the conservative approach as Japanese crews tend to be much more expensive due to higher labour rates. Anecdotal information suggests that a typical Japanese crew would be 15%-25% more expensive than a Canadian crew completing the same work such as that defined by the study between the foundation and the underside of the roof structure.

Panelized Home

The panelized home work items included:

- unloading two 40' containers, a consolidated housing package comprised of: wall panels, finishing materials, and pre-cut floors and roof
- organization, storage and protection of the building materials on site
- installation of all floors, erection of house panels, installation of second floor ceiling, all finishing plus the installation and connection of services above the foundation

Modular Homes

Modular home work items included:

- removing the wheel and hitch assemblies
- craning modules onto foundation and second floor
- join the modules with structural connectors
- complete the finishing of the modules as noted in Figures #'s 8A & 8B, and
- connect services at the foundation line.

Table # 2:
Modular & Panelized Home Manufacturing & Assembly Costs And Comparative Totals
Six Module Home Option

			Vancouver Plant	Okanagan Plant	Vancouver Plant	Okanagan Plant
Manufacturing						
Manufacture Modules	+		$ 23,952	$ 23,952	$ 23,952	$ 23,952
Manufacture Panels	-		3558	3558	3558	3558
Premium to Man.Mod's	=	(A)	20394	20394	20394	20394
Construction / Assembly						
Assemble Panels	+		34131	34131	34131	34131
Required Panel Equip.	+		1050	1050	1050	1050
Total Panel Assembly	=	(B)	35181	35181	35181	35181
Assemble Modules	+		4328	4328	4328	4328
Required Module Equip.	+		1500	1500	1500	1500
Total Module Assembly	=	(C)	5828	5828	5828	5828
Premium Panels Ass'bly		(B-C)	29,353	29,353	29,353	29,353
SUMMARIES						
Modular Shipping Premium (Table # 1)	+	(E)	10,716	11,156	9,654	10,094
Modular Premium	+	(A+E)	31,110	31,110	31,110	31,110
Panel Assembly Premium	-	(B-C)	29,353	29,353	29,353	29,353
MODULAR PREMIUM	=		**$ 1,757**	**$ 2,197**	**$ 695**	**$ 1,1,35**
Average Premium						**$ 1,446**

Five versus Six Module Homes

The work in this study has been conservatively based on discussion of a **six** module home. This home encompasses some 144 sq.m. and represents the average imported home. However, there also exists a viable market for homes in the 120 sq.m., or **five** module range. In order to assess the impact of exporting this model, the above calculations were rerun substituting the appropriate figures.

That analysis shows that the five module home ranges from $600 to $2,400 , or an average $1,250 **less expensive** to complete than a comparable panelized home finished to similar standards. However, the six module home will continue to be used for analysis and evaluation in order to maintain a conservative position, and to reflect the ongoing move to larger Japanese homes.

Market Analysis

To understand the potential beneficial impact that the introduction of this new export product might have on Canadian manufacturers, it is first necessary to estimate the potential level of market penetration such a product might enjoy. The first step in any analysis however must be a general understanding of the prevailing conditions and attitudes which influence the analysis within a given market . The following section provides a brief, general overview of the current Japanese market environment in which Canadian exporters will find themselves operating.

Market Environment

Traditionally, those wishing to do business in Japan had a perception, whether justified or not, that there existed a number of regulatory and cultural impediments which inhibited their opportunities to fully participate in the Japanese market place. However, in a recent effort to reduce the cost of new housing through the greater use of imported housing materials and housing systems, the Japanese government has undertaken a number of initiatives to counter any real , or perceived, impediments to imports, and thus ease the flow of cost-effective imported housing. These initiatives included both regulatory changes and the promotion of imported housing. This section looks at some of the government, and non-government, initiatives, or conditions, which effect the market climate upon which the subsequent market analysis assumptions and calculations are based.

Impediments

There are a number of impediments to the development of a modular export industry to Japan. These arise from two sources, those driven by market or manufacturing forces , and those established by various Japanese authorities.

Market Driven Impediments

During the background research for this project, concerns were expressed regarding the viability of a potential modular export industry, and they must be either countered or addressed in order to establish the appropriate atmosphere and context for this work.

Among the more interesting stated impediments is the belief that modular units must be ready for use and that Japanese contractors do not like to do 'touch-ups'. This statement is hard to rationalize when one considers that the bulk of Canada's current housing shipments to Japan consists primarily of pre-cut, consolidated and panelized components , all of which require essentially complete on-site building of the residence, and certainly all services, finishing and 'touch-ups'. In the best case, that of panelized exports, we are , in general , shipping components comprised of wood studs, ply or OSB exterior sheathing, some installed windows and door and occasionally inserted batt insulation . By comparison , if the markets are liberalized as Canadian negotiations seek, the modules being proposed will be complete with the exception of inter-module service connections, and finishing of the joints between the modules. This high degree of completeness will give the contractor a marked advantage over the user of current export products particularly in a market place where labour is becoming increasingly scarce and consequently increasingly expensive.

It has also been noted that the Japanese are very insistent upon adherence to tight delivery schedules, and questions were raised about the manufacturers' ability to meet the normally tight time-frames being requested of the panel manufacturers. In response , we must look at the overall construction process, and acknowledge that panels must be delivered rapidly as there still remains a significant , on site , work component which must be concluded before the homes may be occupied.

Further, panel deliveries must be rapid. First, to respond to the consumer's natural desire to get into their new homes and secondly , to allow additional *float time* to accommodate the vagaries of the Japanese weather , particularly their extremely wet 4-6 week period in the Spring , and the typhoon season in September. By comparison, modules are weather protected, high quality and plant built with delivery according to an ordered manufacturing and shipping schedule. Thus they will be preferred to the weather dependent panels currently being purchased by Japanese contractors.

Questions were similarly raised about manoeuvering the modules in Japan. References were made to both their highways and restricted job sites, particularly noting the difficulties currently encountered unloading containers, manoeuvring panel components and building a home. There will be sites, possibly many, for which the delivery or manoeuvring of modules is either problematic or prohibitive. However, there are numerous single, and multi-family home sites which can still accommodate the units in question. This is recognized in the following market analysis by the use of a very modest scale of projected market share.

Conversely however, even with mechanical assistance, unloading long panels from a container is difficult. While the containers are probably loaded from a raised dock and certainly from a clean concrete or asphalt surface over which panels can be pushed or readily carried by a fork-lift, the same panels must generally be unloaded at a flat, muddy construction site with the protruding foundations and service trenches.Problems which don't arise with modules.

One might argue that part of the problem with handling panels is the protracted time frame over which the panels are placed. Given the comparatively slow pace of panelized construction, with the intervening periods of floor framing, this requires an extended period of crane rental and a resultant cost. By comparison, modules not being containerized, eliminate the unloading problem, and it is an inherent part of the concept that they are craned onto their foundation from their street delivery point. Thus, the state of the construction site is an irrelevant issue. Further, a crane can be provided for the one single day during which the five or six modules of a typical home will be placed, thus reducing equipment costs. In summary , shipment and placement concerns appear to be without merit.

It was also suggested that there is no demand for this type of product being contemplated. In response, one need only point to Japan's existing annual market for some 43,000+/- modular homes , or the fact that one company alone , Sekisui Hiem , already produces some 20,000 +/- modular homes yearly. Regarding a perceived lack of a demand for Canadian modular products, as these units have never been offered in that market,what other condition could one expect ? However, about three years ago , there was essentially no meaningful market for Canadian panels, now we are Japan's largest housing supplier, holding somewhere around 45% of what was approximately an 11,000 unit market in 1996, and which is expected to grow to 50,00 plus homes in 3-4 years.

As further evidence of the growing popularity for export housing one need only turn to the publication put out by the Canadian Embassy in Tokyo titled *TRENDS in Housing and Building Products in Japan.* The January 1997 quarterly issue, listed four new companies which were entering the import housing market and announced the opening of a North American Housing Centre in the Saitama Prefecture. It is assumed that if modularized housing can meet its stated price and convenience objectives that this construction approach will enjoy increasing acceptance from residential builders.

Government Directed Impediments

On the regulatory side, the Japanese Ministry of Construction (MoC), has publicly stated its desire to reduce housing costs. The government sees imported housing and regulatory reform as key elements in achieving this goal. Some might argue that this represents but another element in a continuing strategy of appearing to respond to external trade pressures while actually continuing to protect domestic markets. However, there is significant evidence to suggest that is not the case and it is a legitimate effort to reduce trade barriers.

This evidence includes statements from the Japanese government, such as those in April of 1996 in which they indicated their desire to meet their import housing goal of 50,000 units annually and identified initiatives in immigration policy as one strategy towards that end. These moves will ease , and quicken, procurement of temporary working papers for contractors and construction supervisors whose participation in import housing is critical to its long term success.

This new attitude was demonstrated on November 19, 1996, when officials from the Ministry of Justice, acting on a complaint from the Canadian Embassy in Tokyo, visited the Yokohama Immigration office and finding 23 applications which had been stalled for over two months, approved them the same day. This discovery led to further action the following day, November 20th. , when the Director General for Immigration instructed all immigration offices to give priority to temporary work applications from construction workers and to approve them within three weeks, as was the stated government policy.

Similar progress on the technical level has included sending a new Water Works Law to the Diet for approval. This is particularly important in the context of this study. Previously, only plumbing contractors with businesses in any particular Prefecture could work in that area. This could have been a critical stumbling block to the import of fully serviced , and finished modules. However , with this potential relaxation, more of this work will be possible off-site , and make the use of Canadian produced products a viable option.

Further demonstrations of the Japanese market's, and the Japanese government's accommodation of foreign products, particularly Canadian lumber, can be found in any number of examples such as:

- 2x4 starts reached a new high in 1996
- the Canadian share of the market is up 63% on the preceding year
- the Japanese Ministry of Construction is in the process of approving the use of OSB from APA approved mills without the need for further grading to Japanese standards , and
- Japanese acceptance of North American grading standards and Canadian MRS rated wood ease the access for our exported lumber.

One might wonder if these government pronouncements have a publicly supported underpinning. The short answer must be YES! , for how else could one explain the phenomenal growth in both westernized 2x4 construction and the equally impressive growth in the sale of imported homes. Furthermore , there is considerable evidence that Japan's restrictive marketplace is breaking down . The widespread impact of **"kakaku hakai"** or "price busting" , is being felt in all segments of the consumer market. From the importation of dish detergents to the establishment of retail giants like TOYS 'R US , consumers are clearly exhibiting a preference not just for high-quality , but also for value pricing, innovative design and variety. Given these conditions, it is unlikely that the housing market will return to its earlier roots of traditional home and exorbitant pricing.

This finding is validated by a number of sources. One , the Japanese English publication TRADESCOPE goes so far as to include a report by the Sanwa Research Institute Corporation which suggests that deregulation and lower prices will ultimately be beneficial for the economy. in a sense, the Japanese market place is becoming, like its North American counterpart of the early 90's 'leaner and meaner.

Given this market background, it would appear appropriate to suggest that despite current impediments to the import of fully finished modular units, the government and the market place are moving to make their importation more of a reality, and it is against this background that the market analysis was conducted.

Market Analysis

Market analysis is by definition speculative. This is particularly true in this instance where we are discussing the use of modular components. This is a well understood and accepted construction approach within Japan but, we are also discussing acceptance of 'finished' components from a new and somewhat unconventional source and their delivery in an entirely new approach. Furthermore , the Japanese housing market is in a period of rather extreme fluctuation. Both local and imported 2x4 housing are experiencing phenomenal growth as consumers increasingly seek the space, comfort and cost-efficiency of modern homes. Recent code acceptance of three storey wood structures and the potential for multi-family low-rise buildings to employ this form of construction are also contributing to this market's growth.

Against this background , it is difficult to predict the potential market share for the type of construction being proposed; however , the following analysis attempts to provide a general overview of this issue and provide some indication of whether the concept merits serious consideration. While reviewing these figures , it is appropriate to remember that we are dealing with a market in which , at a time when Canada constructed 110,000 homes, the Japanese built 1.5 million or 13.5 times as many despite having only five times the population. However, despite this buoyant market, whenever choices are possible, a reserved approach and numbers are utilized in order to render the most conservative figures

Assumptions

These analysis and calculations are based on the following primary assumptions:

Cost Impact

Because the cost of the modular and panelized approaches are almost identical, it is felt that there will be no significant impact on contractors' decisions to favour either system. In reality, it is expected that the administrative ease and speed with which a modular home can be built will actually favour this system. However, this belief is not reflected through an increase in the figures and a neutral position is adopted for the analysis.

Catchment Area

The initial analysis is limited to those areas which fall within 150km of the four major Japanese ports of Hiroshima , Osaka, Nagoya, and Tokyo plus the island of Hokkaido.The areas, shown in Figure # 10, represents a combined market of some 80+ million people or 2/3 of the Japanese population , and encompasses in excess of 80 percent of their housing starts. The 150km radius was chosen as a reasonable limit over which one could expect contractors to transport the modules during the initial introductory period for both the product and its delivery system.

Housing Scope

The work assumes that the various efforts by the Japanese government to broaden access to their housing markets and lower housing costs will be effective within the next couple of years , and that wooden construction will be permissible in all residential structures up to three storeys. Consequently, approximately 82 percent of all housing construction or some 1,230,000 units will be accessible to the type of modules being contemplated in this study. Previously, only single-family homes , which constitute approximately 44.5 percent of the marketplace , were accessible to wood frame construction thus these new initiatives represent an almost doubling of the potential market.

Though it is not part of this study, nor accounted for in the market analysis, manufacturers should remember that there also exists a potential market for small-scale, commercial, institutional and retail structures, and that these markets should also be aggressively pursued. In many regards, this might be an easier market to crack, as there will not be the need to deal with the intricacies, tastes and personal requirements of typical home buyers.

Market Share

Canada currently holds a commanding 45 percent+/- of the imported housing market; however , given Canada's experience with modular construction, and our ready access via RORO carriers , it is suggested that we will each be able to capture 55 - 60 percent of any wood based modular market which we are instrumental in initiating and developing. Consequently, the analysis uses a compromise market share figure of 57.5 percent for impoted modular homes.

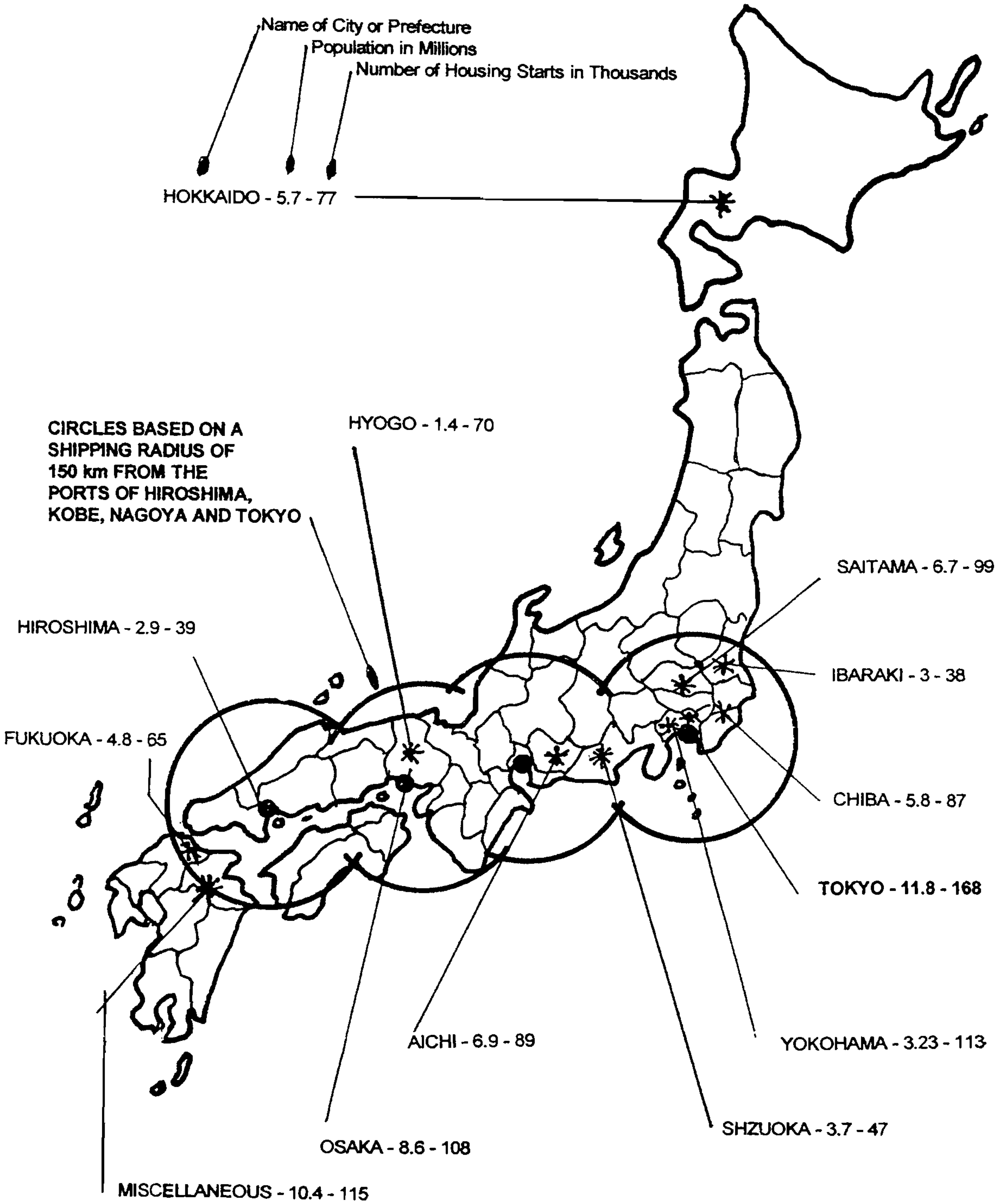
Imported Housing Rate

While the government has a stated policy of increasing the rate of imported housing to the 50,000 unit per year mark , Mr.Matsuki Mihara, Chairman of the Internationalization Committee of the Japan 2x4 Home Builders Association when speaking at a joint Canadian- Japan housing conference in June of 1996 noted that he believes that imported housing will eventually constitute 5 percent of all low-rise housing starts. When one includes all low-rise forms up to three story apartments, this constitutes 5 percent of some 1,230,000 units, as noted above, for a market demand of approximately 61,500 residential units. Given the very rapid growth in the 2x4 and imported housing markets , this assumption is not deemed excessive and consequently is the figure used in this analysis.

Market Penetration

A number of individuals and organization foresee a much expanded mature 2x4 housing industry . Some Canadian experts envision starts in the order of 250,000 units per year while some Japanese pundits suggest that 2x4 might capture upwards of 50% of all single family residential starts. This translates to some 350,000 +/- units per year. For the purposes of this study, we will conservatively use a low average of 275,000 2x4 starts per year.

Figure # 10:
Market Analysis: Catchment Area



Prefabrication & Modular Start

This represents a most difficult area to estimate as there is extremely limited disaggregated information available . Consequently, very conservative figures have been utilized in this section. While the official figures for prefabricated wood construction is in the 2.9 percent range of all starts, this figure must be carefully analysed to properly understand its true impact. Foremost , one must note that these 2.9 percent starts encompass some 36,000 units but because of previous restrictions within the Japanese Building Code , at the time these figures were compiled, all of these units would have been drawn from the single family housing component of starts. Furthermore , whereas the 'traditional' form of post and beam housing does not readily lend itself to panelization or modularization , it is assumed that the bulk of these 36,000 units are drawn from the small population of non-traditional starts which entails a more limited 94,000 units [Total wooden starts 697,000- 603,000 traditional homes.]. Consequently , the 36,000 prefabricated starts out of a 94,000 non-traditional population represents a 38 percent prefabrication rate for those units which are adaptable to this form of construction.

This figure represents a very significant conceptual increase in the rate and scale of prefabrication , and as such must be tested. To do this , we can look at the reported prefabrication rate for all forms of construction. Japanese construction data for 1991 indicates that the overall rate of housing prefabrication for all forms of construction was 19.4 percent. However , these figures again include the traditional homes noted above which should be excluded from the analysis for their lack of suitability for prefabrication. The net result is that the 19.4 percent of starts or some 288,500 prefabricated units are drawn from an accessible pool of 900,000 eligible units [1.5 million starts - 603,000 traditional homes]. This works out to be a prefabrication rate of 32 percent of eligible units.

While this figure is approximately 1/5th. lower than the single family home wood prefabrication rate note above, the two figures do roughly coincide and suggest that use of a conservative 32 percent rate of housing prefabrication in the following analysis is justified.

Modular-vs-Panelized Construction

Finally , we must consider what percentage of the prefabricated starts are modular units versus the more popular panelized homes. The best available information suggests that modular construction is approximately 15 percent of all prefabricated starts, and while it is reasonable to suggest that this percentage could be increased as Canadian exporters promote the advantages of wood-framed imported modules, we will use this conservative , existing figure in our calculations.

Given the various foregoing assumptions and calculations, we can generate the following range of market share calculations:

Analysis # 1 - Optimistic Scenario

This analysis assumes that modular starts within Japan will not only assume their fair share of the opening non-traditional , low-rise , wood-framed housing market, but that they will also secure an additional share of the traditional market as those units are increasingly replaced by 2x4 construction methods and materials.

Total housing starts			1,500,000	units
Eligible wood bldgs.	@ 82%	=	1,230,000	
Import target	@ 5%	=	61,500	
Prefabricated units	@32%	=	19,680	
Modular share	@15%	=	2,952	
Canada's share	@57.5%	=	1,697	units

However , as noted above , the initial market penetration is limited to that 80 percent of total

Japanese housing starts which occur within 150 km. of the major ports . Consequently, the initial market demand must be reduced by 20 percent.

Initial market	@80% =	1,358 units

For the purposes of this study it is estimated that the typical Japanese home will encompass some 120 sq.m. With the modules having an average area of 23.8 sq.m. this would suggest that each home can be assembled from 5 modules ; however in recognition of the vagaries of residential design , and inherent inefficiencies of typical layouts, we assume that each home employees 6 modules , although not all modules may necessarily be the full permitted 9 m in length. Further it is suggested that because apartment design tends to be more systematic and regimented each apartment unit can be assembled from just 3 modules . Given these figures and an assumed 80/20 split between single family homes and apartments, a 1,358 unit market share translates into a total of 7,333 modules. As the market matures , and we can base our production on 100 percent of the Japanese market , the annual potential will be some 9,166 modules.

To put this in perspective, this volume of manufacturing would, in the initial market , represent some 1,548 conventional mobile homes or roughly 24 percent of Canada's current production and require a total of 49 typical fully loaded RORO carriers, each carrying 150 modules, to transport the units to Japan . In the mature market, the corresponding figures are 1,933 mobile homes , 31 percent of current production and requiring 61 RORO carriers , or almost 2/3 of all RORO vessels visiting Vancouver, to transport modular housing units to Japanese markets.

Analysis # 2 - Modest Scenario

This analysis assumes that modular construction will only capture market share within the area of non-traditional housing and the 350,000 traditional units which will remain after conventional 2x4 construction has made its inroads , will not be accessible to further market penetration.

Total housing starts		1,500,000	units
Eligible wood bldgs.	@82% =	1,230,000	
Minus traditional market		-350,000	
	=	880,000	
Import target	@5% =	44,000	
Prefabricated units	@32% =	14,080	
Modular share	@15% =	2,112	
Canada's share	@ 57.5% =	1,214	
Initial limited market	@80% =	972	units
Modules		5,249	

In a Canadian perspective, the initial limited market represents the equivalent of 1,099 mobile homes or an increase of 18 percent in industry production and will require 36 RORO carriers to move the product to Japan . In a mature market the number of modules rises to 6,555 with the other figures rising to the equivalent of 1,374 mobile homes, a 22 percent increase in production and require the use of 44 RORO carriers.

Analysis # 3 - Minimalist Scenario

This analysis assumes that modular construction will be strictly limited to the 2x4 housing market component , and while deemed very unlikely , it is included as a worst-case scenario.

Total 2x4 housing starts	=	275,000	units
Import target	@ 5% =	13,750	
Prefabricated units	@ 32% =	4,040	
Modular share	@ 15% =	660	
Canada's share	@ 57.5% =	380	
Initial limited market	@ 80% =	304	units
Modules	=	1,641	

From a Canadian perspective, the initial limited market represents the equivalent of 345 mobile homes or an increase of 5 percent in production and will require just 11 RORO carriers to move the product to Japan . In a mature market the number of modules rises to 2,042 units or the equivalent of 432 mobile homes or a 6 percent increase in production and requiring 14 RORO carriers.

While the Canadian equivalents have been quoted as percentages of the entire national mobile home production, the reality is that the bulk of any new Japanese modular exports will likely come from B.C. and Alberta manufacturers; consequently, any increase in production will have a more dramatic impact on that fraction of the industry.

In summary , it would appear that in all but the most pessimistic , and unlikely, of scenarios, the potential market for modular units is quite significant and merits serious consideration by manufacturers and exporters. Further is must be recalled that the units identified in this analysis are in addition to existing or potential exports of panelized, pre-cut or consolidated homes. Further , no effort was made to identify the potential for sales into the non-residential wood framed marketplace. However , one would suspect that given our tradition with wood framed construction when coupled with some easing of the Japanese building code , that opportunities will exist , particularly for those already dealing in residential exports, to pursue and capture supplemental sales.

Market Impact

Having established a potential range for the increase in export activity of modular housing, it is possible to estimate the economic impact that activity will have on the manufactured housing industry. Like market analysis, true economic impact assessment is a complex issue and beyond the scope of this study. Rather, the following work draws together the various individual findings to provide a *sense* of the impact these new exports will have . Further, it does so based on a number of qualifying assumptions and exclusions. These includes:

i. The work is limited to the modular manufacturing process. Sectorial gains for increased transportation, dock or shipping activity are considered minimal by comparison and are therefore excluded.

ii. The analysis is limited to the impact of the labour transferred to Canada from the Japanese job site. No benefit is assessed for any potential increase in material sales. This avoids errors arising from varying material costs between plants, or benefits which are erroneously applied to goods which pass through Canada on their way to other export markets. Further, from a plant's perspective, materials are a pass-through expense and have limited benefit.

iii. Calculations are based solely on the *difference* between the costs of panelized and modularized manufacturing. This eliminates overestimating by assuming that even if modules were not introduced, the sale would probably have happened, as a panelized product, due to an expanding market.

iv. The calculations are based on the more conservative initial markets figures and thus are at least 20 percent below what one would expect in a mature and vigorous modular market.

v. The analysis is based on the use of the six module home design. However, it is assumed that the manufacturers will lower their prices by the amount of the average premium up charge noted above in order to compete directly with panelized homes of the same size.

Given that the average final cost premium for a six module, modular home is $1,446 , this is subtracted from the manufacturing benefit of $20,394 to give us a per unit , adjusted, beneficial cost impact , net off of the line of $18,948, which is the base figure used in the following analysis.

While not reflected in this analysis, one would expect the manufacturers of five module homes to conversely increase their prices by the average difference between themselves and panelized homes in order to secure the maxium price and profit.

Based on the above assumptions, we generate the following three analysis for impact, impact with profit, and multiplier effect impact. Figures in each have been calculated for each of the three market analysis scenarios.

While reviewing the following information, the reader should recall that in 1996 the Canadian share of the Japanese imported housing market was valued at some $143 Million. To put the following figures in perspective, each is accompanied by a figure which expresses the increased market impact as a percentage of those gross 1996 Japanese sales.

Further, and more importantly, readers , especially potential buyers of these modular homes **must** remember that, in this section, we are not discussing module costs, house costs or absolute profit margins. Rather, we are discussing the impact of the *differences* between a panelized and a modularized approach as they apply at the plant and any subsequent cost for modules delivered to a Japanese construction site will vary enormously from the figures quoted below.

These figures merely demonstrate that a modular approach to the construction of a home in the 34-42 tsubo range is both beneficial for the manufacturers and cost effective for the Japanese consumer; consequently, this approach merits serious consideration.

Potential Sales	x	$18,948	= Impact	= Percent
304	x	$ 18,948	= $ 5,760,190	= 4%
972			= 18,417,460	= 13%
1,358			= 25,731,380	= 18%

Profit

While profit was excluded from previous calculations, it is included here to provide some sense of the true impact or benefit this approach could have on manufacturing plants. However, as profit is perhaps the greatest variable in these equations, it poses the greatest difficulty. Attitudes between plants, or in one plant over time, can vary from "We need the work, let's do it at cost to keep the employees occupied" to "Let's charge whatever the market will bear." In application , this can mean anything from 0-55percent profit.

However, the current profit margin within the more traditional residential construction and the manufactured housing industries in Canada tends to run in the 5-10 percent range. By contrast, typical profit margins in the Japanese residential construction industry run in the 25 percent range. Given that the proposed modular homes represent a premium product, and we are dealing only with that element of the home which enjoys the greatest value-added component, a 15 percent profit margin is considered acceptable within the proposed Japanese context and is therefore utilized.

When applied to the above figures, we generate the following revised impacts.

Potential Sales x $18,948 x 15% = Impact = Percent

304	x $ 21,790	= $ 6,624,220	= 4.6%
972		= 21,180,075	= 15%
1,358		= 29,591,090	= 21%

Multiplier Impact

While these figures represent a significant potential increase in income for the plants, it is also possible to consider what impact these increased sales might have on related industries, or the economy as a whole as a result of the *multiplier effect*.

In B.C., where it is assumed that the bulk of the manufacturing will occur, the Canadian Home Builders Association has calculated that a new home generates 2.8 man years of work. The spin-off, or *multiplier effect* on the community generates another 1.2 man years of work which can be expressed as a 1.42 *multiplier*. However, this effect is based on the construction of a full home which includes the following items which contribute the associated percentages to the total costs: land servicing -3%, foundations-11%, sitework-3%, exterior finish-12%, roof-5% plus permits & hook-ups-7%, for a TOTAL of 41% of work and value.

Whereas these elements are excluded from a modular home package, the *multiplier effect* must be reduced by a corresponding amount. Further, the value of the *multiplier* will vary depending upon the size and quality of the home; consequently, a reduction in the order of 40 percent appears reasonable, and results in a reduction to a .85 *multiplier*.

Because of the efficiency of manufactured housing and the lower pay scales to be found in the plant setting, it would be appropriate to reduce the *multiplier* even further. Pursuing the conservative approach underlying the work a further reduction of 50 percent is applied thus resulting in a *multiplier effect* of .425 percent. When in turn, this is applied to the potential sales figures noted above we generate the following broad societal impact. Because this operation is applied to the absolute impact figures, complete with included profit, the percentage impacts remain the same while the absolute economic benefits increase as noted:

Potential Sales x $21,790 x 1.425= Societal Impact

304	x $ 31,050 =	$ 9,439,200 =	4.6%
972		30,180,600 =	15%
1,358		42,165,900 =	21%

Whereas the three sets of above figures represent the potential increase in export sales, it would appear that even at its modest scale, this market merits further investigation and possible development.

CHAPTER 5 - MODULAR ADVANTAGES & FUTURE POTENTIAL

Non-Monetary Advantages

While costs play a very significant and often deciding role in the selection of a construction product or system, they aren't the only consideration. As noted in Chapter 1, residential construction in Japan is in a period of flux both in the traditional terms of the number of starts, costs and new materials, but also in philosophical terms of what constitutes a 'modern, home, how long that home is expected to last or how the very housing industry which produces the home is organized. It is against this moving backdrop that Japanese contractors must consider, not just the dollar implication of their decisions, but how the products they offer fit into the market and how they fit into the industry. Consequently, it is also against this backdrop that manufacturers must position their products and market their benefits.

The six module home is very slightly more expensive than a traditional panelized home. However, the modular approach offers Japanese contractors some very significant non-monetary benefits which manufacturers must highlight in any presentation of their systems. These benefits are addressed in this chapter.

Additional potential advantages were not factored into the cost analysis as it was felt that the modules should be judged upon the basis of quantifiable criteria. Further, it was felt that any site related, added costs, or benefits, were too dependent upon the skill of the contractor, the season during which the units are placed and the locale in question for any individual benefit to be quantifiable for the study at large.

However, these benefits must be considered by any potential client, or contractor contemplating the use of modules, and should be used as selling points by the module manufacturer. The modular approach to residential construction offers benefits in four areas: marketing, contractor organization, ease of construction and new markets for Canadian initiatives.

Marketing:

Modular construction offers two marketing benefits. First, because the units are built indoors by a relatively stable and well trained work force, the units will be of a consistently high standard. Further, both manufacturers and contractors should emphasize for the consumer that with a modular produced home, the framing and sheathing of their homes are never subjected to the rain, snow or winds and potential damage which are typical of a site constructed residence. Also, it must be noted that Canadian produced units are not only built with the latest technologies, but unlike much of the Japanese housing stock, which was traditionally built to last 20-25 years and then replaced, Canadian units are built to last for generations.

Secondly, and more importantly, modules can be delivered according to a far more strict time schedule than conventional site-built or panelized housing. This benefit will be of particular interest to the large number of Japanese buyers who will be demolishing an existing residence to rebuild on the same site.

Because the modules can be produced while the family is living in their home and the site work is now essentially limited to demolition, foundations, roof and exterior finishes, the displaced homeowner will be able to reestablish themselves in their new home in a matter of weeks rather than the months which would have been required of a completely site-built home.

This benefit will become increasingly apparent and appreciated over time. The Misawa Home Institute has predicted that if things remain unchanged, by the year 2003, the average Japanese home will take something like two and a half years to complete.

Contractor Organization

Contractors do not make money building homes, they make money selling the homes they've built. Consequently, the more homes they can sell, the more money they will make. Modular construction helps them achieve this goal in a number of ways. First, because the contactor does not have to administer the manufacture or building of the bulk of a modular home, he can handle the organization of more foundations, roofs and siding crews and consequently increase the volume of his output with little , if any, increase in the size of his office staff. He could even see a reduction in his production staff.. Even when the contractor elects to maintain the same number of sales, his workload is greatly reduced , his overhead is reduced, his carrying charges are reduced while his profits increase.

This organizational benefit is further compounded when the Japanese contractor imports the modules directly from the Canadian manufacturer and eliminates the administrative burden, overhead and expense of dealing with a middle-man importer or distributor.

Another reduction the contractor will enjoy is the reduction in the number of customer complaints or queries during construction. Because so much of the home is either finished, or very quickly enclosed, there is less opportunity for, understandably sensitive, customers to review or criticise every stud and sheet of sheathing. In effect, it will be possible to use less 'cosmetically' attractive lumber. However it must be understood, this is **not** a call for utilizing sub-standard lumber and materials in the manufacture of the modules. Not only will such practices soon be noticed , and any such company penalized in the market place, but such practices will call into question the quality of all Canadian homes and greatly detract from the perceived premium value of our exports. It should also be noted that although the units are essentially finished on the interior and at least sheathed on the exterior, there are many exposed studs along the mating wall, plus the ceiling and floor structures will be open to significant review and evaluation until the modules are mated on the construction site.

Lastly, because the work required to place and complete a modular home is both greatly reduced and generally requires less skill, the contractor can draw from a larger labour pool for the general construction or module placement and assembly. When he is required to utilize more highly skilled personnel, such as in the finishing, the contractor will require their higher priced expertise for a far shorter period. This will become increasingly important as the number of construction workers continues to decline some 45 percent by the turn of the century, and a further 30 percent over the following decade.

Canadian residential manufacturer can assist in further reducing the site component of the work, while increasing their value-added contribution, by offering additional components beyond the modules which are the focus of this study. Every modular manufacturer is in essence a panel assembler. That is to say, modules are produced from panels which the manufacturer first frames up and then assembles. Consequently, limited additional effort is required for manufacturers to offer contractors a series of framed, and sometimes finished panels for such elements as veranda decks and roofs or semi-enclosures for car ports. These panels can be shipped inside the modules at no additional charge and assembled, or installed, by the contractor on site at a considerable saving in organizational bother and labour expense. This would include the PWF foundation systems which were discussed earlier.

Lastly, Japanese contractors should be encouraged to consider the potential which might arise from using the modules as shipping containers for the importation of foreign construction materials. Because the modules are transported essentially empty, they are very light , when compared to traditional ship cargoes. Consequently, shipping charges are based on module volume and not weight. Thus, it is possible for the contractor to work with his module manufacturer to use that interior module space much like a container and import light-weight, but bulky items which he can now ship essentially free from Canada.

Ease of Construction

The contractor will also see benefits on the actual job site. Because the units have been engineered, there is less material wastage in the units for which the contractor must pay. Perhaps more importantly, this approach produces significantly less, on-site, construction waste for the contractor to pay to dispose of. In some jurisdictions, construction waste haulage and disposal can represent a very significant cost element.

On a more modest scale, modular work entails far less damage , either from competing trades or the weather, less lost time due to poor weather and less theft, pilfering or vandalism.

Given this range of supplemental benefits, current modular, single family residential construction merits serious consideration as a construction approach.

New Markets & Canadian Initiatives

While the report has focused on the use of modular units in single and multi-family residential settings, manufacturers should consider potential sales in the non-residential markets. Small office buildings, retail outlets and site work offices can all be built with modular components. One area in which modular building are particularly cost effective are the more remote construction sites where the importation of highly skilled labour can prove prohibitive. In these instances, plant manufacturer and shipping can often prove very competitive.

Once a manufacturer has established the value of his products in the market place and forged a viable relationship with a suitable contractor they should begin to explore alternate structures types on which to bid. However, as many buildings are designed in such way so as to preclude their modularization, manufacturers should be prepared to market their products to potential clients, engineers, architects and designers at the pre-planning or pre-design phases in order to have an impact on the subsequent building layout.

The Canadian manufactured housing industry, either as individual companies, or as associated suppliers, might consider some organizational initiatives which would improve the performance of all Canadian suppliers within the Japanese market.

First, they can establish industry wide Japanese sales or information offices which would provide easier access, for both consumers and contractors to technical information on all available systems, companies and products. While much of this work is currently undertaken by various Canadian government agencies, moving to a more commercial operation would provide greater opportunity to commercialize the operation.

Next, Canadian companies working in Japan might wish to consider some level of centralized Japanese joint stockpiling of common elements so that they can rapidly respond to shortages or damage in shipments. As an extension of this idea, they may also wish to jointly establish a service centre to provide repairs, warranty work or to locally make-up any panel and product shortages or damage.

This approach recognizes the inherent difficulties and expenses involved in pursuing remote markets. It also suggests that within these markets, Canadian manufacturers are not necessarily each other's prime competitor, but rather the conventional builder, the Japanese contractor and other exporting nations pose a more significant challenge. The Canadian housing industry jointly developed the technology which Canadian firms now export, it might be advisable for Canadian exporters to jointly develop the means to pursue those markets.

SUMMARY

The information gathered for this study and the associated economic analysis suggests that modular homes can compete effectively in the new home residential market once the on-going inter-governmental negotiation open these markets to the use of these products. Building on the current success of the Canada's panelized and consolidated home exporters, manufacturers should be able to successfully introduce and develop a modularized housing export industry to Japan.

The introduction of this new building approach will help to secure a larger share of the overall imported housing market, and achieve significantly increased Canadian content on each modular home. Further, modest changes to designs and marketing, manufacturers should also be able to tap new markets in the non-residential sphere.

The success of these efforts will be largely dependent upon the manufacturers' willingness to explore new materials, new designs and new markets. However, each such exploration will contribute to solidifying that manufacturer's share of their market and establish a pattern of innovation and growth which the market place will reward. To this end, the industry is encouraged to continue development in this field.

APPENDIX

This section of the report contains the six pages which were provided to the site contractor to assist him in identifying construction components and costs for both the panelized and modular homes.

These pages were also reviewed by the panel and modular manufacturer as a guide to the anticipated level of finishing and required connector details.

COSTING WORK SHEET for SITE FINISHING COMPONENTS

ITEM	WORK ELEMENT DESCRIPTION	DW REF.	MAN HRS.	LABOUR COSTS	MAT. QTY.	MAT COSTS	TOTAL ITEM COST
	MODULE # 1						
1	Patch flat south wall joint , as per Detail # D9 and wallpaper 1.7m of wall	1.1					
2	Patch 3 protruding wall ends , as per Detail # D1 and paint	1.2					
3	Patch 5.3m x .6m of flat ceiling paint in to match	1.3					
	MODULE # 2						
4	Secure floor joint and install approximately 12m^2 of hardwood flooring	2.1					
	MODULE # 3						
5	Trim out two openings , as per Detail # D2 and install one swing door and one sliding shoji door	3.1					
6	Secure floor joint and carry hardwood flooring to edge of tile under door	3.2					
	EXTERIOR						
7	Install two sets of flat metal ties over module joint and two sets of angle ties in corners as per details # D4 / D9	E.1					
	MODULE #4						
8	Trim out and install swing door . Roll down carpet and seam under closed door	4.1					
9	Finish two wall pilasters and 2.4m of overhead arch , as per Detail # D1/ D7, paint to match	4.2					
10	Install bull nosing to step and roll down carpet to 2.4m wide riser as per detail #	4.3					

SEE SHEETS # 7 & # 8 FOR DWG. REFERENCES

SHT. # 3

ITEM	WORK ELEMENT DESCRIPTION	DW REF.	MAN HRS.	LABOUR COSTS	MAT. QTY.	MAT COSTS	TOTAL ITEM COST
	MODULE # 5						
11	Secure floor joint and install last .3+/-m x 2.4 M of hardwood flooring and install riser baseboard	5.1					
12	Patch floor in front of vanity , fold down and secure sheet vinyl and install toe kick face per Detail # D6	5.2					
13	Patch one protruding & one flat wall joint , paint full recess 3 m^2 Details D1/ D9	5.3					
14	Patch flat ceiling over 1.5m joint width and paint full room ceiling Detail # D7	5.4					
15	Patch horizontal 5-6m seam around stairwell and repaint to match, carpet joint in stair rise & run.	5.6					
	MODULE # 6						
15	Trim out opening and install swing door. Roll down carpet and seam under closed door.	6.1					
	EXTERIOR						
16	Install 3 sets of flat seismic straps and one set of corner seismic straps.	6.2					
	MISC.						
	MISC.						
	MISC.						
	MISC.						
	SUB-TOTAL COSTS						
	ADMINISTRATIVE BURDEN & PROFIT -------%						
	MISCELLANEOUS MULTIPLIER ---% (IF REQUIRED)						
	TAXES						
	TOTAL COST						

SEE SHEETS # 7 & # 8 FOR DWG. REFERENCES

SHT. # 4

GENERAL CONSTRUCTION NOTES

ELECTRICAL

Wiring from main floor modules shall be fed through the crawl space and fed up into the electrical panel located opposite the kitchen entry in the back hall.

Wiring from modules 4 & 5 on the upper level shall have sufficient leads to be fed down the wall and into the main floor electrical panel as the units are lowered into place.

Wiring from optional modules # 6 shall be gathered and fed through a pre-installed conduit on the top of module # 2 and pulled down into the electrical panel.

PLUMBING

Piping from the main floor shall be gathered in the crawl space as appropriate and led to soil stacks. Additional costs for working in the crawl space, but not form materials etc. shall be included.

The sink waste shall be led over to the toilet stack by working both under the sink and from an access panel in the exterior wall. The sink drain and the soil stack shall be joined, and fed down the wall between module units #'s 1 & 2

FINISHES

Wallpaper;
Rooms # 1, 3, 5 & 14 - All other walls will be painted.
Flooring
Wood Flooring
Rooms # 1, 3, 4 & 10 - For a total of 48.5 sq.m. (Includes 12 sq.m. installled on site)
Sheet Vinyl
Room # 12-1.7 sq.m.
Ceramic Tile
Rooms # 2, 6 & 7 Total of 6.3 sq.m.
Cabinets
Kitchen cabinets will be supplied as assembled components ready for installation.

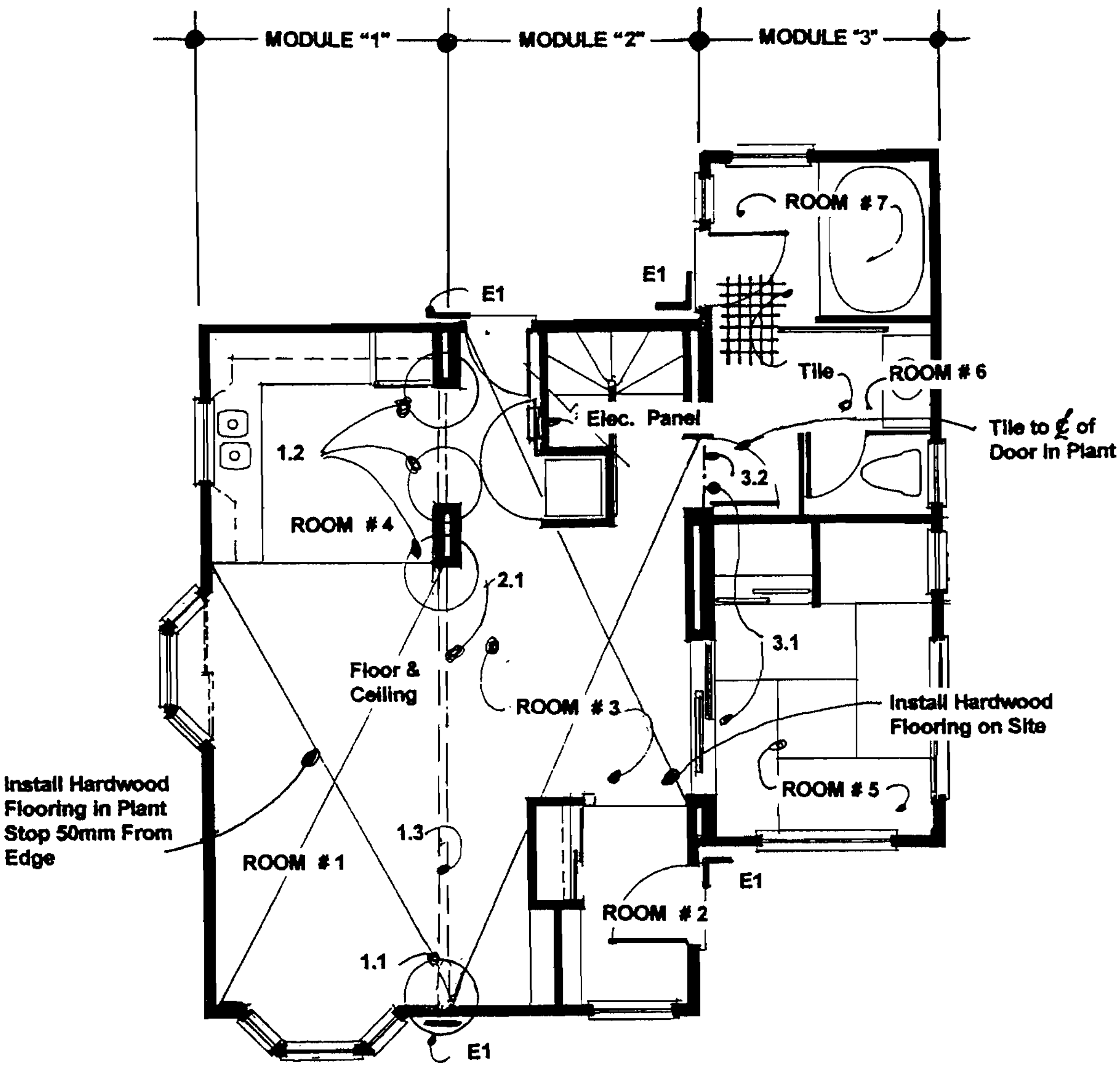
SHT. # 5

SITEWORK - Common to both modular and panelized approach and consequently not costed

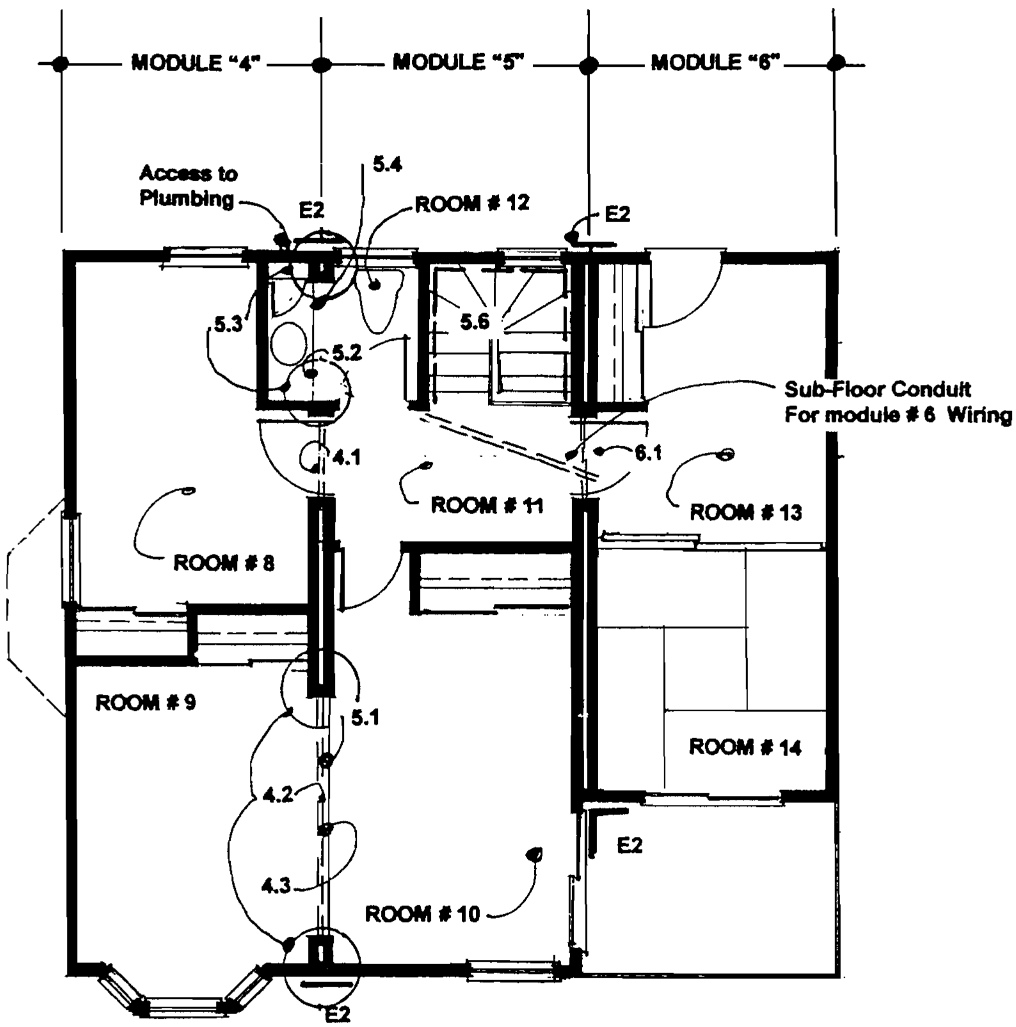
Site preparation and all servicing
Foundations and installation of seismic or hurricane ties to first floor
Exterior decks, walkways and any driveway requirements.
Patio roof over front entry
Field installed, surface mounted, Bay windows.
Exterior housewrap and finishes beyond the sheathing
Roof assembly and finishing (attic insulation and vapour barriers will be part of upper floor modules.
Tatami mats will be supplied and installed on site, as will any custom finishing in the alcove..

Mechanical systems were not included as they can be common to both of the construction systems. Further, they can also be so varied as to preclude simple comparison between conceptually similar units

SHT. # 6


MODULE "1"
MODULE "2"
MODULE "3"
ROOM # 7
E1
E1
Tile
ROOM # 6
Elec. Panel
Tile to ℄ of Door in Plant
1.2
3.2
ROOM # 4
2.1
3.1
Floor & Ceiling
ROOM # 3
Install Hardwood Flooring on Site
Install Hardwood Flooring in Plant Stop 50mm From Edge
ROOM # 5
1.3
ROOM # 1
E1
ROOM # 2
1.1
E1

SHT. # 7


MODULE "4"
MODULE "5"
MODULE "6"
Access to Plumbing
5.4
E2
ROOM # 12
E2
5.3
5.6
5.2
Sub-Floor Conduit For module # 6 Wiring
4.1
6.1
ROOM # 11
ROOM # 13
ROOM # 8
ROOM # 9
5.1
ROOM # 14
4.2
E2
4.3
ROOM # 10
E2

SHT. # 8