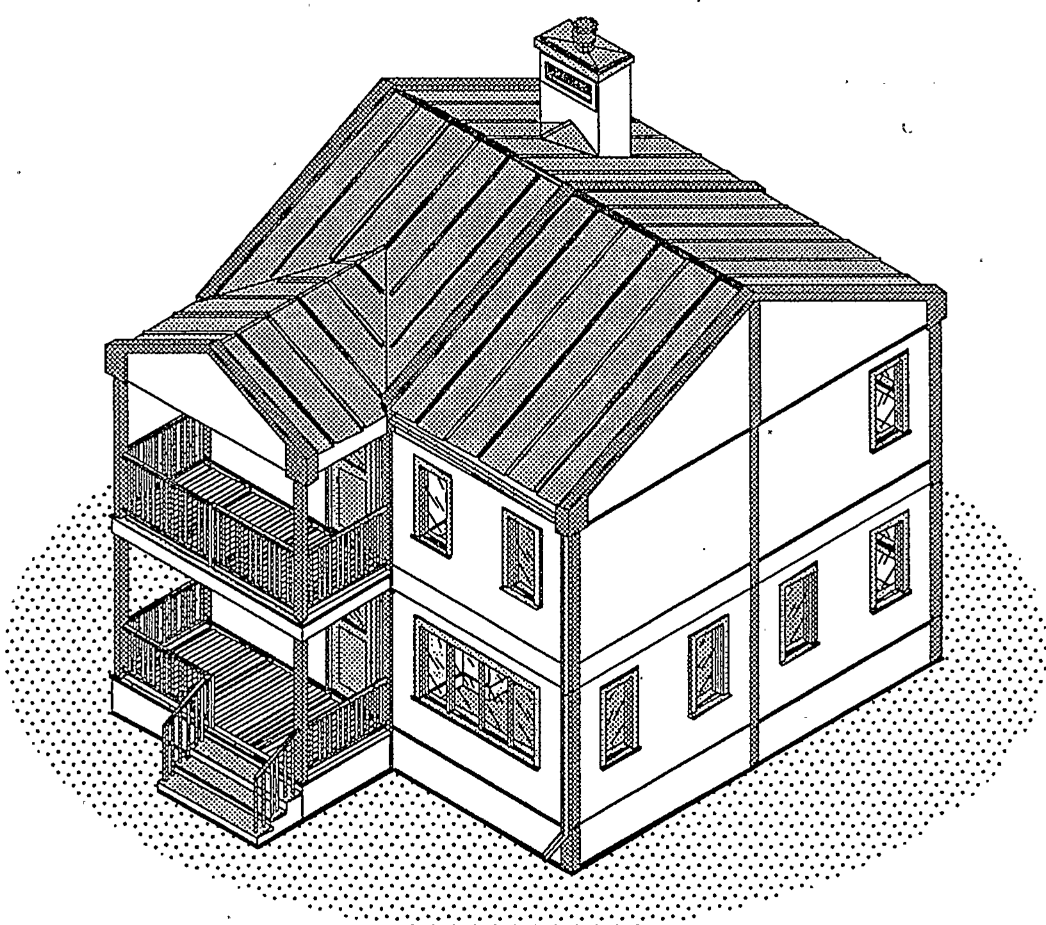
THE INCREMENTAL HOME:
AN ADAPTABLE BUILDING SYSTEM FOR THE DYNAMICS OF INHABITATION

By
Niels Wilde



ISBN 0-315-83309-2

THE UNIVERSITY OF CALGARY

FACULTY OF ENVIRONMENTAL DESIGN

The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled The Incremental Home: An Adaptable Building System for the Dynamics of Inhabitation submitted by Niels Wilde in partial fulfillment of the requirements for the degree of Master of Environmental Design.

Supervisor

Date Aug 26 '92

ABSTRACT

THE INCREMENTAL HOME:
AN ADAPTABLE BUILDING SYSTEM FOR THE DYNAMICS OF INHABITATION
by Niels Wilde August, 1992

prepared in partial fulfillment of the requirements of the M. E. Des. degree in the Faculty of Environmental Design, The University of Calgary
supervised by M. R. Kirby

Our homes can be a very important part of our lives and come to acquire a deep personal significance. The introduction of this document examines the factors which influence the relationship which we develop with our homes, and how they might be enhanced to reinforce this relationship.

Among the factors considered are: the necessity that the occupants have a significant degree of *control* over their homes in order to insure an appropriate and meaningful environment; the importance of *engaging* in all the facets of a home, from design and construction to decoration and maintenance, as a way of manifesting this *control* and reinforcing the personal relevance of the home; and the advantages of an adaptable building system which can easily adjust to many of the changes which might occur in the needs of the occupants.

The *Incremental Home* building system attempts to address these issues by achieving the following objectives:

• to be adaptable to changing user needs by allowing for easy and economical renovations
• to be a rational and comprehensible building system which facilitates the participation of laymen during the assembly, maintenance. and modification of the dwelling
• to be applicable to most residential and some other building types
• to be accessible to a broad cross-section of the housing market, including the financially disadvantaged, by allowing for a wide variety of different layouts and sizes
• to be lightweight and compact during transport, thereby allowing for national or world wide distribution

The main body of this document is divided into two sections: 'The Building System', which describes the components of the building system and they way they are assembled, and 'Applications', which looks at a number of different ways in which the system can be used. This is followed by a cost analysis, which calculates the estimated cost of the system; a market analysis, which considers who might be interested in the system; and a conclusion that attempts to ascertain the success of the *Incremental Home* in achieving the design objectives. A list of the basic components of the building system, structural details, and additional house plans are included in the appendices.

Key Words: Home, Engagement, Control, Dynamics, Flexibility, Incremental, Components, Standardization, Module, Prefabrication

I greatfully acknowledge the assistance of my supervisor Robert Kirby, and my committee members Tang Lee and Jim Graham, during the production of this document. I would also like to thank Ron Oates and the Siver Fern Group for providing me with the resources which made it possible to accomplish this task.

dedicated to the two lovely ladies,
Carol and Shauna

Almost the entire contents of this document were generated on a *Macintosh IIci* computer with an 8MB RAM and a 200MB hard disk. The software used to compile the text was *Micrsoft Word V4.0,* and most of the graphics were generated with *Power Draw V3.0.*

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INTRODUCTION

Photo 1 Photo-collage of various free-standing homes

1.1
THE PERSONAL SIGNIFICANCE OF THE HOME

> **...the house is one of the greatest powers of integration for the thoughts, memories and dreams of mankind. The binding principle in this integration is the daydream. Past, present and future give the house different dynamisms, which often interfere, at times opposing, at others, stimulating one another. In the life of man, the house thrusts aside contingencies, its councils of continuity are unceasing. Without it man would be a dispersed being. It maintains him through the storms of the heavens and through those of life. It is body and soul. It is the human being's first world. Before he is "cast into the world," as claimed by certain metaphysics, man is laid in the cradle of the house. And always, in our daydreams, the house is a large cradle. A concrete metaphysics cannot neglect this fact, all the more, since this fact is a value, an important value, to which we return in our daydreaming. Being is already a value. Life begins well, it begins enclosed, protected, all warm in the bosom of the house.**
>
> **Gaston Bachelard, The Poetics of Space[1]**

What is a home? The problem with addressing this question is that the answer cannot be found merely by examining physical attributes and other tangible qualities. This is because a home is far more than simply a structure which encloses space, but also a place which can come to hold tremendous personal significance to its inhabitants. As the location where many of life's dramas, both great and small, take place, the home plays an integral part in the daily experience of our lives. First and foremost it is the place in which we dwell.

The concept of dwelling has played a key role in the work of many psychological, existential, and phenomenological thinkers. For example, in his book The Poetics of Space, Gaston Bachelard takes the reader on a phenomenological journey through the regions of a house. The vehicle for this journey is the 'daydream', as Bachelard calls it. Through the faculty of the imagination, the experience of a place can become influenced by recollections of other places, both real and imaginary, as well as an endless array of other associations which may range from the resonance of universal archetypes to the memory of uniquely personal experiences.

This associative process is an inescapable aspect of cognition in our experience of any environment, but it acquires a special psychological significance when it comes to the way in which we inhabit our own homes. This is because, of all the environments in which we find ourselves, the one in which we invest most meaning is frequently the home. The home is an amalgamation of a tremendous range of personal and cultural symbols, which address us on many psychic levels, and generate a veritable universe of images and associations.

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[1] Bachelard, The Poetics of Space, p6 &7

Through our homes we can manifest many facets of our beings, from the most personal and idiosyncratic, to the most public and contrived. With each choice we make regarding our dwellings: such as location and setting; size; layout; style, and the many articles we chose to furnish and adorn them -all reflect to some degree our personalities and our relation to society.

For most of us, our homes provide the only environment which we have the freedom to manifest our personal creativity to a significant degree. Here we do what we will in accordance with, or in defiance of, social norms -the one place where we can truly be ourselves. It is our refuge from the world: a psychological microcosm of the universe filled with personally relevant objects and associations. Above all, it is a place where our psyches can experience recuperation, reaffirmation, and renewal.

In order for the home to realize the potential significance that it can attain, it must provide us with a safe and secure environment in which we can manifest our needs and choices. This can only be achieved if it is an environment over which we perceive to have a certain degree of *control*: *control* over the right to occupy the dwelling as well as *control* over its appearance and activities that take place within.

The amount of *control* which we desire to have over our homes can vary greatly from individual to individual. For some it is sufficient merely to have a room in which to sleep and keep one's things; for others the home can become the ultimate vehicle of self expression and the focus of countless hours of thought and activity. In either case the home can be an adequate and satisfying environment as long as *the degree of control perceived is sufficient* for the needs of the inhabitants.

The importance of *control* over the home environment becomes apparent when some need of the occupant is not being met. As long as it is within the *control* of the occupant to resolve whatever has caused the problem, then the home can continue to be satisfying environment. But if it is outside of the *control* of the occupant to resolve the conflict, then a *dissonance* arises with the home which can result in dissatisfaction with the environment. In the context of this document, the term '*dissonance*' has been intended to imply the unease or alienation which can be experienced from occupying an incongruous or inappropriate environment.

Dissonance can be experienced in varying degrees, from mild irritation to extreme psychological stress, depending on the importance of its source. Perhaps the most extreme form of *dissonance* is experienced by the homeless, who live in a temporal places such as shelters for the homeless, and in the public domain where some modicum of protection from the elements has been provided. Since they have no dwelling which is truly theirs, they have virtually no *control* over the environments which they inhabit and thus are deprived of the psychological reinforcement that a home of their own could provide.

Although most members of society do not suffer from this extreme form of *dissonance*, the mere thought of losing one's home can generate a strong emotional reaction. It seems clear that our homes are often seen as an integral part of our lives, and the security which they provide is essential to our physical and psychological well-being.

The provision of security may be the most important aspect of *control* which we must have over our homes, but there are many other possible sources of *dissonance* which can be detrimental to the satisfaction which we feel for our dwelling places. In general, the more different aspects of *control* we have over our homes, the more likely that any conflicts which may arise can be resolved rapidly and effectively.

Some aspects of *control* have very pragmatic applications. The maintenance of a home, for example, often consists of the resolution of a succession of problems, often minor but sometimes serious. What sets the minor inconveniences apart from the major problems is the degree of disruption which is inflicted on the lives of the occupants and the ease with which the problem can be resolved.

Maintenance problems can range from relatively trivial tasks such as replacing a burnt out light bulb, to far more serious and difficult endeavours such as replacing a damaged roof or a collapsed floor. Between these extremes are a wide range of problems which may or may not be a serious inconvenience for the occupants, depending on their expertise.

A variety of tasks, such as repairing a leaky faucet or realigning a door, can be a relatively minor endeavour for someone with the appropriate tools and the necessary skills, but can be far more inconvenient, time consuming and costly for someone who must call in skilled labour. The maintenance of a home can pose a variety of problems and, in general, the more knowledgeable people are of 'handyman' skills, the less stress they will experience with their homes.

'Handyman' skills can greatly improve the relationship with one's home, not only because it reduces the possible sources of *dissonance* which may arise, but also because it can increase the level of *engagement* between occupant and dwelling.

Engagement is an intrinsic aspect of dwelling. It occurs with every reflective decision we make and every action we take regarding our homes. The more we become *engaged* with our homes the better we understand them, and the more meaning and personal relevance they can come to have for us. By acting on our homes, they will come to manifest, not only our identities, but also the work and effort which was exerted to create and maintain them.

It would seem that the more aspects of the home that we *engage* in, and thereby have some degree of *control* over, the more appropriate and satisfying our homes are likely to be.[1] Under ideal circumstances, this *engagement* could apply to all pertinent aspects of the home, ranging from the decoration and furnishing of the rooms, to the design, construction, and maintenance of the building itself.

Not all of us may have the time or the desire to become *engaged* in all of the design, construction, decorative, and maintenance aspects of our homes. Nevertheless, if we wish, it is important that we have the opportunity to do so, since every aspect of dwelling that we *engage* in can enrich the associations which we acquire with our homes, and the breadth of personal significance which they can come to hold for us.

From the moment we begin to inhabit our dwellings, we begin to express ourselves through our environment. Every object with which we choose to adorn our homes: be it a self-made object such as a painting or sculpture; or a valued aquisition such as a vase, a book, or a treasured photograph, usually holds some kind of personal significance. Combined, this collection of bric-a-brac creates a tapestry of associations which acts as a material testimony of our lives and the things we hold dear.

By decorating our homes they can come to acquire great personal relevance, but decoration is only one of several possible avenues of personal expression. The home can reach an even greater degree of personal relevance if the inhabitants are able to engage in other aspects of the home: from the design and construction, to finishing and maintenance of the dwelling....All these forms of engagement can help to elevate the personal

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1 Rapoport, 'The Personal Element in Housing: an Argument For Open-ended Design', R.I.B.A. July 1968, p300

significance of the the home, from a mere commodity worth little more than its market value, to a meaningful entity which is the object of thought, care, and labour. In this way the home can become a product of the choices and action of the inhabitants and thereby insure that it will be an environment which is both phenomenologically rich and existentially satisfying.

1.2
THE DYNAMICS OF INHABITATION

> **At each scale the environment and space organization have meaning for the inhabitants, particularly in the measure that they can give it their *own* meaning. In the case of housing, giving meaning becomes particularly important because of the emotional, personal, and symbolic connotation of the house and the primacy of these aspects in shaping its form...**
>
> **Amos Rapoport, 'The Personal Element in Housing...'[1]**

A very commonly held desire in our society is to own the home in which we live. This desire has a very deep rooted source in our need for territorial security, as well as it allows the occupants to make any changes to their home that they wish. In 1986, six out of ten Canadian households owned their homes[2] , the vast majority of these being free-standing or semi-detached houses. What this statistic does not indicate, however, is the number of households who wish to own their homes but are unable to do so, for financial or other reasons.

Nevertheless, most of us who are fortunate enough to be able to purchase a home are limited to selecting from existing housing stock. Very few houses in Canada are *custom-made* in the sense that the occupants have a direct influence on the design of the building. The additional time and costs involved in the design of a *custom-built* house are certainly contributing factors to their scarcity. But there is another significant factor involved which arises, not as a response to constraints, but as a result of our expectations.

A house is often understood as a static entity; an inert enclosure which contains the lives and activities within. Usually we expect our homes to be be existing structures which we then make our own by introducing our personal belongings and, over time, modifying the interior to suit our preferences. Most of these activities are of a decorative nature, however, and most occupants generally do not have a significant input into the design of the enclosure itself.

The selection of a new home can be one of the most important decisions of our lives, not only because of the considerable financial obligations involved, but because of the significant role which the home can have in accommodating and expressing our lives. Yet, for most potential homeowners, this selection is strictly limited by the available housing stock. This problem is further exacerbated by the high cost of housing, which may cause many of the available homes to be not affordable to the average homeowner.[3]

From the outset, the selection of a home can involve some serious compromises. One must indeed be very fortunate to find a house which has precisely the right layout,

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1 Rapoport, 'The Personal Element in Housing: an Argument For Open-ended Design', R.I.B.A. July 1968, p300

2. Census Canada, Housing and Construction. p7-7

3 In 1986, the average cost of a house in Canada was $84,800, $100,500 within the city limits of Calgary, from 'Home ownership', Canadian Social Trends, Statistics Canada

character and size, and is located in a desirable area. Often not all these priorities can be satisfied, and the objectives which are deemed most important, such as the location of the home, are met only by sacrificing other objectives such as finding a home which is the ideal size.

Compromise is an inherent aspect of all facets of life. Yet, if compromises are made which are too great, *dissonance* may be experienced by the occupants -greatly inhibiting the satisfaction with the new home and the degree of personal significance which it might otherwise acquire.

For example, if the overall size of the home or the layout of the rooms is inappropriate for the types of domestic activities intended, then the occupants are faced with the choice of either tolerating their circumstances or modifying the structure to meet their needs. In other words, the occupants must either adapt themselves to the limitations of their home, or adapt the home to correct any inconsistencies with their needs. Obviously the latter alternative is by far the most desirable, but renovating one's home can often be a very demanding and costly endeavour.

One of the reasons that makes it difficult to alter the structure of our homes is because of the way in which they they are built. Most existing and newly constructed houses in Canada have been built using a 'stick-frame' structural system.[1] Despite the considerable merits of 'stick-frame' construction as an economical, efficient, and versatile building system, it is a system which is not in the least bit amenable to being modified once initial construction has been completed.

For example, if additional rooms are constructed adjacent to an existing stick-frame structure, the wall between them cannot be removed because it is usually load-bearing, and a beam must be installed over any aperture cut into the wall between the new and existing spaces. This type of structural alteration can be costly and time consuming, and requires a certain degree of construction expertise in order to be done correctly. Furthemore, the exterior cladding, insulation, and vapour barrier in what has become an interior wall no longer serve any useful function, but to remove them may be more trouble than its worth. This resistance to change applies to many other structural systems as well, and seems to reflect our conception of buildings as 'fixed entities' which are not designed to be easily modified.

The efficiency of a building system can be measured by the relative amount of time and resources that are required to produce an enclosure which meets the needs of the occupants. 'Stick-frame' construction has become the preferred house building system in Canada because it meets these objectives. But because of the amount of time and energy required to modify this type of structure, it is an efficient system *only if the spatial needs of the occupants remain constant* throughout the duration of occupancy.

Most conventional homes are built to meet the initial needs of the occupants but do not often make provisions for any major changes which might occur to these needs. What they do not take into account is the dynamic nature of inhabitation. Our lives, although sometimes slow to change, are never static, and our homes, as reflections of ourselves, change with us. Often we can reflect changes in our lives by making only decorative

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[1] 85.3% of new housing starts in Canada used 'stick-frame' construction in 1987, from Wiedemann, Friedman, & Rybczynski, Modular Prefabrication Versus Conventional Construction Methods as an Affordable Option in the Development of Single Family Detached Housing, p9

alterations to our homes, such as new ornaments or furniture arrangements. Sometimes, however, our lives undergo far more significant changes that place new spatial demands on our homes.

The spatial needs of a family, for example, can fluctuate dramatically over time. A young childless couple may require only a minimal amount of living space and privacy. If they have children, however, more living space becomes necessary. When the children are still very young, the need for privacy is not all that great, but it becomes progressively more important as they grow older, as does the amount of space that they require for their own activities. If the children leave home and only the parents remain as occupants, this progression can be reversed as both the need for living space and the degree for privacy are reduced. Eventually a couple's needs may be much the same as when they began their cohabitation.

This description of the evolution of a family is only a generalization and, given the heterogeneity of Canadian families, may not even be typical of the average household. Yet it demonstrates the dynamic nature of our lives and how the demands which we have of our homes can change greatly over time. Thus, even when a new home meets precisely the initial needs of the occupants, this is no guarantee that, over time, it will continue to provide adequate and appropriate accommodation.

When the *dissonance* between the occupants and their home becomes critical, they are faced with the choice of modifying the home to meet their changing needs, or moving into a more suitable building. But for many people 'home' is more than just a building. It is a location, a neighbourhood, a place. Moving to a new home may be able to satisfy functional needs, but only by sacrificing the attachment to one's existing dwelling place. Often the alternative of modifying the existing dwelling is seen as far more desirable than moving elsewhere, even if the results are far less than ideal from a functional point of view.

The ability to adapt one's home is important, not only for functional reasons, but also because it can have deep psychological implications as well. Numerous architects, psychologists, and other analysts have examined the role which the home can play in the psychological well-being of its inhabitants,[1] and the need to develop new building practices which would allow, and even encourage, adaptive behaviour.[2]

Amos Rapoport for example, who is an Australian architect and theoretician with anthropological inclinations, places great emphasis on the personal meaning which we attribute to our homes. In an article entitled 'The Personal Element in Housing: an Argument For Open-ended Design,' Rapoport links the degree of personal significance which the home can acquire to the extent to which this environment can be manipulated by the occupants.[3] In this article he makes a number of suggestions in order to make homes

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1 Some books which have influenced the author's understanding of the significance of the home are: Norberg-Shultz, Genius Loci; Amos Rapoport, House, Form, Culture; Gaston Bachelard, The Poetics of Space; and Witold Rybczynski, Home

2 For example, the importance of adaptive behaviour is the main thesis of Mary Beeler's User Adaptations of Wartime Housing, and Amos Rapoport's 'The Personal Element in Housing: an Argument for Open-ended Design', and is emphasized in Charles Moore's The Place of Houses

3 Rapoport, 'The Personal Element in Housing: an Argument For Open-ended Design', R.I.B.A. July 1968, p300

more adaptable, such as rooms which can allow several different furniture layouts, and greater participation of the occupants in more facets of the design and maintenance of their dwellings.

Nevertheless, Rapoport bases his suggestions on the conventionally held belief that the home is essentially a 'fixed shell' and that most modifications are limited to decorative, rather than spatial, manipulations of the dwelling. In some contexts, such as rented accommodation or multiple unit dwellings, this limitation applies, but it need not apply to free-standing or semi-detached dwellings whose overall size and form can be altered.

In North America, many people live in free-standing or semi-detached houses. Often these houses are placed on lots which are sufficiently large to allow for additions to be built onto the existing structures. Thus the occupants of these houses have the opportunity to expanding their dwellings. Yet a casual survey of free-standing homes would seem to reveal that this opportunity is not frequently realized, and most additions which are made usually provide only a modest addition to the overall space of the enclosure.

This observation is corroborated in a study by Mary Beeler who investigated the kinds of adaptations made by the occupants of 'Wartime'[1] houses to their homes over an extended period of occupation. The study, entitled User Adaptations of Wartime Housing, examined the perceptions, attitudes, and aspirations which the occupants had of their homes and how their houses were modified to manifest these needs

In most cases the types of adaptations cited by Beeler were of a decorative nature, such as the refurbishing of floors and walls, or the installation of a picture window. These changes often resulted from the need to replace deteriorating materials, or simply as a reflection of the changing tastes of the occupants. Alterations to the layout of the rooms were also undertaken. Larger living rooms or kitchens were provided by removing walls, and the need for more living space was addressed by developing the basement and attic areas of the house.[2]

The provision of undeveloped space in Wartime housing was a deliberate design strategy to enable the occupants to expand their living space if and when it became necessary or desirable to do so. In this way the house could be made affordable without seriously limiting its size and the number of occupants which could be accommodated. This strategy has also been employed in the design of the 'Grow Home' -an affordable housing prototype developed at McGill University.[3] Under certain circumstances, for instance in the context of a townhouse, it is an excellent strategy for making homes affordable without greatly limiting their size.

Nevertheless, there are certain disadvantages to this approach. Although the additional space may be undeveloped, it must still be enclosed, insulated, heated, and maintained. These additional costs produce little benefit for the occupants until the space becomes used.

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1 'Wartime' or 'Levitton' houses are modest-sized, free-standing dwellings which were constructed in large numbers during the decade following World War II. They were often constructed on lots which provided ample room for possible additions.

2 Beeler, User Adaptations of Wartime Housing, pp 100 - 129

3 Rybczynski, Friedman, & Ross, The Grow Home: Project Paper No. 3, p11

Since the construction costs are not greatly reduced, the savings which result from this strategy are due to the need for fewer finishing materials and less labour. If the undeveloped space is finished at some future date, however, the cost of materials may be substancially higher than what the contractor could have acquired them for, and offset the initial financial advantages. In addition there is the danger that the lack of emphasis placed on undeveloped space during the design of the home may result in inferior spaces. The inadequate headroom and lack of natural illumination of the basement and attic spaces in Wartime housing are a case in point.

Very few of the homeowners documented in the study by Beeler attempted to make structural modifications to their homes. In most cases the overall volume of space contained within the homes remained the same, and any additions which did occur were relatively modest, such as an enclosed porch or an expanded bathroom or kitchen area.[1]

The reluctance of many homeowners to expand their homes beyond the enclosure of the existing structure, if they have the opportunity to do so, may be attributed to several factors. For example, if a home is large enough to accommodate all the activities which take place within it, then the need to expand the home may never arise. This would imply that the composition and activities of the household remains relatively constant throughout the period of occupation or that, at times, the house is larger than the needs of the occupants would warrant.

It may often be the case that a homeowner does not embark on a major renovation project, not out of lack of need or desire, but because it can be a very demanding endeavour which involves considerable time, inconvenience, and expense. To a large extent, renovations can be very demanding because of the building techniques used in the construction of the original building. Renovations made to 'stick-frame' structures, for example, can be discouragingly complex both in terms of design and construction, and are often very disruptive to the lives of the occupants while they are being undertaken. Thus it may be, in part, the building system itself that prevents us from making substantial alterations to our dwellings -thereby inhibiting the adaptive process by which we personalize our homes and insure that they continue to meet our needs.

The inflexibility of our homes is at odds with the dynamic nature of our lives. As a result, our homes are often too large or too small, and only rarely are they *exactly the right size* for our needs. Because we are unable to easily adapt our homes to meet our changing circumstances, we become forced to *adapt ourselves* to the limitations of our dwellings. This can result, not only in the experience of *dissonance* with the home, but also the very detrimental perception that our homes, and by implication our lives, are beyond our control.

If we lived in homes which were truly flexible, such problems would never arise. This would require the development of a building system which could easily be added to, taken from, or otherwise modified. A home constructed from this type of building system could manifest precisely the spatial needs of the inhabitants *at any time* during its occupation by growing or shrinking accordingly. The interior subdivision of space should also be flexible so that the rooms could be altered as, over time, some activities became obsolete and others gained emphasis.

A home constructed with a truly flexible building system could readily adapt to almost any change in the needs and desires of the inhabitants. This would insure that the

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[1] Beeler, User Adaptations of Wartime Housing, pp 108. 110, 118

occupants had a significant degree of *control* over their environment, and that it would be an accurate and appropriate reflection of their lives *for the entire duration of occupancy*. Ultimately it is this amenity to change, this responsiveness to the dynamics of inhabitation, that the *Incremental Home* building system has been designed to achieve.

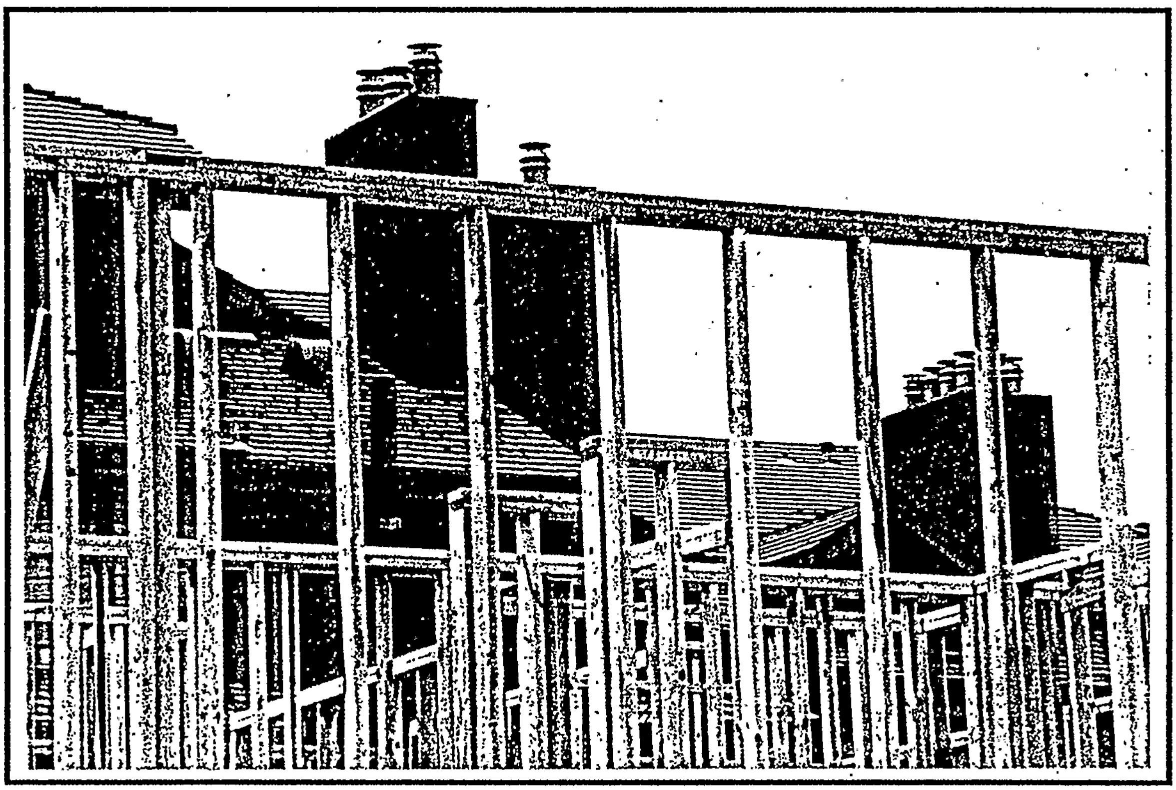

Photo 2 A typical example of stick-frame construction

1.3
INTRODUCTION TO THE INCREMENTAL HOME

> **Housing, as an environment within the control of its inhabitants, can be the base for reinforcement of personal identity through exploration and manipulation of the physical surroundings. Adaptation of the house may be considered a source for developing a sense of competence in dealing with the larger environment, as well as a means of personalizing or improving a given physical form. The house itself can be a resource for learning to carry out effective behaviour, a place where an individual's competence and self-worth may be enhanced. Thus, a house design which facilitates modification and change may be more desirable than one which initially meets all the user's criteria, but which is difficult to adapt as desires and circumstances evolve later.**
>
> **Mary Beeler** User Adaptations of Wartime Housing[1]

The *Incremental Home* is not any specific building, but rather a building system which can be used to construct a variety of different building types with a large number of different sizes and possible room layouts.[2] The primary design objective, however, is not to maximize the number of different building types possible with the system, but to maximize the flexibility of any individual building so that it may respond to any changes which may take place in its occupation. In this respect an *Incremental Home* is never a finished product but rather a vehicle for change -a mutable enclosure ready to accommodate many modifications to its use as a result of the ebb and flow of our needs and our fortunes..

In some respects this design approach is at odds with conventional architectural practices. Many buildings are designed to achieve a far more permanent and immutable result. This specificity most often applies to the building envelope, which governs such facets as the overall size and form of the building, as well as the location of windows and doors which reflect the interior layout. Often the design process goes further than simply the enclosure of space, but can include other decorative aspects such as the selection of finishes and even the design of furniture and fixtures. The inclination to control as many aspects of the design as possible can easily be understood from an architectural point of view since all these aspects of a building can help to reinforce and enhance the design objectives of the architect. In some cases, particularly in the design of large public and institutional buildings, this degree of specificity may be entirely appropriate.

In the design of private dwellings, on the other hand, the aesthetic sensibilities and priorities of the client plays a far more predominant role. Because of the personal significance which the building will hold for the occupants, the role of the architect is not to express his own aesthetic vision, but rather to act as a facilitator and enhancer through whom the client may realize his own personal objectives. The responsibility of the architect

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1 Beeler, User Adaptations of Wartime Housing, p8

2 For further elaboration, see Section 3: Applications

is to provide his client with a home which is structurally sound and in accordance with applicable building codes and other requirements, but it should be up to the client to determine the overall size, form and layout of the home so that it will meet the type and range of activities intended to take place there.

Through the *engagement* of the homeowner in the design process, the home can come to acquire far greater personal meaning. Yet only a very small percentage of us have had a direct influence in the design of our homes. Usually even the brand new homes which we move into have been determined by a developer with only the most generic understanding of the needs of the future occupants. The reasons are largely economic: the design and construction of a home is a complicated procedure which only becomes more costly and time consuming if the future occupants are involved in the process.

An essential aspect of the design philosophy of the *Incremental Home* is that the occupants can become *engaged* in all of the facets of their homes, including the initial and/or subsequent design. The strategy to achieve this has been to develop a rationalized building system which greatly simplifies, both conceptually as well as in terms of construction, the process of building a home. The elements of a building have been reduced to standardized components, such as floor, wall, and roof panels, all of which are systematically assembled according to a modular dimensional system. Thus the interior space of an *Incremental Home* is a collection of standard volumetric modules contained within an envelope comprised of panels and other components.

One advantage resulting from the standardization of building components is that the occupants would find it much easier to have a direct influence on the design of their homes, and in a fraction of the time usually required for the design of a conventional 'custom-built' house. The repetition of similar and identical components, and the systematic way in which they are assembled, should greatly facilitate the ability of a client to understand the available options and encourage interactive design.

The role of the client in the design of an Incremental Home might take place in the following way. The needs of the client and the properties of the building system are discussed in detail. With the aid of computer technology,[1] a number of suitable size and layout options are then displayed on a computer screen to help ascertain the individual preferences of the client. The most appropriate configuration is selected and further refinments are made: such as additions; reductions; and any other alterations to the layout, until the design is precisely what the client requires. Attention is given, not only to the initial design of the home, but also how the spatial needs of the client may change in the future, and what configuration may best accommodate these anticipated changes.

Once the final design decisions have been made, it should be possible to produce a complete set of working drawings within hours. This is in contrast to the weeks or months of consultation between the client and the designer which is necessary in order to produce a set of working drawings in the conventional manner. In this way, the *Incremental Home* can greatly reduce the amount of time and expense involved in the custom design of a home and enable far more homeowners to participate in the design of their own homes.

The *Incremental Home* encourages occupants to become *engaged* in the design of their homes, not only during the initial construction, but *at any time* when their spatial

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[1] The computer is an ideal vehicle to produce drawings and specifications for the *Incremental Home* because of the standardization of components and the systematic nature of their assembly.

needs undergo significant change. The Incremental Home attempts to be a truly adaptable building system which can expand, shrink, or be modified in any number of different ways to meet the changing circumstances of the occupants. In order to achieve this, all the building components are attached together with demountable fasteners such as screws and clips. This makes it possible to add to, remove, or alter the location of any portion of the building relatively easily and without damaging any of the components. Components which are demounted can subsequently be used elsewhere in the building or sold to other *Incremental Home* owners.

The ease with which this building system can be modified makes it possible for the initial size of an *Incremental Home* to meet only the current needs of the occupants without having to provide additional space as a contingency for future increases in occupancy. For example, a young couple may be inclined to buy a conventional house which is larger than their immediate needs warrant or that their financial resources can comfortably support, in order to provide room for children which have yet to be born.

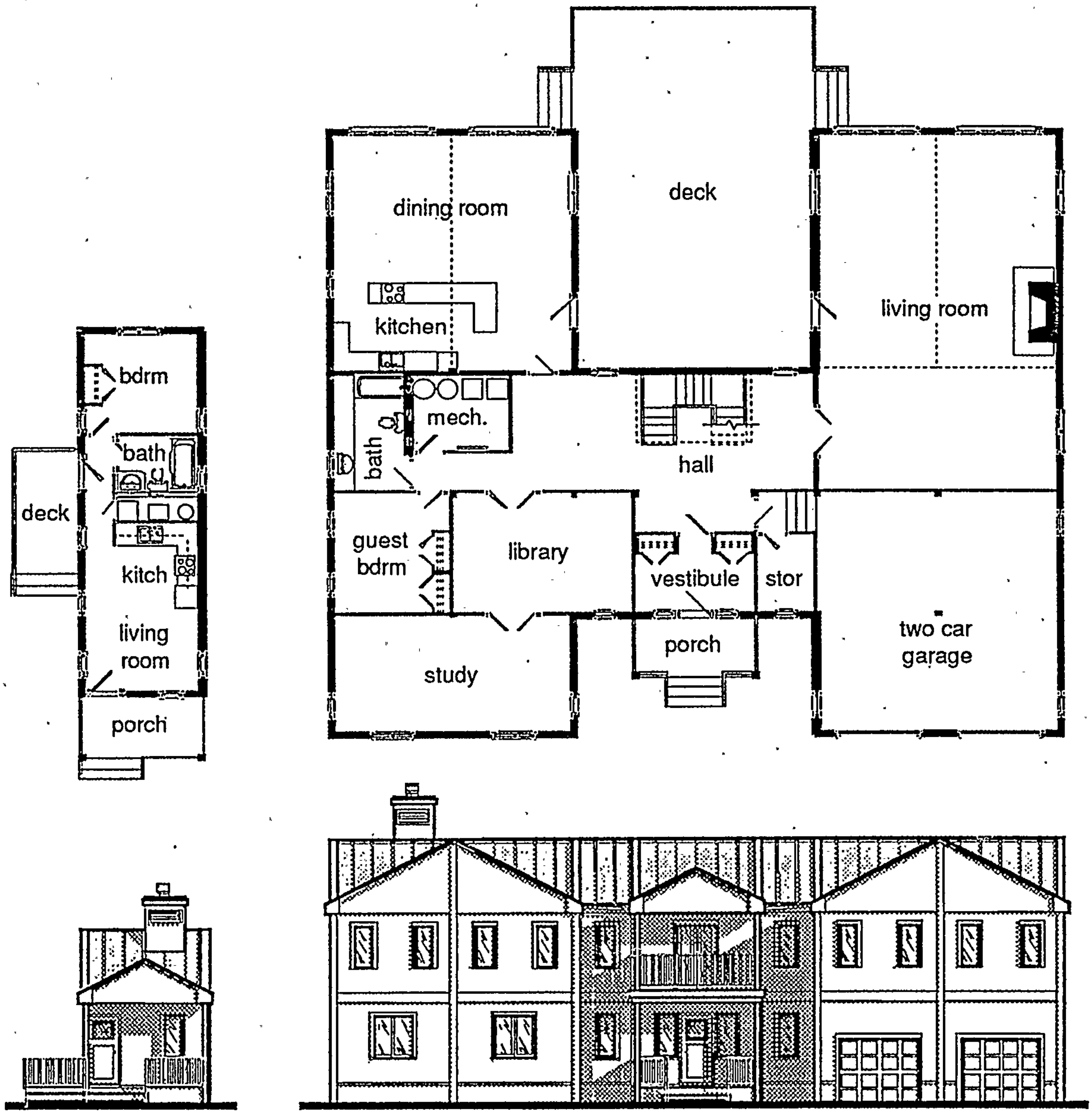
An *Incremental Home* need only be as large as the current needs of the occupants require. In the future, additional space can be provided according to demand and at only a small fraction of the time, inconvenience and expense which is usually involved in the renovation of a conventional structure. By phasing the construction of a home to meet the needs of the occupants *only as they arise*, construction costs, mortgage payments and even property taxes[1] need never be any higher than necessary.

The smallest practical size for an *Incremental Home* is embodied in the concept of the *Core House*. The *Core House* provides approximately 52 square meters (or 575 square feet)[2] of floor area and contains bathroom and kitchen facilities. The rest of the interior space can be further subdivided to provide a separate bedroom, or simply be left as an open plan. The *Core House*, which can have a variety of configurations, should be sufficiently large for the needs of most single occupants or couples. Smaller dwellings with only 39 square meters (or 430 square feet) are possible, but their size may be considered inadequate for the domestic activities of more than a single occupant.

On the other hand, there is no inherent maximum size for an Incremental Home. A building with several hundred square meters of floor area and several storeys in height can be built, either initially or in a series of incremental stages, as long as the components conform to the structural parameters of the building system. Thus an *Incremental Home* which is located on a large piece of land can expand indefinitely in any direction, and with any number of rooms (see figure 1.3.1).

1 This applies to property taxes which are affected by the market value of the building.

2 Conversions between Metric and Imperial measurements are only approximate since the dimensions of all the components will vary somewhat depending on whether the raw materials, such as studs and sheathing, have been cut according to Imperial or Metric dimensions. For further elaboration see Section 2.1: The Dimensional System.



COTTAGE
39 sq m or 430 sq ft

MANSION
510 sq m or 5650 sq ft

Figure 1.3.1 Plans and elevations of a very small and a very large house, demonstrating part of the range of building sizes possible with the *Incremental Home* building system

The prefabricated nature of the building system greatly simplifies the construction of an *Incremental Home*. Since all the components are prefabricated, very little actual construction takes place at the building site. Instead, the building is *assembed,* with components which fit precisely into place without any cutting or other site adjustments. As a result, the time between commencement and completion of an Incremental Home is only a small fraction of the time required to construct a conventional structure of the same size.[1]

The *Incremental Home* would have to be classified as a prefabricated building system because the manufacture of the components takes place in a factory, and only a small percentage of the work takes place at the building site.[2] There are several advantages inherent in prefabricated building systems, which will be discussed in greater detail in Section 2.3 The Industrial Process. Prefabrication, however, is not only a desirable aspect of the *Incremental Home,* it is an necessary element in order to achieve the objectives of a versatile and easily modified building system. After all, if a builder had to construct the building components before assembling the building, then the *Incremental Home* may take as long to construct or alter as a conventional structure. The widespread availability of new and used components is essential to the facility with which an Incremental Home can be erected or modified.

The simplicity of the system also makes it possible for occupants without advanced building skills to participate in the assembly of their homes. Once familiar with the system, homeowners may also be able to make future modifications to their homes without professional assistance. These modifications need not be limited to the components described in the basic *Kit of Parts*, but may include any number of other specially designed components which conform to the dimensional system.

The *Incremental Home* is primarily concerned with the enclosure of space rather than the imposition of any particular aesthetic. The overall size, layout, and number of storeys of a particular *Incremental Home*, as well as the placement of windows, doors, chimneys, and other elements, has great impact on the massing, balance, and proportion of the building. Since the building system has been designed to facilitate and even encourage renovations, the appearance of any *Incremental Home* may undergo significant changes over time. For this reason the *Incremental Home* has what might be called a 'transitory aesthetic' since the form of the building at any given time is inherently impermanent. Nevertheless, the standardization of components and, in particular, the dimensional system, should insure a degree of formal cohesiveness for an *Incremental Home* with any configuration.

The appearance of an *Incremental Home* can further be modified by the colour scheme of the components. Contrasting colours can be used to articulate and differentiate different types of components, such as wall panels, roof panels, battens and flashing, to create a lively, decorative appearance. Conversely, if all the components are finished in analogous or identical colours, a more subtle and formally homogeneous effect would result. Theoretically, *Incremental Home* components could be available in every colour

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[1] A *Core House* can be fully assembled in four days, including site work and foundations, by a team of four experienced workers, see Section 2.4 The Assembly Process

[2] Wiedemann, Friedman, & Rybczynski, Modular Prefabrication vs Conventional Construction.... p 2

and hue[1], but even a limited selection would allow for a large number of different combinations and effects.

Despite these variables, an *Incremental Home* assembled entirely from prefabricated components would inevitably have certain stylistic qualities, and the homeowner may want a home with other attributes. For example, additional cladding such as wooden siding or stucco could be added to the exterior surface of wall panels. This type of alteration could greatly alter the appearance of the building. Other styles of windows, doors, or interior finishes could also be used at the discretion of the homeowner. Some of these modifications may complicate future changes made to the building, but this disadvantage may be considered secondary to the personal expression of the occupants.

As a result of all these variables, no two *Incremental Homes* need be identical in appearance. Even very simple structures, such as *Core Houses*, can have numerous variations in layout, window size and placement, colour schemes, and so on. Through their deliberations and decisions, each variable gives the occupants the opportunity to engage in an aspect of the design of their homes.

The greatest benefit from participation of the occupants in many aspects of the design, assembly, and maintenance of their dwellings may be the enhanced sense of *control* over, and identification with, the home. The simplicity of the *Incremental Home* building system acts to facilitate the manipulation of the home environment by the inhabitants. In this way the home can continue to be an accurate reflection of the needs, desires and preferences of the occupants for as long as they chose to live there. Perhaps all forms of *engagement* with the home, ranging from design to decoration, can help to realize the full potential of the relationship which can develop between ourselves and our homes.

In the following section of this document, 'The Building System', the building components of the *Incremental Home* are examined in greater detail. This section identifies a basic set of components, called the 'Kit of Parts'; their industrial manufacture; and the way in which they are assembled. This is followed by a section entitled 'Applications' which explores how the building system can be used as well as a hypothetical scenario that demonstrates how an *Incremental Home* can be modified over a long period in order to meet the changing needs of the occupants...

> **The failure of our surroundings to establish where we are and who we are seems to us to require a search for the 'habitable' - both the physically habitable, where we can be comfortable and live our lives, and the metaphorically habitable, where we can go beyond where we actually are and to wherever our imaginations will transport us. Establishing a territory for habitation, physical and metaphorical, is the prime basis of architecture, and therefore house-building...**
>
> **Charles Moore, The Place of Houses**[2]

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[1]Some very dark hues are not recommended for certain components, such as wall panels, because excessive solar heat gain may damage the rigid insulation and cause other problems.

[2]Moore, Allen, and Lyndon, The Place of Houses, p49

2
THE BUILDING SYSTEM

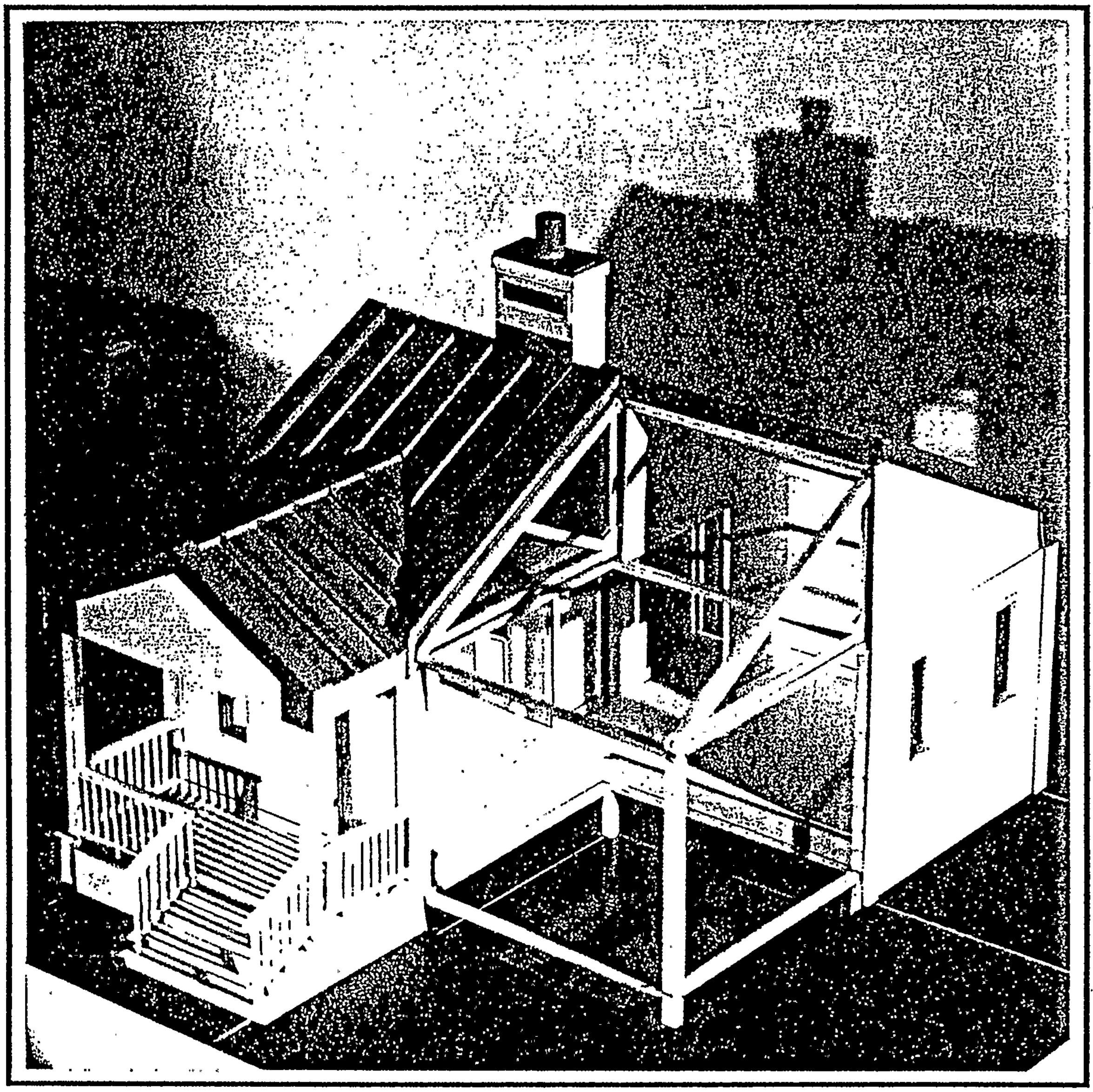

Photo 3 Model of a *Core House* exposing interior and structural frame

2.1
THE DIMENSIONAL SYSTEM

The *Incremental Home* is based on two parallel dimensional systems: one in metric units and the other in imperial units. Two separate systems have been used because the components of the building system are manufactured from standard sizes of building materials such as plywood and studs. This can greatly reduce the amount of cutting and waste of materials during the manufacture of the components, and improve the cost effectiveness of the system. In North America, most building materials continue to be produced in imperial dimensions, and it would be impractical to adjust their size to conform to a metric system. Thus, if the Incremental Home were to be manufactured from readily available North American materials, a dimensional system based on imperial units would be most appropriate. On the other hand, if building materials cut according to metric units are to be used, then a metric dimensional system would be more suitable.

For this reason, many of the measurements included in this document are provided in both metric and imperial units which are approximately, but not exactly, equivalent. In plan, the location of the structural posts and the main enclosure components are delineated by grid lines spaced at regular intervals. The standard distance between grid lines is a *module*, which is 3.6 by 3.6 meters in metric. or 12 by 12 feet in imperial. Both these measurements are common dimensions for sheathing and other materials in their respective dimensional systems. Although the metric and imperial *modules* are approximately the same, the imperial *module* is, in fact, one and one-half percent larger than its metric counterpart.

All the structural and enclosure components, such as exterior wall, floor, and roof panels, are designed according to the dimensions of a *module,* or a *half-module*. The *half-module* is only half as wide as it is long, and has been included in order to allow for a greater variety of building configurations.

In three dimensions, the standard *volumetric module* between floor panels is a square prism which is two-thirds of a module in height. Since the roof panels are sloping, however, *volumetric modules* under the roof may also have a top which has a slope of 1:2 (see figure 2.1.1).

By combining exterior wall, floor, and roof panels, an enclosure is created which is invariably a multiple of *volumetric modules* (see figure 2.1.2). Nevertheless, the interior space can be subdivided by interior wall partitions and ceiling panels which do not have to be aligned to the modular grid, thereby making it possible for any number of spatial variations to take place within the constraints of the structural system.

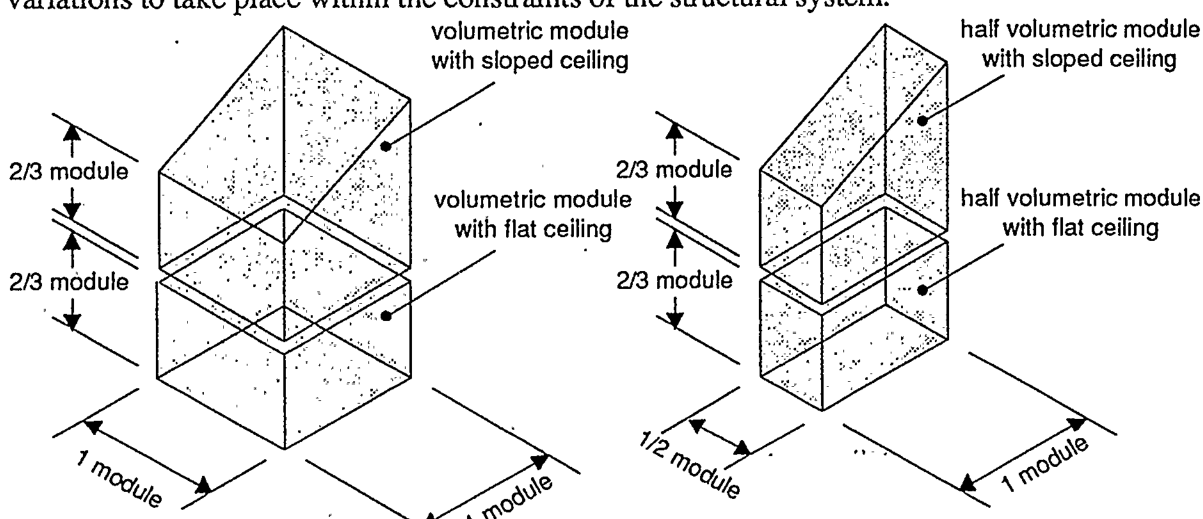

Figure 2.1.1 Isometric illustration of full and half size *volumetric modules*

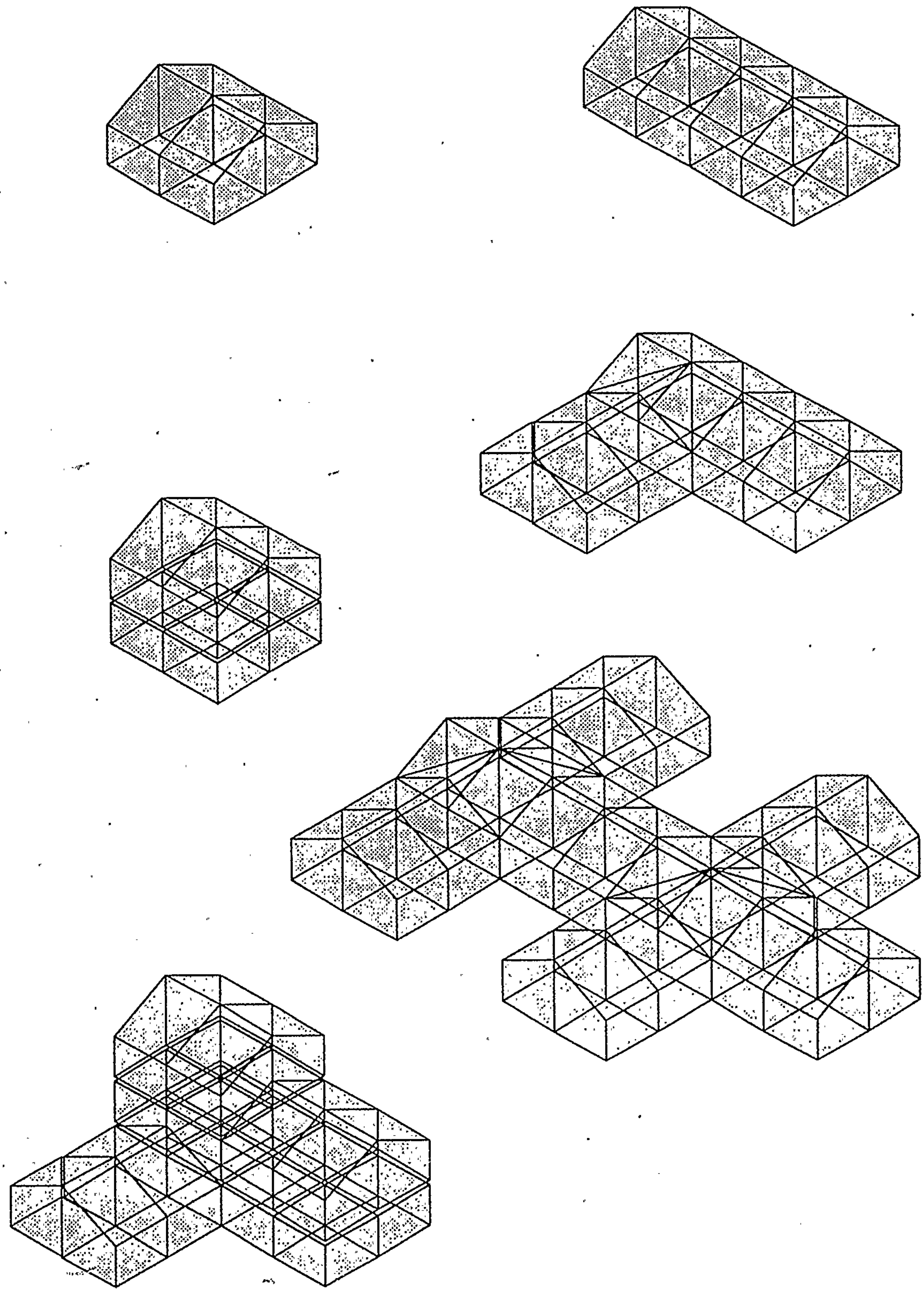

Figure 2.1.2 Some possible *Incremental Home* configurations using only full size modules

2.2
THE KIT OF PARTS

2.2.1 THE STRUCTURAL FRAME

The frame provides the underlying dimensional coordination of the *Incremental Home* building system. All the structural components, such as the posts, plates, and girder trusses, are centered at exact module or half module intervals.

Metal angles are used to fasten the structural components together. The type of joints described in this document permit attachment of structural components only along the three orthagonal axes. As a result, all the plans illustrated herein have walls which are aligned to a rectilinear grid.

It would be possible, however, to design spatial joint adaptors which would permit walls to be aligned to triangular, hexagonal, or other non-rectilinear grids. Some of these variations would require the design of special floor, roof, and trim components to conform to the new geometric configuration. Due to the nature of component systems, the addition of a new component such as a joint adaptor, can greatly increase the variations possible with the system, but it will also increase the number of different components required to complete the building.

With the exception of the fasteners, all the components of the structural frame are made of wood. This material has been selected because it is light-weight, relatively inexpensive, readily available in Canada, and very easy to work with. Any structural grade of lumber, such as Douglas Fir, would be able to withstand the loads of virtually any configuration of an *Incremental Home* -up to three of four storeys high.

The components of the substructure, the part of the frame which extends below grade, are pressure-treated to keep them from rotting in the ground.[1] They consist of posts which are joined to foundation pads, made from built-up two-by-sixes, by a galvanized metal shoe. Because all the loads of an *Incremental Home* are directly transfered to the structural frame, the entire weight of the building is channelled into point loads which rest on the foundation pads.

Since individual building sites can vary in regard to topography or soil conditions, posts of various lengths and different sizes of foundation pads may have to be offered to meet specific site conditions. The foundations illustrated in this document assume a level site and stable soil conditions typical of many sites in Canada.

The superstructure, the part of the frame which extends above grade, is composed of components made from kiln dried, but untreated structural grade lumber. They are fastened together with metal angles and heavy guage screws. These components include plates, posts, girder trusses and ridge beams. When assembled, the components of the superstructure of an *Incremental Home* can be placed on any type of foundation system designed to meet the size and spacing of the point loads. The most convenient and least expensive foundation is probably the one included in the *Incremental Home* building system. Other types of foundations however, such as concrete frost walls or piles, could also be used and would require only minor alterations to some fasteners.

For example, the superstructure of an *Incremental Home* could be bolted to a concrete foundation which provides a full height basement, or a concrete slab if the building is intended to be used as a garage. It should be noted, however, that concrete can take up to a month to set properly and may greatly increase the length of time required to erect an *Incremental Home*.

As with all the other components of the building system, the structural frame is attached together with demountable fasteners. This allows the frame components to be

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[1] Current methods of pressure-treated lumber require the use of poisonous chemicals which seem to seep into the surrounding earth over time. This is a very significant draw back, and one would hope that, in time more inert techniques to preserve wood will be developed.

added to or removed with a minimum of inconvenience and without any significant damage to the components (see figure 2.2.1.1).

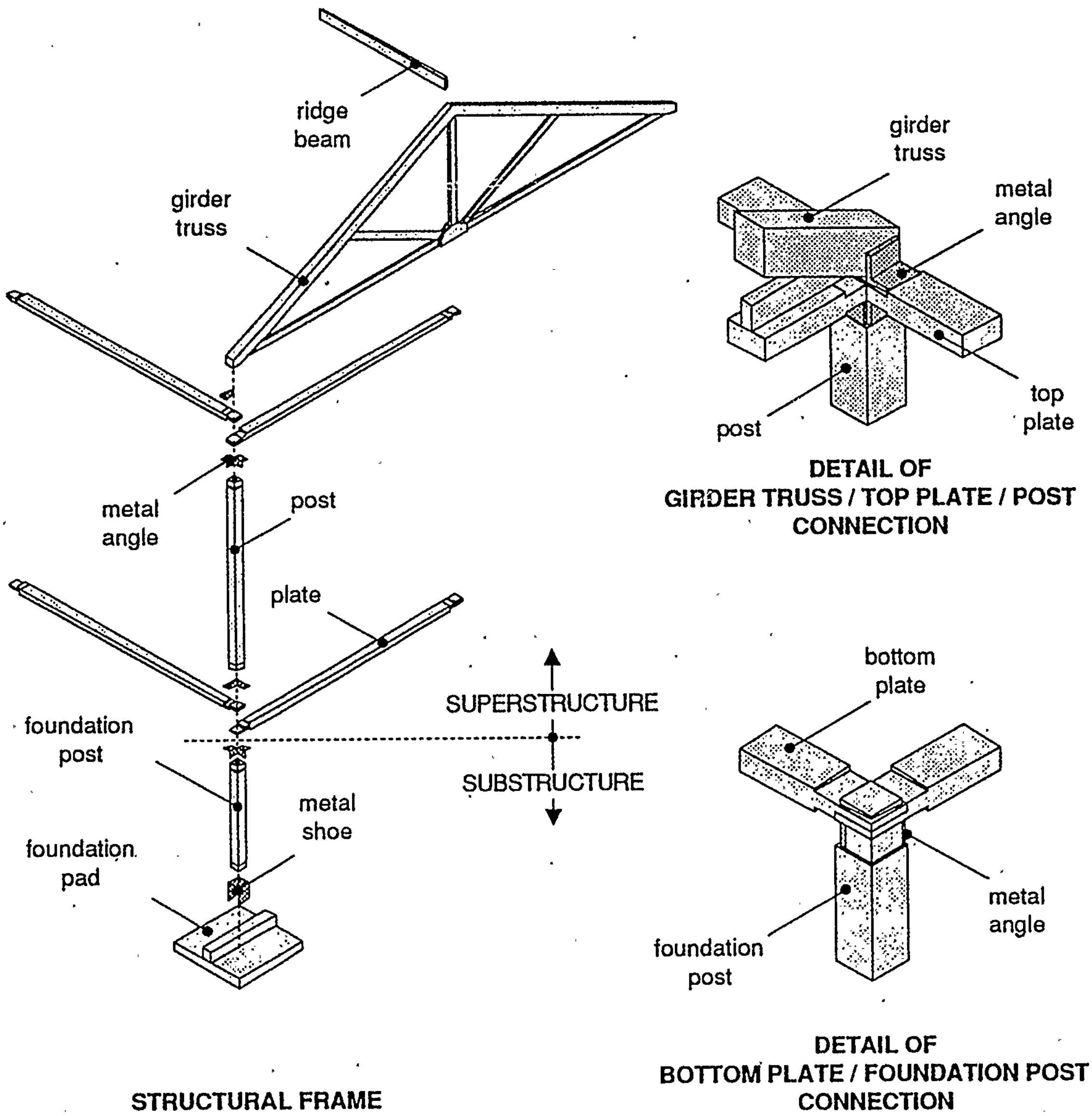


Figure 2.2.1.1 Isometric details of structural frame components

LIST OF STRUCTURAL FRAME COMPONENTS

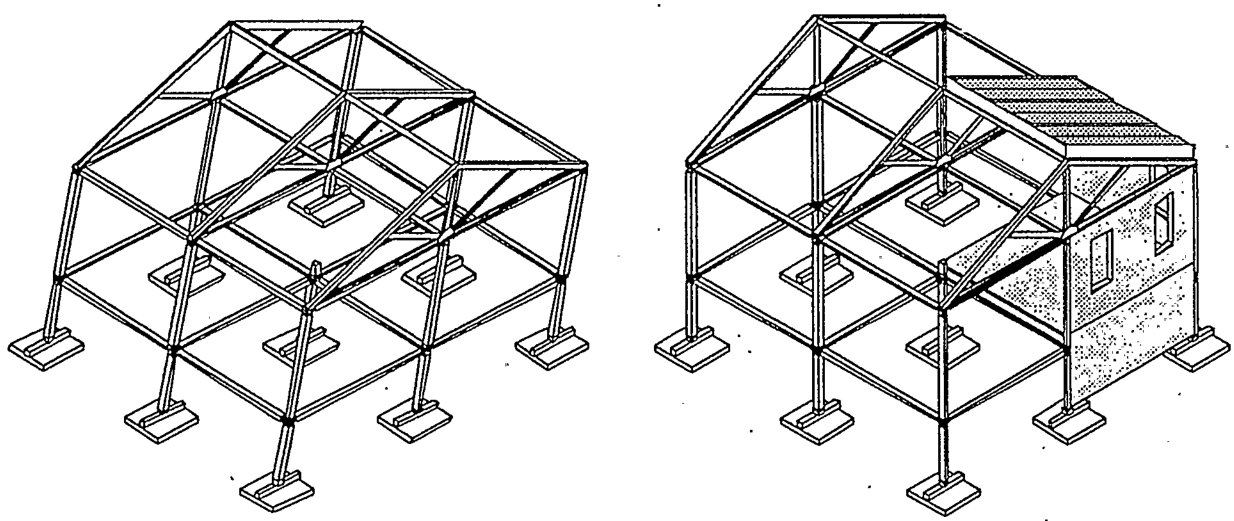
SUBSTRUCTURE	
Foundation Pad	built-up PWF 2x6's
Foundation Post	built-up PWF 2x6's & 2x3's
Foundation Shoe	preformed galvanized iron
SUPERSTRUCTURE	
Plate	2 ply 2x6'
Post	built-up 2x6's and 2x3's
Girder Truss	top chord: 3 ply 2x6's

	web: 2x4's, bottom chord 2x4
Ridge Beam	1 ply 2x6
FASTENERS	
Metal Angles	3x3x1/2" steel, various configurations
Screws	heavy guage

2.2.2 THE ENCLOSURE COMPONENTS

The walls, floors, and roof of the *Incremental Home* are comprised of standardized panels which are fastened to the structural frame. Since all the loads from these panels are transfered directly to the structural frame, they do not carry any external dead loads. This makes it possible for any individual panel to be moved without jeopardizing the structural integrity of the building.

The floor, external wall, and roof panels do have a structural function, however, in that they assist the metal angles in providing diagonal stability to the frame. Yet it requires only a minimum of components, in the proper configuration, to make the entire frame fully rigid (see figure 2.2.2.1).



Possible distortion of structural frame without diagonal bracing

Minimum number of enclosure panels required to make entire frame rigid

Figure 2.2.2.1 Isometrics demonstrating the diagonal stability provided by the enclosure panels

By combining these three types of panel components within the structural frame, many different sizes and configurations of space can be enclosed. The overall dimensions of the enclosure will always be strictly delineated by the dimensional module of the building system, but by subdividing the space with interior partitions, rooms with virtually any proportions can be created.

Floor panels are provided in two basic formats: square panels which are a full module in both length and width (1:1); and rectangular panels which are a full module in length but only one-half a module wide (1:1/2). A full sized floor panel provides approximately 13 sq.m [or 144 sq. ft.] of floor space - sufficient for a medium sized room, a small room adjacent to a corridor, or a number of other possible arrangements (see figure 2.2.2.2).

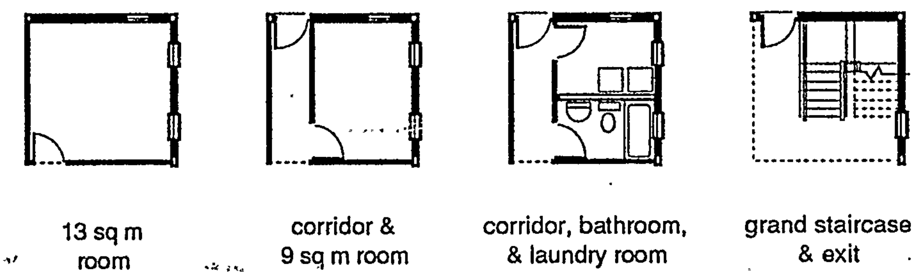


Figure 2.2.2.2 Some possible spatial arrangements within a single full sized floor panel (one module: 3.6 m or 12ft, in length and width)

Half sized modules are not sufficiently large to provide living spaces by themselves, but accommodate service spaces such as bathrooms, laundry, mechanical or storage rooms, or provide the room needed to fit a staircase (see fig. 2.2.2.3). Of course, when more than one floor panel is used, the combined area can accommodate any number of rooms of almost any size.

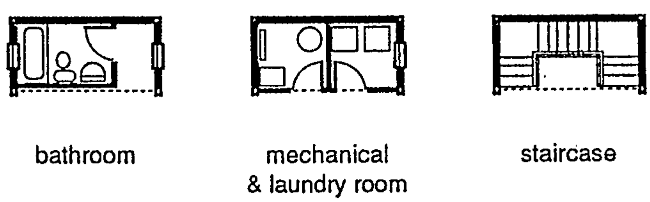


Figure 2.2.2.3 Some possible spatial arrangements within a single half sized floor panel (one by one half module: 3.6 x 1.8 m or 12 x 6ft)

The live loads to which the floor panels will be exposed are supported by 'truss joists' -composite wooden joists which have a solid upper and lower chord attached together with a plywood web. The advantage of this type of floor joist is that large holes can be cut through the web without reducing the bearing capacity of the joist. This allows all the services of the building, from ventilation ducts to plumbing and electrical conduits, to be contained within the floor rather than having to pass over or under it.

Wall panels are also provided in two widths: a full and a half module. As with the structural frame, the materials of the wall panels differ somewhat depending on whether they are to be used above or below grade.

Because of their contact with the ground, foundation wall panels are sheathed on both sides with preserved-wood plywood and contain pressure-treated studs. For more steeply sloping sites only foundation wall panels which are 2/3 or even a full module in height may be required to insure the integrity of the building envelope. An exterior finish is applied to the portion of the panels which will be above grade when installed.

The exterior wall panels of the superstructure are finished on both sides. The exterior sheathing is made of a special composite board which can double as the exterior finish of the building.[2] Exterior wall panels are all 2/3 of a module in height and have two widths - full module and 1/2 module. They come with a variety of openings to

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[2] For example *Cedarstripe* prefinished wood panel sidings; Champlain siding systems; MacMillan Bloedel Building Materials

accommodate doors and different window arrangements. In all variations, the location of the openings align with interior studs which are centered on 1/3 module increments. Both exterior wall and foundation panels contain rigid insulation with a resistance value of RSI 3.5 (R 20).

The roof panels are the largest and most complex of the panel components. They contain twice as much rigid insulation as the wall panels and have air gaps above the exterior sheathing to provide adequate ventilation. Roof loads are supported by the same kind of 'truss joints' contained in the floor panels. Unlike most conventional roofing systems however, these 'rafters' span from side to side rather than from top to bottom. This arrangement permits all roof loads to be transmitted to the girder trusses and subsequently the posts of the structural frame, and leaves the wall panels free of any load-bearing function.

Roof panels are clad in raised seam metal roofing which has been turned up at the sides and top to insure a water tight membrane. Strapping between the metal cladding and the exterior sheathing provides an air gap which permits air to circulate freely from the soffit to ventilation holes along the ridge. By insuring that the roof panels are properly ventilated, many problems associated with excessive moisture or heat gain can be prevented.

Roof panels come in the two standard widths: full module and half module, as well as a triangular panel for roof assemblies where two ridges meet at right angles. Some roof panels have an opening for the chimney chase and other services, or for a skylight. There are three standard locations for this aperture, which, by offsetting the flue, allows the furnace to be placed in almost any location in the building[3] (see figure 2.2.2.4).

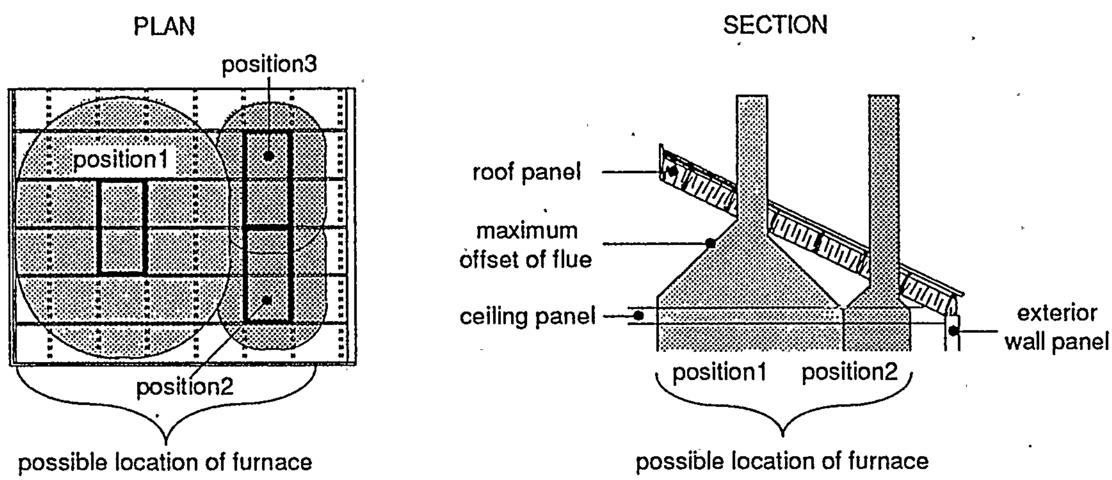


Figure 2.2.2.4 Plan and Section of roof panel with aperture showing possible locations of furnace

Gable end panels complete the list of components required for the enclosure of the *Incremental Home*. They are screwed to either side of the girder trusses and have both an interior and an exterior component. The rigid insulation of these two components together has an RSI value of 3.52 (R20).

Lap joints are used extensively throughout the system: between panels; and between the panels and the structural frame. This type of joint can insure the proper alignment of the components, and helps to make the building envelope weather tight.

By combining various numbers and arrangements of the panel components, supported by a structural frame, many different *Incremental Home* enclosures can be

[3]The 1990 Alberta Building Code allows a maximum flue incline of 45° from the vertical: article 9.21.2.3

created. These components alone, however, would provide only the most rudimentary form of shelter which was neither completely water tight nor air tight. Additional components, such as windows, doors, and flashing, are required before the building envelope achieves the necessary degree of isolation between the interior and exterior environments (see figure 2.2.2.5).

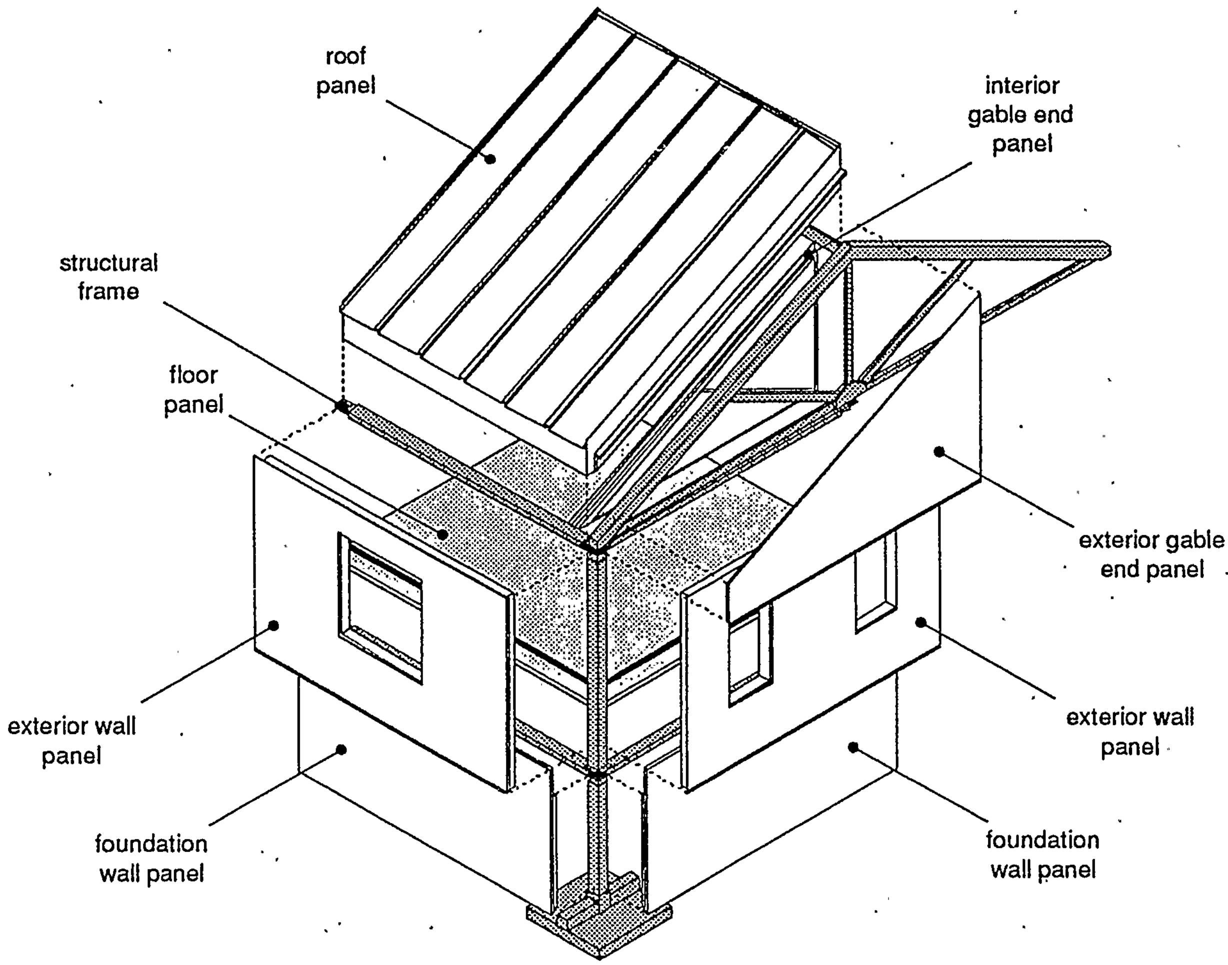


Figure 2.2.2.5 Examples of various enclosure panels and their location in the structural frame

LIST OF ENCLOSURE COMPONENTS

Foundation Wall Panel	PWF plywood, both sides 2x6 PWF frame RSI 3.5 (R20) rigid insulation
Exterior Wall Panel	composite board c/w exterior finish 2x6 frame RSI 3.5 (R20) rigid insulation drywall
Floor Panel	plywood subfloor truss joists drywall c/w interior finish

Roof Panel	raised seam metal roofing strapping plywood sheathing truss joists RSI 7.0 (R40) rigid insulation drywall c/w interior finish
Exterior Gable End Panels	composite board c/w exterior finish 2x2 frame RSI 1.8 (R10) rigid insulation
Interior Gable End Panels	drywall c/w interior finish 2x2 frame RSI 1.8 (R10) rigid insulation

2.2.3 WINDOWS, DOORS, EXTERIOR TRIM AND FLASHING

Windows have been designed to fit tightly into the apertures of the exterior wall panels. They come in three standard widths: 1/6, 1/3, and 2/3 of a module and are generally 1/3 of a module in height. Windows can have any number of panes or type of opening mechanisms and are restricted only in their overall dimensions. The windows illustrated in this document are among the most simple and economical available. They are single pane, double glazed windows with wooden frames which fit alone, or in multiples of two or four, within the apertures provided in the exterior wall panels. They can be either fixed, or have a casement opening system -depending on the ventilation needs of the interior spaces. Since the wall panels are nonload-bearing, lintels are not needed over either the windows or the doors.

Under some circumstances, as in certain bathroom or kitchen locations, a full height window may not be appropriate. In this case a window of suitable height can be installed and the unused portion of the aperture in the wall panel filled with insulation and clad (see figure 2.2.3.1). This approach should be more economical than producing special wall panels for windows at unusual heights.

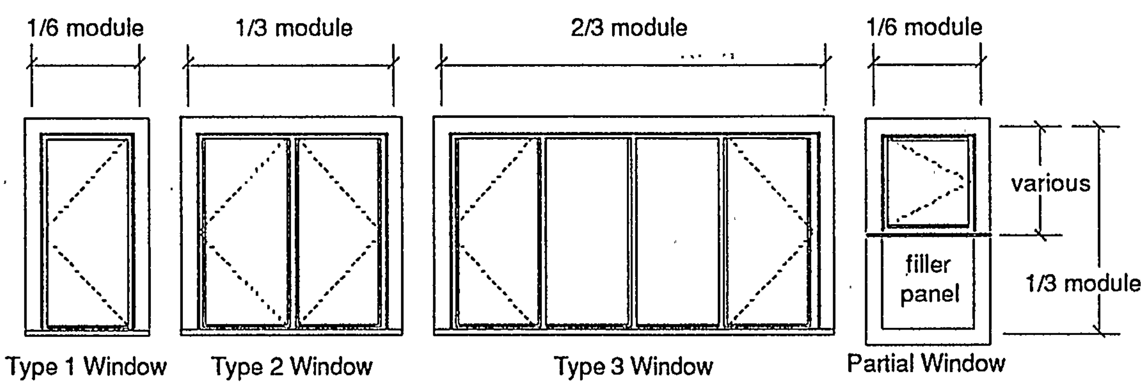
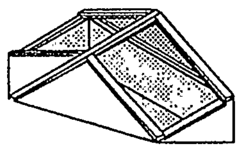


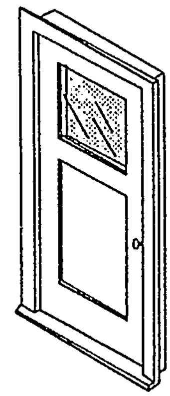
Figure 2.2.3.1 Examples of standard full height windows and a partial window

Apertures have also been provided in some roof panels to allow for the penetration of the chimney chase and other vents. These roof panels can also be surmounted by a skylight which might greatly enhance the atmosphere of some interior spaces.

A variety of door styles can be used with the *Incremental Home* system as long as they fit the dimensions of the aperture in the wall panel. The doors illustrated in this document are 6 ft. - 8 in. high (a standard in the building industry), 1/4 of a module wide, and can contain a window. Both the doors and the windows are installed after the wall panels are in place, in order to reduce the damage which might occur during transportation, and to facilitate subsequent replacement (see figure 2.2.3.2).



SKYLIGHT



EXTERIOR DOOR

Figure 2.2.3.2 Isometrics of skylight assembly and standard exterior door

The batten components cover the vertical joints between wall panels. They help to insure the weather tightness of the building envelope, as well as cover the screws which fasten the wall panels to the structural frame. They also can cover and any other irregularities which might occur at these joints.

There are essentially two types of battens: corner battens which cover wall panels which meet at right angles; and side battens which cover flush joints between panels. They are composed of the same material as the cladding of the panels which they cover, but can be finished in a different colour if a greater articulation of these joints is desired. The same is true for the fascia board which covers the joint between exterior wall and roof panels.

The joints between roof panels and at the gable ends are covered by preformed metal flashing. This flashing has four kinds of components: side and edge flashing, which covers the ridges at the sides of roof panels; top and bottom caps which attach to either end of the side flashing; and ridge flashing which runs along the ridge of the roof. Combined, these components insure that the roof will function as an impermeable membrane to rain and other natural phenomena.

Rain water is channelled away from the building with an integrated system of eaves-troughs, scuppers, and downspouts. Eavestroughs are fastened to the fascia boards and lead to special bottom caps which also function as scuppers. Down spouts are fastened to the bottom of these bottom caps which direct the flow of water away from the foundation of the building (see figure 2.2.3.3).

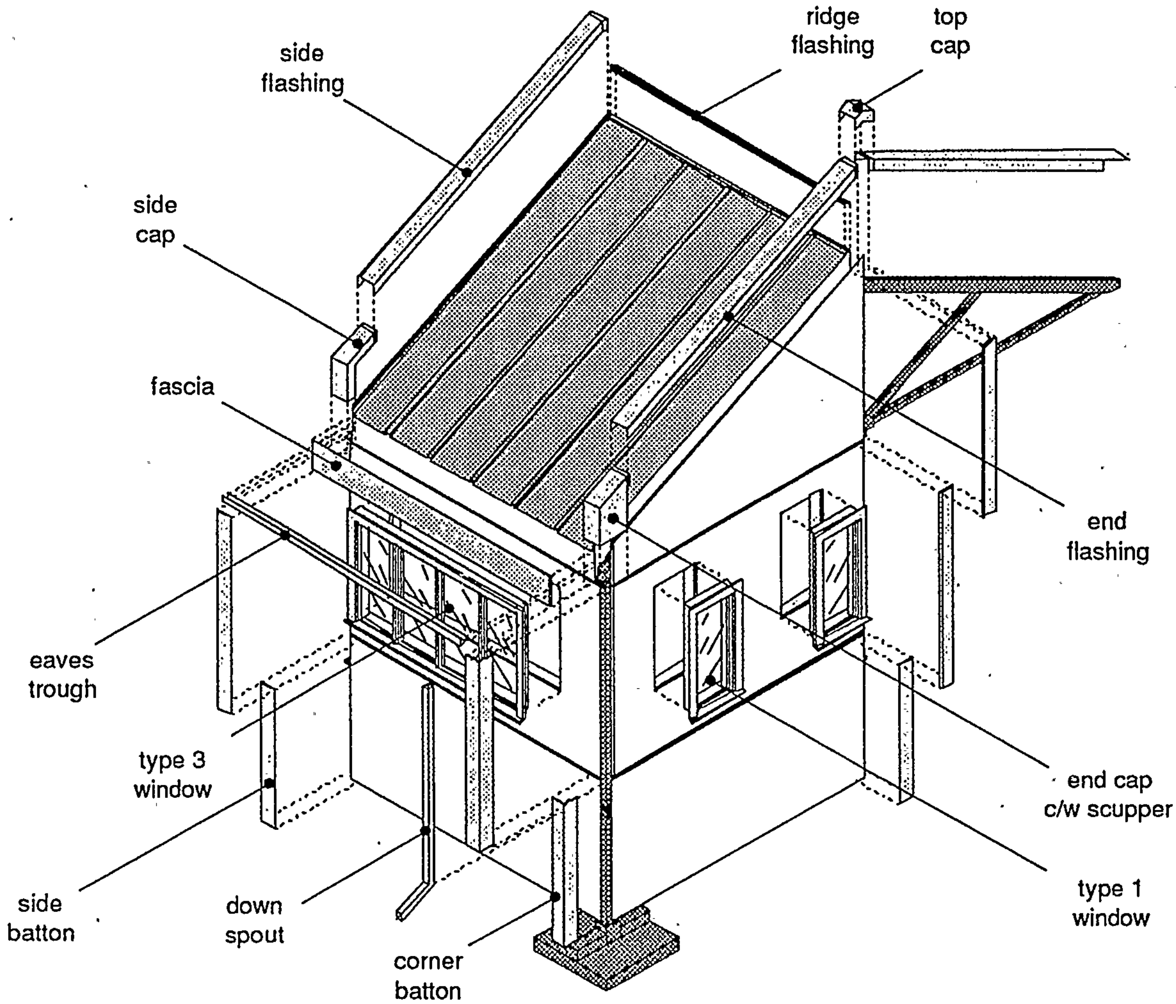


Figure 2.2.3.3 Examples of various windows; flashing; and exterior trim, and their location on the building envelope

When all the components described in this section are added to the basic enclosure of an *Incremental Home*, the building envelope is weather tight in every respect except as an air barrier. In order to allow the enclosure to 'breathe', the joints between components are not made completely air tight. The necessary air barrier is comprised of the interior cladding of the panels and is made continuous only when the interior trim has been installed. Several other interior components are also required before the enclosure can provide all the necessary services and amenities to which we have become accustomed in our domestic environments.

LIST OF WINDOWS, DOORS, EXTERIOR TRIM AND FLASHING COMPONENTS
WINDOWS & DOORS

Type 1 Window	single pane; double glazed wooden frame; casement or fixed
Type 2 Window	two panes; double glazed wooden frame; casement or fixed
Type 3 Window	four panes; double glazed wooden frame; casement or fixed

Skylight	special assembly; double glazed metal frame; fixed
Exterior Door	standard door [eg. 3'0"x 6'8"] metal insulated with or without window
BATTENS	
Side Batten	PWF or plywood c/w finish
Corner Batten	PWF c/w finish
Fascia Board	plywood c/w finish
METAL FLASHING	
Side Flashing	preformed metal reinforced with plywood
Ridge Flashing	preformed metal
Top Cap	preformed metal
Standard Bottom Cap	preformed metal reinforced with plywood
Bottom Cap with Scupper	special assembly of plywood and metal
Eavestrough	preformed metal
Downspout	preformed metal

2.2.4 INTERIOR PARTITIONS, TRIM, AND CABINETRY

The interior wall partitions of the *Incremental Home* building system share only some of the same functions as their exterior wall counterparts, such as insuring visual and acoustic isolation. But, because they do not function as a barrier to the outdoor environment, they do not provide the same degree of thermal insulation, air tightness, and other factors that are required for the building envelope. Consequently their design is significantly different.

In accordance with the design philosophy of an adaptable building system, the interior wall partitions can be easily installed and subsequently moved without damaging the components. Because the interior wall partitions are nonload-bearing and independent of the structural frame of the building, their location is not constrained by the dimensional module of the building system. For this reason, they can be installed in any location - allowing rooms of virtually any size or proportion to be created within the the standardized dimensions of the building system.

The typical interior wall partition is 1/3 of a module wide and 2/3 of a module in height. They consist of a 2x3 wooden frame sandwiched between two sheets of drywall. Within the wooden frame is a kraft paper honeycomb which serves to keep the drywall rigid. The panels are joined together at their sides by splines and are fixed in place by rails mounted to the floor and ceiling. These joints are subsequently covered by baseboard and ceiling trim to help insure that the partition provides an effective acoustic barrier.

Although most of the interior walls of an *Incremental Home* will be comprised of standard interior wall partitions, special components may also be required under some circumstances. Door panels, for example, are the standard overall size but contain a reinforced aperture to accommodate a pre-hung door. Components of different widths have also been provided to allow the overall length of walls to vary from increments of 1/3 of a module. Partitions which are located under a sloping ceiling also require special upper components to fill the gap between the standard 2/3 module height and the ceiling.

The ceiling of an *Incremental Home* is inherently sloped since the building envelope has sloping roof elements. This allows all of the rooms within the enclosure to have a sloping ceiling. For certain rooms however, particularly with small rooms and service spaces, this may not be a desirable attribute. For this reason ceiling panels can be installed over any portion of the floor area at a height of 2/3's of a module.

In general, ceiling panels would only be installed over bathrooms, mechanical rooms and kitchens, but they can be installed over any number of rooms. The wedge of space between the ceiling panel and the roof can be used to contain venting ducts and other services, or for storage. However, this space has not been intended, nor designed, to be inhabited.

The finish of the rooms is completed by the installation of baseboard and ceiling trim. This trim covers and articulates the joints between components and provides a surface on which to mount electrical receptacles and other service elements (see fig. 2.2.4.1). The trim along the interior surface of the building envelope also serves to complete the air barrier, and is equipped with gaskets to insure that the seal is air tight.

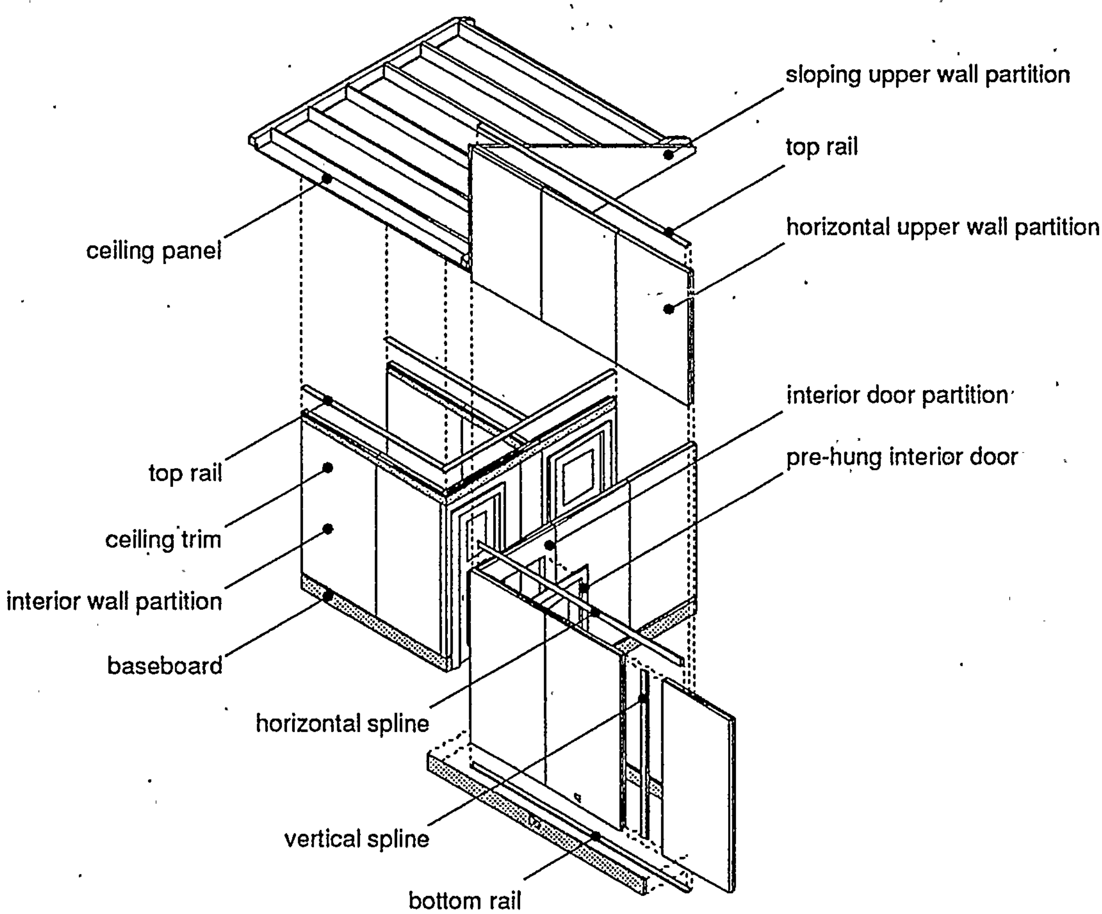


Figure 2.2.4.1 Examples of interior partition and trim components

The cabinets, vanities, cupboards, and closets which are included in the *kit of parts* are brought to the home in pre-cut pieces which are then assembled and fastened into place with screws.[4] Unlike the interior wall partitions which must also function as an acoustic barrier, or the external wall panels which must provide insulation and an air barrier, the cabinetry of an *Incremental Home* need only function as a visual barrier. For this reason,

[4] This system is similar to the way in which some *Ikea* furniture is assembled.

these components can be assembled from particle board panels which are economical to manufacture and relatively easy to install (see figure 2.2.4.2).

	Type of Barrier			
	Air	Thermal	Acoustic	Visual
Exterior Wall Panels	x	x	x	x
Interior Wall Partitions			x	x
Cabinetry				x

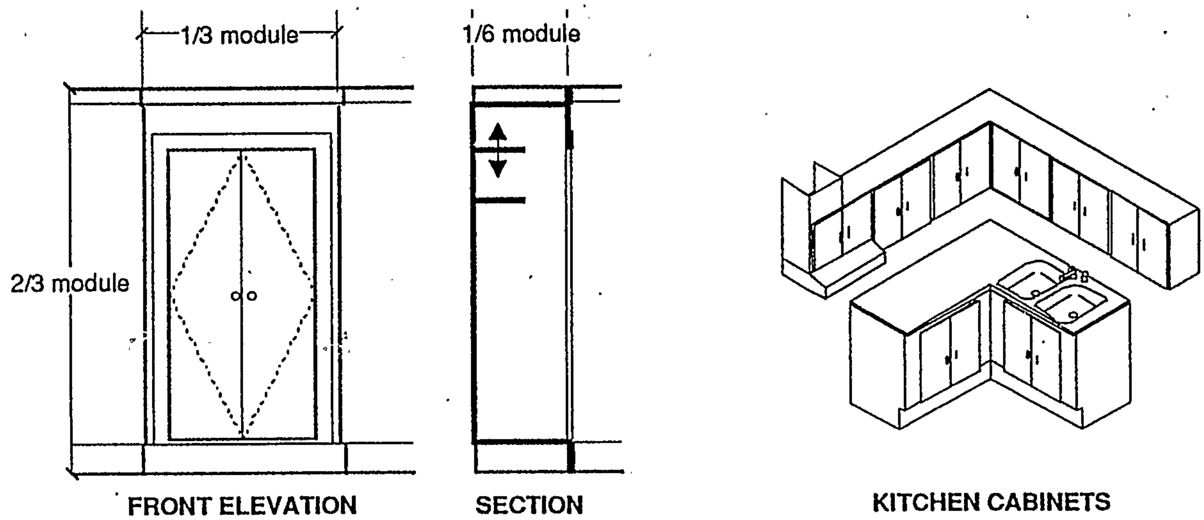


Figure 2.2.4.2 Examples of cabinetry: elevation and section of typical closet; and isometric of cupboards for a small kitchen

LIST OF INTERIOR PARTITIONS, TRIM, AND CABINETRY COMPONENTS

INTERIOR PANELS	
Interior Wall Partition	dry wall -both sides 2x3 frame craft paper honeycomb
Interior Door Panel	2x3 frame 2x3 reinforcing around aperture drywall -both sides craft paper honeycomb
Prehung Interior Door	wooden frame solid-core panel door various styles
Ceiling Panel	2x8's-doubled at ends drywall -one side optional plywood-one side various sizes
TRIM	
Baseboard	painted particle board [MDF] c/w gaskets for exterior walls
Ceiling Moulding	painted particle board [MDF] c/w gaskets for exterior walls

CABINETRY

Kitchen Cabinets	painted particle board [MDF]
Bathroom Vanity	painted particle board [MDF]
Closet	painted particle board [MDF]

2.2.5 THE SERVICE COMPONENTS

Up till now, most of the components which have been discussed have had an architectonic application -concerned with the structure, enclosure, or interior subdivision of space. Most contemporary buildings, however, also provide a number of other amenities which have become a necessary part of our domestic environments. These include the provision of electrical services, plumbing, heating, and ventilation equipment.

The size and number of service components will vary according to the size of the *Incremental Home* and the number of occupants. A small building, a *Core House* for instance, would require only a single bathroom, a small furnace, and perhaps laundry facilities. Larger buildings or substantial additions to small buildings would require additional services to be added to meet the increased demand.

Heating, plumbing, and electrical services have been centralized as much as possible in order to facilitate installation and minimize the amount of ducting, pipes, and other service components which are needed. For this reason bathrooms, kitchens, laundry and mechanical rooms are located in close proximity to one another, either adjacent or vertically stacked, whenever possible.

A prefabricated plumbing wall has been designed which contains all the necessary plumbing for a full bathroom (bathtub, toilet, and sink) as well as hook-ups for a kitchen sink and dishwasher, or a washing machine. The prefabricated plumbing wall greatly reduces the amount of time and expertise required to install and hook-up plumbing fixtures, and prevents any unnecessary drilling through panels and interior wall partitions.

The plumbing wall is composed of a two-by-six frame which supports the supply pipes, drains, and stack. It is clad on one side with drywall which can be removed in part to access the plumbing tree. The side facing the bathroom (plumbing walls are always installed adjacent to bathrooms) has been treated with a special waterproof finish (see figure 2.2.5.1).

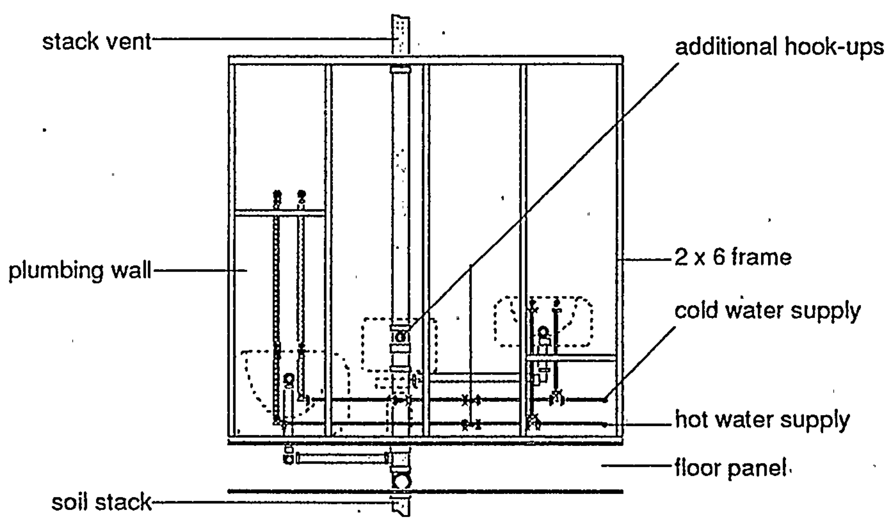


Figure 2.2.5.1 Example of a plumbing wall showing hot and cold water supply, and drainage piping

The capacity of the furnace installed will depend on the volume of the house. A Core House, for example, would only require a small furnace with a capacity of about 20 MJ (20,000 Btu). Larger buildings or substantial additions could use a series of small furnaces which served different parts of the building. By heating an *Incremental Home* with a series of small furnaces, major alterations to the building can easily be accommodated by adding or removing furnaces accordingly.

Supply air passes through the floor in the space between the floor joists, and leads to floor vents. If the air is travelling parallel to the floor joists, this cavity can function as an air plenum and no ducting is needed. When air is being led across the floor joists or between panels, then 200 mm diameter ducting is used.

In multiple storey structures, return air can also pass through the floor from ceiling vents. For the rooms directly under the roof, all return air is ducted through the space between the ceiling and the roof. This space also contains the ducting for kitchen and bathroom vents, which are led up the chimney chase along with the stack vent, combustion air supply, and the flue (see figure 2.2.5.2). The 1990 Alberta Building Code recommends a minimum of 3 m between air intake and exhaust vents to prevent contamination of incoming air[5] This minimum distance could be accomplished with a tall chimney assembly, or by providing a fresh air intake vent at some other location in the building.

One further possibility would be to install a switching mechanism which could reverse the intake and exhaust vents. Since the vents are located at opposite sides of the chimney assembly, this would insure that air intake always took place at the windward side of the chimney.

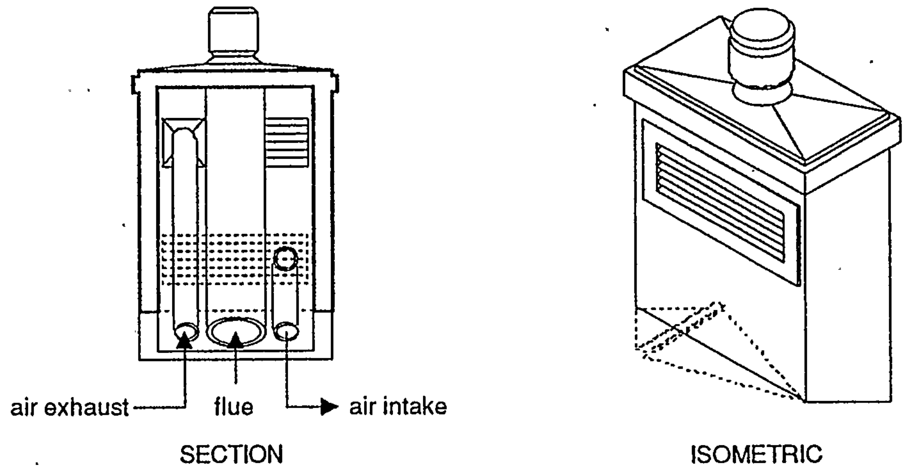


Figure 2.2.5.2 Section and isometric of chimney assembly

Whenever possible, the electrical power supply will be provided by a buried cable. Wiring within the building is almost entirely contained in the floor and ceiling panels. Switches, receptacles, and other electrical components in the interior wall partitions are connected by a loop of wire which passes through a single hole at the top and/or bottom of the panel. All receptacles are mounted on the baseboard and can also be installed in exterior wall panels. The plumbing wall provides the main vertical passageway between the floor and the ceiling (see figure 2.2.5.3).

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[5] Alberta Building Code 1990, article A-6.2.2.5

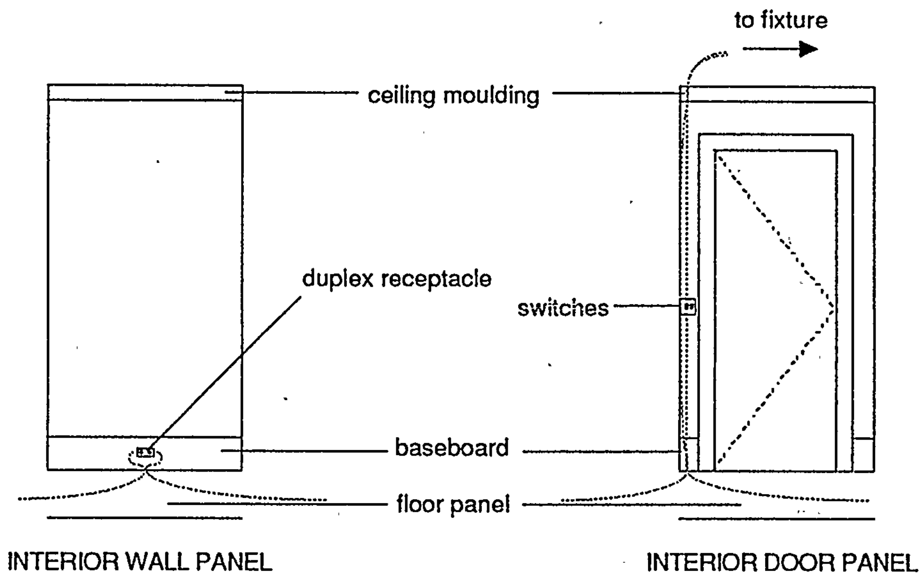

Figure 2.2.5.2 Elevations of interior wall and door panels showing electrical hook-up for receptacles and switches

LIST OF SERVICE COMPONENTS

PLUMBING	
Plumbing Wall	2 x 6 frame
	drywall -both sides
	-one side w' waterproof finish
	PVC piping, drains & stack
Hot Water Heater	180 liter (40 gallon) tank
Fixtures	bathroom sink
	toilet
	bathtub c/w shower
	kitchen sink
ELECTRICAL	
Electrical panel	various sizes (min. 100A)
Receptacles	duplex
	ground fault in bathroom
	waterproof outside
Switch	as needed
Light Fixtures	various
Wiring	as needed
HEATING AND VENTILATION	
Furnace	20 MJ (20,000 Btu)
	-one or more
Ducting	200 mm dia. where necessary
Floor and ceiling vents	75 x 300 mm
Flue	300 mm dia.
Chimney assembly	composite board c/w exterior finish
	2x6 framing
	RSI 3.5 (R20) rigid insulation
	plywood

2.2.6 ADDITIONAL COMPONENTS

Although not an essential part of the *Incremental Home* building system, there are a few other components which should be mentioned. For example, multiple storey *Incremental Homes* would require a staircase. Two staircases have been designed which can fit into a variety of different room layouts (see figure 2.2.6.1).

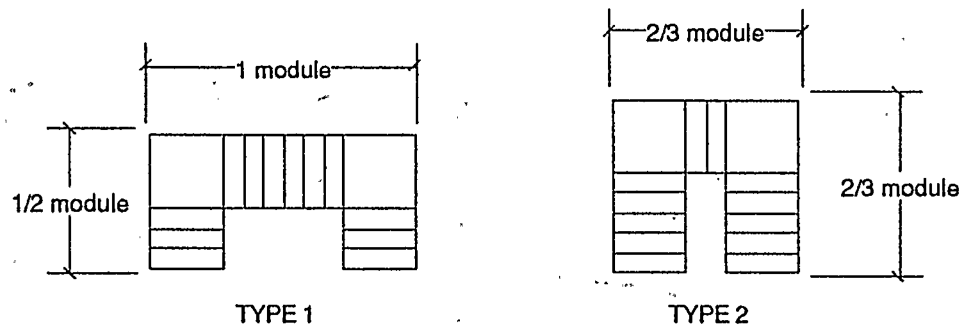

Figure 2.2.6.1 Examples of two staircase layouts

Another set of components which may frequently be included with the *Incremental Home* are porch and deck elements (see figure 2.2.6.2). Decks can be supported on the same type of foundation as the rest of the building, thereby making it possible to replace the deck with a floor panel and incorporate it into the rest of the house without having to dig additional foundations.

Other special components, such as fireplace of bay window wall panels, may also be worth consideration. There is no limit to the different kinds of components that could be specially designed for custom orders, or mass produced if demand was sufficiently great.

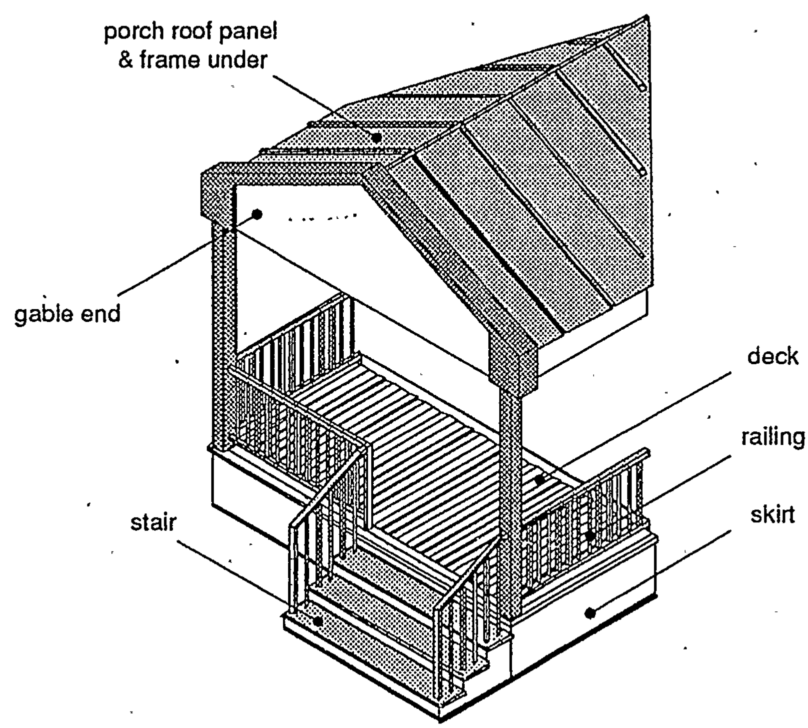

Figure 2.2.6.2 Porch components

2.3
THE INDUSTRIAL PROCESS

Prefabricated or *industrialized* construction can be differentiated from conventional construction by the extent to which the parts of a building are manufactured in a factory rather than at the construction site. This difference is only a matter of degree since there are several elements in most conventionally built dwellings which are also manufactured before they reach the site. These may include pre-cut studs; masonry; windows; pre-hung doors; roof trusses; cabinets; as well as fixtures and service components.

Prefabricated housing, however, also includes the manufacture of larger components such as walls, floors, and roofs. In this way the majority of the building can be constructed in a factory, and the work which takes place on the site is largely a matter of assembling the prefabricated components.

Assembly line manufacture can be applied to almost every aspect of the building process, from the production if individual sub-systems to the manufacture of entire buildings. For this reason the term 'prefabricated housing' encompasses a wide variety of building systems which vary in the degree of industrialization involved in the construction process as well as the kinds of building materials used.[1]

The systems which have been developed in the prefabricated housing industry can be ordered into three categories: pre-cut; panelized; and sectional prefabricated housing.[2] These categories are essentially a measure of the degree of completeness of the home before it leaves the factory. In general they refer only to the superstructure of the building since, in most cases, the foundations are constructed on site in a conventional manner.

Pre-cut Prefabricated Housing

Pre-cut housing systems provide most or all of the material necessary the construct the building envelope of a house. This type of system differs from conventional construction only in that all the material required for the structure of the building is pre-cut and provided in a single package. The amount of on site construction is reduced somewhat because all the components of the building: such as beams; studs; sheathing; and so on, have been cut to size prior to arrival. Nevertheless, a considerable amount of time and expertise is still required to erect a pre-cut house since it is assembled using largely conventional construction methods. One of the most popular, and most appropriate, structures to make use of the pre-cut strategy is the log house.

Panelized Prefabricated Housing

A panelized building system reduces a building to a series of planar components such as walls and floors, and sometimes roofs. Each component is manufactured individually and then shipped to the building site where they are assembled. These components can be finished on both sides and include windows, doors, electrical conduits, and other services. Assembly of a panelized building is far more rapid than with pre-cut

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[1] [1]Reidelback, Modular Housing, p231

[2] Wiedemann, Friedman, & Rybczynski, Modular Prefabrication versus Conventional Construction..., p3

systems. The *Incremental Home* could be categorized as this type of prefabricated housing but, because the panels are suspended on a structural frame, it is a hybrid system which does not fit comfortably in any of these three categories.

Sectional Prefabricated Housing

Of the three types of systems, sectional prefabricated housing is the most 'manufactured', in the respect that most of the work takes place in the factory and very little at the building site. Most sectional houses are comprised of two or more sections which are shipped as fully assembled volumes, and fastened together at the building site. The size and fragility of these sections, however, can make them difficult to transport over long distances. A mobile home can be considered an extreme example of a sectional house with only one fully finished section and no permanent foundation (see figure 2.3.1).

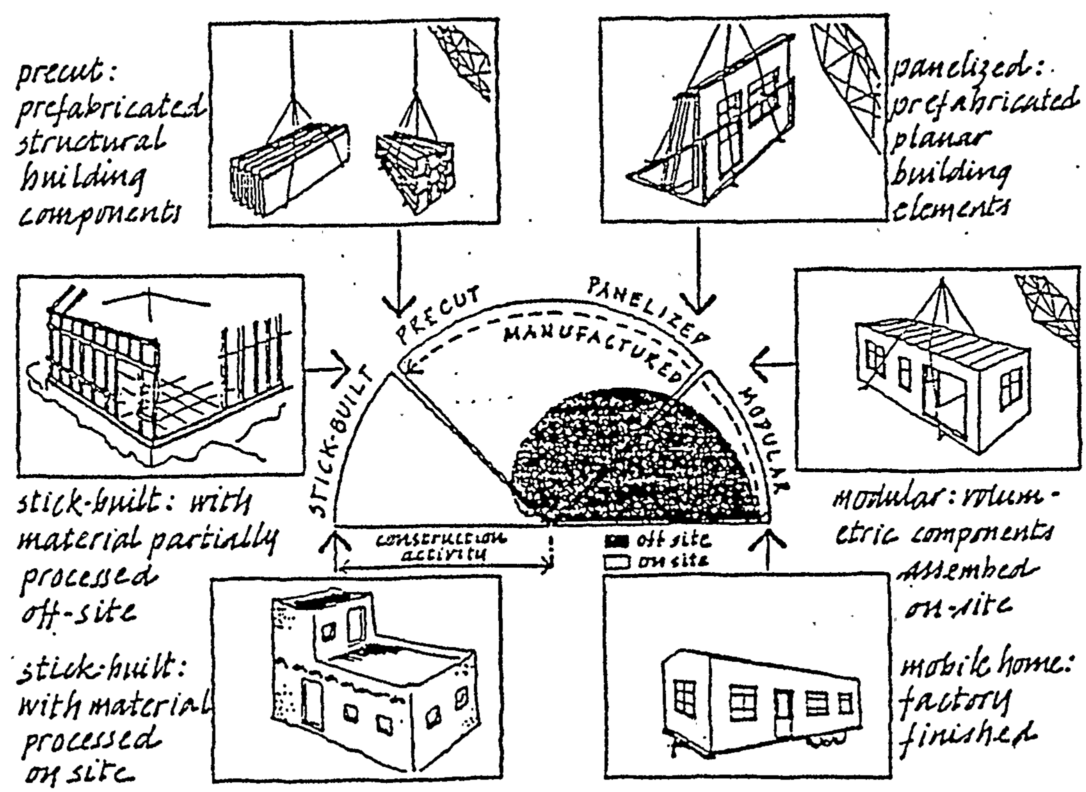

Figure 2.3.1 The housing construction spectrum[1]

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[1] Modular Urban Housing: a Design Challenge, City of Boston Public Facilities Dept. Urban Design Unit, 1988

There are several advantages which prefabricated building systems have over conventional construction. Below is a list of advantages which prefabricated techniques can have over conventional construction:[1]

Quality Control: High-precision machinery imposes a schedule and a discipline. Higher tolerances, more accurate measurements, with less maintenance and material waste and greater consistency of finish, result.

Production Control: Programmed production, timed delivery and/or erection lessen the need for large stock inventoried left in the factory or on the site. Construction is faster on the site where a more efficient order of building sequences can be maintained.

Inventory Control: The tighter inventory controls possible in a factory setting, over small-piece building materials and components-piping, ducts, fans, windows, bricks, and tools-virtually eliminate the high rates of theft and vandalism on the site.

Labour Control: More extensive use of unskilled labour is possible in the factory because of improved supervision (one foreman can adequately supervise more men) and because of the quality control inherent in the machinery.

"Wet" trades, in which labour is already in short supply, are eliminated as well as costly hours spent on skilled labour due to overlapping of plumbing, electrical, and finish carpentry trades.

A permanent site of employment guarantees full-time all-year jobs which provide a more successful continuous type of employment relationship for both employee and employer.

Climate Control: Factory conditions release certain areas from the "building season" limitations imposed by their climate conditions. A permanent labour force that can be employed when days lost to bad weather are minimized also reduces costs of training and initiation to jobs.

Problem Control: The detailed appraisal of constructional problems before work begins results in fewer delays in construction after commencement on the site.

Given these advantages it is hardly surprising that, when industrialized housing systems were first becoming popular, it was commonly believed that the economic gains made possible by mass-production would soon lead this systems to dominate the housing industry. Four decades later, however, industrialized housing is still not nearly so dominant as these earlier forecasts had projected. In fact, by 1987, only 11.4 of all housing starts in Canada (not including mobile homes) were prefabricated homes.[2]

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[1] Cutler, Handbook of Housing Systems..., p22-23

[2] Wiedemann, Friedman, & Rybczynski, Modular Prefabrication versus Conventional Construction..., p7

A study conducted by McGill University, which examined fifteen prefabricated housing companies, concluded that these companies were unable to realize cost savings though prefabrication techniques:

> **It is believed that the primary reasons for the higher cost of prefabricated housing [as opposed to conventional construction] are related to the following factors of production. Firstly, the prefabrication industry must sustain considerably larger amounts of overhead. This overhead results from the factory building itself and the larger amounts of machinery which are needed in the production process, as well as, large amount of land for the plant, administration buildings, and the material and product storage. Many manufacturers also must invest in vehicles to transport their product to the site. Secondly, due to the higher structural quality needed to sustain the transport to the site a higher cost for the unit is levied. Overbuilding between the first and second storey modules also increases the unit cost. Thirdly, as each building on the production line is generally different, requiring individual sets of plans, and as the volumes absorbed by the Canadian market are quite low it is very difficult to achieve the economies of scale needed to maximize cost savings using the factory production process...**
>
> **from Modular Prefabrication versus Conventional Construction...** [1]

The *Incremental Home* has several advantages over the prefabricated housing companies surveyed in this study. Unlike all of these companies, and prefabricated homes in general, the *Incremental Home* includes a prefabricated foundation system. Most other systems only manufacture the superstructure of the house, which is then fastened to conventional foundations. Although this is an option with the *Incremental Home*, prefabricated foundation components can also be used which can significantly reduce the amount of time and site work required, and consequently the costs involved.

All but two of the companies surveyed produce sectional houses -a prefabrication system which maximizes factory construction but has several disadvantages. The most serious problem is distribution: the overall size of the sections can be strictly limited by transportation and other restrictions, as is the distance from the factory to which they can be economically transported.

A panelized system like the *Incremental Home* is far more compact and versatile to transport since the components can be packed in one or more containers in a number of different ways, depending on the type of transportation and the location of the building site. Because of the lightweight and compact nature of the components, the radius of distribution from the factory can be far greater than for most sectional homes. Widespread distribution on a national or even an international scale could ensure market stability and large scale production.

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[1] Wiedemann, Friedman, & Rybczynski, Modular Prefabrication versus Conventional Construction..., p35

Although a tremendous variety of sizes and configurations of buildings are possible with the *Incremental Home*, all these buildings are assembled from a small number of identical or similar components. This duplication should facilitate the mass-production of components, and their systematic assembly makes it a simple task to generate plans for any individual building.

Nevertheless, the outstanding feature of the *Incremental Home* is not the initial construction of the building, but the ease and economy with which subsequent modifications can be made.

The viability of any prefabricated housing company relies in the efficiency of the manufacturing process to outweigh the additional overhead costs which arise from setting up and running a factory. These overhead costs can be considerable.

Perhaps the most important decision to be made regarding the manufacture of components is which components to produce in-house and which to subcontract out. To manufacture most of the components in-house can improve coordination and flexibility, and reduce their cost. However,the increase in efficiency and control over production is accompanied by increased overhead costs which result from a larger workforce, more machinery, and a bigger plant.

The strategy envisioned for the *Incremental Home* is to begin by manufacturing only the most essential components, such as the structural frame, the exterior and interior panels, the exterior battens, and perhaps the trim. At this time the windows, doors, cabinetry, metal flashing, and service components would be subcontracted to other manufacturers. This approach would only require a small plant and basic machinery such as cutting tables, truss jigs, and presses.

If demand came to outstrip production, more sophisticated manufacturing equipment could be acquired, and more components could be produced in-house. This expansion of production facilities might eventually lead to the in-house production of all but the most specialized components such as plumbing fixtures and other service elements. Even the manufactured of some building materials: such as the truss joists; rigid insulation; and even the exterior cladding material, may be considered.

The type of vehicle used to transport the components would depend on the location of the building site and its distance from the factory. For local distribution, say within a 200 km. radius of the factory, a flat-bed truck could be used. This truck would be equipped with a lightweight crane which would assist in the loading and unloading of the components,.as well as the installation of roof, floor, and even wall panels. Flat-bed trucks would be either leased or owned by the company, depending on the number of deliveries made (see photo 4).

In order to reach far greater distances the *Incremental Home* components could be packed into individual containers and shipped on transport trucks, rail cars, or cargo vessels. Once near their final destination, the containers are transferred onto flat-bed trucks which take them to the building site.

Despite the relatively poor performance of prefabricated housing companies in the North American housing market, these advantages may give the *Incremental Home* a competitive edge. In order for any prefabricated housing company to succeed, the overhead costs for the plant, equipment, and administration must be outweighed by the economies of scale which result from mass-production. By appealing to a broad cross-section of the housing market, at home and abroad, the *Incremental Home* may be able to acquire an adequate share of the market.[1] Successful widespread distribution would not only maintain the financial viability of the system, but it would also insure the continued availability of components to *Incremental Home* owners who wish to modify their dwellings.

The following section 2.4 The Assembly Process, described the sequence of stages in which the building components are assembled once they have been delivered to the building site. Although *Core House A* has been used as an example, the assembly techniques described apply to *Incremental Homes* of any size.

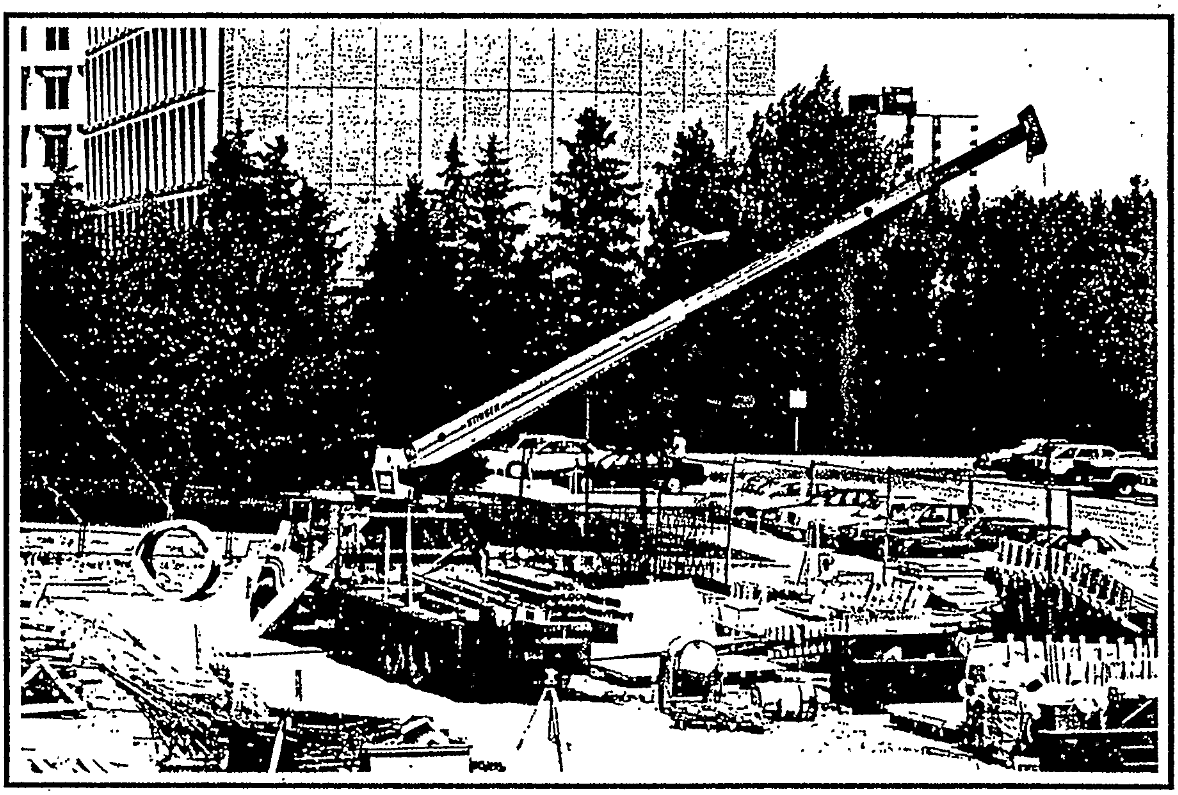

Photo 4 A typical flatbed truck with crane

1 see Section 3.5 Market Analysis, for further elaboration

2.4
THE ASSEMBLY PROCESS

The following pages are a series of drawings illustrating the construction stages of an *Incremental Home*. The example used in this sequence is *Core House A* (see figure 2.4.1). A building of this size would require about four days to complete with a team of four workers familiar with the building system. Larger buildings or a different workforce could have a significant impact on the time required to complete an *Incremental Home*.

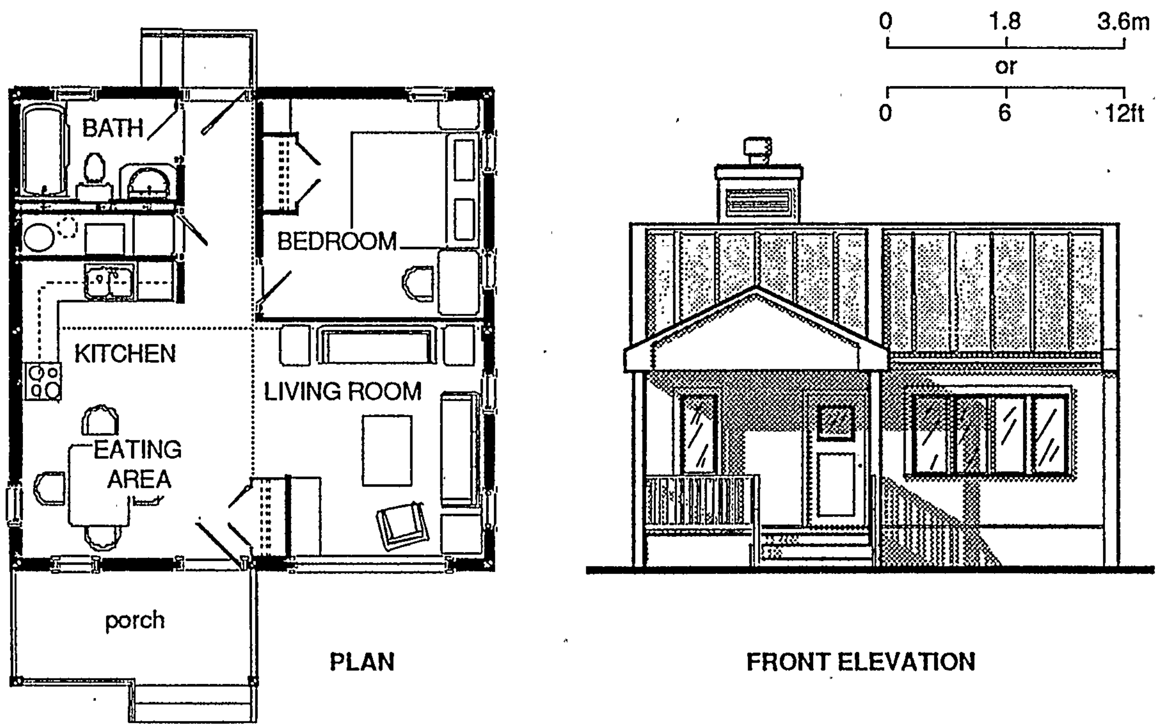

Figure 2.4.1: Plan with possible furniture layout, and elevation of *Core House A*

CONSTRUCTION SCHEDULE

DAY 1:	Site preparation
DAY 2:	Installation of foundation frame
	Installation of floor panels and erection of structural frame
	Installation of enclosure panels
DAY 3:	Completion of exterior
	Installation of plumbing wall, peripheral trim and interior partitions
DAY 4:	Completion of interior

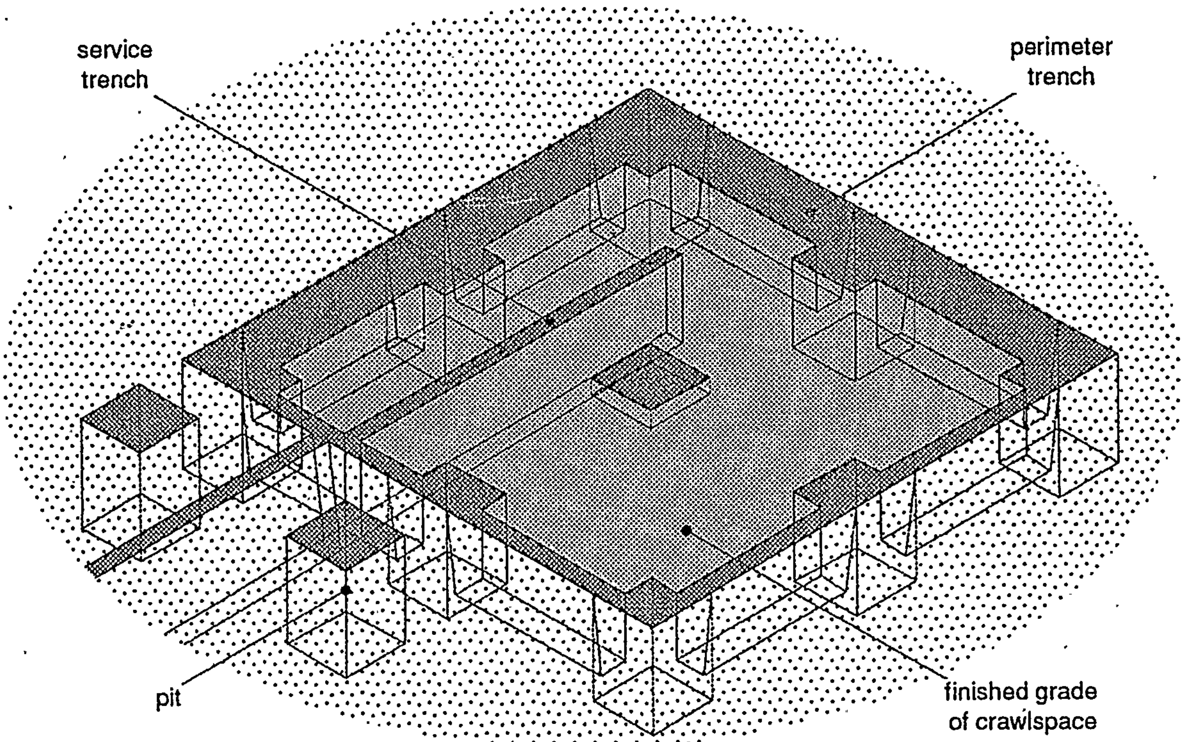

Figure 2.4.2 Site preparation

DAY 1:

- Make any necessary cuts and/or fills to adjust the overall grade of the site
- Dig trenches and pits to accommodate foundation wall panels, posts, and pads to below frost line
 (approx. 1.2m in Calgary)
- Adjust grade within future enclosure to establish height of crawlspace
 (approx. 0.3 to 0.6m on a flat site)
- Dig service trench(es) and lay services
- Pour gravel into pits and compact to depth of approx. 150mm
- Check elevations and add or take away gravel to insure a level plane (+/- 10mm)

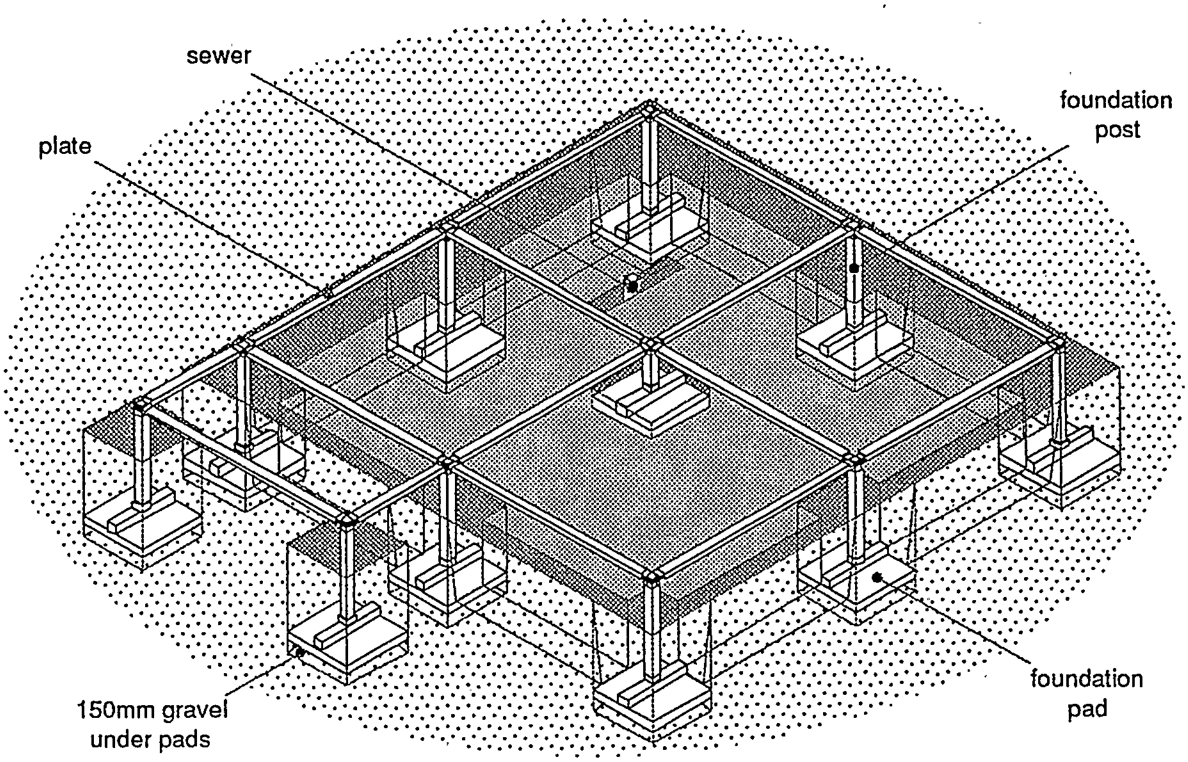

Figure 2.4.3 Installation of foundation frame

DAY 2:
- Install foundation pads
- Insert foundation posts into shoes and check elevations
- Add fillers where necessary to insure alignment (+/- 2mm) and fasten posts to shoes
- Fasten angle irons to posts and attach plates

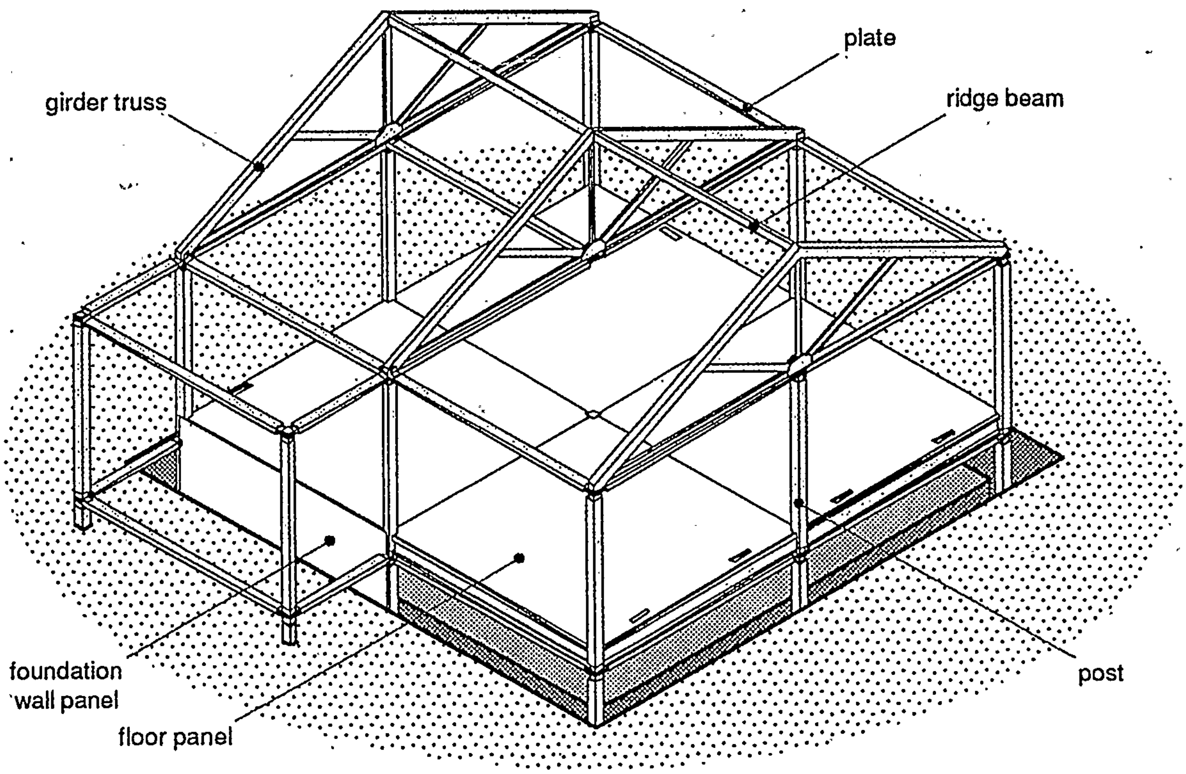

Figure 2.4.4 Installation of floor panels and erection of frame

DAY 2 (cont):
- •Attach angle irons to plates
- •Fasten posts to plates
- •Install floor panels (use of crane may facilitate this stage)
- •Fasten angle irons to top of posts
- •attach top plates
- •Fasten angle irons to plates and attach girder trusses and ridge beams
- •Check alignment

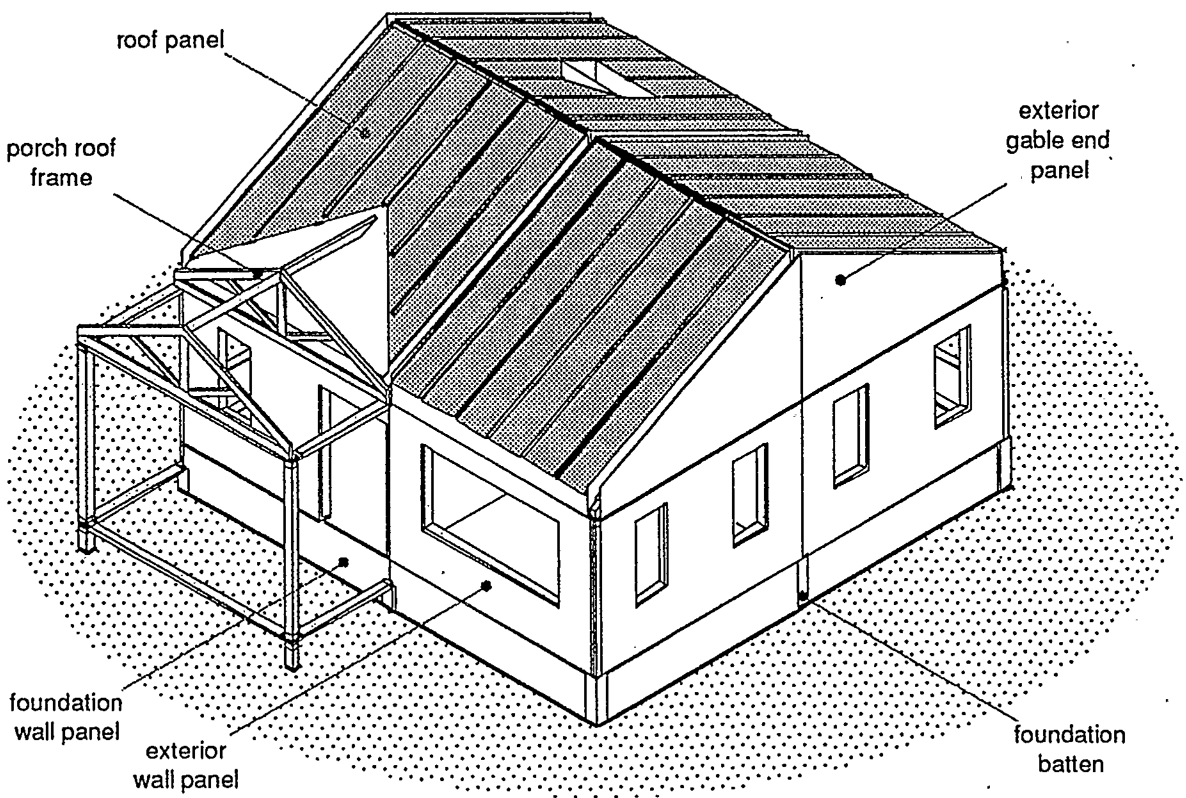

Figure 2.4.5 Installation of enclosure panels

DAY 2 (cont):
- Install foundation wall panels and battens
- Install drainage tile if necessary
- Fill peripheral trench
- Install exterior wall and gable end panels
- Install roof panels with assistance of crane
- Attach structural frame of porch roof

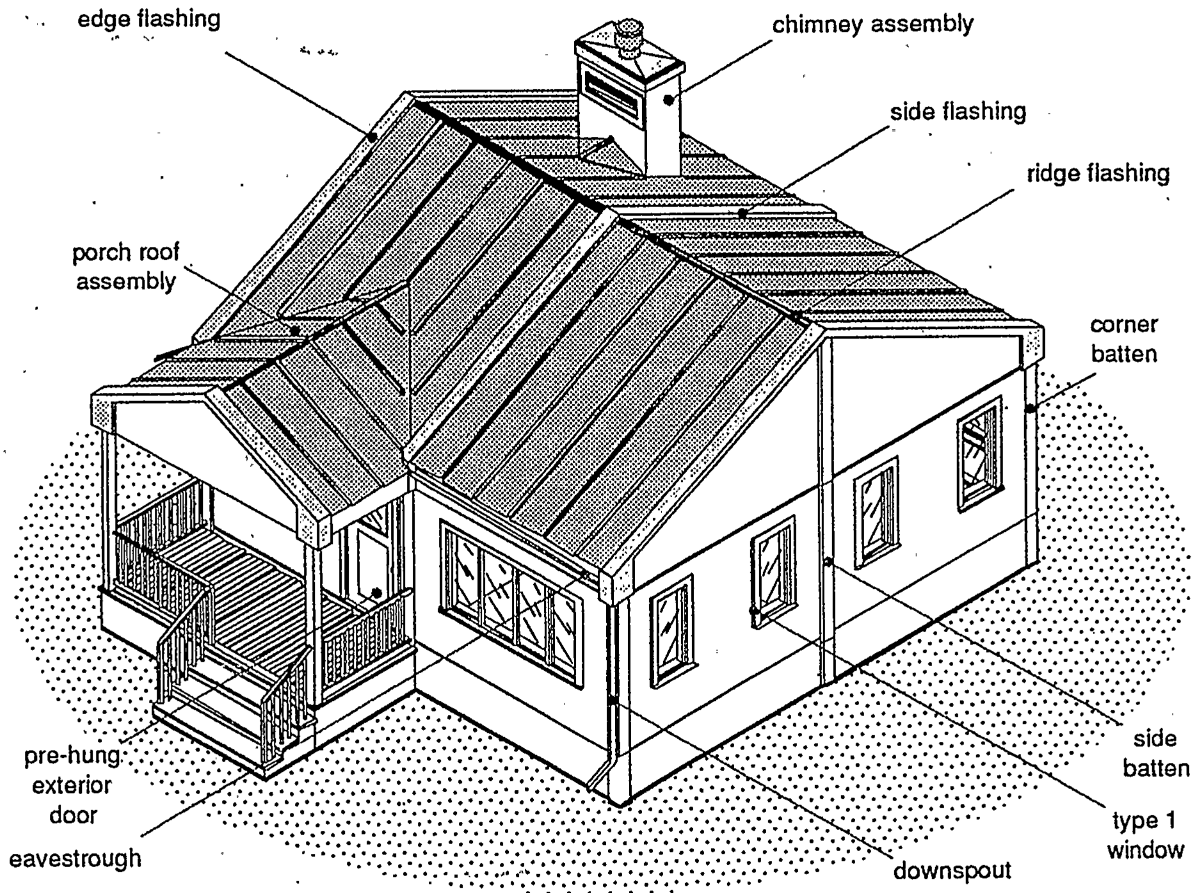

Figure 2.4.6 Completion of exterior

DAY 3:

- Attach side battens, corner battens, and fascia
- Install porch roof and chimney assembly
- Attach ridge and edge flashing
- Install windows and exterior doors
  - the building can be locked at this stage
- Install porch deck, railings, and steps
- Attach eavetroughs and downspouts

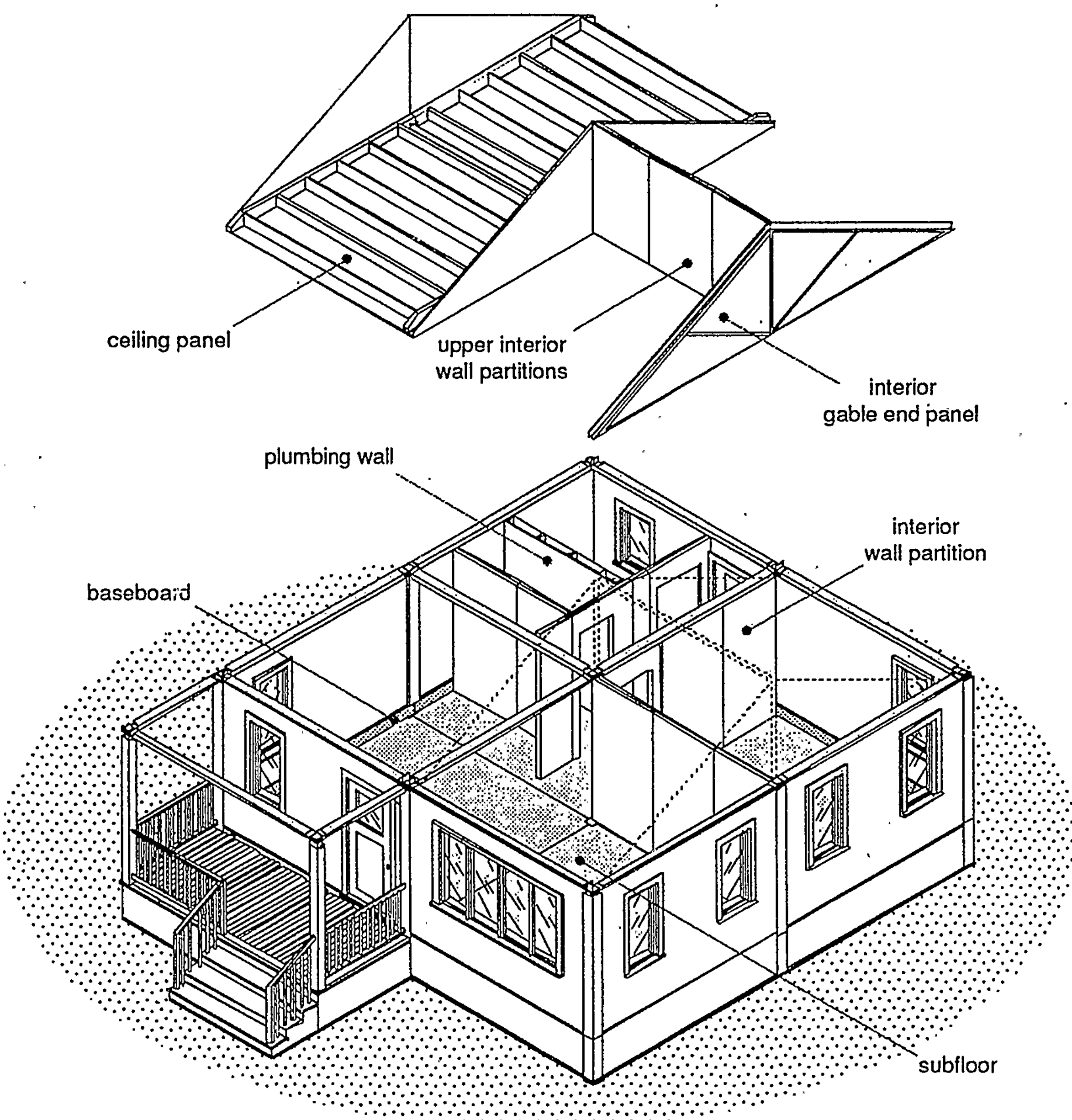

Figure 2.4.7 Installation of plumbing wall, peripheral trim, and interior partitions

DAY 3 (cont):
- •Install interior gable ends
- •Install interior trim along perimeter
- •Install plumbing wall
- •Install ceiling panels, rails and interior wall partitions

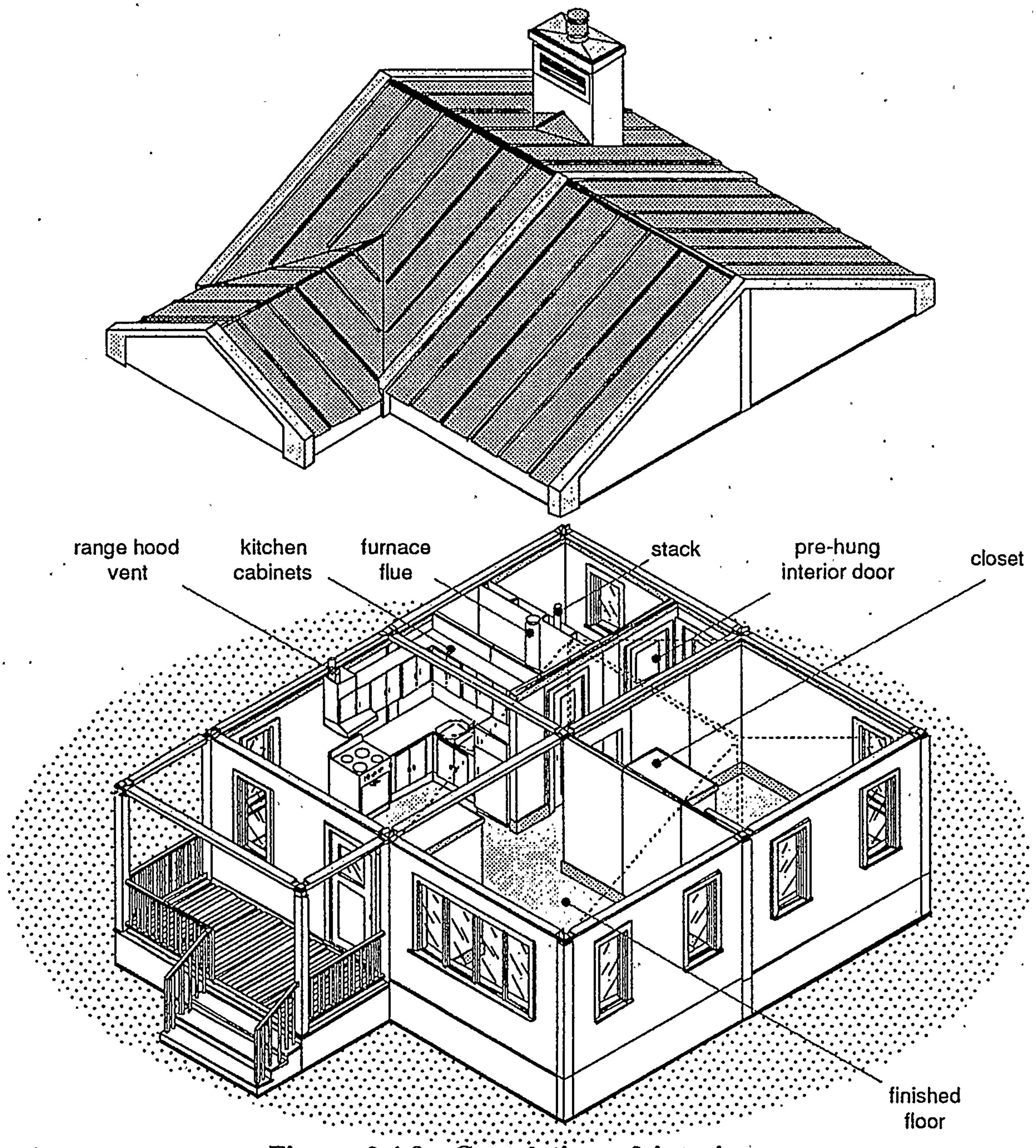

Figure 2.4.8 Completion of interior

DAY 4:

•Install plumbing and electrical fixtures
•Hook-up plumbing, ventilation, and electrical services
•Install floor finishes and pre-hung interior doors
•Assemble and install cupboards, vanities, closets and shelves

2.5 RENOVATING THE INCREMENTAL HOME

The single most outstanding feature of the building system is the ease and economy with which an *Incremental Home* can be modified. This flexibility has been achieved by isolating the structure of the building from the panels which enclose space. Since all of the components of the *Incremental Home* are attached together with demountable fasteners, any of the panels can simply be detached from the structural frame without jeopardizing the structural integrity of the building or damaging any of the components. The removed components can then be used elsewhere, thereby reducing the number of new components needed for the renovation.

The flexibility of the building system enables an *Incremental Home* to be enlarged, reduced, or otherwise altered in only a fraction of the time, and with far less inconvenience and expense, than would be required for a similar renovation made to a conventional structure using conventional techniques. By facilitating the renovation process, *Incremental Home* owners might be encouraged to modify their dwellings as often as they see fit, thereby insuring the on going suitability of their homes.

If a sufficiently large building site is available, there is no limit to the amount of horizontal expansion possible with the *Incremental Home* building system. Additional spaces can be added to any side of an *Incremental Home* according to a layout determined by the occupants of the home. The *Incremental Home* can also be expanded vertically to become a building which is three or possibly four storeys in height.

Horizontal expansion has been illustrated by the addition of two volumetric modules to *Core House A*. This would increase the floor area of the house by 50%, and allow for the addition of two rooms, or in this case, one additional room and an enlarged living and bedroom (see figures 2.5.1 and 2.5.2).

Vertical expansion has been illustrated by the addition of four volumetric modules to *Core House A*. This would increase the floor area of the house by 90%, and allow for the addition of three bedrooms and a bathroom upstairs, and an enlarged living/dining area downstairs (see figures 2.5.3 and 2.5.4).

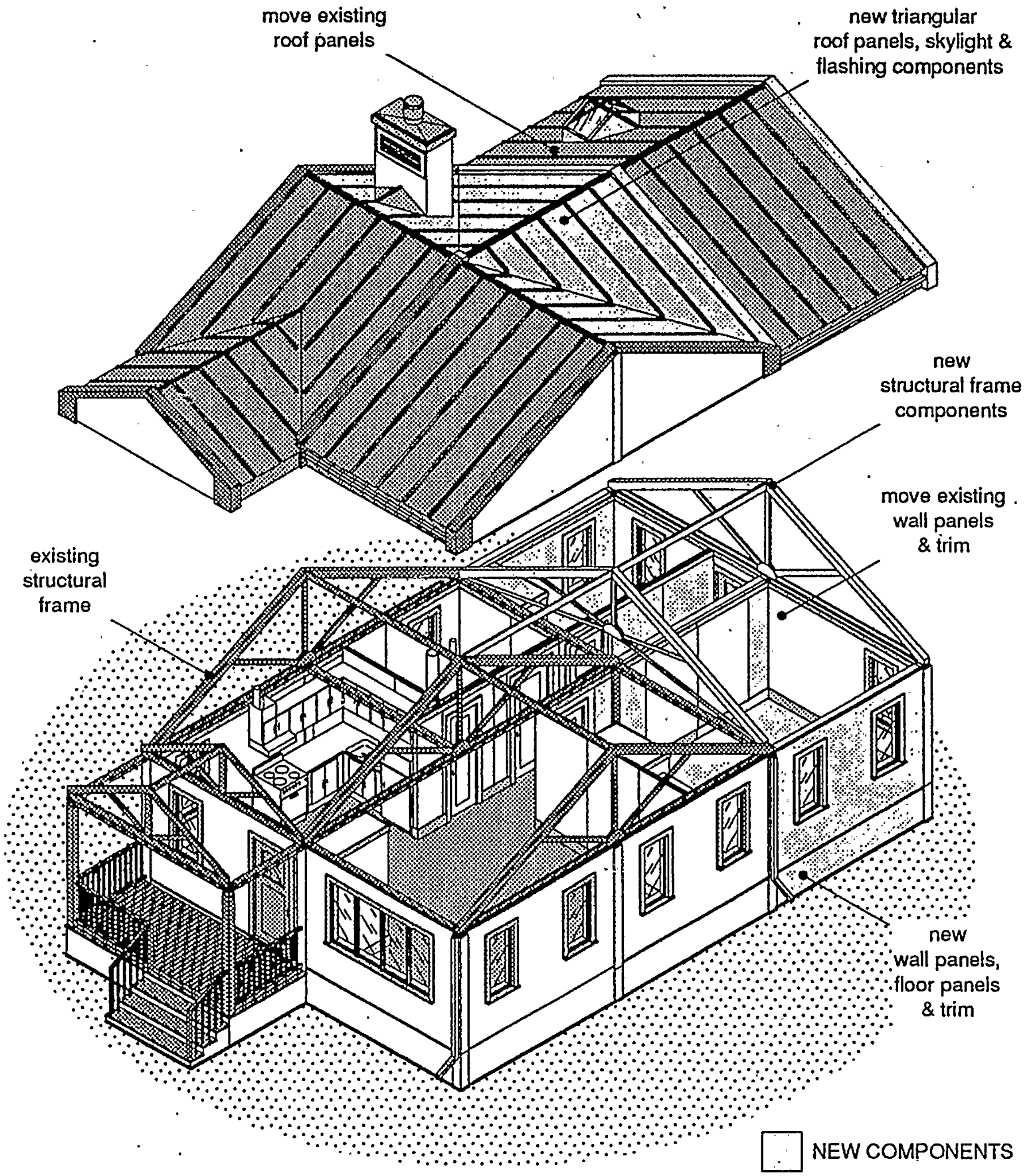

Figure 2.5.1 Addition of two volumetric modules to *Core House A*
Area of addition: 26 sq m or 280 sq ft

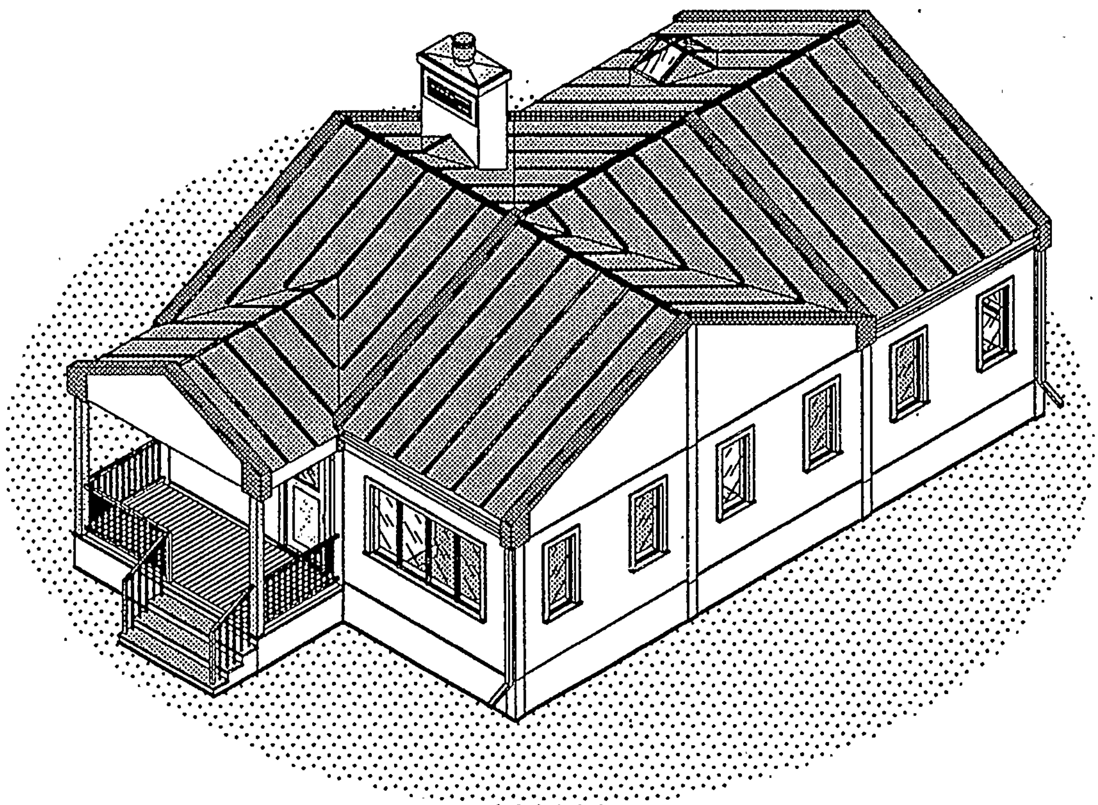

Figure 2.5.2 ***Incremental Home*** **after horizontal expansion**
Total floor area: 78 sq m or 840 sq ft

DAY 1:
•Dig pits and trenches for foundations and along foundation wall panels to be moved
•Remove trim, wall, and roof panels to be moved
•Install new foundation, post, and roof structural components, and attach to existing frame
•Install new and moved enclosure, flashing and trim components
DAY 2:
•Remove interior wall and trim components to be moved
•Install new and moved interior components, additional.sevice components, and finish

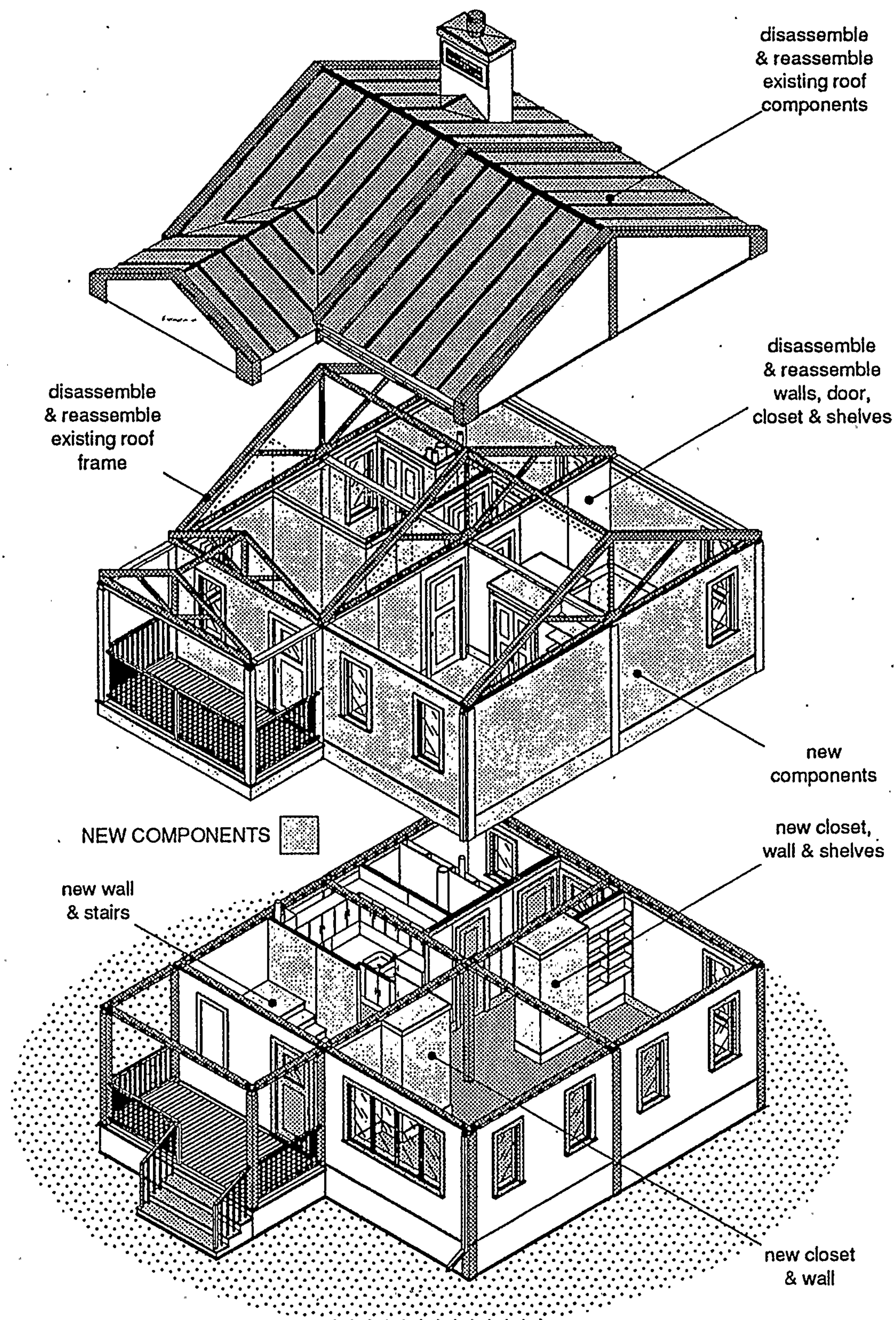

Figure 2.5.3 Addition of second storey to *Core House A*
Area of addition: 46 sq m or 510 sq ft

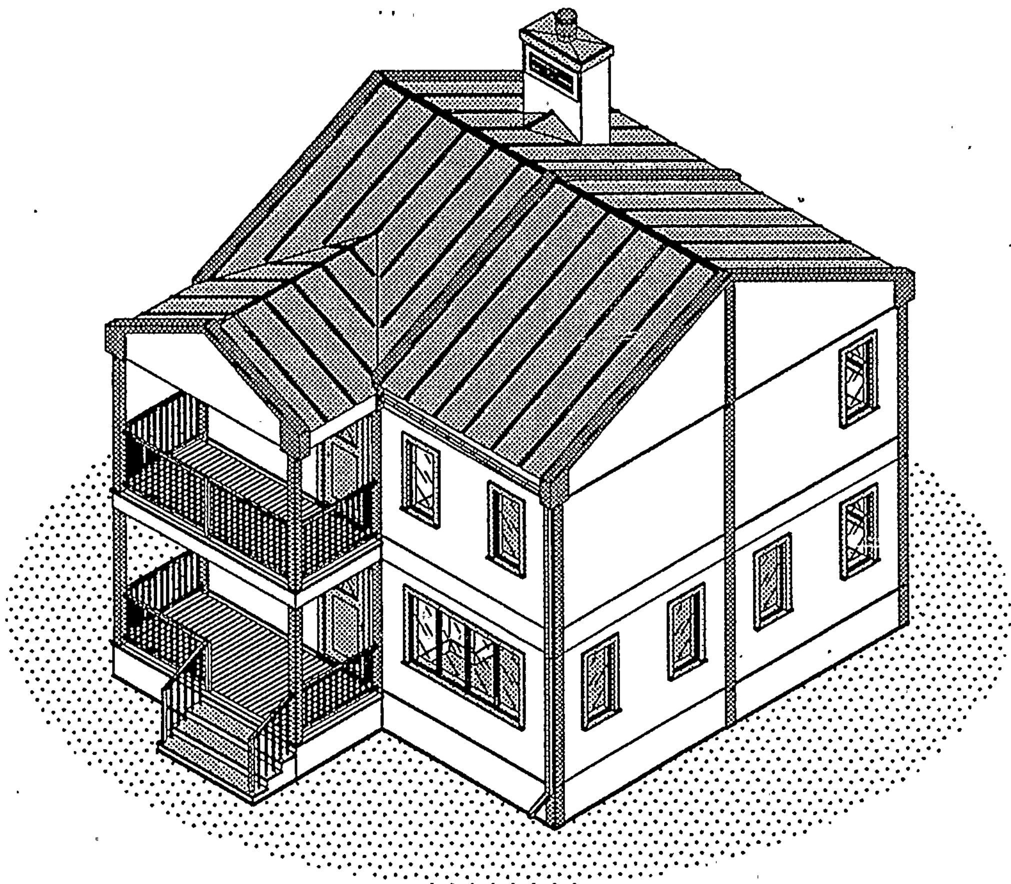

Figure 2.5.4 ***Incremental Home*** **after vertical expansion**
Total floor area: 98 sq m or 1090 sq ft

DAY 1:
•Disassemble roof components to be moved
•Install new structural components, and attach to existing frame
•Install new floor, wall and trim components
•Reassemble moved roof components
DAY 2:
•Install new staircase
•Remove interior wall and trim components to be moved
•Install new and moved interior components, additional sevice components, and finish

3
APPLICATIONS

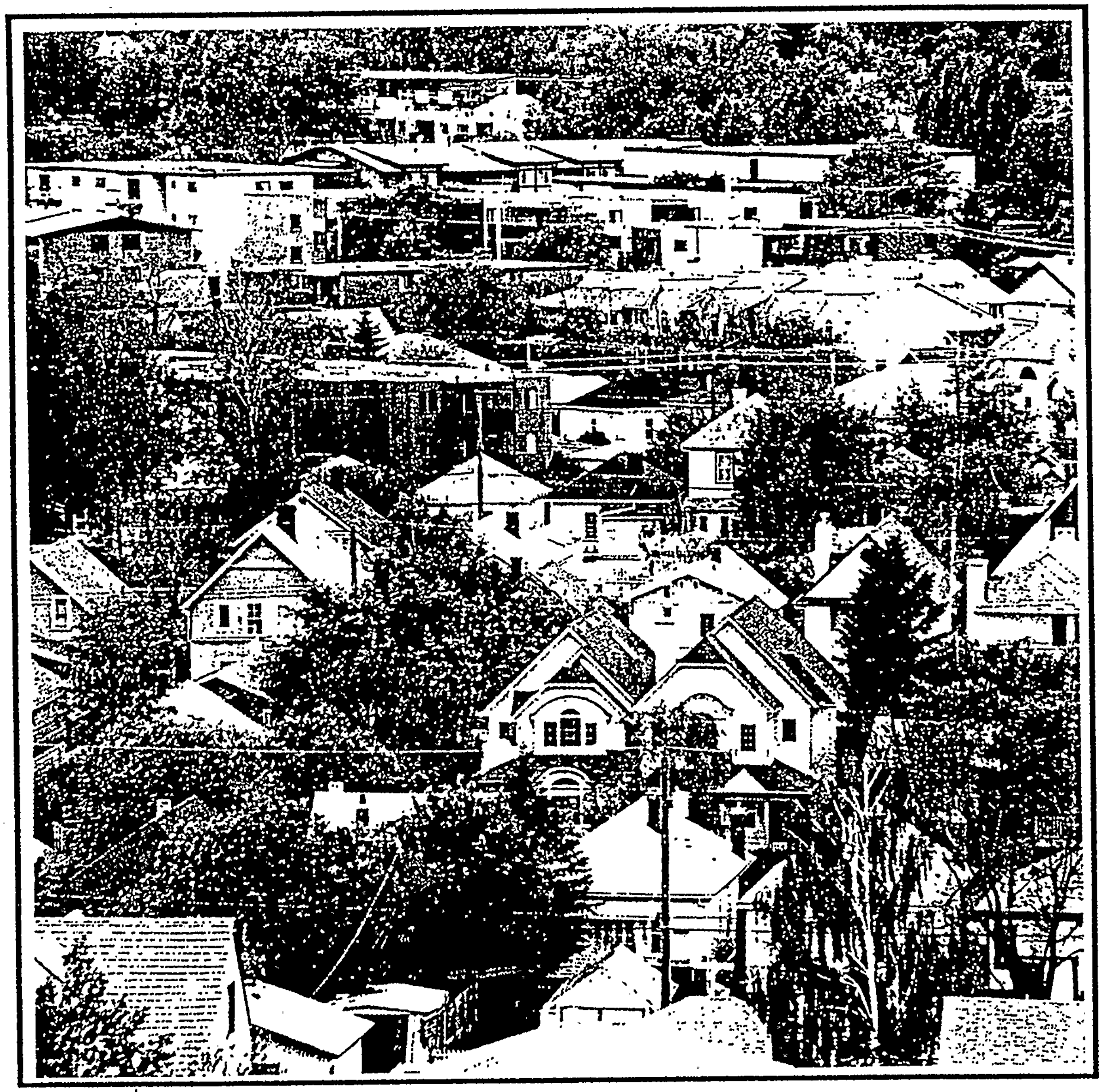

Photo 5 A residential neighbourhood

3.1
THE FREE-STANDING INCREMENTAL HOME

3.1.1 THE CORE HOUSE

Although a variety of different applications are possible with the *Incremental Home* building system, some of which are described in further detail below, the system has been designed primarily for the purpose of constructing free-standing, single family dwellings. Due to the expandable nature of the building system, these dwellings have no fixed size or configuration and can address the needs of a broad range of the housing market.

The smallest practical size for an *Incremental Home* is embodied in the concept of the *Core House*. The *Core House* provides approximately 52 square meters (or 575 square feet)[1] of floor area and contains bathroom and kitchen facilities. The rest of the interior space can be further subdivided to provide a separate bedroom, or simply be left as an open plan. The amount of space enclosed by a *Core House* should be sufficiently large for the needs of most single occupants or couples. Smaller dwellings with only 39 square meters (or 430 square feet) are possible, but their size may be considered inadequate for the domestic activities of more than a single occupant.

The *Core House* is not a specific building, but rather a collection of a minimum number of building components which can be assembled in a number of different ways to produce a variety of layouts. The layout of the *Core House* would depend, in part, on the future expansion plans of the occupants. The layout of *Core House A*, for example, facilitates the addition of a second storey. *Core House B*, on the other hand, is better suited to horizontal expansion. Other variations have been designed to address specific site conditions such as a *Core House C*, for a narrow lot, and *Core House D*, for very remote biulding sites (see figures 3.1.1.1 and 3.1.1.2).

The most significant difference between a *Core House* and other small houses is the ease and economy with which it can be expanded. A *Core House* can be modified with many different types and sizes of rooms using only the components listed in the *kit of parts*. The roofing components limit the width of additions to 7.2 meters or 24 feet, but there is no restriction to the overall length. With the exception of some service rooms, he interior space can be left unbroken, or it can be subdivided by wall and ceiling panels in any way desired by the occupants. Even special variations such as two storey or split level spaces can be accommodated by the building system with relative ease (see figure 3.1.1.3).

A *Core House* may, for example, may be well suited to the spatial needs and financial resources of a young couple. The house can subsequently be expanded at some later date to provide more living space for children or other developments. In this way the *Incremental Home* owner need only finance what is currently needed, and does not have to support the cost of additional space that may only be needed at some future date.

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[1] Conversions between Metric and Imperial measurements are only approximate since the dimensions of all the components will vary somewhat depending on whether the raw materials, such as studs and sheathing, have been cut according to Imperial or Metric dimensions. For further elaboration see Section 2.1 The Dimensional System.

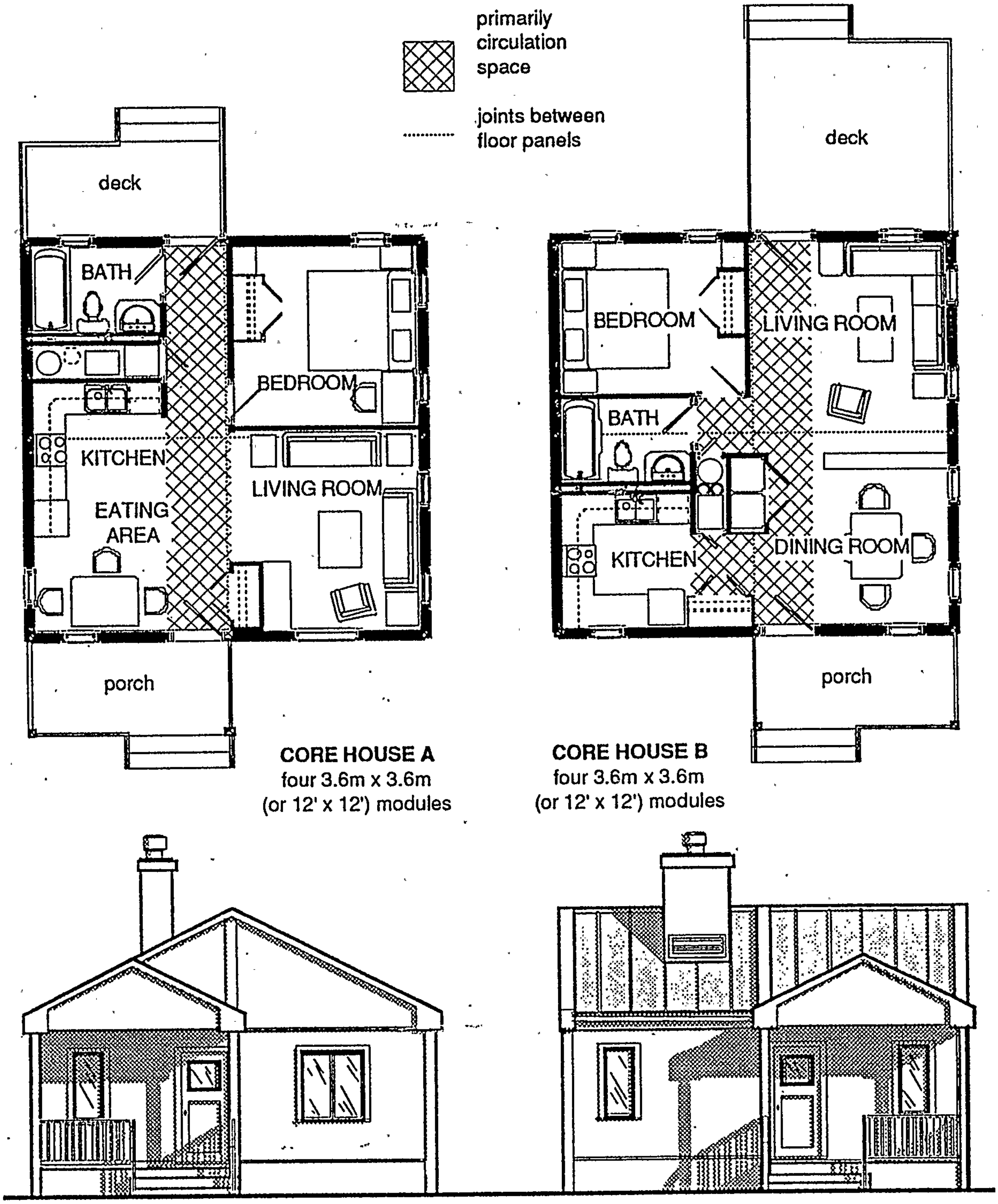


Figure 3.1.1.1 Plans and elevations of *Core House A:* suitable for horizontal, and particularly for vertical, expansion; and *Core House B,* particularly suited for initial horizontal expansion

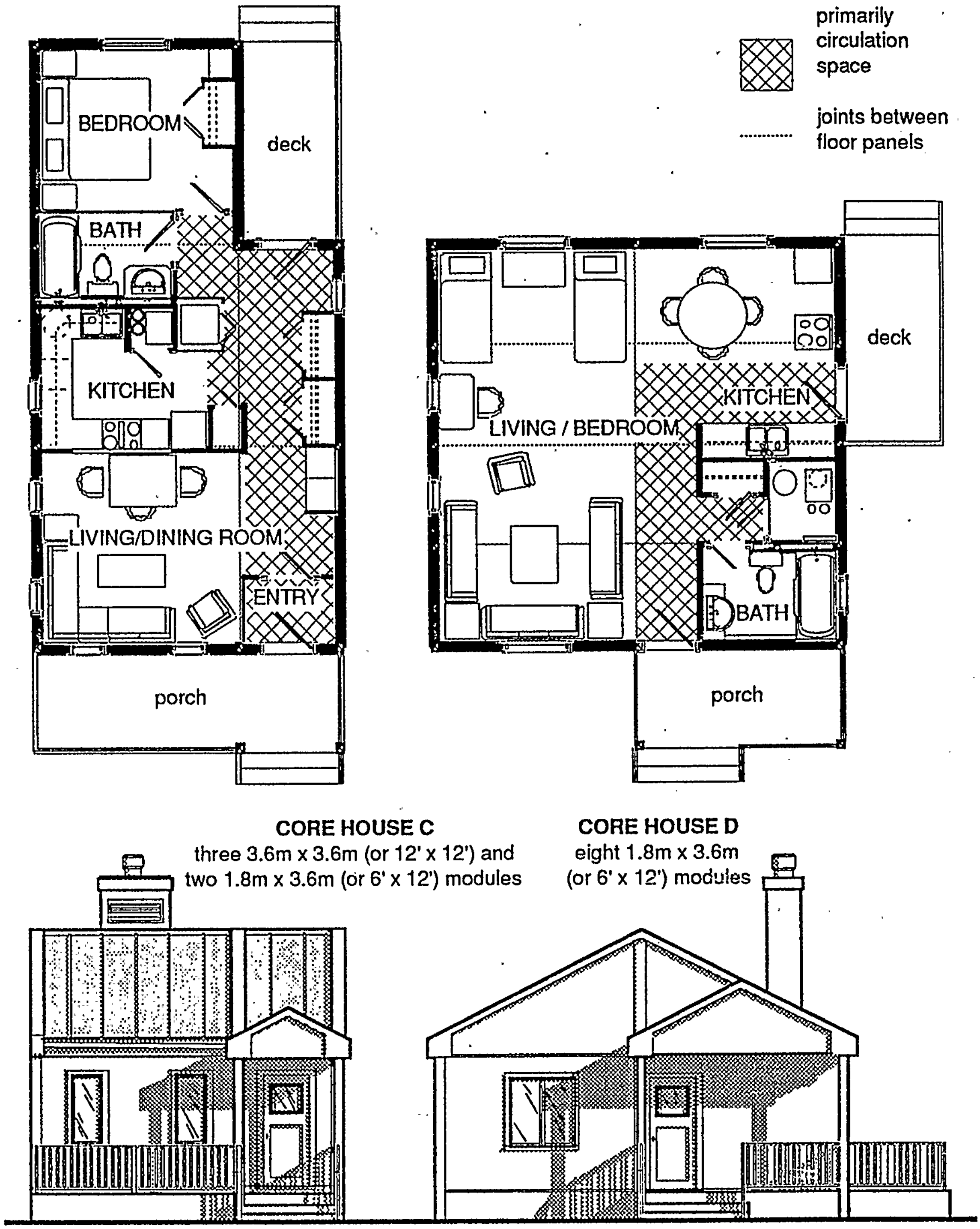


Figure 3.1.1.2 Plans and elevations of *Core House C:* suitable for narrow lots; and *Core House D,* suitable for locations too remote for a crane

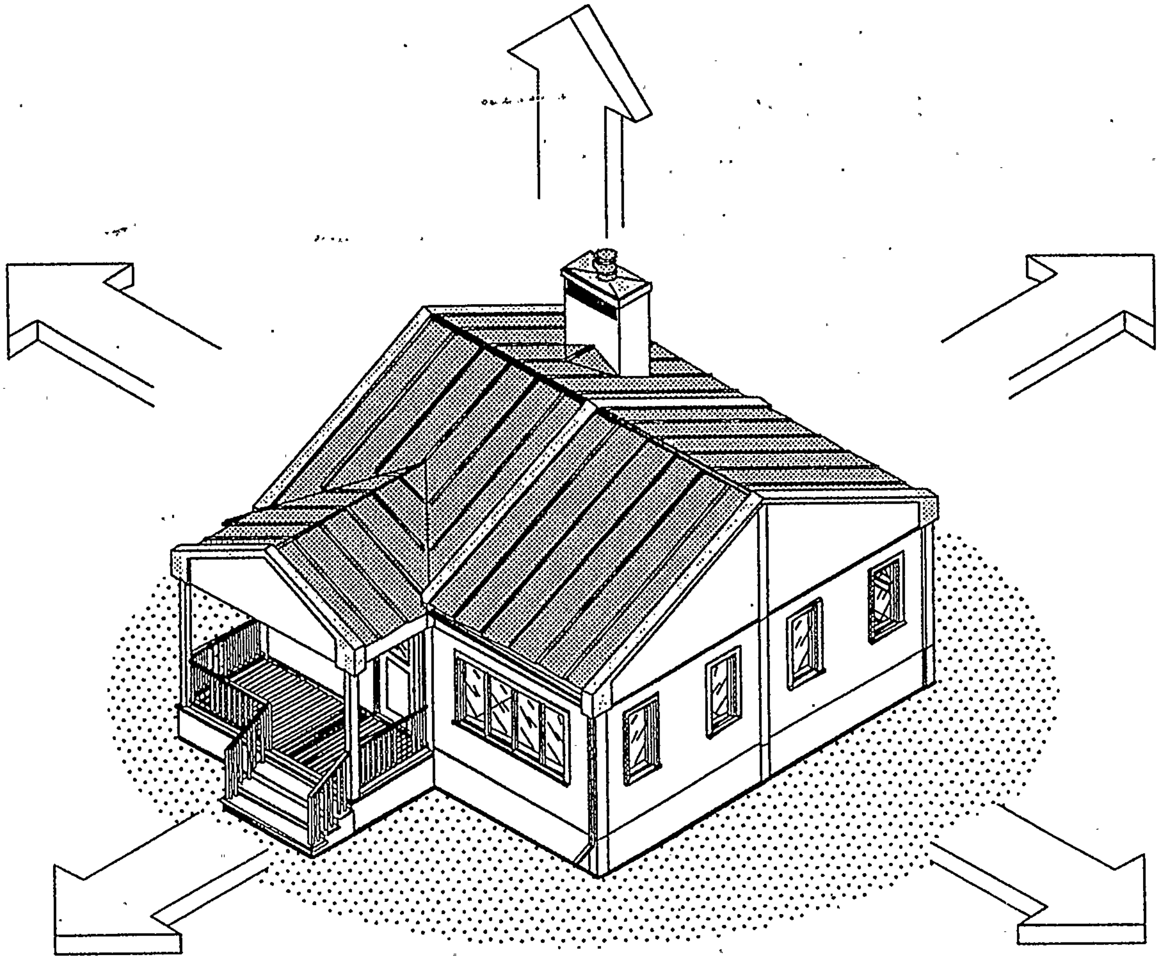


Figure 3.1.1.3 Directions in which a standard *Core House* can expand.

3.1.2 RURAL SETTINGS

One factor which can have considerable impact on the cost of the dwelling is the location of the site on which an it is built. Whether the *Incremental Home* is located in a rural or an urban context, for example, can have an impact on land costs as well as several aspects of the cost of construction. The design constraints on the building can also vary significantly between these two contexts.

The ideal location of an *Incremental Home* is on a large parcel of land. A large lot is desirable because it allows the building to expand in any direction without being restricted by the limits of the property. This situation is most frequently found in the country where, in general, lots are larger and relatively less expensive. A rural setting also permits the *Incremental Home* to adopt any configuration without being restrained by the many by-laws which are often imposed on urban lots, such as height and yard restrictions, or the formal demands of community development plans. Instead, the building is free to respond to environmental parameters such as sun, wind, and the lay of the land (see figure 3.1.2.1).

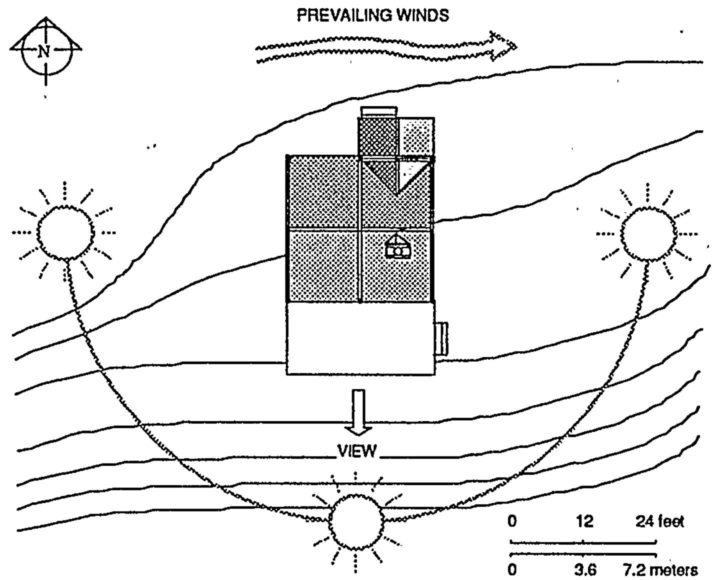


Figure 3.1.2.1 Design parameters in the countryside: natural elements such as sun, wind, and topography

The prefabricated nature of the *Incremental Home* has a significant cost advantage over conventional techniques when building in the country. This is because the assembly process of an *Incremental Home* is greatly simplified and requires much less on-site construction. This results in the need for fewer trades, as well as the number of times that these trades must visit the site. Particularly in more remote locations, the time accumulated by the trades travelling to and from the site can become a sizeable fraction of the overall building costs. If the homeowner chooses to finish the building himself, these costs can be eliminated once the building envelope is complete.

The *Incremental Home* system can be used even in very remote locations. This is because the components of the system can be arranged in a variety of different ways during transportation. Under normal circumstances, most of the largest components, such as roof, floor, and wall panels, are laid flat and stacked in a load 12 feet (3.7 meters) wide. If necessary, however, the components can be transported standing up -allowing the load to be as narrow as necessary. In this way even locations accessible by very narrow roads can still be reached.

Furthermore, an *Incremental Home* can be constructed using only components based on the 6' by 12' module rather than the standard 12' by 12' module (1.8 by 3.6 meters rather than 3.6 by 3.6 meters). This approach has the advantage, not only of further reducing the necessary width or height of the load during transport, but also because the components are small and light enough to eliminate the necessary use of a crane during assembly. Core House D in an axample of an Incremental Home which makes use of only half-module components (see figure 3.1.1.2).

3.1.3 URBAN SETTINGS

The costs of constructing an *Incremental Home* in an urban context can vary in several ways with the construction of an identical building in the country. Proximity to the component manufacturing plant, for example, may result in lower transportation and on-site labour costs, and the presence of an existing service infrastructure could eliminate the need for items such as fuel storage or septic tanks.

What is often a far more significant factor in the overall cost of a dwelling, however, is the price of the land on which it sits. The cost of real estate in the city is often much higher than in the country. This can result in the value of a lot being as much or even more than the value of the dwelling which is built on it. Consequently, in order to reduce the overall cost of the dwelling, there is a strong inclination to keep to a minimum the size of the lot on which it is built.

The financial advantages of a small lot are unfortunately at odds with the expandable nature of the *Incremental Home*. The standard *Core House*, for example, has a square footprint which is 24 1/2 feet (7.4 meters) on each side. If we assume a sideyard restriction of 4 feet (1.2 meters), which is typical for Calgary and many other cities, then this dwelling would fit comfortably on a lot which was 32 1/2 feet (9.9 meters) wide. Any future additions, however, can only take place vertically, and to the front and back since the building has already reached its maximum permissible width (see figure 3.1.3.1).

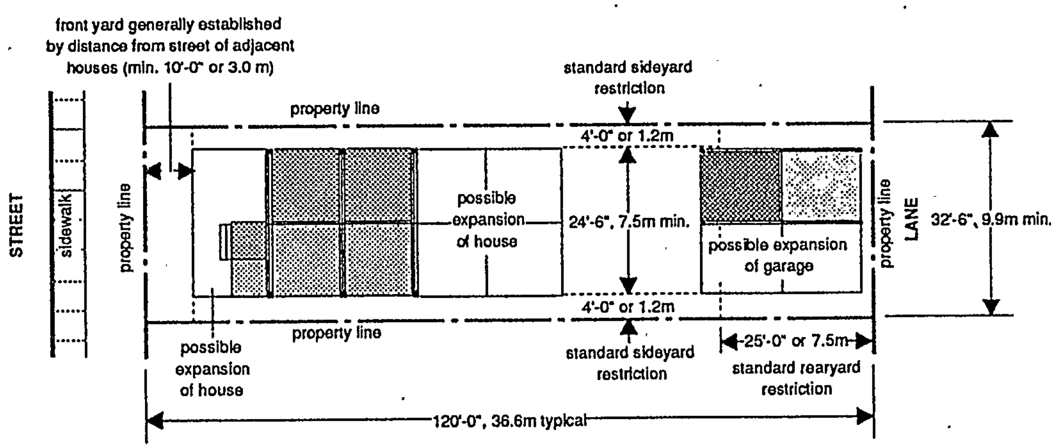


Figure 3.1.3.1 Minimum lot width required for a standard *Core House*.

The *Incremental Home* can be designed to fit into more narrow lots by using half modules which are 6 feet (1.8 meters) wide, and joining two or more units together to eliminate sideyard restrictions. The latter approach is discussed in further detail below under the headings of 'Duplexes' and 'Townhouses' In all these cases the lateral expansion of the building is inhibited, but expansion in some other directions remains possible.

Perhaps the most common land subdivision to be found in Calgary and other western cities are lots which are 50 feet wide by 120 feet long (15.2 by 36.6 meters). A lot of this size is well suited to an *Incremental Home* since it would allow a *Core House* to expand both in length and width according to the desires of the occupants. For the homeowner who intends to expand his house considerably over the course of time, a lot of this size would seem to be the best compromise between minimizing land costs while assuring room for expansion (see figure 3.1.3.2).

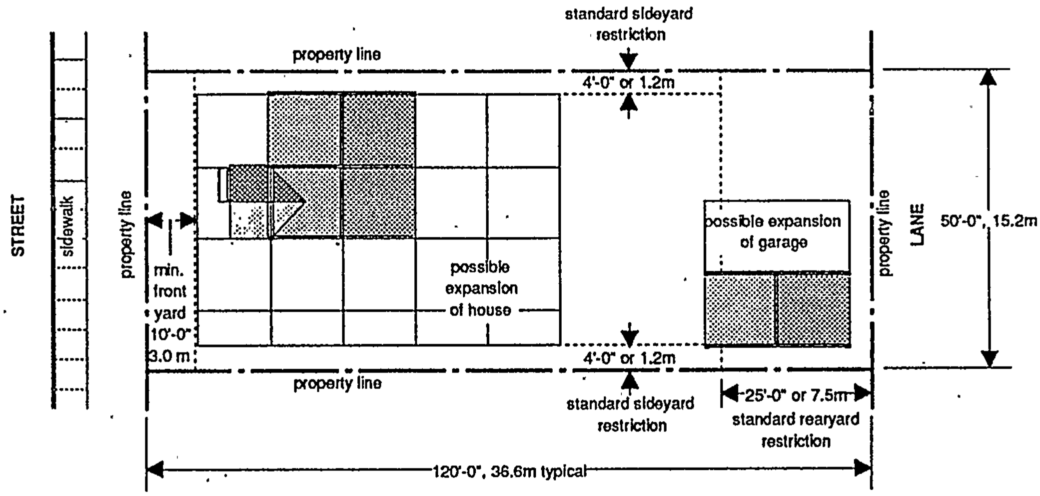


Figure 3.1.3.2 Horizontal expansion possible with a *Core House* on a standard 5o foot (15.2 meter) wide lot.

Other restrictions also come into play when building in the city. Zoning bylaws, for example, can enforce limits such as the maximum height of a dwelling, the maximum percentage of the lot which a building may cover, or even the distance between the front of the building and the property line. These restrictions can vary between different types of residential zones defined by the city, or even similar zones in different communities. Awareness of such restrictions would be essential for determining the growth patterns possible for an *Incremental Home* in any given location.

3.2
OTHER APPLICATIONS

Although the *Incremental Home* has been designed primarily to serve as a free-standing, single family dwelling, there are a number of other possible applications to which this building system is well suited. In some cases, these alternative applications may require some additional, specially modified, components in order to address certain conditions (such as common walls and extra long roof spans) not inherent in the single family home.

Due to the modular nature of the *Incremental Home*, there is no limit to the overall size of the buildings which can be constructed. Buildings can be any size initially, starting from as small as 150 square feet (13.9 square meters), and can be expanded both horizontally and vertically according to need. In most cases the 24 foot (7.2 meter) span of the roofing system should be adequate, but if necessary, girder trusses and roof panels could be manufactured to accommodate larger spans.

It should be noted that this report only describes the most basic components of the *Incremental Home* building system. With the addition of each new component, the versatility of configurations and the range of applications of the system increases considerably. Below is a brief description of some alternative uses of the *Incremental Home* and any special components which may be required in addition to the standard *Kit of Parts*. The list is intended to demonstrate that this building system can address, not only the needs of a wide cross-section of the residential construction market, but other facets of the building industry as well.

3.2.1 DUPLEXES

The duplex has long been an established alternative to the free-standing dwelling. The popularity of this arrangement arises largely from two factors: improved economy of construction; and higher residential densities, both which can result in a lower cost per unit. A duplex constructed with the *Incremental Home* building system can benefit from both of these factors.

Improved economy of construction, for example, can make the cost of a duplex substantially less than that of two free-standing dwellings which, when combined, are equal in size. One reason for this is because all the components of the common wall between the two units, from the foundations to the roof, are shared. This reduces the overall number of components required for each individual unit. Further savings can result from simplified site preparation, such as the reduced amount of excavation required, and shared services which branch only when they reach the common wall.

In order to meet certain fire and acoustical isolation requirements, the common wall between the units would contain specially designed wall panels. Unlike the standard exterior wall panel, this component would be faced on both sides with an interior finish, and treated in order to insure sufficient fire resistance required by the appropriate building code.

The higher residential density possible with duplexes may also have a significant impact on the cost of the dwellings. Particularly in an urban context, where the cost of land is much greater than in the countryside, the duplex provides a way to reduce the size of the lot for each unit. Unlike two adjacent free-standing dwellings, the common wall of the duplex is centered on the the property line between the lots, and the building occupies the space that would otherwise be left vacant due to side yard restrictions. In this way the overall width of the lot necessary for a given building is reduced by the width of the required sideyard, and the number of dwellings for a given area can be greater.

For example, a duplex comprised of two square *core houses* would have an overall width of 48 1/2 feet (14.8 meters). Assuming a 4 foot (1.2 meter) sideyard on either side of the building, a standard sideyard dimension in Calgary, each unit of the duplex could fit on a lot 28 1/2 feet (8.7 meters) wide. This is in contrast to a free-standing *Core House* which requires a lot which is at least 32 1/2 feet (9.9 meters) wide (see figure 3.2.1.1 and 3.2.1.2).

In order to further decrease the necessary width of the lot, a specially designed duplex can be constructed which uses a combination of 6 foot and 12 foot (1.8 and 3.6 meter) bays. Each unit of the duplex would be 18 feet (5.4 meters) wide, and could be built on lots at least 24 1/2 feet (7.4 meters) wide (see figure 3.2.1.3).

As explained earlier, building on a lot of minimum width inhibits the potential for expansion of the *Incremental Home,* since the building cannot become any wider than it is. Expansion lengthwise and vertically, however, remains possible, and could be undertaken either jointly or one unit at a time.

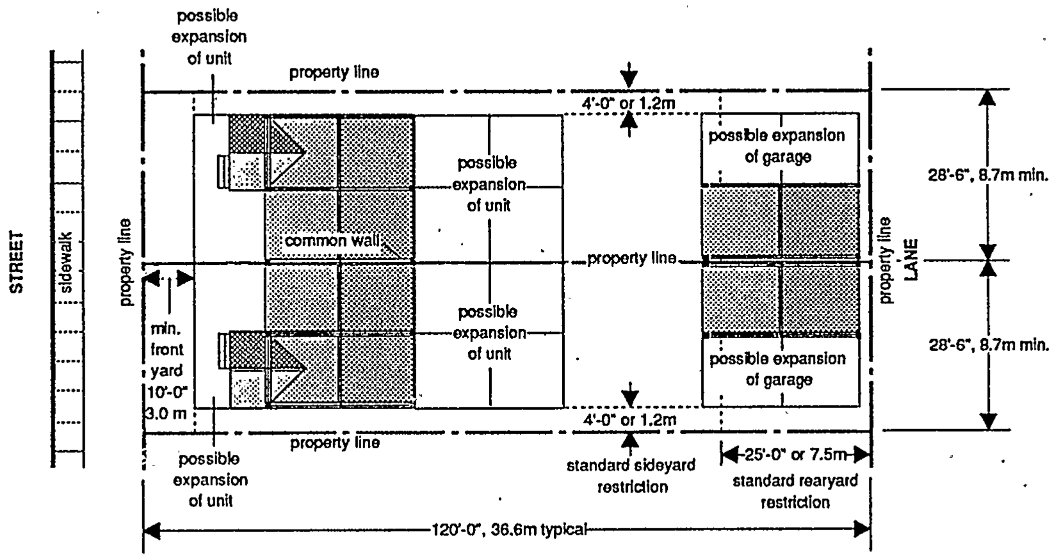


figure 3.2.1.1 Minimum lot widths for a duplex composed of two 24 feet (7.3 meter) units

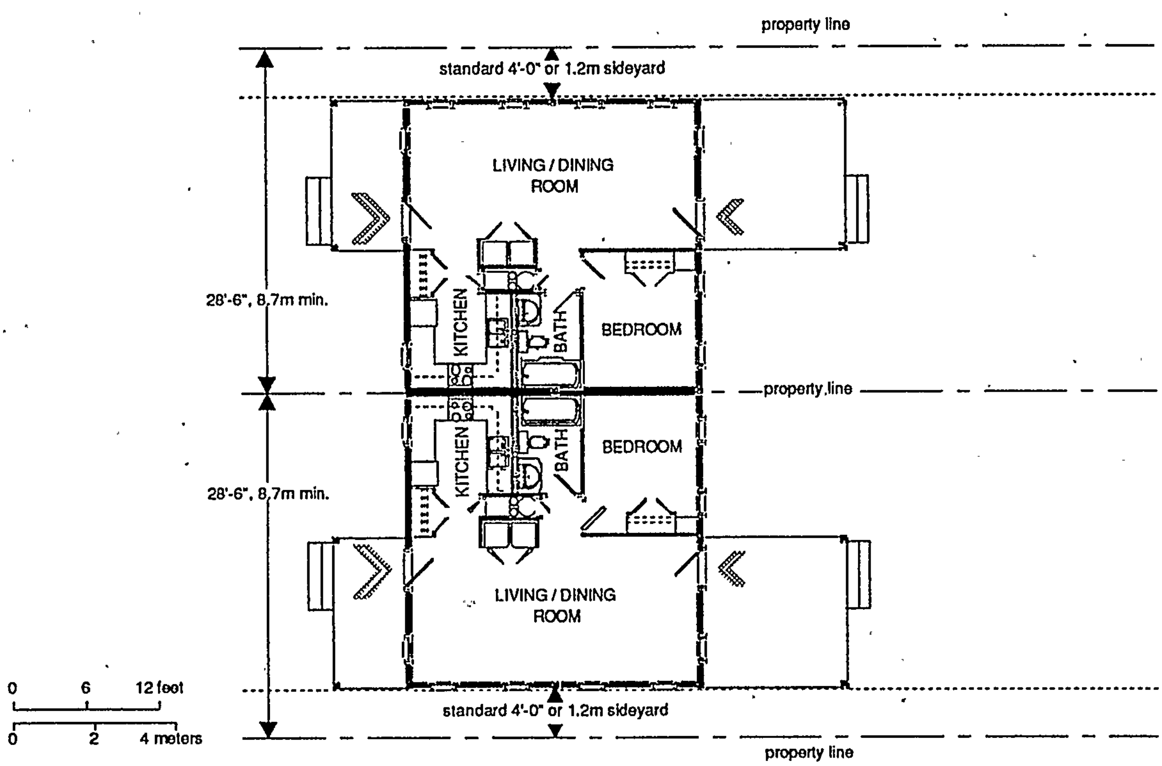


Figure 3.2.1.2 Example of a duplex comprised of two standard *Core Houses* Each unit requires a minimum lot width of 28 1/2 feet (8.7 meters).

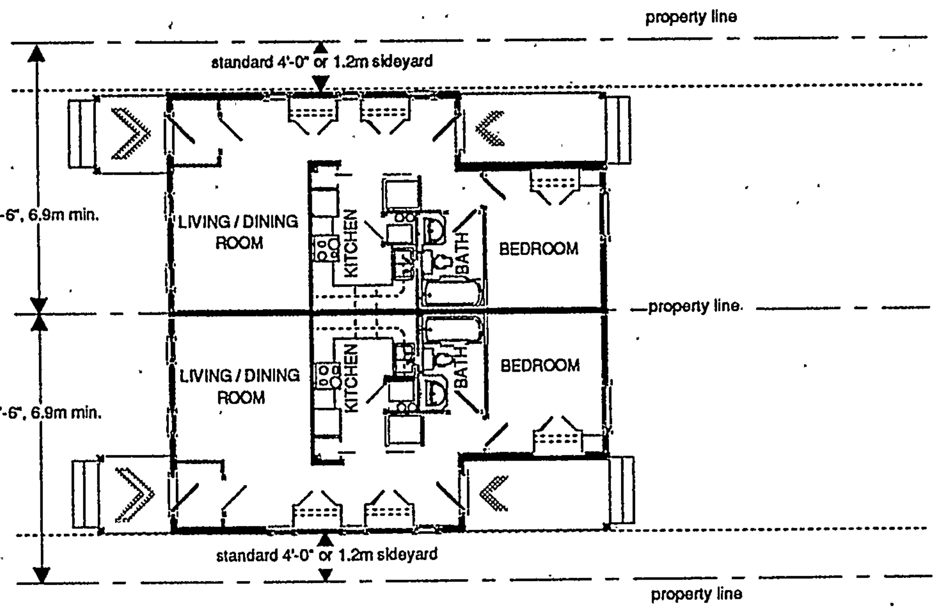


Figure 3.2.1.3 Plan of narrow width duplex. Each unit requires a minimum lot width of 22 1/2 feet (6.9 meters)

3.2.2 TOWNHOUSES

A further extrapolation of the common wall approach is the row or townhouse. In this case, with the exception of the end units, both lateral walls are shared with neighbours. For the same reasons that applied to duplexes, but to an even greater degree, the townhouse configuration can result in reduced land, site preparation, and construction costs.

Land costs are minimized because each lot need only be as wide as the distance between the center lines of the common walls. In this way the strip of land that would otherwise be required as a sideyard can be eliminated. The higher densities possible with townhouses can also result in a reduction of the cost of services such as sewer, water, power, and gas lines. The construction cost per unit is also reduced in the townhouse arrangement because of simplified excavation and the sharing of components in the common walls.

The width of each unit can be as narrow as 12 feet (3.6 meters). By North American standards, however, this width may be considered too small and larger units with widths of 18 or 24 feet (5.4 or 7.2 meters) might be considered more appropriate. In any case, it is possible to construct rowhouses of various sizes and unit dimensions using the *Incremental Home* building system (see figure 3.2.2.1).

Although the townhouse may be the most economical way to achieve a given amount of living space, it is also the configuration which most restricts the *Incremental Home*'s potential for expansion. Nevertheless, the cost benefits and higher densities possible in this arrangement may outweigh the advantages of future expansion under some circumstances.

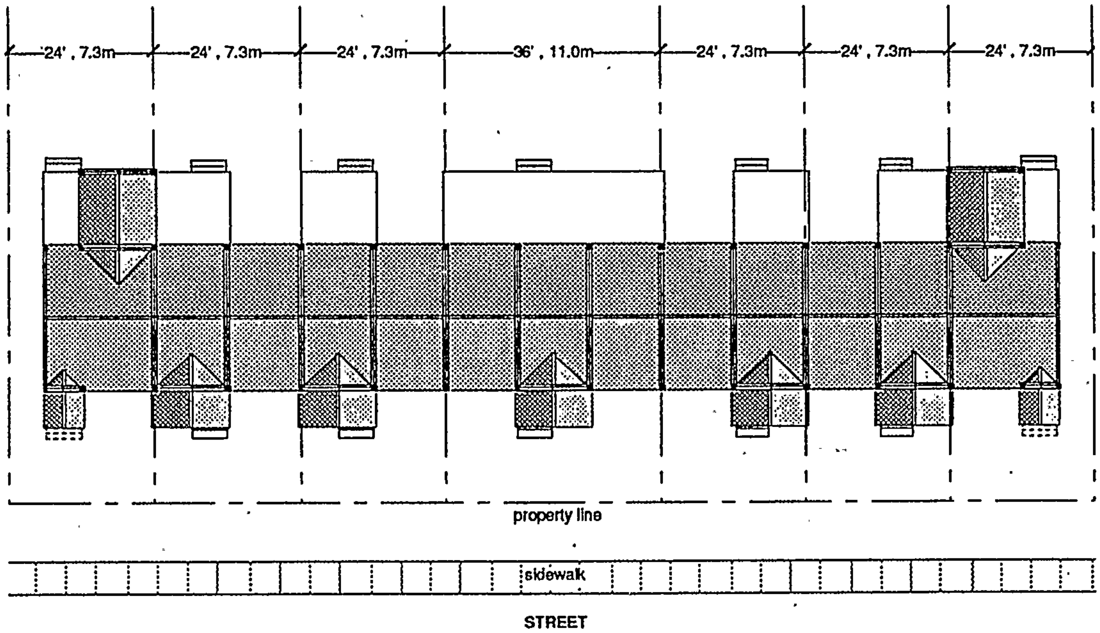


Figure 3.2.2.1 Example of a townhouse comprised of units which are 18, 24, and 36 feet wide (5.4, 7.2, and 10.8 meters).

3.2.3 COMMUNAL DWELLINGS

Although this report is primarily focused on single family dwellings with a limited number of occupants, the *Incremental Home* can also be applied to much greater occupancies. Camps, communes, and other organizations, for example, often require either temporary or permanent accommodation for larger groups of people.

Organizations, much like families, are not fixed entities but can experience considerable change in both size and character with the passage of time. For this reason, the *Incremental Home* system is well suited to this type of application.

Given a sufficiently large floor plate, the interior walls of an *Incremental Home* building can be arranged in any number of ways to produce single occupancy bedrooms, dormitories, common areas, and any other required spaces. A given spatial arrangement can, of course, be altered at some future date to reflect any changes which may take place in the internal organization of the group (see figure 3.2.3.1).

Modifications to the overall size of the building can also be made with a facility and economy impossible to achieve with conventional construction methods. This applies, not only to expanding the building, but also to reducing its size as well. Under some circumstances a communal dwelling may become larger than necessary. In this case it would be possible to remove some of the components which could then be sold to other interested parties. Entire buildings can be disassembled in this way and either reassembled elsewhere, in any number of different configurations, or sold as component parts.

Most of the standard components listed in the *Kit of Parts* would be adequate for the construction of communal dwellings. The plumbing and heating systems, however, would have to be expanded to accommodate increased demand. Larger roofing components, with a free span of 36 feet rather than 24 feet (10.8 meters rather than 7.2 meters) may also be desirable in some cases.

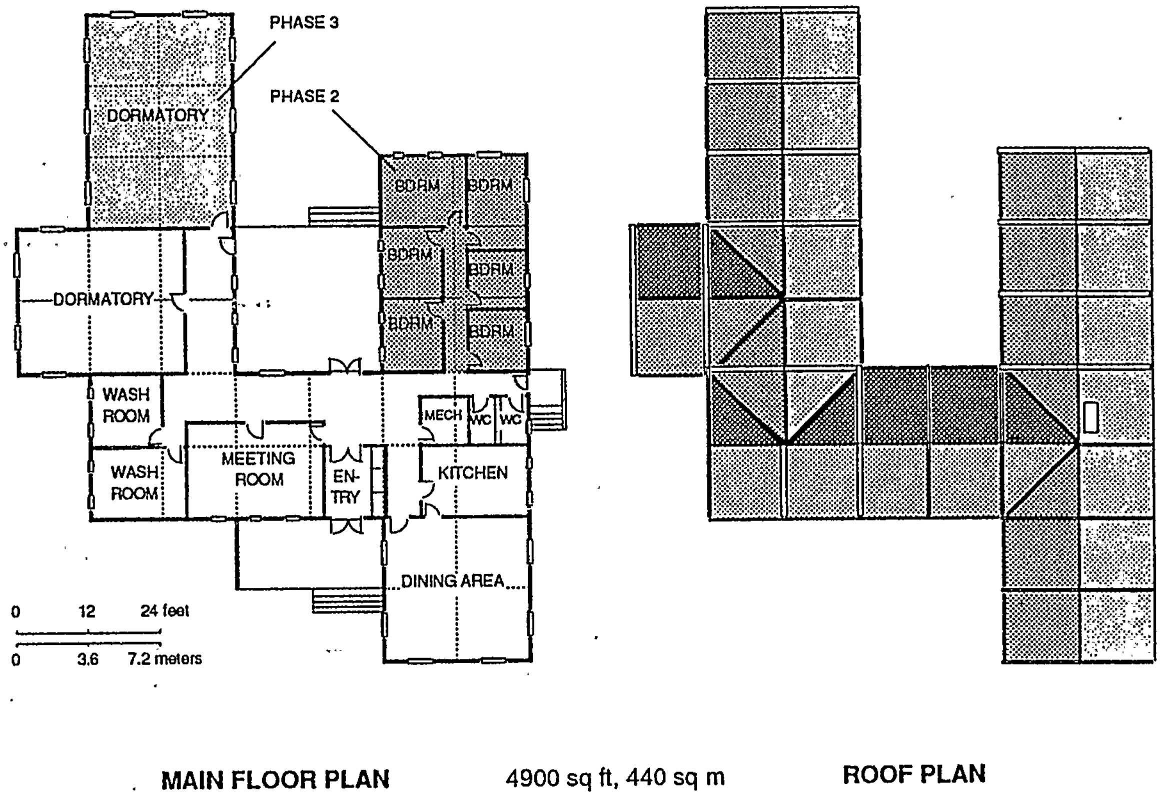


Figure 3.2.3.1 Example of a communal dwelling showing three possible phases of construction

3.2.4 TEMPORARY BUILDINGS

As has already been noted in a number of sections above, a building constructed with the *Incremental Home* system can be entirely dismantled and transported to a new location. This property of the building system could make it appropriate for certain specialized applications which require temporary buildings, such as emergency shelters or worker housing at remote construction sites. Because of the lightweight and compact nature of the building components, these sites could be located anywhere in the world with an appropriate climate.

In the event that an *Incremental Home* is relocated, all the components, including the pressure-treated wood foundations, can be reused. Depending on the size and complexity of the building, the entire dismantling procedure could be accomplished in as little as two days. Once the new site has been prepared, which involves excavation and provision for access to services, re-assembly of the building envelope would only be a matter of a few more days. Thus a simple *Incremental Home*, such as a *Core House*, could be dismantled and reassembled in less than a week. Additional time may be required for such contingencies as lengthy transport, elaborate finishing of the interior, or landscaping of the site.

It should be noted that when the building is being reassembled, the configuration of the components need not be identical to their previous arrangement. The same components could be arranged in a different fashion, new components could be added, or some components could be removed -entirely according to the needs of the occupants.

3.2.5 ADDITIONS TO EXISTING BUILDINGS

One further possible use of the *Incremental Home* could be for additions to existing structures. Unfortunately a number of problems arise from this type of application.

One such problem, from a structural point of view, would be the way in which the new addition is attached to the existing building. Depending on the specific circumstances, some of the standard components may have to be specially modified to merge with the existing structure. Yet, with the use of some custom-made components, it should be possible to resolve most of the structural problems which may arise.

Another more difficult issue to resolve is that of formal compatibility. In general, most successful additions are achieved by continuing the formal vocabulary of the existing building: such as window size and proportion; roof pitch and overhang; exterior cladding, and so on. The *Incremental Home* has its own specific formal vocabulary and, because of the prefabricated nature of the components, these attributes would be very difficult to modify. Given the variety of styles which are found in existing housing stock, formal compatibility may be very difficult to achieve in most cases. Nevertheless, the possibility of a successful merger of architectural forms should not be excluded.

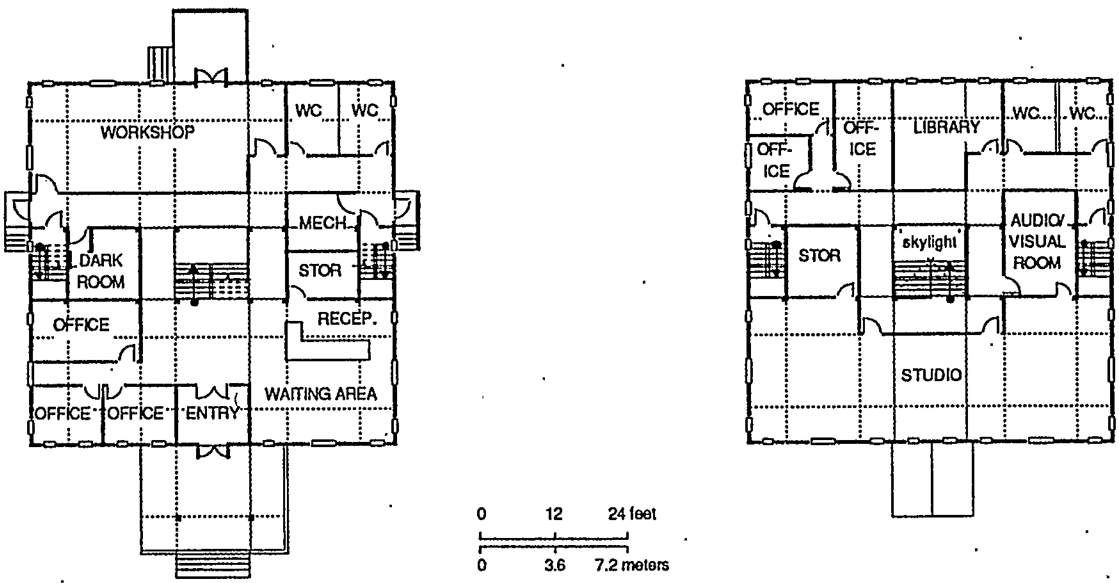
3.2.6 GARAGES

The superstructure of an *Incremental Home* can also be used to house one or more cars in an attached or detached garage. In this application the standard floor panels would be replaced by a concrete slab on grade or some other suitable surface. Two full sized modules would provide a narrow one car garage. Two additional modules would produce a spacious two car garage. Since the building components are insulated, even detached garages could be provided with a space heater or another type of heating system.

3.2.7 NON-RESIDENTIAL APPLICATIONS

Although primarily designed for dwellings, the *Incremental Home* may also be suitable for some non-residential applications such as offices or workshops. A small business, for example, may choose to construct its offices with the *Incremental Home* system (see figure 3.2.6.1). A building of this kind could enhance the flexibility of the company since its overall size could vary with the changing fortunes of the business as it grows or diminishes in size. Even if the company were to relocate, it would be possible to dismantle the building and transport it to a new location.

Depending on the intended function of the building, some modifications to the plumbing and electrical services may be required, but on the whole the standard building system would be adequate for a variety of non-residential functions. The range of possible applications would, of course, be limited to structures which do not demand specialized construction such as very long spans, overheight ceilings, or other modifications which would not be easily accommodated by the standard building system.



MAIN FLOOR 4650 sq ft, 432 sq m SECOND FLOOR

Figure 3.2.6.1 Example of a small *Incremental Home* office building containing an architectural office. Note the use of both 6 x 12 foot and 12 x 12 foot (1.8 x 3.7 meter and 3.7 x 3.7 meter) modules

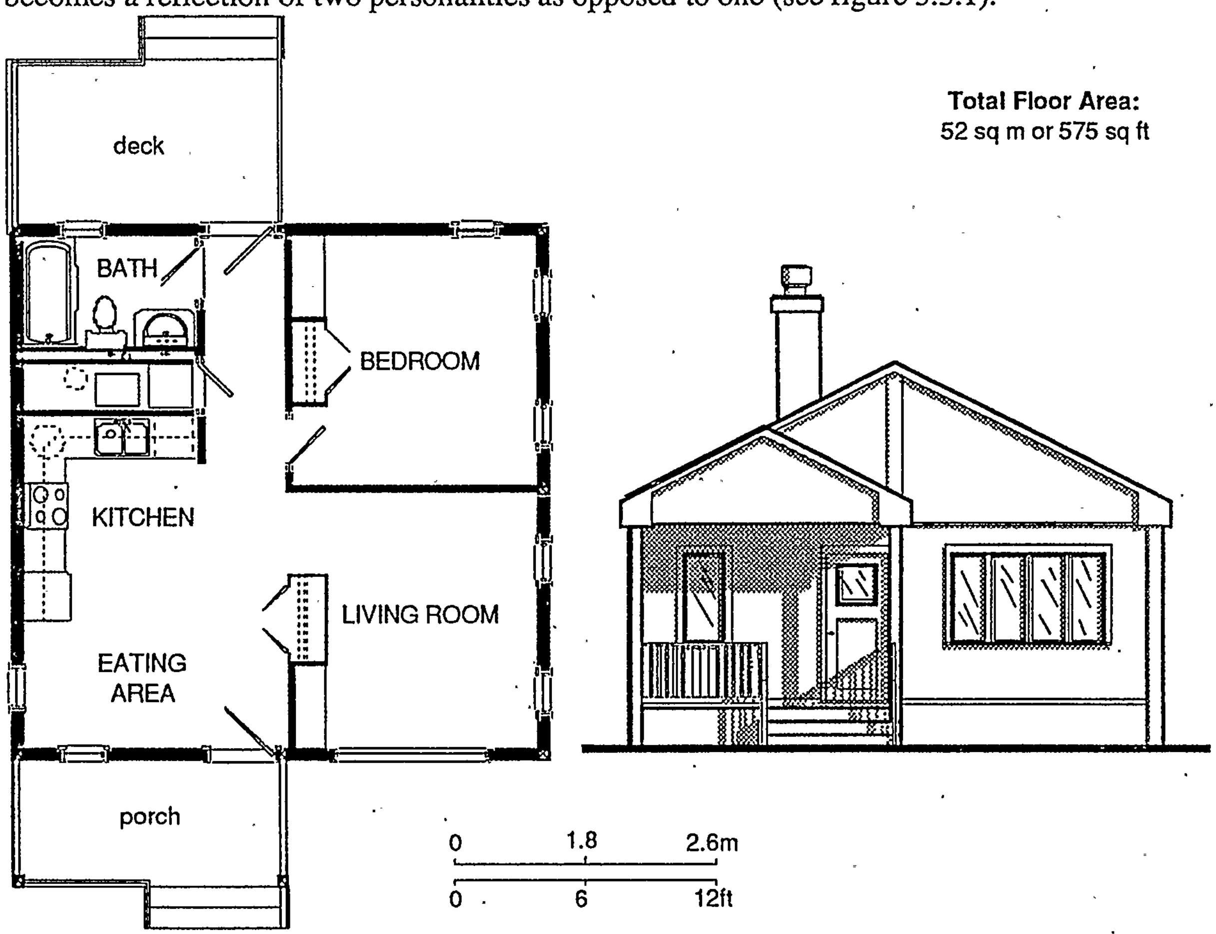
3.3
HYPOTHETICAL SCENARIO: THE EVOLUTION OF AN INCREMENTAL HOME

Phase 1: The Core House

Julian was at the threshold of his adult life, entering his first year of university, and about to leave home for the first time. All he had known was his family home, designed by his father (an architect) and decorated by his mother (a sculptress). Needless to say every corner of this home had deeply personal meaning for every member of the family. Julian's father had inherited a large waterfront lot from his own father many years ago and now sees the ideal use for this property. Julian's new home will be erected here, on land handed down from his grandfather, already invested with an underlying meaning of family continuity.

Julian would begin his academic career from a solid base in a *Core House*, a small home but adequate for his current needs. A bedroom, kitchen, living room, and dining area, small, but versatile enough to grow and change along with its new owner.

Julian, after completing his first year at university declares his major in art history and makes arrangements to spend the summer travelling in France. He arrives home in the late summer accompanied by Corrin, his fiance, whom he met in Paris. Julian's parents give the couple a fall wedding in the family home. Corrin brings a more exotic touch to the *Core House* with the purchase of carpets and tapestries. Their waterfront abode now becomes a reflection of two personalities as opposed to one (see figure 3.3.1).



MAIN FLOOR PLAN FRONT ELEVATION

Figure 3.3.1 Plan and elevation of Core House A

Phase 2: Second Floor Addition

Julian, now finished his honours degree, decides to go on and do graduate work. He receives a scholarship and a large gift of money from his parents, who are happy with his decision to continue his academic career. Corrin has only one year left in her Interior Design Program so the couple decide to start a family and invest in a second storey for their home. Leaving Julian's father in charge of the renovations, they go away for a second honeymoon. The second storey is initially left unfinished but with the help of Julian's parents the couple complete most of the finishing themselves. The master bedroom is moved upstairs thus providing a lot more room downstairs to be utilized by a large living dining area and a little vestibule where the dining area used to be. Corrin becomes pregnant and to the surprise of all gives birth to twin girls (see figure 3.3.2 and 3.3.3).

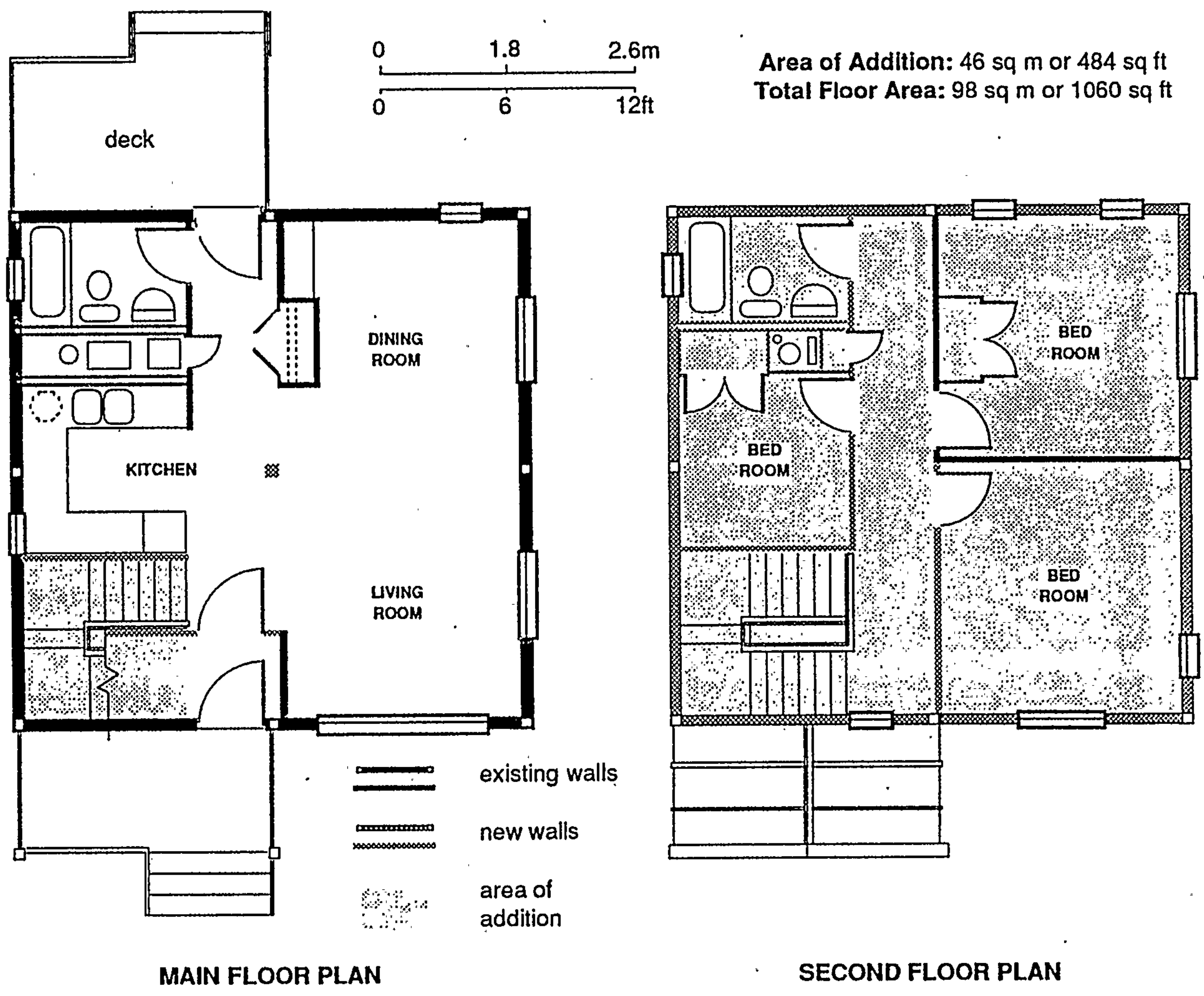


Figure 3.3.2 Floor plans of Phase 2: Second Floor Addition

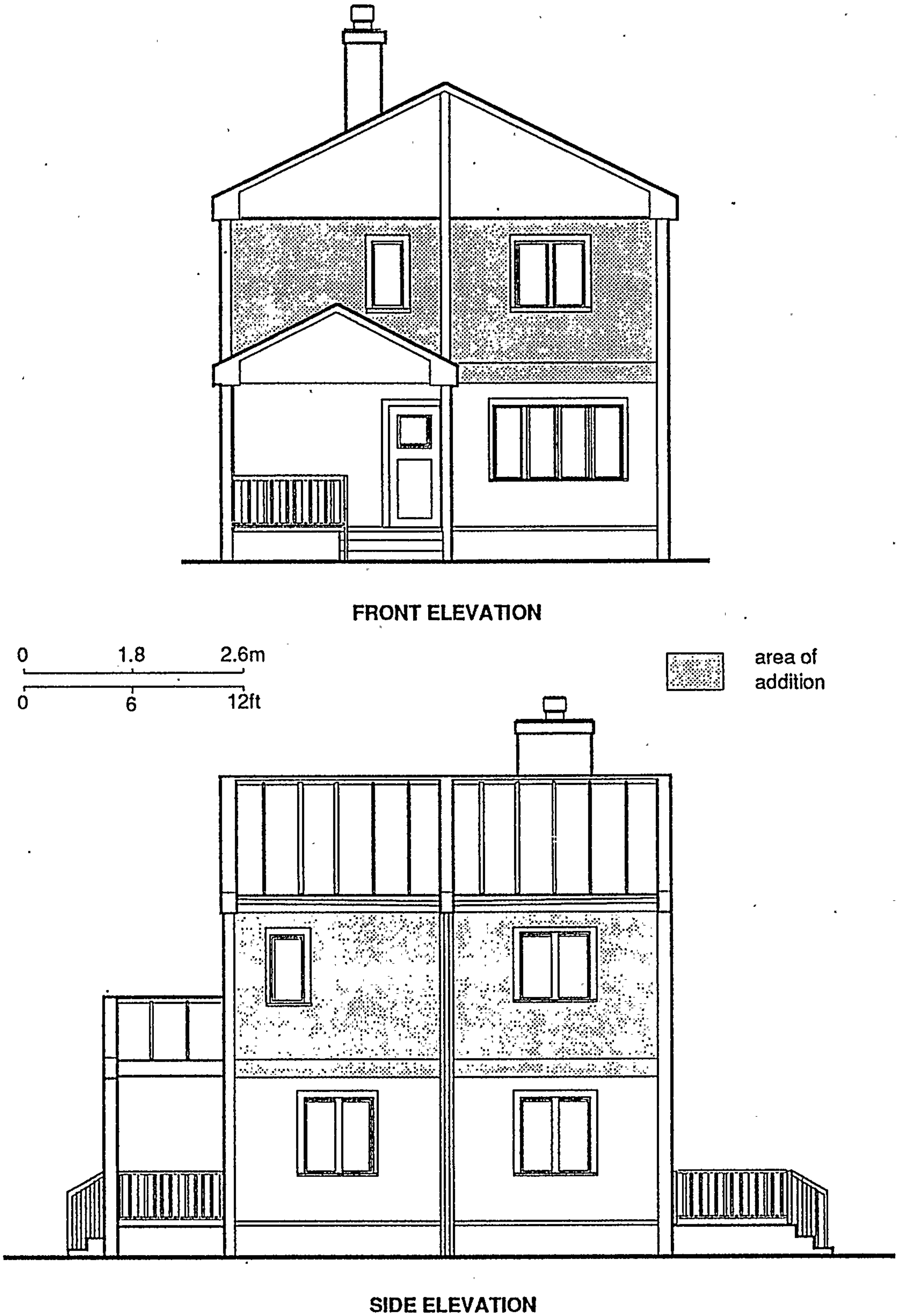


Figure 3.3.3 Elevations of Phase 2: Second Floor Addition

Phase 3: Master Bedroom/Family Room Addition

After being discharged from the hospital, Corrin is convinced by her husband to stay with his parents for a week, in order to recover from the birth of her their children. Corrin was overjoyed to find, upon her arrival home, that her in-laws had arranged a very special surprise for her and the twins--yet another addition to their *Incremental Home*. This was the third phase of growth, a master bedroom upstairs complete with it's own ensuite, and a new family room downstairs. The wall between the two front bedrooms had been temporarily removed to create a giant nursery for Simone and Alexandra. The small bedroom beside the bathroom had been transformed into a laundry room, complete with brand new washer and dryer. Corrin was amazed at how much change had taken place in just one short week. Downstairs, the dining room had become study (as yet to be furnished) and the dining room was now where the old living room had been. The new family room was large and bright, having windows on three sides, and in the corner, with sunlight beaming down on it was the sculpture that Corrin had so often admired in Julian's parents home. Corrin and Julian were now equipped to settled into family life. The girls grew, Julian finished his Master's Degree, went on to a PhD. and a teaching position at the university. Corrin went to work when the girls started elementary school. Things went smoothly until the girls turned fifteen, when Simone became unmanageable and left home to live with her grandparents (see figure 3.3.4 and figure 3.3.5).

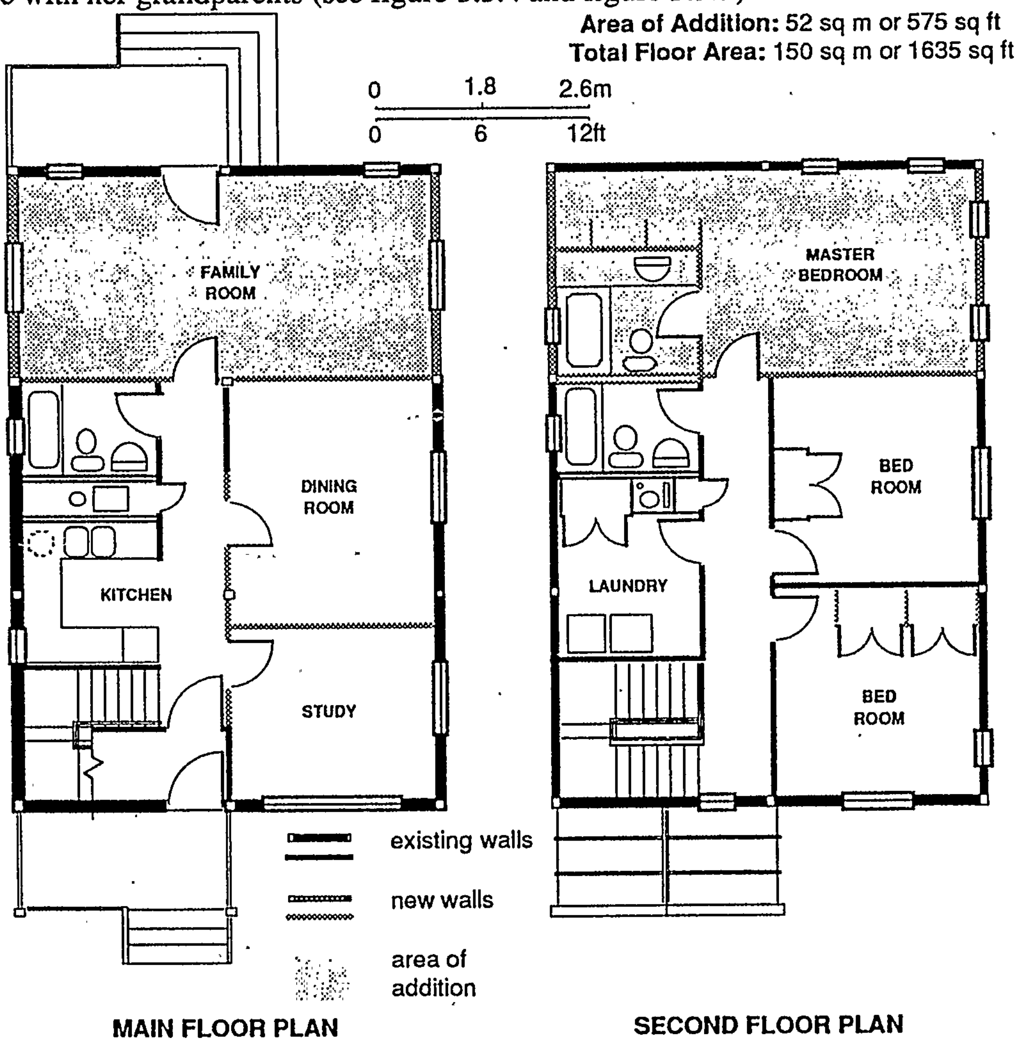


Figure 3.3.4 Floor plans of Phase 3: Master Bedroom/Family Room addition

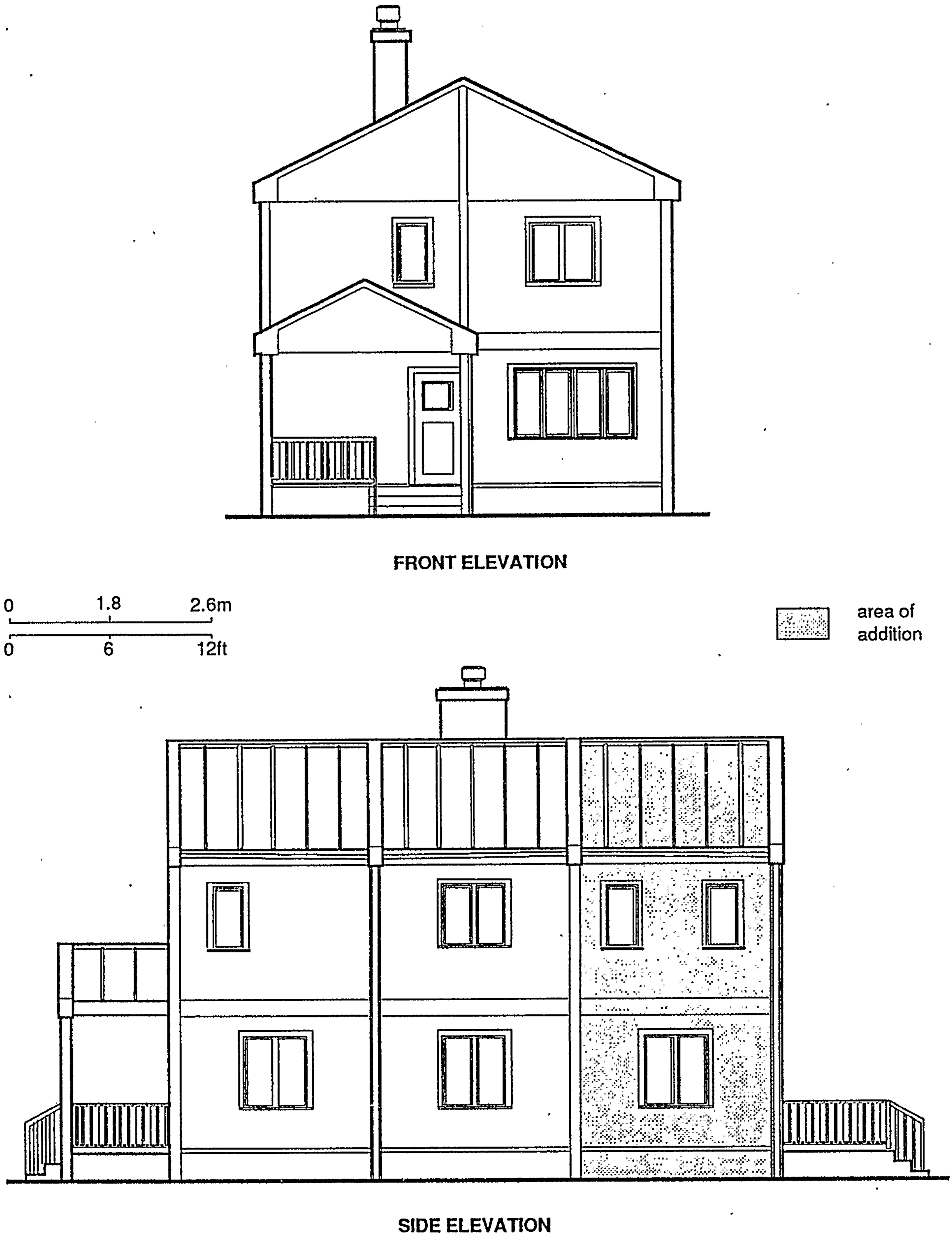


Figure 3.3.5 Elevations of Phase 3: Master Bedroom / Family Room addition

Phase 4: Vestibule / Studio / Bedroom Expansion

Corrin has become a successful interior designer and the couple decide it is time for her to have a work space at home. This is accomplished by adding a two storey bay protruding from the main body of the house. The study will again become the dining room and the dining room will become a large studio with windows on three sides. The upstairs addition is to Alexandra's bedroom, a reward for her good grades. It is agreed that the next addition, planned to take place during Julian's sabbatical [in two years] will be his personal space and his decision.

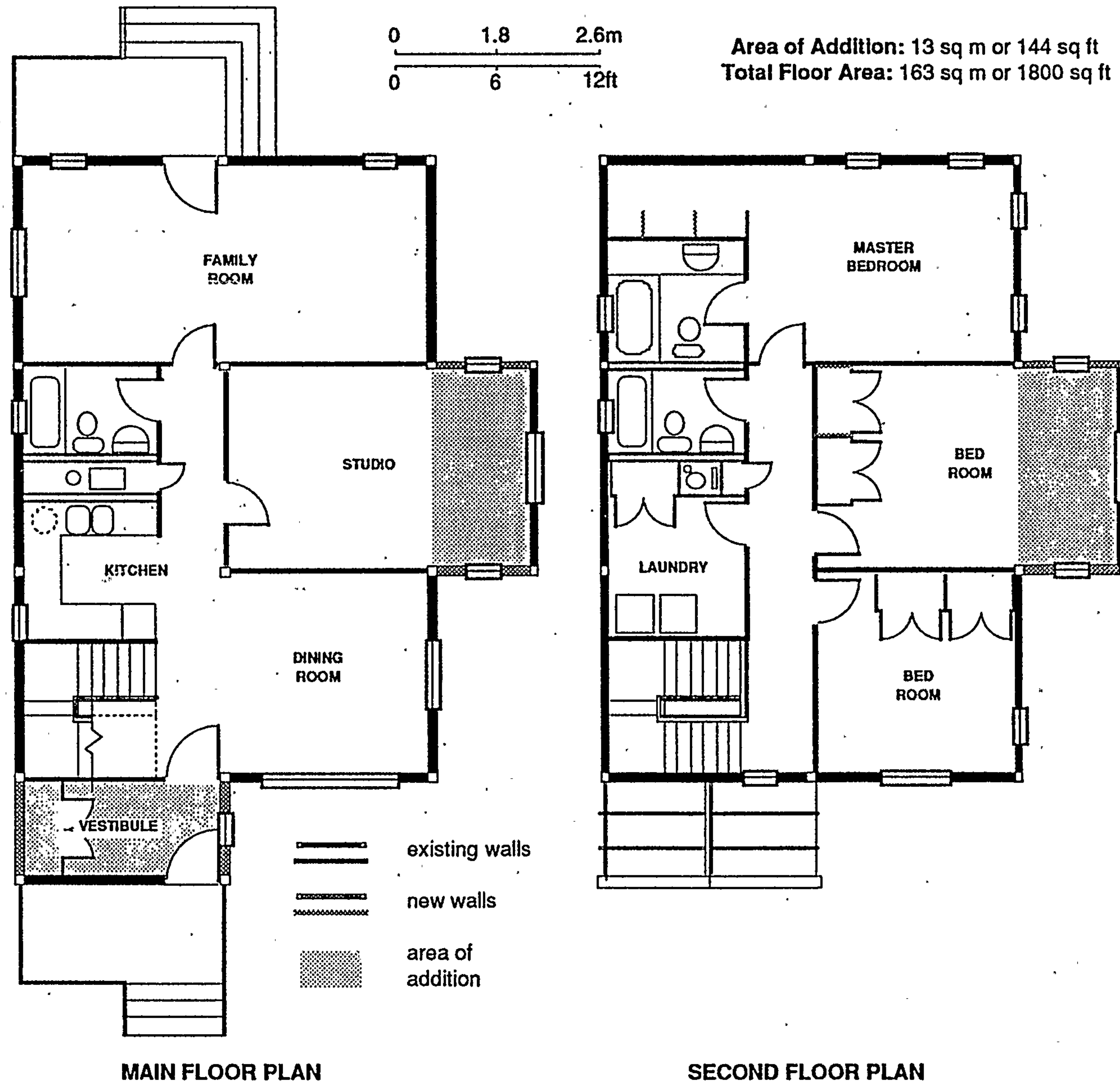


Figure 3.3.6 Floor plans of Phase 4: Vestibule / Studio / Bedroom Expansion

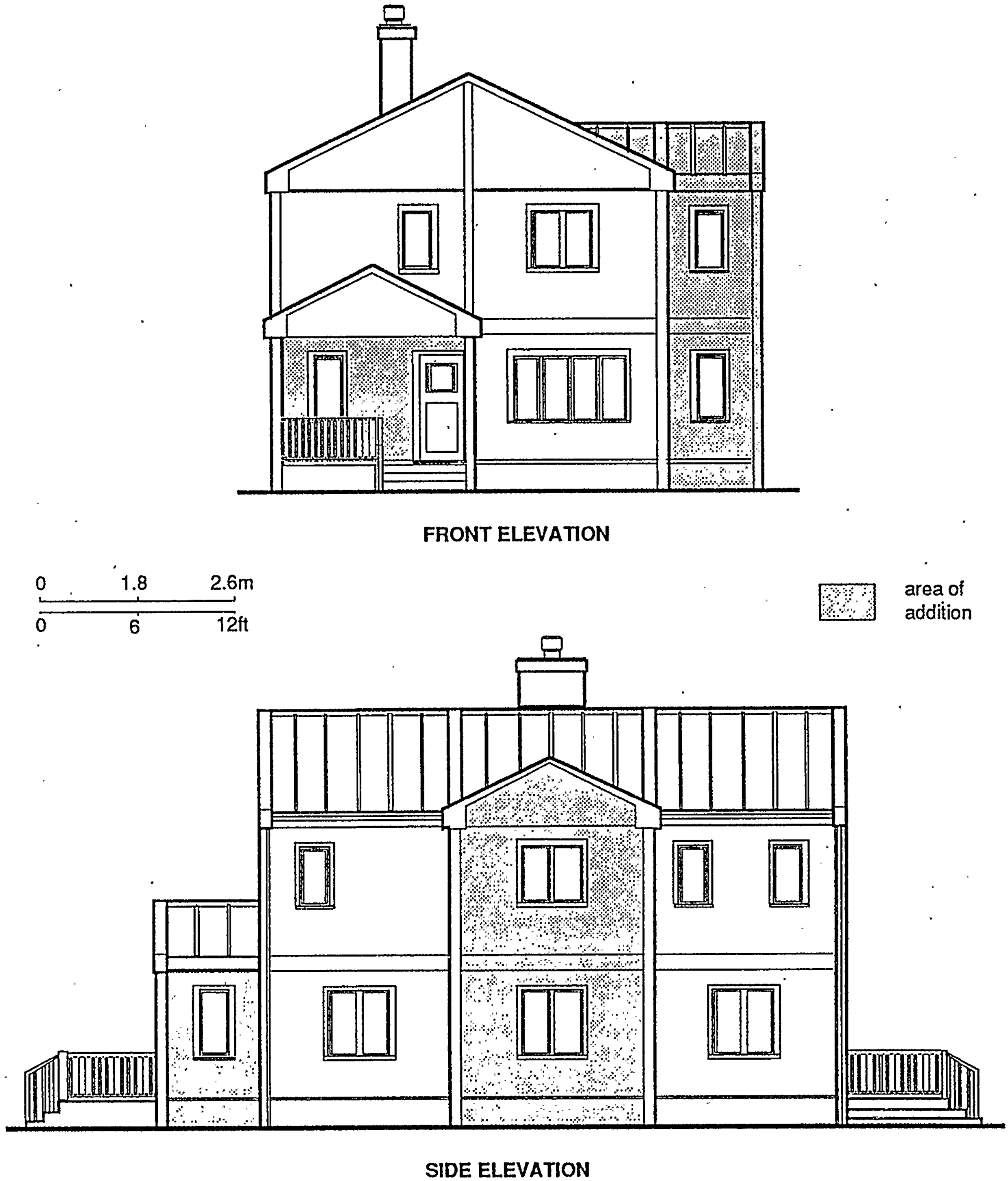


Figure 3.3.7 Elevations of Phase 4: Vestibule / Studio / Bedroom Expansion

Phase 5: Kitchen / Dining Area Expansion

Alexandra, after graduating, is sent by her parents to study in Paris, where she will live with her aunt. Upon hearing of her sister's departure Simone decides she would like to move back home. Her parents agree and Simone takes over her sister's room. Julian begins his sabbatical and decides he will expand the kitchen. The result is a country kitchen, a one storey addition of 26 sq m (or 288 sq ft) with windows on three sides. He then decides, as a surprise for Corrin and Simone (who is now working with her mother) to have the wall removed between the studio and the dining room thus transforming the studio into a much larger space capable of accommodating his wife and daughter as they embark on business together.

This home has kept many options open for Julian and Corrin over the years and is ever ready to expand or contract with the changing needs of the family protected by it's walls.

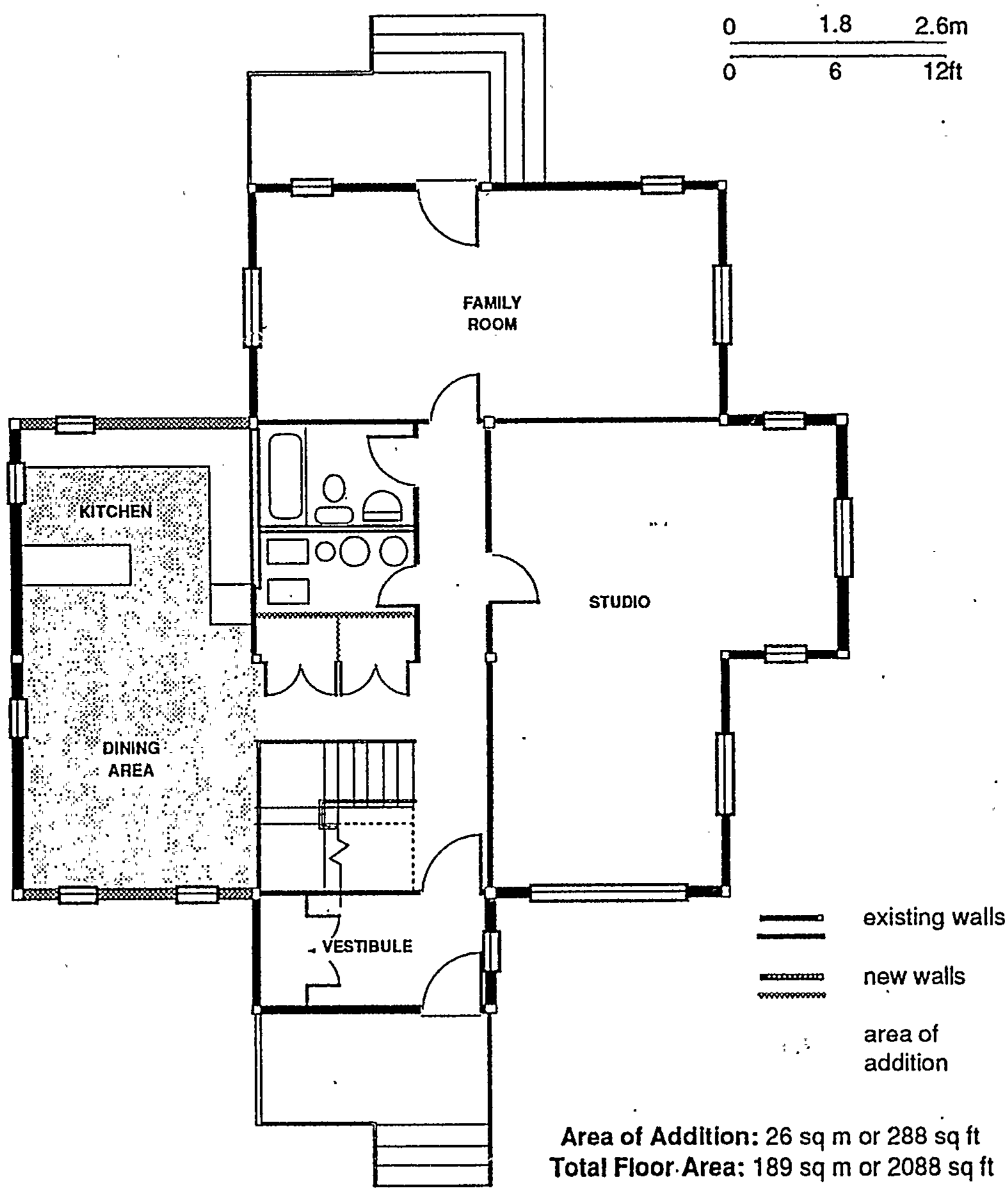
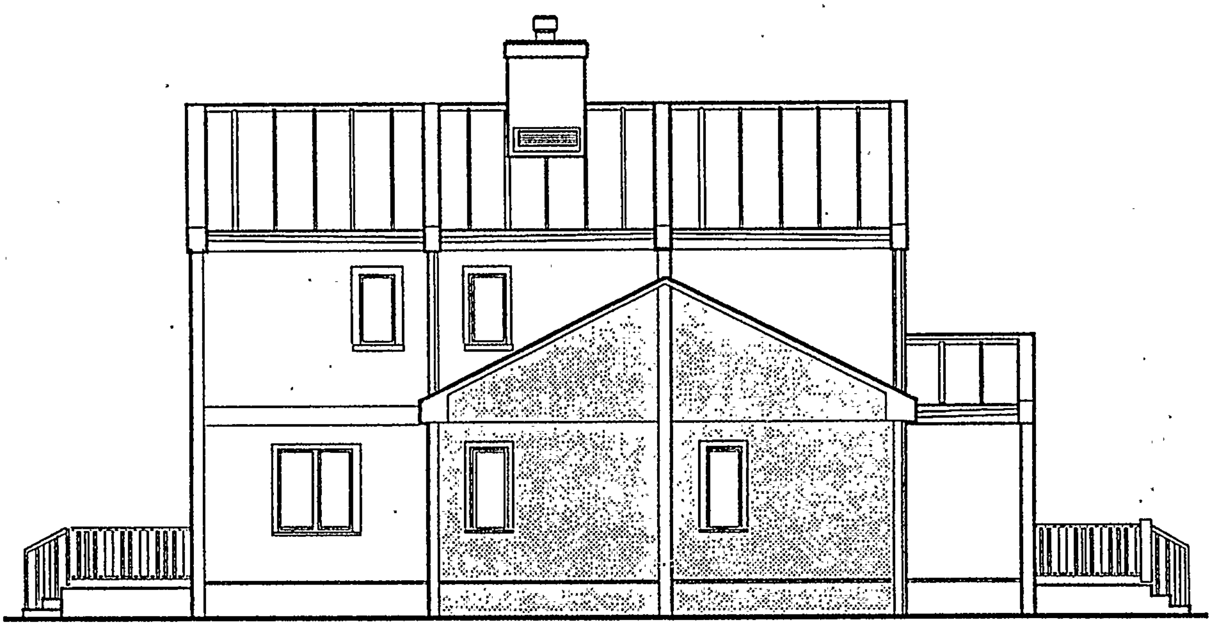


Figure 3.3.8 Main Floor Plan of Phase 5: Kitchen / Dining Area Expansion

FRONT ELEVATION

0 1.8 2.6m
0 6 12ft

area of addition



SIDE ELEVATION

Figure 3.3.9 Elevations of Phase 5: Kitchen / Dining Area Expansion

3.4
COST ANALYSIS

3.4.1 COST REDUCTION STRATEGIES

A number of cost reduction strategies have been pursued during the design of the *Incremental Home* building system in order to make the cost of the system competitive with conventional construction. The pre-fabricated foundation included in the system, for example, reduces the amount of time, material, and site excavation normally required to construct a foundation.

The dimensions of the components have been based on the standard sizes of available building materials. In this way both labour and material can be saved because most building materials do not have to be cut to size before they are assembled into components. This efficient use of materials applies to the construction site as well, producing very little of the detritus usually associated with conventional building sites.

Floor and roof joists only span short distances, which reduces the necessary depth and spacing of the joists and the size of the foundation pads.

The use of mass-production techniques can result in efficient manufacturing and assembly processes, and lower material costs.

Services have been centralized, either adjacent or vertically stacked, whenever possible to reduce the length of pipes and ducts. The preassembled plumbing wall greatly simplifies the installation of plumbing services and the amount of time required.

Due to the simplicity of the *Incremental Home* building system, it should be possible for the homeowner to contribute significantly to the assembly of the home. This 'sweat equity' may result in reduced labour costs, as well as enhance the personal significance of the building.

The ease and economy with which the building system can be altered makes it possible to phase the construction of the house. In this way renovations need only take place when the demand arises or the funds become available, rather than during initial construction.

3.4.2 COST CALCULATION TABLES

TABLE 1: MANUFACTURING COSTS OF *INCREMENTAL HOME* COMPONENTS

This table calculates the material costs of the building components and estimates the amount of time required for their manufacture. Material costs were established by contacting local distributors in Calgary and are in 1992 Canadian dollars. Labour costs are based on a wage of $30/hour and assume certain manufacturing equipment such as jigs, cutters, and presses.

TABLE 2: ASSEMBLY COSTS OF CORE HOUSE A

This table determines that the total hard costs of building a 52 sq m *Core House* (in Calgary) will be about $26,500 -a figure which does not include property costs. The 'selling price' of the components was determined by adding 50% to the material and labour costs combined. Overhead, administration, transportation costs, and profit are all covered by this mark up.

TABLE 3: COST COMPARISON BETWEEN CORE HOUSE A & CONVENTIONAL CONSTRUCTION

This table indicates that the initial construction costs of an *Core House* will be about 5 to 10% more expensive than a comparable conventional structure. This higher cost is due to a number of factors, including the structural frame, and higher overhead costs. In return, however, the homeowner acquires a high quality and very flexible structure which, in the future, will be less expensive to renovate.

TABLE 4: COST COMPARISON FOR 26 SQUARE METER ADDITION

In this table, the cost of a 26 sq m addition to an *Incremental Home* is compared to a similar conventional addition. Because components can be moved, and assembly is far less labour intensive, renovations can be as much as 15% less expensive to an *Incremental Home* than a conventional structure. The time required is also far less -about 1/5 of the time the renovation would take using conventional techniques.

TABLE 1: MANUFACURING COSTS OF INCREMENTAL HOME COMPONENTS

Component	Constituents	Unit Cost Can $	Cost per Component	Labour $30/manh	Manufact. Cost
STRUCTURAL FRAME					
Foundation Pad	84' of PWF 2x6's	890/M	$75	5	$80
Foundation Post	18' of PWF 2x6's	890/M	$16	4	$20
Plate	24' of 2x6's	210/M	$5	2	$7
Post	27' of 2x6's	210/M	$5.60	2	$8
Girder Truss	80' of 2x6's	210/M	$16.80		
	40' of 2x4's	280/M	$7.50		
		total:	$24.30	10	$34
Ridge beam	12' of 2x6's	210/M	$2.50	2.5	$5.00
ENCLOSURE PANELS					
Foundation Wall Panel	48' of PWF 2x6's	890/M	$42.70		
	72 sq ft 5 1/2" rigid insul	.85/sq ft	$61.20		
	4 1/2 sheets PWF 1/2" ply	35/sheet	$157.50		
		total:	$260.00	20	$280
Floor Panel	4 1/2 sheets 3/4" plywood	19/sheet	$85.50		
	130' of 12" TJI's	.20/ft	$26		
	144 sq ft 1/2" drywall	.16/sq ft	$72		
		total:	$183.50	20	$200
Wall Panel	3 sheets Cedarstripe™	45/sheet	$135		
	56' of 2x6's	210/M	$11.75		
	90 sq ft 5 1/2" rigid insul	.85/sq ft	$76.50		
	96 sq ft 1/2" drywall	.16/sq ft	$15.35		
		total:	$91.85	20	$110
Roof Panel	160 sq ft metal sheathing	.5/sq ft	$82.50		
	90' of 1x2's	120/M	$18		
	5 sheets of 1/2" plywood	35/sheet	$175		
	84' of 12" TJI's	.20/ft	$16.80		
	160 sq ft 11" rigid insul	1.7/sq ft	$270		
	160 sq ft 1/2" drywall	.16/sq ft	$25.60		
		total:	588	30	$620
Interior Gable End	36 sq ft of drywall	.16/sq ft	$5.75		
	36 sq ft 2 1/2" rigid insul	.45/sq ft	$16.20		
	52' of 4x2's	380/M	$6.60		
		total:	$28.60	10	$40
Exterior Gable End	1 1/8 sheets Cedarstripe™	45/sheet	$50.60		
	36 sq ft 2 1/2" rigid insul	.45/sq ft	$16.20		
	52' of 4x2's	380/M	$6.60		
		total:	$73.40	10	$80

TABLE 1: MANUFACURING COSTS OF INCREMENTAL HOME COMPONENTS

Component	Constituents	Unit Cost Can $	Cost per Component	Labour $30/manh	Manufact. Cost
EXTERIOR TRIM					
Side Batten, foundn	1/8 sheet PWF 1/2" ply	35/sheet	$4.50	0.5	$5
Corner Batten, foundn	1/4 sheet PWF 1/2" ply	35/sheet	$8.75	0.5	$9
Side Batten	1/4 sheet Cedarstripe™	45/sheet	$11.25	1	$12
Corner Batten	1/2 sheet Cedarstripe™	45/sheet	$22.50	1	$23
Fascia Board	12' of 1x12	500/M	$6		$6
FLASHING					
Side Flashing	28 sq ft sheet metal	.52/sq ft	$14.50	1.5	$16
Ridge Flashing	6 sq ft sheet metal	.52/sq ft	$3.10	1	$4
Cap	2 sq ft sheet metal	.52/sq ft	$1.00	1	$2
Scupper	3 sq ft sheet metal	.52/sq ft	$1.50		
	1/4 sheets of 1/2" plywood	35/sheet	$9		
		total:	$10.50	5	$15
Eavestrough	12' of 30 guage metal	1/ft	$12		$12
Downspout	10' of 30 guage metal	1/ft	$10		$10
INTERIOR PANELS					
Interior Wall Panel	64 sq ft of 1/2" drywall	.16/sq ft	$10.25		
	24' of 2x3's	200/M	$3		
	32 sq ft of 2 1/2" honeycomb		$0.50		
		total:	$14	10	$24
Interior Door Panel	32 sq ft of 1/2" drywall	.16/sq ft	$5.00		
	40' of 2x3's	200/M	$4		
	10 sq ft of 2 1/2" honeycomb		$0.25		
		total:	$10	10	$20
Ceiling Panel	144 sq ft of 1/2" drywall	.16/sq ft	$23.00		
	130' of 2x8's	310/M	$54		
		total:	$78	$12	$90
SPECIAL ASSEMBLIES					
Plumbing Wall	64 sq ft of 1/2" drywall	.16/sq ft	$10.25		
	56' of 2x6's	210/M	$11.75		
	PVC piping, drains & stack		$20		
	64 sq ft of wetproof drywall	.24/sq ft	$15.40		
		total:	$57.40	30	$90
Chimney Assembly	72' of 4x2's	380/M	$18.25		
	2 1/4 sheets Cedarstripe™	45/sheet	$101.25	20	$120

TABLE 2: ASSEMBLY COSTS OF CORE HOUSE A

Elements	Manuf. Cost	Selling Cost	Number Req'd	Combined Cost	Man Hours	Labour Cost	Total Cost
SITE PREPARATION							
Excavation					11	330	330
ASSEMBLY OF FRAME							
Foundation Pad	80	120	9	1080			
Foundation Post	20	30	9	270			
Foundation Shoe		2	9	18			
Plate	7	10	24	240			
Post	8	10	8	80			
Girder Truss	34	50	3	150			
Ridge Beam	5	7.5	2	15			
Angle		0.5	80	40			
Screw		0.15	240	36			
			Total:	1930	22	660	2590
BUILDING ENVELOPE							
Foundation Wall Panel	280	400	8	3200			
Floor Panel	200	300	4	1200			
Wall Panel	110	160	8	1280			
Roof Panel	620	900	4	3600			
Interior Gable End	40	60	4	240			
Exterior Gable End	80	120	4	480			
Screw		0.15	420	60			
Chimney Assembly	120	180	1	180			
			Total:	9760	16	480	8640
WINDOWS & DOORS							
Type 1 Window		170	4	680			
Type 2 Window		260	2	520			
Type 3 Window		500	1	500			
Exterior Door		250	2	500			
			Total:	2200	4	120	2320
EXTERIOR TRIM							
Side Batten, foundn	5	7.5	4	30			
Corner Batten, foundn	9	14	4	52			
Side Batten	12	18	4	72			
Corner Batten	23	30	4	120			
Fascia Board	6	9	4	36			
			Total:	310	3	90	400
FLASHING							
Side Flashing	16	24	3	72			
Ridge Flashing	4	6	2	12			
Cap	2	3	7	21			
Scupper	15	22	2	44			
Eavestrough		12	4	48			
Downspout		10	2	20			
			Total:	220	3	60	280

TABLE 2: ASSEMBLY COSTS OF CORE HOUSE A

Elements	Manuf. Cost	Selling Cost	Number Req'd	Combined Cost	Man Hours	Labour Cost	Total Cost
INTERIOR FINISHING							
Interior Wall Panel	24	36	7	250			
Interior Door Panel	20	30	3	90			
Door Hardware				50			
Ceiling Panel	90	145	2	290			
Interior Door		40	3	120			
Closet		150	2	300			
Vanity		200	1	200			
Kitchen Cabinets		1000	1	1000			
Baseboard		3.5	14	50			
Cornice		2	14	28			
Carpet		2/sq ft	420	840			
Lino		.3/sq ft	140	40			
			Total:	3260	22	660	3920
PLUMBING							
Plumbing Wall	90	135	1	135			
Installation & fixtures				1800			
			Total:	1935	11	330	2260
ELECTRICAL							
Wiring				850			
Fixtures				200			
			Total:	1050	11	330	1380
HEATING							
furnace, flue, & ducts				1000	6	180	1200
APPLIANCES							
Range Hood & fan				100			
Electric stove				580			
Refrigerator				680			
Bathroom vent				100			
			Total:	1460	2	60	1520
TOTAL HARD COSTS:				23100	110	3270	**26440**

TABLE 3: COST COMPARISON BETWEEN CORE HOUSE A AND CONVENTIONAL CONSTRUCTION

CORE HOUSE A	Mat'l Cost	Man Hours	Labour Cost	Total Cost	CONVENTIONAL CONSTRUCTION	Mat'l Cost	Man Hours	Labour Cost	Total Cost
SITE PREPARATION									
Excavation		11	330	330	Excavation		10	330	330
ASSEMBLY OF FRAME					FOUNDATION				
Foundation Pad	1080				Cribbing		22	660	660
Foundation Post	270				Conc footings	200	2	60	260
Foundation Shoe	18				Conc Walls	1000	4	120	1120
Plate	240				Dampproofing	50	1	30	80
Post	80				Vapour Barrier	22	2 / 3	20	44
Girder Truss	150							Total:	2160
Ridge Beam	15				ROUGH CARPENTRY				
Angle	40				Framing Material	1750			1750
Screw	36				Truss	560			560
Totals:	1930	22	660	2590	Framing Labour		50	1500	1500
BUILDING ENVELOPE								Total:	3810
Foundation Wall Panel	1600				CLADDING				
Floor Panel	1200				Roof & Flashing	370	7	210	480
Wall Panel	1280				Siding	700	11	330	1030
Roof Panel	3600				Parging	20	2	60	80
Interior Gable End	240							Total:	1590
Exterior Gable End	480								
Screw	60				INSULATION	500	14	420	920
Chimney Assembly	180								
Totals:	8160	16	480	8640					
WINDOWS & DOORS					WINDOWS & DOORS				
Type 1 Window	680				Type 1 Window	680			
Type 2 Window	520				Type 2 Window	520			
Type 3 Window	500				Type 3 Window	500			
Exterior Door	500				Exterior Door	500			
Totals:	2200	4	120	2320	Totals:	2200	8	240	2440
EXTERIOR TRIM									
Side Batten, foundn	30								
Corner Batten, foundn	52								
Side Batten	72								
Corner Batten	120				EXTERIOR TRIM				
Fascia Board	36				Soffit & Fascia	310	4	120	430
Totals:	310	3	90	400	Eavestrough	48	1	30	80
FLASHING					Downspout	20	1	30	50
Side Flashing	72								
Ridge Flashing	12								
Cap	21								
Scupper	44								
Eavestrough	48								
Downspout	20								
Totals:	220	3	60	280					
LOCK-UP TOTALS:	12800	60	1740	14560		9500	140	3740	13240

TABLE 3: COST COMPARISON BETWEEN CORE HOUSE A AND CONVENTIONAL CONSTRUCTION

CORE HOUSE A	Mat'l Cost	Man Hours	Labour Cost	Total Cost	CONVENTIONAL CONSTRUCTION	Mat'l Cost	Man Hours	Labour Cost	Total Cost
INTERIOR FINISHING					FINISHING				
Interior Wall Panel	250				Drywall	500	14	420	920
Interior Door Panel	90				Interior Door	120	2	60	180
Door Hardware	50				Door Hardware	50	1	30	80
Ceiling Panel	290				Closet	300	1	30	80
Interior Door	120				Vanity	200	1	30	80
Closet	300				Kitchen Cabinets	1000	3	90	1090
Vanity	200				Baseboard	50	1	30	80
Kitchen Cabinets	1000				Cornice	28	1	30	60
Baseboard	50				Carpet	840	6	180	1020
Cornice	28				Lino	40	2	60	100
Carpet	840				Painting	150	14	420	570
Lino	40				Totals:	3280	46	1380	4660
Totals:	3260	20	660	3920					
PLUMBING					PLUMBING				
Plumbing Wall	135				Instal'n & fixtures	1800	30	900	2700
Instal'n & fixtures	1800								
Totals:	1935	10	330	2260					
ELECTRICAL					ELECTRICAL				
Wiring	850				Wiring	850			
Fixtures	200				Fixtures	200			
Totals:	1050	10	330	1380	Totals:	1050	10	300	1350
HEATING					HEATING				
furnace, flue, & ducts	1000	6	180	1200	furnace, flue, & duct	1000	10	300	1300
APPLIANCES					APPLIANCES				
Range Hood & fan	100				Range Hood & fan	100			
Electric stove	580				Electric stove	580			
Refrigerator	680				Refrigerator	680			
Bathroom vent	100				Bathroom vent	100			
Totals:	1460	2	60	1520	Totals:	1460	2	60	1520
TOTAL HARD COSTS:	23100	110	3270	26440	TOTAL HARD COSTS:	18090	240	6680	24770

TABLE 4: COST COMPARISON FOR 26 SQUARE METER ADDITION

CORE HOUSE A	Mat'l Cost	Man Hours	Labour Cost	Total Cost	CONVENTIONAL CONSTRUCTION	Mat'l Cost	Man Hours	Labour Cost	Total Cost
SITE PREPARATION					SITE PREPARATION				
Excavation		6	180	180	Excavation		6	180	180
ASSEMBLY OF FRAME					DEMOLITION		2	60	60
Foundation Pad	360								
Foundation Post	90				FOUNDATION				
Foundation Shoe	6				Cribbing		10	300	300
Plate	40				Conc footings	100	2	60	160
Post	30				Conc Walls	500	4	120	620
Girder Truss	100				Dampproofing	25	1	30	55
Ridge Beam	15				Vapour Barrier	10	1 / 2	15	25
Angle	16				Totals:	635	18	525	1160
Screw	16				ROUGH CARPENTRY				
Totals:	675	6	180	850	Framing Material	900			900
BUILDING ENVELOPE					Truss	300			300
Foundation Wall Panel	800				Framing Labour		30	900	900
Floor Panel	600				Totals:	1200	30	900	2100
Wall Panel	320				CLADDING				
Roof Panel	1800				Roof & Flashing	250	7	210	460
Interior Gable End	120				Siding	350	6	180	530
Exterior Gable End	240				Parging	10	2	60	70
Screw	25				Totals:	610	15	450	1060
Totals:	3665	2	60	3720					
WINDOWS					INSULATION	250	7	210	460
Type 1 Window	510	1	30	540					
EXTERIOR TRIM					WINDOWS				
Side Batten, foundn	15				Type 1 Window	510	6	180	690
Side Batten	36								
Fascia Board	18				EXTERIOR TRIM				
Side Flashing	48				Soffit & Fascia	310	4	120	430
Ridge Flashing	12				Eavestrough	48	1	30	80
Cap	9				Downspout	20	1	30	50
Eavestrough	24				Totals:	380	6	180	560
Totals:	162	1	30	190					
INTERIOR					INTERIOR				
Interior Wall Panel	160				drywall	250	8	240	490
Ceiling Panel	145				Baseboard	14	1	30	40
Closet	150				Cornice.	8	1	30	40
Baseboard	7				Carpet	560	4	120	680
Cornice	4				Wiring & Fixtures	100	2	60	160
Carpet	560				Ducting	40	2	60	100
Wiring & Fixtures	100				Totals:	965	18	120	1260
Ducting	10								
Totals:	1140	4	120	1260					
TOTAL HARD COSTS:	6150	20	600	6750	TOTAL HARD COSTS:	4550	108	3240	7790

3.5
MARKET ANALYSIS

There are two distinct approaches which could be pursued in the marketing of the *Incremental Home* building system. On the one hand, the system could be distributed as a 'blueprint', complete with working drawings and assembly instructions. Most of the major components could then be constructed by the future occupants, and only specialized components, such as fasteners, flashing, and services, would need to be purchased. Although this would be a very time consuming approach: the components could be manufactured at leisure; the *engagement* of the occupants with their home would be greatly enhanced; and the total cost of the building might be less due to reduced outside labour costs.[1]

The industrialized approach emphasized in this document, however, would be far less demanding for the client. Factory produced components would facilitate the construction and time required to erect an *Incremental Home* while still allowing the future occupants to participate in important design decisions such as the size, configuration, and layout of their dwelling.

According to the cost calculations included in this document, the *Incremental Home* building system would be about five percent more expensive than a conventional structure[2]. Nevertheless, the advantages inherent in the system, such as rapid assembly and the possibility of widespread distribution, may outweigh the additional cost. The most important attribute of the system, and what sets it apart from most other existing prefabricated building systems, is its flexibility. As a result, renovations to the *Incremental Home* can be up to fifteen percent less expensive than comparable conventional renovations, and take only one-fifth as long. An prefabricated *Incremental Home* building system may be appropriate for any occupants who anticipate significant changes to their needs over time. Below is a list of some of the potential markets which the *Incremental Home* can address:

- home purchasers who seek a small inexpensive home (eq. a *Core House*) which has the potential for substantial future expansion

- for homeowners who wish to build their own homes with only layman's skills

- as a second home or cottage

- for remote locations with limited access

- as temporary housing for transient communities such as construction or exploration sites

- for large community dwellings and dormatories

- for overseas export to other parts of the world with similar climates

- for offices and other non-residential applications that would benefit from a building which can easily be enlarged, reduced, or otherwise altered

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[1] Any construction templates, such as jigs for trusses, could be stored for future use in the manufacture of additional components.

[2] The additional cost is largely because rigid, rather than batt, insulation has been used in the building system.

4
CONCLUSIONS

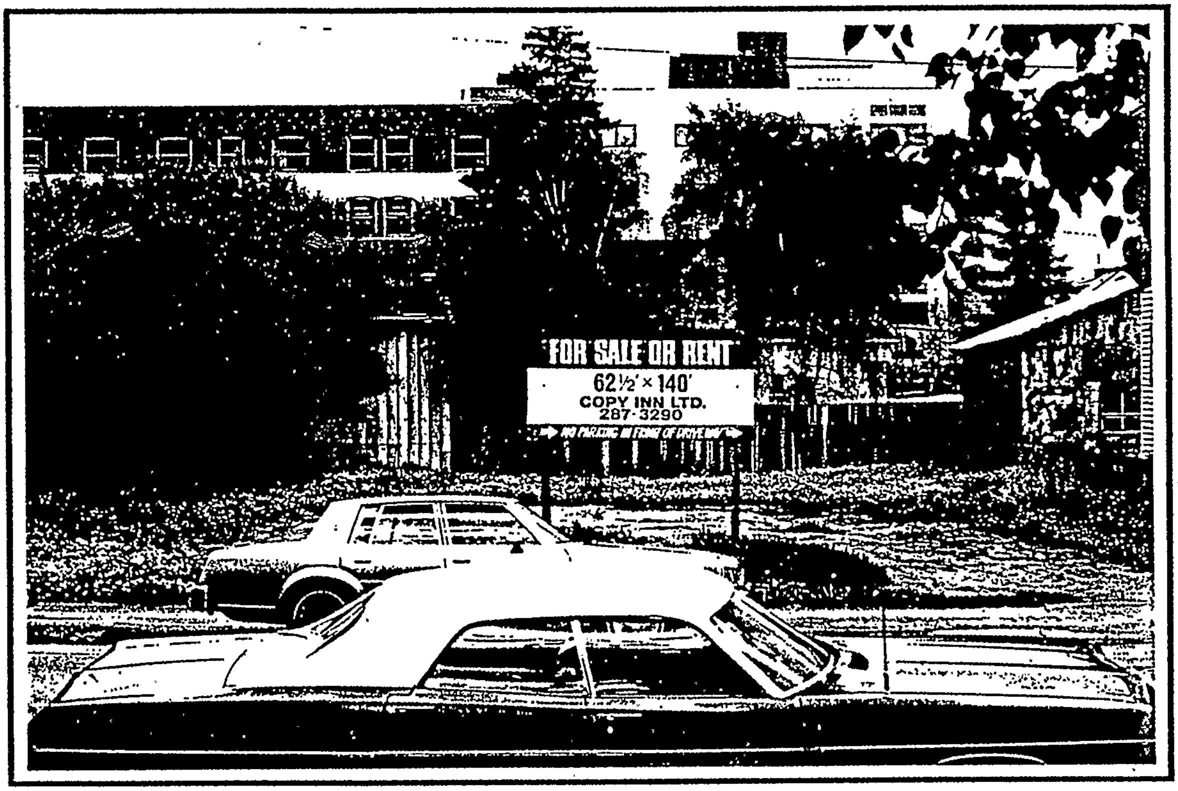


Photo 6 An empty residential lot

The *Incremental Home* has attempted to achieve a number of design objectives in the hope of producing a building system which might improve the personal relevance and suitability of our homes, and thereby the quality of our lives.

The foremost design strategy in order to achieve this goal has been to develop a dynamic building system which can be easily and economically modified to meet the changing needs of the inhabitants. This flexibility can insure that an *Incremental Home* will remain a satisfying and appropriate environment. Since the building can adapt to the needs of the occupants, the occupants do not have to adapt themselves to their home, or experience the *dissonance* which can result from living in an inappropriate environment.

By reducing the number of building components and simplifying their assembly, the *Incremental Home* attempts to be a rational and comprehensible building system. This should make the assembly process very rapid, and make it possible for the occupants themselves to contribute to the design, construction, modification, and maintenance of their homes. Not only can this participation reduce initial and subsequent labour costs, but it gives the occupants a greater degree of *control* over their homes. By engaging in these activities, the home may also come to acquire a more profound personal significance.

The *Incremental Home* can be applied to a number of different building types with a wide range of layouts and sizes. This should result in a significant advantage over most other existing prefabrication systems which have more limited market. *Incremental Homes,* ranging in size from *Core Houses* to far larger dwellings, may appeal to many prospective home owners, from the financially disadvantaged to the affluent. The potential market is further enhanced by the possibility of large scale international distribution because of the lightweight and compact nature of the building components, and the many different ways in which they can be packed during transport.

Ultimately, the success of a prefabricated *Incremental Home* building system would largely depend on its popularity. The economies of scale which are made possible through mass-production techniques, can only be realized through large scale production. Given the broad range of markets to which the *Incremental Home* can be applied, the potential for widespread use is at least theoretically possible. If this can be achieved, the cost of the system would be substantially reduced, and the availability of new and second hand building components for all existing and potential *Incremental Home* owners would be insured.

If the *Incremental Home* was to prove that it had long-term viability then, over the years, the components would almost certainly undergo significant changes themselves. The system would inevitably evolve as a result of dynamic pressures such changing demand and availability of materials, and other refinements to the system. As long as the dimensional module of the system and certain fastening details are maintained, or special adaptors are provided, the compatibility between all the evolutionary stages of the system could be insured

Perhaps the single most important factor which sets the *Incremental Home* apart from other prefabricated building systems is its design philosophy. The *Incremental Home* does not produce specific 'models' or buildings which are fixed and intransitive. Rather, the *Incremental Home* provides a framework to contain space which can be easily assembled and modified -inherently ready to respond to the changing needs of the occupants, initially or at any subsequent time during its occupation.

5
APPENDICES

5.1
LIST OF COMPONENTS FROM THE KIT OF PARTS

STRUCTURAL FRAME COMPONENTS

SUBSTRUCTURE	
Foundation Pad	built-up PWF 2x6's
Foundation Post	built-up PWF 2x6's & 2x3's
Foundation Shoe	preformed galvanized iron
SUPERSTRUCTURE	
Plate	2 ply 2x6'
Post	built-up 2x6's and 2x3's
Girder Truss	top chord: 3 ply 2x6's web: 2x4's, bottom chord 2x4
Ridge Beam	1 ply 2x6
FASTENERS	
Metal Angles	3x3x1/2" steel, various configurations
Screws	heavy guage

ENCLOSURE COMPONENTS

Foundation Wall Panel	PWF plywood, both sides 2x6 PWF frame RSI 3.5 (R20) rigid insulation
Exterior Wall Panel	composite board c/w exterior finish 2x6 frame RSI 3.5 (R20) rigid insulation drywall
Floor Panel	plywood subfloor truss joists drywall c/w interior finish
Roof Panel	raised seam metal roofing strapping plywood sheathing truss joists RSI 7.0 (R40) rigid insulation drywall c/w interior finish
Exterior Gable End Panels	composite board c/w exterior finish 2x2 frame RSI 1.8 (R10) rigid insulation
Interior Gable End Panels	drywall c/w interior finish 2x2 frame RSI 1.8 (R10) rigid insulation

WINDOWS, DOORS, EXTERIOR TRIM AND FLASHING COMPONENTS

WINDOWS & DOORS	
Type 1 Window	single pane; double glazed wooden frame; casement or fixed
Type 2 Window	two panes; double glazed wooden frame; casement or fixed
Type 3 Window	four panes; double glazed wooden frame; casement or fixed
Skylight	special assembly; double glazed metal frame; fixed
Exterior Door	standard door [eg. 3'o"x6'8"] metal insulated with or without window
BATTENS	
Side Batten	PWF or plywood c/w finish
Corner Batten	PWF c/w finish
Fascia Board	plywood c/w finish
METAL FLASHING	
Side Flashing	preformed metal reinforced with plywood
Ridge Flashing	preformed metal
Top Cap	preformed metal
Standard Bottom Cap	preformed metal reinforced with plywood
Bottom Cap with Scupper	special assembly of plywood and metal
Eavestrough	preformed metal
Downspout	preformed metal

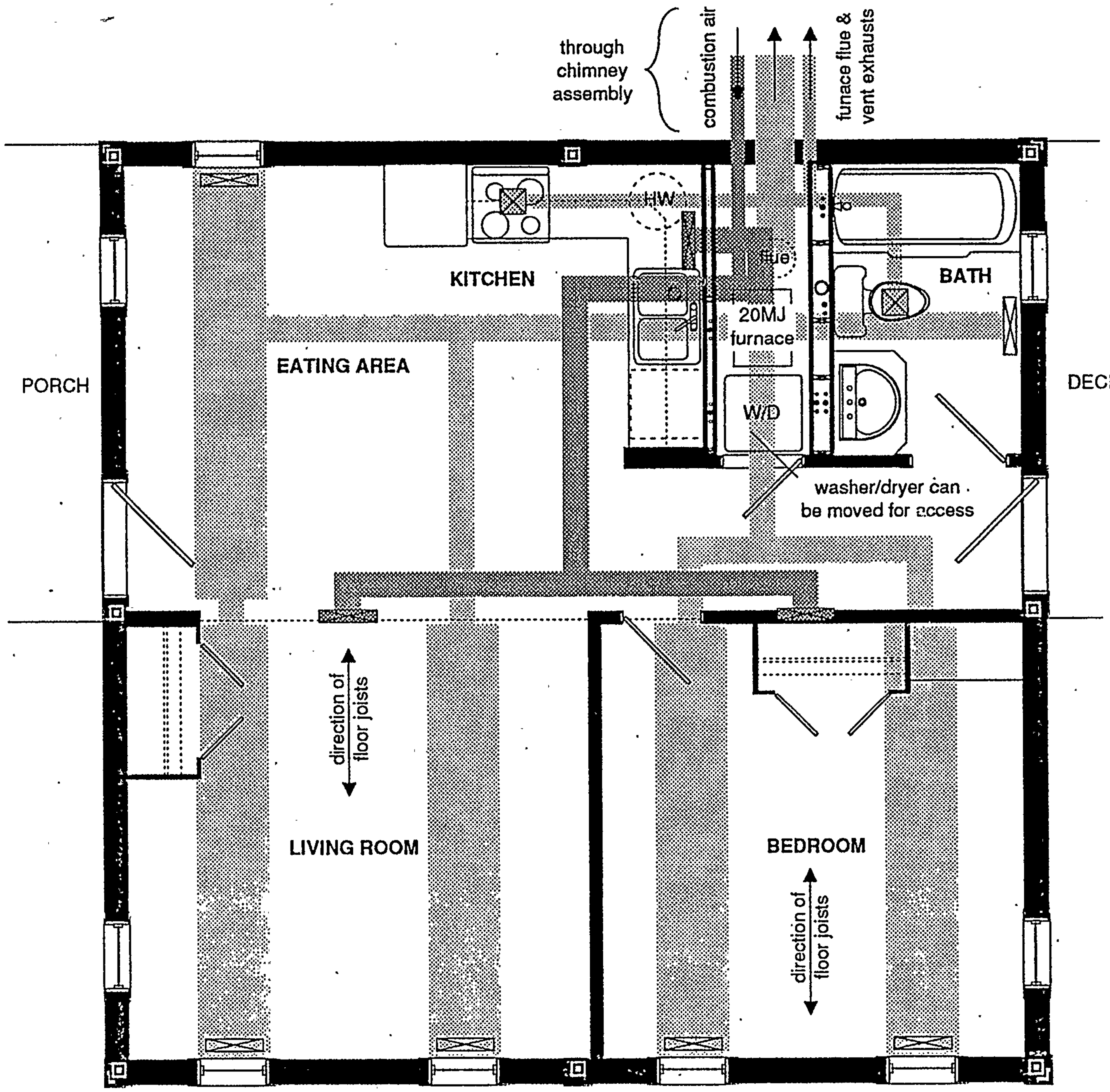
INTERIOR PARTITIONS, TRIM, AND CABINETRY COMPONENTS

INTERIOR PANELS	
Interior Wall Partition	dry wall -both sides 2x3 frame craft paper honeycomb
Interior Door Panel	2x3 frame 2x3 reinforcing around apeture drywall -both sides craft paper honeycomb
Prehung Interior Door	wooden frame solid-core panel door various styles
Ceiling Panel	2x8's-doubled at ends drywall -one side optional plywood-one side various sizes

TRIM	
Baseboard	painted particle board [MDF] c/w gaskets for exterior walls
Ceiling Moulding	painted particle board [MDF] c/w gaskets for exterior walls
CABINETRY	
Kitchen Cabinets	painted particle board [MDF]
Bathroom Vanity	painted particle board [MDF]
Closet	painted particle board [MDF]

SERVICE COMPONENTS

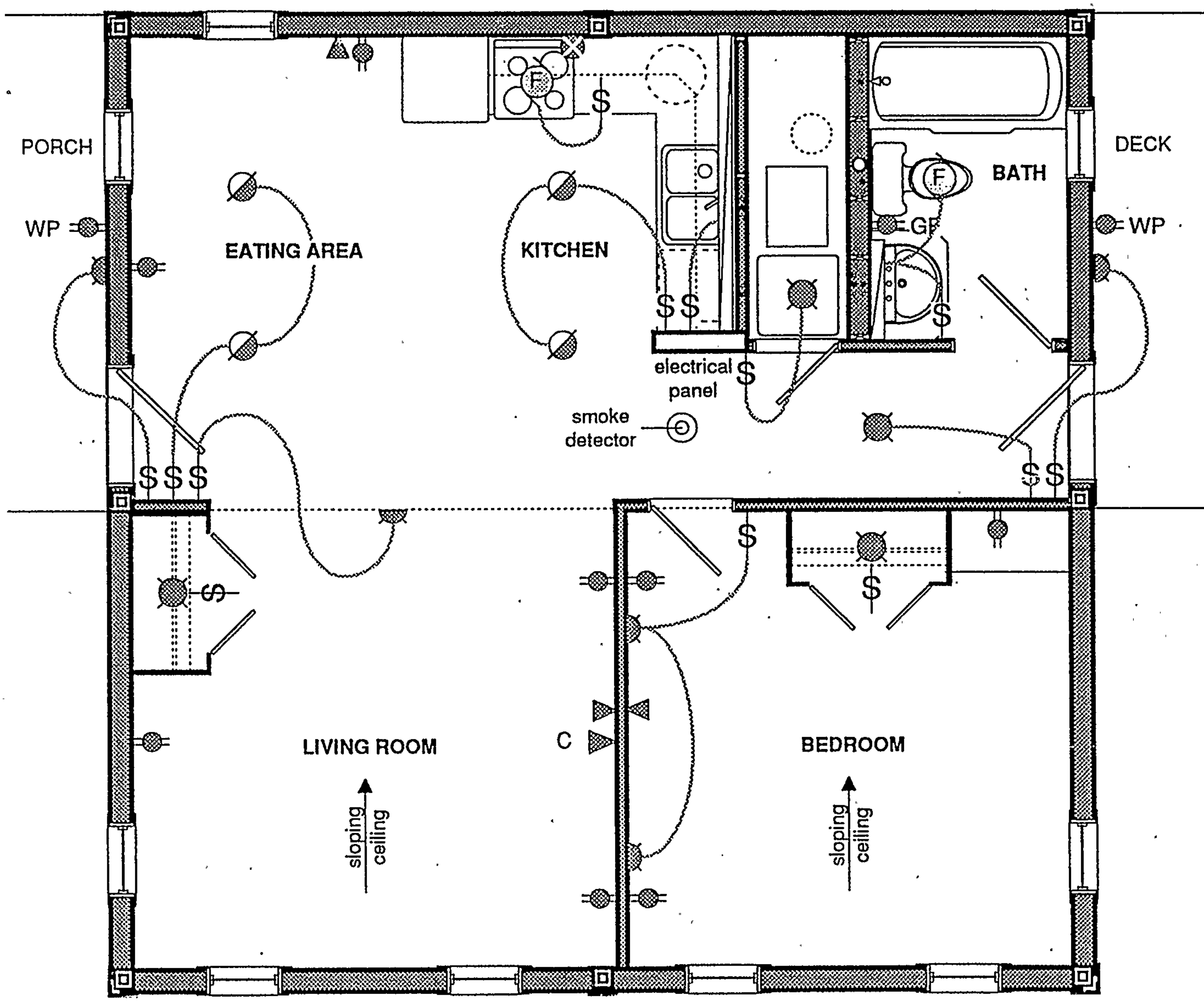
PLUMBING	
Plumbing Wall	2 x 6 frame drywall -both sides -one side w' waterproof finish PVC piping, drains & stack
Hot Water Heater	180 liter (40 gallon) tank
Fixtures	bathroom sink toilet bathtub c/w shower kitchen sink
ELECTRICAL	
Electrical panel	various sizes (min. 100A)
Receptacles	duplex ground fault in bathroom waterproof outside
Switch	as needed
Light Fixtures	various
Wiring	as needed
HEATING AND VENTILATION	
Furnace	20 MJ (20,000 Btu) -one or more
Ducting	200mm dia. where necessary
Floor and ceiling vents	75 x 300mm
Flue	300mm dia.
Chimney assembly	composite board c/w exterior finish 2x6 framing RSI 3.5 (R20) rigid insulation plywood



LEGEND OF SYMBOLS

supply air	return air	exhaust air
floor vent	ceiling vent	exhaust vent

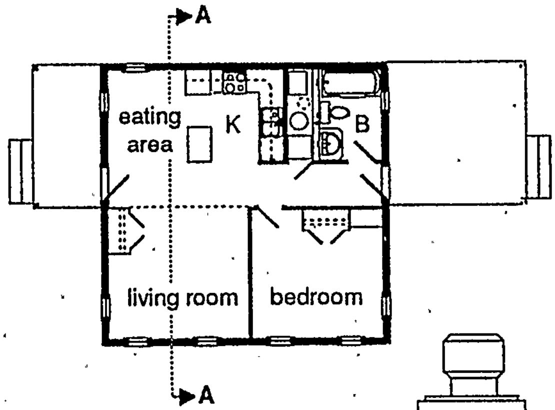
5.2	THE INCREMENTAL HOME CORE HOUSE A	MECHANICAL PLAN SCALE 1:50	1



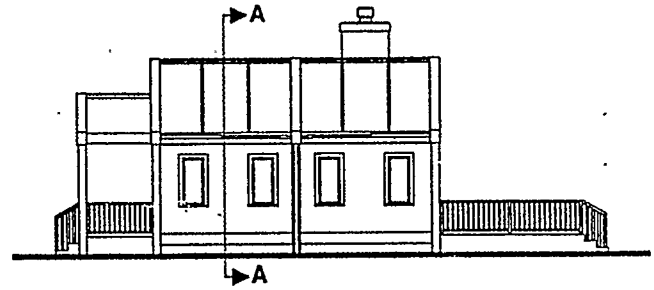
LEGEND OF SYMBOLS

	Incandescent fixture - ceiling mounted		Fluorescent fixture	GF	Ground fault receptacle
	Incandescent fixture - wall mounted	$	Single pole switch		220v receptacle
	Incandescent fixture - pot light		Duplex receptacle		Telephone jack
$	Pull chain fixture	WP	Waterproof recept.	C	Cable
				F	Fan

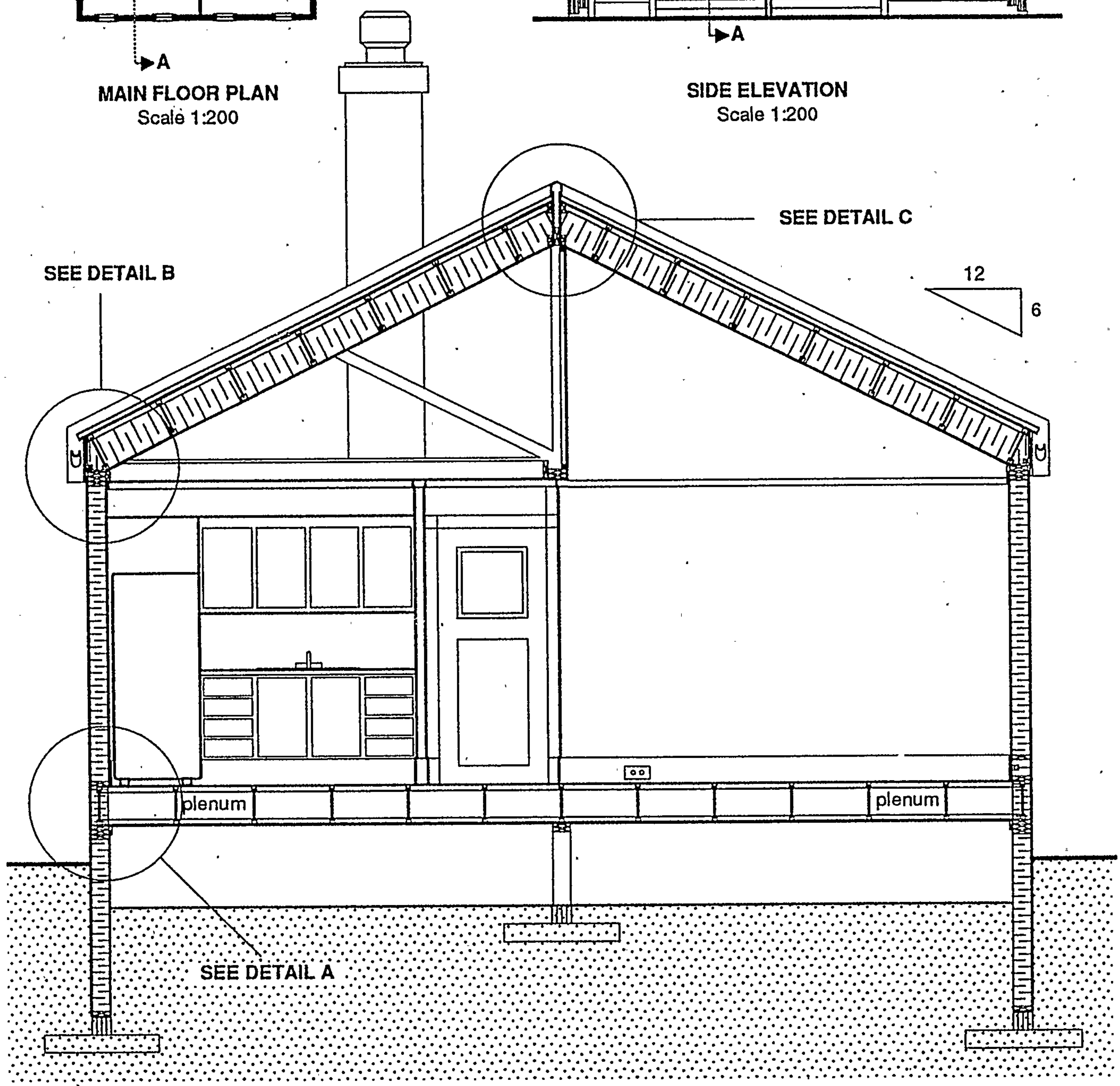
5.2	**THE INCREMENTAL HOME** CORE HOUSE A	**ELECTRICAL PLAN** SCALE 1:50	2



MAIN FLOOR PLAN
Scale 1:200

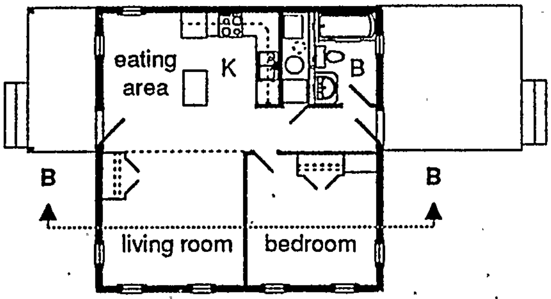


SIDE ELEVATION
Scale 1:200

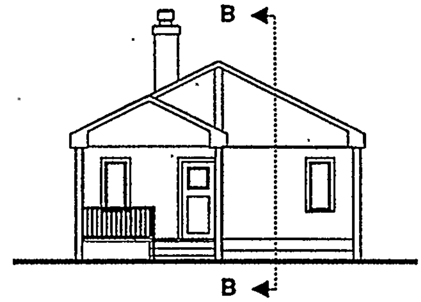


SECTION A-A
Scale 1:50

5.2	**THE INCREMENTAL HOME** CORE HOUSE A	**SECTION A-A** SCALE AS SPECIFIED	3

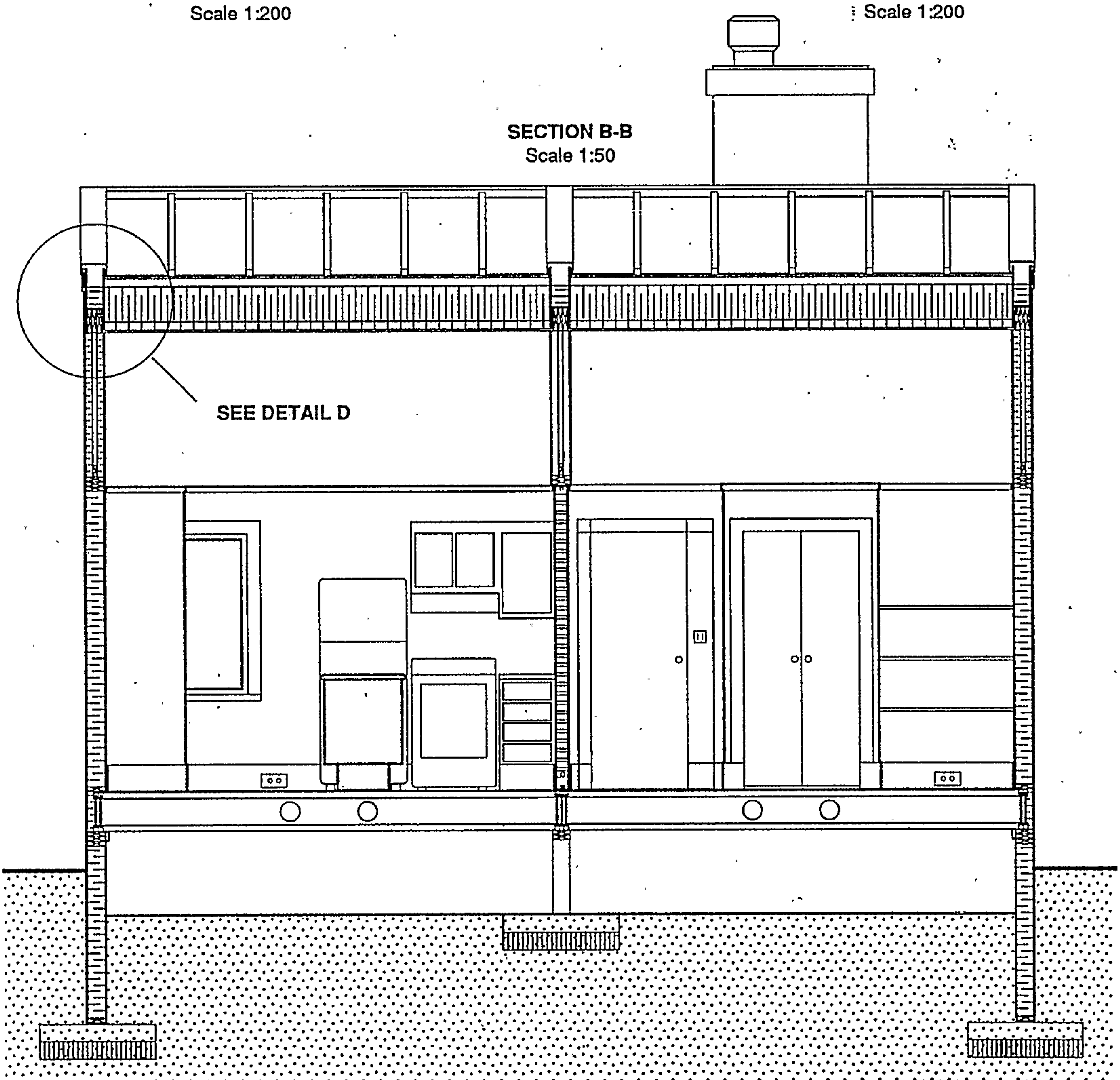


MAIN FLOOR PLAN
Scale 1:200

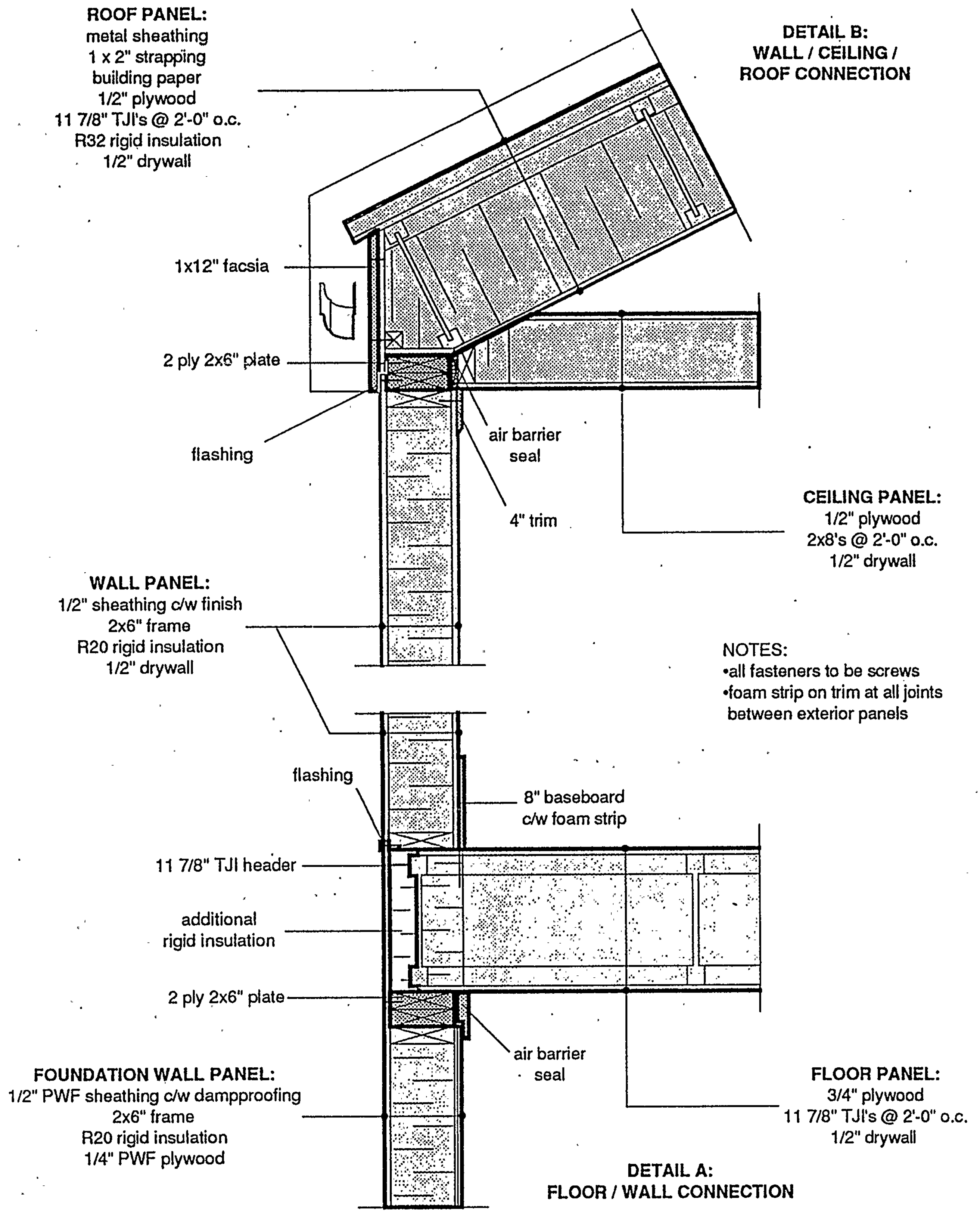


FRONT ELEVATION
Scale 1:200

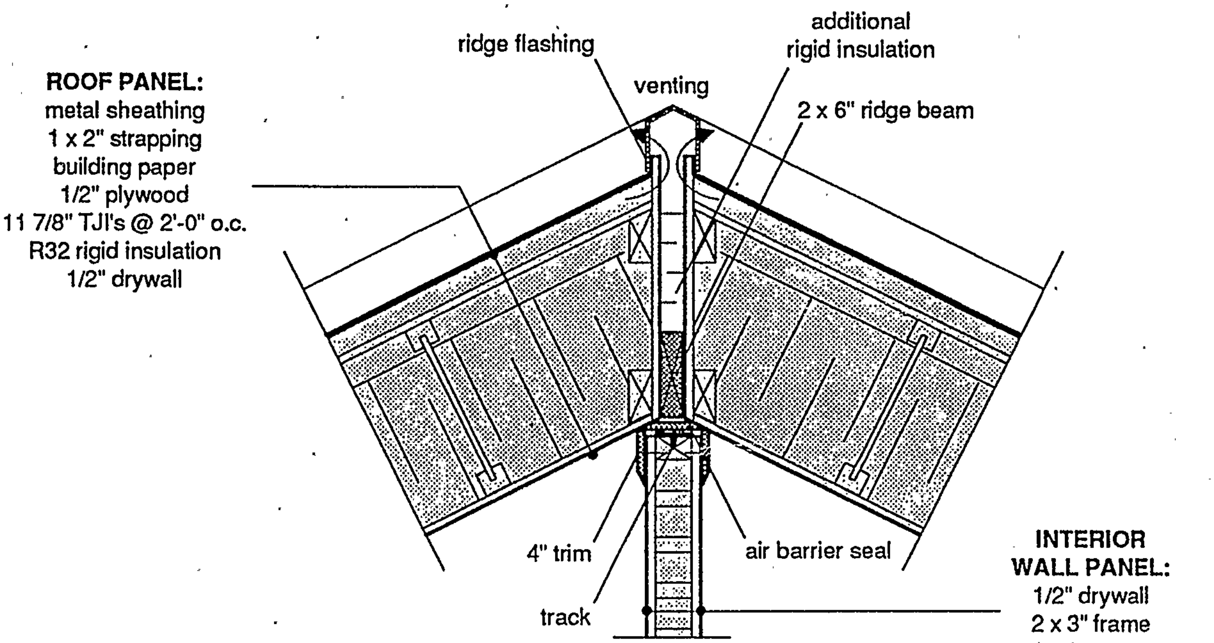
SECTION B-B
Scale 1:50



5.2	**THE INCREMENTAL HOME** CORE HOUSE A	**SECTION B-B** SCALE AS SPECIFIED	4

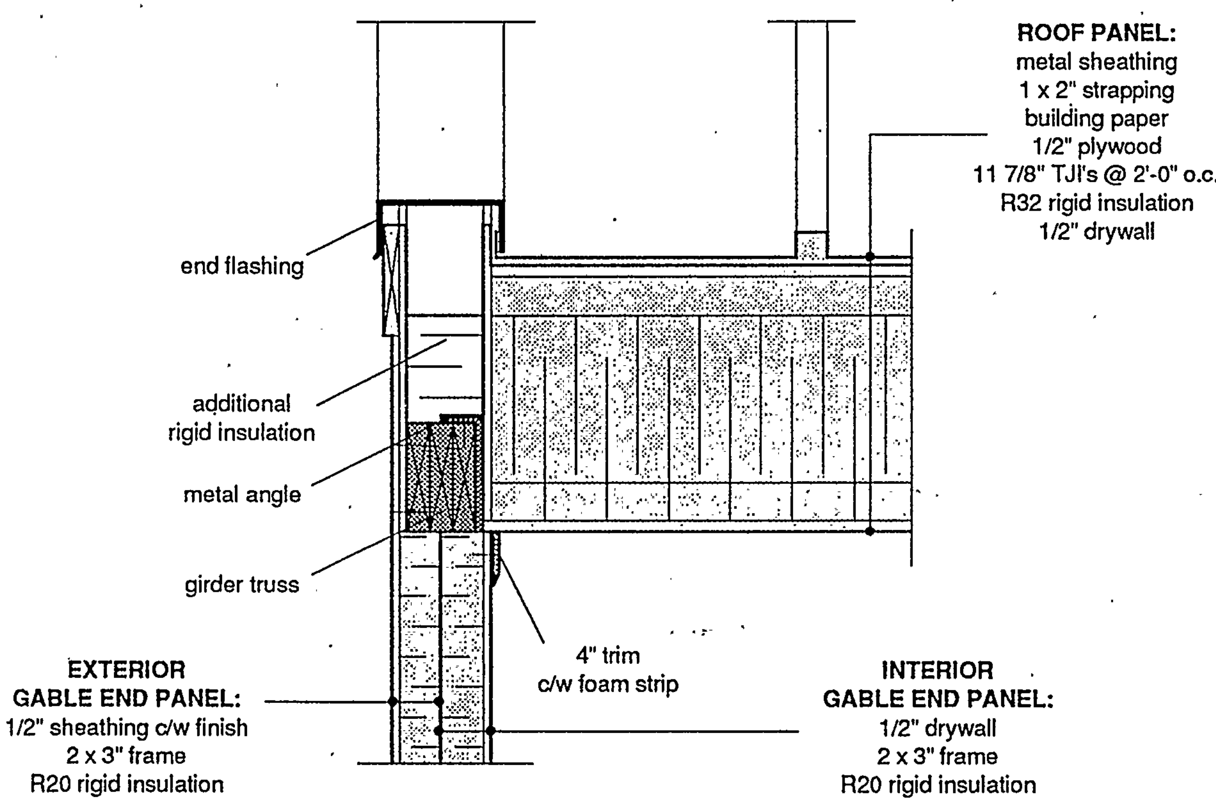


5.2	THE INCREMENTAL HOME CORE HOUSE A	DETAILS A & B SCALE 1:12	5



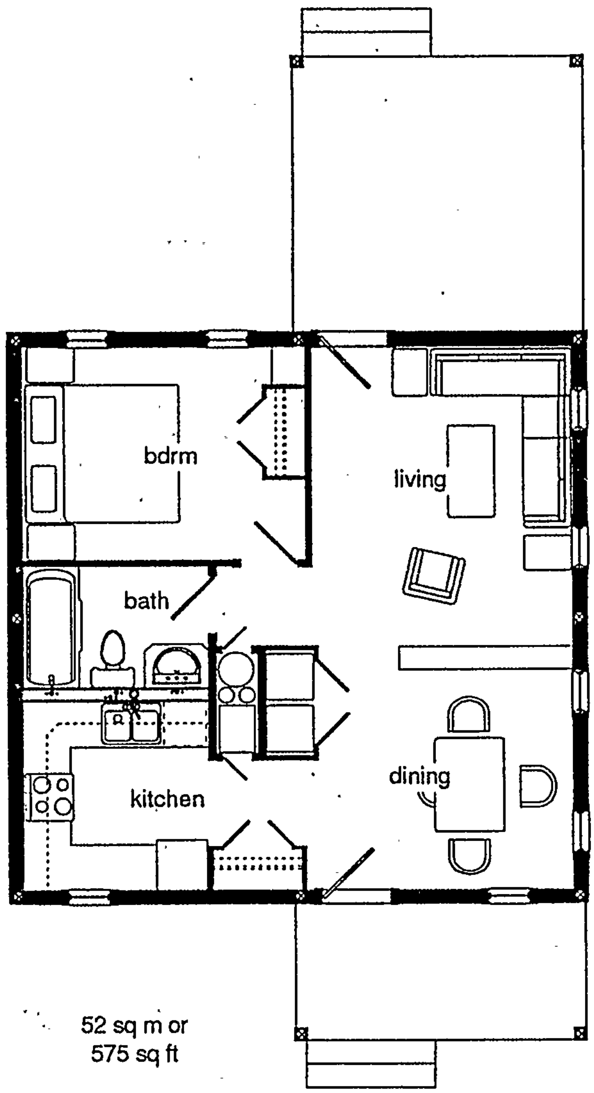
NOTES:
•all fasteners to be screws
•foam strip on trim at all joints between exterior panels

DETAIL C:
ROOF RIDGE CONNECTION



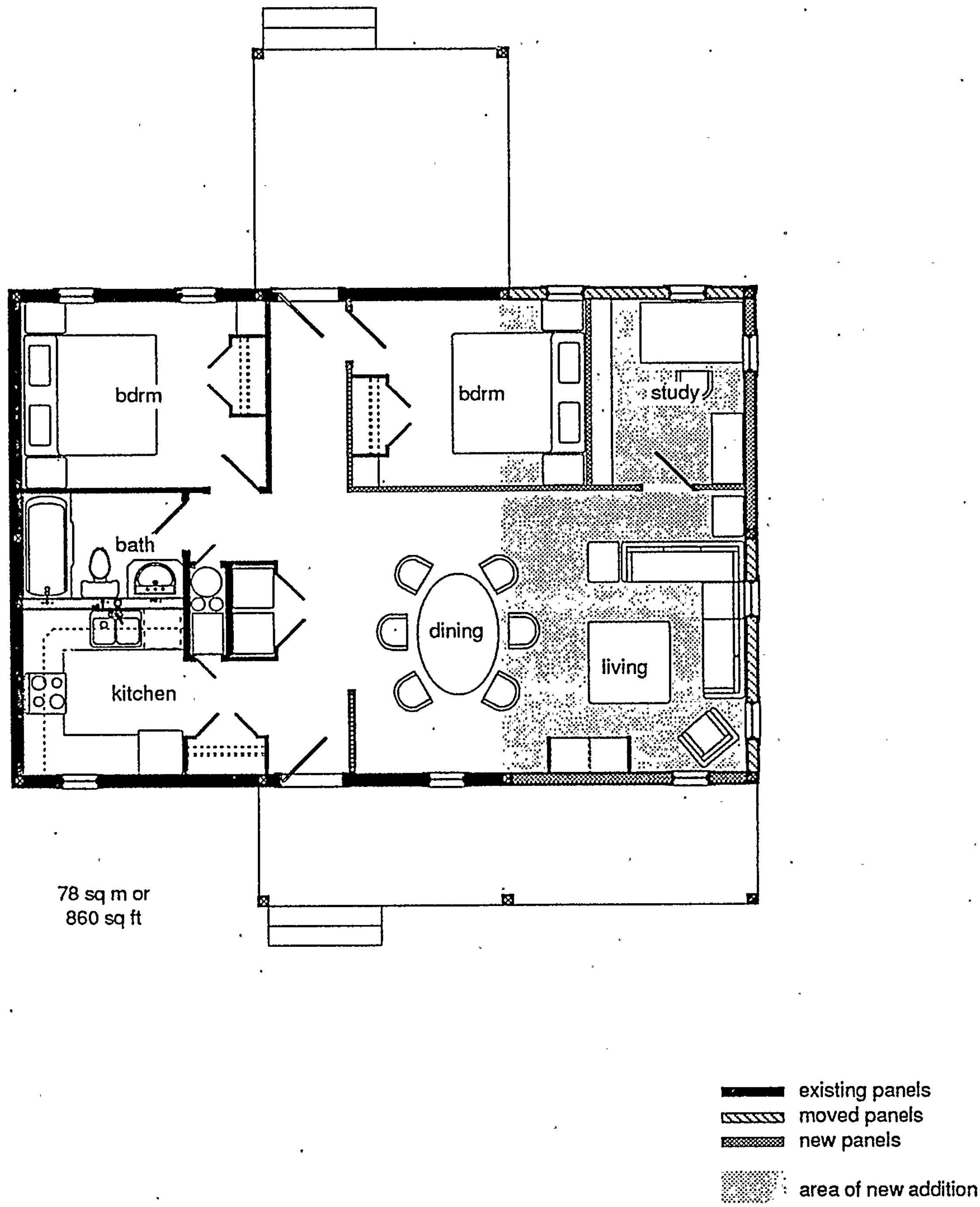
DETAIL D:
ROOF / GABLE END CONNECTION

5.2	**THE INCREMENTAL HOME** CORE HOUSE A	**DETAILS C & D** SCALE 1:12	6

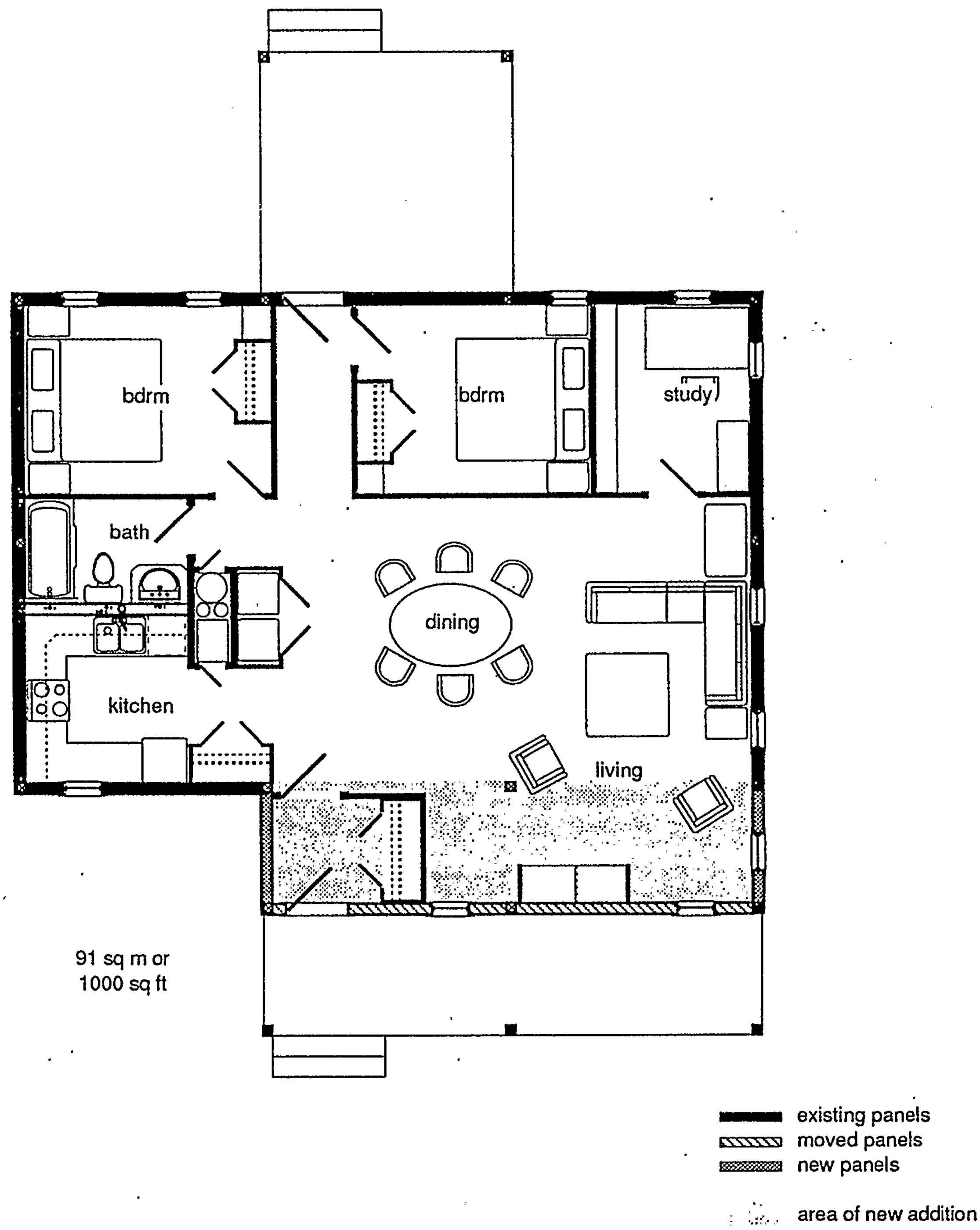


52 sq m or
575 sq ft

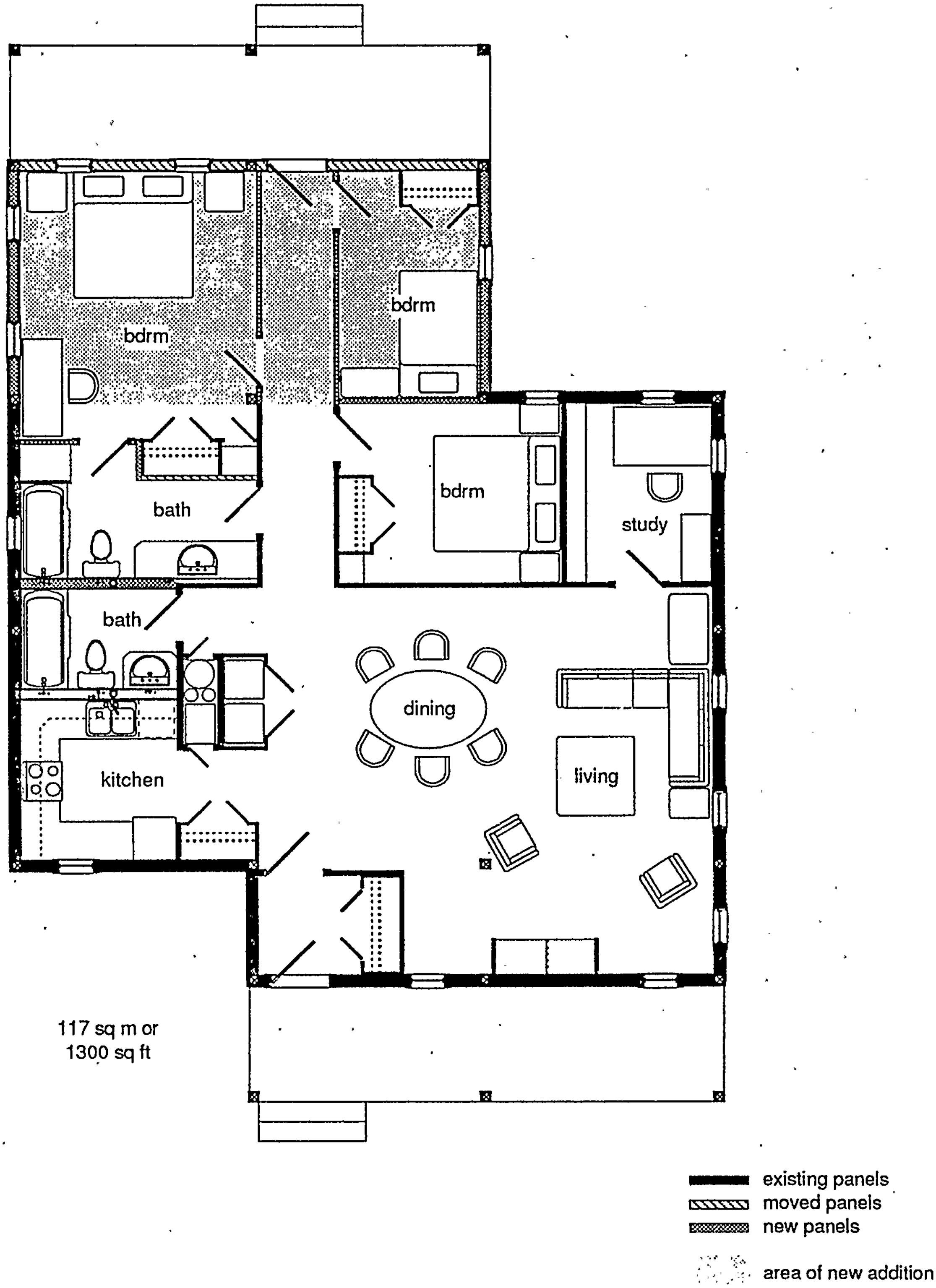
5.3.1	**THE INCREMENTAL HOME** EXPANSION OF CORE HOUSE B	**SEQUENCE 1: PHASE 1** SCALE 1:100	1



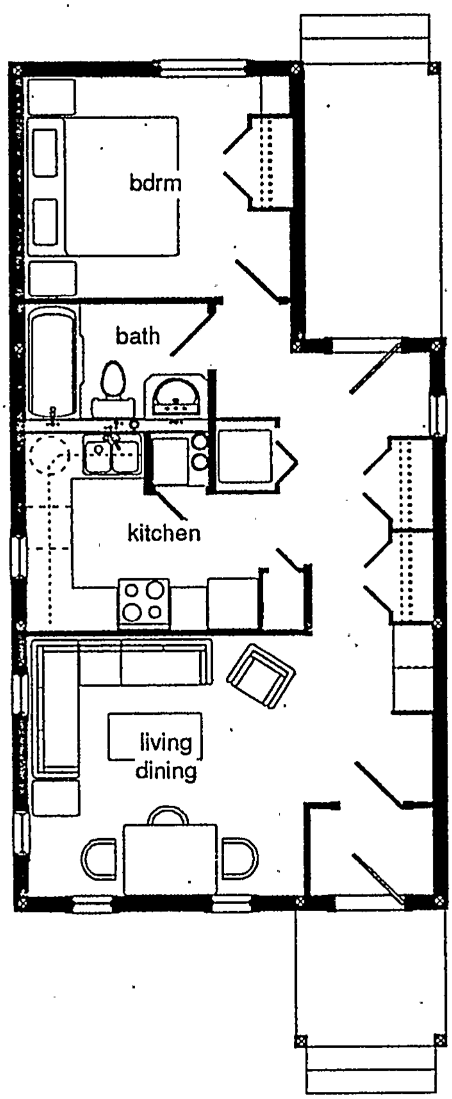
5.3.1	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE B	SEQUENCE 1: PHASE 2 SCALE 1:100	2



5.3.1	**THE INCREMENTAL HOME** EXPANSION OF CORE HOUSE B	**SEQUENCE 1: PHASE 3** SCALE 1:100	3



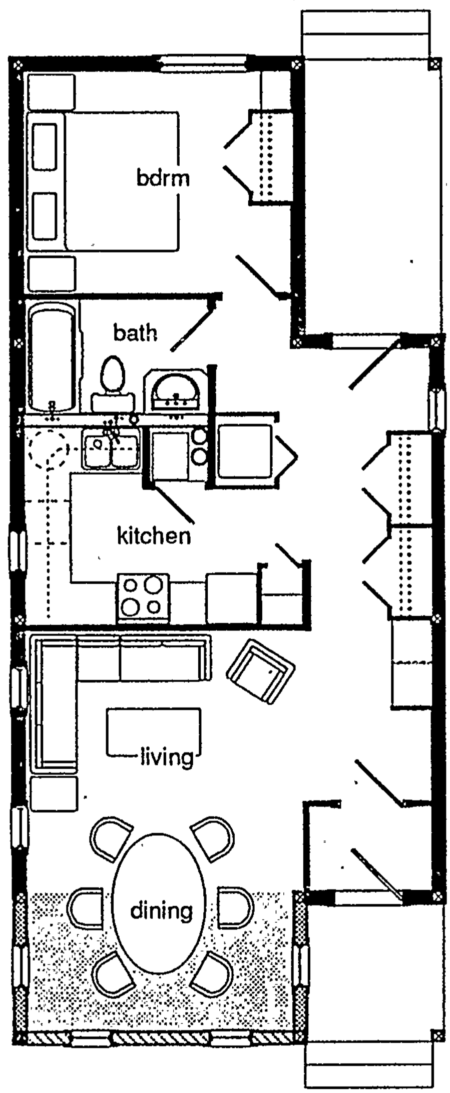
5.3.1	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE B	SEQUENCE 1: PHASE 4 SCALE 1:100	4



52 sq m or
575 sq ft

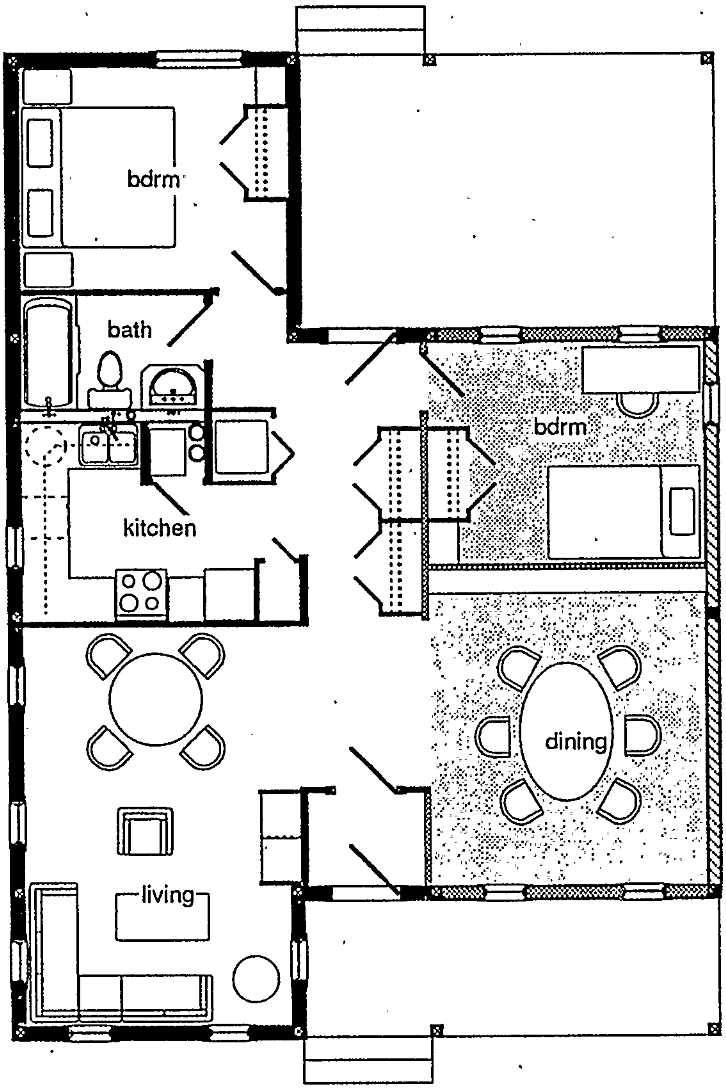
existing panels
moved panels
new panels
area of new addition

5.3.2	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 2: PHASE 1 SCALE 1:100	1



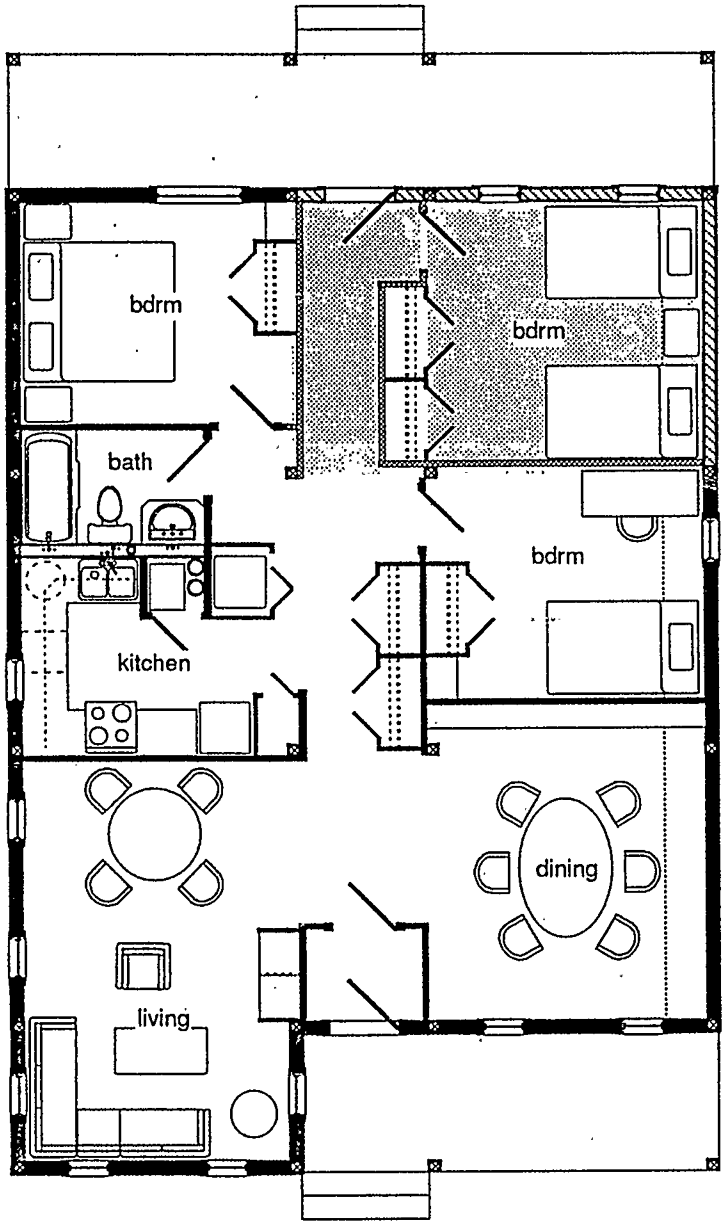
58.5 sq m or
650 sq ft

5.3.2	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 2: PHASE 2 SCALE 1:100	2

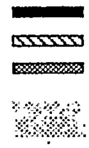


84.5 sq m or
935 sq ft

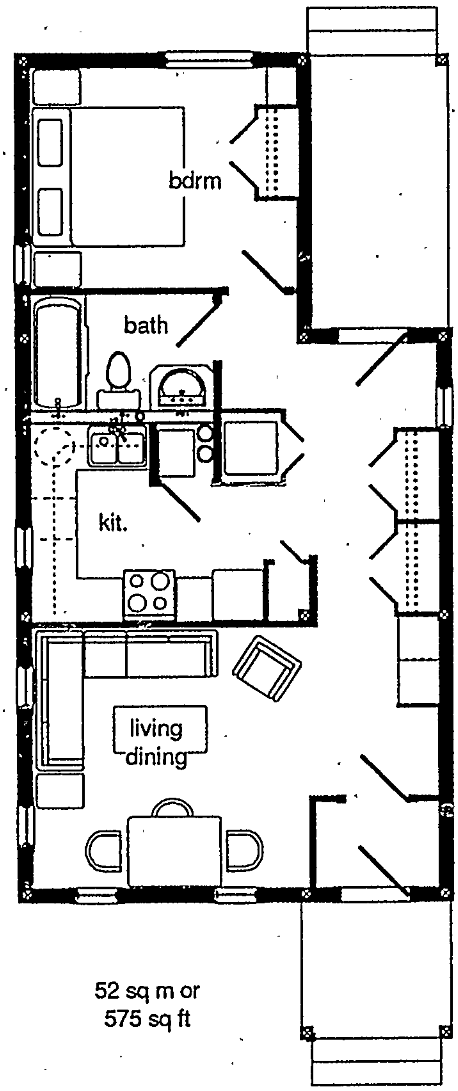
5.3.2	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 2: PHASE 3 SCALE 1:100	3



104 sq m or
1150 sq ft

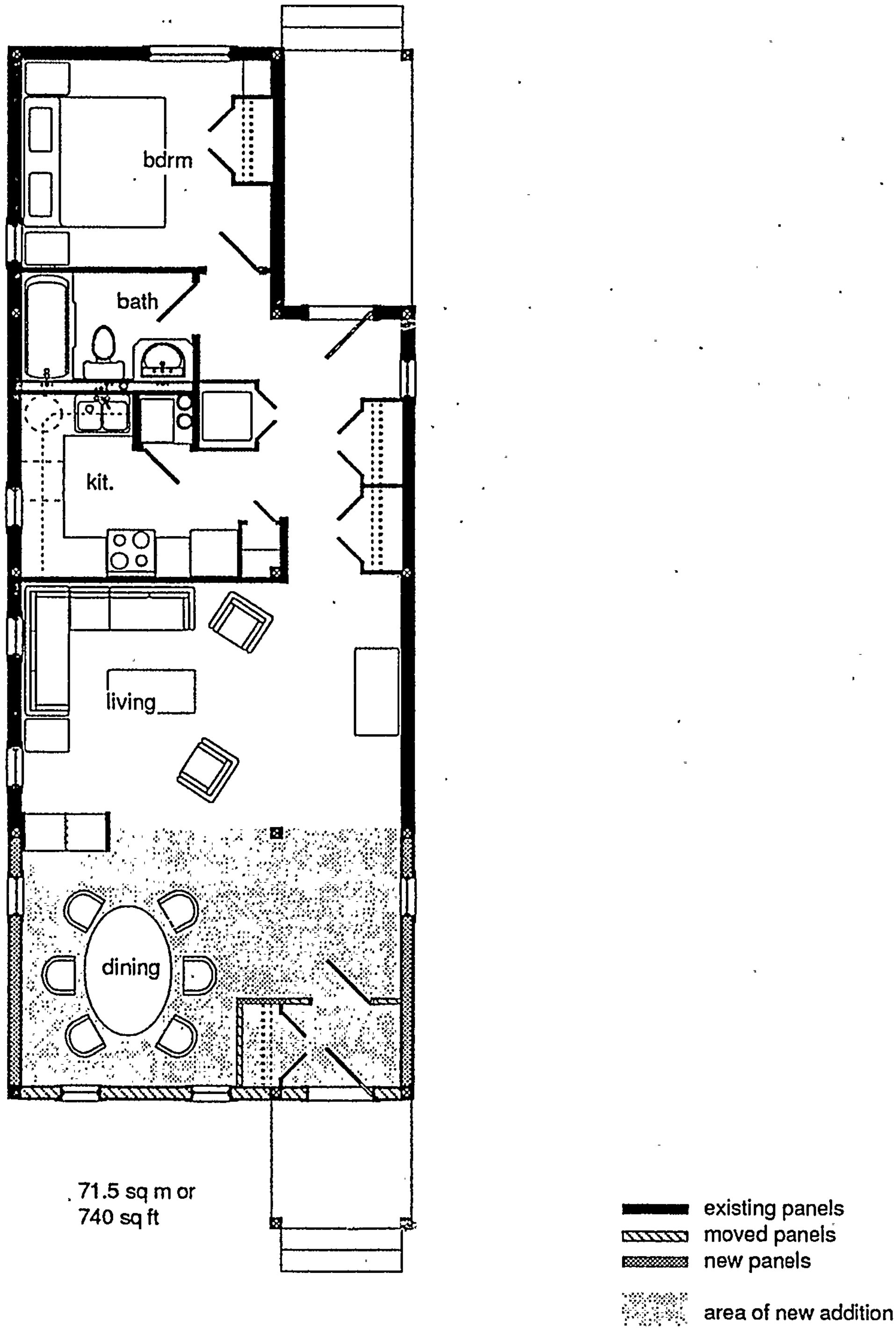


5.3.2	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 2: PHASE 4 SCALE 1:100	4



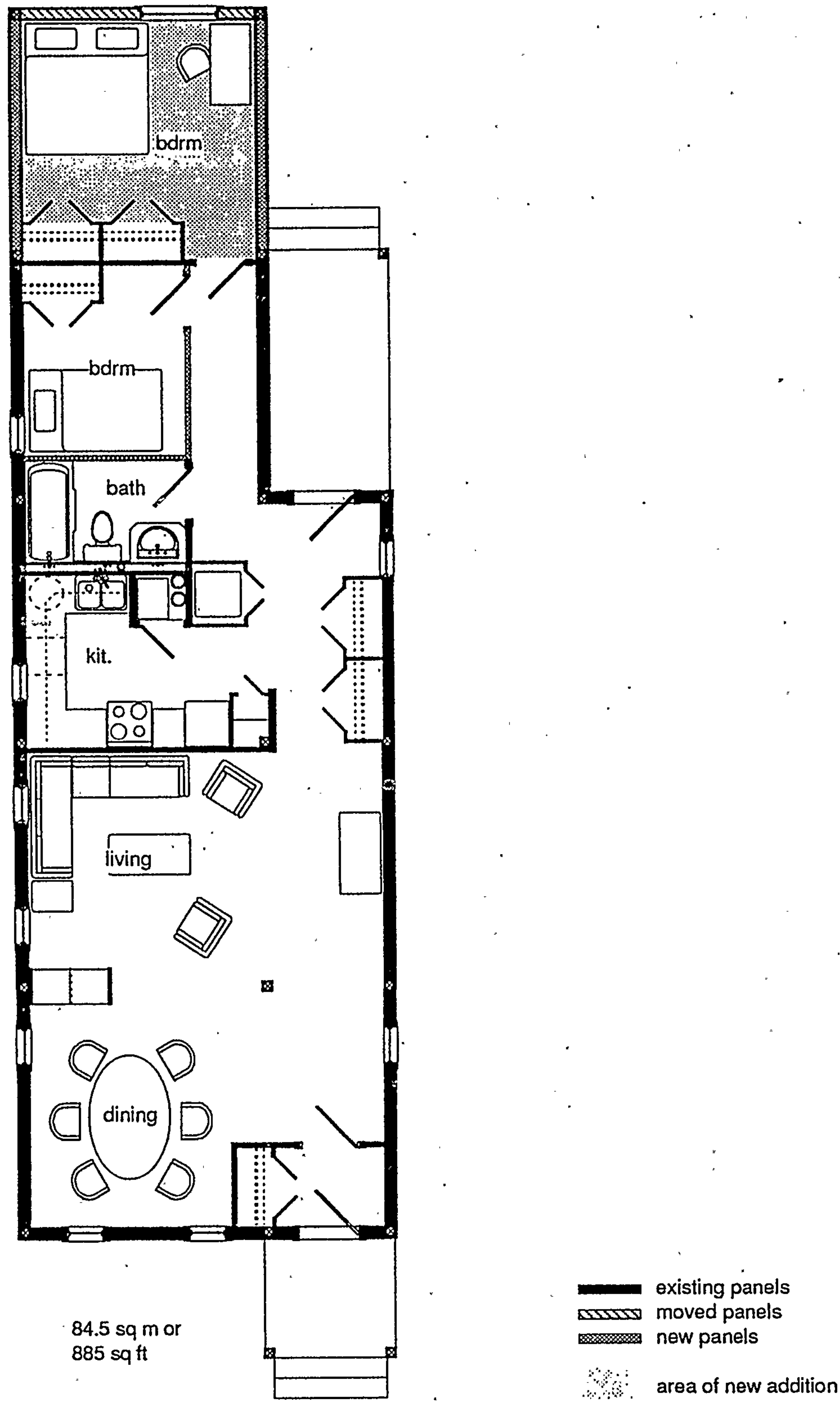
52 sq m or
575 sq ft

5.3.3	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 3: PHASE 1 SCALE 1:100	1



71.5 sq m or
740 sq ft

5.3.3	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 3: PHASE 2 SCALE 1:100	2



5.3.3	THE INCREMENTAL HOME EXPANSION OF CORE HOUSE C	SEQUENCE 3: PHASE 3 SCALE 1:100	3

5
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