MODULAR TOWERS
A User-Involved Housing System

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ABSTRACT

This work is the record of a prefabricated, wood-framed residential housing design study. Its initial concern is improvement of modular housing by the use of vertical multi-story units ("Modular Towers") instead of the usual horizontal single story units. Two house designs exemplify this building concept.

The study continues with evolution of the Modular Tower idea, emphasizing convenient home alterability and construction and alteration cost savings through owner involvement in design and building. The plan module is increased from 10 ft. square to 12 ft. square as trailer transport is briefly explored.

The study concludes with sketches of examples of use of various components of one of two small house models using a re-designed lumber and plywood rigid-framed structure with diagonal floor framing.

In essence, the system offers the unskilled home buyer the cost savings and enjoyment of participation in the construction and subsequent alteration of a home using a combination of prefabricated and "do-it-yourself" building pieces and a home construction manual explaining standard building techniques and including plans for home construction and specific home modifications. Construction can then be continued (by the owner) using additional completely prefabricated Modular Towers, pre-framed Towers (without walls) and regular building materials, kits of prefabricated Tower building components and materials, or the owner's own choice of materials and design.

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CONTENTS

1 INTRODUCTION 2

2 MODULAR TOWERS 4
   Figures 1 through 4

3 COST AND ALTERABILITY 10
   Figures 5 through 12

4 REFINEMENTS 21
   Figures 13 through 23

5 REVISED STRUCTURAL SYSTEM 34
   Figures 24 through 31

6 CONCLUSIONS 43

BIBLIOGRAPHY 44
1. INTRODUCTION

Cost savings and personal satisfaction are the potential rewards of owner participation in construction and alteration of residential housing. These benefits are generally accessible only to the skilled few. This work is the record of a design study directed toward development of a building system that makes these benefits more accessible to the less skilled.

The study resulted in an attempt to fill the gap between the professionally built home and the completely owner-built home, through a system designed to give the home buyer the opportunity to acquire and subsequently to alter a home in the form of a mix of manufacturer-fabricated and owner-fabricated building pieces. The owner would determine the mix on the basis of his or her skills, finances, potential assistance, etc. It would include a completely prefabricated kitchen, bath, stairway, and mechanical core, in one or two modular units, and either additional completely prefabricated modular units, preframed modular units and building materials, kits of modular unit structural components and building materials, materials and architectural design by the owner, or any combination of the above.

Design criteria were as follows:

1. Factory prefabrication provides the means of production of those building pieces which the homeowner does not produce.

Among its advantages over onsite construction are construction
environment weather control, more effective quality control, and the use of assembly-line processes and equipment.

2. Reliance on current standard methods of small building construction, meaning the use of readily available materials that can be manipulated in easily understandable ways, using simple, inexpensive tools, by the home-owner, to produce aesthetically as well as functionally acceptable results.

3. Size of prefabricated building pieces is limited by state highway regulations. Truck load width is generally limited to 12 ft., height to 13 ft. 6 inches, and length to 60 ft.

4. Minimum cost is essential and to be achieved in the following ways—by provision for replacement of some professional labor with owner labor, through appropriate design, by small size, compactness, and design for convenient future alterability, and use of relatively inexpensive building materials.

5. The house designs must be architecturally acceptable to the potential buyer, relying on traditional general appearance but with visual and spatial variety.

Evolution of the problem statement occurred concurrently with the generation of solutions, these two processes together comprising the design procedure employed herein.
This study began as an attempt to develop a better modular housing system than had previously been encountered in the field. Potentially, modular housing has all of the advantages generally associated with industrialization. And it generally uses standard construction materials and techniques, minimizing the manufacturer's capital investment in equipment and dependency on specially skilled workers. Thus, the housing product is potentially highly alterable by the owner.

In practice, modular housing construction has several deficiencies in comparison with onsite construction. Modular units are generally greatly over-built to avoid damage from weather and physical loading prior to jobsite erection. They require extensive onsite labor to complete stairways, mechanical systems, and inter-modular roof, wall, and floor joints. Truck load size limitations and the necessity for standardization of modular units inhibit effective architectural design.

The design of vertical multi-story modular units, rather than horizontal single-story ones, tends to diminish these problems. The Phase II Houses '1' and '2' (figures 1 through 4) are examples of experiment with this idea. Their 10 ft. square Modular Towers would be constructed standing up, then tilted onto a standard 3 ft. bed-height trailer, trucked to the jobsite,
and re-erected using a crane. Roof sections, plumbing systems, and stairways would be factory-completed. Over-building is minimized and the houses are visually and spatially varied. House '1', however, is inefficient in shape, has cramped vertical circulation, and consists of too many modular units to be cost-competitive with the same house built onsite. House '2' has the economies of small size and few building pieces, but shares with House '1' a cramped stairway and uses a non-standard shaped stair module. Because of the module plan size, the bedrooms in both houses fail to comply with F.H.A. standards.

To make the Modular Towers concept more responsive to potential buyers, the ideas of limited custom design for each buyer by the manufacturer's architectural staff, and of offering unfinished units at reduced cost were considered and rejected as impractical. Furthermore, aside from being constructed of workable materials, the Phase II Houses are devoid of provision for future alteration.

This critique formed the basis for continued design investigation.
3 COST AND ALTERABILITY

Like the Phase II Houses, House 'A', (figures 5 and 6) was designed as a prototype, but with a more efficient shape, the modular plan dimension increased to 10 ft. 6 inches and a more convenient stairway. It incorporates "split" floor levels, a spatial attribute inherent in the use of vertical modular units. A cellar, while likely to provide relatively inexpensive enclosed space, was considered to be optional in order to minimize foundation cost. Similarly, it was considered unnecessary to make garages integral to the building system.

House 'B' (figures 7 through 11) followed as a small basic house which an owner might eventually modify and expand to a form similar to House 'A' (figure 9). Attention was given to structural details (figure 8), such as a standard corner post to be used in all towers together with various standard size wall panels. A vertical mechanical chase was incorporated to simplify installation of plumbing and ventilation systems, to provide future access to these systems, and to serve as a route for mechanical systems additions. Electrical wiring and the piping required for hydronic baseboard heating (an alternative to the usual electric baseboard heating) presented a routing and accessibility problem.

Standard light wood framing was used in all floor, wall, and roof panels, to facilitate ease of construction and to permit
subsequent alteration of these surfaces using inexpensive tools and materials. Each tower has a standard shingle roof and interior surfaces finished with gypsum wallboard (walls and ceilings) or plywood (floors) and with wood trim (figure 8).

To facilitate the adaptability that seemed increasingly important, it was decided that the perimeter walls of each tower, with possible exceptions such as stair support panels, should be non-structural and demountable (figures 10 and 12). The Modular Tower would be constructed as a rigid frame structure, not requiring shearwalls or bracing. Since most of the walls in a given small house would also be tower perimeter walls, their demountability would aid convenient alteration, especially since home alteration is likely to take the form of perimeter expansion.

Horizontal baseboard and ceiling raceways built into the walls, in conjunction with the interior spaces in angle-section wood corner posts, provide accessible electrical cable and small-diameter water pipe routes throughout the outer surface of each tower.

House 'B' and its construction system had several areas of needed improvement. The module plan required further enlargement, ideally to 12 ft. square, if shipping methods would permit. Addition of space partially or completely prefabricated
in quantities less than the 220 sq. ft. of a two-story 10 ft. 6 inch tower would be essential to increase the flexibility of the system. Further study was required on foundation and weatherproofing details and development of at least one additional house model, preferably with a more efficient stairway layout.
HOUSE 'B' PLANS

10'6" MOD.

Figure 7
House 'B' was expanded to an 11 ft. 10 inch (framing dimension) module to create House 'C' (figure 13). The plan layout was revised to improve the possibilities for future expansion. Transportation of Towers of such plan dimensions and a few standard heights could be accomplished with a low bed (1 ft. 6 inch) trailer by positioning the trailer wheels relative to the frame and load so that they would project onto the Tower through the opening created by the absence (or removal for shipping) of a wall panel (figure 14).

The bolt-on cantilevered bay (figures 15 and 16) was developed as a method of adding 70 sq. ft. (or less) to the perimeter of the building. The bay would simply replace a demountable exterior wall panel.

House 'D' (figure 17) was intended as a study sketch showing possible uses of the bolt-on bay. Its principle impracticality is incorporation of the plumbing in the bays rather than in a tower, where it could be completely prefabricated and frost-protected in the factory. However, it was the prototype for House 'E' (figures 18 and 20), a smaller and therefore less expensive house with a more efficient stairway than that of House 'C'. House 'E' Modified (figure 19) is an example of and expanded House 'E'.
Exterior exposure of the house structure (figures 21 and 22) presented a serious weatherproofing and a kit-form building access problem.

To insure adequate foundation crawl space, it was decided to raise each tower 16 inches on integral corner posts.

It seemed crucial that, to reduce construction costs and depending on a home buyer's skills, finances, and fear of the social degradation and/or responsibility of building a home, the buyer might choose a home, if available, in one of a variety of stages of partial completion (figure 23). The housing system, then, must provide not only for alterability, but for availability in a variety of forms in which most of the more difficult work has been done, but varying degrees of construction work and design are left to the owner. For example, a buyer might purchase a completely finished kitchen-bath Tower, and live in it temporarily while completing a surrounding structure of working/living/sleeping spaces built from used bridge timbers and surplus Army tents.

An integral part of the system would be a handbook of basic building techniques and plans for Tower erection and specific home modifications, some of which would employ prefabricated building components, such as the bolt-on bay side brackets.
TRAILER LAYOUT
HOUSE 'E' PLANS
1/4
11'-10" MOD.
1200 S.F.

NOTE: NON-DEMOUNTABLE WALLS SHOWN SHADED.

MODULAR TOWERS
EXAMPLE: A TYPE 'E' BASIC HOUSE UNDER INITIAL CONSTRUCTION

FACTORY-BUILT TOWER WITH STAIRS & FINISHED BATH & KITCHEN

FACTORY-BUILT WALL PANELS

NEW &/or USED BUILDING MATERIALS

FACTORY-FRAMED TOWER WITH FINISHED ROOF

OWNER-BUILDERS &/or HIRE WORKERS

PREFABRICATED BOLT-ON BAY COMPONENTS

FACTORY-FABRICATED COMPONENTS

INSTRUCTION HANDBOOK
5 REVISÉD STRUCTURAL SYSTEM

The final eight drawings (figures 24 through 31) supersede the previous drawings and are denoted with a black square in the upper right corner. They depict adaptation of the Modular Tower and the two previous house model plans (Houses 'C' and 'E') to a revised structural system which is exposed to the building interior. The principle advantage of this system is more efficient weather-protection of the structural elements and building interior. In addition, material is used more efficiently than in the earlier schemes and the interiors, due to the exposure of structural elements and the dictates of diagonal framing, are visually and spatially enlivened.
HOUSE 'E2'
PLANS 3/4
11'10" MOD 1
1200 SF
MODULAR TOWERS
HOUSE 'E2' MODIFIED PLANS

1/4

1860 SF (INC. FLS) MODULAR TOWERS
BOLT-ON BAY SIDE BRACKET DETAILS

TYPICAL 3 FLR TOWER WITH 2 BOLT-ON BAYS

BOLT-ON BAYS

MODULAR TOWERS
Erection of San-Prefab, 152' — Prefab Core Towers & 2 Preframed Towers, or 2 Kit Towers.
OWNER-BUILT HOUSE
EMPLOYING
"IZZIE"
CORE TOWER
6 CONCLUSIONS

The last three drawings (figures 29 through 31) demonstrate four ways in which some or all of the prefabricated pieces of the basic House 'E2' might be used in the initial construction of a home. House 'E2' is comparable in size and facilities to a typical "sectional" (modular) or small site-built "tract" house. It has the cost and quality advantages of factory prefabrication and the much greater cost and design flexibility advantages of availability to the buyer as various partially or completely prefabricated building parts. It is more readily altered by relatively unspecialized methods, because of its initial configuration, construction system, and by being part of a building system that offers various additional prefabricated building pieces. The marketability of its straightforward, slightly rustic exterior and lively, structurally expressive interior is, of course, beyond the concern of this work.

This study might be pursued in the following three areas—construction and study of a test house using this system, continuation of design studies in this area of owner-buildable and -alterable housing, and development of complementary owner participation mechanical systems.
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