A HOUSING SYSTEM:
CAPABLE OF ADAPTING TO VARYING TOPOLOGICAL CONDITIONS

By:

PAUL DEAN HOAG

Bachelor of Architecture
University of Oklahoma (1971)

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Author

Department of Architecture

Certified by

Thesis Advisor

Accepted by

Chairman Departmental Committee
On Graduate Students

Archives

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Dean William Porter
School of Architecture and Planning
Massachusetts Institute of Technology

Dear Dean Porter:

In partial fulfillment of the requirements for the degree of Master of Architecture, Advanced Studies, I hereby submit this thesis entitled:

A HOUSING SYSTEM:
CAPABLE OF ADAPTING TO VARYING TOPOLOGICAL CONDITIONS

Respectfully,

Paul Dean Hoag
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This thesis is dedicated to Linda and Chat.
ABSTRACT

A HOUSING SYSTEM: CAPABLE OF ADAPTING TO VARYING TOPOLOGICAL CONDITIONS

By: Paul Dean Hoag

Submitted to the Department of Architecture on May 11, 1973, in partial fulfillment of the requirements for the degree of Master of Architecture, Advanced Studies.

This thesis is intended to develop an industrialized system for housing produced in the factory, using both concrete and steel as structural materials, with the capability of being erected on a site with varying topological conditions.

The written section of this thesis provides a brief description of the system developed and establishes areas of concern, long range potentials, and constraints within which the design proposal is made.

The design proposal demonstrates how modular coordination of basic living elements with given interior components can generate many combinations of modules ready for shipment and erection. Using the sample modules and varying the module length, the proposal illustrates the many variations possible and demonstrates new site planning concepts generated by these units.
INTRODUCTION

An expanding and shifting population within the United States has its impact focused on the urban areas of the country. These urban centers already contain over 50% of the total population and are increasingly faced with growth constraining factors of excessive land costs as competition for the diminishing available land becomes a more determinant factor.

Much of the steep slope land in these urban areas is within easy access of the urban cores of the various cities. As a result, the available sloped land could become highly desirable from a development standpoint.

Because of the close relationship of the sloped land areas to the urban cores, and man's need to be near his work, it becomes apparent that the sloped land might be utilized for housing. This could be a potentially desirable solution for the urban areas already faced with serious housing shortages.

At the same time, the basic structure of the typical house in the United States remains unchanged past mid-century despite early attempts in the use of mass production as far back as the early 1900's. This has resulted in the continually spiralling labor and material costs of traditional on-site construction.

The publicity of Moshe Safdie's Habitat at Expo 67, the Operation Breakthrough project sponsored by the Department of Housing and Urban Development, and the success of the mobile home have encouraged architects, engineers, and manufacturers to seriously study the potential of dwelling modules. These modules are suitable for factory production,
and are capable of being transported over our present highway system. Once the modules have reached the site, they are positioned by cranes and organized in various configurations. This approach is a faster and cheaper method of constructing housing than the conventional on-site method, and will become increasingly more economical as traditional construction labor costs rise. Another important aspect of industrialized housing is the ability to maintain a higher standard of quality control not presently being achieved in conventional construction.

The attempt of this thesis is to develop an industrialized system for housing with the capability of adapting to the urban areas where high slope ratio of the surrounding terrain prevents expansion under present conventional construction methods. This system utilizes the present factory technology to produce a finished concrete or steel modular unit which can be transported to the site, and stacked in an overlapping configuration to reflect the topography of the site or in a vertical, more conventional high-rise configuration.
AREAS OF CONCERN AND RESTR AI NT

UNIT TYPE

Individually shipped manufactured units that incorporate minimum volumes of shipped air and maximum use of existing technology.

UNIT SIZE

a. 14' - 0" maximum shipping width.

b. 70' - 0" maximum shipping length.

c. 13' - 6" maximum shipping height.

BUILDING CONDITIONS

a. For high, medium, and low-rise density.

b. Middle-upper middle income groups.

c. Provide apartment units with 1-4 bedrooms.

d. Structural materials to be concrete or steel produced and assembled in a factory.
DESCRIPTION OF THE SYSTEM

The system developed is made of either concrete or steel floor, wall, and ceiling panels that are welded together to form modular units for housing. The units are completely finished except for the final utility connection at the site and minimum interior finishing where more than one module make up a single dwelling unit. These modules can be arranged to form different apartment types and sizes. Emphasis is placed on direct resolution of structural and mechanical needs, while minimizing the restraints these functions have on planning.

The objective of the terraced configuration is to provide the capability of conforming to different topological conditions. Slopes of the sites for the terraced situation can vary from approximately 15 to 32 degrees and maintain comfortable exterior pedestrian circulation up and down the slope. For slopes greater than 32 degrees, pedestrian circulation will be limited to stairs with intermediate landings between apartment levels or through the use of inclined elevators.

To incorporate the system in a more conventional high-rise configuration, it is necessary to provide full-storey trusses at every fifth level thereby carrying four levels of modular units. These levels at the trusses could then be left open or infill construction provided to maintain a pedestrian street. The infill construction might then become more apartment units or commercial and public space. A typical core of elevators and firestairs would be constructed at the
bottom of the slope and wherever necessary to provide ingress and egress to the high-rise configuration. The high-rise building then in turn could serve as a supportive structure in terms of services and circulation for the terraced configuration.

Structural System
The basic structural element is the modular box of either lightweight reinforced concrete panels or steel truss walls. The concrete unit has vertical ribs cast in at intervals of 3' - 6", while the steel unit has a system of alternating vertical trusses and steel columns. In either case, the walls act as beams and are load bearing with welded connections. The ribs or columns allow for horizontal displacement of the modules at 3' - 6" intervals, thus determining the different slopes of the terraced configuration, while lessening the weight of the modules in either configuration.

Mechanical System
Heating, ventilation, and air conditioning are provided by either fan coil, or hot water radiation units with air conditioning being an option. Final utility connections are made after the modules are placed at the site. Kitchen and bathroom exhausts are ducted through the utility chase to points pre-determined in the total plan.
Concrete floor, wall, & ceiling panel connections made

Facade units installed and sealed

Interior partitions, cabinetwork, & toilet fixtures installed

Plumbing and electrical connections made

All interior finishes applied

Openings covered and sealed for exposure

Concrete Module

Facade, Finish, and Weather Protection
Steel floor, truss-wall, & ceiling panel connections made

Facade units installed and sealed

Interior partitions, cabinetwork, & toilet fixtures installed

Plumbing and electrical connections made

All interior finishes applied

Module wrapped for exposure protection

Steel Module

Facade, Finish, and Weather Protection
ALTERNATE STRUCTURAL STEEL COMPONENTS

Floor Panel

Wall Panel

Ceiling Panel
Stamped steel floor, wall, & ceiling panel connections made

Facade units installed and sealed

Interior partitions, cabinetwork, & toilet fixtures installed

Plumbing and electrical connections made

All interior finishes applied

Module wrapped for exposure protection

Alternate Steel Module

Facade, Finish, and Weather Protection
Doors

Walls

Appliances

Closets

Fixtures

Cabinets/Worktops

INTERIOR COMPONENTS
CONCRETE WET MODULE
STEEL WET OR DRY MODULES
ALTERNATE STEEL WET OR DRY MODULES
Unit bKL
Steel
Unit bcKL/2
Concrete
Unit KkB
Concrete
Unit bsbB/1
Concrete
Unit bsbB/2
Concrete
Unit bsbB/2
Steel
Combinations of two modules

Combinations of three modules

MODULE PLAN RELATIONSHIPS
Plan Displacement
Unit bKL

Type A1-Efficiency

Unit bcKL/1

Type A2-Efficiency

Unit bcKL/9

Type A3-Efficiency

APARTMENT PLANS
Unit KbB

Type Cl-2 br unit
Type D3-3 br unit

Lower Level

Type D3-3 br unit

Upper Level
SLOPE ALTERNATIVES

32° Slope

27° Slope

24° Slope

SLOPE ALTERNATIVES
21° Slope

18° Slope

15° Slope
32° Slope

30° Slope
0° Slope
Vertically stacked units

Random Slope
Vertically stacked units
Terraced Configuration

GENERAL SECTIONS AND ELEVATIONS
5" REINFORCED CONCRETE AT RIBS AND ENDS OF MODULAR UNIT

1" TOLERANCE BETWEEN UNITS

6" CONCRETE FLOOR SLAB WITH STEEL PLATES AT CONNECTIONS

STEEL PLATE

5" CONCRETE CEILING SLAB WITH STEEL PLATES AT CONNECTIONS

WELDED CONNECTION

SECTION AT JUNCTION OF FOUR MODULAR UNITS

2 1/2" WALL BETWEEN RIBS

RIGID INSULATION

REINFORCED CONCRETE RIBS AT 3'-6" O.C.

PLAN OF WALL AT RIBS OF TWO UNITS

CONSTRUCTION DETAILS
WALL BEYOND

FLOOR FINISH (CARPET)

GROUT TO LEVEL

FLOOR SLAB AT EDGE BEAM

NEOPRENE PAD

COMPRESSIBLE GASKET AND SEALANT

BEAM AT OPENING

SECTION AT OPENING BETWEEN UNITS

RIGID INSULATION

COMPRESSIBLE GASKET AND PLASTIC INSERT

PLAN AT OPENING BETWEEN UNITS
GYPSUM WALL BOARD ON METAL STUDS AT TRUSS WALL

BATT INSULATION

1" TOLERANCE

DECKING ON STEEL FLOOR JOISTS

STEEL PLATE

GYPSUM WALL BOARD AT CEILING JOISTS

WELDED CONNECTION

SECTION AT JUNCTION OF FOUR MODULAR STEEL UNITS

BATT INSULATION

STEEL CHANNELS AT VERTICAL TRUSS

PLAN OF WALL AT COLUMNS OF TWO UNITS
WALL BEYOND

FLOOR FINISH (CARPET)

DECKING ON STEEL FLOOR JOISTS

NEOPRENE PAD

GYPSUM WALL BOARD AT CEILING JOISTS

GYPSUM WALL BOARD ON METAL STUDS ABOVE OPENING

SECTION AT OPENING BETWEEN UNITS

BATT INSULATION

COMPRESSIBLE SEALANT AND PLASTIC INSERT

PLAN AT OPENING BETWEEN UNITS
BALCONY DECK ON PLASTIC TOPPING

STEEL FLOOR PANEL

COMPRESSIBLE GASKET AND SEALANT

STEEL CEILING PANEL

SECTION AT STEEL MODULE AND BALCONY

STEEL BALCONY END UNIT

BALCONY DECK

PLASTIC TOPPING

STEEL CEILING PANEL

SECTION AT BALCONY

BATT INSULATION

COMPRESSIBLE GASKET AND SEALANT

PLAN AT FACADE BETWEEN TWO MODULAR UNITS
REINFORCED CONCRETE PANEL
(OR STEEL TRUSS WALL) OF MODULAR UNIT

1" TOLERANCE

INTERIOR WALL PANEL
AT BATHROOM

CLOSET FITTING

REINFORCED CONCRETE FLOOR PANEL
(OR STEEL FLOOR PANEL)

MODULAR UNIT BEYOND

SECTION AT UTILITY CHASE
WITH INDIVIDUAL PLUMBING
WALL BEYOND

INTERIOR WALL PANEL
AT BATHROOM

CLOSET FITTING

DOUBLE THREADED
PIPE CONNECTION

STEEL ANGLE CONTINUOUS
AT UTILITY CHASE

MODULAR UNIT BEYOND

SECTION AT UTILITY CHASE WITH COMMON PLUMBING
1/2" INSULATING GLASS IN ALUMINUM FRAME

HOT WATER FIN TUBE RADIATION UNIT WITH METAL GRILL AND WOOD CHAIR RAIL

STORAGE CABINET

OPTIONAL AIR CONDITIONING

REINFORCED CONCRETE FLOOR SLAB (OR STEEL FLOOR PANEL)

REINFORCED CONCRETE CEILING SLAB (OR STEEL CEILING PANEL)

SECTION AT FACADE WITH RADIATION SYSTEM
1/2" INSULATING GLASS IN ALUMINUM FRAME

THREE PIPE FAN COIL UNIT

RIGID INSULATION

PRECAST CONCRETE ENCLOSURE SECURED TO WALL PANELS

REINFORCED CONCRETE FLOOR SLAB (OR STEEL FLOOR PANEL)

REINFORCED CONCRETE CEILING SLAB (OR STEEL CEILING PANEL)

SECTION AT FACADE WITH FAN COIL UNIT
CONSTRUCTION SEQUENCE
CRANE POSITION
FOR TERRACED CONFIGURATION
1 Parking
2 Elevators and Firestairs
3 Pedestrian Street to Slope
4 Pedestrian Circulation on Slope

PEDESTRIAN CIRCULATION
PEDESTRIAN CIRCULATION AT MAXIMUM SLOPE
COMPOSITE SITE PLAN
MODEL PHOTOGRAPHS
BIBLIOGRAPHY


