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OPERATION BREAKTHROUGH

U.S. Department of Housing and Urban Development

A DOCUMENTARY OF TRANSPORTATION AND HANDLING SYSTEMS

VOLUME

3

preface

The Department of Housing and Urban Development initiated Operation BREAK-THROUGH in May 1969 to demonstrate techniques of quality housing for all income groups to help meet a critical housing shortage across the country. With this aim in mind, the Department selected 21 housing systems producers (HSPs) to design and build housing models on nine specially selected sites in the country.

The purpose of this document is to provide a general record of the transportation, handling, storage and erection systems employed by each of the BREAKTHROUGH producers during Phase II and to describe certain methods that appear to offer opportunities in reducing overall logistics and construction costs while fully protecting the finished module, panel or component from damage.

In addition, those specific, accepted improvements — in terms of highway and rail transportation standards, procedures or equipment — that resulted directly from the BREAK-THROUGH experience, have been defined.

The Department appreciates the valuable assistance rendered by other federal agencies, state transportation organizations, the American Association of State Highway Officials and the railroad and highway transport industries.

Michael H. Moskow
Assistant Secretary for Policy
Development and Research

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introduction

The Department of Housing and Urban Development first initiated Operation BREAK-THROUGH in May 1969, to support volume production of quality housing for all income groups to help meet critical housing shortages in the United States. With this aim in mind, the Department selected 21 housing system producers to design and build systems on nine specially selected sites across the country. BREAKTHROUGH was designed in three phases: I, the selection of program participants and the design of selected systems; II, the prototype site development of a variety of housing units; and III, the volume-production of housing units.

The following documentary of transportation and handling systems, used in Phase II of Operation BREAKTHROUGH, is aimed at the facets of the building industry, ranging from the designer and producer of manufactured buildings to the on-site conventional home builder. It identifies those concepts relating to the movement of factory-produced housing systems from the production line all the way to their final emplacement at the building site. These experiences, some of which were pioneering efforts, may prove of value to existing and future entrepreneurs in their attempts to satisfy the housing needs of America.

BREAKTHROUGH units ranged from single family detached dwellings through town-houses, low-, mid- and high-rise apartments. Their construction materials ran the gamut of wood, steel, concrete and polyester composites. The deliveries from plant to building site covered rural, suburban and urban environments. Distances ranged from local 12 mile trips to transcontinental 2700 mile hauls. The shipments traversed the highways and rail-roads of 30 states. Phase II activities, involving transportation, storage, handling and erection, occurred between June 1971 through August 1973. In Phase III (which began about mid-1972 and will continue through 1974), practically all of the 48 continental states will have experienced either enroute or destination deliveries of the factory-built units.

The importance of the "logistical" phase (occurring directly after inplant production) cannot be overemphasized. Every effort must be skillfully planned to assure that the finished building-product (module, panel or component) ultimately arrives at the final destination and is emplaced in virtually the same condition as it emerged from the production phase. Yet, usually, this logistics phase is often taken for granted by management. Further, it is largely during this period that the module, panel or component is not directly under the builder/developer's custody. Often costs, schedules, and product integrity are adversely impacted.

Economic competition in residential construction is extremely keen. Transportation and handling costs can often materially contribute to the success or failure of a manufactured building system. Further, the technical aspects must be sufficiently developed to assure routine, timely delivery without damage.

In BREAKTHROUGH, producers were required to prepare plans for transporting the units from factory to site. Handling and packaging techniques were experimented with in order to simplify and standardize loading/unloading and erection techniques. Packaging became a major concern as "all-seasons" building schedules were enforced, and long-distance shipments were—in some cases—required to meet these commitments. Temporary storage, at both the plant and building site locations, required careful attention in packaging of the units and was an essential part of the transportation plan.

Erection is the final logistical step, mainly involving vertical or horizontal transfer of the delivered unit onto its foundation or into the building stack. It is a complex task that requires extensive planning to maximize productivity and minimize damage.

From the last station on the assembly line through all the functions, culminating with the final erection process, there are many interrelated operations. The planning team (designers, production engineers, logistics managers) should take advantage of optimizing such operations.

The all-important transportation-rate issue is not the purpose of this document. There are other sources in BREAKTHROUGH which address this traffic-management aspect. Rather, this document addresses the physical transportation and handling processes.

In order to pass on this knowledge in a timely fashion, only the essentials of these systems have been discussed. No attempt has been made in this document to define each system in complete detail. Rather, those techniques which appear to be readily useable by a wide range of building manufacturers are presented.

The basic information contained in this publication was furnished directly from the BREAKTHROUGH participants and/or the files of the Department of Housing and Urban Development. Because of the innovative characteristic of Operation BREAKTHROUGH, certain changes in procedure and detail were commonplace. Some of the methods and techniques described herein may therefore have been subsequently altered or eliminated. Additionally, several systems have been omitted from this document either because transportation-related data was not available or because the system's characteristics closely paralled those of other housing systems described herein. The systems not covered in this document are: Christiana Western, Pemtom, Republic Steel, Rouse-Wates and Townland. Stirling Homex terminated its agreement with BREAKTHROUGH before any units were produced.

A comprehensive description of all BREAKTHROUGH Systems is presented in the document entitled "Phase I — Design and Development of Housing Systems" published by the U.S. Department of Housing and Urban Development and can be purchased from the Superintendent of Documents, U.S. Government Printing Office.

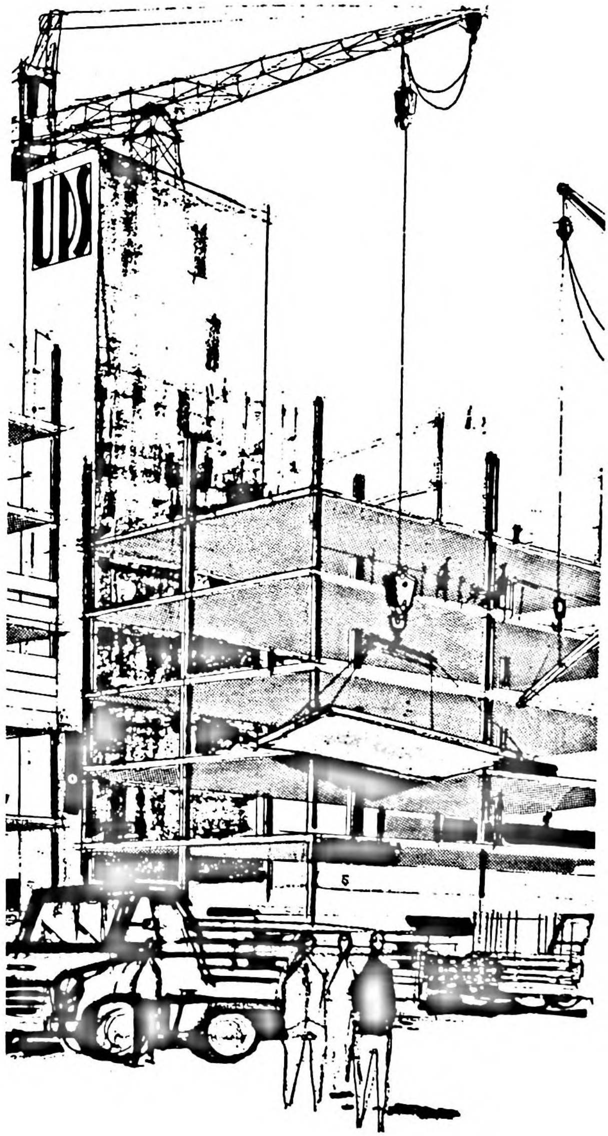
1.

DESCRIPTIONS of HOUSING SYSTEMS

GENERAL

Under the Operation BREAKTHROUGH program, housing systems producers were chosen from over 200 competitors to attain the best possible balance of technical, financial, managing and marketing capabilities. Some of the producers were giant corporations; others were relatively small firms. The selected producers utilized housing systems ranging from precast concrete, or wood-framed modules to units constructed largely of plastic or metal. Some systems were already in production when selected, while others were new and untested. At the nine prototype sites, a mixture of housing types demonstrated the interplay of different systems.

The following description of housing systems is presented to familiarize the reader with the wide variety of housing types, materials and methods employed by BREAKTHROUGH participants. In so doing, it is anticipated that the many phases of movement for factory-built housing—from the assembly line, through storage, transportation and erection—will be brought into clearer perspective.



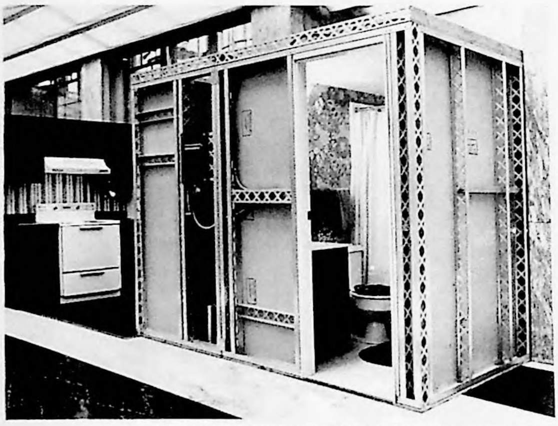
ALCOA CONSTRUCTION SYSTEMS, INC.
512 Allegheny Center
Pittsburgh, Pennsylvania 15212

Sites:

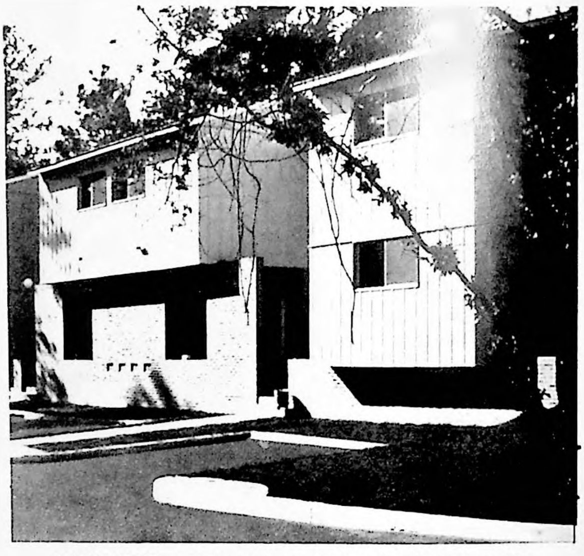
Sacramento, California
Macon, Georgia
King County, Washington

The Alcoa system utilized prepackaged central core service modules and a variety of site-erected components, including wall, roof, partition, and floor panels. The factory-produced service module included a kitchen, one or more bathrooms, laundry facilities and principal components of the plumbing, heating, ventilating, air conditioning and electrical services. Lengths ranged from 22 ft. to 30 ft. depending on the design requirements. A uniform 8 ft. width was maintained for economical handling and ease of shipping.

Exterior wall panels were fabricated from either aluminum or wood framing and sheathed with fiberboard or plywood. Shop-fabricated Alcoa Alumiframe interior partition panels were used. For the wood-framed walls, 2 in. x 3 in. or 2 in. x 4 in. studs were used as required. Floor panels consisted of wood or aluminum framing with plywood subflooring, except for slab-on-grade concrete first floors. Panels ranged in lengths from 4 ft. to 26 ft. Traditional roofing systems were used throughout.



BATHROOM/KITCHEN MODULE UTILIZING INCOMBUSTIBLE ALCOA ALUMIFRAME



COMPLETED ALCOA MULTIFAMILY LOW RISE UNITS

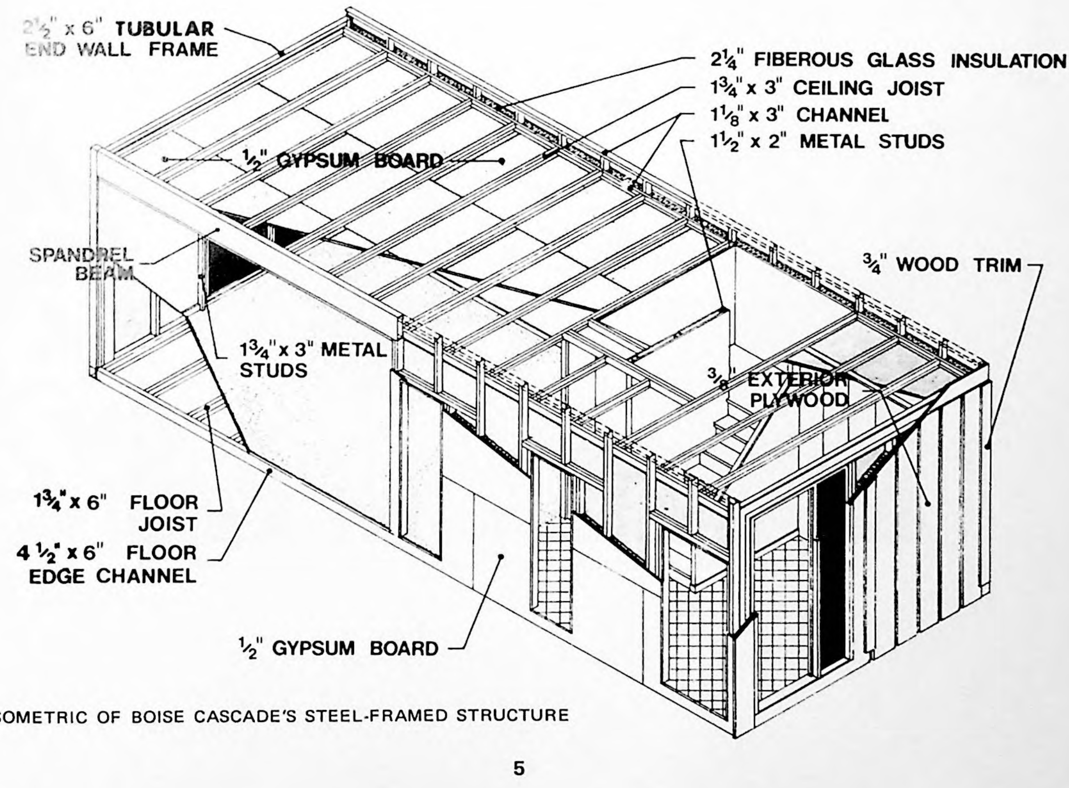
BOISE CASCADE HOUSING CORP.
61 Perimeter Park East
Atlanta, Georgia 30341

Sites:

- Sacramento, California
- Macon, Georgia
- Memphis, Tennessee

Boise-Cascade employed two different framing systems for their stack-on modular type units which were erected at three prototype sites. The Sacramento modules, built in Meridian, Idaho, were wood-framed structures. The modules for the Macon and Memphis sites, built in Arabi, Georgia, were steel-framed structures. In both the steel and wood systems, the roof, ceilings, wall and floor members were spaced 24 in. o.c. in lieu of the more conventional 16 in. o.c. Steel framing consisted of light-weight (18 ga.) sections welded together to form the desired configuration. Module end frames were formed of heavy gauge steel, 3/16 in. thick. Interior surfaces were painted gypsum while exterior walls were decorative plywood.

Sizes of the individual modules varied from 9 ft. to 11 ft. 8 in. in width, and from 20 ft. to 42 ft. in length, with a uniform height of 9 ft. Gross weight of the units varied from 6,500 lbs. to 18,000 lbs. These modular units when shipped from the factory were complete, with the exception of minor hook-ups and trimming out, thus very little additional on-site construction labor was necessary.



ISOMETRIC OF BOISE CASCADE'S STEEL-FRAMED STRUCTURE

BUILDING SYSTEMS INTERNATIONAL, INC. (BSI)
1414 Peachtree Center
230 Peachtree Street, N.W.
Atlanta, Georgia 30303

Site:
Macon, Georgia

BSI's basic structural system was composed of a series of precast concrete panels produced at a central plant, trucked to the site and assembled. Essentially, the system consisted of large load-bearing exterior and interior concrete panels which supported roof and floor panels to create an integral structure. The thickness of the panels varied according to the structural requirements. Exterior panels were made up of several layers of materials produced in horizontal casting machines, each layer having a specific function to perform; i.e., aesthetics, insulation, strength. The panels contained necessary electrical, plumbing and heating/ventilation components, so that only connection to adjoining units was required. Panels were 8 ft. high and ranged in length from 8 ft. to 30 ft. Most floor slabs were 12 ft. by 30 ft.

BSI PRECAST CONCRETE PANEL BEING PLACED AT THE BUILDING SITE

CAMCI, INC.
320 W. Fordham Road
Bronx, New York 10453

Site:
Jersey City, New Jersey

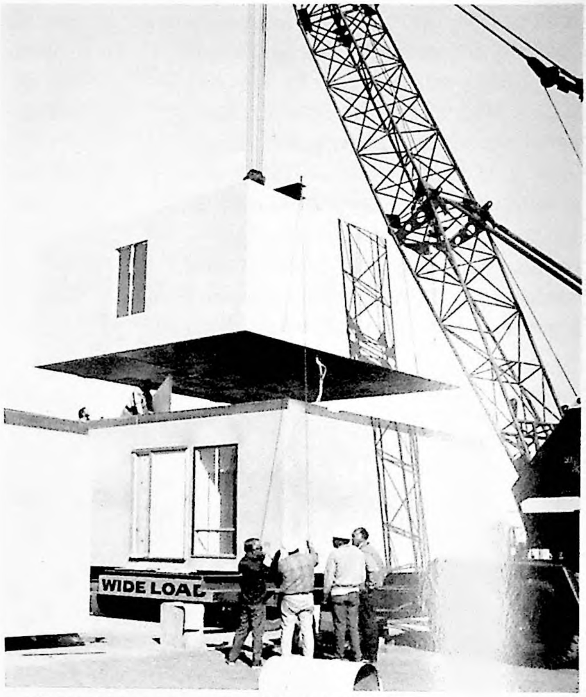
The CAMCI method of high-rise construction for multifamily occupancy was basically a precast concrete concept designed to eliminate costly on-site skilled labor through the utilization of panel production by semi-skilled plant labor and reusable forms. This housing system utilized factory line production for complete prefabrication of concrete panels. Mechanical connections were made to structurally tie all components together after crane placement of precast panels. The floor, roof panels and wall partitions, where required, had windows, doors and finish materials in place upon leaving the factory; however, the mechanical and electrical systems were job-site installed. Wall panels ranged in length from 22 ft. 11-1/4 in. to 25 ft. 6 in., and in width from 8 ft. 7/8 in. to 9 ft. 2-1/4 in. Typical floor slabs were 25 ft. 1 in. x 12 ft. 1 in. Panels and floor slabs were approximately 6 in. thick.

CAMCI'S MULTIFAMILY HIGHRISE UNIT AT JERSEY CITY

COMMUNITY TECHNOLOGY CORP. (TRW)
One Space Park
Redondo Beach, California 90278

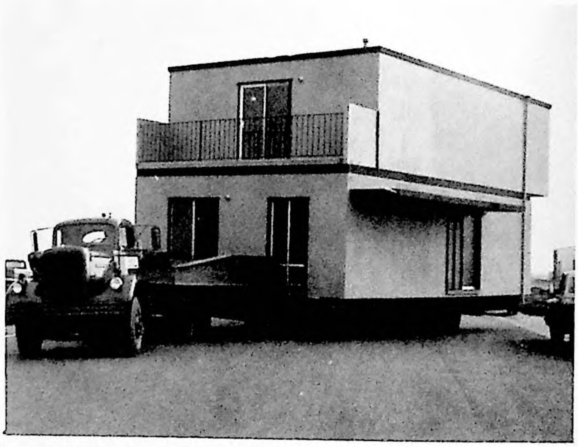
Site:
Sacramento, California

Community Technology Corp. (TRW subsidiary) introduced a new composite system in producing townhouse modular units and single-family detached panel units. The load-bearing walls, ceilings and floors of the TRW modular and panel units were manufactured from a paper honeycomb core with polyester resin and fiberglass structural membranes on both sides and faced with gypsum board for fire protection. Exterior wall surfaces were coated with a modified polyester resin base finish which closely resembled stucco. The finished system was appreciably lighter than conventional wood frame construction of comparable size.



UPPER MODULE OF THE TWO-STORY UNIT BEING SET IN PLACE PRIOR TO SHIPMENT TO THE BUILDING SITE

The design of the individual panels permitted the modular unit to be assembled at the main plant, or the panels may be shipped directly to the building site for final assembly. The modular townhouse units for the Sacramento site were assembled some twelve miles away and transported to the final location as completely finished two-story housing units. TRW was the only housing systems producer that shipped *completely assembled* houses from the factory. The modules were 21 ft. 4-1/2 in. wide, 9 ft. high and 24 ft. to 32 ft. long. Each unstacked module weighed approximately 23,000 lbs.


COMPLETELY ASSEMBLED TWO-STORY TOWNHOUSE IN TRANSIT

DESCON/CONCORDIA SYSTEMS, LTD.

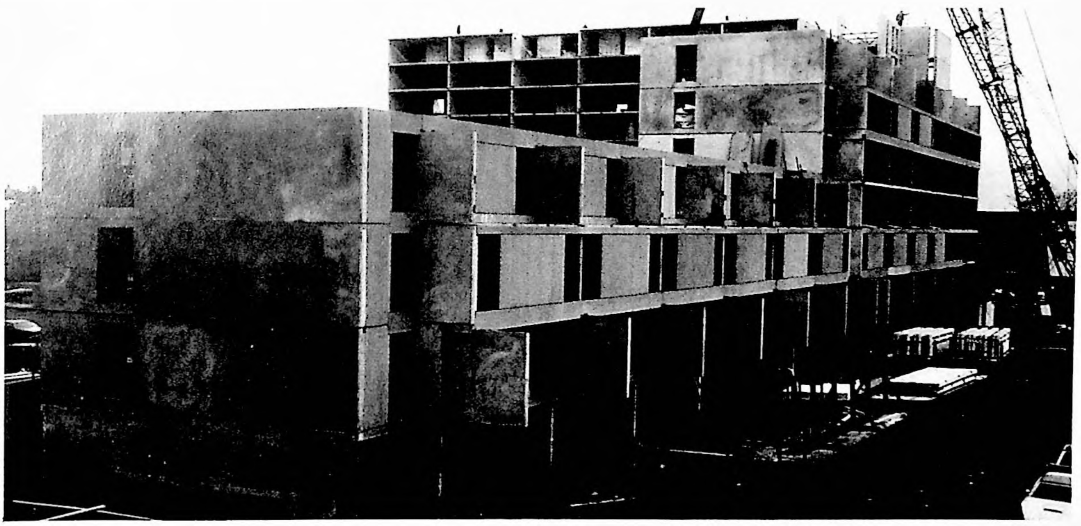
P.O. Box 239
Montreal 114, Quebec, Canada

Sites:

St. Louis, Missouri
Jersey City, New Jersey

The primary structural components utilized by Descon Concordia were precast concrete floors, walls and beams, fabricated in existing conventional concrete panel casting facilities. All-weather assembly of these components, using a mechanical joint system, was accomplished at the site. Supplementing these panels were non-load bearing exterior composite panels, complete with interior finish, window and doors to reduce on-site labor requirements. The utilities were distributed through this high rise structure via prefabricated service modules which included electrical wiring and plumbing assemblies. The floor slabs ranged from 3 ft. 8 in. to 10 ft. 8 in. in width and from 22 ft. 1 in. to 24 ft. 8 in. in length and 6-1/2 in. in thickness. The bearing wall panels ranged up to 40 ft. in length and 8 in. in thickness.

WALL-BRACING USED DURING ASSEMBLY OF DESCON'S UNITS



DESCON'S RESIDENTIAL APARTMENT BUILDING – 75% COMPLETED

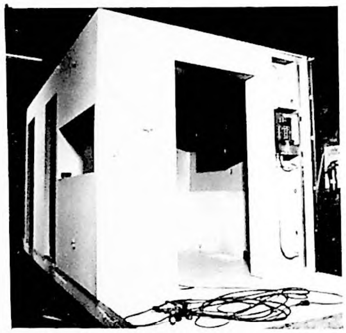
FCE-DILLON, INC.
1730 Akron-Peninsula Road
Akron, Ohio 44313

Sites:

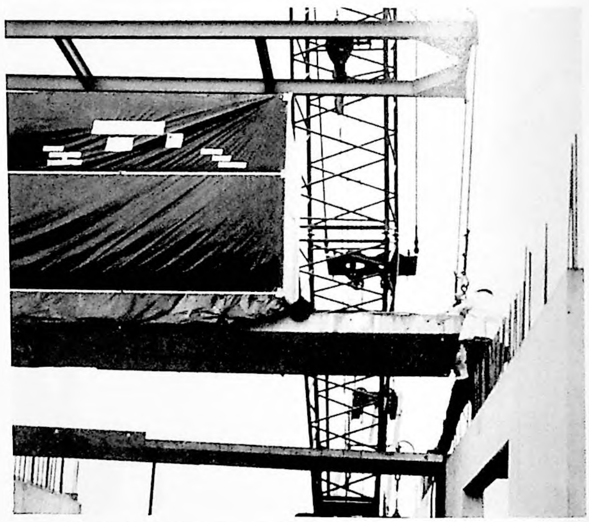
- Sacramento, California
- Indianapolis, Indiana
- Kalamazoo, Michigan
- Memphis, Tennessee

FCE-Dillon's system featured reinforced, precast concrete panels augmented with extensive on-site casting for required bearing walls, floors, and roof elements. To reduce the need for skilled labor at the prototype sites, steel framed mechanical core units, containing completely finished bath and kitchen areas, were factory fabricated and attached to a prestressed concrete floor slab prior to leaving the plant. The cores themselves contained the primary mechanical systems including electrical distribution, plumbing and heating components for each living unit. Interior partitions and facades were factory fabricated using metal studs and were erected on-site as panels after the primary concrete structural shell was in place.

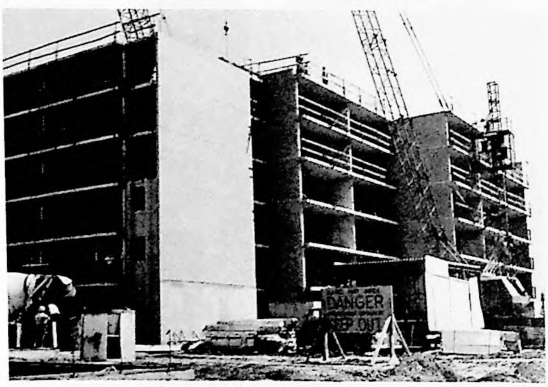
The elevator shaft was constructed of precast one-story-high concrete modules which were put in place with the construction of each floor of the building. The mechanical core module was built on an 8-ft. by 22-ft. by 8-in. prestressed concrete slab. This completed module weighed about five tons. The floor, or deck slabs, 4 or 6 in. thick, ranged in width from 5 ft. 7-1/4 in. to 8 ft., and up to 32 ft. in length. Wall panels, 8 in. thick, were 7 ft. 11-1/2 in. wide and ranged in length from 19 ft. to 32 ft. 11 in.



FCE-DILLON MECHANICAL CORE MODULE AT FACTORY



SLAB OF CORE UNIT BEING SET TO MATE WITH CONCRETE/BEARING-WALL



FCE-DILLON'S CORE AND PANEL SYSTEM UNDER CONSTRUCTION AT ONE OF THE PROTOTYPE SITES

GENERAL ELECTRIC CO. (GE)

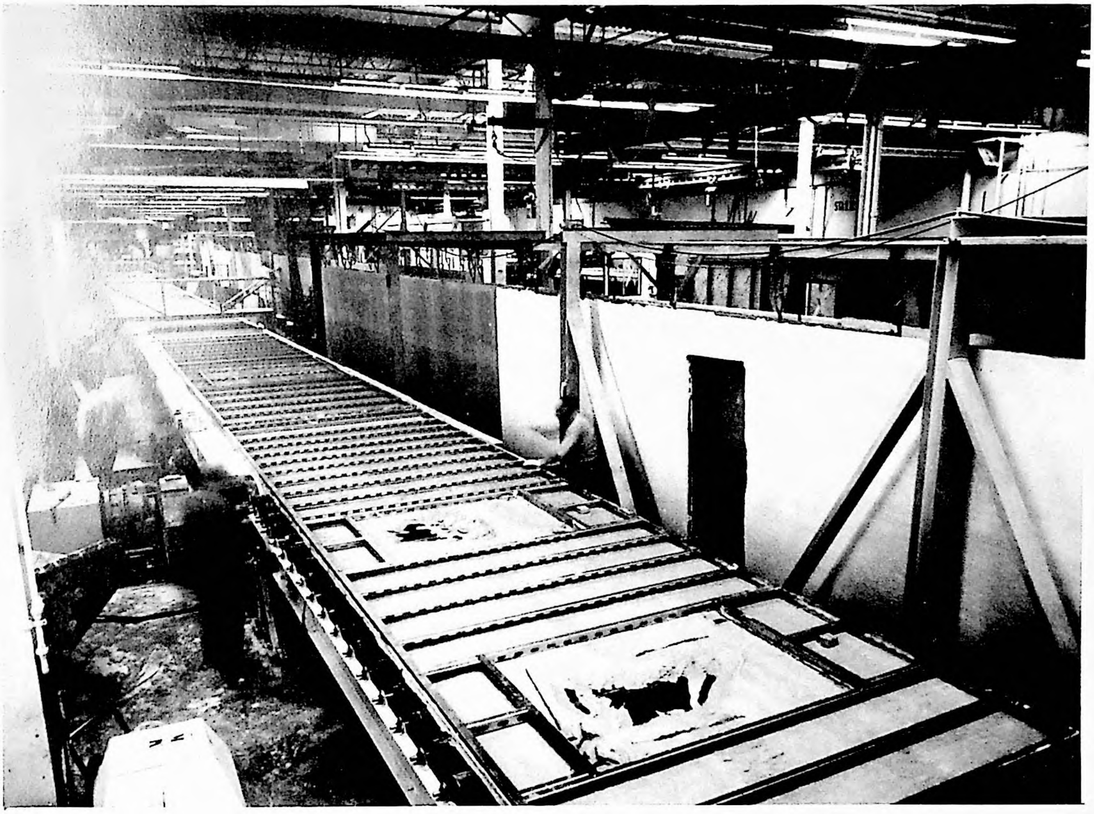
Building A: Room 20A-19
P.O. Box 8518
Philadelphia, Pennsylvania 19101

Sites:

Indianapolis, Indiana
Memphis, Tennessee

A unique feature of the GE modular system was the use of cast plaster in the fabrication of the wall system. Galvanized steel studs were embedded into a special uncured plaster which hardened around the framing within 30 minutes to produce a one-piece wall system.

The two-story modular construction, demonstrated at two sites, utilized wood frame construction for the floor, ceiling and flat roof elements in conjunction with the cast plaster walls. The cast plaster wall system was used for both bearing and non-bearing walls. The factory assembled modular units were 12 ft. wide, 10 ft. to 11 ft. high with lengths of 19 ft. and 30 ft. Weight of the modules ranged from 9,600 lbs. to 19,000 lbs. Decorative plywood panels were factory applied to the exterior of the units.



FABRICATION OF THE GENERAL ELECTRIC "CAST PLASTER" WALL

HERCOFORM MARKETING, INC.
(HERCULES)
910 Market Street
Wilmington, Delaware 29889

Sites:

Macon, Georgia
Kalamazoo, Michigan

The Hercules approach embodied use of conventional wood framing techniques to factory-fabricate modular units. The concept used was unusual in that individual modules were designed and manufactured to be joined together either in a conventional horizontal manner or vertically serving full two stories. The two-story sections were transported in a horizontal position, but once on the site, they were simply tilted up 90 degrees to their final vertical position and joined to other horizontally placed modules. The resultant townhouses and garden apartments were finished with various exterior siding materials. Size of individual modules was 12 ft. in width, up to 48 ft. in length and up to 10 ft. in height. Weight of the modules ranged from 13,000 lbs. to 19,500 lbs.

LOWERING "TILT UP" MODULE ON FOUNDATION—HERCULES

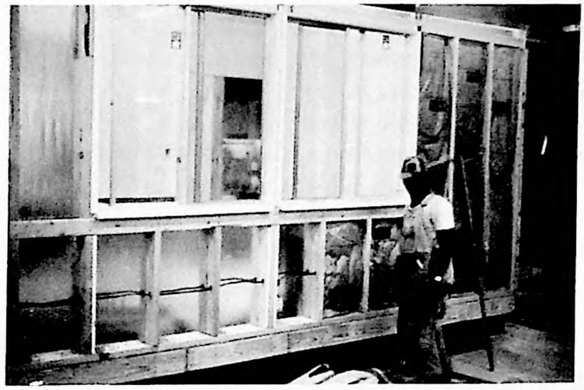
HOME BUILDING CORP.

P.O. Box 1213
Sedalia, Missouri 65302

Sites:

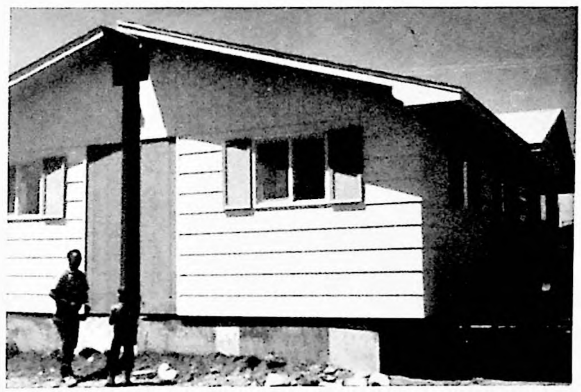
Indianapolis, Indiana
Memphis, Tennessee

Single-family attached and detached modular housing units were produced for two of the prototype sites. The units were typically of wood-frame construction, with extensive use of glue in combination with nails. Tongue-and-groove plywood stressed-skin panels, glued and nailed, were used for the floor system. Upon leaving the factory, each module was ready for site erection except for minor finishing details.



HBC'S WOOD-FRAMED MODULE ON ASSEMBLY LINE

For some units, supplemental prefinished floor and roof components were supplied in order to provide additional space in the living unit. Prefinished panel components were installed between individual modules at the site. This additional 3 ft. wide space was generally used for hallway and closet areas and provided flexibility in design in comparison to other typical 12 ft. wide modular systems. The modules measured 11 ft. high and ranged in length from 36 ft. 9 in. to 48 ft. 9 in. Weights ranged from 16,000 lbs. to 18,000 lbs.



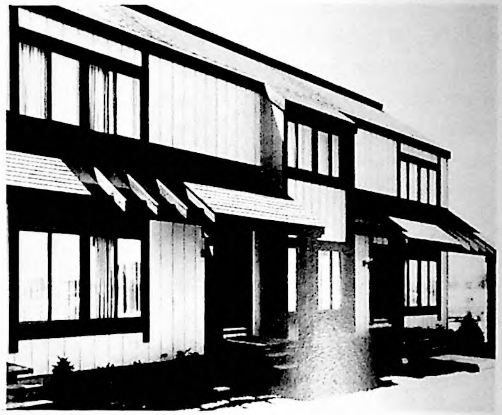
ASSEMBLED SINGLE FAMILY ATTACHED UNIT – NOTE SITE ASSEMBLED HALLWAY BETWEEN MODULES

COMPLETED TOWNHOUSE MODULAR UNITS

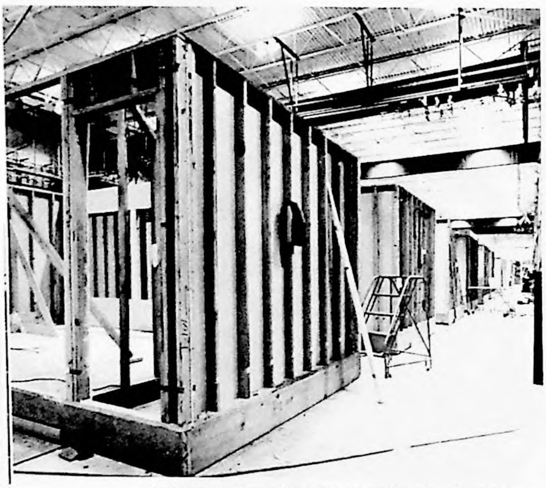
LEVITT TECHNOLOGY CORP.
P.O. Box 155
Battle Creek, Michigan 49016

Sites:
- Kalamazoo, Michigan
- King County, Washington

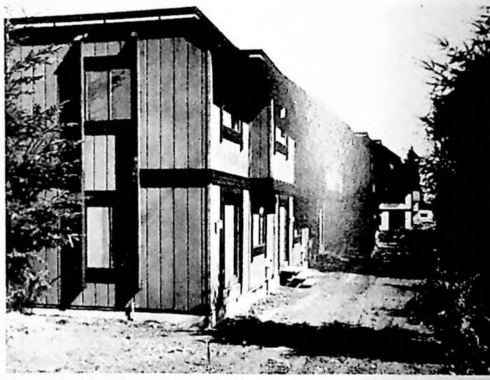
The structural system used by Levitt was typically wood-framed, with additional strength and rigidity achieved by using a 12 ft. wide plywood stressed-skin floor panel system. Garden-type apartments and townhouse units were located on the sites. In order to conform with maximum shipping width limitations, and yet achieve a non-boxlike final appearance, a system of hinged roof panels and slide-out three-dimensional window components was provided. Once the modules were on the site, the prefinished items were rotated or slipped into their final position to form sloped roofs, roof overhangs, balconies, and bay windows. Modules ranged in length from 28 ft. to 60 ft. and were 10 ft. 2 in. high. The largest module weight 27,000 lbs.



COMPLETED TOWNHOUSE UNITS WITH ROOF OVERHANGS



MODULE ON ASSEMBLY LINE AT LEVITT BATTLE CREEK PLANT



MULTI FAMILY LOW RISE UNITS AT KING COUNTY, WASHINGTON

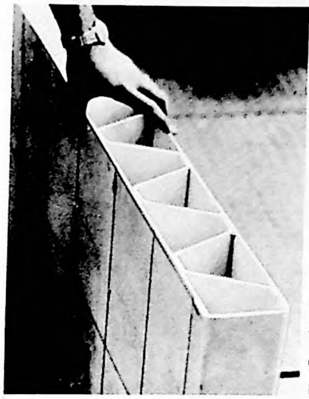
MATERIAL SYSTEMS CORP. (MSC)

751 Citracado Parkway
Escondido, California 92025

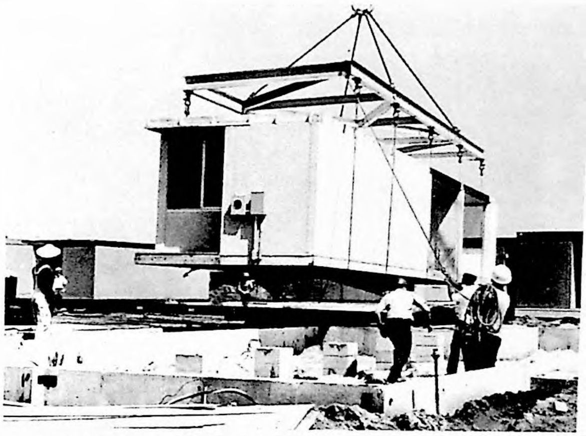
Sites:

- Sacramento, California
- Macon, Georgia
- Indianapolis, Indiana
- Kalamazoo, Michigan
- King County, Washington

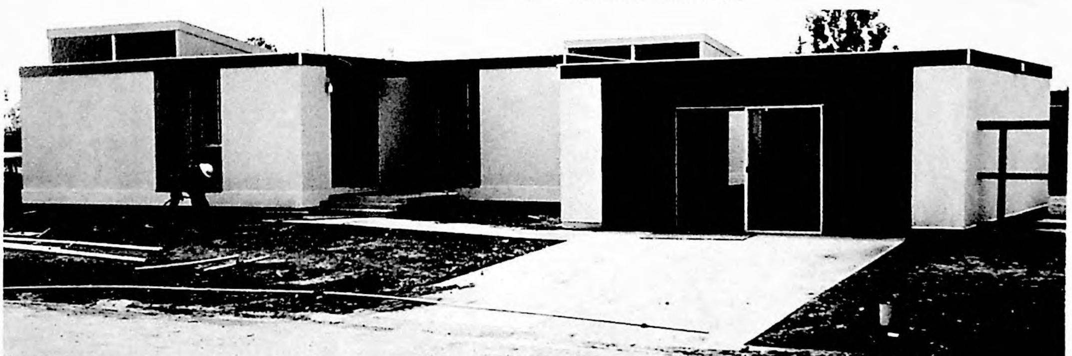
Through the use of fiberglass reinforced polyester composite, MSC developed one of the more innovative systems in the Operation BREAKTHROUGH program. The floor framing system consisted of a conventional wood joist and plywood subfloor. Other primary structural elements, such as exterior, interior walls and roof, were composed of molded polyester composite panels. These panels contained a corrugated-core covered by reinforced polyester sheets which provided the strength features of stress-skin construction. Once off the production line, the prefinished panels were connected together by gluing to form the completed modules in the factory. Both one- and two-story flat-roof living units were produced and transported to five of the prototype sites. All modules were 12 ft. wide, 10 ft. high and ranged in length from 30 ft. to 52 ft. Modules ranged in weight from 9,500 lbs. to 18,000 lbs.



TYPICAL WALL CONSTRUCTION SHOWING CORRUGATED CORE AND SURFACE ELEMENTS



FACTORY ASSEMBLED MODULE BEING LOWERED INTO POSITION AT THE SITE



SINGLE FAMILY DETACHED UNIT RECEIVING FINAL TOUCH UP AT THE SITE

NATIONAL HOMES CORP.

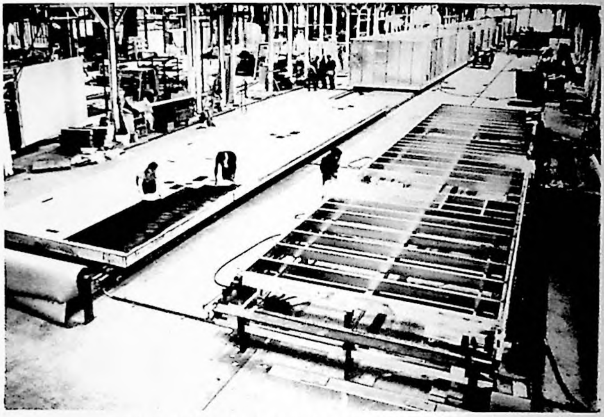
401 So. Earl Avenue
Lafayette, Indiana 47092

Sites:

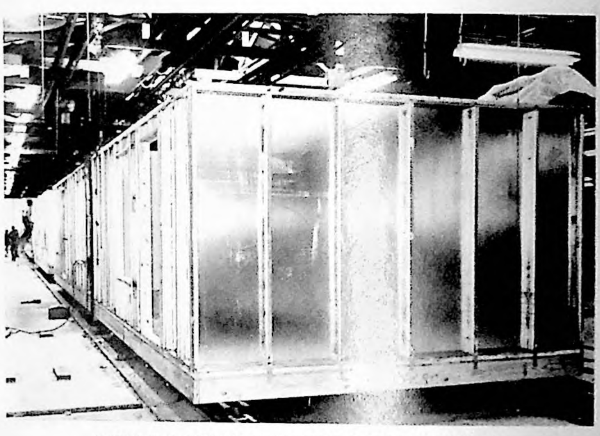
Indianapolis, Indiana
Kalamazoo, Michigan

These two-story stack-on modular housing units (townhouse type) were fabricated from a combination of steel and wood. The primary structural elements, such as floors, walls and roofs, utilized specially designed light-gauge galvanized steel shapes spaced 24 in. o.c., and welded, as required, to other steel framing members. Other structural elements, such as first-floor ceilings, were fabricated from wood and also spaced 24 in. o.c. Gypsum wall board was screwed to the interior side of the steel-wall studs, while exterior plywood finishes were applied with an adhesive/mechanical connection process.

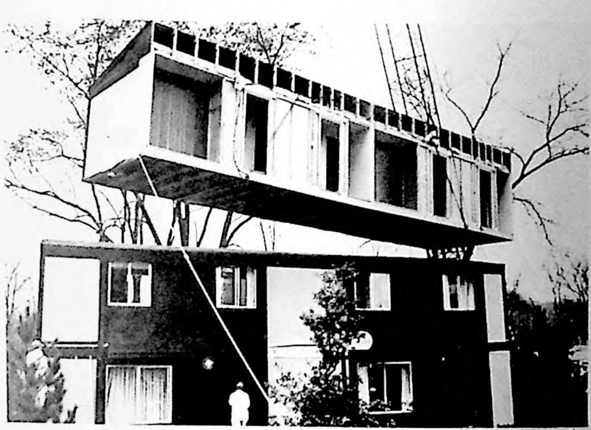
The units, on leaving the factory, were complete with the exception of minor hook-ups and finishing details which were completed at the site after the units were placed on previously prepared conventional foundations. Modules were 12 ft. wide, 10 ft. high and ranged in length from 36 ft. to 54 ft. Weight of the modules ranged from 11,000 lbs. to 18,000 lbs.



WALL PANEL ASSEMBLY OPERATION



MODULE ASSEMBLY USING METAL STUDS



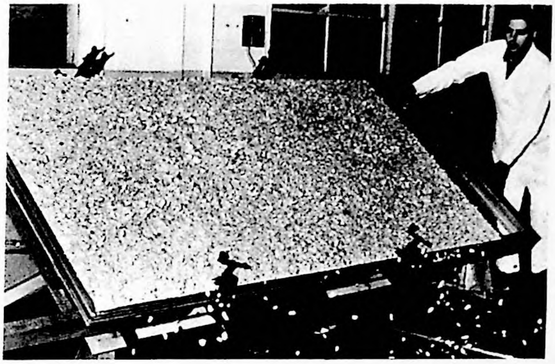
MODULE PLACEMENT AT THE SITE

PANTEK CORP.
P.O. Box 2117
Boulder, Colorado 80302

Sites:

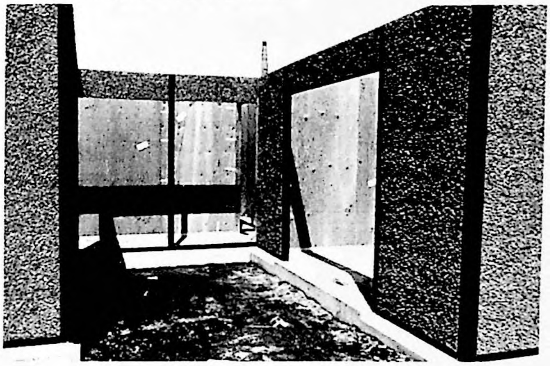
Sacramento, California
Indianapolis, Indiana

Pantek used a panel system in construction of two-story living units. This panel system utilized a composite wall of 3 in. of urethane foam as the core material sandwiched between an asbestos/aggregate-epoxy exterior surface and a plywood/gypsum board interior surface. The basic panel was bounded by aluminum extrusions which acted as edge constraints and formed the joint detail.

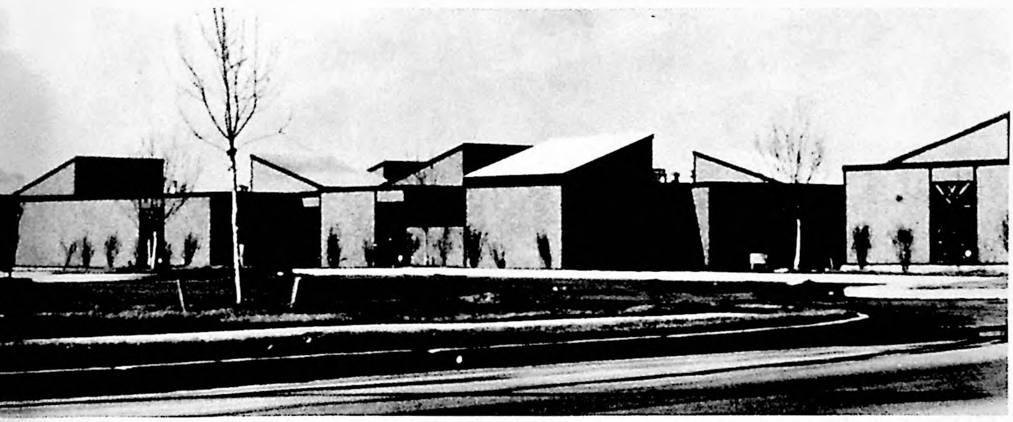


STRUCTURAL PANEL AFTER INCORPORATION OF STONE AGGREGATE

Plastic or aluminum splines were driven into the extrusions of adjacent factory-produced panels as an interlocking mechanism. Light-gauge steel joists or concrete were used for the floor systems. The roof/ceiling assembly was fabricated from 18-in. wide light-gauge steel pans. Gypsum board of varying thicknesses, depending on the fire resistance requirements, was field applied to the panels. The aggregate-covered exterior wall panels weighed approximately 220 lbs. each, while the interior wall panels weighed approximately 110 lbs. Both exterior and interior panels measured 4 ft. x 8 ft.



PANELS ASSEMBLED AT THE SITE



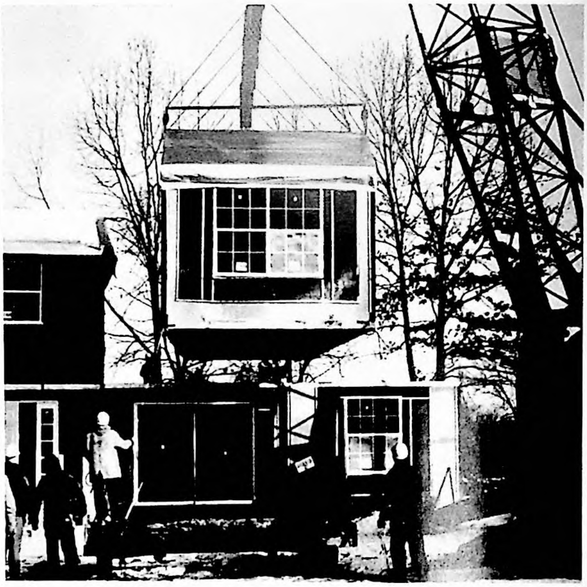
COMPLETED TWO-STORY PANELIZED LIVING UNITS

SCHOLZ HOMES, INC.
3497 East Livingston
Columbus, Ohio 43227

Sites:
- Indianapolis, Indiana
- Kalamazoo, Michigan

This housing system producer utilized conventional wood framing entirely to fabricate modular units for single-family attached and multifamily low-rise living units. Prior to leaving the factory, the individual modules were completely wired, plumbed and finished and thus required a negligible amount of on-site labor to bring the units to a "move-in" stage. To enhance the exterior appearance of the Scholz units at the two prototype locations, a variety of exterior siding treatments was applied.

Structural adhesives, in combination with nailing, were used throughout the units to attach plywood subfloors, walls, ceiling and roof sheathing to the framing. This fastening method minimized the possibility of damage to the completed units during transit from factory to final placement at the building site. All modules were 12 ft. wide, 11 ft. high with lengths ranging from 18 ft. to 56 ft. The weight of the modules ranged from 18,500 lbs. to 26,000 lbs.



PLACEMENT OF SCHOLZ MODULES AT THE SITE

COMPLETED SCHOLZ TOWNHOUSES AT KALAMAZOO, MICHIGAN

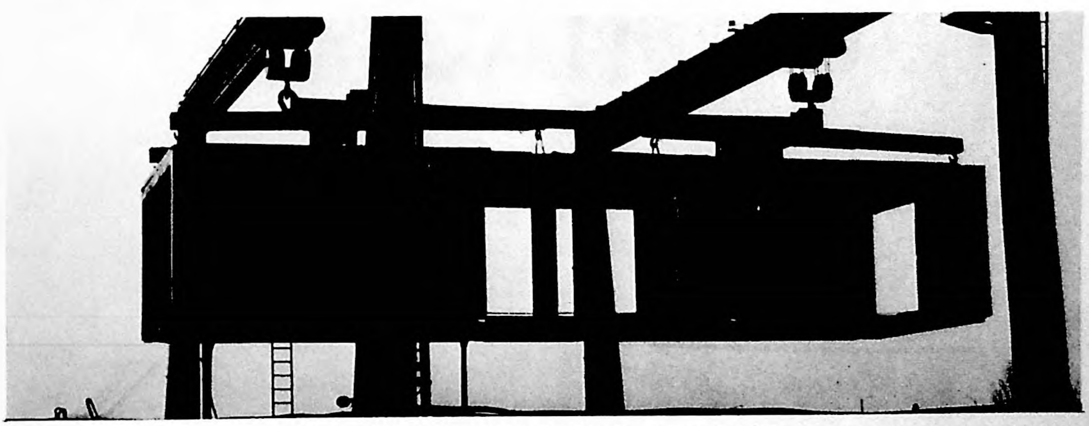
SHELLEY SYSTEMS, INC.
400 Park Avenue
New York, New York 10010

Site:
Jersey City, New Jersey

The unique feature of this reinforced concrete modular system was the "created" usable space obtained by alternately stacking the heavy modules in a checkerboard fashion. The units were structurally supported by load-bearing columns which were an integral part of the module's walls. This method of stacking, unlike typically stacked modular systems, eliminated the duplication of walls and floors, and permitted high rise construction of up to 25 stories. In effect, the checkerboard stacking doubled the usable floor area without additional structural fabrication.

While the box units themselves were self-contained, wall panels and partitions were site-erected to finish the space within and between the modular boxes. Two sizes of modules were produced. The smaller module was 44 ft. long and 8 ft. 7 in. high; the other being 52 ft. long by 8 ft. 6 in. high and both having a 13 ft. 6 in. width. The weight of the modules ranged from 48 tons to 53 tons.


MODULES BEING ERECTED AT JERSEY CITY SITE


FACTORY-CAST STRUCTURAL CONCRETE BOX MODULE

2.

STRUCTURAL MODIFICATIONS

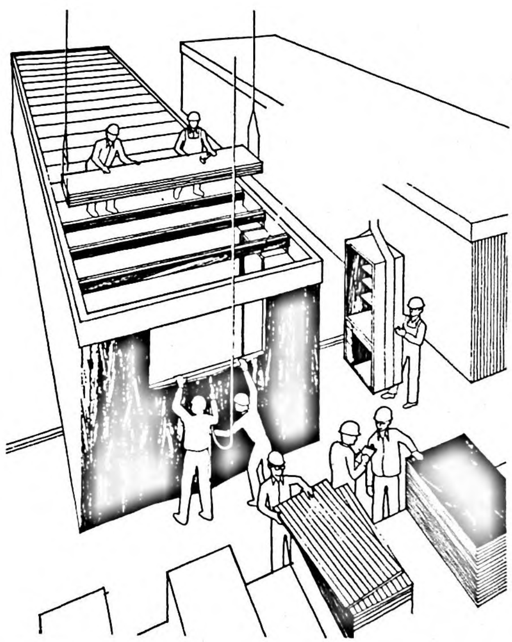
GENERAL

The stresses and deformations that a modular type housing unit undergoes after leaving the factory production line require that special design-consideration be focused on certain of its structural elements. Because a modular house often travels hundreds of miles from the factory to the building-site, and in the process may be hoisted several times before being placed in final position on the foundation, it must often be modified to withstand these imposed conditions.

The housing system producers in the Operation BREAKTHROUGH program were aware that damage during handling and transporting could result if special precautions were not taken. As a consequence, certain structural modifications were adopted to ensure that their units could withstand the racking and twisting which occurs during transportation. Similar structural safeguards were incorporated in the designs to assure that the modules would withstand the sometimes severe stresses induced during the lifting and erection process.

While several of these structural additions were unique to the industry, some are commonplace. For example, the use of continuous double sills at the bottom of the units and the application of structural adhesives to supplement normal nailing practices are generally accepted and used by most modular manufacturers today. The temporary covering of openings with plywood, which is removed after the module is erected, and other temporary structural additives are procedures considered necessary to eliminate or to minimize damage during transit.

This section presents a discussion of several structural modifications utilized by some of the BREAKTHROUGH producers.

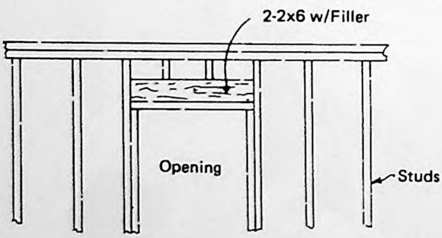


National Homes Corp.
Scholz Homes, Inc.

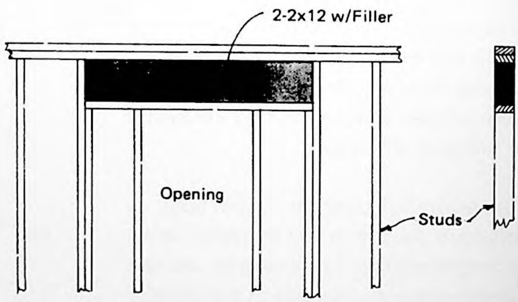
Both of these manufacturers utilized identical modifications in the walls of their modular units to provide additional strength. To avoid cracks or other damage, particularly to interior finish materials, double 2 in. by 12 in. wood headers were used over all window and door openings. These potential points of weakness were structurally supplemented by extending the headers an additional stud-space past the opening on each side. This form of reinforcing is especially beneficial in the longitudinal walls, which, because of their length, are more subject to critical bending and flexing during transit and erection. Because Scholz Homes utilized transporters which did not provide continuous support under the full length of the module, a stronger than normal structural configuration was required.

SCHOLZ MODULE BEING ERECTED AT INDIANAPOLIS – SHEATHED WALLS WERE USED TO PROVIDE ADDED STRENGTH

Structural sheathing of the intermodule walls is normally not required after the module is erected at the building site. However, in order to assure that the structural integrity of the unit would not be compromised during transport and erection operations, these manufacturers stapled 3/8 in. plywood to the outside of the wall studs. This procedure, in effect, transforms a relatively weak stud wall into a deep girder possessing structural characteristics sufficient to limit deflection and reduce damage. This sheathing was removed once the module was in final place at the building site.



TYPICAL HEADER FRAMING

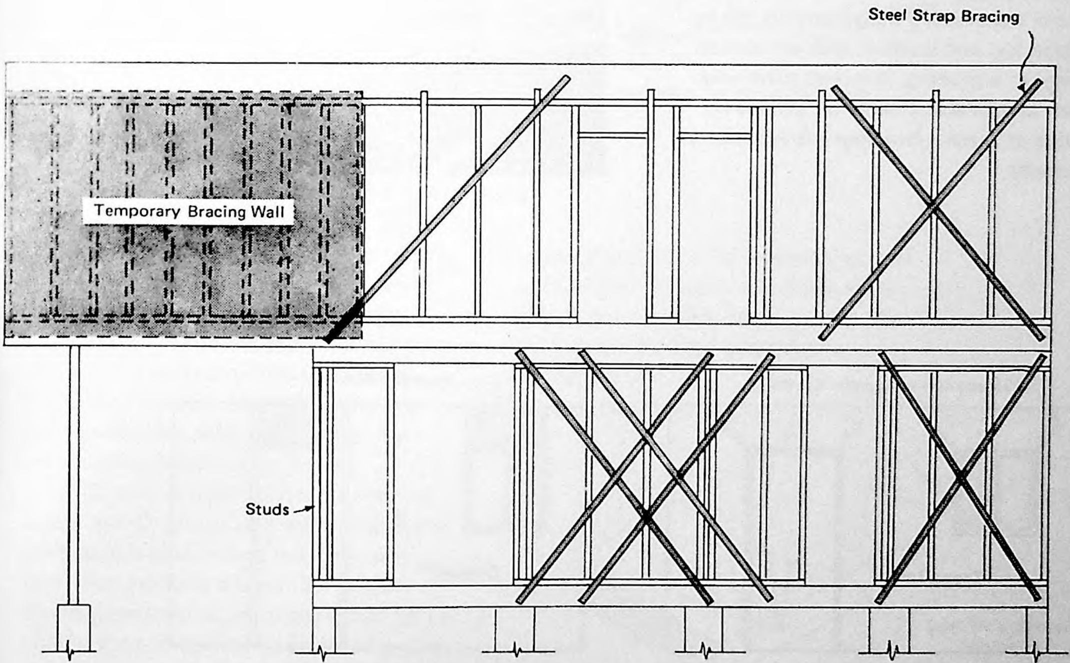


SPECIAL HEADER FRAMING

General Electric Co.

This housing system producer used 1-1/2 in. wide, .035 in. thick steel straps on interior longitudinal (party) walls to impart additional strength to this primary structural element. This type of bracing was also applied to exterior walls prior to application of wall sheathing material. The number of double x-bracing or single diagonal straps varied depending upon location, as shown in the drawing below. These straps were fastened to the top plates and bottom sills with metal screws, and as a general rule were applied in the wall areas next to the window and/or door openings. After placement of the housing module at the site, these steel strap bracings were not removed and remained as a permanent part of the building structure.

To provide additional reinforcement to walls containing an extremely large opening (as the typical opening between living room and dining room) a temporary bracing-wall was installed at the factory. Once the module was placed at the site, this temporary bracing-wall, constructed of wood studs and plywood sheathing, was removed.

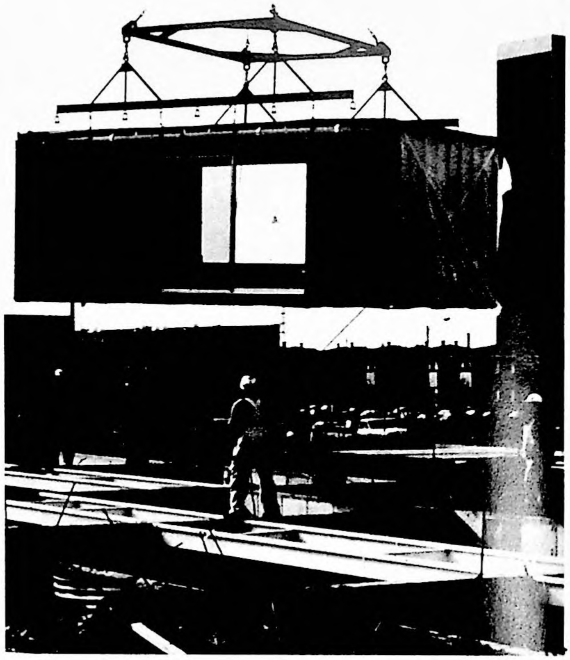


SIDE VIEW OF GENERAL ELECTRIC MODULES SHOWING WALL BRACING

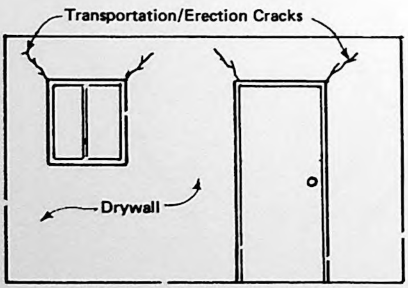
Home Building Corp.

One of the most common types of damage, which occurs to modular units as a result of transportation and erection activity, is the occurrence of cracks in the drywall at the upper corners of doors and windows. These diagonal cracks are created by stress concentrations due primarily to the flexure of the module while in transit and also to the use of improper lifting techniques. To minimize or offset this troublesome problem, Home Building Corporation eliminated all drywall construction over each door and window opening and replaced it with decorative plywood accent panels. Structural materials, other than plywood, could be utilized for these panels to achieve the same results.

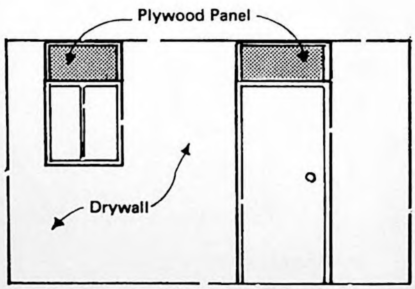
The Home Building Corporation also attached steel strappings to the unsheathed mating walls of modular townhouse units, to obtain additional structural racking resistance. These flat steel straps were nailed diagonally to the opposite top and bottom wall-corners to form an x-bracing. A gusset plate was then installed at the center cross-over point of these x-bracings for additional strength.



STEEL STRAP X-BRACING IN MATING WALLS



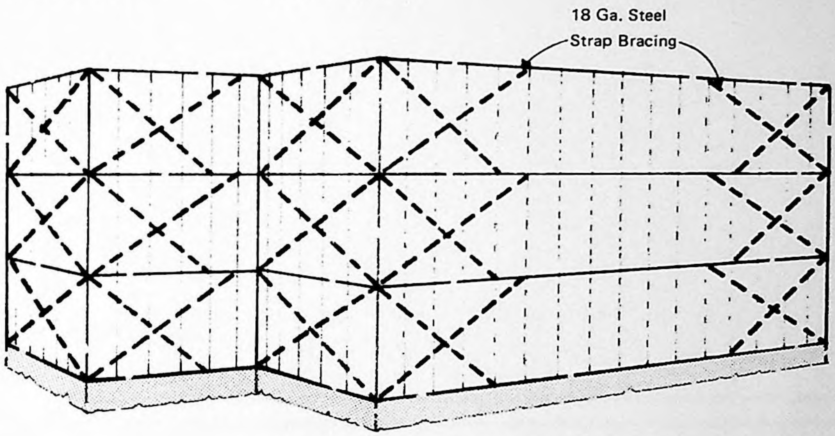
DAMAGE WITH TRADITIONAL CONSTRUCTION METHOD



HBC CONSTRUCTION METHOD TO PREVENT DAMAGE

Boise Cascade Housing Corp.

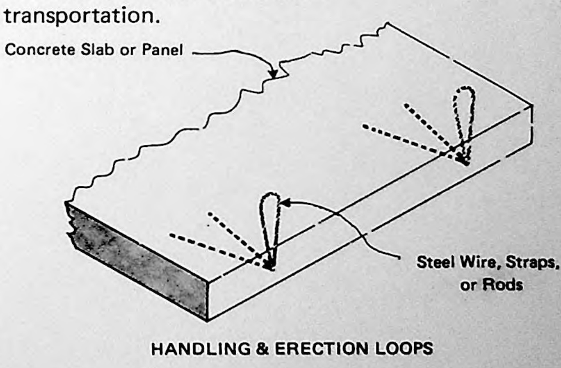
Additional wall strength for the steel frame three-story structures fabricated by Boise Cascade at its Arabi, Georgia, plant was obtained through the use of 18 gauge steel straps, 3 in. wide, which were spot-welded to the studs and primary floor and ceiling framing members. This x-bracing was generally welded to both sides of the module close to each end. Occasionally, an x-brace would be eliminated from one side when design and transportation requirements permitted. Every box, however, had at least one set of x-bracing at each end, with its location actually based on the configuration of the completed structure. This type of bracing not only provided added rigidity for transportation purposes, but also contributed structural strength to the wall to resist wind pressures and other imposed loads. (Further discussion of modifications to Boise's metal system is included in the "lifting frame" section of this report.)



BOISE CASCADE'S BRACING SYSTEM

Miscellaneous

Because of the lightweight nature of their component elements, some wood-frame and lightweight metal panel producers (Alcoa, Pantek, etc.) did not require any special structural modifications. On the other hand, housing systems producers, who used heavy concrete components and/or boxes, (FCE-Dillon, Building Systems International and Descon/Concordia), incorporated steel straps, strand-wire, or rods into their systems during fabrication. These were embedded in the concrete to enable the element to be safely lifted. In at least one situation, a concrete modular producer found it necessary to increase the amount of reinforcing steel in the lintel adjacent to certain door openings to prevent shear cracks from developing during handling and transportation.



HANDLING & ERECTION LOOPS

3.

PACKAGING and STORAGE

GENERAL

Within the vast complex of this nation's manufacturing industries, it is commonplace to produce, package and store products for future delivery to the marketplace. This process was also applicable to industrialized housing producers involved in the Operation BREAKTHROUGH program. In most cases, it was necessary for modules and/or components to remain in storage while awaiting shipping schedules designed to coincide with the sometimes unpredictable progress at the building site. Manufacturers who shipped by train were required to maintain a storage facility, and all producers faced the prospect of delays due to unforeseeable weather conditions. More than any other factor, the very nature of plant production, which necessitates a somewhat constant assembly line flow for the process to be successful, almost dictates the need for storage facilities.

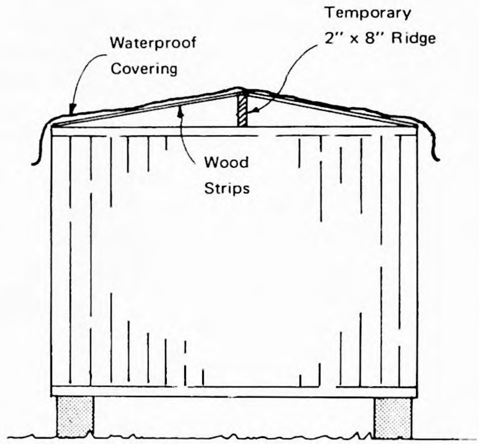
Inasmuch as open temporary storage of modular units and components was essential, it was therefore necessary to afford protective packaging to assure that rain water, ground moisture infiltration, rodent infestation and other damages would not occur. Special consideration also had to be given to the proper placement of units to permit access for fire-fighting equipment, loading and unloading equipment, and inspection of modules. Similarly, the housing system producers had to contend with possible entry and accumulation of road dirt during miles of transit from the factory to the building site. It was also necessary to apply techniques to prevent damage which could result from shifting of appliances, swinging doors and other unfastened items located inside the modules. A diverse assortment of packaging methods and materials was therefore utilized, ranging from blocking and strapping of movable components to installation of light-gauge sheet metal temporary roofs. Most manufacturers attempted to use protective packaging materials and devices which were economical and also disposable at the job-site after use.

While protection against potential damage from natural elements was of prime concern, it was also necessary to consider possible damage from vandalism while the modules were in storage and in transit. In addition, some housing system producers, in the early stages, utilized the exterior packaging to advertise their housing product. They soon became aware that this prominence attracted mischief and theft, particularly during railroad transit. Some manufacturers also found it beneficial to temporarily place plywood over windows to prevent breakage from rock-throwing, tree branches and other unanticipated hazards.

The following pages provide an indication of some of the various methods employed by the housing system producers to minimize or eliminate possible damage which would be anticipated during the storage and transportation phases.

Material Systems Corp.

A triple-layer, reinforced waterproof paper product was applied to the roof and all walls of the fiberglass modules produced by Material Systems Corp. At first, this protective covering material was held firmly in place by thin wood battens stapled to the module to avoid billowing at high transport speeds. However, because the staples were difficult to remove and also left holes in the exterior finish after removal, this producer changed to a taping procedure for joining and sealing the sheets of protective covering. Subsequently, 1/2 in. wide nylon bands, pneumatically tensioned to 90 lbs., encircled the modules, longitudinally and laterally, to keep the covering in place during storage and transit. For large openings in the side wall, MSC installed temporary 2 in. by 4 in. wood frame uprights to provide support for 1/8 in. thick 4 ft. by 10 ft. plywood sheets which were backed with a bonded waterproof paper. To prevent pockets of water from forming on the vulnerable flat-tops of the first floor modules, a temporary ridge was built-up using 2 in. by 8 in. lumber which was installed longitudinally on the top of the first-floor ceiling joists. Covering material was then placed over this sloped framing. Whenever possible, all protective packaging material remained intact until modules were stacked to avoid weather damage. All material, including the temporary build-up ridge, was removed and discarded at the job site.

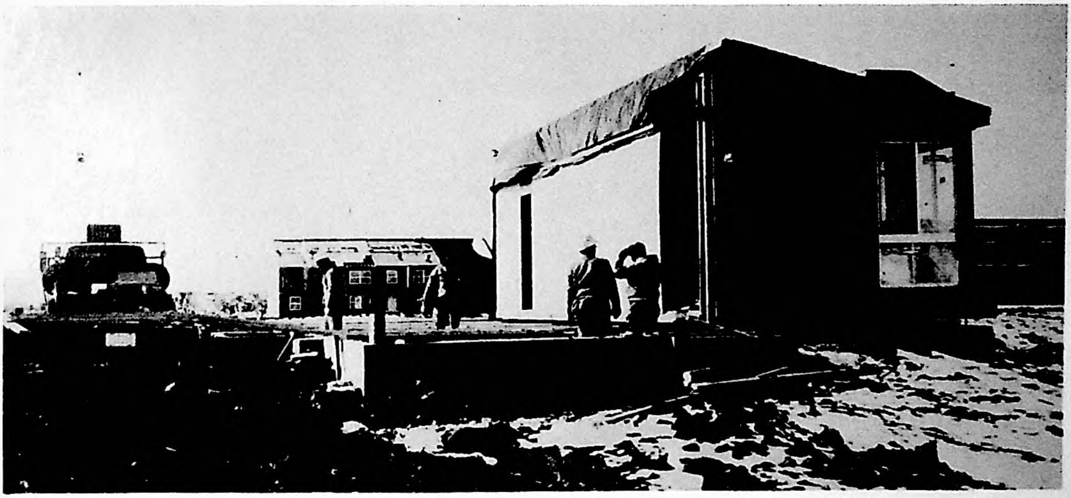


MSC MODULE SHOWING TEMPORARY ROOF COVERING STRUCTURE

MSC COVERED MODULES STORED AT SACRAMENTO, CALIFORNIA, AWAITING TRANSCONTINENTAL RAIL SHIPMENT TO INDIANAPOLIS.

Home Building Corp.

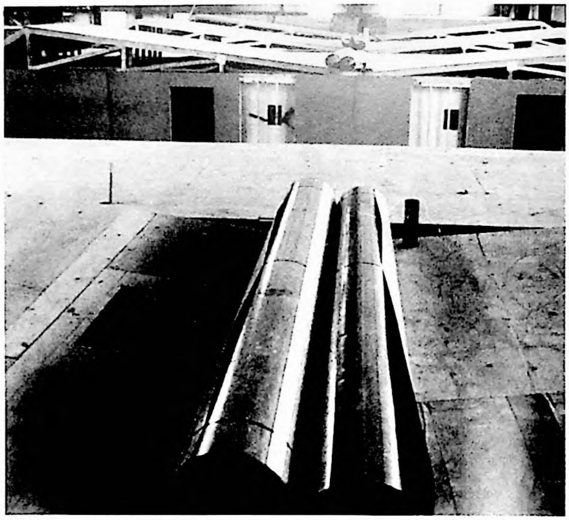
The unfinished side of this manufacturer's modular unit was covered with tongue-and-groove plywood to assure tight joints during storage and transporting by truck. All other unfinished areas, such as the eaves and corners, were covered with polyethelene which was firmly attached to the module with wood slats. Trim and other loose items to be applied on-site, were stored in a specific pattern on the floor. All doors were fixed with tape or blocked in a closed position. The tongue-and-groove plywood was removed and sent back to the factory for reuse on other modules. Other packaging and protective materials were discarded at the job-site. The HBC modular units were stored outside at the plant on wood frames or on empty oil drums for periods generally less than ten days.



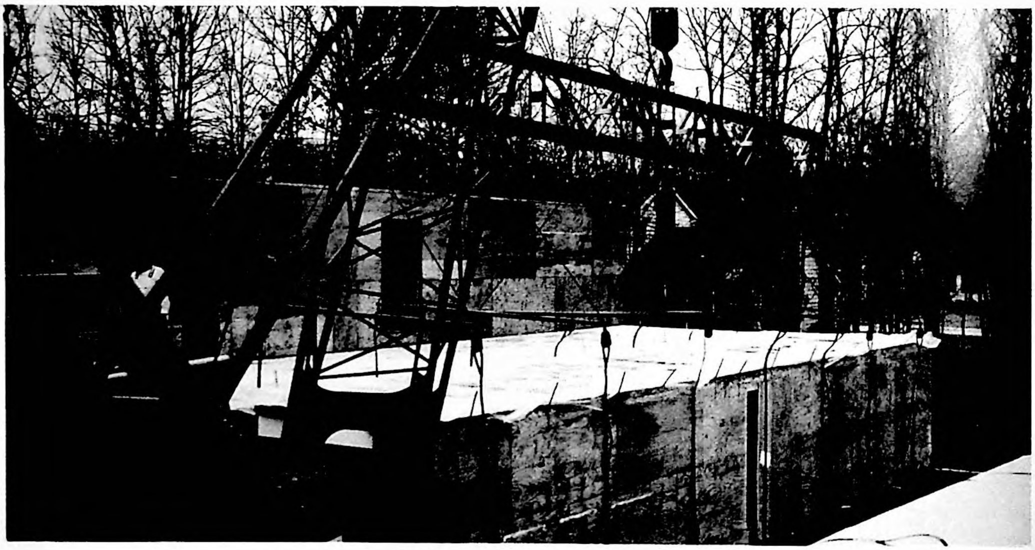
HBC PROTECTED MODULE IN PLACE AT SITE – PLYWOOD ON THE LEFT SIDE IS REMOVED PRIOR TO INSTALLATION OF ADJOINING MODULE

Scholz Homes, Inc.

This manufacturer of wood-framed stack-on modules utilized different methods for protecting the first- and second-floor ceiling framing systems during storage and shipment. The tops of all first-floor ceiling joists were covered with plywood, over which 30 gauge galvanized sheet steel was attached with staples. This one-piece sheet steel covering, installed over plywood, not only afforded protection from the weather, but also minimized accidental ceiling damage during site erection. Additional fire protection between the upper and lower story was achieved by leaving the sheet metal in place after erection. A polyethelene covering, held in place by stapled wood-slats, protected all exposed ceiling joists of the second-story modules since roofing was not installed until the module was placed on its foundation at the site. The openings in mating walls were temporarily covered with plywood. All protective packaging materials were discarded at the job-site. Concrete blocks and wood cribbing were used to support the modular units during yard storage for period up to two months.



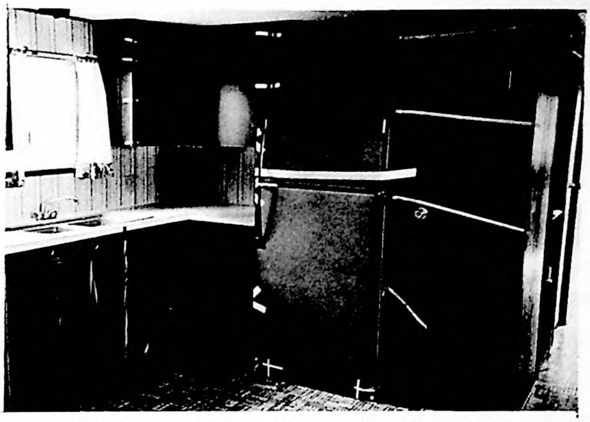
INSTALLATION OF 30 GAUGE GALVANIZED SHEET STEEL ON MODULE TOP AT SCHOLZ FACTORY



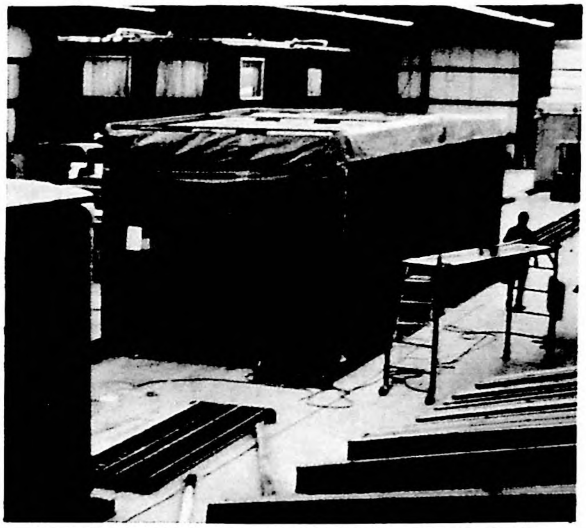
SCHOLZ PROTECTED MODULE AWAITING ERECTION AT SITE

Boise Cascade Housing Corp.

The modular units manufactured by Boise Cascade were protected with a 4-mil thick high density cross-laminated polyethelene film. This material does not tear as readily as regular ployethelene and is self-extinguishing when ignited. It was held in place with wood lath and double-headed nails to facilitate removal at the building site. Temporary plywood covers and polyethelene were placed over all exterior wall openings. The interior doors were braced open while bifold closet doors were blocked shut. Applicances, such as the hot-water heater and dishwasher, were blocked and/or strapped to the wall to prevent movement during transportation. Loose trim items, required to finish the house after erection, were attached to the floor with strips of surplus carpeting. The Boise modules were stored on wood-cribbing for periods of ten to sixty days. This protective packaging method was utilized for both railway and highway transportation. Emphasis was placed on minimal modular storage periods at both the plant and building site. Because of the extremely tight sealing by the polyethelene material, some damage caused by entrapment and condensation of moisture was observed, thus provisions had to be made for venting the units during plant and site storage.



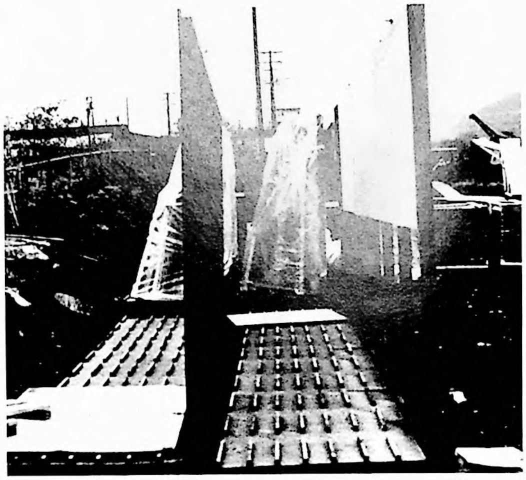
TYPICAL METHOD OF SECURING CABINETS AND APPLIANCES FOR TRANSIT



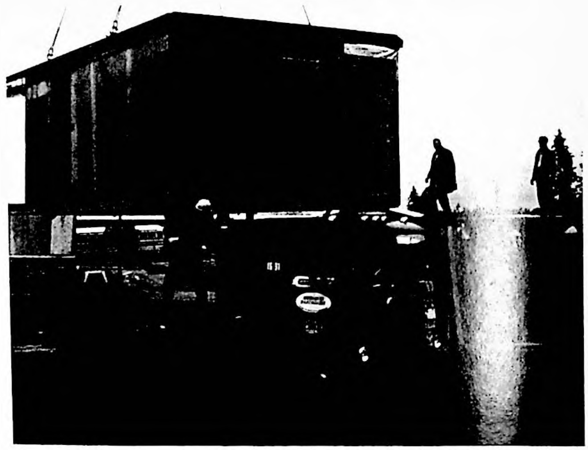
PACKAGED MODULE READY TO BE MOVED FROM FACTORY TO STORAGE AREA

MODULE STORAGE AREA AT BOISE CASCADE'S ARABI, GEORGIA PLANT

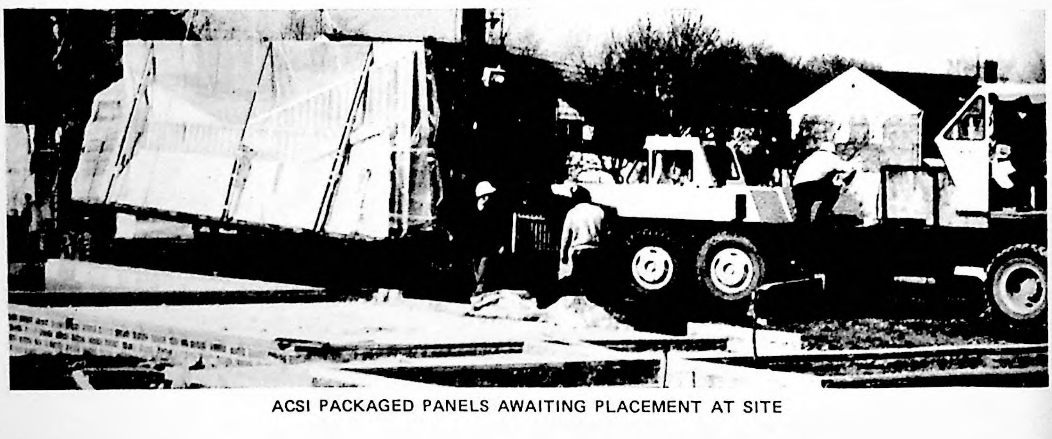
Alcoa's completed panels were covered with polyethelene and banded together in individual packages sized to fit onto specially designed storage/shipping racks after leaving the production line. These wood frame "L" shaped racks were approximately 8 ft. high and 4 ft. wide, with lengths up to 14 ft. Each storage rack could, depending on its length and the lengths of the individual panel packages, accommodate one or several packages. The packages were, in turn, securely banded to the rack itself. The loaded and banded racks either remained in storage at the plant, or were loaded in back-to-back fashion on the trailer for shipment to the site. At the building site, each rack was off-loaded and provided an interim job-site storage facility, protecting the finished components until erected. Empty racks were returned to the factory for reloading. To protect the mechanical core modules, all openings in the side walls were temporarily covered with plywood. In addition, the tops of these modules were protected with a heavy "tar paper" type material which was folded over the sides and fastened with thin wood strips.



RACKS USED TO STORE AND SHIP PANEL PACKAGES



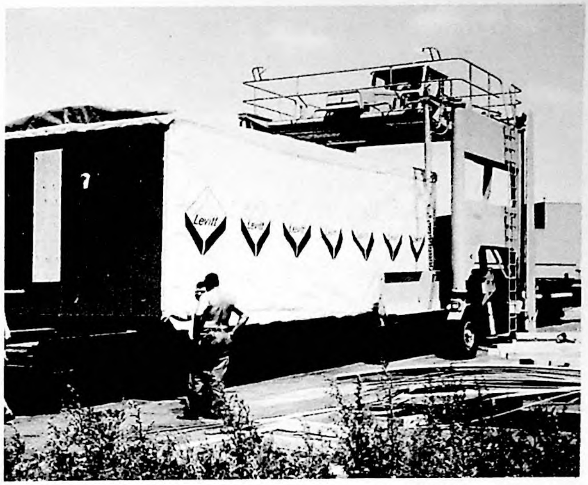
PLACEMENT OF ACSI SERVICE MODULE AT A BUILDING SITE



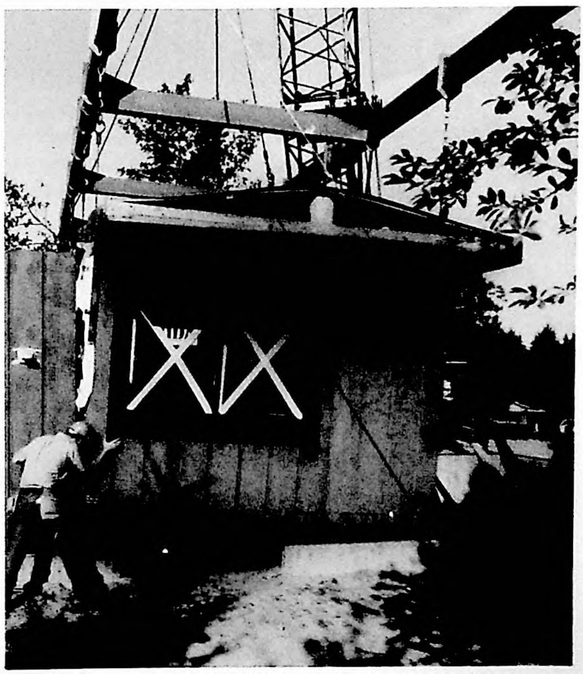
ACSI PACKAGED PANELS AWAITING PLACEMENT AT SITE

Levitt Technology Corp.

This manufacturer of two-story stack-on modular units used a reinforced waterproof paper for exterior side walls and other surfaces which did not have finish materials applied at the factory. The paper was stapled at the top and bottom of the walls and further held in place by two banding straps that horizontally encircled the units. While the second-story module, with factory-finished tilt-up roof, required only minimal protection, the tops of all first-story modules were protected by a temporary arch-shaped frame, formed by wood-slats installed over raised center supports. The slats provided support for application of a thin composition board which was covered with a continuous piece of polyethelene. All interior doors were blocked in a closed position, while cabinets, refrigerator and other appliance doors were taped shut. Trim items, required to finish out the module at the job-site, were fastened to the floor with strips of carpeting. All protective and packaging materials were discarded at the job-site. This protective packaging method was employed to railship modules 2500 miles, plus the truck haul from rail siding to site, without any significant damage. In addition, this packaging method successfully withstood extended outside storage under Michigan winter conditions.

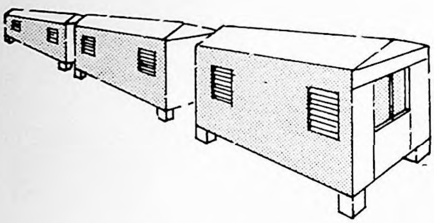


LEVITT PACKAGED MODULE BEING LOADED ON RAIL-CAR



LEVITT FIRST–FLOOR MODULE BEING ERECTED – NOTE TEMPORARY ARCH-SHAPED ROOF

A waterproof reinforced paper was initially used by GE to protect their modular units during storage and transportation. However, several shipments by both truck and rail experienced high winds and torrential rains during Hurricane AGNES and this protective covering material sustained severe damage. A cross-laminated high density polyethelene was then substituted as the standard protective packaging material. The laminated covering was secured with ropes and steel banding straps which horizontally encircled the unit. A pipe, which ran the length of the building along the center of the roof, acted as a temporary ridge beam and provided a slope to prevent pockets of water from collecting. Large window openings were covered with plywood. Each module was provided with two louvered and screened ventilators located in openings of all mating walls in order to reduce moisture entrapment during storage and transit. Once the modules were delivered to the building site and were ready for erection, the louvers were removed. The storage period at the plant was generally not longer than two weeks. The modules were stored on cement block footings when transporters were not available.



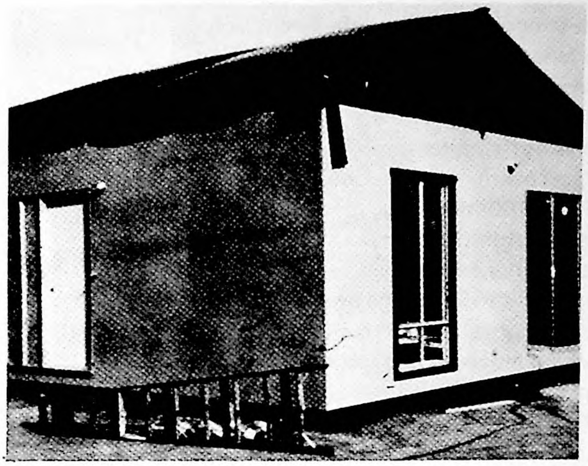
LOUVERS INSTALLED TO REDUCE INTERIOR MOISTURE ENTRAPMENT

ORIGINAL PACKAGING THAT FAILED DURING FIRST RAIL SHIPMENT TO MEMPHIS AND WAS LATER REPLACED WITH CROSS-LAMINATED HIGH-DENSITY POLYETHELENE

GENERAL ELECTRIC MODULE READY FOR PLACEMENT AT SITE. THE PICTURE WINDOW END WALLS WERE STRENGTHENED TO RESIST RACKING LOADS CAUSED BY RAIL TRANSPORT.

Community Technology Corp.

This system producer transported the living units as a completed structure, thus protective packaging was not required during transit. However, open yard storage required that a temporary protective cover be applied to the lower unit prior to the stacking assembly of the two-story unit. Because the units at the first-floor/ceiling level contained exposed ductwork and ceiling cutouts, a temporary pitched roof (composed of simple trusses and plastic covering) was placed over the lower module prior to placement of the upper unit.



CTC MODULE SHOWING TEMPORARY PITCHED ROOF

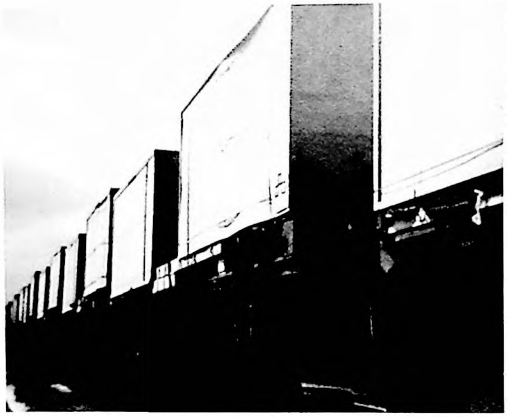
National Homes Corp.

This housing system producer stored its completed modules on the same transporters used to ship from factory to the prototype site. The maximum period of storage at the plant was one week. During the storage and transportation cycles, the modules were protected by a canvas tarpaulin which completely covered the end-walls, side-walls, and roof. These tarpaulins were then returned to the factory for reuse.

REMOVAL OF TARPAULIN FROM NHC MODULE AT SITE

FCE-Dillon, Inc.

For protective packaging, this housing systems producer used 4 ft. by 8 ft. sheets of fiberboard to fully enclose their "mechanical core" (bathroom/kitchen) units. Additionally, the manufacturer enclosed the bathroom and kitchen appliances in a lightweight polyethelene covering to prevent dust and moisture from entering. Because the initial banding of these sheets to the core was not adequate, some of this protective covering material was lost during the first 2100 mile "piggyback" rail shipment. Additional metal straps were added horizontally and vertically to the modules to solve this problem on later rail shipments. The fiberboard packaging was removed at the job site, prior to placement of the units into the highrise building.



"PIGGYBACK" RAIL SHIPMENT OF FCE-DILLON'S MECHANICAL CORE UNITS

Pantek Corp.

The 4 ft. by 8 ft. aluminum framed Pantek panels were stacked on two 4 ft. by 4 ft. wood pallets. Each stack containing ten panels was securely banded to the pallets with steel strapping for shipment. To protect the panels during highway and rail shipment and while in storage, the stacks were wrapped in polyethelene packaging material.

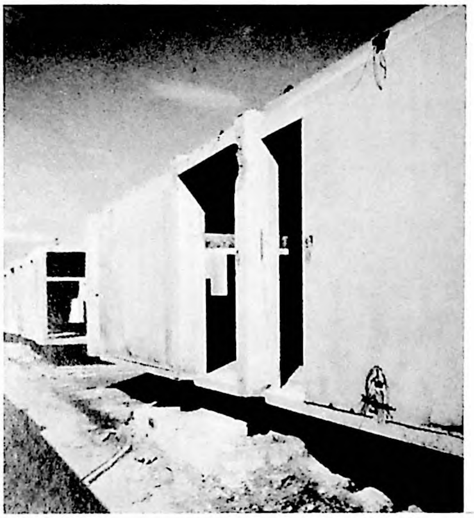
PANTEK'S PANELS STORED ON WOOD PALLETS. NOTE THE EXTERIOR SURFACE OF RIVERBED GRAVEL EMBEDDED IN EPOXY. VERY LITTLE TRANSPORTATION DAMAGE WAS ENCOUNTERED.

Hercoform Marketing, Inc.

This industrialized housing producer covered its modular units with reuseable tarpaulins, which were fastened to the modules with ropes.

Shelley Systems, Inc.

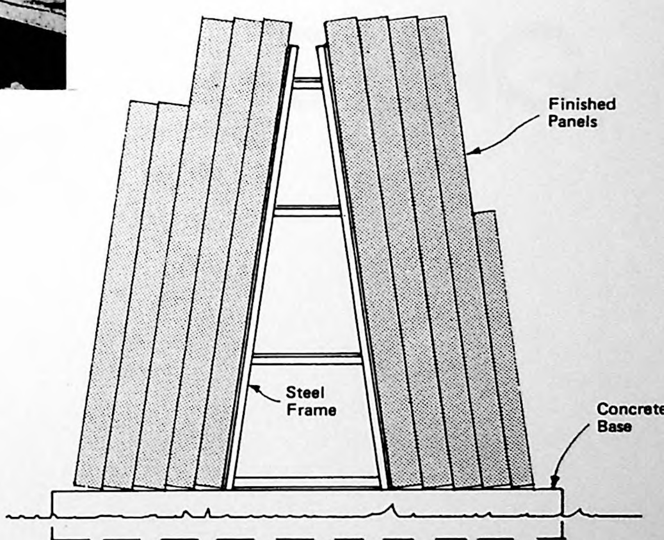
This company utilized heavy tubular steel piers which were embedded into concrete foundations to support their modular units during storage. Because the system was entirely of concrete, no special protective packaging was provided during yard storage or for the 30-mile trip by truck to the building site.



STORED SHELLEY MODULES AT E. PATTERSON, NEW JERSEY

Descon/Concordia Systems, Ltd.
CAMCI, Inc.
Building Systems International, Inc.

These manufacturers used a variety of curing storage racks which were especially designed to accommodate the concrete components they produced. Generally speaking, these racks were fabricated from structural steel and concrete to provide the necessary support for heavy concrete wall panels, floor slabs, and other concrete building elements. The basic nature of this material eliminated the need for protection during storage and shipment to the building site.



CAMCI STEEL FRAMED STORAGE RACKS

4.

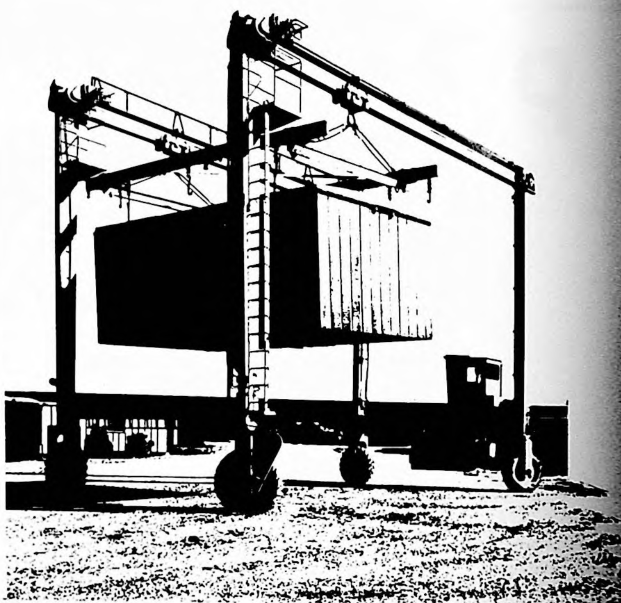
PLANT HANDLING

GENERAL

In this section the term "handling" embraces those actions relating to movement of the finished housing unit or component during (1) the storage period; and (2) the loading or transfer operations prior to the transportation cycle. To a degree, the type of plant handling and moving equipment used for this operation was a direct function of the final transportation mode selected. To accomplish this transitory phase, Operation BREAKTHROUGH housing system producers utilized a wide variety of fork lift trucks, lifting cranes and devices, and specially designed mechanisms. While efficiency of movement was an important consideration, all producers were cognizant of the necessity to use hoisting and short-haul apparatus which were capable of safely maneuvering the sometimes extremely heavy and bulky housing elements, often within confined storage and loading areas.

In some cases, it may be noted that the handling equipment employed by the producers was borrowed from other industries. An example would be the "travel-lift" yard carrier, which reportedly had its origin in the boat manufacturing industry. This type of yard moving equipment seemed to be the most prevalent of all systems employed at the end of the fabricating process. It was used to transfer the housing product relatively short distances to the storage yard, or to waiting transporters for final shipment to rail siding or building site. In at least one instance, the "travel-lift" or straddle type apparatus was utilized to load modules directly onto railroad flatcars.

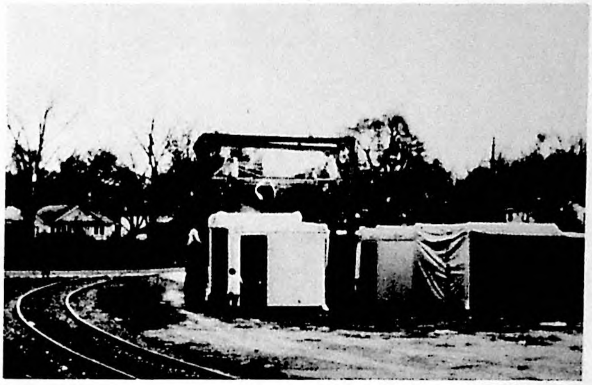
The following pages present some of the various methods and equipment used for plant handling by the Operation BREAKTHROUGH housing systems producers.



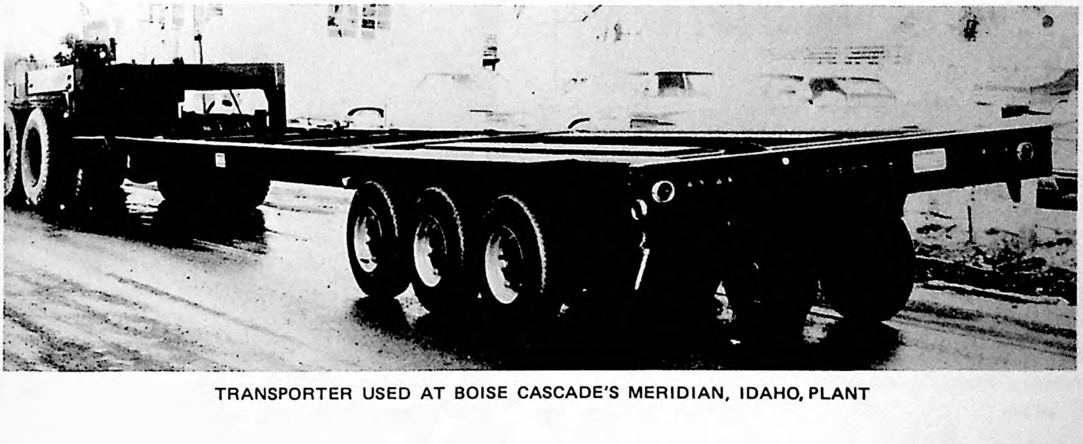
Boise Cascade Housing Corp.

This housing system manufacturer employed different techniques at its two plants for moving modules from the production line to the storage yard. The first technique, used at the Meridian, Idaho, manufacturing facility, involved the use of a low transporter with a built-in short stroke hydraulic lift system. To transfer a modular unit from the production line, the multi-wheeled transporter was driven under the module and, once in position, the hydraulic lift system was activated to clear the fixed production line equipment. This custom-fabricated yard trailer was additionally equipped with rear steering designed to ease the aligning procedure when backing under the module at the end of the production line or when positioning the unit on cribbing for storage purposes. Once in place on the cribbing, the bed of the trailer was lowered and pulled from beneath the unit. All towing of these carriers in the yard was accomplished with a fork lift truck. These same transporters were also used for highway transit.

The second technique, employed at the Boise Cascade plant in Arabi, Georgia, was the "travel-lift" type carrier, used in conjunction with a special lifting frame. The structural steel frame received four short cables with hooks that were attached to the top of the module at the four corner columns. The spreader frame provided the necessary support during movement from the assembly line to the storage area. The self-powered "travel-lift" carrier, because of its steering mobility, could readily and accurately locate the modules on either storage blocks or on the highway transporter for final shipment to the prototype site.



TRAVEL-LIFT USED AT BOISE CASCADE'S ARABI, GEORGIA, PLANT

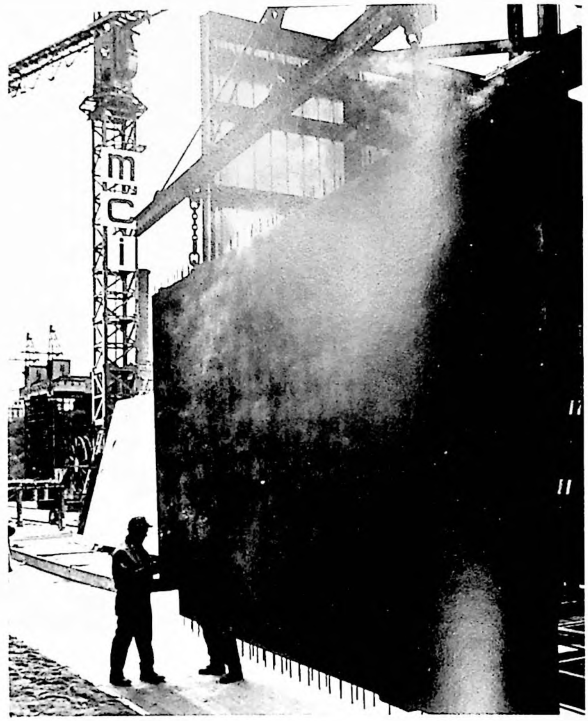


TRANSPORTER USED AT BOISE CASCADE'S MERIDIAN, IDAHO, PLANT

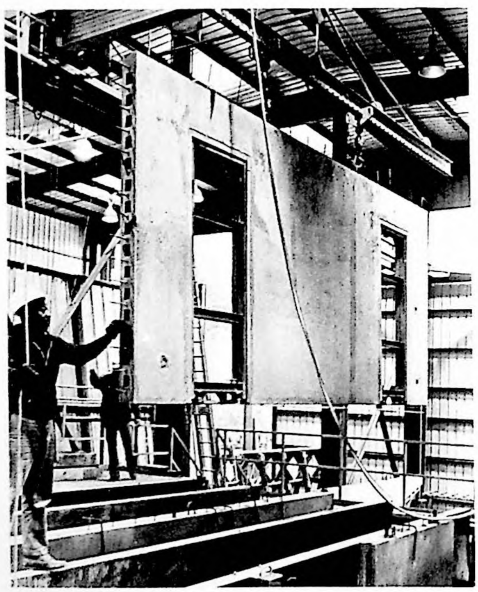
CAMCI, Inc.

The photographs on this page provide a pictorial description of some of the extensive plant equipment utilized by CAMCI to effectively handle the heavy precast concrete panels produced for assembly at the Jersey City prototype site.

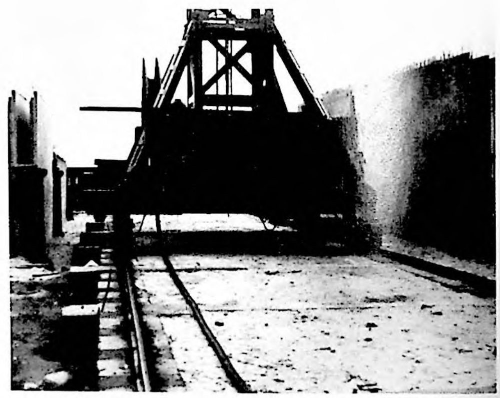
Inside the factory, overhead cranes serviced a series of molds for the unusually large panels and floor slabs. Following removal from the molds, panels were transferred by crane to an outside curing and storage yard. There, a tower crane traveling on tracks was used in stacking and loading operations.



FLOOR PANEL BEING MOVED TO CURING AREA



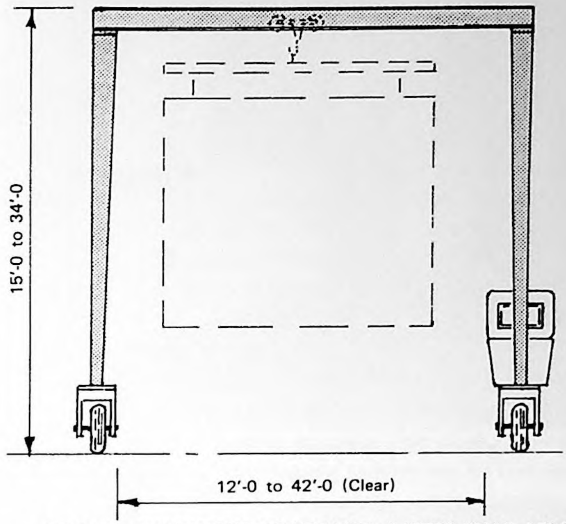
WALL PANEL BEING REMOVED FROM CASTING MOLD



BASE OF TOWER CRANE IN STACKING AREA

General Electric Co.
Descon/Concordia Systems, Ltd.
National Homes Corp.
Boise Cascade Housing Corp.
Hercoform Marketing, Inc.
Levitt Technology Corp.
Shelley Systems, Inc.

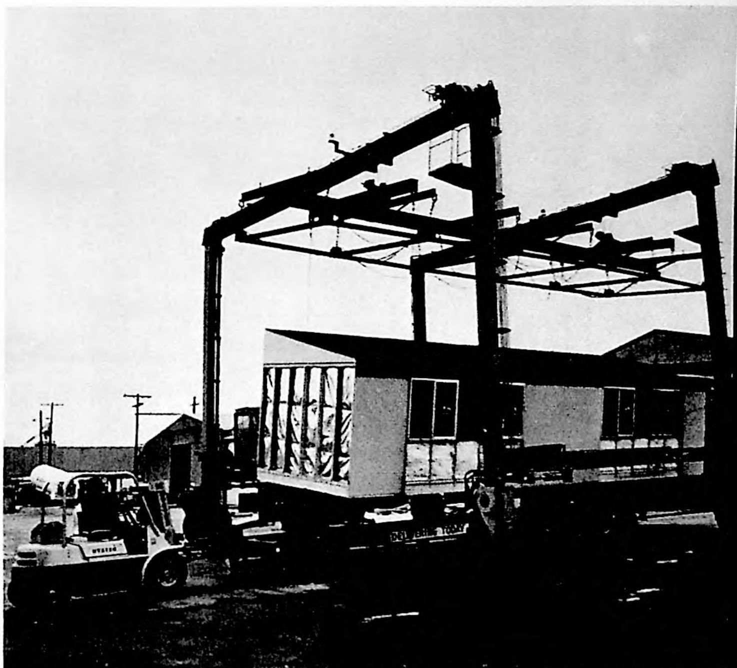
The fact that at least seven of the BREAKTHROUGH housing systems producers made use of "travel-lift" or straddle type yard carriers provides an indication of the usefulness of this equipment for short-haul movement of heavy and bulky factory-produced housing elements. Six of the producers used this four-wheeled structural steel frame mechanism for the transfer of complete modular units. One manufacturer, Descon/Concordia, employed this device to lift and move heavy precast concrete wall panels and floor slabs. Maximum lifting capacity of these carriers ranges upward to 120,000 lbs.



TYPICAL DIMENSIONS OF "TRAVEL LIFTS" AVAILABLE FOR YARD STORAGE AND PLANT HANDLING OF MODULAR HOUSING UNITS

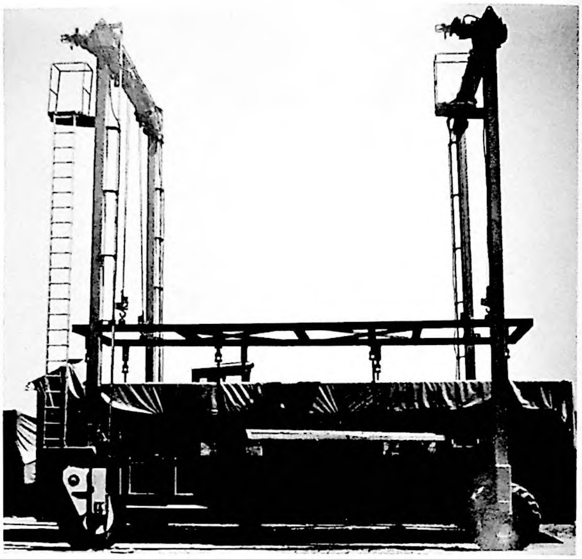
Typically, a "travel-lift" carrier is self-powered by either a gasoline or diesel engine, and is operated by two men. One pair of the four large rubber-tired wheels is steerable and provides drive for the unit; the other set is non-powered and fixed in direction. While all carriers of this type are equipped with hoists for vertical lifting, some may additionally be outfitted with side-to-side movement capability.

The height of the "travel-lift" carrier is the limiting factor in its ability to stack modular units. When storage space is at the premium, this stacking feature has

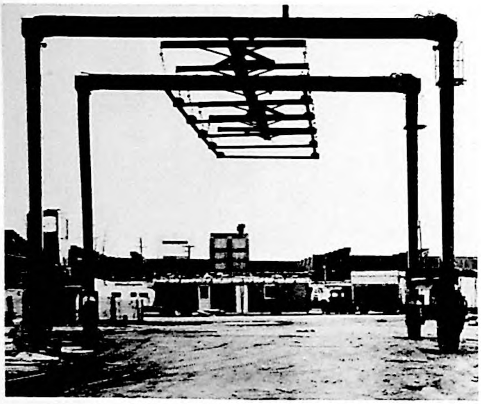


NATIONAL HOMES' MODULE BEING LOADED ONTO TRANSPORTER merit. It is also advantageous to be able to lift units high enough to clear other units in storage. In this way, the carrier can operate between rows of modules to place or retrieve units anywhere in the storage area.

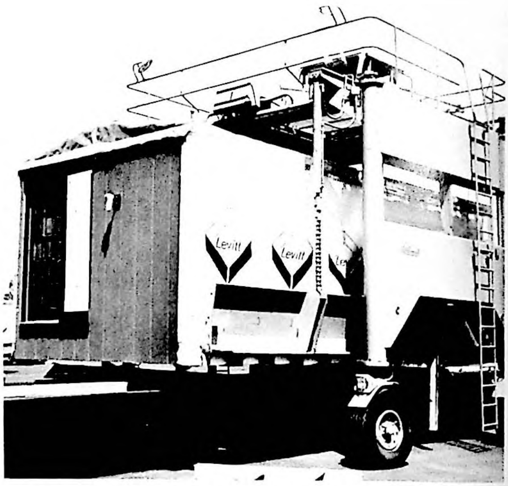
When this type of handling equipment is used to load modules onto railway flat-cars (as Levitt did) advance planning is required to assure that proper sequence is maintained for off-loading at the point of delivery. Failure to do so can result in costly delays when the straddle crane is required to thread the loaded train to retrieve a unit improperly positioned.



HIGH-LIFT CARRIER POSITIONS HERCOFORM MODULE



TRAVEL-LIFE CARRIER, AT NATIONAL HOMES PLANT, WITH SIDE SHIFT CAPABILITY TO PRECISELY POSITION MODULE ONTO TRANSPORTER OR STORE IN CONGESTION YARD

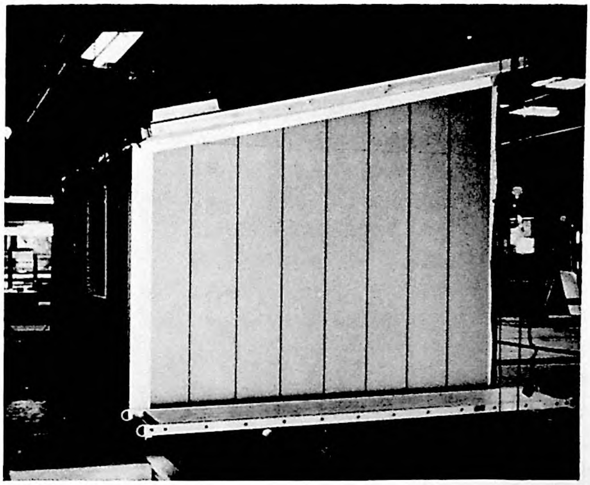


LEVITT STRADDLE CARRIER LOADING MODULE ONTO RAILCAR

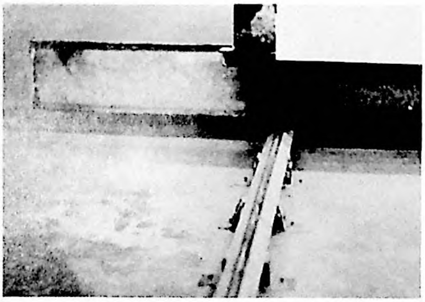
Home Building Corp.

This modular manufacturer employed a specially designed horizontal steel-tracked system permanently fixed to the concrete floor of the factory. These tracks (which traversed the assembly line and ended at the shipping-pit) were fabricated true and square; and considerable care was taken to properly shim and level the steel-angle tracks. Structural steel cross-beams (with two steel V-grooved wheels attached at each end and spaced the same distance apart as the tracks) provided the necessary support for the module. The track system terminated at the loading dock pit, where adjustable-height transporters could back under a modular unit and receive it for transfer to the storage yard; or transport it directly, via highway, to the prototype building site. Manual force was needed only to transfer the module between production stations on the assembly line and onto the truck transporter. *All lifting was essentially avoided.*

MODULE MOVING DOWN ASSEMBLY LINE ON TRACK SYSTEM



MODULE OVER LOADING DOCK PIT AWAITING TRANSPORTER

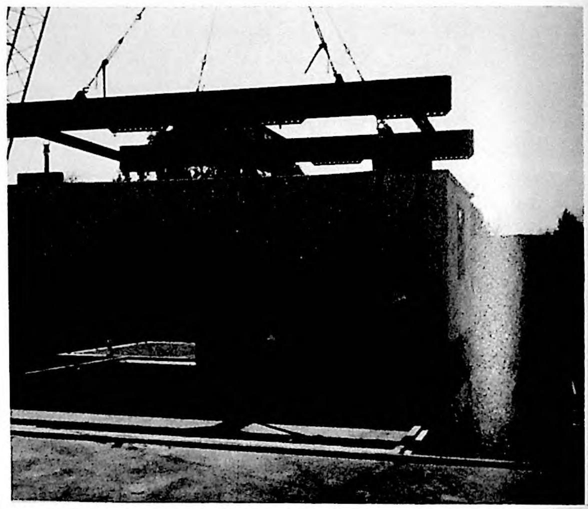


V-GROOVED WHEEL ON MATING TRACK RAIL

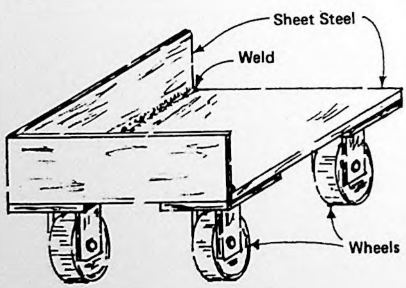
Community Technology Corp. (CTC)

At the beginning of the factor assembly line, CTC placed four temporary castors on the bottom of each floor panel. These castors (each containing four wheels) were located at all four corners of the modules, and remained with the unit until just prior to its being loaded on the transporter for shipment to the building site; or until crane-lifted for stack-on assembly at the plant. Once off the production line, a fork lift was utilized to push the units to the storage shipping area.

A spreader-bar lifting frame and a mobile crane were used to lift the second-story module and place it on top of the first-floor module at the plant. The castors from the second-story module were removed and returned to the assembly-line for re-use. Hydraulic jacks then raised the double-stacked units sufficiently to permit positioning of a special-purpose highway transporter underneath the load. Meanwhile, the castors from the first-floor unit were removed and also returned to the assembly-line. The use of this temporary castor-wheel arrangement, in combination with complete erection of two-story stack-on units at the factory, minimized lifting strains since the top modular unit was crane-lifted just once and the bottom module not at all.



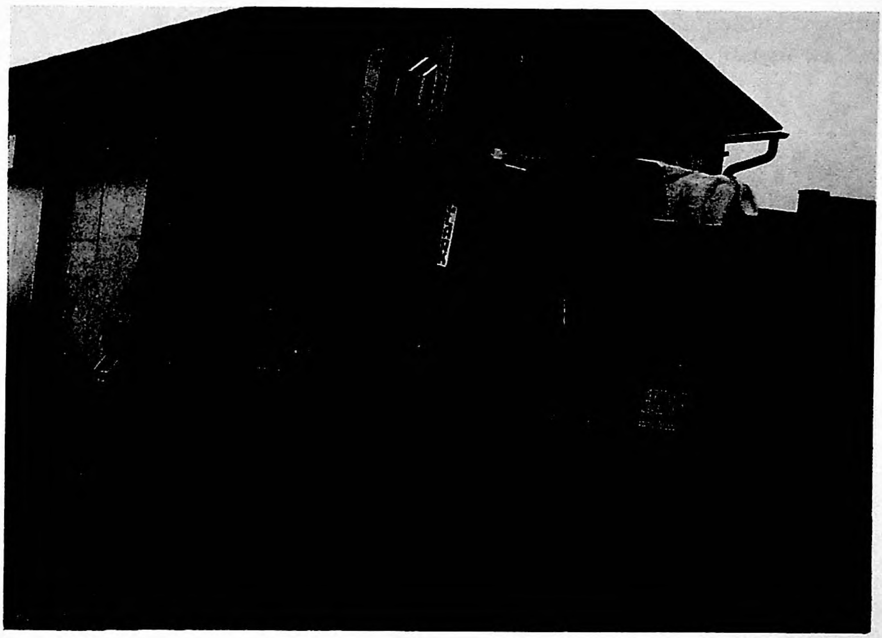
CTC SECOND-STORY MODULE BEING PLACED ON TOP OF FIRST-STORY MODULE (TWO MODULES ARE THEN PLACED ON TRANSPORTER AND MOVED AS A COMPLETE UNIT TO BUILDING SITE)



STEEL FRAMED CASTERS

FCE-Dillon, Inc.

A special-purpose 15-ton capacity fork-lift truck was utilized by FCE-Dillon to handle the factory-completed mechanical core units from the production line to storage, or directly to a flatbed trailer for movement to the job site. Within the factory itself, a 25-ton conventional bridge crane was used to move the core units (complete with precast concrete floor slabs) from their final assembly point to the factory door. Since two core units were shipped at the same time on one flatbed trailer, it was essential during the forklift operation to exercise extreme care in positioning the forward module, the slab of which overlapped the other unit by some five feet. Other concrete panel components were also moved from the plant to storage areas and/or transporters by smaller forklift trucks.



FCE-DILLON 15–TON FORK LIFT TRUCK EMPLOYING SPECIAL TINES

OTHER HOUSING MANUFACTURERS:

Material Systems Corp.

Movement of the completed modules, from the assembly line to the storage yard, was accomplished by overhead crane and low-bed transporters. In the storage area, hydraulic jacks were used for raising the modules from the transporter and lowering them onto blocks.

Pantek Corp.

Completed panels were transferred from the production line to the storage area on 4 ft. by 10 ft. dollies. These four-wheeled carts were towed by a motor tug.

Alcoa Construction Systems, Inc.

This manufacturer used a high-lift forklift truck to transfer both panel components and kitchen/bath modules from the final assembly station to storage.

ALCOA'S MECHANICAL CORE MODULE BEING SHIFTED IN STORAGE YARD

Scholz Homes, Inc.

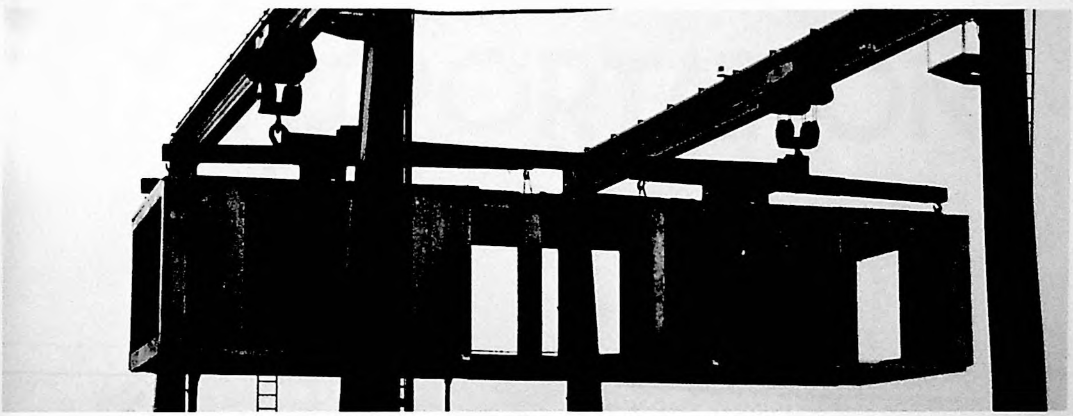
The factory-finished modules were transferred to the storage area by means of a rail-track system, an extension of the production line track. Double-flanged wheels (which were attached to the bottom of the module at the start of the production line) were removed once the module was hoisted by a 35-ton cable crawler crane. This crane then positioned the module in the storage yard or loaded it directly onto a highway transporter for shipment to the building site.

Building Systems International, Inc.

Within the factory, a 20-ton capacity bridge crane was used for transferring concrete panels for the final assembly station to the packaging area. Three-wheeled dollies (equipped with special saddle brackets to accommodate the 8 ft. by 8 ft. panels) were used to transfer the panels to the storage area. The larger 8 ft. by 30 ft. panels were moved by truck tractor, while the 12 ft. by 30 ft. concrete slabs were moved by bridge crane.

Shelley Systems, Inc.

A large crane (shown below) was utilized by Shelley, within the plant, for transfer of the completed concrete modules from the assembly line to the curing/storage yard. This special purpose crane was also used for loading the module onto the highway transporter.



LIFTING ASSEMBLY AT THE SHELLEY CASTING AREA

5.

HIGHWAY TRANSPORTATION

GENERAL

Although highway transportation of modular units and other factory-produced components has been successfully accomplished by a very large number of manufacturers, the BREAKTHROUGH experience brought renewed attention to the many obstacles encountered in over-the-road shipment. Distance has always been a primary consideration of the modular shipper, since it directly contributes to the final cost of his product. Most manufacturers have attempted to limit highway transportation to 200 or 300 miles, generally considered to be the maximum economical shipping distance.

Operation BREAKTHROUGH encouraged the concept of centralized plants with greater capacity, and required several participating producers to transport their housing systems far beyond the usually accepted limits. While rail shipment was utilized for most of the longer distances, many modules were routinely transported by highway more than 1000 miles. BREAKTHROUGH also provided other unusual highway situations, including the movement of stacked two-story townhouse modules a distance of 12 miles to the building site, and over-the-highway transportation of concrete modules weighing nearly 60 tons.

While BREAKTHROUGH studies encompass the full range of matters involved in highway transportation, particular emphasis was placed on:

- Reducing the costs of highway shipment;
- Encouraging simplification and uniformity of interstate highway regulations; and
- Prevention or reduction of damage during highway transportation.

Concurrently, BREAKTHROUGH conducted formal negotiations with leaders of the Mobile Home Housing Carriers' Conference Inc. which resulted in a rollback of MF-ICC Modular Tariff #24 rate-increase in early 1971. Nationwide highway modular costs were stabilized as a result, and remained so until September 27, 1973, when a five-percent increase was effected.

The following section briefly describes: (1) the revised regulatory procedures (which benefit both mobile home and modular manufacturers); (2) information on highway transport operations (the equipment used, cost data and other BREAKTHROUGH findings); and (3) the highway transportation techniques, (used by a number of housing system producers).

Note: For an extensive, in-depth review relating to transportation of wide loads (housing modules), the reader is referred to the Joint U.S. DOT/HUD report entitled "Economic Evaluation of Mobile and Modular Housing Shipments by Highway," by Midwest Research Institute, April 1974.

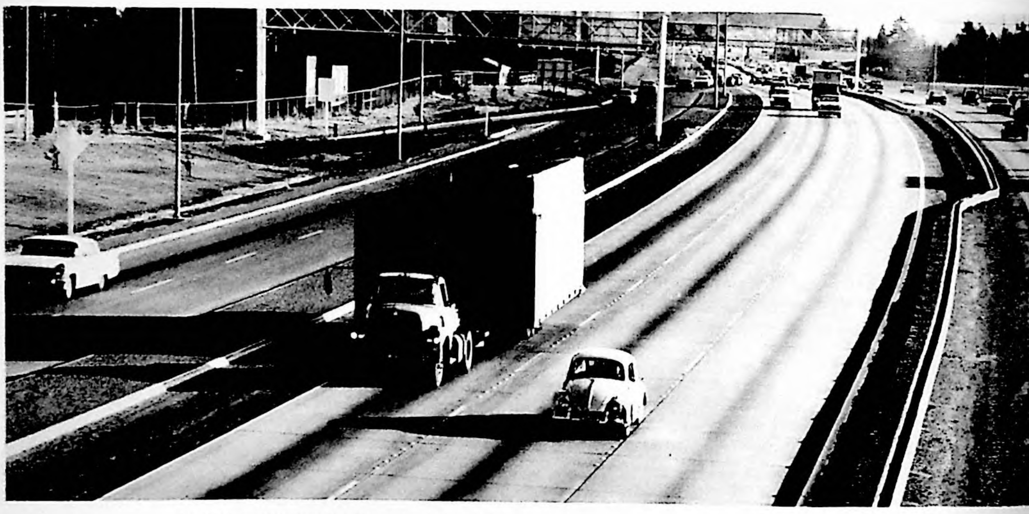
Since each state has sovereign control over the highways within its boundaries, there were (within the U.S. continental limits) 48 differing sets of rules at the inception of BREAKTHROUGH. The official coordinating body on state highway matters is the American Association of State Highway Officials (AASHO), which establishes voluntary standard procedures and policies as determined by majority vote of the highway directors of each state. Generally, these procedures and policies are adopted and followed by the state highway departments. However, state legislatures can override AASHO recommendations, so that complete acceptance is not always assured. In any event the first step, toward attaining standardization among the states, involved securing AASHO approval of more uniform highway procedures. BREAKTHROUGH made formal concentrated efforts in this direction.

Restrictions

The state highway regulations found most restrictive by modular manufacturers were:

- *Prohibition of "Divisible-Load" Travel:* Assuming that fifty-five feet was a hypothetical state's legal load-length limit, the following dilemma confronted modular manufacturers: An interstate trailer-load, comprised of two thirty-foot modules (or 60 feet in length) would be illegal and the load would, therefore, be required to be shortened to one module (or to a thirty foot load-length). Conversely, one single module, measuring 60 feet (which could not be physically divided to meet the 55-foot limit) would be legally acceptable by waiver.

Under common-carrier truck rates (established by the Interstate Commerce Commission), the freight costs for transporting modules could potentially be reduced by as much as 30 percent if more than one unit was simultaneously transported on a trailer. A "divisible-load" authorization, together with the use of expandable trailers, could also substantially reduce the size of the manufacturer's trailer fleet, significantly cut shipping costs, and conserve fuel.



SHORT-LENGTH MODULE LEAVING URBAN AREA ON INTERSTATE HIGHWAY

- *Permits: Treatment of the standard 12-ft. wide module as a "special movement":* Standard practice has typically required the issuance of a separate permit from each state highway department over the planned route, usually for each module, for each trip, thereby adding greatly to transportation costs with no appreciable benefit to the state, carrier or shipper.

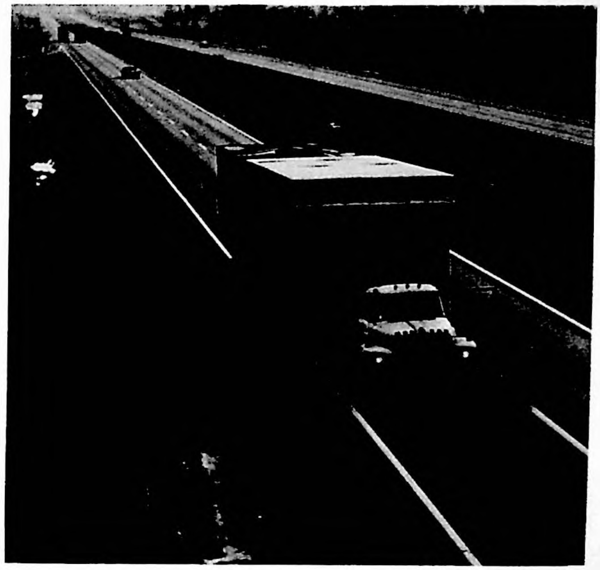
- *Absence of standardized travel times, sign requirements, escorts, etc:* Because of the maze of varying highway regulations, interstate shipment-planning called for extensive preparation which often included providing excess equipment needed to meet differing requirements. During any given trip, it was not unusual for a driver to stop at a state line and wait for a specified time of day before continuing his trip into the next state. Sometimes a shipment in one state was authorized to travel over an interstate highway but upon entering an adjoining state was re-routed to use only secondary roads.

Routing

"Twelve-wide" movements have come of age since 1971. Initially, state-determined routings were truly circuitous. As BREAKTHROUGH progressed, the gathered data was provided to the states. Experience indicated that use of the high visibility, multi-laned, divided freeway was the optimum method for such routing.

For example, in shipping over 130 modules from eastern Pennsylvania to Macon, Georgia in 1971, circuitious routing required 15 percent additional mileage per trip. In 1973 the same trip would require only 8 percent additional mileage.

An analysis, recently requested by HUD, of 500 actual shipments (traveling over 89,000 miles) of modular and mobile housing, indicated a 7.9 percent circuity factor as an average U.S. figure. Costs, associated with circuitous routing, increase directly with the additional mileage.



ROUTING ON INTERSTATE HIGHWAY OFTEN REDUCES COST

Cost Impact

It was estimated that by removal of several of these restrictions (including the "divisible load") and by simplification and/or standardization of others that highway transportation costs could thereby be reduced between 25 and 40 percent. Therefore, BREAKTHROUGH vigorously pursued these matters with AASHO.

Safety

The AASHO representatives were initially reluctant to recommend changes in procedures in view of safety considerations and previous experiences with other wide-load shipments. Further discussions revealed that improvements in the design of transporters and control of tractor operations would eliminate several of the concerns expressed. Accordingly, the following safety improvements were promoted by HUD, in cooperation with AASHO:

- Use of heavier transporter frames manufactured from tubular steel or other suitable steel shapes, in place of transporter frames employed to transport the lighter weight mobile homes.

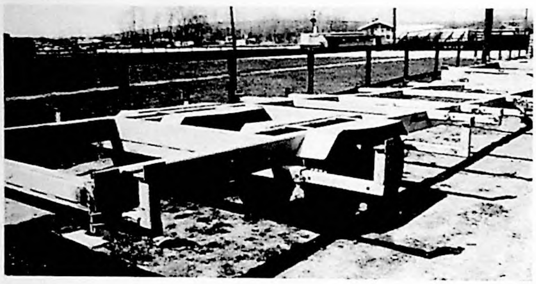
- Use of a "fifth wheel" tractor-to-transporter connection, instead of the pintle-hook, hitch-ball or lunette-eye hitch which had been commonly used.

- Substitution of an air-brake, or air and hydraulic system, for the more popular electric braking systems often employed on transporters.

- Improved horsepower-to-weight ratios to provide better tractor pulling and vehicular control, particularly on higher speed roads.

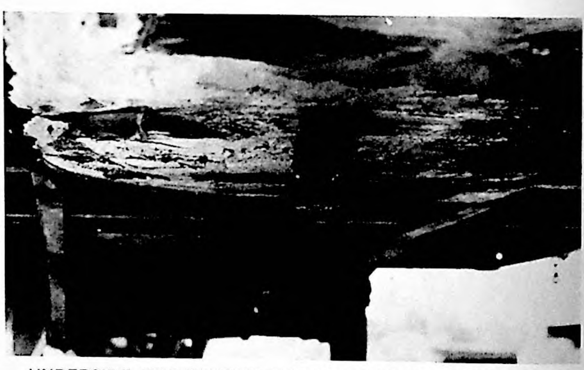
- Use of pneumatic-suspension systems for enroute load-leveling.

While all these transportation safety improvements were not completed during the relatively short period of Phase II of Operation BREAKTHROUGH, HUD's willingness to encourage their adoption by private, contract, and common carrier operators resulted in AASHO acceptance of most of these recommendations.



TYPICAL HEAVY TRANSPORTER FOR MODULAR HOMES

5th WHEEL PLATE AND SLOT FOR ACCEPTING PIN



UNDERSIDE OF TRANSPORTER SHOWING 5th WHEEL PIN

New Recommended Policy

Revised AASHO policies*, covering the highway shipment of mobile and modular units, became effective in May 1973. A total truck and module load length of 85 ft. is now permitted. More than one module may be carried on a single trailer. The new policy includes a system of standarized protective flags and signs, and treats a 12-ft. wide module as a "routine" movement. AASHO also encouraged the establishment of mutually connecting interstate routes. This could result in much more direct travel over the interstate highway system.

It should be carefully noted that although the new AASHO recommended policy has been endorsed by all state highway departments, these regulations may not be completely acceptable to the respective legislative bodies. It is therefore recommended that all modular shippers maintain close contact with state highway departments along their delivery routes.

The adoption of these changes is a significant step toward resolving highway transportation problems faced by the manufactured-housing industry. By providing more uniformity, the new policy can also serve to reduce the final cost of shelter delivered from the factory.

While the original restrictions were an impediment during BREAKTHROUGH's Phase II, these new policies should be very significant in Phase III (the volume production phase), and for the entire U.S. manufactured-housing industry.

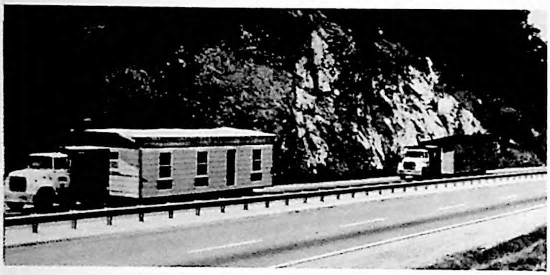
*"Recommended Policy on Maximum Dimensions and Weights of Motor Vehicle to be Operated Over the Highways of the United States" Section 3.04: "Special Procedures for Movement of Mobile and Modular Homes", page 17 (printed February 23, 1973, and released April/May 1973 by AASHO, Washington, D.C.)

DIVISIBLE LOADS IN TRANSIT

OPERATIONS

Highway travel experience during BREAKTHROUGH's Phase II was broad and comprehensive. Modules typically traveled 200 to 300 miles from the factory to the building site, but one producer logged more than 300,000 module miles shipping by highway to a site over a thousand miles away.

A variety of highway types were involved, including interstate, state, county, township, and unpaved roads. For the most part, transportation occurred during weekday, daylight hours and encountered rain, snow, high winds and other adversities of weather. The terrain included flatland, hills, mountains, and urban areas.

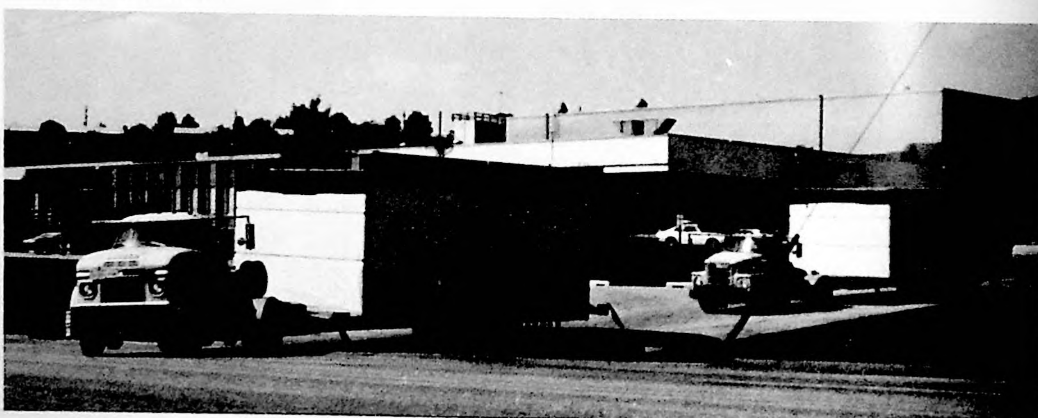


MODULES IN TRANSIT THROUGH MOUNTAINOUS TERRAIN

Transportation Systems

Three types of highway transportation systems were available to the BREAKTHROUGH housing systems producers: common carrier, contract carrier and private carrier.

Most BREAKTHROUGH participants used interstate common carriers (members of the Mobile Housing Carriers Conference, Inc.), who supply owner/operators to haul the transporters provided by the module producer. These common carriers (experienced in all facets of modular shipping) are governed by ICC and DOT regulations.



COMMON CARRIER LEAVING G.E.'S FACTORY FOR 1135 MILE TRIP TO MEMPHIS, TENN. WITH CAST-PLASTER WALL MODULES

Briefly, the disadvantages of common carrier are:

1. competition with mobile-home manufacturers for the limited truck and driver resources during the former's traditional peak production season (May through October);
2. driver reluctance to accept changing production and erection site schedules which often result in substantial pick-up and delivery delays;

The advantages are obvious:

1. nationwide, stabilized freight tariffs, usually lower than contract or private carrier operations;
2. no commitment of investment capital for services of tractors, drivers, maintenance help (as would be required for private carrier);
3. commitment of funds for transport services solely on an "as needed and when needed" basis (as contrasted to an agreed-upon minimum use commitment when contract carriers are involved).

"PIGGYBACKING" TRANSPORTERS ON RETURN TRIP

A few BREAKTHROUGH producers employed *contract carriers* which provided both operator, tractor and transporter.

Advantages of contract carrier operations include:

1. quick availability of personnel and equipment;
2. considerable flexibility in their schedules to accommodate plant and job-site delays;
3. intimate knowledge of the producer's transport requirements.

However, unless an unusually large shipment volume is anticipated, such special-service costs are about twenty-five percent higher than those charged by common carriers.

Private Carriers:

Private carriage is the most responsive service, wholly tailored to the module or panel producers' style of operation. Three BREAKTHROUGH module producers operated small privately owned fleets of tractors and drivers, augmenting this nucleus with on-call common-carrier service whenever factory output was heavy. Hauling equipment costs varied widely depending upon equipment type and terrain (from 1-1/2 tons for light equipment operating in flatlands — to 5 tons for dual-transmission tractors employed in Rocky Mountain operations). Generally, the fixed capital costs, required to support private carriage, are not acceptable unless a high utilization of equipment and labor can be achieved. Either daily use, or transporting other products that the parent company produces, is necessary to assist in absorbing a portion of overhead costs.

Suggestions for Cost-Savings

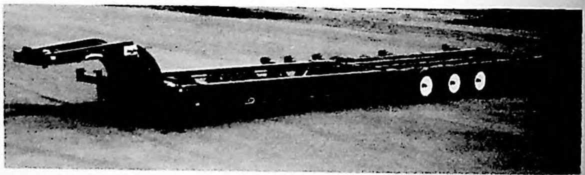
In all three cases (common, contract, private), there are fundamental steps that can be taken to reduce the per-mile transport costs. These are:

1. the shipper (or carrier) should endeavor to obtain a MULTIPLE-TRIP PERMIT covering overdimensional loads *directly* from each state or municipality (as opposed to paying for each permit on a per-trip basis);
2. if a multiple-trip permit cannot be acquired, the shipper has the option of *directly* obtaining the requisite single-state or municipality permits, and thereby eliminating sizable administrative costs, charged by the carrier;
3. use of maximum length-of-load (considered to be a maximum of 85 feet including tractor and transporter) in order to transport more than one module or panel simultaneously;
4. "piggy-backing" of empty transporters to achieve minimum-cost back-hauls;
5. direct consultation with state officials to ascertain the most expeditious interstate routing possible in order to reach a "loaded-mile" distance agreement with the carrier prior to shipment. Alternatively, the use of the publication "Household Goods Tariff #9" can be the mileage criterion (unless the carrier can provide written support that circuitious routing is required by state permit-issuing authorities);
6. assuring that "short-line" mileage distance computation is employed in computing the per-mile cost distance for return of empty transporters;
7. providing and maintaining portable electric-light "harnesses" (required by U.S. Department of Transportation and certain state regulations) to reduce rental costs;
8. if possible, negotiate with state and/or local authorities to alleviate the requirement for escort cars particularly on high-visibility highways.

Equipment Costs

Simple cost comparisons between the various highway transportation methods are apt to be misleading. Highway transportation is complex and BREAKTHROUGH cost decisions required careful consideration of all factors involved.

Transporters initially cost between $5,500 and $11,000, and were usually amortized over a five-year period. Maintenance costs varied and ranged between .01 cents and .05 cents per mile, largely involving tire and brake repair and replacement. Several of the producers found that steel-belted radial tires were preferable for transporter use since better wear was achieved under heavy loads. The steel-belted tires lasted approximately 20,000 miles. BREAKTHROUGH experience indicated that transporter mileage ranged from 15,000 to 20,000 miles per year.



TYPICAL MODULE TRANSPORTER

The number of transporters required was governed by the manufacturing plant output and by the effective recycling of the transporter fleet. Efficiency was appreciably reduced when transporters were idled because of standby at the plant, waiting to be unloaded at the building site, making an empty return trip to the factory, or out-of-service for repairs. These factors, therefore, had to be watched closely by both plant and site management.

In a few instances common carriers provided transporters, in addition to the tractors, and charged published ICC tariff rates for their use. By providing multi-factory service, they improved efficiency and obtained 30,000 to 50,000 miles per year, per transporter.

For those companies performing their own transporting, tractor (power-unit) requirements averaged about one for every 3.5 transporters. The tractors initially cost between $7,500 and $9,000.

TYPICAL TRACTOR POWER UNIT USED WITH TRANSPORTERS

Driver's pay, maintenance and operating costs totaled approximately $0.41 per mile. Tractor utilization averaged about 50,000 miles per year and equipment remained in service about four years. (This motor-element is the most costly part of the entire highway transport system, and therefore factory output must be quite large to justify a private-carrier operation.)

Escort Regulations

Escorts or pilot cars were helpful both to the driver of the towing vehicle and to motorists approaching from the front or rear. Escorts served (1) to guide the driver away from situations which could have been hazardous; (2) to caution motorists in the vicinity of a wide-load; (3) to expedite non-stop deliveries through suburban and urban areas adjacent to BREAKTHROUGH plants and building sites. For those reasons, all but three states required escorts on at least some routes, and all states (including the three with no specific regulations) reserved the right to designate escort requirements as they deemed necessary. Also, some states had the option to require a flagman.

Although a few states specify police, truck-regulatory, or state-certified escorts, most escort services are provided by private contractors. Frequently, housewives, retirees, or students working on a part-time basis are used. This is possible because there are almost no barriers to entry into the escort business. Almost any automobile can be rigged with required accessories which may include warning signs, flags, and lights similar to those required on the tractor-transporter itself.

ESCORT REGULATIONS FOR 12-WIDES
(IN EFFECT OCTOBER 1973)

		Conditional Escort Requirements							
		Escort Designation by Highway Characteristics				Escort Designation by Dimensions			
State	Required for All Moves	2-Lane	4-Lane or Divided	Interstate	Lane Width	Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Alabama	–	–	–	–	–	–	–	–	–
Arizona	–	Front and Rear	Front and Rear	–	–	–	–	–	–
Arkansas	–	–	–	–	Front if < 11 ft.	–	–	Front on 2-lane if combination > 75 ft.	–
California	–	–	–	–	–	–	–	State map designates where front escorts are required	c/
Colorado	–	–	–	–	–	–	–	State map designates where front escorts are required	–
Connecticut	Front	–	–	–	–	–	–	–	c/
Delaware	–	–	–	–	–	Front if > 75 ft.	–	Rear also on 2-lane if combination > 85 ft.	–
Florida	–	–	–	–	–	–	–	–	–
Georgia	–	–	–	–	–	Rear if > 75 ft.	–	–	–
Idaho	–	Front	Front	–	Front, Rear if < 10 ft.	–	–	–	a/
Illinois	Flagman	–	–	–	Front if < 11 ft.	–	–	–	–
Indiana	–	–	–	–	–	–	–	Front, rear if load exceeds 1/2 of roadway	–
Iowa	–	–	–	c/	–	Front if > 70 ft.	–	–	–
Kansas	–	Front	–	–	–	–	–	–	–
Kentucky	–	Front	–	–	–	–	–	–	–
Louisiana	–	–	–	–	Front if < 10 ft.	–	–	–	–

(Continued)

Conditional Escort Requirements

State	Required for All Moves	Escort Designation by Highway Characteristics: 2-Lane	4-Lane or Divided	Interstate	Lane Width	Escort Designation by Dimensions: Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Maine	–	Front	Rear	Rear	–	–	–	–	c/
Maryland	Front	–	–	–	–	–	–	–	–
Massachusetts	–	–	–	–	–	Front if > 70 ft.	–	–	–
Michigan	–	–	–	–	–	Rear if > 80 ft.	–	–	–
Minnesota	–	–	–	–	–	–	–	–	–
Mississippi	–	–	–	–	–	–	–	–	–
Missouri	–	Front	Rear	–	–	–	–	–	–
Montana	Front	–	–	–	–	–	–	–	–
Nebraska	–	–	–	Rear	–	–	–	Front in metropolitan areas on 2-lane	–
Nevada	–	–	–	–	–	–	–	–	–
New Hampshire	–	Front	Rear	Rear	–	–	–	–	c/
New Jersey	–	–	–	–	–	–	–	–	–
New Mexico	–	–	–	–	Front if < 10 ft.	Front if > 90 ft.	Front if > 70 ft.	–	–
New York	–	Front	–	–	–	–	–	–	–
North Carolina	–	Front	–	–	–	–	–	–	–
North Dakota	–	–	–	–	–	–	Front if > 75 ft.	–	–
Ohio	–	–	Rear	Rear	–	Front if > 80 ft.	–	State map designates where front escorts are required	–
Oklahoma	–	Front	–	–	–	–	–	–	–
Oregon	–	Front	–	–	–	–	–	–	–

(Continued)

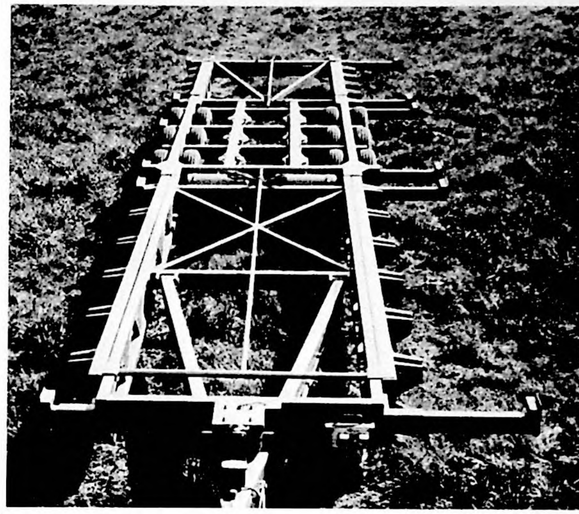
State	Required for All Moves	Conditional Escort Requirements: Escort Designation by Highway Characteristics: 2-Lane	4-Lane or Divided	Interstate	Lane Width	Escort Designation by Dimensions: Combination Length	Coach Length	Other Escort Designations	Additional Requirements
Pennsylvania	–	–	–	–	–	–	–	Front on 4-lane or divided; front, rear on 2-lane if combination > 85 ft.	–
Rhode Island	–	–	–	–	–	Front if > 80 ft.	–	–	–
South Carolina	–	–	–	–	–	–	–	–	–
South Dakota	–	–	–	–	–	–	–	–	–
Tennessee	–	–	–	–	–	Rear if > 75 ft.	–	State map designates where front escorts are required	–
Texas	–	–	–	–	–	–	–	Front, rear if load exceeds 1/2 of roadway	–
Utah	–	–	–	–	–	Rear if > 90 ft.	–	–	b/
Vermont	–	Front	Rear	Rear	–	–	–	–	–
Virginia	–	Front and Rear	–	–	–	–	–	–	–
Washington	–	Front and Rear	–	–	–	–	–	–	c/
West Virginia	–	Front	Rear	–	–	–	–	–	–
Wisconsin	–	–	–	–	–	–	–	State map designates escort requirements	–
Wyoming	–	–	–	–	–	–	–	Front, rear on 2-lane, rear only on 4-lane, divided if combination > 90 ft.	–

Notes: a/ State map available summarizing specific escort requirements.
b/ Escort must be state certified.
c/ Two-way radio required.
– Indicates escort not required for all moves

Use of two-way radios (between tractor and escort vehicles) proved valuable and is strongly recommended.

In BREAKTHROUGH, special emphasis was placed on selective use of escort service for the hilly southeastern U.S. where the escort costs averaged $0.06 per loaded-mile. In the Midwest, average 1971-72 escort costs were about $0.02 per mile. In Phase III, New England and New York State costs were substantial. Overall BREAKTHROUGH's escort costs averaged $0.03 per loaded-mile. The table titled "Escort Regulations for 12-Wides" contains a summary of the *present* state regulations governing escorts.

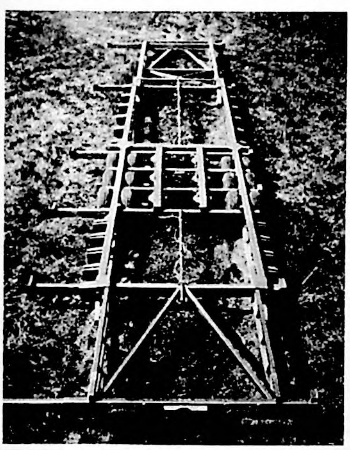
Actual use of escort cars averaged $0.30 per escort-mile per car. All such costs incurred are passed to the shipper and, ultimately, to the home purchaser.



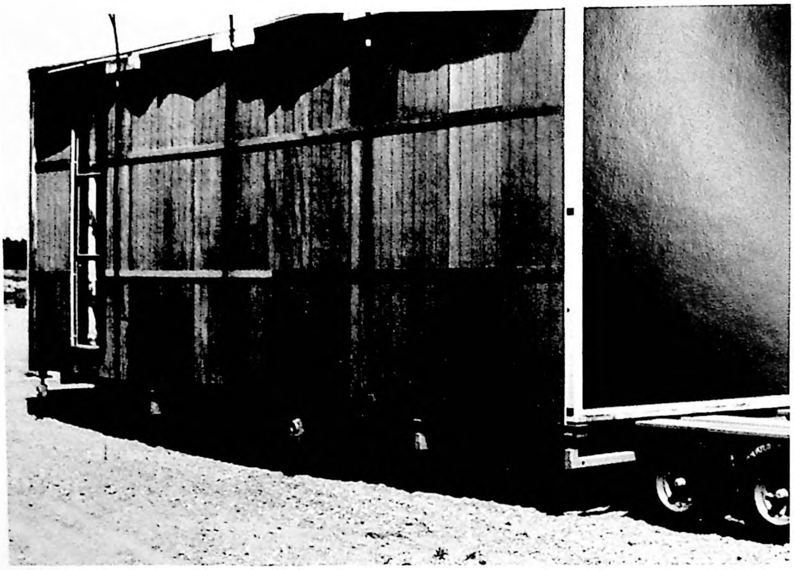
TRANSPORTER WITH EXPANDABLE OUTRIGGERS

Transporter Characteristics

The highway transporter (the trailer upon which the module is carried during highway transit) is a key element in the movement of units from the factory to the building site. Early in the distribution stage, several BREAKTHROUGH producers found that the typical general-purpose inexpensive transporter often was unsatisfactory. Its lack of rigidity resulted in undesirable module deformations, (i.e., wall cracks, minor racking). It was not versatile enough to transport the various sizes and weights of modules being produced, and frequent repairs, causing substantial down-time, occurred. Consequently, most producers replaced their initial lightweight transporters with those constructed of heavier tubular steel. Expandability also was a feature of most replacement transporters, allowing 12-ft. and even 14-ft. wide loads, 65 ft. long to be carried. For the return trip, these expandable-type units could be reduced to the normal legal 8 ft. wide by 40 ft. long measurements so that special highway permits were not required. Tubular steel construction allowed the adjustable members to be "sleeved", permitting extension and retraction, usually by six-inch increments.



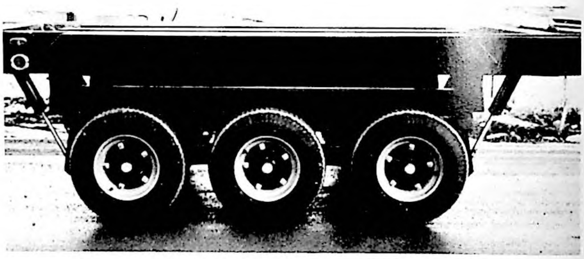
EXPANDABLE TRANSPORTER CAPABLE OF HANDLING MODULES 60 FEET LONG



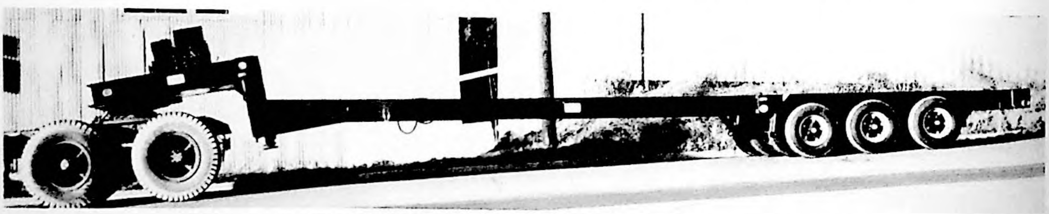
HERCOFORM'S SPECIAL TRANSPORTER MADE WITH HEAVY TUBULAR STEEL
– NOTE OUT-RIGGER PADS WITH ADJUSTMENT SCREWS

Several producers had the transporter manufacturer study their specific module design support requirements. Outriggers were located to provide support at points of concentrated load to reduce module flexing during transit. One producer equipped the outrigger pads (which supported the module) with vertical screw adjustments. This permitted compensation for outrigger flexing under load, corner sag, etc., and assured uniform support. Those producers who transported long loads and used fully extended transporters (up to 60 ft.), found it desirable to stiffen the transporter main frame to avoid adverse module flexing. Most producers secured the module to the transporter with standard lagscrews driven into the module joists through preformed holes in the outrigger pads and bolsters. Other methods used are outlined in the discussion of specific producer's techniques.

An enroute load-leveling feature was provided on some transporters, using both hydraulic and pneumatic systems.



HYDRAULIC LEVELING SYSTEM

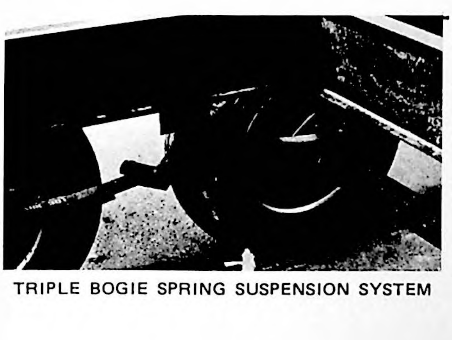


LEVELING SYSTEM POWER-SOURCE LOCATED ABOVE FIFTH-WHEEL HITCH

The hydraulic systems were operated by a gasoline engine, mounted on the transporter, or by a DC motor. Pneumatic systems included an air tank filled for each trip, which was used to inflate air bags on the transporter frame. Air bags usually were doughnut or cylindrical in shape.

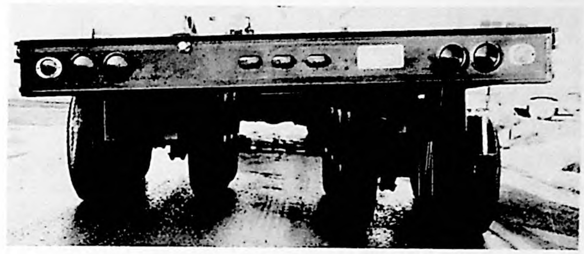
Both systems allowed independent raising or lowering of either side, front or back of the transporter, in addition to raising or lowering the entire transporter frame. Thus weight distribution could be adjusted, a heavier side could be raised, and load-leveling over high-crowned roads accomplished.

In some cases, this vertical lifting feature was used for loading at the factory and for unloading the module from the transporter directly onto foundations or temporary supports at the building site *without the use of a crane.* The transporter could be lowered to clear the stored module, backed under the module, then raised to lift the module off its temporary support for movement to the building site. At the building site, the process was reversed to place the module on a three-sided foundation (the fourth wall to be built later), or on temporary supports. This feature also was used to level the module on sloping ground in preparation for sliding over rails onto the foundation walls or onto railcars for shipment. The pneumatic system also served to reduce shock and vibration during travel, particularly over the roughest part of the trip from the main highway to the building site and over the on-site dirt roads.



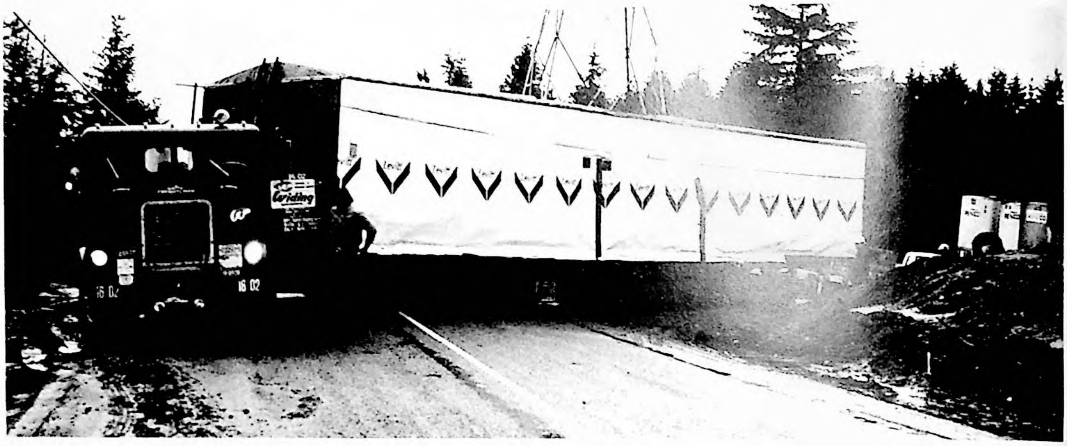
TRIPLE BOGIE SPRING SUSPENSION SYSTEM

The most widely used axle suspension system was the "triple bogie". With this system, axles are connected by springs, torsion bars or other devices to distribute the weight more evenly to each wheel. One company used transporters with a cable suspension system which served to accomplish the same result.



REQUIRED DOT LIGHTS AND REFLECTORS

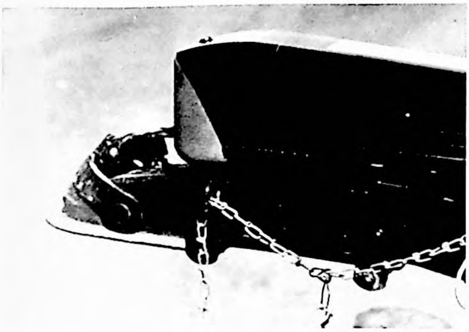
Typically, tire sizes were 800x 14.5-12 ply, with 12 tires normally required per trailer. All transporters moving interstate had lights conforming to U.S. DOT regulations.



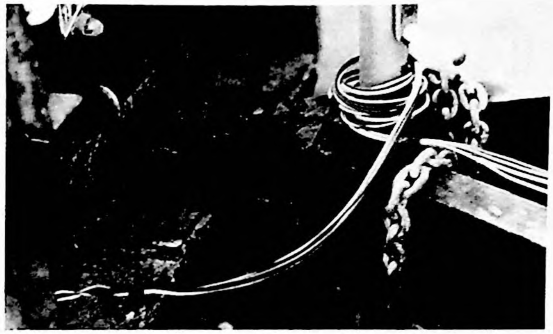
TRANSPORTER WITH 60 FT. MODULE

Transporter weight is an important consideration, since some interstate common carriers charge for the total (module and transporter) weight. Empty transporter weight ranged from 7,000 to 11,000 pounds depending on capacity, size, expandability, etc. Since expandable transporters tended to weigh about 3,000 to 5,000 pounds more than the non-expandable ones (and substantial excess weight is paid for during the life of the transporter), the module producer had to keep this in mind when selecting the optimum type of transporter. However, for those producers able to carry two modules on one extended transporter, the savings in transportation cost and requirements for fewer transporters easily offset the costs of the added weight.

Various hitch connections between transporter and tractor were used. The fifth-wheel hitch was promoted by HUD and used by about half of the housing producers. By this method, a major portion of the load weight is transferred to the tractor thereby providing better handling and improved safety during both highway and on-site travel. An additional five or more feet of transporter length is required for the fifth-wheel mounting, which occasionally caused loads to exceed certain state highway restrictions. The fifth-wheel system is also more costly because of (1) the addition of a "goose-neck" to the trailer; and (2) it generally required a larger powered tractor. Extra costs were off-set by greater load-control and improved highway performance.

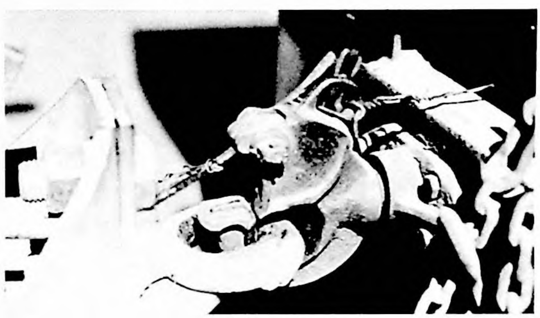


BALL TYPE HITCH



BALL HITCH ATTACHED TO TRACTOR

LUNETTE EYE HITCH



LUNETTE EYE ON TRANSPORTER

LUNETTE HITCH COUPLED TO TRACTOR

Other connections used included the hitch-ball connection, (traditionally used to transport lighter *mobile home* units). This connection was considered to be marginal by several producers, particularly those who shipped heavier modular loads over hilly terrain. The pintle-hook, developed by the military, was used satisfactorily by one producer, but experience with it in BREAKTHROUGH appeared to be too limited to offer a clear comparison with the fifth-wheel hitch. Several manufacturers used the lunette-eye hitch which some shippers considered to be standard equipment for the heavy tubular steel transporters.

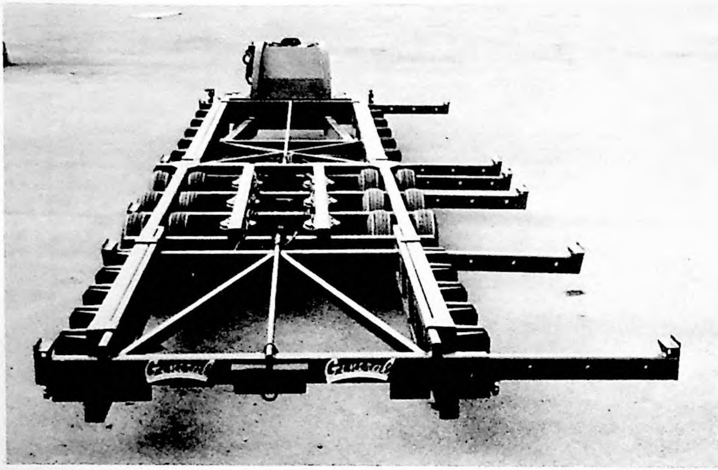
The following table, "Summary of Highway Transporter Specifications" provides a comparison of equipment used during Phase II of Operation BREAKTHROUGH. Photos of several of the types of transporters described in the table are included.

SUMMARY OF HIGHWAY

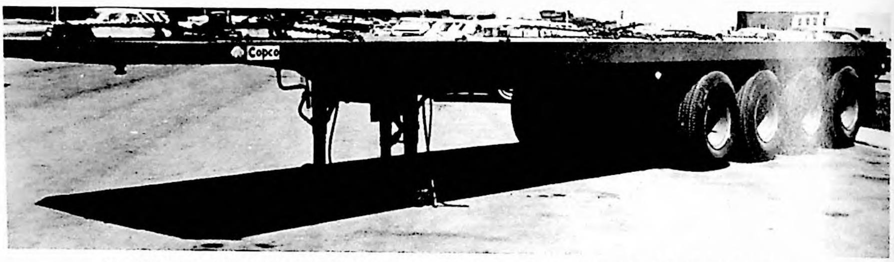
HOUSING MANUFACTURER	CARRIER SOURCE	TRANSPORTER TYPE	FRAME CONSTRUC-TION	CAPACITY (LBS.)	WIDTH (FT.)
Alcoa	Common	Flat Bed	I-Beam	40,000	8
Boise (Arabi)	Common	Expandable	Tubular	36,000	8–14
Boise (Meridian)	Private	Fixed and Expandable	I-Beam	40,000	8 and 8–12
BSI	Contract	Fixed	I-Beam	40,000	8
CSC	Contract	Low-Boy	I-Beam	60,000	12
Camci	Private	Fixed	I-Beam	40,000	8
Descon/Concordia	Contract	Fixed	I-Beam	40,000	8
Dillon	Private	Flat Bed	I-Beam	40,000	8
GE	Common	Fixed and Expandable	Tubular	40,000	8–14
HBC	Private	Expandable	Tubular	36,000	8
Hercoform	Common	Expandable	Tubular	36,000	8–14
Levitt	Common	Expandable	Tubular	36,000	8–14
MSC	Contract	Expandable	Tubular	36,000	8–14
National	Private	Expandable	Tubular	30,000	8
Pantek	Contract	Flat Bed	I-Beam	40,000	8
Scholz	Private	Two-Section Adjustable	Tubular	36,000	8–14
Shelley	Contract	Low-Boy	I-Beam	120,000	10

TRANSPORTER SPECIFICATIONS

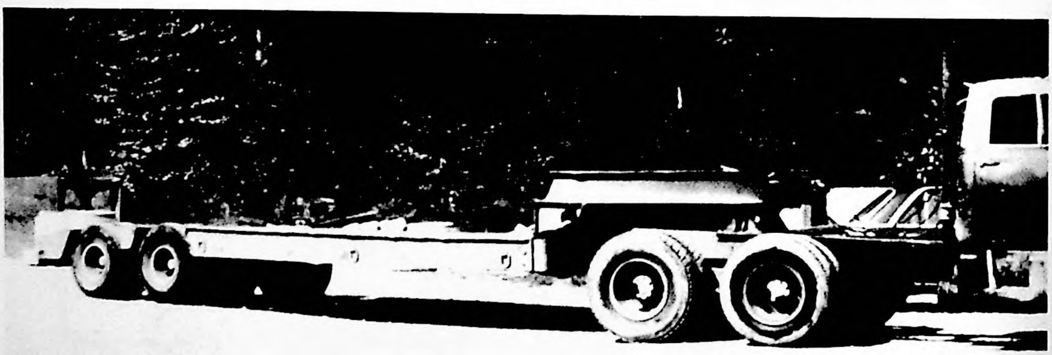
LENGTH (FT.)	HEIGHT (IN.)	TYPE HITCH	BRAKES	SUSPENSION	AXLE		NO. TIRES
40	54	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	8
36–60	31	Lunette	Air/ Hydraulic	Bogie	Triple	8.00x14.5–12 Ply	8
65 and 45–65	32	5th Wheel	Air	Walking Beam	Dual	7.50x15–12 Ply	12
40	42	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	8
36	40	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	16
40	42	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	8
40	42	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	8
40	42	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	8
22 and 40–68	30	Ball	Elec.	Bogie	Triple	8.00x14.5–12 Ply	12
36–60	30	Pintle	Elec.	Bogie	Triple	8.00x14.5–12 Ply	12
40–68	30	Lunette	Elec.	Bogie	Triple	8.00x14.5–12 Ply	12
40–68	30	5th Wheel	Elec.	Bogie	Triple	8.00x14.5–12 Ply	8
40–60	31	5th Wheel	Air/ Hydraulic	Bogie	Triple	8.00x14.5–12 Ply	12
40–50	30	Pintle	Elec.	Bogie & Cable	Triple	9.00x14–12 Ply	12
45	42	5th Wheel	Air	Spring	Dual	9.00x15–12 Ply	8
N/A	18	Special Ball	Elec.	Spring	Triple	7.50x15–12 Ply	12
53	36	5th Wheel	Air	Trunnion	Dual	10.00x15–14 Ply	16



EXPANDABLE MODULE CARRIER SHOWING PNEUMATIC-RIDE LEVELLING SYSTEM LOCATED BETWEEN THE BOGIES



AN EXPANDABLE FLATBED SUITABLE FOR TRANSPORTING COMPONENTS



A TYPICAL 5th WHEEL LOWBOY

Physical forces, caused by input accelerations, generated by highway travel, were measured independently by several housing system producers. The table below, prepared by General Electric Co., was developed by actual test in order to assess the gravitational ("G") forces induced into a typical module moving over a variety of road-conditions and speeds.

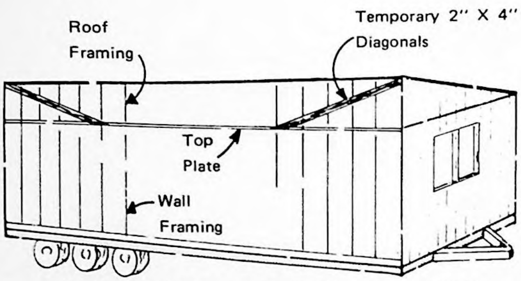
As expected, critical vertical acceleration generally occurred on non-interstate highways; that is when unexpected bumps and chuck holes were experienced, they were often encountered on secondary-road systems or on rough terrain adjacent to open-storage and building site areas.

Acceleration-loads, applied to the module while traveling on uneven roads, results from up-and-down movement of the transporter chassis. These loads were transferred to the module through the wheels and suspension system. Vertical forces could also be generated from an uneven up-and-down motion of the transporter-hitch. When either severe or cumulative, these forces can cause, at minimum, racking of walls resulting in crack damage. In general, fifth-wheel hitches were found to moderately reduce this latter movement since a more uniform modular weight distribution is obtained as compared to the conventional hitch-ball connection system. Use of fifth-wheel hitches also afforded more precise highway-driving control particularly when hauling the heavier modules. Non-uniform dynamic loading, experienced on uneven road surfaces, was reduced by use of heavier transporters. Several Operation BREAKTHROUGH producers switched or modified their transporter inventory to meet rough-road conditions.

Use of pneumatic or hydraulic load-leveling devices (to compensate for "off-center" modular loads i.e., "wet" sections), usually brought vertical oscillations well under control.

ROAD TRAVEL TEST RESULTS

Conditions	Speed (MPH)	Maximum Vertical Force on Module ("G's")	Frequency (H_Z)
1. a. Freeway	30	0.4	7
b. Freeway	60	0.7	20
2. a. Two Lane Blacktop	20	0.9	5
b. Two Lane Blacktop	30	0.7	5
c. Two Lane Blacktop	40	0.6	4
3. a. Washboard	02	1.5	9
b. Washboard	15	1.4	5
4. a. Single Bump	10	1.3	4
b. Single Bump	25	1.5	9



TEMPORARY 2" X 4" DIAGONALS INSTALLED IN SIDEWALL ABOVE WALL PLATE LINE TO RESTRAIN LONGITUDINAL MOVEMENT CAUSED BY SUDDEN BRAKING.

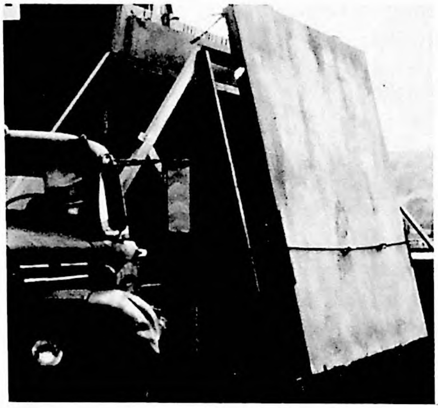
Highway longitudinal forces were generally well absorbed by most module and panel units. Several HPS's countered the tendency of roof-sections of modular-loads to travel forward ("parallelogram"), during sudden stops, by adding 2 in. by 4 in. temporary diagonals (see diagram above) in order to stiffen the upper sections.

The BREAKTHROUGH transporters were remarkably free of lateral sway and the "fish-tailing" phenomenon often observed by the private motorist in passing a mobile home load.

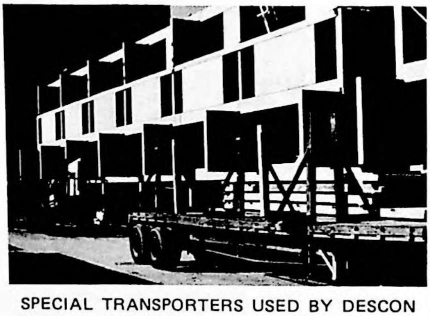
Concrete Panel Transportation

Although transporting prestressed/precast concrete panels over the highway involves some of the same considerations as for modules, it also presents additional and different problems. A substantial part of the cost of a precast panel is the cost of handling. Therefore, designers and manufacturers endeavor to make the units as large as possible, since the increased cost of handling a larger unit is minor when considering the gain in panel area obtained. Limitations on panel size in the factory are such that most panels can be transported within the normal highway size restrictions – 8 ft. wide, 13 ft. 6 in. high, and 40 ft. long. Oversize load permits can be secured (as with modular units) but involve the same restrictions on movement and similar costs.

In actual practice, panel weight tends to be a limiting factor. Flatbed or low-boy type trailers can transport up to 40,000 lbs. without a special permit. Eight-foot wide panels can be carried flat, supported by wood blocking. As long as weight limits are not exceeded, additional panels can be stacked on top of each other, separated by wood blocking. Tie-downs usually are unnecessary because of the weight, but truck chains are often used to secure the panels to the flatbed for safety reasons. Somewhat larger panels can be carried in a semi-upright position by constructing special A-frame racks on the trailer. By lowering the rack to less than a foot from the pavement, additional panel height can be handled without requiring special permits.



SPECIAL DESIGNED TRANSPORTER USED BY CAMCI. "A"-FRAMED RACK IS ONLY TWELVE INCHES FROM THE PAVEMENT



SPECIAL TRANSPORTERS USED BY DESCON FOR TRANSPORTING PANELS

Boise Cascade

Operating as a private carrier, Boise Cascade highway transported its wood-frame modules from its Meridian, Idaho, plant to Sacramento, California, a distance of 930 miles. For this operation, custom-made transporters with I-beam frames, dual-axle walking-beam suspensions, and fifth-wheel hitches were used. One transporter was expandable from 45 ft. to 65 ft. in length, and from 8 ft. to 12 ft. in width. Boise also owned six fixed transporters, 8 ft. by 65 ft. These extra sturdy units were 32 in. high, weighed between 16,000 and 18,500 pounds, and were capable of transporting loads up to 40,000 pounds.

Experience showed that steel-belted, radial tires were best suited for these units. Boise used 750 x 15-12 ply, which last 25,000 to 30,000 miles. Maintenance on the units was limited for the most part to replacement of brake shoes every 15,000 to 20,000 miles and to packing wheel bearings.

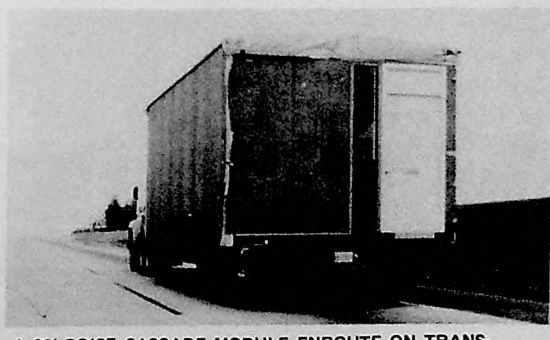
The transporters were designed to allow for raising and lowering as well as for rear steering. All of these functions were controlled from the tractor cab, which enabled the driver to more readily maneuver and align the transporter when loading or unloading modules.

Three-axle, 318-horsepower diesel tractors equipped with air brakes were used for power.

The tie-down systems, used to secure Boise's wood-frame modules, utilized dacron straps which vertically encircled the unit. The same straps were also used in lifting by crane and for securing the modules during railway shipment.

Low-profile transporters, used at the Arabi, Georgia, plant for steel-frame modules, were constructed of tubular steel, adjustable in width from 8 to 14 ft. and, in length, from 36 to 60 ft., with lunette-eye hitch, triple-bogie suspensions and air-hydraulic brakes. They weighed between 9,000 and 11,000 pounds and were capable of transporting up to 36,000 pounds. A common carrier was used to haul the transporter 520 miles to Memphis, Tennessee. Four of these transporters were owned by Boise and three were supplied by the carrier.

The steel-frame modules, manufactured by this firm, were anchored to the trailer with six chains. Single chains were attached to the steel floor joists and the trailer frame at the front and rear, and two were provided on each side of the module.



A 30' BOISE CASCADE MODULE ENROUTE ON TRANSPORTER FROM ARABI, GA. PLANT TO MEMPHIS, TENN. SITE

Community Technology Corp.

An unusual feature of this modular system involved the highway transportation of completely assembled and finished two-story townhouses. These completed units weighed approximately 30 tons and were transported a distance of 12 miles from the factory to the building site.

Prior to undertaking this unique over-the-highway movement, a 21-ft. by 32-ft. long one-story unit weighing 23,000 pounds was transported along a 7.1-mile test route to determine the feasibility of the proposed shipping procedure. An 8-ft. by 40-ft. long flatbed transporter, equipped with two 21-ft. long heavy steel beams (8WF40) as the primary lateral supports, was utilized for this test shipment. In addition to moving the test module over ordinary roads, a special "bump" course was traversed at varying speeds to determine shock effects on the module. It was determined that highway movement of the fully erected townhouses could be achieved at a maximum speed of 5 m.p.h. with little or no damage to the units.

The production shipment of finished two-story modular units was accomplished with a low-bed 16-tire trailer. This 40-in. high unit, 12 ft. by 36 ft. long, was fitted with three heavy steel cross beams which provided support for longitudinal I-beams on which the modular units rested. The transporter was equipped with air brakes, a fifth-wheel hitch and was capable of transporting 30 tons. The entire operation was handled by a contract carrier, who provided a 360-horsepower tractor, equipped with air brakes, to move the units.

To transport these housing assemblies, it was necessary to make advance arrangements to raise overhead power lines and move other obstructions along the proposed route. Because of the weight of the connected units, no tie-downs were required. The entire shipment of townhouses from the plant to the site was accomplished with minimal damage.

TOWNHOUSE ENROUTE TO BUILDING SITE

COMPLETED TOWNHOUSE READY FOR PLACEMENT ON FOUNDATION

The Alcoa building system, a combination of mechanical core units and panelized construction, required two different transportation methods. To ship the core units, Alcoa utilized dual axle, 40-ft. by 8-ft by 54-in. high flatbed trailers, and simply secured the units to the transporters with chains. Panels, roof trusses and other necessary building elements were shipped on both flat-bed and low-boy trailers.

These component parts were banded together on "L" shaped wooden racks at the factory and shipped back-to-back in an upright position on the trailer. Steel strapping encircled the racks and connected to the frame of the trailer to provide securement during transit. Common carrier service was utilized to transport the core units and panels from the factory to the building site.

"L" SHAPED WOODEN RACKS BEING UNLOADED AT BUILDING SITE

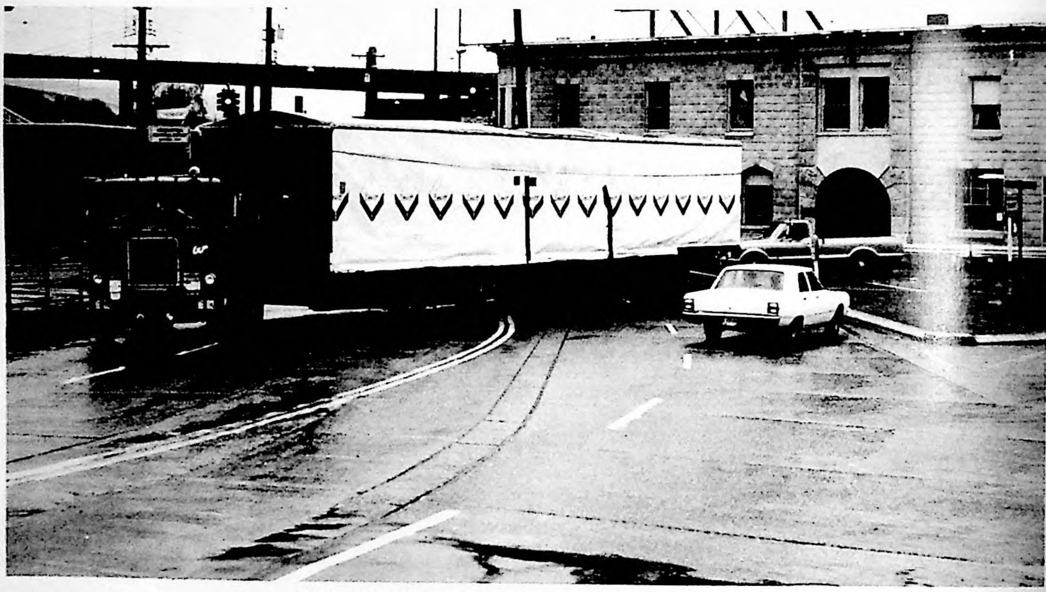
CORE UNITS ENTERING BUILDING SITE

"L" SHAPED RACKS SECURED TO TRANSPORTER

Levitt
National Homes
Hercoform

The highway transporters used by these three companies were all constructed from tubular steel, were 30 in. high and used electrical brakes. National Homes' transporters had a capacity of 30,000 pounds, whereas both Levitt's and Hercoform's could carry up to 36,000 pounds. Levitt used a fifth-wheel hitch, National, a pintle-hook and Hercoform, a lunette-eye hitch. All three producers used triple-bogie suspension, although National used a cable suspension system on some of its units. Hercoform employed two common carriers and Levitt utilized a contract carrier while National provided its own transportation.

An electric-powered leveling system was found by National to cause minor problems because of intermittent battery failure and the inaccessibility of the batteries which were located on the transporter under the module. National also found that transporters with tubeless tires were undesirable. It was discovered that, when enroute, if the loaded transporter moved off the pavement onto the road shoulder, in moving back onto the pavement the tubeless tire may be pushed away from the rim causing a flat tire. To overcome this problem tubes were installed in the tires of all the transporters.

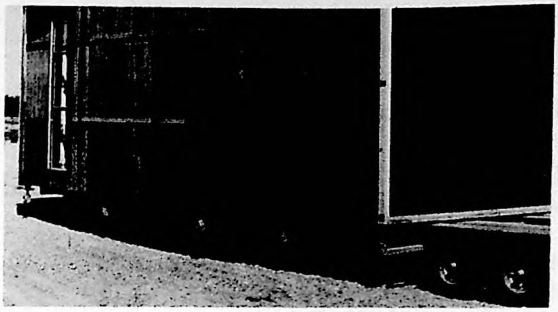


LEVITT MODULE IN TRANSIT ON TRANSPORTER

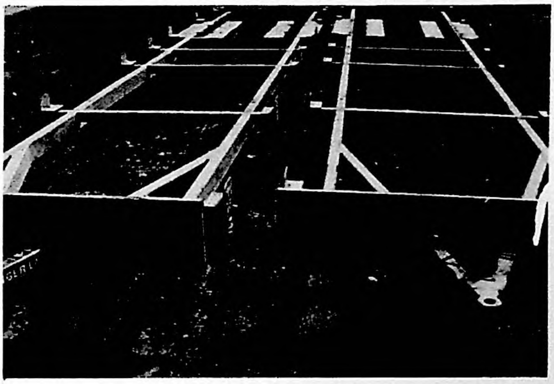
ONE TYPE OF TRANSPORTER SIMILAR TO THOSE USED BY LEVITT, NATIONAL HOMES AND HERCOFORM

The transporters utilized by National were adjustable in length from 40 to 50 ft. Those used by Levitt and Hercoform could expand in length from 40 to 68 ft., while the width could be varied from 8 to 14 ft. This flexibility permitted transportation of a wide variety of modular and component sizes. For example, Levitt was able to include a completed roof section and a standard rectangular module on one trailer load. The flat design of the trailer bed allowed two or more empty trailers to be transported piggy-back for the return trip. Because of the adjustable length and width feature of these transporters, the empty trailers on the trip back to the factory could be adjusted to conform to state highway requirements for permit-free shipment.

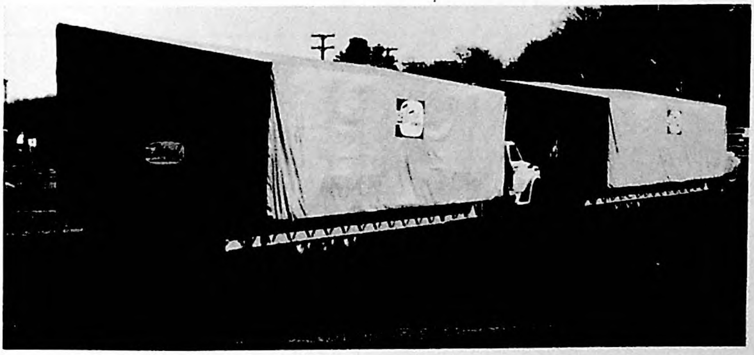
Both National Homes and Hercoform used a tie-down system which secured the module at its base, thus making additional chains or straps unnecessary. Depending on the length of the module, National Homes used from four to six steel brackets attached to the wood floor system and then bolted to the transporter frame. Hercoform used eight 1/2-in. lag bolts through the trailer's steel frame into the module floor system. Both systems were easily installed at the factory and quickly removed for unloading at the job site.



TRANSPORTER USED BY HERCOFORM EQUIPPED WITH ADJUSTABLE OUTRIGGER



TRANSPORTER SHOWING OUTRIGGER ATTACHMENTS

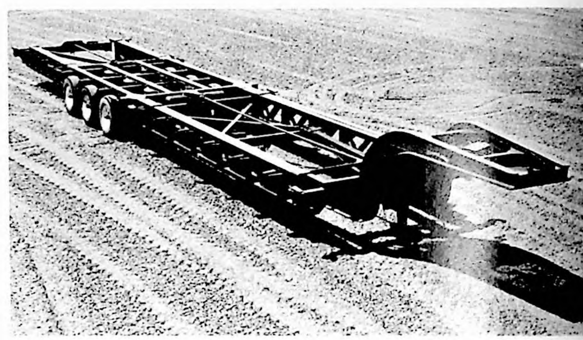


NATIONAL HOMES MODULES APPROACHING BUILDING SITE

Material Systems Corp.
Home Building Corp.

Both of these producers transported modules over the highway on telescoping trailers constructed of tubular steel with triple-bogie suspension and a 36,000-lb. capacity. The adjustable length feature permitted movement of various length modules and allowed a permit-free return trip to the plant.

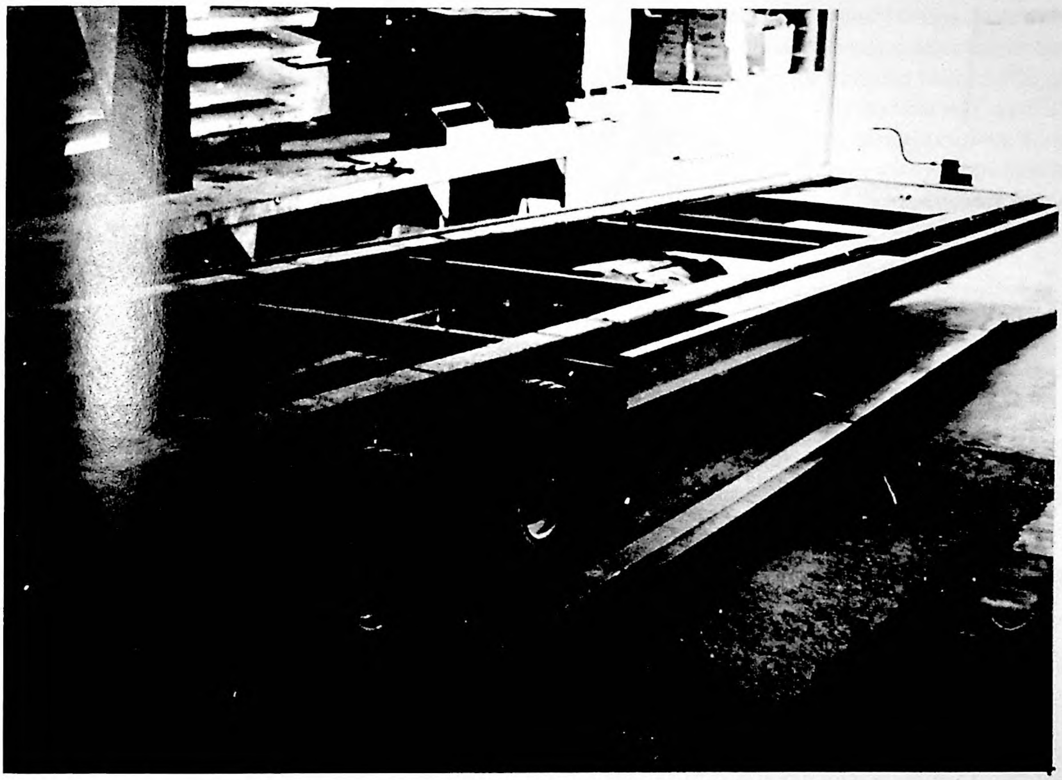
Material Systems Corp. used the service of a contract carrier in the Midwest and a common carrier in the West. The transporters were adjustable in width to 14 ft., and featured air-hydraulic brakes and a fifth-wheel coupling-hitch. The transporter bed could be raised or lowered at either end or side to provide a level platform for the module as well as adjustment for various road conditions. The unit also provided vertical adjustment of the outriggers to compensate for deflection when extended. The tie-down system utilized dacron straps which vertically encircled the unit to secure the module to the transporter. The same straps were also used in lifting by crane, and for securing the modules during railway shipment.



TRANSPORTER USED BY MATERIAL SYSTEMS CORP.

MATERIAL SYSTEMS CORP. MODULE SECURED TO TRANSPORTER WITH DACRON STRAPS

The Home Building Corp. transporter, — 8 ft. wide and 30 in. high — was adjustable in length from 36 to 60 ft., and had electric brakes and a pintle-hitch. HBC performed its own transporting. The modular units were tied down with 1 1/4-inch wide steel bands attached at four points to the transporter and the perimeter joist. Wood blocks were wedged between the module's floor sills and the transporter frame on both sides at the front and rear transporter cross members, and at the transporter jack nearest the hitch to further secure the module against horizontal movements.

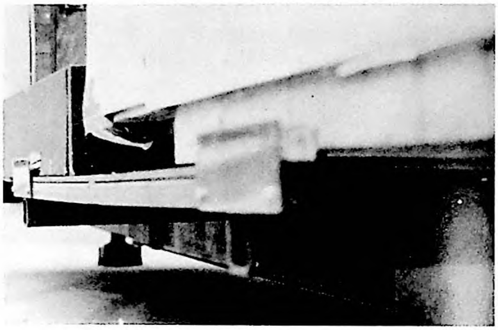


HOME BUILDING CORP.'S TRANSPORTER AT LOADING PIT IN FACTORY

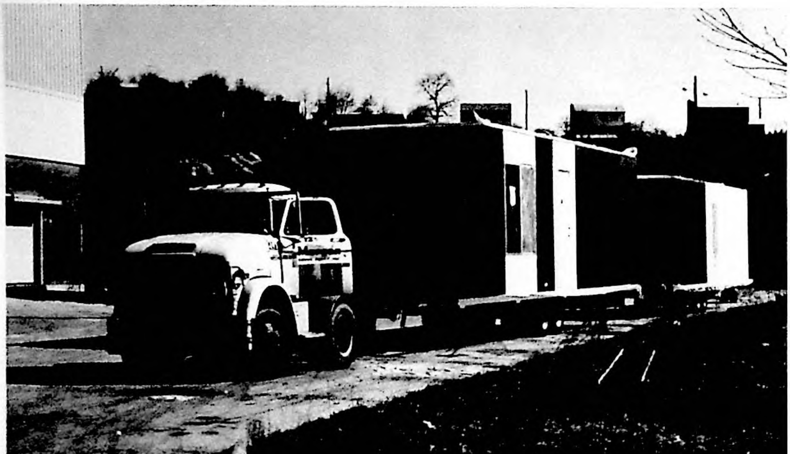
G.E. employed an interstate common carrier trucking firm to move about 96 cast-plaster, steel-stud modules from its Valley Forge, Pa., factory 1,137 miles to the BREAKTHROUGH site in Memphis, Tenn. The modular units, which varied in weight from 9,600 to 19,000 pounds, were moved singly and were allotted five days for delivery. Interstate highways were used, and minimal damage was experienced.

A total of 79 trailers were purchased by G.E. in three different sizes, ranging from 22 ft. long to the expandable type which could be extended to 68 ft. and retracted to 40 ft. Hitch-ball connections were used, and the largest transporter had triple-bogie suspension and a 36,000-lb. load capacity supported by 12 tires. The transporters were constructed from tubular steel, had electric brakes and cost approximately $7,000, which was amortized over five years.

The tie-down method consisted of bolting the module to the trailer. Bolts were used at three places on the front and rear braces of the trailer. Lag bolts were also used for attachment of the module through the support pads on four outriggers of the trailer. The module was thus secured at its base, and no straps or chains were required. The bolts and lag screws were easily installed and removed for unloading.



MODULE SECURED TO TRANSPORTER



G.E. MODULES ON TRANSPORTER AT PLANT IN VALLEY FORGE, PA.

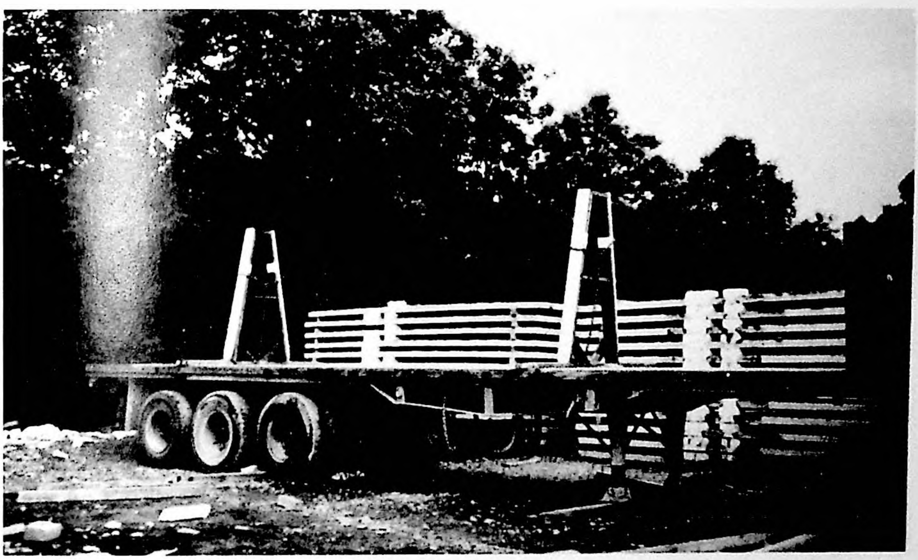
Dillon's mechanical core modules were manufactured on prestressed, precast concrete slabs. Highway transportation was used only to move the modules to and from the rail head for piggyback rail shipment. For this purpose, they were loaded onto regular 8-ft. by 40-ft. trailer-on-flatcar (TOFC) flatbed trailers equipped with a fifth-wheel hitch and a spring-suspension system. Two modules were placed on each trailer by overlapping the slabs about five feet. This resulted in a concentrated load of approximately 9,000 pounds being placed on the bottom slab in the overlapped area.

To support the top slab beyond the overlap, oak-blocking was provided at the far end and near the midpoint of the unit.

At the point of overlap, additional wood blocking was used and the slabs were held firmly together with two-inch wide steel straps to prevent grinding of the surfaces.

Wall panels were transported on these same flatbeds which were equipped with "A" frames in order to hold the panels semierect. Floor slabs were transported flat on the trailers and were supported by wooden blocking.

The Top Roc Precast Corp. (manufacturer of the precast slabs and panels) used its own tractors and trailers and also leased additional trucks in order to highway transport these components to the various sites.



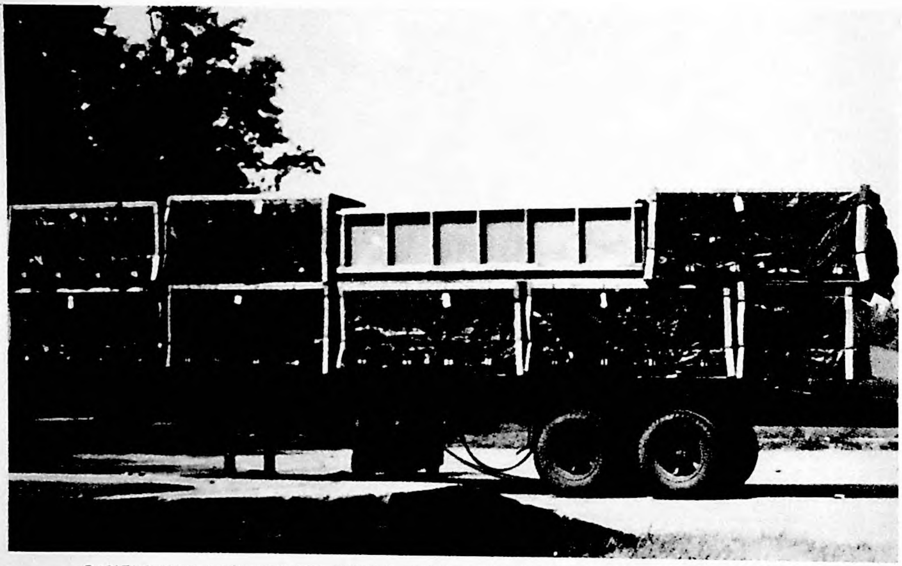
FCE DILLON PANEL TRANSPORTER

Pantek

The lightweight urethane foam core panels (produced by Pantek) were typically 4 ft. by 8 ft. by 4 in. thick. These panels were shipped from Muncie, Indiana, to Indianapolis, Indiana, and Sacramento, California, by contract carrier on standard flatbed trailers carrying 40,000 lbs. each. The trailers measured 8 ft. wide by 45 ft. long, by 42 in. in height. Other features of the transporters were spring-suspensions and fifth-wheel hitches. A 318-horsepower tractor, equipped with air brakes, provided towing power.

Pantek's panels were the smallest units shipped in BREAKTHROUGH. Their handy size made transport relatively simple and easy.

The panels were secured to the flatbed trailer with steel chains that encircled the load.



PANELS FOR 1-1/2 PANTEK SINGLE FAMILY ATTACHED UNITS ON TRANSPORTER

The two-section Scholz transporter supported the module only at its front and rear ends. This required that the module provide sufficient structural rigidity to prevent deflections during transportation. The front of the module was fastened to a separate towing tongue assembly which was ball-hitch connected to the tractor. A specially designed wheeled carriage or dolly was positioned at the rear one-third point of the module and secured to the module with lag bolts.

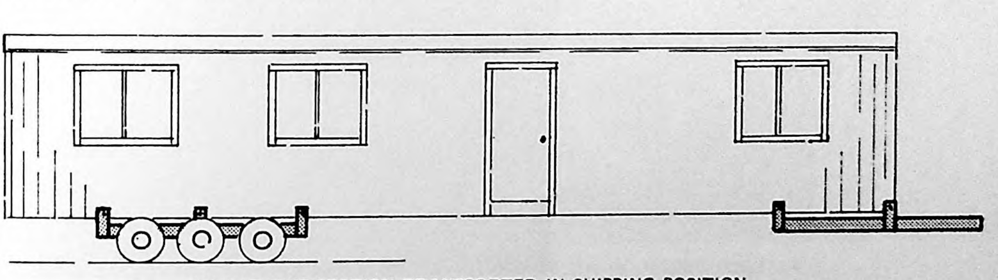
The towing tongue assembly extended six feet under the module and had adjustable tubular outriggers which extended to the module's side rim joists. Lag bolts were used to secure the tongue assembly to the module at the outrigger-rim joist interface and at the front rim joist.

The rear dolly had three sets of wheels on each side (12 tires). For width flexibility, lateral adjustment between these wheels was made possible by the telescoping tubular steel construction. Telescoping outriggers also extended to the sides of the module for added support.

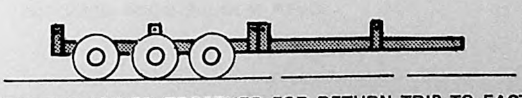
For the return trip to the factory, short tubular steel stubs of the tongue assembly were mated and secured to the steel tubular members of the dolly. This created a trailer on which four additional carriages and tongues could be stacked and chained.

Tires on the dolly were 750x 15-12 ply rated at 5,300-lb. capacity. It was equipped with electric brakes which were automatically locked if the rear dolly broke away from the tractor duing transit. Twenty sets of dollies and tongue assemblies were used by Scholz. A specially installed 2-5/16 in. ball-hitch connection cn the tractor had a capacity of 20,000 pounds.

DOLLY SECTION OF SCHOLZ· TRANSPORTER WITH TONGUE, REMOVED



SCHOLZ TWO-SECTION TRANSPORTER IN SHIPPING POSITION

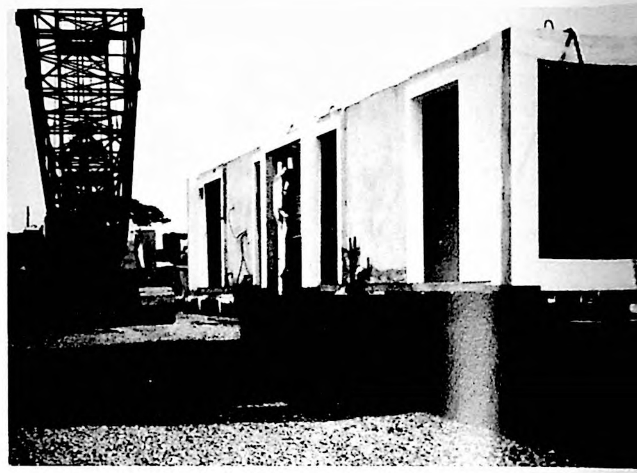


TRANSPORTER JOINED TOGETHER FOR RETURN TRIP TO FACTORY

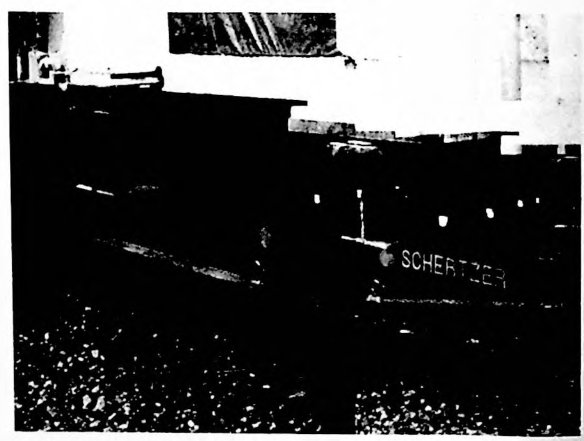
Shelley Systems

To transport concrete modules and panels (produced in East Patterson, N.J., to the prototype building site in Jersey City), Shelley utilized a special purpose 60-ton capacity drop-bed trailer which measured 36 in. high, 10 ft. wide and 53 ft. long. This dual axle, 16-tire (1000 x 15-14 ply) heavy-duty transporter required a special double-transmission tractor to haul the modules, the largest of which weighed 53 tons. Units were loaded onto the trailers at the factory using a straddle-lift carrier.

Initially, cross beams were used to support the module at the front and rear under built-in structural columns, but severe cracking over door openings occurred during the first shipment. Thereafter, the trailers were modified and fitted with folding outriggers made from I-beams to which were attached (at the ends) pneumatic doughnut-shaped cushions. These outriggers extended the transporter to 14 ft. wide and folded into an upright position for the empty return trip.



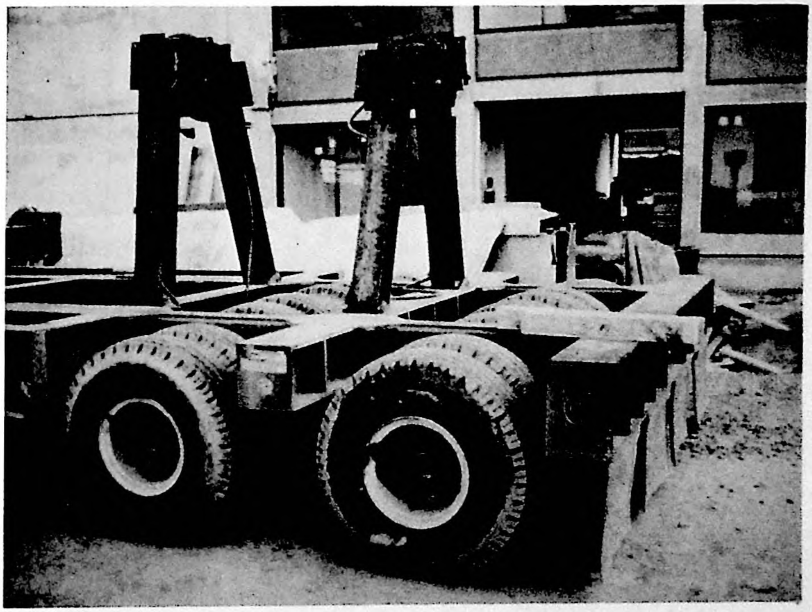
SHELLEY MODULE ON TRANSPORTER



PNEUMATIC CUSHIONS ADDED TO PREVENT CRACKING OVER MODULE DOOR OPENINGS

The weight of the modules precluded the need for tie-downs. Chains were loosely fitted around the units and through the lifting eyelets for added safety. Local regulations restricted road speeds to less than 15 m.p.h. Police escorts were also required to block traffic at intersections and to permit continuous movement without interruption. The entire transportation operation (tractors, trailers, escorts, etc.) was subcontracted.

Flatbed trailers were fitted with special steel "A" frames to transport the precast concrete end panels. These panels were placed on edge and leaned against the frames, and were secured in this position with chains running from the trailer frame to the lifting cables which were cast into the panels.



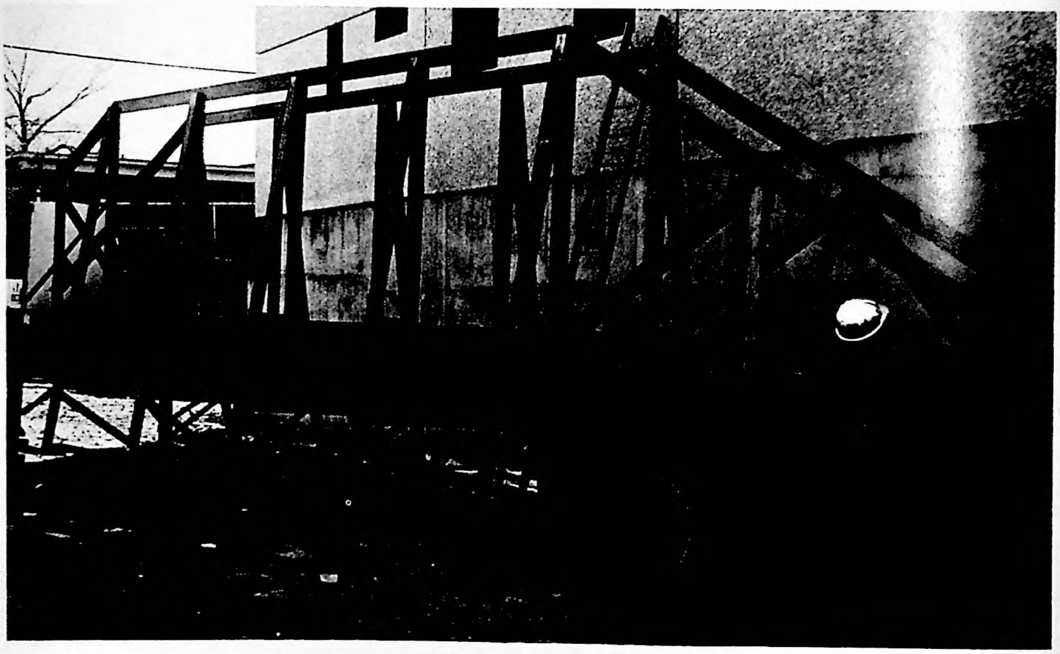
REAR OUTRIGGER IN FOLDED POSITION

BSI
CAMCI
Descon/Concordia

These three producers utilized factory-built precast concrete panels in their building system designs. Highway transportation of these panels, from each manufacturing plant to the several job sites, was accomplished with various types of specially fitted trailers. All three companies used standard truck chains to secure the panels to the transporters.

CAMCI used a fifth-wheel semi-trailer fitted with a padded steel A-frame which could accommodate two panels (one on each side). This frame extended below the chassis to within 12 inches of the ground, in order to lower the overall height of the loaded panels and avoid the necessity of obtaining a special permit for movement. Nine trailers and three leased tractors were used. CAMCI provided drivers.

BSI outfitted fifth-wheel trailers with finger frames which held the panels upright on top of the trailer bed. Descon/Concordia moved wall panels upright using both of these techniques, and transported floor panels lying flat on the trailer bed, supported on air bags. Both companies employed contract carriers which supplied tractor and trailers.



"A" FRAMED TRANSPORTER USED BY CAMCI

FINGER-FRAMED TRANSPORTER USED BY DESCON AND BSI

DESCON TRANSPORTER EQUIPPED WITH AIR BAGS FOR SHIPMENT OF FLOOR PANELS

6.

RAILWAY TRANSPORTATION

GENERAL

Within the shipping radius of the typical American modular producer's marketing area, the economics of rail shipment formerly precluded the use of this means of transportation. Ordinarily, unless a sizable market can be established at some distance from the manufacturing plant, no competitive advantage over truck shipment can be anticipated.

Operation BREAKTHROUGH encouraged the concept of centralized rather than decentralized production plants, in order to gain economies-of-scale. Under this concept, a manufacturer could conceivably use a few strategically located and fairly large plants to cover a substantial portion of the U.S. housing market, instead of fragmenting into numerous plants serving smaller marketing areas. The maximum shipping radius could thus theoretically expand far beyond previously accepted mileage limits. Since highway transport of modules as a general rule places the manufacturer in a non-competitive pricing position for distances over approximately 300 miles, the potential economic advantages of rail shipment appeared well worth exploring.

In May 1971, HUD and seven of the BREAKTHROUGH producers jointly undertook to catalyze a "total system" of rail transportation. Key developments in this project were as follows:

- Guidelines were proposed for consideration by over 300 U.S. railroads in order to set a rate formula and operating conditions.

- Special government ("Section 22") freight rates and operating conditions were negotiated with specific railroads, which were at least 30 percent below existing tariff rates.

- A special arrangement was made with Trailer Train, Inc., to lease its 89-foot flatcars directly to modular shippers at a nominal rate.

- A joint BREAKTHROUGH/American Association of Railroads "Railroad Technical Group" conducted hardware research and testing to develop a single, standardized, economical method for securing modules to railcars.

- Data was obtained to measure the performance of module shipments throughout major U.S. geographic regions in routine and adverse climatic and rail conditions.

- "Total cost-profiles" were developed, leading to specific improvements in ancillary operations: scheduling, truck-shuttle, loading, plant-spur/track interface, etc.

BREAKTHROUGH rail experience was gained in actual plant-to-site shipments involving multiple car consignments and full unit trains. By late 1972, a goal of a "total system" began to be realized. Illustrative of progress were the Material Systems Corp. rail shipments which were routinely spanning long distances at about $0.55 per module-mile. (This rate included all handling, loading, tie-down, and rail transportation costs.) These shipments required five days in transit to cover the 2000 mile approximate distance. The units arrived at their destination in satisfactory condition.

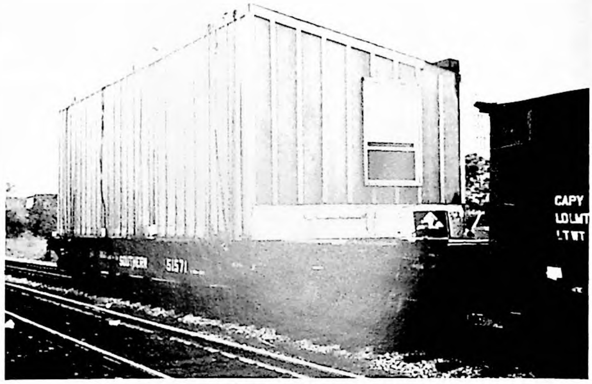
The following section summarizes BREAKTHROUGH findings in the area of rail transport, and describes some of the experiences of participating system producers.

Definitions

Unit Train: A method by which an entire trainload (between 20 to 50 cars) moves as a single shipment to destination, without diverting to add other shippers' cars. The carrier provides a designated engine and crew and free return of empty cars. The shipper provides the loaded cars.

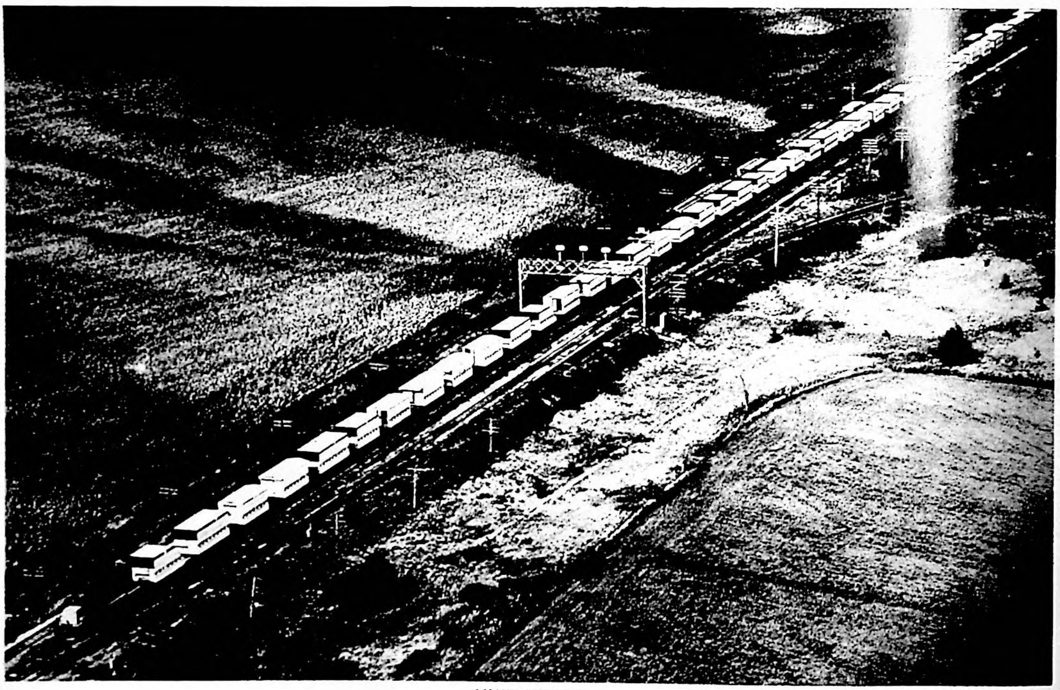
Multiple-Car Consignment: A shipment, consisting usually of 5 to 20 cars, which travel as a single "block" from origin to destination. While the consignment is attached to other trains, the cars are not individually humped. Empty cars are returned free.

Rate: The railroad's line-haul charge published in I.C.C. tariffs. The term, "Section #22 rate", applies to a special rate offered to the government (federal, state or local) under certain conditions.



SINGLE-CAR SHIPMENT

MULTIPLE-CAR CONSIGNMENT



UNIT TRAIN

Rail transportation presents the housing manufacturer with an entirely different set of problems, not encountered in the more typical highway mode of shipment. At both the plant and job site, for example, the manufacturer can fully control the handling of modular units. That control is substantially reduced when his product leaves the rail siding.

Handled properly, rail shipping in certain situations can clearly overcome distance/cost barriers, but BREAKTHROUGH experience indicates that its use requires the skills of a full-time, experienced transportation manager who possesses authority to control the entire operation. Rail shipping is unique and quite complex, and many past failures with this mode of transportation can be attributed to the absence of such skills or the lack of adequate authority.

There are a number of important factors which must be carefully and fully examined when shipping modules by railroad. Some of these factors are discussed in the sections that follow.

Module Construction

BREAKTHROUGH's rail experience provided enough evidence to substantiate that most module floor-joist systems are capable of self-support and do not require additional perimeter support when directly resting on a flatcar's deck. The module bottom should be uniformly flat to make the widest possible contact with the railcar deck. Some shimming is normally required to compensate for the minor camber built into flatcars. Rub-rail type flatcars, when appropriately modified, can accommodate modules with ductwork, piping, and wiring under-slung below the floor joists. However, to standardize operations and reduce damage, it is best to design the module so that nothing protrudes below the joists.

UNIT TRAIN LOAD OF LEVITT MODULES ENROUTE FROM BATTLE CREEK, MICH. PLANT TO KING COUNTY, WASHINGTON PROTOTYPE SITE

It was found that close attention was required in design and construction of module corner connections and bracing in order to offer greater resistance to the racking forces induced by railcar sway. At least one manufacturer found it necessary to provide "X" — bracing in the end walls to eliminate damage to large window areas caused by these forces.

BREAKTHROUGH conducted pressure tests to observe actual turbulence and suction effects of passing trains and conditions encountered in narrow tunnels. A maximum of 10 lbs. per square foot was recorded on a 52-foot modular sidewall with no adverse effect.

Protection

Experience indicates that water is the module's greatest enemy — not shock and vibration. Water threatens the unit in the company's open storage lot, during the entire transport and handling cycle, until the module is fully set in place and closed at the building site. Therefore, protective coverings should be applied and remain on the module throughout these periods, if possible.

Protective wrapping is recommended to (1) protect exteriors from roadbed grime, (2) protect against speed-driven rain, hail and snow, and (3) camouflage the module to minimize component theft and vandalism. Modules with three finished sides can be protected on the open side by installing temporary supports, to which plywood can be fastened and covered with waterproof paper.

Water ponding, on a module's flat roof, can be avoided by contructing a temporary camber from each side of a ridge pole. Alternately, bow-string trusses can be attached and removed after the module reaches its destination.

Rates

Most U.S. railroad companies have adopted "guidelines" which formulate the regular commercial charges for special trainloads of modules or for multiple-car shipments. However, Section 22 of the Interstate Commerce Act gives a carrier authority to offer reduced rates for government (federal, state or local) sponsored housing. A series of 1972 negotiations with more than 300 railroads, jointly conducted by HUD and General Services Administration (GSA), resulted in a rate of $17.00 per trainload mile for 25 cars or 2500 linear feet of train in the southern U.S. Comparable per unit charges were obtained for 10- to 20-car multiple shipments in the West and Midwest. Rates in the Northeast were somewhat higher. The negotiated rates were more than 30 percent below those previously applied. These reduced rates can now be used by other shippers for commercial as well as government sponsored shipments.

PROTECTION OF UNIT DURING RAIL SHIPMENT

Both HUD's BREAKTHROUGH office and many of the HSP's examined a wide variety of railroad-owned cars throughout the United States as well as those possessed by one of the major rail car suppliers, Trailer Train. Intensive physical impact as well as over-the-road tests were conducted to determine the capabilities and ride characteristics of rail cars which ranged from 40 ft. to 89 feet in length. The following paragraphs describe their noteworthy characteristics. Later, the use of these cars will be described in the individual HSP subsections.

The Trailer Train, 89-foot flatcar "TTX" basic type is prevalent nationally and available at economic per diem rental rates. The car's underframe is composed of an all-welded steel structure with a "fish-belly" center sill and an all-steel car deck. Originally built to transport 8-foot wide highway trailers in piggyback service, many cars have protective side sills which extend 8 in. vertically above the car deck. Usually, the car's maximum width is 9 ft. Approximately 85 feet of the car's deck is useable, the last 4 ft. are reserved (by USDOT regulations) for emergency brake use.

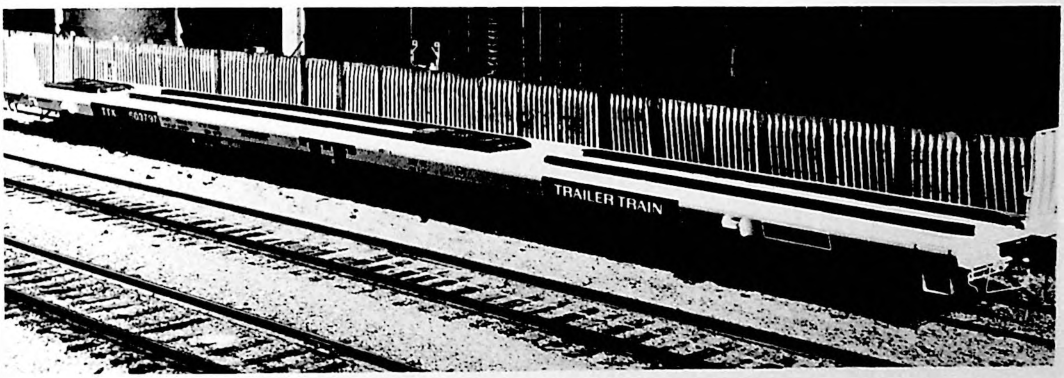
Longitudinal deck-camber ranges between 1-1/2 to 3 inches.

Height above the rails varies: the "standard deck" car approximates 3 ft.-6 in. while the low deck car is about 2 ft.-9 in. in height.

Unless specifically modified, these cars do *not* possess hydraulic-cushioned end-of-car couplers.

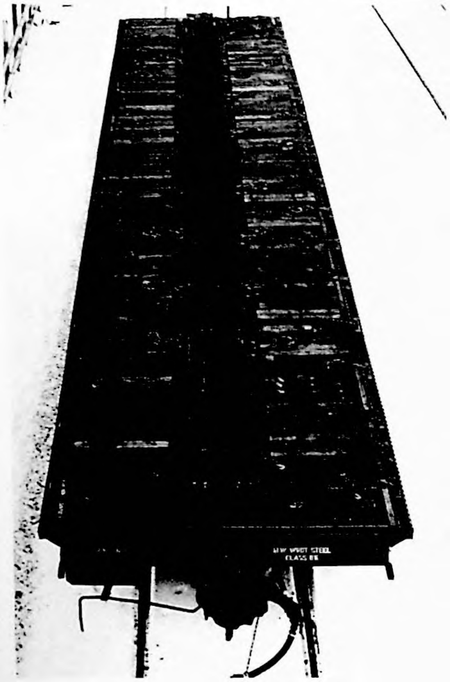
Many of the 89-foot class possess retractable vertical "hitches" which are used when transporting piggyback trailers. The hitches, when in a "down" position, rarely pose a modular-loading or securement problem.

Trailer Train also possesses a variety of flatcars having *no* side sills. These range from 50 ft. to 89 ft. in length. Many cars (from 50 ft. through 75 ft.) have oak decks which facilitate blocking and bracing by merely nailing cargo restraints to the deck instead of welding or bolting them. Among the more interesting versions in this range is the 60-ft. OTTX car



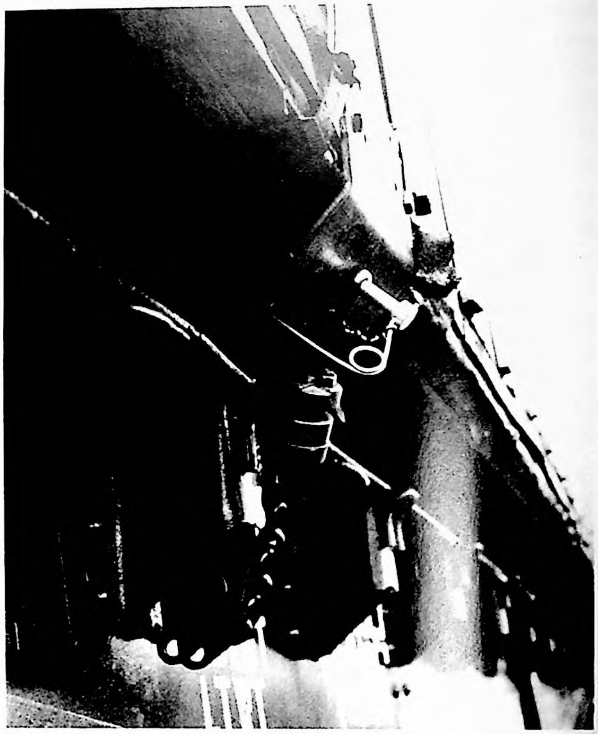
A TTX (PIGGYBACK) FLATCAR 89 FT. 4 IN. LONG.

(agricultural equipment flatcar). It is equipped with special built-in tie-down channels on the car deck, which run

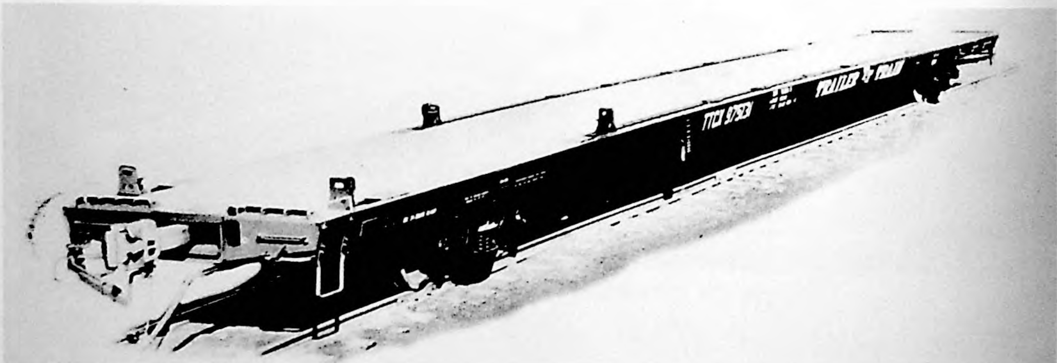


AN AGRICULTURAL EQUIPMENT FLATCAR (OTTX) 60 FT. LONG. NOTE SPECIAL BUILT-IN TIE-DOWN CHANNELS RUNNING FULL LENGTH OF CAR.

along its entire length, both on the extreme sides and adjacent to the center sill. These channels can accommodate chain, wire, dacron-strapping, or mechanical tie-down devices for restraining modular, panular or building-component shipments. Portable winches, which fit into the tie-down channels in the decks of the cars, are available. These rachet-type winches are relocatable and can be retracted into the deck area. The Trailer Train cars possess hydraulic cushioning couples which considerably lessen impact.

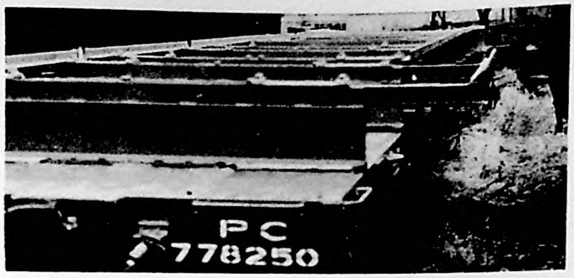


PROTOTYPE OF AN ADJUSTABLE SECUREMENT SYSTEM SUITABLE FOR INSTALLING IN RAIL CAR'S STAKE POCKETS



TTCX "CONTAINER" CAR

A very popular transporter is the 89-foot TTCX "Container" car. It has a true flush-deck allowing a modular shipper almost full, unobstructed use. These cars are equipped with 16 movable container pedestals which can be either recessed into the flush-deck or raised and used as a cargo-restraint. The car's 15 in. of coupler-cushioning is very effective in damping longitudinal shock. (Use of this car is described later in this section).

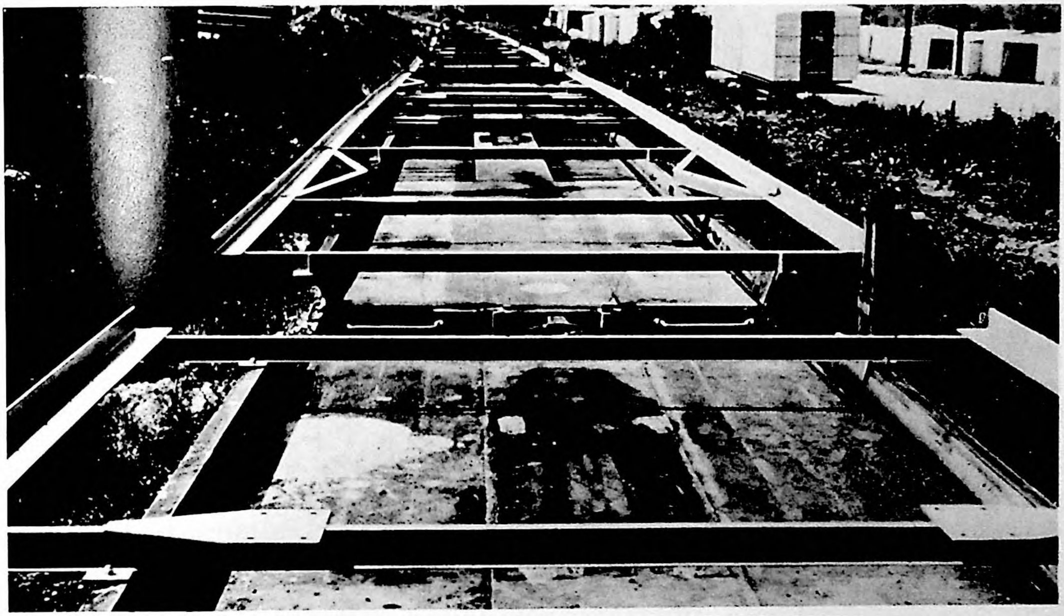


PENN CENTRAL'S "FLEXIVAN" SPECIAL-PURPOSE MODULAR PROTOTYPE RAILCAR. NOTE EXTENDED OUTRIGGER.

The Penn Central Co. considerably modified one of their well-known "Flexi-Van" cars expressly to transport building-modules. A series of demonstration tests, using this rail car, was conducted during BREAKTHROUGH. This car features a high underclearance and a retractable set of outriggers which can be expanded to 14 ft. in order to completely support a module's longitudinal perimeter joists. The car's length is 85 ft. and is supplied with standard couplers.

A variation of this permanently installed modular "carrying-rack" concept is shown below.

Each railroad, in addition to having potential access to the Trailer Train inventory, has its own fleet of cars. Interested shippers should critically examine the equipment, assisted by the originating carrier's mechanical department. A "Summary Table of Car Characteristics" is presented on page 104.



FLAT CAR SHOWING "FIXED" RUBRAILS WITH SEMI PERMANENT SECUREMENT SYSTEM

SUMMARY OF RAILWAY CAR CHARACTERISTICS

Car Length (Feet)	(Approx.) Extreme Width (Feet)	Designation	Height Above Rail (Feet)	Cushioned Couplers	Flush Deck	Rub Rail	Type of Deck Material	Remarks
50		TTX	3'-05"	No	No	Yes	Wood	
60	10'-06"	OTTX	3'-08"	Yes	Yes	No	Wood	
68	10'-06"	TTPX	3'-08"	Yes	No	No	Wood & Steel	High end of car bulkheads
75		ATTX	3'-06"	No	No	Yes	Wood	Has continuous tie-down loops at car center and at side sill
85		TTX	3'-06"	No	No	Yes	Steel & Wood/ Steel Comb.	
89	9'-0"	TTX	3'-06"	No	No	Yes	Steel	Possess 2 retractable hitches to secure 2 each 40' highway trailers
89	9'-0"	TTX	2'-09"	No	No	Yes	Steel	Same, but is a "low-deck" car
89	9'-0"	TTCX	either 3'-06" or 2'-09"	Yes	Yes	No	Steel	Has 16 retractable container pedestals
85	14'-0" when expanded (8'-09" normal)	Penn Central Flexi-Van	Approx. 5'-0"	No	No	Yes	No main deck	Possesses permanent expandable modular outriggers

Car Selection: Rail car types may be surveyed through review of the Trailer Train "Equipment Brochure"; the North American Car Company's summary; and the "Railroad Equipment Register." The possible selections are quite numerous. The use of matching sets of cars facilitates standardized loading and unloading procedures, thereby saving time and costs.

In practice, proper car selection and actual acquisition is the most important task next to the rate issue. BREAKTHROUGH found that, in actual practice, availability of certain types of cars was extremely limited.

An optimum car length is 75 ft. for transporting two average 30- to 35-foot modules (since about 3 to 4 feet at the "brake-end" of the car have to be free for emergency use). These cars were not generally available. The Trailer Train 89-foot flatcars were available usually with outboard rub-rails, renting at approximately $5.00 per day for a 50-day lease under a special agreement negotiated by BREAKTHROUGH with Trailer Trains' management.

Although billed as a "standard" type, each car varied in its actual configuration (due to earlier design changes). The result was that usually, one out of every five cars received was a "problem" and required modification by the shipper's labor force. The only alternative to modification by the shipper was requesting a replacement and awaiting its arrival. Once corrections were made, the cars were expeditiously recycled for consecutive trips and no further delays were encountered.

Clearances

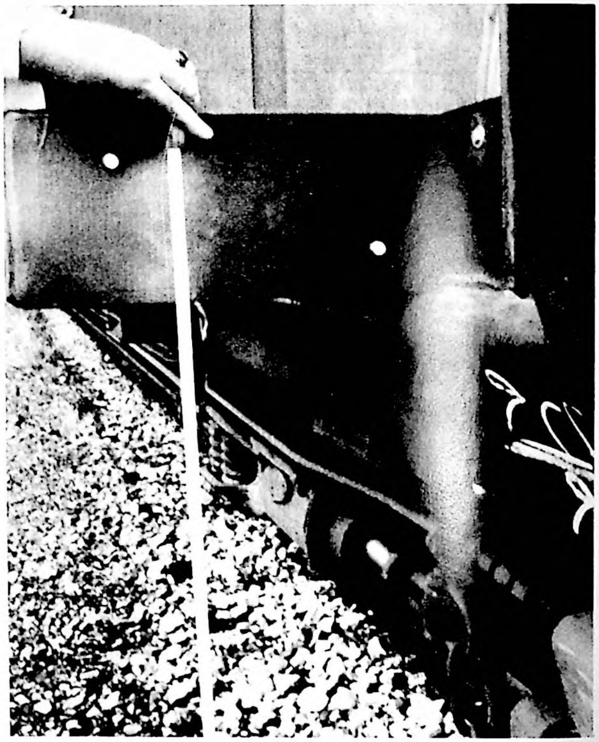
Modules are technically classified by the railroads as "high, wide" loads, with clearances varying between railroads and even between routes on the same railroad. The northeastern part of the U.S. was generally the most restrictive. All of the 12-ft. wide BREAKTHROUGH modules were found to be acceptable for rail transport in most of the South, West and Midwest without extensive special routing. In the Northeast, although more restrictive, rail shipment could be accomplished with careful attention to routing.

Usually this class of shipment (high, wide load) can be cleared for 12 ft.-6 in. wide and 16 ft. high measured from rail top to the highest load point. Thus, modules which are either higher or wider would require special attention. The length of the flatcar is another necessary consideration since longer cars require narrower loads to allow clearance on curves.

Underdeck or "low wide" vertical clearances are also crucial. These restrictions vary with the railroad and average around 4 ft.-2 in., measured upwards from the rail's top to the lowest point of the overdimensional load. In the East, this clearance may increase to 4 ft.-6 in. or higher.

The originating railroad should assure that minor impediments (tree and bush branches) are removed before shipment, and should forward a letter to the shipper specifying the minimum fixed clearance requirements and indicating availability of a clear track from origin to final destination.

Approval for movement of the module over the rails rests in the hands of the originating carrier's representative. To avoid frustrating delays, it is vital that arrangements be made for the carrier's operating representative to observe and approve, in writing, the first loaded and secured module. In one case, three day's lost time occurred because such arrangements were not made. Thereafter, an early approval was obtained and no similar delays were encountered.



ACTUAL MEASUREMENT BEING TAKEN OF A CRITICAL UNDERCLEARANCE FOR TRANSCONTINENTAL UNIT TRAIN SHIPMENT. NOTE THAT THE MEASUREMENT OCCURS UNDER SECUREMENT CRADLE, NOT UNDER MODULE.

Shown in the supporting illustrations are railroad clearances and the effect of modular housing units upon them. In summary, the times when clearances will be an exceptional problem are:

1. on double track, or passing track, situations built to 13 ft-0 in. center-to-center distances. The clearances between a module and carrying frame 12 ft.-1/2 in. wide and Plate "C" cars (standard maximum size) will be reduced about 31 percent or 8-3/4 in. at points 50 in. to 54 in. above the rail. Below that level, no reduction and above, only 7-3/4 in. (maximum) intrustions;
2. in old tunnels and on bridge structures or those built to less than AREA (American Railway Engineering Association) minimums;
3. on curves, depending upon the length of the railroad car and the degrees of curvature.

Each of the above cases must be studied in detail by the railroads proposing to handle the traffic.

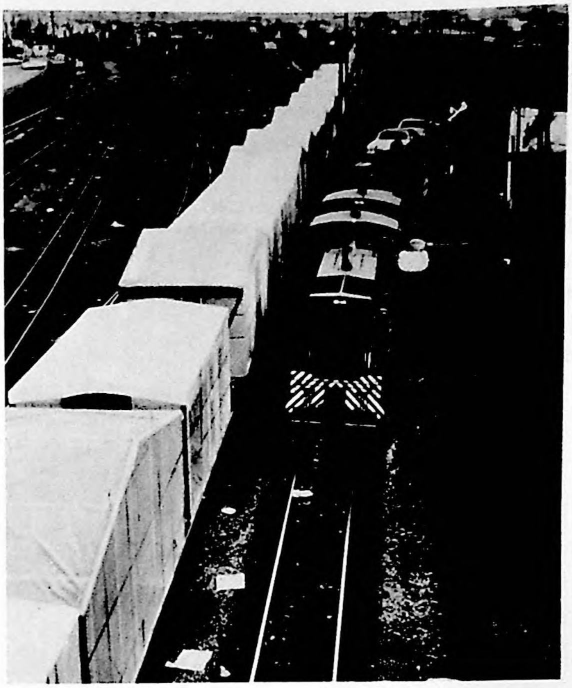


PHOTO DEPICTS A VERTICAL CLEARANCE POTENTIAL PROBLEM. COMPARE ROOF-PEAK HEIGHT TO THE ADJACENT TRI-LEVEL AUTO TRAINLOAD. MODULE'S SECUREMENT WAS INSTALLED TOO HIGH (ABOUT 4'–06") RESULTING IN ROOF HEIGHT OF 16'–06".

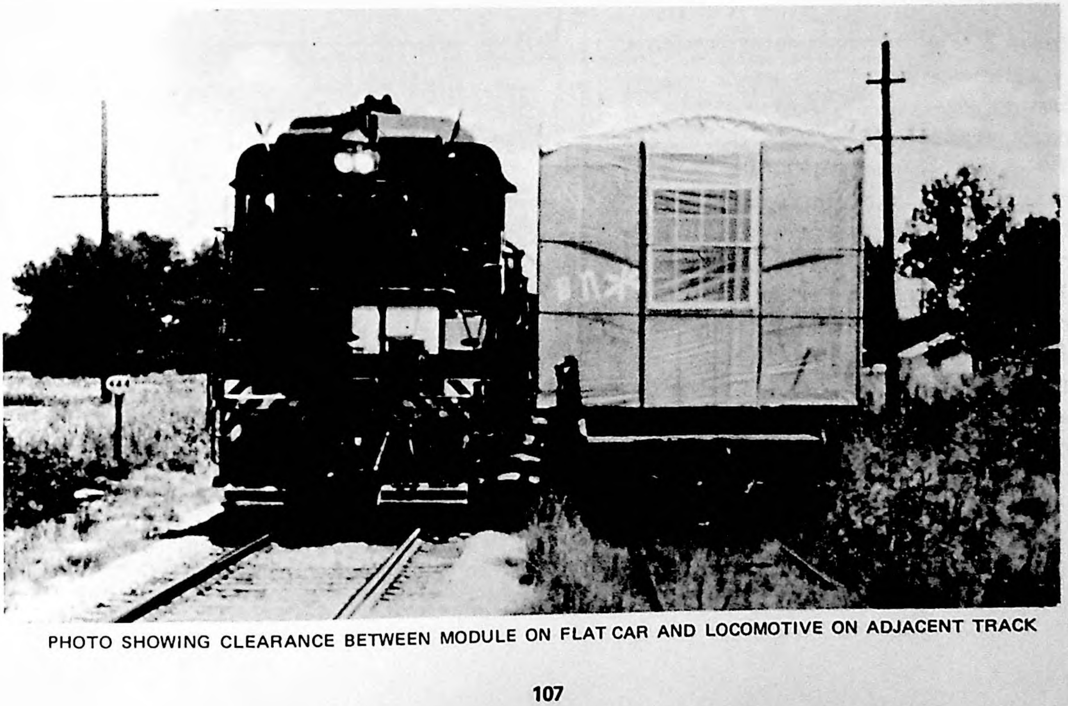


PHOTO SHOWING CLEARANCE BETWEEN MODULE ON FLAT CAR AND LOCOMOTIVE ON ADJACENT TRACK

Figure 1

Illustrates the current maximum size car accepted in nationwide general interchange service. The AAR (American Association of Railroads) Plate "C" car on tangent track with 46'-3" truck centers, is 10'-8" wide and 15'-6" high. It will clear 95% of the nation's rail mileage.

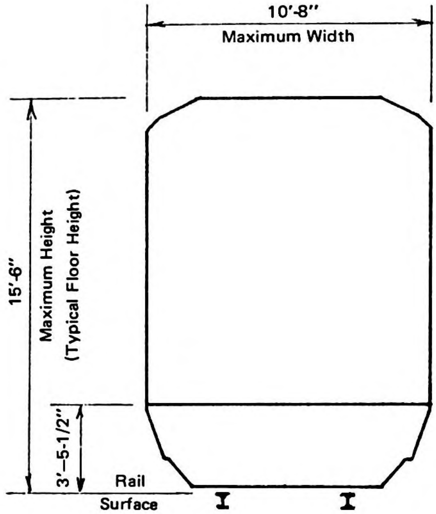


FIGURE 1
AAR PLATE C EQUIPMENT
CLEARANCE DIAGRAM

Figure 2

Shows a conventionally-sized module, packaged and secured, measuring 12'—1-1/2" wide by 11'-11" high mounted on a flatcar with rub-rails. The base of the module lies at 54-1/8" above rail measured at the car's bolster and 1-1/2" higher at car center due to camber. This highest height is 16'—5-1/8". On cars with flush decks, the base of the modules would be at about 46" above the rails and have an overall height of approximately 15'-5".

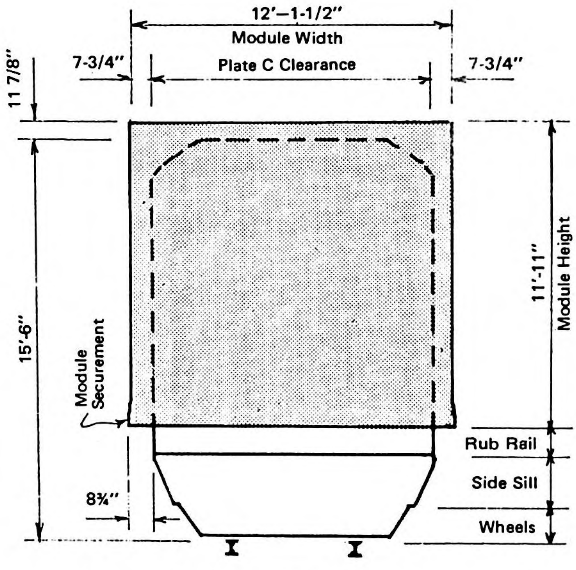


FIGURE 2
MODULE ON FLATCAR WITH
PLATE C DIAGRAM

Figure 3

Portrays the shipment passing through a bridge or structure built to AREA minimum clearances.

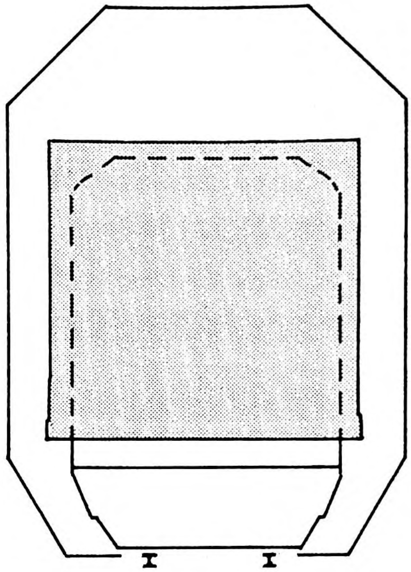


FIGURE 3
MODULE WITH AREA MINIMUM
BRIDGE/STRUCTURE CLEARANCE

Figure 4

Exemplifies a shipment negotiating a tunnel built to AREA minimum single track clearances.

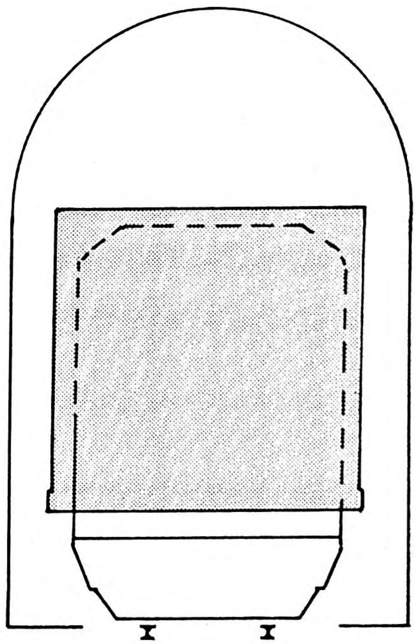


FIGURE 4
MODULE WITH AREA MINIMUM
SINGLE TRACK TUNNEL CLEARANCE

Figure 5

Illustrates the situation that exists when two Plate "C" cars are passing on double track built to 13'-0" between track centers. Most existing double or passing trackage is built to this dimension. There is 2'-4" of clearance between outermost extremities of the two cars.

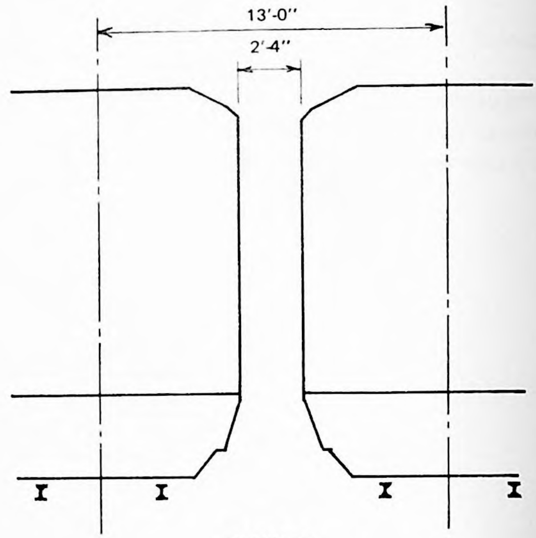


FIGURE 5
DOUBLE TRACK SITUATION
CLEARANCE BETWEEN PLATE C CARS

Figure 6

Illustrates module passing a Plate "C" car. Minimum clearance is reduced 8-3/4" to 1'-7-1/4". In the extremely rare circumstance, when two modules are required to pass (as in a switching situation or in cross-hauling) then the clearance will be reduced to 10-1/2". Thus, in the former case, the safety margin is reduced 33%, in the latter 66%. It is obvious that the latter should be avoided.

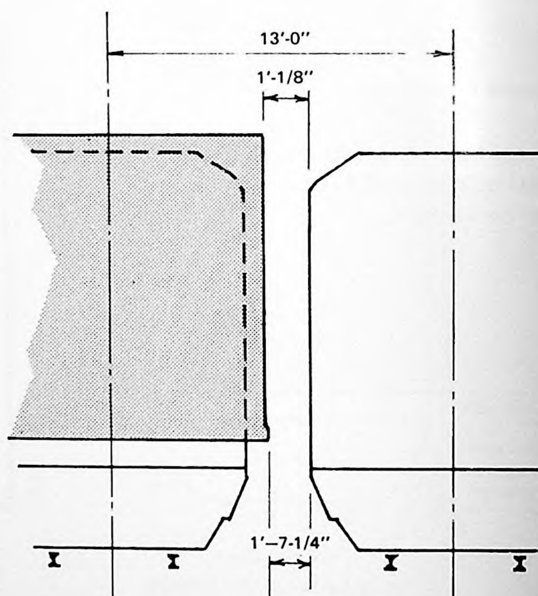


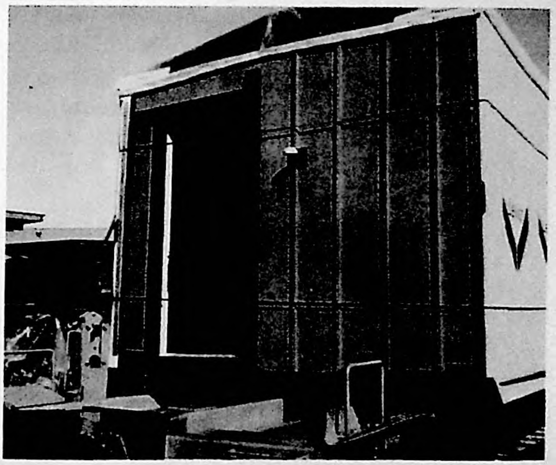
FIGURE 6
DOUBLE TRACK SITUATION
MODULE PASSING PLATE C CARS

Tie-Down Methods

Module-to-flatcar securement systems varied between manufacturers, but can generally be categorized as either employing the "fixed" or the "floating load" method. Levitt Technology Corp. employed a typical fixed-load method, in which structural steel angles were transversely welded to the railcar and the module lag-bolted to these beams. Boise Cascade and Material Systems Corp. used a floating system, tying the modules to the flatcar with flexible dacron straps which permitted the unit slight movement as shocks were encountered. Although this tie-down method reduced racking forces, special provisions had to be made for gutters, folding roofs or other features which could not withstand the high tension loads required for effective strapping.

Using the floating load method, two modules were secured to a flatcar in approximately 60 minutes. In addition, heavy timber-blocking or cribbing [as required by the American Association of Railroads (AAR)] added another 60 minutes per unit for a total estimated securement time of 90 minutes per module.

After extensive analysis of this successful BREAKTHROUGH experience the AAR Loading Rules Committee has officially approved the floating load system, coupled with the use of shock-cushioned cars, and has incorporated the system and data into Circular No. D.V.-1785, page 106 for all U.S. railroads to accept.



LEVITT'S RIGID SECUREMENT SYSTEM. NOTE 8" X 8" TRANSVERSE PREFORMED ANGLE IRONS AT MODULE'S BASE

Loading/Unloading

In planning rail shipments, it is important to keep in mind the desirability of arranging for the uninterrupted loading and unloading of modules. A spur track, capable of accommodating at least ten coupled cars, should be selected to avoid excessive switching and to maximize the continuous use of a crane. Loading in sequence (to permit serial unloading of modules, as needed at the construction site) can substantially reduce crane time, as well as expedite unloading. BREAKTHROUGH data indicated that such loading procedures usually saved at least 30 percent in handling costs.

Accurate, center-line loading is a requisite to meet horizontal (width) clearance requirements. For longer modules (over 40 ft.), a 60-ft. crane boom is recommended to acquire speed and flexibility in alignment of the module on the transporter and flatcar. Three modules per hour was accepted loading practice in BREAKTHROUGH with a 1972 average crane cost of $40 per hour. One manufacturer's experience with a straddle carrier indicates that this type of lifting device lacks the flexibility required in loading and unloading a long string of rail cars.

Ancillary costs (those costs incurred in [a] trucking to and from railhead; [b] loading and unloading; [c] securing and [d] switching) were roughly estimated at an average of $220 per module. This cost did not include the railroad line-haul charge.

Lifting modules, by heavy dacron slings which encircle the unit, can speed up rail car loading and unloading operations. BREAKTHROUGH experience, prior to using dacron straps, indicated an unloading rate of approximately one module per hour as compared to four units per hour when using the straps.

BREAKTHROUGH experience indicates that:

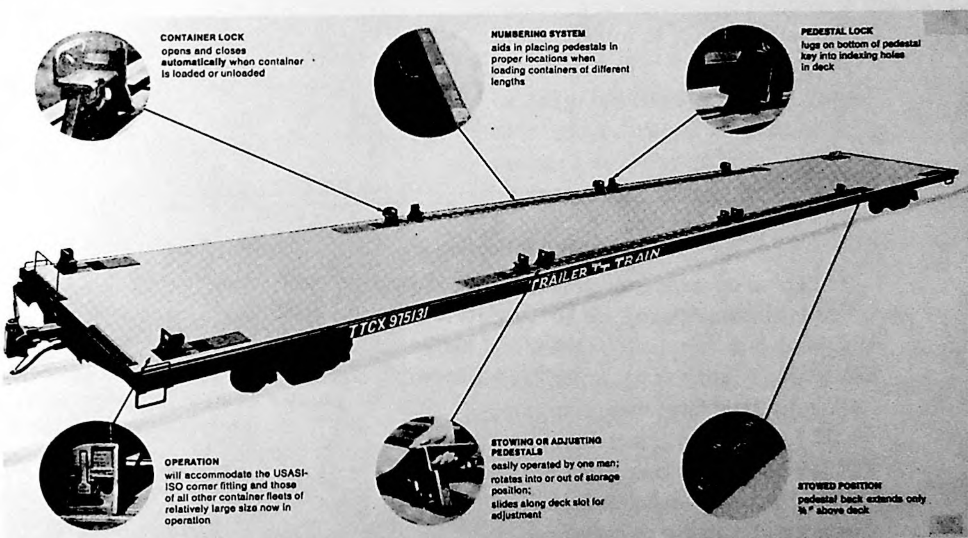
- Services of a competent company "train rider", stationed in the caboose, should be required during the entire trip for full unit-train shipments. He should be equipped with tools and spare parts to make minor repairs to the packaging, loose items, tie-down tightening, etc. A simple shock recorder should also be provided and a two-way radio for communication with the train engineer. On the other hand, *multiple-car* consignments generally moved satisfactorily without company observers.

- Since modules are classified as high-wide loads, special handling is required and *the larger the group of cars being moved the more expeditious and safe will be the handling.* Anything less than five cars will receive secondary treatment and significant delays should be anticipated. BREAKTHROUGH experience began at three weeks for a single-car shipment (900 miles) and improved to four days for a ten-car shipment (900 miles). Full trainloads regularly traveled long distances (2,500 miles) in five to six days.

- Speed-control can be negotiated with the originating carrier and stipulated on the bill-of-lading. Elimination of all humping, car separation, etc., must be clearly stated on the bill-of-lading. Car-multiples should remain as a unit. Claim action may be instituted against the originating carrier for proven deviations, if damage to cargo is incurred.

- The optimum module ride occurs about five car lengths behind the engine. Locations closer than this result in excessive road grime. Unless shock-cushioned cars are used, a tail-end position imparts car-coupler forces that become excessive in train lengths exceeding 27 cars.

- Based on BREAKTHROUGH experience, the most suitable standard railcar is the Container Car (TTCX) normally used for export container shipments. This 89-ft. long car has 15 in. end-of-car cushioning and a flat, unobstructed deck for almost its entire length.



TYPICAL TTCX USED. NOTE FLUSH DECK AND RETRACTABLE PEDESTALS.

Switching

Origin and destination switching costs averaged $30 per switch, per car. This cost can be reduced by loading at least six and preferably ten cars at one time. Crane and handling labor costs are also materially reduced by such multiple-car loading. An available 600- to 1,000-ft. straight spur track is therefore a minimum requirement at both origin and destination points.

Spur track leasing can often be eliminated or substantially reduced through negotiations with the railroads or the industrial park lessee. In BREAKTHROUGH negotiations, these costs were reduced from $1,000 per use, to zero.

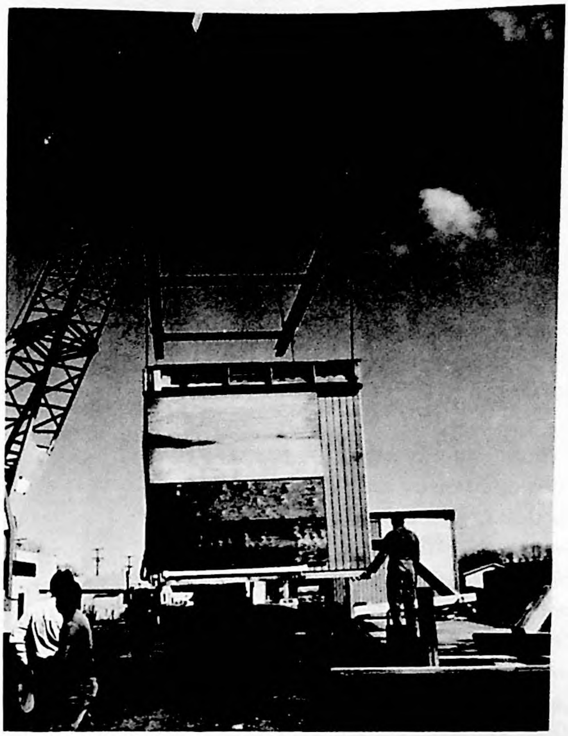
TRAIN LOAD OF LEVITT MODULES ON MAIN TRACK.

The following pages outline specific systems employed by several BREAKTHROUGH producers. They show a variety of methods used in shipping, packaging, handling and securing.

Boise Cascade Housing Corp.
Materials Systems Corp.

Both of these companies employed the same "floating load" rail securement concept rather than a rigid tie-down system. Boise Cascade shipped 200 wood-framed modular units 900 miles by rail over the Western Pacific and the Union Pacific railroads, from its plant in Boise, Idaho, to the construction site in Sacramento, California. It shipped in multiple-car loads averaging 12 cars every three weeks in order to maintain a low storage inventory.

Subsequently, MSC's fiberglass reinforced polyester modules were moved in 83 carloads from Sacramento to BREAKTHROUGH sites in Macon, Georgia, (2,700 miles) and Indianapolis, Indiana, (2,300 miles) involving the above railroad lines and the Southern and the Norfolk & Western railroads. MSC shipped in large lots of 16 to 20 cars per movement.



BOISE'S MODULE BEING LOADED ONTO TTCX RAIL CAR

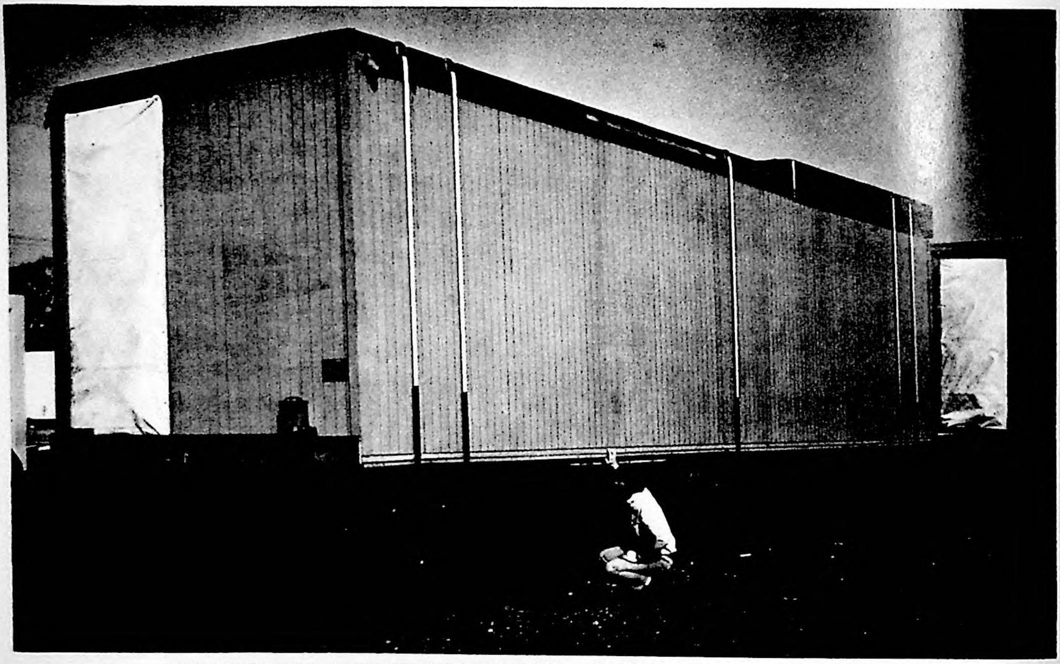
SECUREMENT OF BOISE'S MODULE TO LOW-HEIGHT RAIL CAR

These shipments were made, not as exclusive unit trains, but in consignments averaging twelve or more cars, each car normally carrying two modules. The multiple-car consignments were connected to scheduled fast freights, in the first one-third of the train's length. Movements of the MSC modules occurred in hot weather and cold, with snow and ice conditions existing. Although a 50 mph restriction was imposed by the shipper, actual speeds up to 85 mph were reported.

All shipments arrived on time (3 to 5 days for the Boise shipments, 4 to 7 days for the MSC deliveries) and essentially damage-free. Use of the "floating load" concept is given major credit for this accomplishment. In addition, TTCX railcars (equipped with 15-in. shock-cushioned couplers) were used, reducing the forces which the tie-down system was required to withstand.

Securement principally consisted of flexible dacron-webbing straps; five straps (four for modules shorter than 32 ft.) encircled the module vertically; at the floor-joist level, four additional horizontal straps (two at either end) secured the unit. Strap ends were fitted with "J" hooks which clip onto the rail car side beams. These same straps were used as tie-downs for truck transport to and from railside and also for slings in moving modules between rail car and transporter.

Accurate tensioning of the straps was accomplished by means of a patented torsion buckle adjusted with a torque wrench to 110 ft.-lbs. The dacron straps had an 11 percent elongation capability with a 98 percent tensioning memory, thus accommodating their fit to the load whenever shock and vibration were encountered. The straps were protected from chafing at corners with heavy woven nylon sleeves.

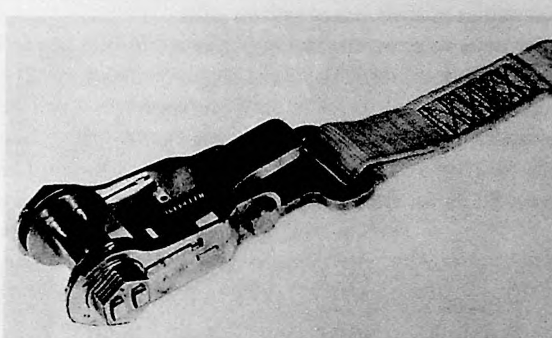


SECUREMENT OF MODULE TO TTCX FLATCAR BY VERTICAL DACRON STRAPS

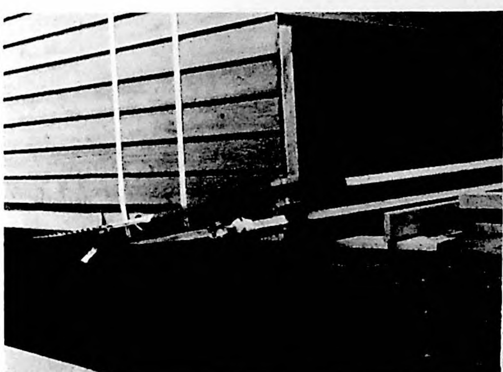
The Association of American Railroads Loading Rules Committee has officially approved this securement system, based upon their inspections and HUD data. On August 15, 1973, it was incorporated into The Loading Rules Manual as a U.S. wide railroad standard.

Rail cars, normally used in standard export containerized service, were also used for module shipments. The cars were 89 ft. long, with flat decks except for built-in adjustable container restraints, which served to secure heavy wood blocking at the ends of each module. This "cribbing" was required by the American Association of Railroads, as were wood guide rails, spiked along the under side of the module to prevent side-to-side shifting. No modification of the car was required, and the normal minor camber of the deck was easily compensated for by wood shimming.

Due to the limited availability of these cushioned cars, a special test was conducted using an instrumented standard 40-ft. uncushioned car. Results indicated that while either type of railcar could have been used with the flexible tie-down system to accomplish these shipments, far less shock results with use of the cushioned car.



BUCKLE AND DACRON STRAP

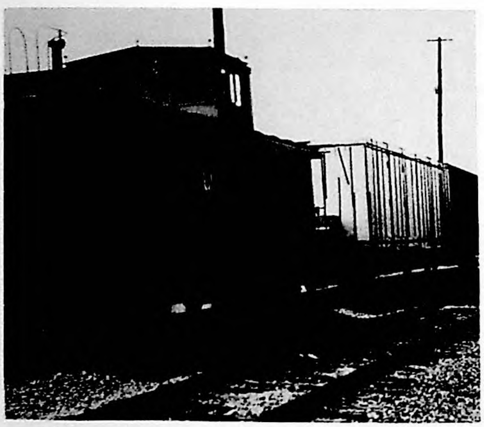


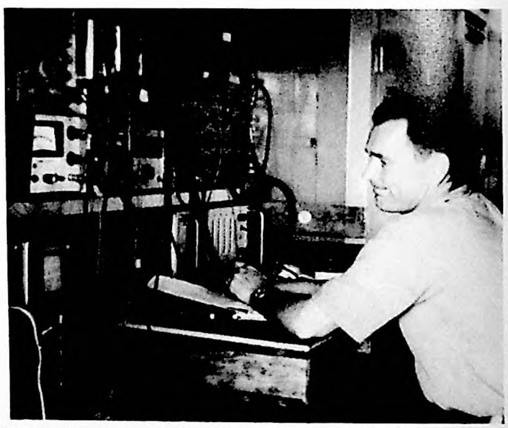
DACRON-STRAP SECUREMENT SYSTEM

Before the MSC shipments, HUD and the U.S. Navy Civil Engineering Laboratory, Port Hueneme, California, conducted a total environmental test and monitored all shock, vibration and other ride-phenomena over the entire 2500-mile trip from Sacramento, California, to Macon, Georgia. (A special technical report will be provided later giving results of this transportation study.)

The same set of dacron straps were successively used to move the Boise Cascade BREAKTHROUGH shipment and then to transport the MSC modules. At the end of Phase II BREAKTHROUGH, these dacron straps, buckles and chain subassemblies were examined and found to be extremely durable and suitable for further use. Each tie-down assembly cost approximately $45.

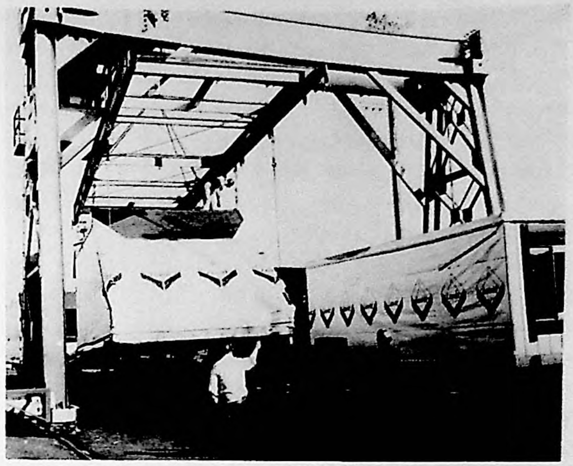
Economies-of-scale were realized with repetitious shipment. Material Systems Corp. reported that costs, including all loading, unloading, truck shuttle and rail transport, averaged $0.75 per module mile for trips up to 1,000 miles and about $0.55 for trips of 2,300 miles.





TRANSCONTINENTAL RAILROAD TESTS BEING CONDUCTED BY U.S. NAVAL CONSTRUCTION-ENGINEERING LAB. (PORT HUENEME, CALIFORNIA) FOR 2500-MILE MODULE TEST (AUGUST 1972 IN BEHALF OF BREAKTHROUGH)

A rigid steel tie-down method was used by Levitt to secure the modules to the railroad flatcar. Shipment of 98 modules from the factory in Battle Creek, Michigan, to the Operation BREAKTHROUGH site in King County, Washington, was made by two unit-trains of 27 cars each. A nominal five days were required for the 2472-mile trip. The originating carrier, Penn Central Railroad, assisted in planning. The Chicago and Northwestern and Union Pacific railroads were the interline and destination carriers.



LEVITT MODULES BEING OFF-LOADED FROM FLATCAR TO TRUCK USING EXISTING FIXED "PIGGYBACK" CRANE AT SEATTLE TERMINAL.

These non-cushioned railroad cars formerly had been used to carry automobiles and had 8-inch high rub rails along each side. Heavy steel angles (8 in. x 8 in. x 5/8 in.-12 ft. long) were laid across the car and securely bolted to the rub rails. These angles were spaced and oriented to allow a module to be set between two of them, securing the module fore and aft. Lag bolts were inserted through pre-drilled holes in the vertical leg of the angles into the front and rear band joists of the module to fasten it to the angles. The heavy transverse steel members were removed from the car after module unloading.

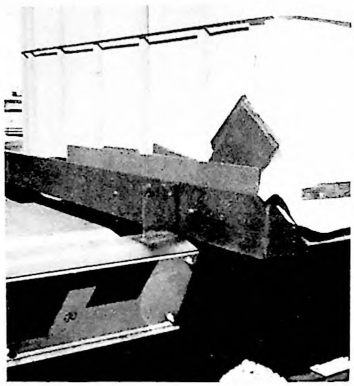
The rub rails allowed 8 in. clearance between most of the underside of the module and the car in order to accommodate the underslung ductwork. To assure uniform contact by the module and to secure it, the rub rails were temporarily fitted with 3 in. by 3 in. wooden sills which were held by steel clips tack-welded to the rub rails. Other clips were nailed into the module's side joists.

UNIT TRAIN METHOD: LEVITT MODULES SECURED BY ANGLE IRONS MOUNTED ATOP TTX-TYPE CAR RUB RAILS

The modules were loaded with a specialized crane which straddled the railcar. The small curved spur track restricted the loading process to three cars at one time. Thus, the work was slowed and repeated switching caused higher costs. Off-loading in Seattle was made directly to trucks with an overhead yard crane.

Temporary cambered roof trusses were installed and covered with sisal-type paper that extended down over the sides of the module. This prevented ponding of water on the roof and protected the module sides from road dirt. Billowing was minimized by tacking battens to the sides.

The problem of mixing high deck (3 ft.-6 in.) and low deck (2 ft.-9 in.) flatcars unduly complicated the Levitt transportation phase. Low deck cars, moving with a 12 ft.-2 in. wide *underside* clearance load, run a high risk of colliding with railroad bridge abutments and switch-signal equipment. Because of the requirement for a minimum height for overdimensional-width clearances, several modules had to be unloaded and the car sides reshimmed to comply with the 3 ft.-2 in. clearance required for the midwest and northwestern routes.



SECUREMENT SYSTEM USED BY LEVITT

SPECIAL FIXED RAILROAD TERMINAL PIGGY-BACK CRANE OFF-LOADING MODULES AT SEATTLE FROM "LOW-DECK" FLATCAR TO FIFTH WHEEL HIGHWAY TRANSPORTER. MODULES TRUCKED 25 MILES TO KING COUNTY SITE.

General Electric Co.

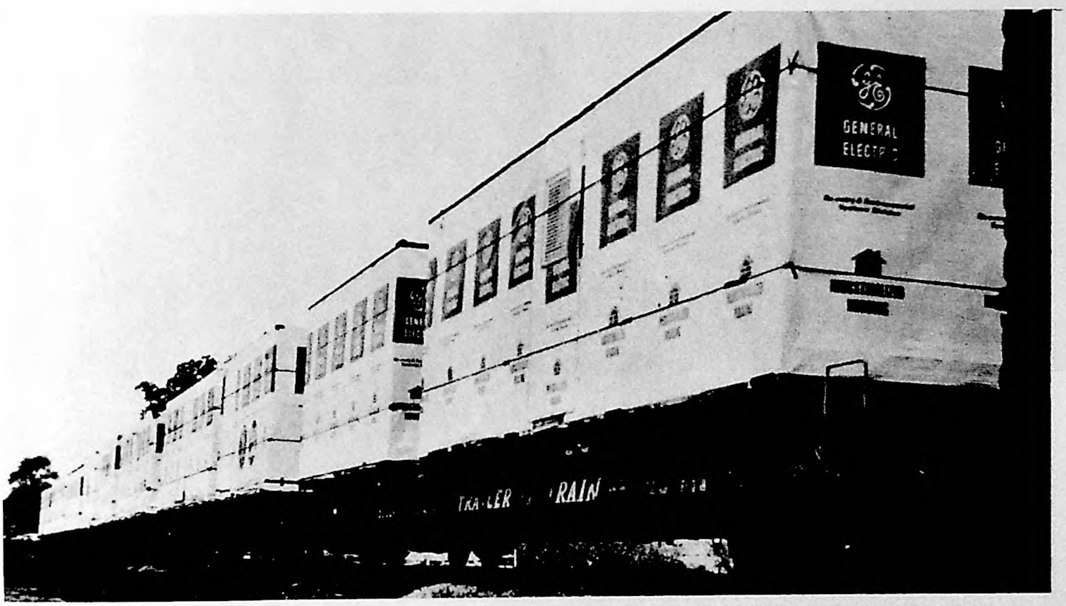
General Electric experimented with both the multiple-car consignment method and the unit-train concept in shipping from its Valley Forge, Pennsylvania, plant.

Memphis Shipment (Multiple-Car Consignment): Twenty-one modules were shuttled by truck to Chester, Pennsylvania, for loading onto the B & O Railroad. Two types of cars were utilized.

Car Type	*Length*	*Width*	*Deck Type*	*Module 1 (length)*	*Module 2 (length)*
TTX	60′	10′-6″	Wood	30′	19′
TTJX	68′	10′-6″	Steel	30′	30′

Two modules were loaded, per car. A rigid tie-down system was used to secure both shipments. The modules were supported on and bolted to heavy specially fabricated transverse steel beams called "bolsters" which were fastened directly to the deck of the flatcar. On each bolster's end, a retractable outrigger slid out laterally to provide fixed support to the module's perimeter-joist system. A predrilled vertical steel plate was welded to the ends of each outrigger, through which 1/2-in. diameter lag-bolts connected directly to the wooden perimeter sills of the module. Five bolsters were used to support each of the 30-ft. modules and three bolsters for the 19-ft. units. Two lag-bolts were used at each end of the outriggers. No other support or tie-downs were utilized with this rail-shipping method.

The first trip consumed eleven days to transport five cars in regular train service; the second trip, eight days to transport six cars. A heavy exterior water-repellent paper wrap, protecting the first shipment, was shredded during transit. Polyethelene sheets were successfully substituted to provide packaging cover for the second trip.

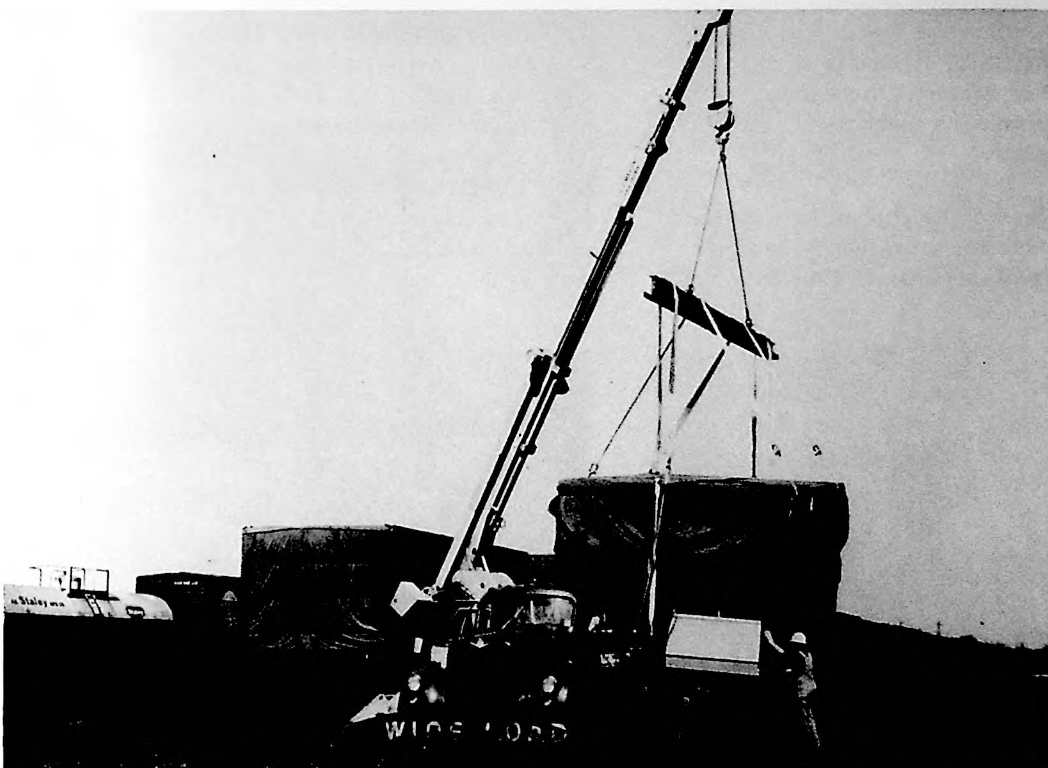


FIVE-CAR MULTIPLE SHIPMENT TO MEMPHIS, TENNESSEE. UTILIZING THE "BOLSTER" SECUREMENT METHOD. THE SYSTEM DID NOT PROVIDE SUFFICIENT RESTRAINT AND WAS LATER DISCARDED

In the first shipment, major damage occurred in the end wall of the 30-ft. living room module which contained a relatively large window area. Improper bracing allowed breakage of the glass in the window, a loosening of the window frame in the wall, and loosening of the nails in the exterior sidings. For the second railroad shipment, the large window area was X-braced, but after shipment it was found that one of these braces had broken in transit and the same damage occurred. It was concluded, however, that properly designed and installed X-bracing of the end wall would have been effective for minimizing or eliminating such damage.

A 60-FOOT RETRACTABLE HYDRAULIC CRANE LOADING GENERAL ELECTRIC'S FIRST TRAINLOAD FROM CHESTER, PA. TO MEMPHIS, TENN. NOTE THE TRANSVERSE BOLSTERS ON FLATCAR

Indianapolis Shipment (Unit Train): The next General Electric shipment involved three whole trainloads (27 cars each trip) to Indianapolis, Indiana. General Electric changed its securement system to one similar to that used by Levitt. However, it leased the "XTTX" 89-ft. flatcar which possesses a much wider exterior rub-rail flange area, making it a relatively easy task to secure the module's perimeter-joists. (Levitt had earlier pioneered using the "TTX Car" whose narrow rub-rail flanges had caused securement problems). Line-haul trips on the rails averaged four days each. No shock or vibration damage occurred enroute. During Hurricane "AGNES", however, torrential rains caused significant water damage due to prolonged exposure of the modular units while awaiting weather abatement prior to erection.



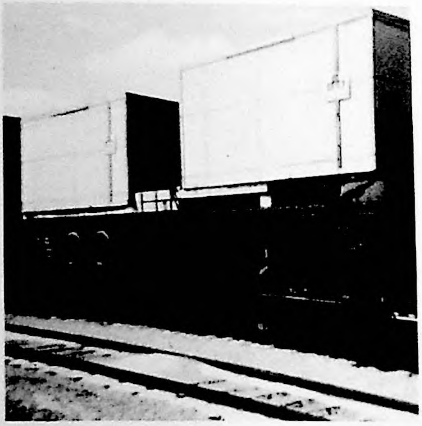
GENERAL ELECTRIC'S 27-CAR TRAINLOAD BEING UNLOADED ADJACENT TO THE INDIANAPOLIS BREAKTHROUGH SITE

Over 100 mechanical core modules, attached to prestressed concrete slabs (8 ft. wide x 22 ft. long), were shipped 2,200 miles by rail from the Akron, Ohio, plant to the BREAKTHROUGH site in Sacramento, California, over the Baltimore & Ohio, Chicago-Northwest, Union Pacific, and Western Pacific railroads. To avoid multiple handling of the modules (at factory, origin-railhead, destination-railhead, etc.), it was decided to transport the modules "piggyback" aboard *standard* width highway trailers loaded aboard 89-ft. TTX flatcars.

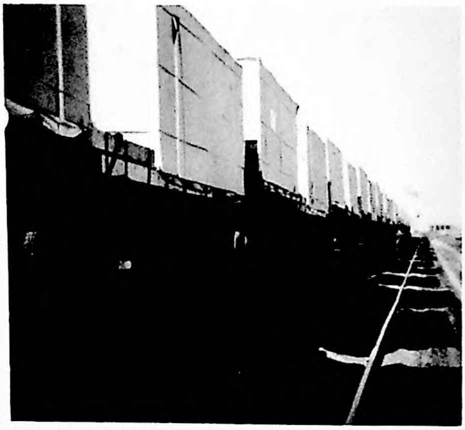
The first shipment involved 88 modules loaded onto 44 trailers, which were secured to 22 rail cars. At the factory, two modules were chainlashed to each trailer and trucked to the railroad's piggyback ramp, where two trailers were rolled onto each flatcar. A special patented "hitch", built into this type of flatcar, connected to the trailer's fifth-wheel pin and no other securement was necessary.

Because of the length of the prestressed module slab, a five-foot overlap on the trailers was necessary. The overlapping slabs were separated by wooden shims and held securely with steel banding to prevent movement and abrasion at the point of contact. Wooden bearing members were inserted between the bottom slab and trailer bed. Bracing of the top module called for center and end bearing pieces shimmed to close tolerance. At destination, the wooden supports were easily removed from under the 9,000 lb. upper slab by inflating two rubber "dunnage" bags under the slabs. With the exception of faulty shimming of seven modules (which caused some slab cracking) all shipments arrived in satisfactory condition.

The units traveled in *normal transcontinental trail-service* with a mixture of piggyback and other express loads. Special arrangements were made with the railroads involved to avoid the usual off-loading of trailer-on-flatcar (TOFC) shipments going through Chicago. Train speed was limited to 50 mph and inspection of the tie-down system was made every 300 miles. The "roll-off" was quickly accomplished in Sacramento, and the trailers immediately driven to the job site.



STEEL STRAPS SECURING OVERLAPPING SLABS



MULTIPLE-CARLOAD OF UNITS BEING SHIPPED TO SACRAMENTO

It is important to note that the FCE-Dillon modules were only 8 ft. in width. If the modules had been the standard 12-ft. width and mounted on the trailer with its additional chassis and wheel height, the TOFC method could not have been used since the units would not have cleared some obstructions such as tunnels and rock cuts.

Train shipments were required to be closely coordinated with on-site construction progress to assure that trailers arriving at the site could be off-loaded promptly. The B & O Railroad provided all TOFC trailers for these piggyback shipments. This relieved the shipper of a capital investment for trailers and the problem of returning the trailers to the point of origin.

WOOD SPACERS BETWEEN FCE-DILLON'S OVERLAPPING SLABS

Pantek

Pantek's 4-ft. by 8-ft. panels (4 in. thick), and weighing 400 pounds each, were loaded on wooden pallets at the plant with their exterior rough surfaces facing each other and pieces of 5/16 in. plywood dunnage inserted as a buffer between the interior surfaces. Each *box-car* contained enough panels for approximately two houses; twenty-three box-cars were shipped in normal train service.

Each pallet was wrapped with "Visqueen" to protect the load while in open-storage at the Sacramento site. Over 7,200 panels were delivered using this method with negligible damage.

7.

LIFTING FRAMES and MECHANISMS

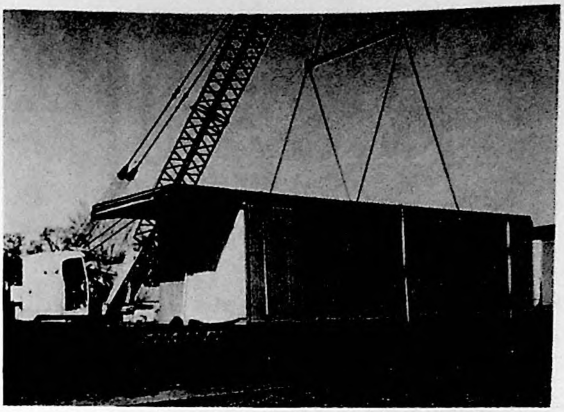
GENERAL

The primary purpose of the various lifting frame mechanisms, used by industrialized housing producers, is to assure damage-free handling of the module or component during loading at the factory or unloading at the building site. Concentrated stresses from the lifting crane must be evenly distributed by these mechanisms along the module or component's geometry to avoid localized structural damage. In addition, the lifting device should provide adequate stability and control of the module while it is suspended from the crane. Supporting steel cables, bands or nylon straps must not be over-stressed. Lifting frame devices, which tend to place excessive compression stresses at the top plate or roofline of the module, should not be used.

As will be noted on the following pages, several different approaches were used by the Operation BREAKTHROUGH producers to achieve effective handling at the factory and building site. The most commonly used system involved spreader-frames fabricated from locally available structural steel shapes. From the main members of these steel frames, the necessary number of vertical supports were suspended to safely handle the unit without placing unusual stresses upon it. While a majority of the modular producers favored the use of lightweight nylon straps with high re-use factors, others used steel cables, steel banding or steel rods as the structural tension material for tying the module to the lifting frame.

Regardless of the method or the material utilized to move the modular units, which ranged in weight upward to 53 tons, all producers made use of adequately spaced support members to transfer loads from the module or panel component to the main lifting frame. Without such methods of load distribution, severe damage to the units could have resulted.

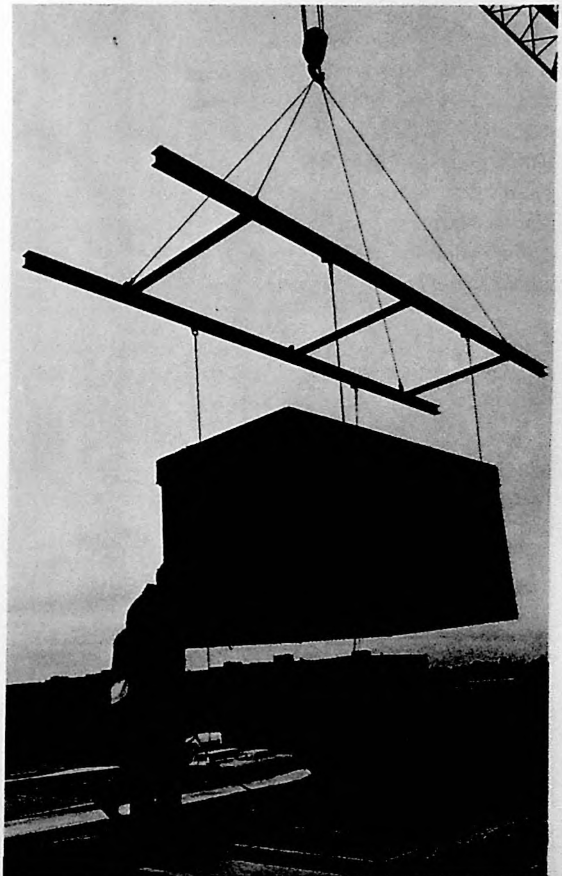
The initial mechanism selected by this producer for lifting the modules was a simple cable arrangement which connected to two points on each side of the unit and then to a single heavy tubular spreader bar. The crane cable pick-up points were located at the ends of the spreader bar. However, it was found that this "double triangle" cable method, although light in weight and relatively inexpensive, did not provide the desired stability needed during placement and movement of the units.



"DOUBLE-TRIANGLE" SLINGING METHOD

To improve handling efficiency and safety, the manufacturer switched to the more typical structural steel rectangular flat frame system, which provided four vertical cable pick-up points from the modular units to the lifting frame. The frame itself was made from readily obtainable structural shapes, which were simply welded or bolted together to form the desired frame configuration.

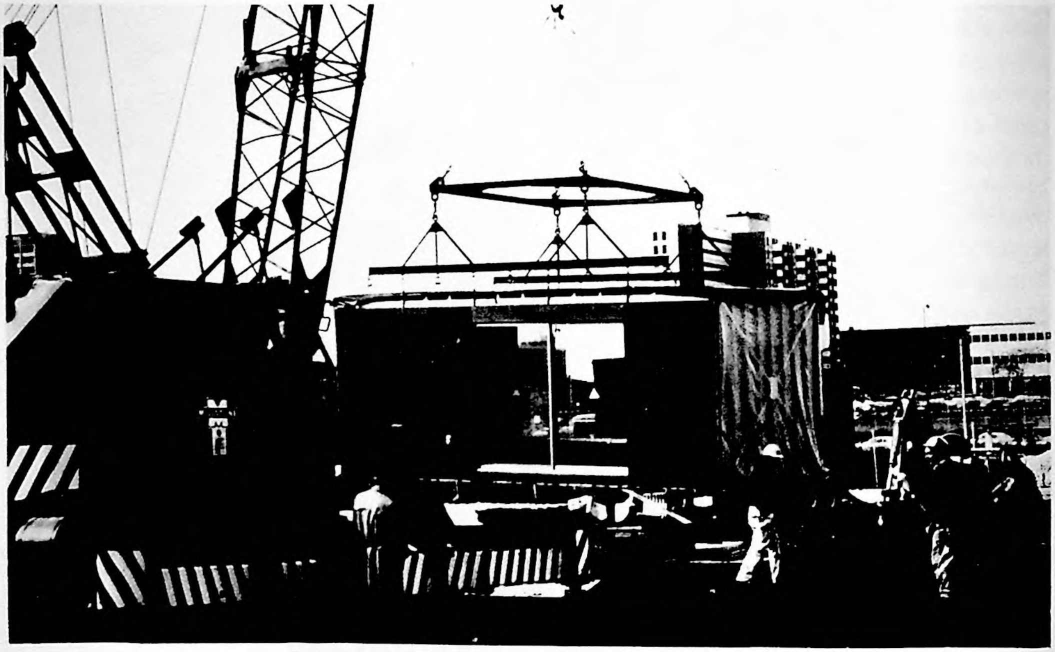
The pipes or "needle beams" (which ran through the double perimeter sills on each side of the module and provided cable pick-up points for the triangular system) were also eliminated in favor of cable or nylon straps. The "needle beam" method was discarded because of damage which could occur to the underfloor mechanical system during the installation and removal of this lifting device. The lightweight and reuseable nylon straps were passed under the bottom of the wood-frame modules and connected directly to the lifting frame. The steel-framed modules, produced by Boise, were designed with holes at the top of each tubular steel corner column to receive the lifting hooks from the spreader frame.



TYPICAL RECTANGULAR SYSTEM WHICH REPLACED THE "DOUBLE-TRIANGLE" SYSTEM

Home Building Corp.

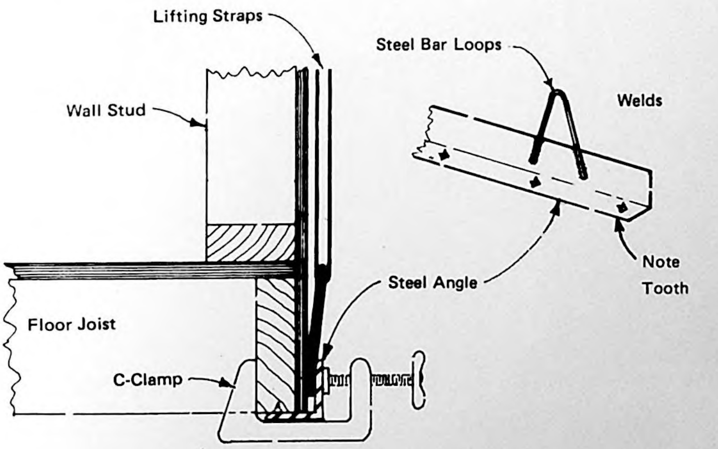
A 12 ft. by 12 ft. spreader lifting frame, with two 24 ft. longitudinal beams suspended from it, was used to handle the HBC modules. The frame and longitudinal beams were contructed from locally available structural steel shapes. On the top corners of the main structural lifting frame were attached four steel rings to receive the four primary cables from the crane hook. Four steel pick-up rings were also located at each bottom corner of the main spreader frame to receive the hooks from the triangular braces attached to the 24 ft. longitudinal beams. In order to distribute pick-up point loads and accommodate various modular lengths, five loops were attached along the bottom of each longitudinal beam. To each loop was attached a 12-in. piece of chain with a hook to receive the looped metal banding straps from the module. The metal banding straps, spaced 4 ft. o.c., fitted into saw kerfs provided in the top plates and wall studs of all first-story modules.



LIFTING FRAME BEING USED TO ERECT MODULES

Second-story modules were lifted by using nylon straps, looped around the beams of the lifting frame and connected to steel bar loops welded to factory-installed angles at the bottom of the modules. The angles were secured to the bottom sills of the module with teeth that were punched out of the angle itself. As an added safety measure, "C" clamps were also used to secure the angles to the sills. The top plate of the first-floor module was slotted to facilitate removal of the angles and clamps after the modules were in place.

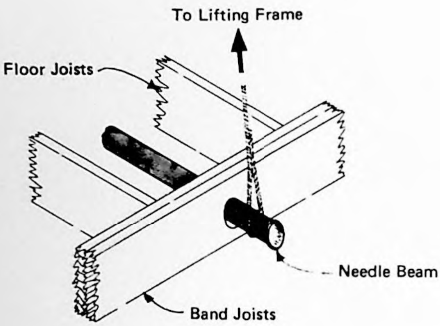
LIFTING STRAPS ATTACHED TO THE FIRST FLOOR WALL STUDS – NOTE SAW KERFS



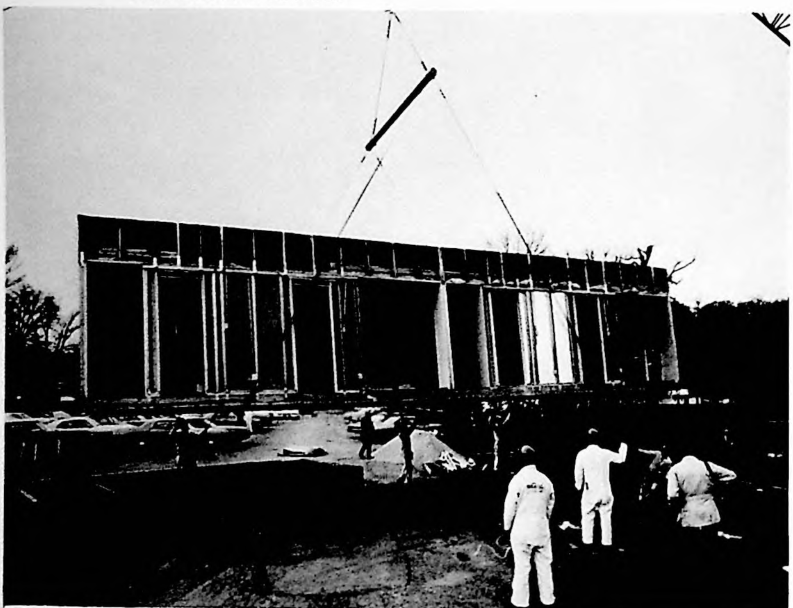
SECOND STORY LIFTING DETAIL

National Homes Corp.

This housing manufacturer utilized a simple triangular cable method identical to the lifting frame system employed initially by Boise Cascade. National also used the same "needle-beam" technique (inserted transversely through the module's perimeter joists) in order to provide low-lifting point on the module.



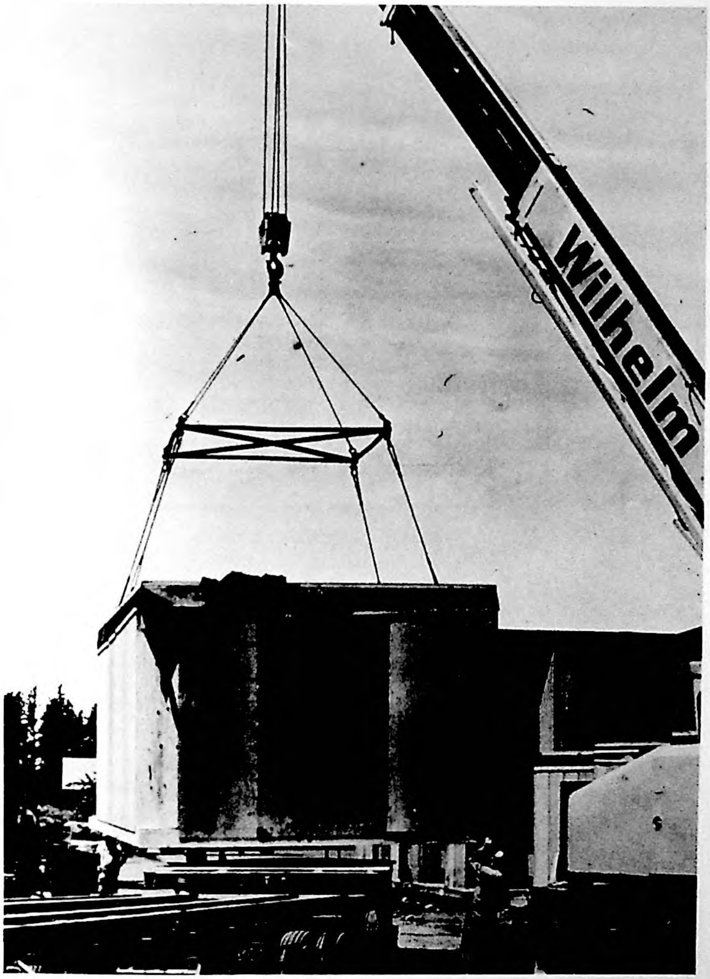
NEEDLE BEAM DETAILS



LIFTING FRAME SYSTEM USED BY NATIONAL HOMES

Alcoa Construction Systems, Inc.

The "heart" (or mechanical-core) modules, produced by this company, were hoisted from the transporter and positioned onto the foundation by a crane which had four cables extending diagonally from the crane-hook down the corners of a simple spreader-frame (fabricated from lengths of large diameter pipe). This X-braced square lifting device was welded together. Eye-hooks were provided on the top and bottom at each corner to receive cables from the module and the crane hook.



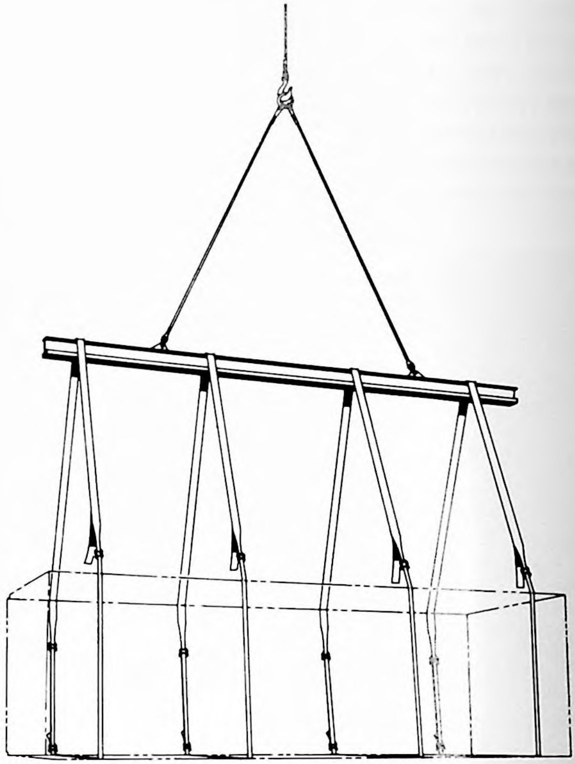
ALCOA'S MECHANICAL CORE MODULE BEING HOISTED FROM TRANSPORTER

General Electric Co.

A simple and inexpensive lifting arrangement was utilized by GE to move their modular units. The lifting scheme involved the use of nylon slings which encircled the unit at four lifting points, and looped over the top of an 8 in. I-beam. The fabric slings were each made up of three pieces of nylon (4 in. by 40 ft. long) and connected by shackles.

The structural beam, shorter than the length of the largest modular unit to be lifted, provided the necessary rigidity and load distribution for this unique system. The two steel eyes were welded to the top flange of the main beam at approximately the quarter points to receive heavy cables which, in turn, were connected to the crane pick-up hook. The floor joists were notched to allow strap insertion between joist and truck or rail transporter-deck.

Although simple in design, this lifting rig required longer loading and erection times as compared to the more elaborate but stable rectangular lifting-frame systems. One of the main disadvantages of this system was the need to very precisely position the nylon slings in relation to the module's center-of-gravity.



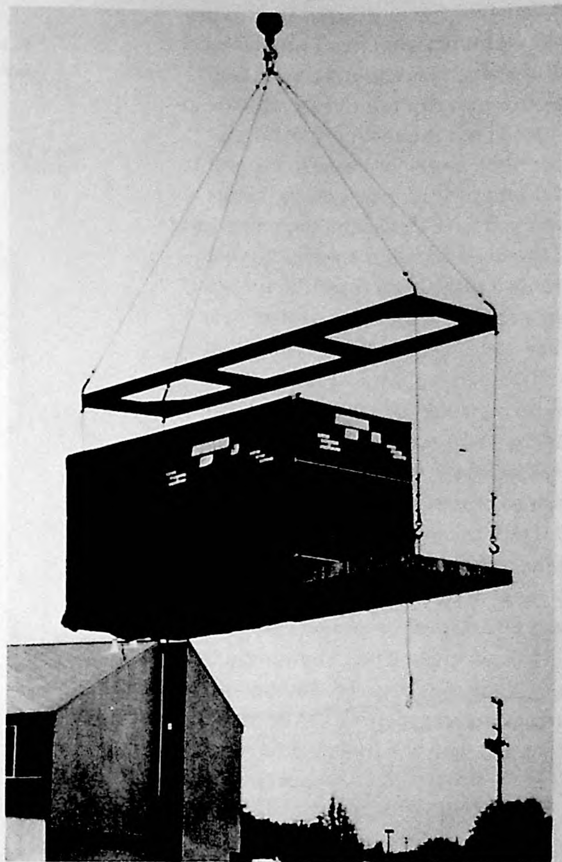
SLING ASSEMBLY METHOD

POSITION OF STRAPS JUST PRIOR TO CRANE TAKING UP SLACK ON GE MODULE BEING TRANSFERRED FROM HIGHWAY TRANSPORTER TO OTTX FLATCAR

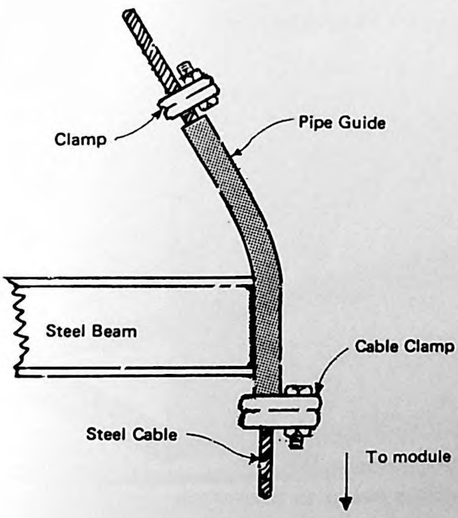
FCE-Dillon, Inc.

This company employed the typical rectangular flat steel frame as the lifting mechanism to unload and erect their core units. The steel frame mechanical core assembly was attached to a precast, prestressed concrete floor slab and shipped as a unit. The lifting frame, fabricated from commonly available structural steel, was basically the same size as the concrete floor slab. Four heavy steel cables ran vertically from the point of attachment, at each corner of the floor slab, through cable guides at the corner of the frame and then to the crane hook. The four lifting points in the slab consisted of 1/2 in. diameter steel strand-wire loops which had been previously embedded a minimum of 24 in. into the concrete slab in order to withstand a 40,000 lbs. pull.

To enable the manufacturer to use this lifting frame system for modules of various heights, as well as to use a *continuous* cable from the slab to the crane hook, pipe-guides were welded to each corner of the steel frame. Cable-clamps, on the lower side of the pipe-guide, determined the position of the lifting frame with respect to the cable ends.



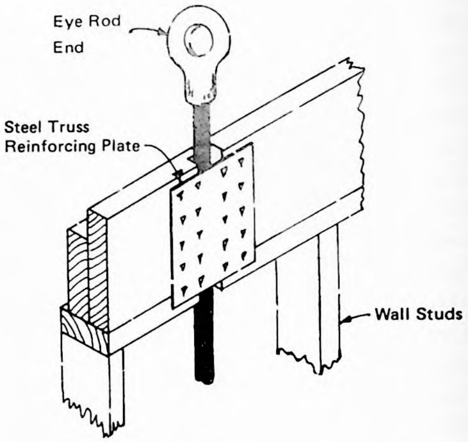
ERECTION OF FCE-DILLON MECHANICAL CORE UNIT



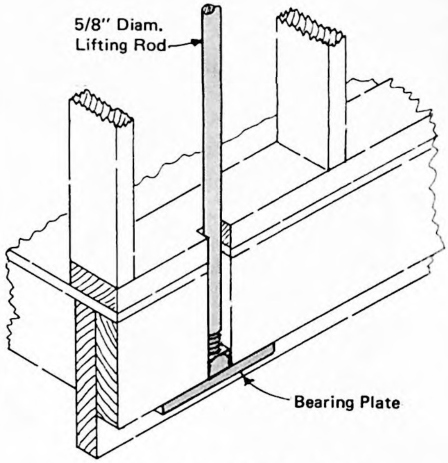
Levitt Technology Corp.

The spreader frame utilized by this producer was fabricated from tubular steel sections, and was equipped with eight eye-hooks on the top of each side member, to which the main cables to the crane hook were connected. In order to distribute pick-up point loads, Levitt employed four steel cables running from the spreader frame to steel rods which extended downward from the spreader frame and were shackled to steel rods which were temporarily installed within the module's woodframe walls. These 5/8 in. diameter lifting rods were provided with an eye-hook at the top and a threaded lower end for structural attachment to bearing-plates located under the sill. Once the module was in place, the lifting rods were unscrewed and removed for reuse in other modules. Some alignment difficulties were experienced by factory workmen when attempting to guide these rods through the top and bottom framing members to engage the lifting rod with the threaded bearing plate.

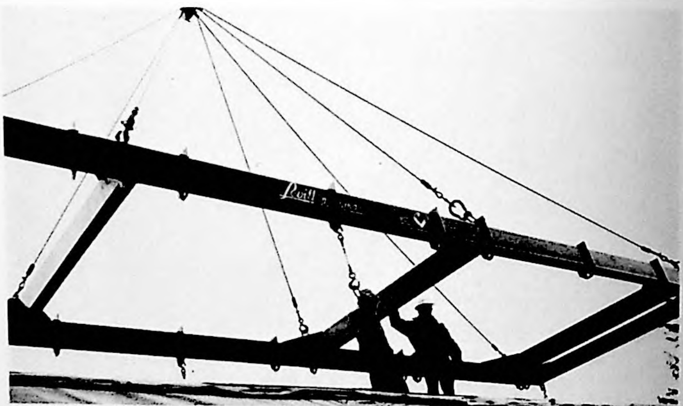
To accommodate various lengths and modular weights, a total of eight movable module-hooking devices were attached to the flanges of each main side member of the frame in order to receive the cables from the modular unit.



FRAMING AT TOP PLATE



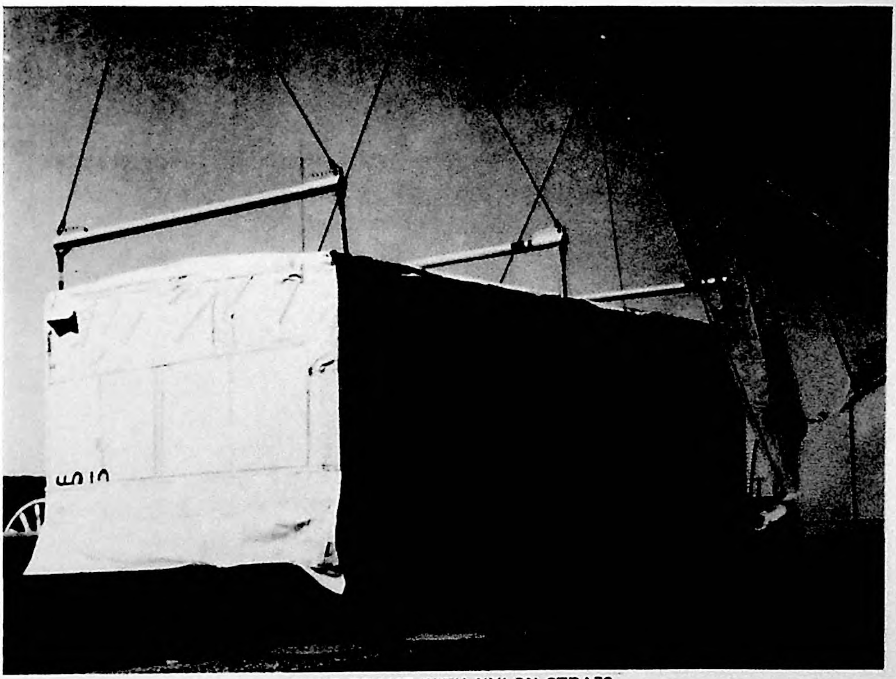
FRAMING AT BOTTOM PLATE



LEVITT LIFTING FRAME IN OPERATION

Materials Systems Corp.

MSC's light weight spreader lifting device made use of a triangular steel truss method. A long, steel tubular main-beam (8 in. in diameter by 95 ft. in length) supported three truss assemblies consisting of 12 ft. wide spreader-bars, suspended, in the shape of a triangle, by cables secured to computed points on the main-beam. In operation, the lifting-mechanism was positioned over the module's top. The eyes of the metal straps (which were previously installed in the factory and which encircled the walls and floor) were then shackled to the spreader-bar ends. Some assembly difficulty was experienced with this system during cold weather where crews lost time in shackling the spreader-beams to the metal straps from the module. Otherwise, the system was very efficient. At certain building sites MSC used the more conventional rectangular lifting frame system for transfer of modules.



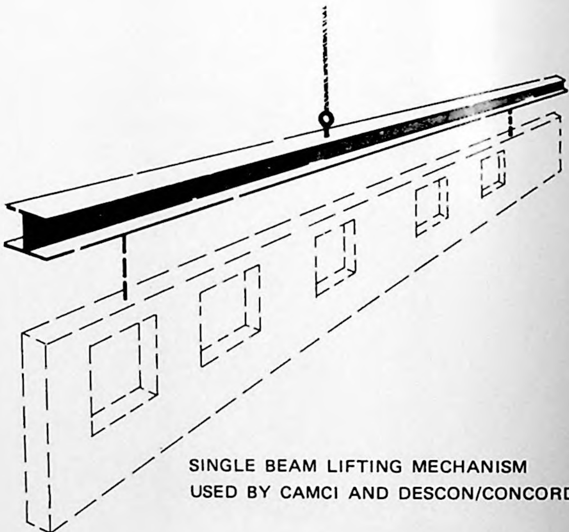
LIFTING FRAME WITH NYLON STRAPS

Descon/Concordia Systems, Ltd.

The lifting mechanism utilized by this housing systems producer consisted simply of a 40 ft. long structural steel beam with a heavy crane cable pick-up ring welded on the top flange at the mid-point. Two similar rings were welded to the bottom side at the outer extremities of the beam to receive straps or cables from the concrete panels.

CAMCI, Inc.

To move various length concrete panels during erection, CAMCI used a simple steel beam arrangement. A steel lifting eye was welded at the center of the top flange of the beam to receive the crane hook. Along the beam, holes were drilled at various intervals to receive the pick-up cables from different size and length components. During plant fabrication of panels, steel lifting straps were embedded in the concrete and were used for all handling operations.

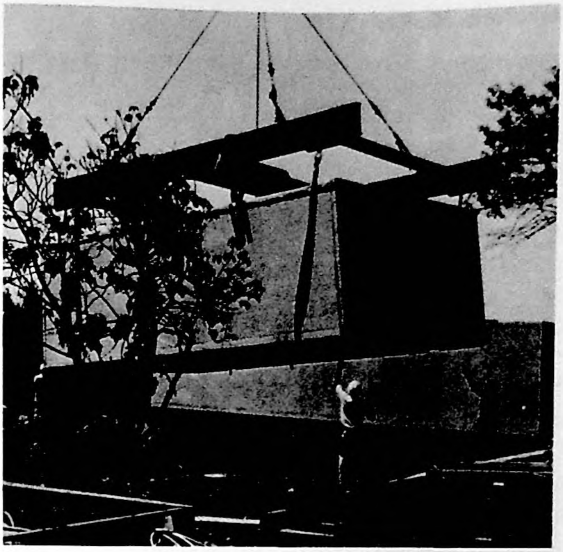


SINGLE BEAM LIFTING MECHANISM
USED BY CAMCI AND DESCON/CONCORDIA

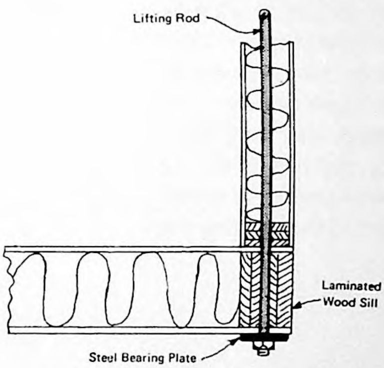
Community Technology Corp.

The initial lifting mechanism used by this producer was an "H" shaped frame fabricated from structural steel shapes. It consisted of a heavy main beam to which a predrilled steel bar was welded at the center of the top flange to receive the lifting clevis. There were five such holes provided on either side of the center hole. The weight distribution of the module being lifted determined the exact hole location for the clevis. To provide rigidity, steel cross beams were located at each end of the main beam.

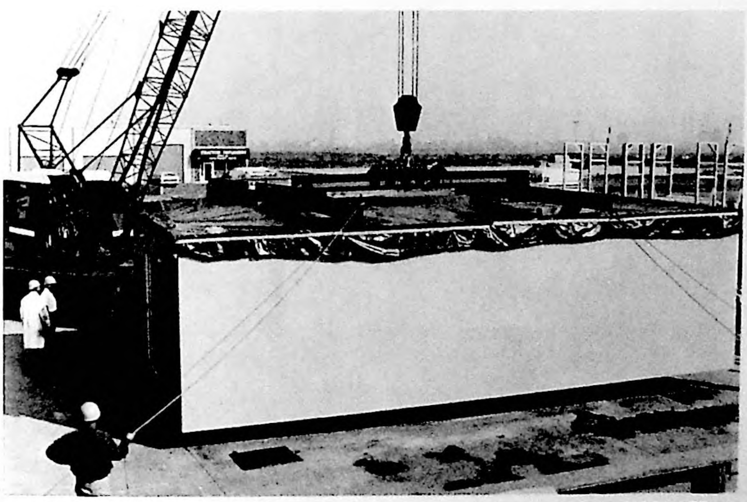
The ends of the cross beams were drilled to receive threaded lifting rods which were located in the walls of the module. The lifting rods ran through the module wall to the bottom laminated sill where they were threaded into a steel bearing plate. Difficulty with this system was experienced in aligning the holes in the top and bottom laminated beams, and in addition water would enter the wall cavity during storage and shipment. For these reasons it was decided to discard this system and use nylon straps which encircled the modules. The four straps were suspended from a typical structural steel spreader frame.



LIFTING FRAME WITH NYLON STRAPS



EMBEDDED LIFTING ROD DETAIL

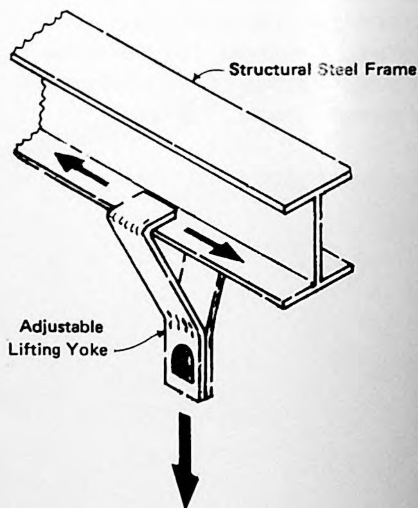


"H" SHAPED LIFTING FRAME USED TO LIFT SECOND STORY MODULES

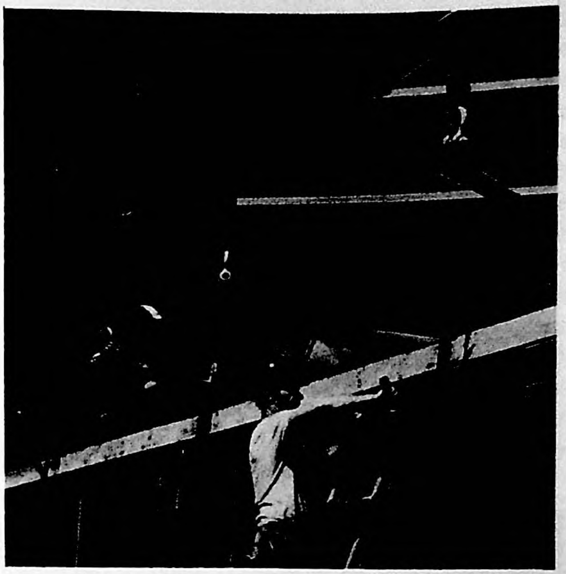
Hercoform Marketing, Inc.

The spreader-type horizontal lifting frame, utilized by Hercules, was fabricated from structural steel shapes. It measured 30 ft. long by 11 ft.-4 in. wide and was outfitted with four lifting yokes on the bottom flange of each main side beam. These yokes were fabricated to fit over the flange in such a manner as to enable their positioning along the beam to satisfy varying modular-load requirements. Two cable lifting eyes were welded on the top near the ends of each frame side member, to which the four primary lifting cables to the crane hook were connected.

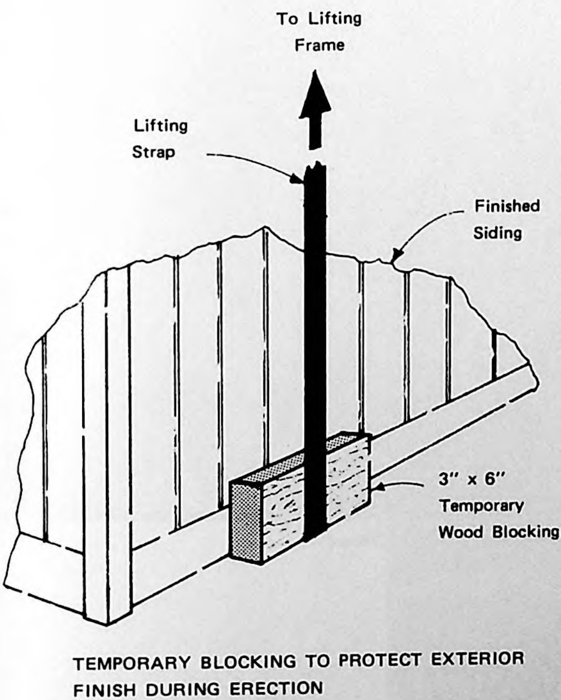
Continuous steel band straps encircled the module at four predetermined pick-up points and connected to the lifting yokes, by shackles, on opposite sides of the spreader frame. These factory-installed banding-straps were 0.05 in. thick and 2 in. wide, and remained in place on the modules until the units were finally installed at the building site.



To prevent damage to exterior trim and finish materials, during loading and unloading, this manufacturer provided 3 in. x 6 in. wood blocking at the top and bottom of the modules where the four lifting straps were located. These blocks of wood acted to distribute the concentrated load from the straps and eliminated indentation in the trim and frictional scars to the finish. When the modular units were in place, both the wrap-around steel straps and the temporary blocking were removed and discarded. Similar methods of blocking were also used by other housing systems producers to minimize potential damage of this type.



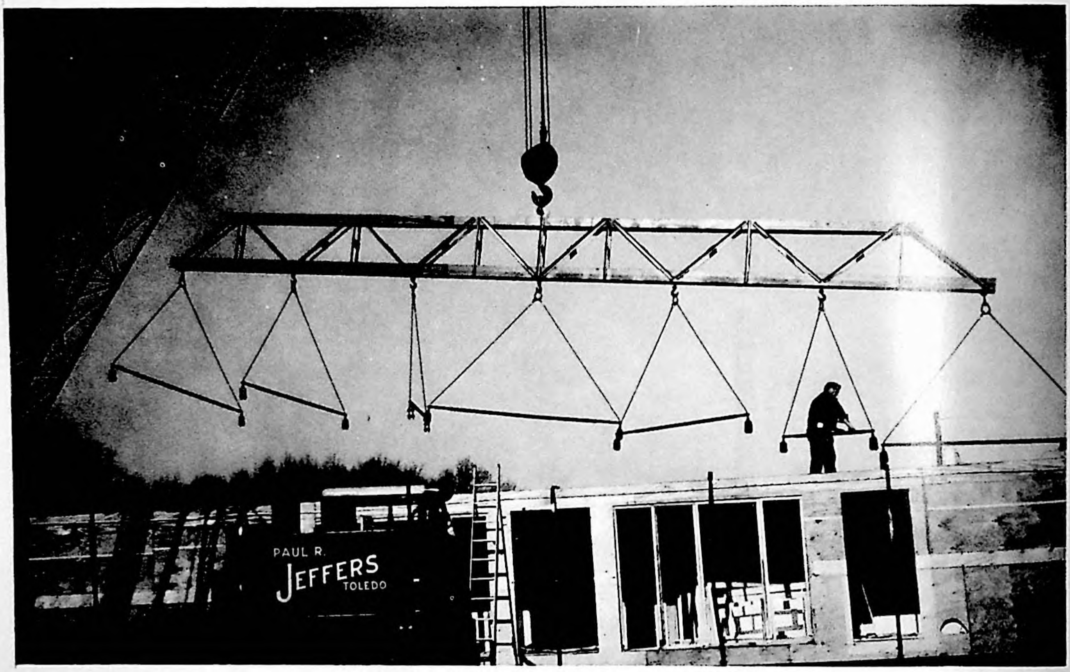
WORKMEN REMOVING LIFTING FRAME FROM HERCOFORM MODULE



TEMPORARY BLOCKING TO PROTECT EXTERIOR FINISH DURING ERECTION

Scholz Homes, Inc.

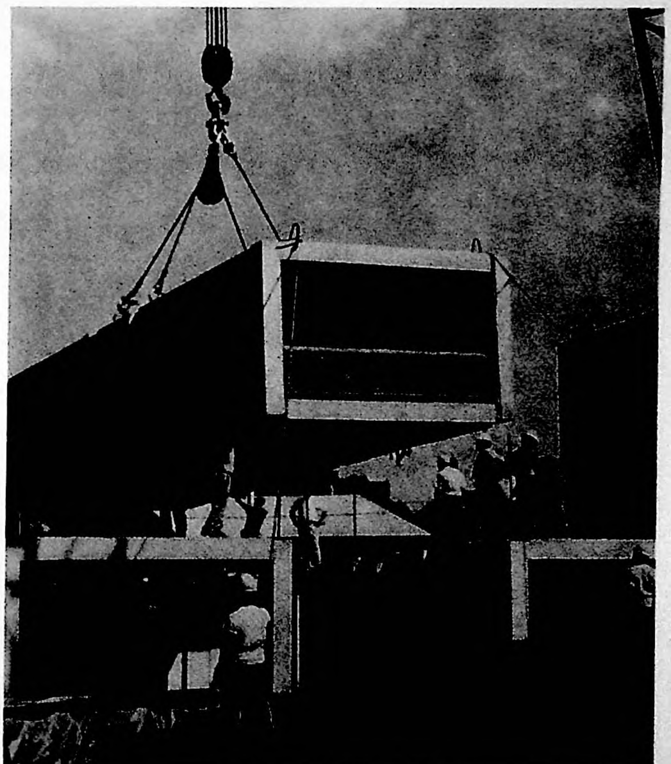
Modules from 18 ft. to 56 ft. long were handled by Scholz's unique lifting system. It utilized a longitudinal welded steel truss supporting seven spreader bars spaced 8 ft. apart. The top member was fitted at the center with a flat steel eyelet for attaching the crane hook directly to the lifting truss. Steel straps, surrounding the modular unit, were attached to the spreader bars which, in turn, were attached to the lifting truss by steel cables. Depending upon the length of the modular unit to be lifted, either 5 or all 7 of the spreader bars could be used.



UNIQUE LIFTING SYSTEM USED BY SCHOLZ

Because of the strength inherent in the Shelley concrete modules, this company did not employ a special lifting frame mechanism to move these units at either the plant or the job site.

Four heavy structural lifting eyes were embedded in the top of the concrete module during plant fabrication. The only additional equipment (other than the crane) required to move these 53-ton stack-on units was four heavy steel cables and shackles to connect the lifting eyes with a ring for the crane-hook. Steel eyelets were also cast into the concrete modules, at each corner, for attachment of guy wires which were used to control the unusually heavy load during removal from the highway transporter and to assist in positioning the modules in the stack.



SHELLY MODULE BEING LOWERED INTO POSITION

8.

SITE ERECTION

General

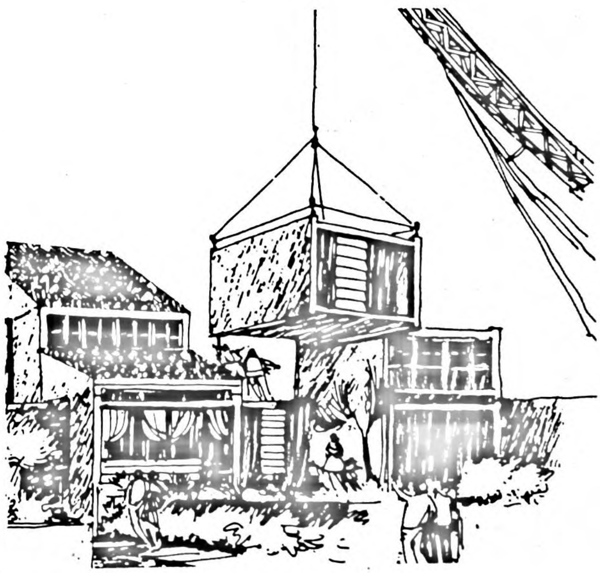
Perhaps the most dramatic phase of the entire industrialized housing process is the assembly and erection of factory-finished modules and components at the building site. This procedure, in many cases, readily converts a site of concrete foundations into a finished housing development complex—sometimes within a matter of days. To accomplish this transformation, BREAKTHROUGH producers employed a variety of erection methods to lift and transfer building elements from transporters to final position in the finished living unit.

The crane, the most prevalent of the erection schemes, ranged in capacity from 35 to 125 tons. Some cranes were truck-mounted hydraulic units, while others were capable of reaching the top of an 18-story building. Several unusual erection systems, incorporating "roll-on" and "drive through" techniques were also utilized to emplace finished modules on previously prepared foundations.

In almost all cases, the erection process was subcontracted. It was noted that as the crane operators developed a familiarity with each producer's system, the efficiency of erection substantially increased with a resultant reduction in per-unit erection cost. Job site complexities, including weather, building setbacks, trees and general site congestion, oftentimes penalized erection performance. While most producers furnished their own specially fabricated lifting frames, the crane contractors frequently found it necessary to make rigging adjustments to accommodate the varying conditions which existed at the individual sites.

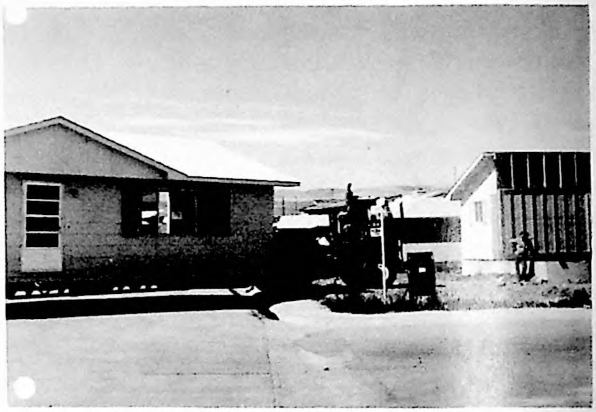
This chapter is, of necessity, less detailed than the preceding ones since the housing systems producers were not required to formally submit an erection-plan; and often the erection process was subcontracted leaving minimal documentation available for research. Each system producer, however, included the necessary module and panel-joining and closure details in its proprietary company instructions.

The following pages provide a general insight into the erection process.



Home Building Corp.

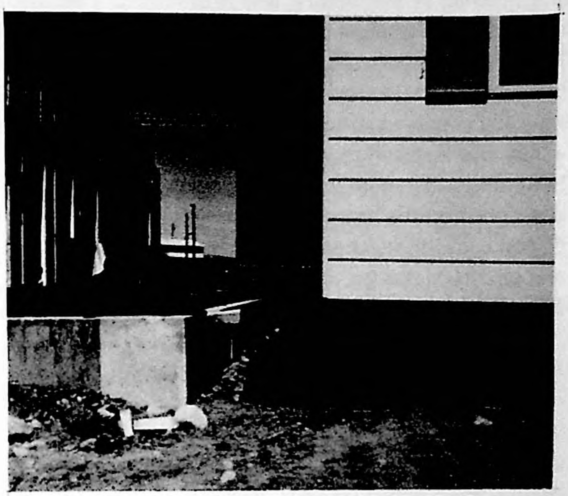
The "roll-on" technique (initially used by HBC at the Indianapolis site for transferring modules directly from the transporter) required first that fairly level ground be available adjacent to the foundation, permitting the loaded trailer to be positioned parallel to the side wall. Once in position, the module was raised from the trailer bed using built-in hydraulic jacks. Specially designed steel tracks were then placed on the trailer bed under the module and on the top of the foundation wall. A similar set of tracks spanned the foundation walls with steel jacks providing additional support at the center of the span and immediately adjacent to the interior side of the walls. The module was then lowered and rolled along the tracks until its proper position over the foundation was attained. When both halves of these single-story detached houses were in alignment, they were bolted together along the center girder beam. The entire house was then raised, as a unit by jacks to facilitate removal of the tracks. The house was then lowered to its final position on the foundation walls.



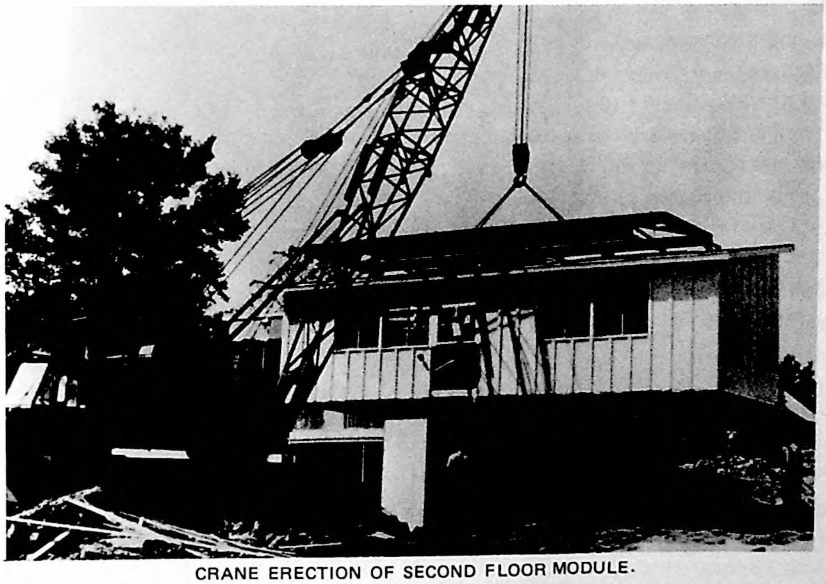
HBC MODULE BEING MOVED ONTO SITE PRIOR TO HORIZONTAL TRANSFER TO FOUNDATION

VIEW OF HOME FOUNDATION PRIOR TO TRANSVERSE POSITIONING OF SECOND HBC MODULE. NOTE HORIZONTAL TRANSFER BEAMS.

This system of erection was later eliminated in favor of the crane and lifting frame technique when it was determined that a considerable amount of time was involved in setting up and removing the tracks. Additionally, the "roll-on" method was limited to single-story construction and could not be used for the two-story townhouse units also manufactured by this producer. A 40-60 ton telescoping hydraulic crane was therefore used with success in reducing erection time and cost. It is suggested that the "roll-on" procedure can be successfully used for single sites, but until it is perfected, for large projects the utilization of the lifting crane technique is considered more practical and least costly on a per-unit basis.



HBC MODULE IN FINAL POSITION PRIOR TO BEING TRANSVERSELY SHIFTED ONTO FOUNDATION. NOTE SLIDE RAILS BETWEEN FOUNDATION AND TRANSPORTER DECK.

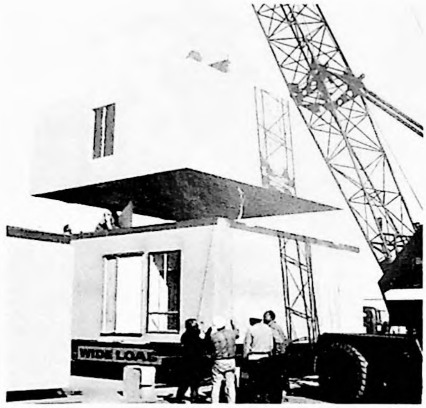


CRANE ERECTION OF SECOND FLOOR MODULE.

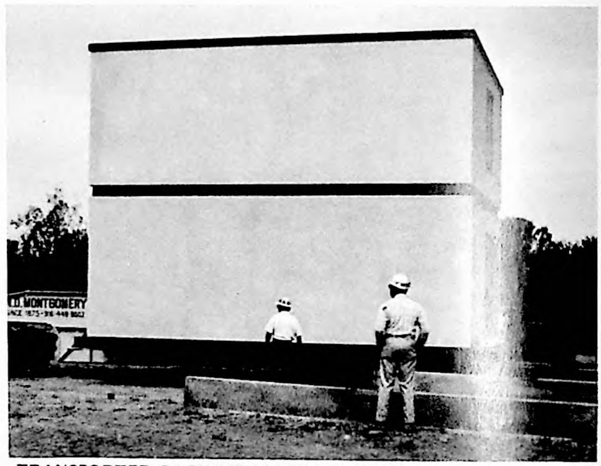
Community Technology Corp.

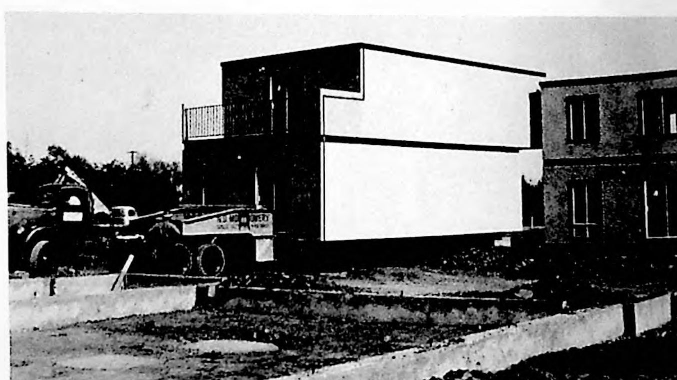
This housing producer provided one of the most innovative plant and on-site erection procedures of all Operation BREAKTHROUGH participants. Two-story, modular units were fully erected and finished at the factory, and then transported as a single unit to the site. The four modules, comprising the completed unit, were crane positioned on a specially prepared structural steel frame which was fastened to a heavy duty low-bed trailer. The modular sections were positioned on the transporter with a 60-ton capacity truck-mounted crane and securely fastened together. The finish trim was then applied.

After the 12-mile journey to the site, the completely finished townhouse was placed on its foundation by backing the transporter between the longitudinal bearing walls. When properly aligned over the foundation walls, the entire unit was raised from the trailer with hydraulic jacks freeing the transporter. It should be noted with this "drive through" technique that only three sides of the foundation walls can be completed prior to placement of the assembled unit. The remaining side was built after the transporter was removed and the unit lowered into final position on the foundation.



UPPER MODULE OF A TWO-STORY UNIT BEING SET IN PLACE.


TRANSPORTER BACKING THROUGH OPEN SIDE OF FOUNDATION WALLS.


COMPLETED TWO-STORY TOWNHOUSE APPROACH FINAL POSITION. NOTE SMALL CREW REQUIRED FOR THIS TECHNIQUE.

Alcoa Contruction Systems, Inc.
Boise Cascade Housing Corp.
General Electric Co.
Hercoform Marketing, Inc.
Levitt Technology Corp.
Materials Systems Corp.
National Homes Corp.
Scholz Homes, Inc.

These housing systems producers manufactured modules using a wood frame system and/or other similar relatively lightweight materials. To erect two-story modules at the prototype sites, this group utilized a variety of cranes and similar placement procedures.

For the placement operation at the site, a minimum crew of two, but sometimes as many as seven men were needed. Even though the flexibility of the crane was adequate to approximately position individual modules, final alignment almost always required the manual "tug and shove" of the erection crew often assisted by handwinch or ratchet devices. Other equipment, common to this operation, included ladders for climbing and guide ropes which were fastened to the lifting frames and held by a workman to control sway of the module.

Cranes: Erection of modules, at the building site, was primarily subcontracted to local crane operators by the housing system producers. Rigging and crane costs were based upon crane-boom length. Initially producers attempted to curtail costs by ordering cranes with boom-lengths between 30 ft. to 50 ft. However, these lengths limited crane flexibility and production. An excessive amount of time was consumed in crane repositioning between truckload and foundation, particularly in stacking multifamily units. Such delays also impacted on the rigging crews as well as delaying highway transporter equipment and trucks. Therefore, longer fixed booms were employed, usually in the 60-foot range; and erection-production materially increased. Crane-weight characteristically averaged one-ton per one-foot of boom. In general, the housing systems producer-designed lifting frames performed well when used by the distant, independent crane-operator.

Planning and Control: The housing producers provided their site managers with detailed plans for both the sequencing of modules to the erection-site, and for joining and closing the units. Final module movement occurred either from a nearby interior storage location, or from a railroad siding, to under-the-crane-hook at the specific building lot. The prototype site developer was responsible for assuring coordination among the various systems producers to avoid undue street traffic disruption by incoming truck loads.

The problem of meshing the crane's lifting and placement cycle with the shuttle deliveries of the modules often indicated that module installation time lagged considerably behind module delivery time, which in turn, caused truck drivers detention penalties. An exception was

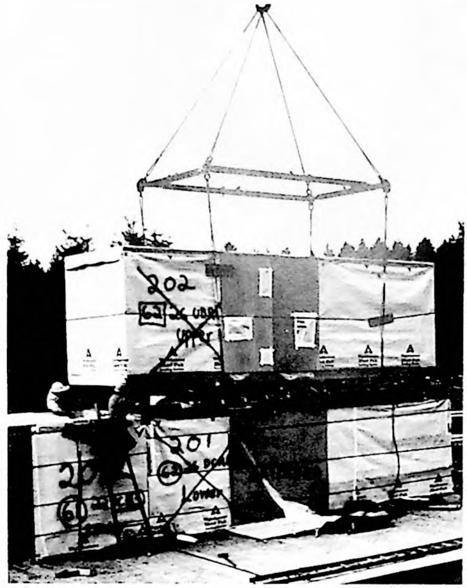
Boise's erecting 32 modules in one day's time at the Sacramento site.

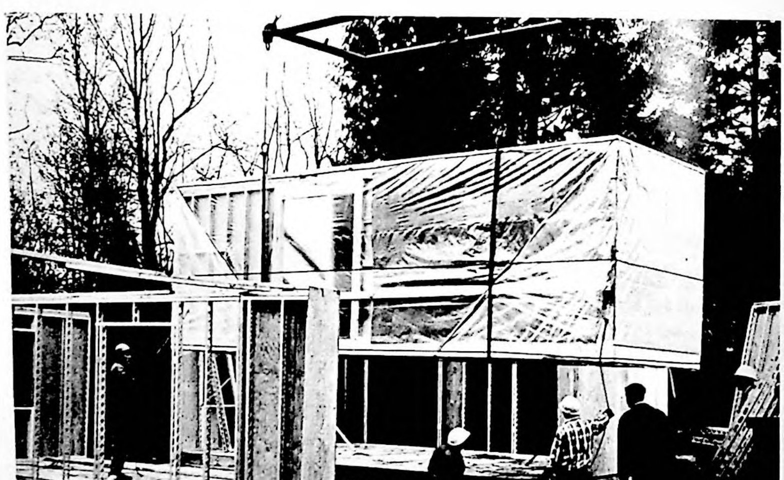
Module Protection: BREAKTHROUGH experience indicated that all protective covering should remain in place until the module was joined and all closure openings secured. Often such closures and utility hook-ups did not occur until 2 to 3 days later. Light-weight disposable wrappings served best for this purpose. During hoisting, sudden heavy rains or wind gusts often interrupted the schedule and could cause minor but troublesome damage to exposed interiors, particularly to 3-sided modules. Exterior siding, susceptible to chafing and marring during the erection process, benefited from retaining the exterior wrap. Temporary polyethelene on carpeting also protected against dirt and grime caused by carpenters installing final trim, etc.

Portrayal:

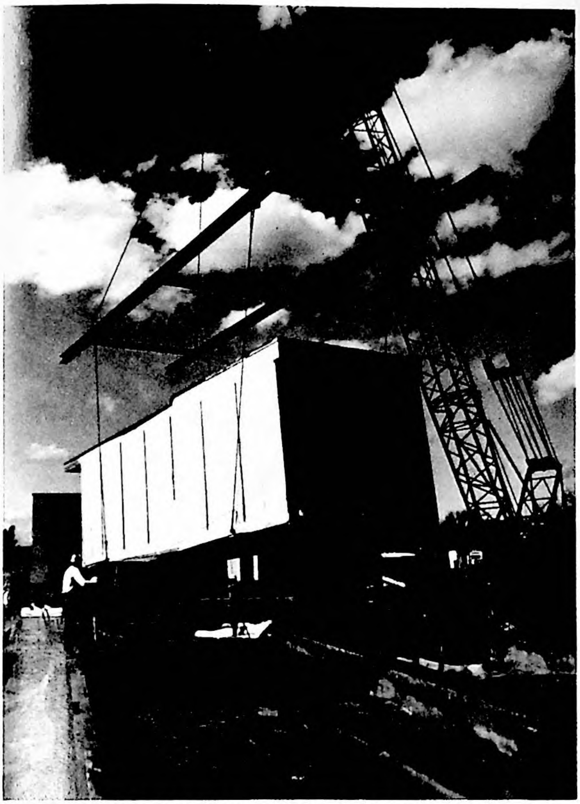
The photographs on the following pages depict the main features of eight BREAKTHROUGH producers' erection processes. Because the photos clearly describe the activity of each manufacturer no further narrative description is included.

Alcoa Construction System, Inc.

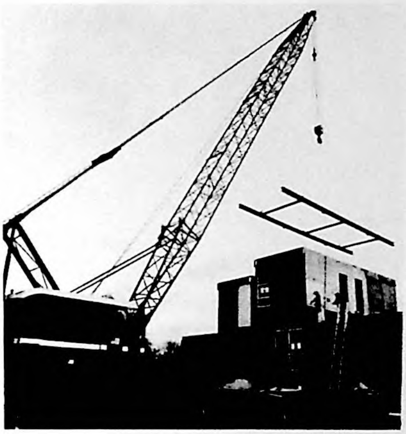




LIFTING AND PLACEMENT OF ALCOA'S MECHANICAL CORE AND ALUMINUM FRAMED WALL SYSTEM. NOTE THAT PROTECTIVE PACKAGING WAS RETAINED IN PLACE UNTIL AFTER CORES WERE ERECTED.

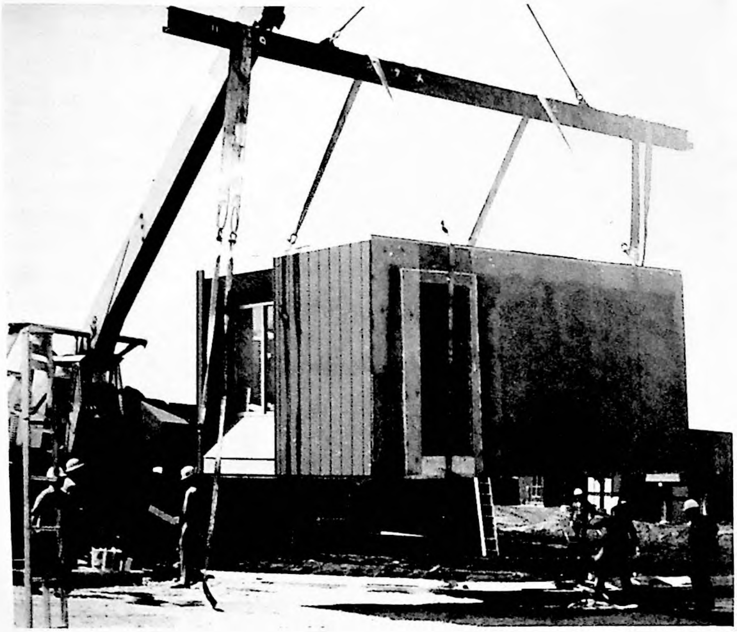


FIRST FLOOR MODULE BEING LOWERED ONTO FOUNDATIONS.

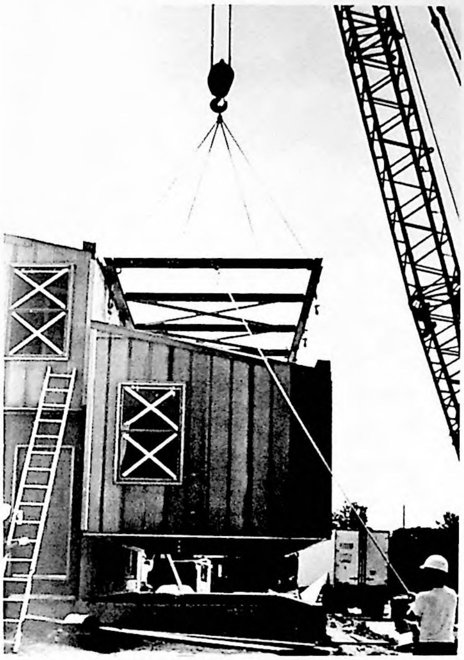
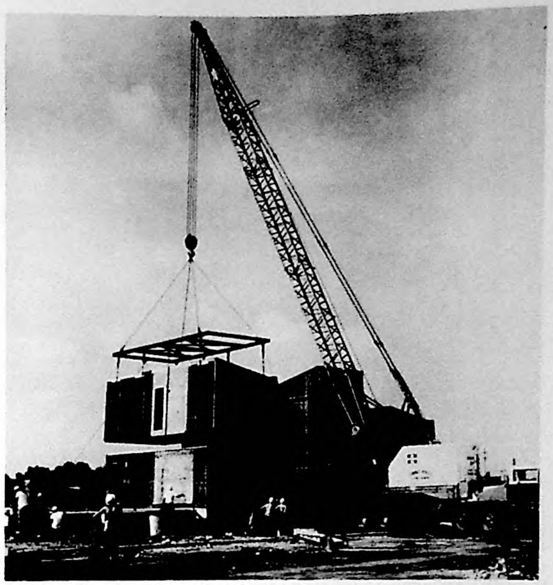


POSITIONING OF SECOND STORY MODULES.

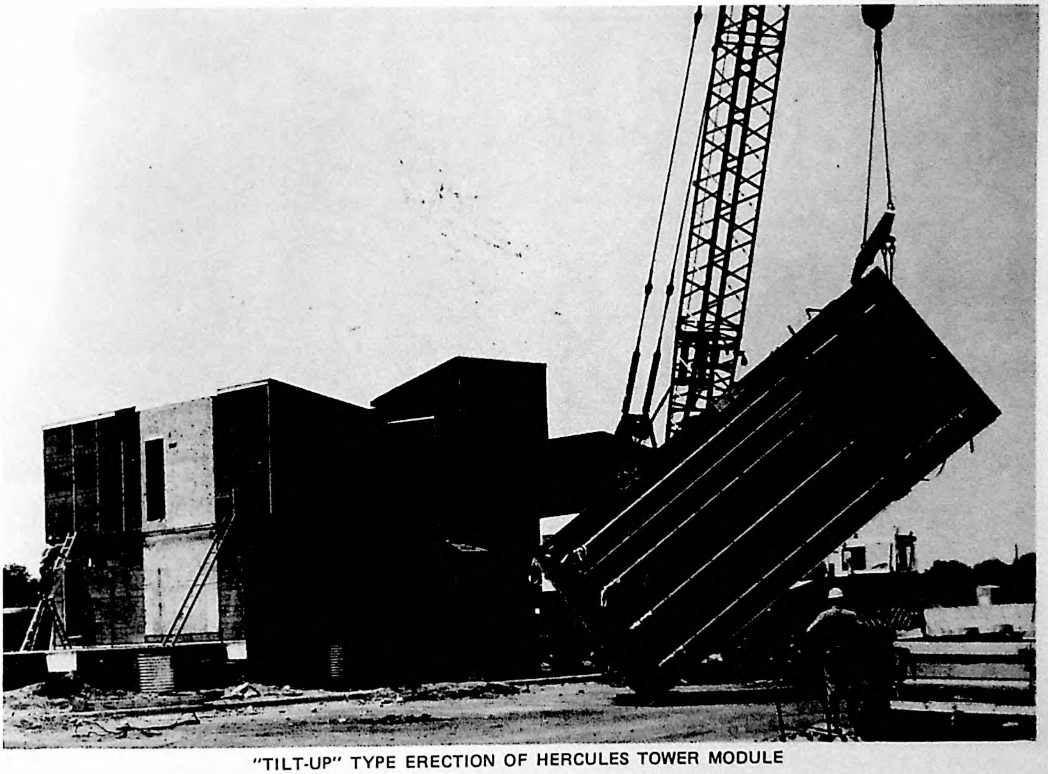
FINAL POSITIONING IS BY MANPOWER. NOTE PINCH BAR.



TRUCK MOUNTED 35 TON HYDRAULIC CRANE USED BY GENERAL ELECTRIC TO EMPLACE MODULAR UNITS.

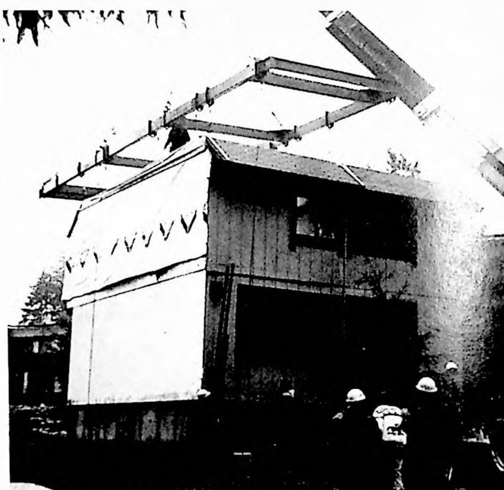



LONG BOOM CRANE USED BY HERCOFORM PERMITS PLACEMENT OF MODULAR CLUSTER FROM ONE LOCATION.



"TILT-UP" TYPE ERECTION OF HERCULES TOWER MODULE

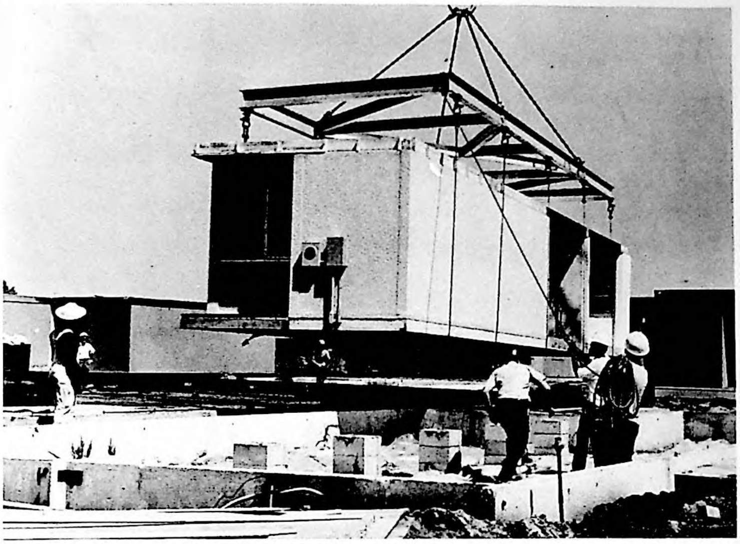
HYDRAULIC CRANE PLACES LEVITT'S FIRST FLOOR MODULE. THESE SIXTY FOOT LONG MODULES WERE INSTALLED WITHOUT DISTURBING THE NATURAL LANDSCAPE.



FINAL MODULE IN POSITION.

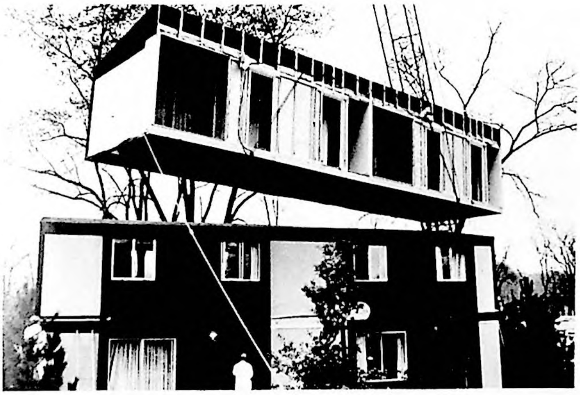
GUIDE ROPES ASSIST IN PLACING MODULES.

Material Systems Corp.



FOUR MEN ASSIST IN CRANE PLACEMENT OF MATERIALS SYSTEMS' POLYESTER MODULE

National Homes Corp.



ERECTION AND POSITIONING OF NATIONAL HOMES SECOND STORY MODULES.

SCHOLZ MODULE BEING LIFTED AT ERECTION SITE

SCHOLZ UTILIZED 60 TON CRANE TO MINIMIZE REPOSITIONING OF CRANE.

Building Systems International, Inc.
CAMCI, Inc.
Descon/Concordia Systems, Ltd.
FCE-Dillon, Inc.
Shelley Systems, Inc.

These participants fabricated their industralized housing product from concrete for utilization in multi-story construction at the prototype site. Their building elements ranged from precast concrete wall, floor and ceiling panels to completely finished modules weighing up to 53 tons. Use of these elements in high-rise construction required considerably more sophistication in the techniques of panel connecting and module joining as compared to those used in low-rise wood-type module assembly. In addition, the required trade skill mix of iron workers, laborers, riggers, etc., was more complex than for the more conventional wood modules.

In most cases these concrete elements were raised into their final position in the hi-rise structures by cranes with lifting capacities of up to 125 tons. This on-site operation, although faster than poured-in-place conventional concrete construction, closely paralleled typical construction procedures employed for this type of structure. Shelley Systems, which used factory finished concrete modules, tended to reduce, even more, the amount of on-site work required. Although hampered somewhat by difficulty in achieving fit when mating the "boxes" in their non-columnar buildings, this housing systems producer, nevertheless, made commendable progress by the use of this construction technique. Another manufacturer, FCE-Dillon, utilized completely finished mechanical core units, which were an integral part of the concrete floor slabs, to hasten final erection of their building. Erection of panels by Dillon was also extremely fast (panels were cycled from truckbed and locked-in-place in the building within 12 minutes).

Realistic experience at the Jersey City site demonstrated the practicality of these erection procedures under urbanized congestion; particularly in terms of scheduling and handling large concrete panels or modular deliveries in older dense business districts. Most site erection operations proceeded normally. However, some positioning difficulty was experienced when adverse wind conditions impacted on the wide but relatively light concrete panels. Periodic delay problems were also encountered in obtaining experienced crane crews for operating the very sophisticated high-lift rigs.

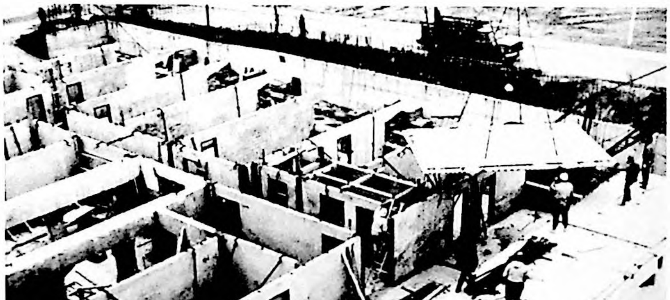
The following photographs illustrate some of the equipment and erection techniques employed at the building site by certain of these factory producers of concrete components and modular units.

Building Systems International, Inc.

VIEW OF CAVITY AT JUNCTION OF WALL & FLOOR PANELS READY TO RECEIVE CONCRETE

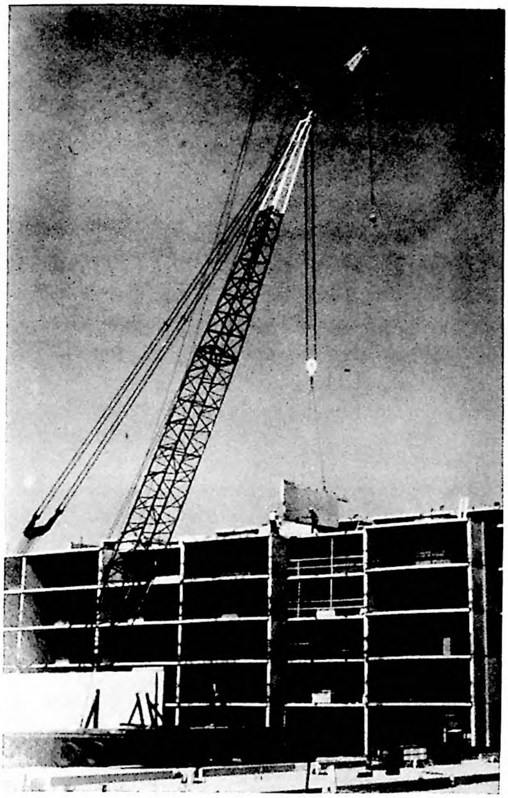
LOWER STORY ERECTION, WITH COMPLETELY ERECTED 20-STORY BUILDING IN BACKGROUND

TYPICAL PANEL BEING LOWERED INTO POSITION

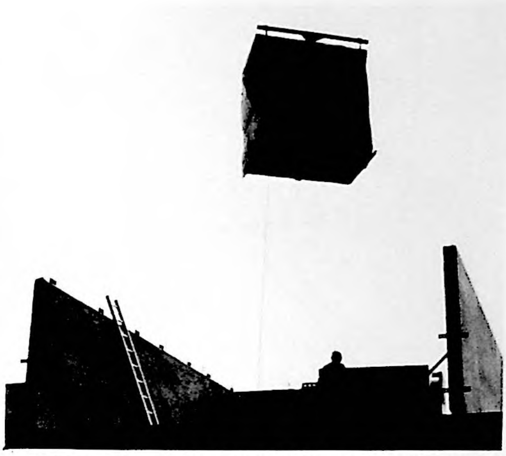


CEILING/FLOOR SLABS BEING PLACED ON WALL PANELS

Descon/Concordia Systems, LTD.

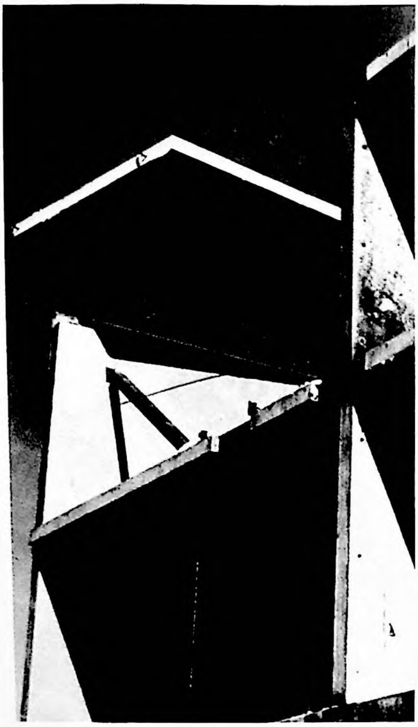


TEN-STORY BUILDING BEING ERECTED AT JERSEY CITY SITE

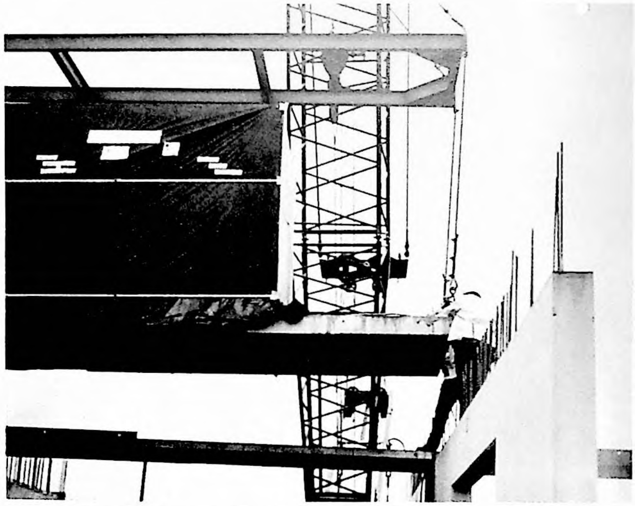


MECHANICAL CORE UNIT BEING LOWERED INTO POSITION AT BUILDING SITE

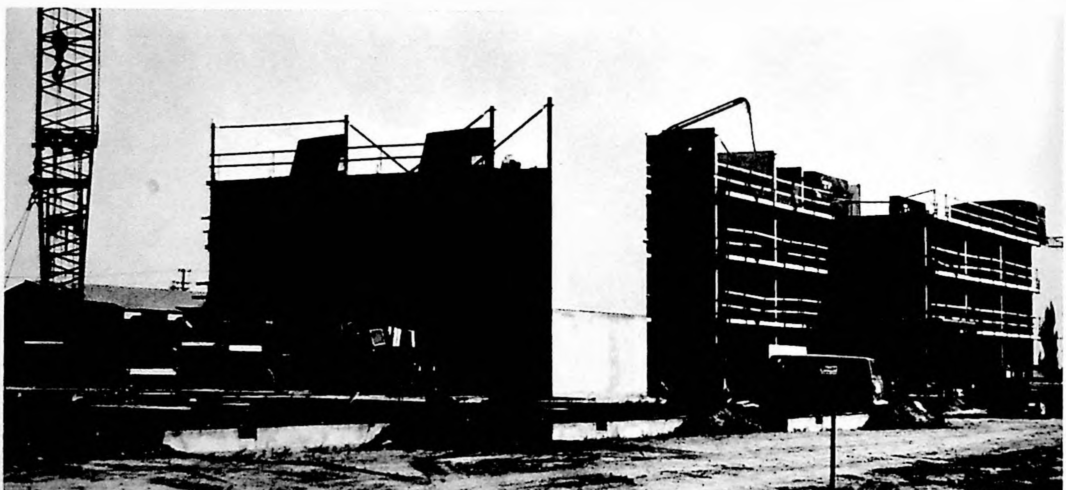
ON-SITE CASTING AT JERSEY CITY SITE



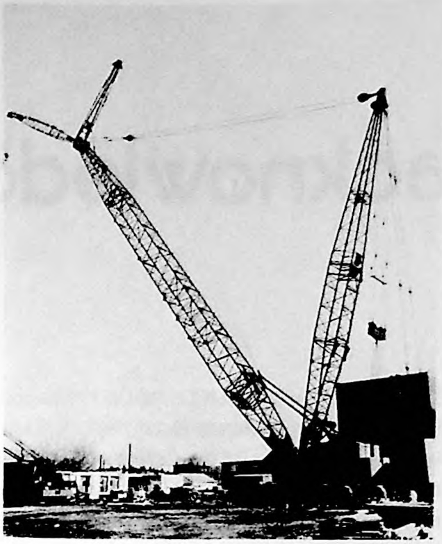
PRE-CAST CONCRETE CEILING/FLOOR PANEL IS LOWERED INTO POSITION.



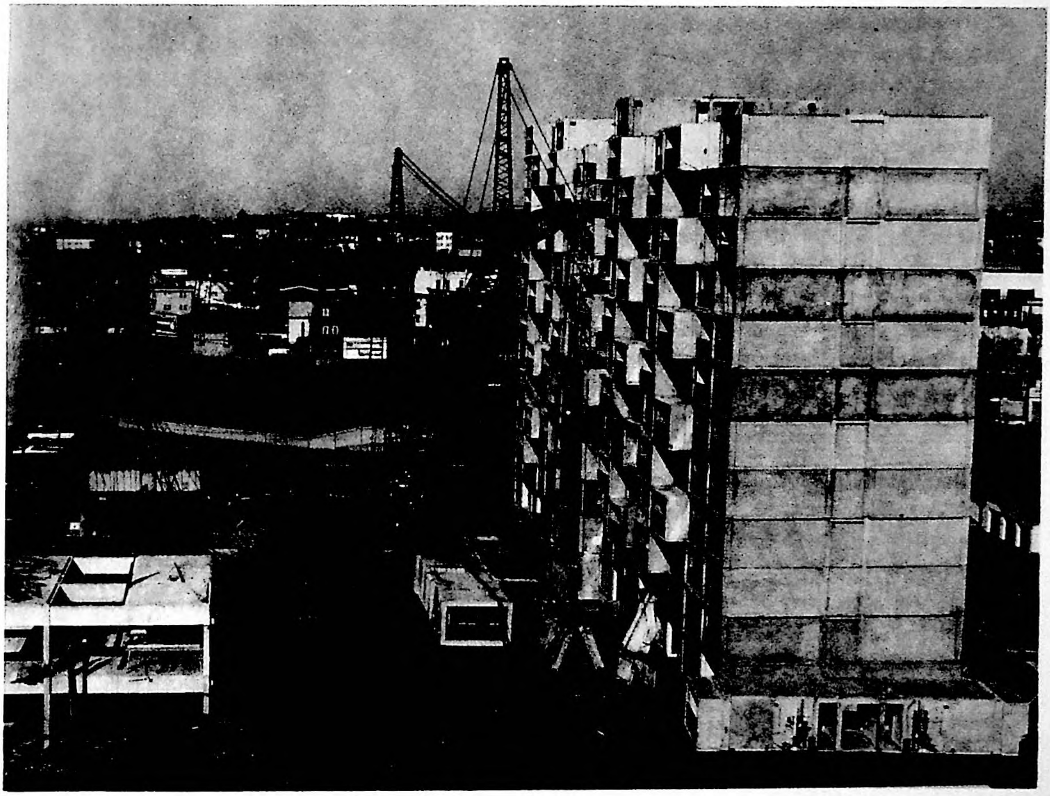
PLACEMENT OF COMBINATION MECHANICAL CORE AND CONCRETE FLOOR SLAB.



VIEW OF THREE COMPLETED FLOORS OF THE NINE-STORY HIGH-RISE BUILDING FOR THE ELDERLY.



"SKY HORSE" CRANE, USED BY SHELLEY, TO HOIST AND POSITION CONCRETE MODULES AT JERSEY CITY.



SHELLEY MODULES OF THIS TYPE WERE STACKED 18 STORIES HIGH

acknowledgements

This Operation BREAKTHROUGH Feedback report was prepared by the Office of Policy Development and Research of the U.S. Department of Housing and Urban Development with the assistance of the Office of Housing Technology, Center for Building Technology of the National Bureau of Standards, Washington, D.C., and Reidelbach-Simpson Associates, Annandale, Virginia.

While a large portion of the material was supplied by the representatives of the Housing Systems Producers, other informational sources included:

Barrett Mobile Home Transport, Inc.
Morgan Driveaway, Inc.
Freight Masters, Inc.
Baltimore and Ohio Railroad Company
Missouri Pacific Railroad Company
Penn Central Railroad Co.
Southern Railway System
Western Pacific Railroad Company
Chicago-Northwestern Railroad Company
Union Pacific Railroad Company
American Association of Railroads
Mobile Housing Carriers Conf., Inc.
American Association of State Highway and Transportation Officials
Forest Products Laboratory
Gifford-Hill Concrete Company
Eastern Schokbeton Corp.
Sto-Cote Products, Inc.
Speed Cut, Inc.
The Binkley Company
Drott Manufacturing Company
Schertzer Sales Corporation
Lakeside Manufacturing Corporation
Midwest Research Institute
National Trailer Convoy, Inc.

suppliers

In responding to requests for transportation information for inclusion in this document, some of the Operation BREAKTHROUGH participants provided specific brand names and/or names of suppliers of products and equipment incidental to this process.

Because of the special nature of this subject, the names and addresses of these individual manufacturers and producers are listed below to assist others in the industry in readily locating these transportation-oriented supply sources.

Manufacturer	Product
Aeroquip Corporation Industrial Division 300 South East Avenue Jackson, Michigan 49203 (517) 783-2585	Module Securement Straps
American Crane and Hoist Corp. 12142 Bellflower Blvd. Downey, California 90241 (213) 773-2404	Crawler Crane
The Binkley Co. Main and Elm Streets Warrenton, Missouri 63383 (314) 456-3455	Highway Modular Transporters
Drott Manufacturing Co. P.O. Box 1087 Wausau, Wisconsin 54401 (715) 359-6151	Straddle-type Crane
General Trailer Co. 15th and South "B" Streets Springfield, Oregon 97477 (503) 746-8218	Highway Modular Transporters

Manufacturer	Product
The Homesote Co. Lower Terry Road Trenton, New Jersey 08628 (609) 883-3300	Packaging Material and Building Insulation Boards
Lakeside Manufacturing Co. 39 East Main Street Honeoye, New York 14471 (716) 229-5177	Highway Modular Transporters
Saint Regis Paper Co. Sisalkraft Division 150 E. 42nd Street New York, New York 10017 (212) 697-4400	Sisalkraft Paper
Schertzer Sales Corp. 32 Prospect Street Somerville, Massachusetts 02143 (617) 666-9100	Heavy Duty Highway Transporters
Signode Corporation 2606 N. Western Avenue Chicago, Illinois 60647	Steel Strapping, Bulkbinding and Heavy Duty Strapping
Speed Cut Manufacturing Co. P.O. Box 1125 Corvallis, Oregon 97330 (503) 753-2291	Modular Transporters
Sto-Cote Products, Inc. 2139 North Wayne Avenue Chicago, Illinois 60614 (312) 525-3711	Tu-Tuff Cross Laminated Poly Sheeting
New Way, Division of Lear Siegler, Inc. P.O. Box 425 Mark Egon, Michigan 49443 (616) 773-3271	Highway Pneumatic-Suspension Systems
Trailer Train, Inc. 300 South Wacker Drive Chicago, Illinois 60606 (312) 786-1200	Railcar Leasing

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