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The Conversion of International Cargo Containers into Lower Cost Housing -- A Socially Designed Home

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by

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INTRODUCTION

Engineering educators have long recognized the importance of the humanities in the curriculum for engineering students. Over the past twenty years, this recognition has been translated into a set of requirements for electives, and accreditation of an engineering curriculum in a University by the Engineering Council for Professional Development and is based, in part, on a minimum number of credits being taken in the humanities. At the University of Denver for example, a minimum of 24 credit hours is required in the humanities out of a total of 188 credit hours for an engineering degree.

Although we live in a world today where almost everything we touch, taste, smell, or breathe is affected to some extent by science and technology, a student in the humanities is not obliged to learn very much about science and technology. Only fifteen credit hours in science are required, and these may be taken in the largely nonmathematical disciplines of biology, geography, or geology.

Humanities students therefore graduate, by and large, with little more knowledge of science and technology than they had at the beginning of their college education. Engineering students pick up a collection of unrelated beginning courses in the humanities and social science, endure them to meet their curriculum requirements, and graduate with very little appreciation for, or understanding of, this part of their curriculum. Yet, both types of students go out into a world which is just as dominated by human beings and their interrelationships as it is by science and technology.

In the practice of his profession, the engineer learns very soon that everything he does professionally involves people, and their interrelationships. The humanities student, on the other hand, finds there is very little he can do without calling on the help of science and technology. The educational problem facing us is to give the engineering student a coherent education in the humanities, and the humanities student an understanding and appreciation of the role of the engineer and technology in society.

An experimental step toward solving this educational problem has been undertaken by the University of Denver by establishing a course entitled "Social Engineering." This is a project-oriented one-year course in which a socio-technological problem of current interest is chosen as the project, and a group of students and faculty from engineering and arts and science address themselves to defining the problem, gaining the deepest possible understanding of both the sociological and technological components of it, and work together to come up with a practical plan for its solution. Last year's project was the problem of providing adequate housing for migrant farm workers, a subject of increasing national attention. Starting from the broad base of migrant workers and their needs in general, the focus was narrowed to migrant workers in Colorado and the problem of providing proper housing for them. The end result of this course was a complete detailed plan for providing such housing, including sociological, technological, financial and legal considerations. The implementation phase of the course consisted of constructing a full-scale demonstration house.

CONTAINERIZATION

International cargo shippers such as Fruehauf, Matson, Sea and Land, etc., utilize dry freight containers to transport goods by truck, rail, and sea. The containers can be loaded from a truck into the hold of a ship and stacked to a depth of 48 feet (six units). Attrition eventually takes the containers and the shippers require newer models. A problem facing container manufacturing companies is what to do with the old, retired units. While still quite structurally sound, the shippers prefer newer units. It was these units the Social Engineering class decided to modify into housing.

BASIC STRUCTURAL UNITS

The dry freight containers used by the class were two 35-foot units and one 20-foot unit. Both types of containers are eight feet wide and eight feet high (exterior dimensions).

Both units are built upon six-inch steel I-beams spaced at 18 inches and tied by a sole plate. Four vertical hollow steel beams four inches by four inches are welded at each corner of the units and are used for hoisting the containers in addition to providing structural integrity. The 35-foot unit has a thin aluminum outer skin fastened to aluminum studs spaced at 24 inches. The 20-foot unit has its aluminum skin overlapped and riveted.

The 35-foot unit has an interior surface of one-eighth inch plywood screwed to aluminum channels cross-braced to the exterior wall studs. The interior and exterior walls are separated by four inches and filled with fiberglass insulation.

The 20-foot unit has a wooden floor bolted onto the I-beams. The 35-foot unit has a thin aluminum skin fastened to the I-beams and an aluminum corrugated floor affixed to this. The ceilings of both units are similar to the walls. The 35-foot and 20-foot units are shown in Figures 1 and 2, respectively.

UNIT DESIGN

The first academic quarter was spent in studying the life style of the migrant worker, and how this life style would be reflected in the design of a house. Working closely with the Colorado Migrant Council and the migrants themselves, the sociology students determined living patterns, traffic patterns, cultural preferences, family size and structure.

The data gained from the sociology team was relayed to an engineering and design team to start preliminary floor plans. Students from political science and economics initiated studies on available land, costs, financing, and attitudes of growers and local residents.

Guest lecturers and consultants were utilized from the areas of social work, sociology, psychology, engineering, public health, sanitation, architecture, contracting, unions (AFL-CIO), developers, and city and county housing authorities. From the research in this quarter, 15 floor plans were created.

Fifteen different configurations for a house utilizing the 20-foot unit and two 35-foot units were obtained. The students did not consider stacking the units to form a two-story dwelling. All 15 floor plans met the Denver Building Code, the Universal Building Code, the Colorado Building Code, and the requirements for the Farmers Home Administration. The plans were evaluated by migrant agencies and finally the migrant families. Only one plan was socially unacceptable to the migrant family. This plan had the kitchen separated from the living room as essentially a privacy area. This was totally rejected by the migrant families who consider the kitchen as part of their communal area.

The plan selected by the families was a four-bedroom unit in an H-configuration. Three bedrooms are in one 35-foot unit, the master bedroom and livingroom/kitchen in the other. The 20-foot unit contains the bath and part of the livingroom (Figure 3). This

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Fig. 1. Dry Freight Container (35-foot)

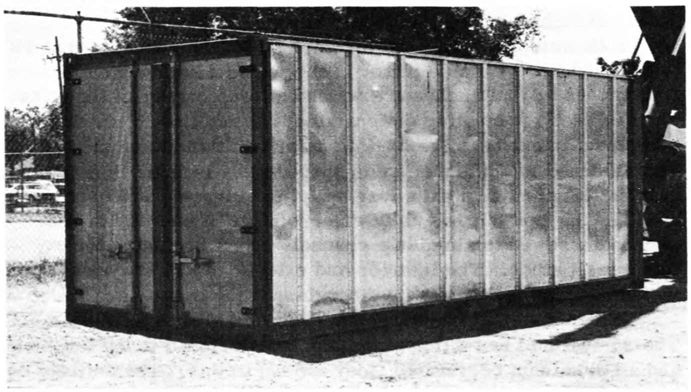

Fig. 2. Dry Freight Container (20-foot)

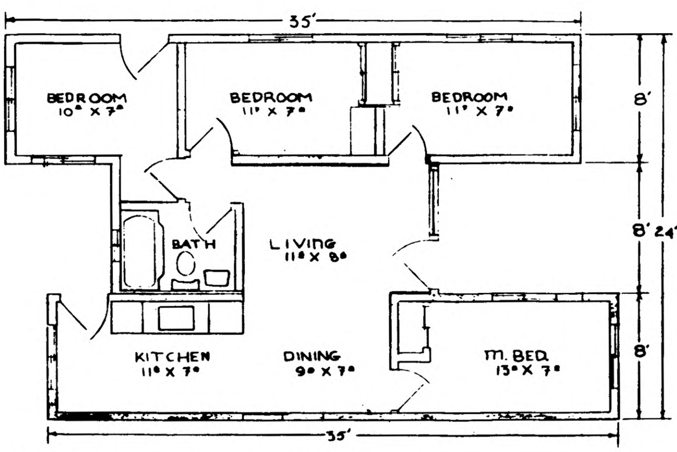

Fig. 3. Floor Plan of Socially Designed Home

four-bedroom unit was preferred over an identical three-bedroom unit because the families quite often travel with the grandparents and prefer an extra room for them. Blueprints were made and submitted to county authorities for a building permit. The students prepared PERT charts (Program Evaluation and Review Technique) and CPM charts (Critical Path Method) outlining the construction sequences.

CONSTRUCTION TECHNIQUES

The third academic quarter, the students initiated construction. A resource team of students contacted Denver supply houses, both retail and wholesale, to obtain as donations construction materials, finishing materials, appliances, and accessories. Approximately $200 was spent in obtaining materials that could not be acquired free.

Container Preparation

Prior to any construction, the units were thoroughly cleaned. The exterior aluminum skin was wire-brushed with a dilute phosphoric acid solution and primed. The steel exposed members were chipped and primed with a metal primer. The roof was coated with a heat reflecting paint. The interior was cleaned and all holes patched and sanded.

Cutting

The door and window openings of the units were easily cut with a circular saw. Adequate face protection must be maintained to protect the worker from the fiberglass dust (Figure 4). Steel members, such as sole plates, ladders, etc., were cut with an oxy-acetylene torch. Students were trained in all operations (Figure 5). The existing double doors of all units were removed.

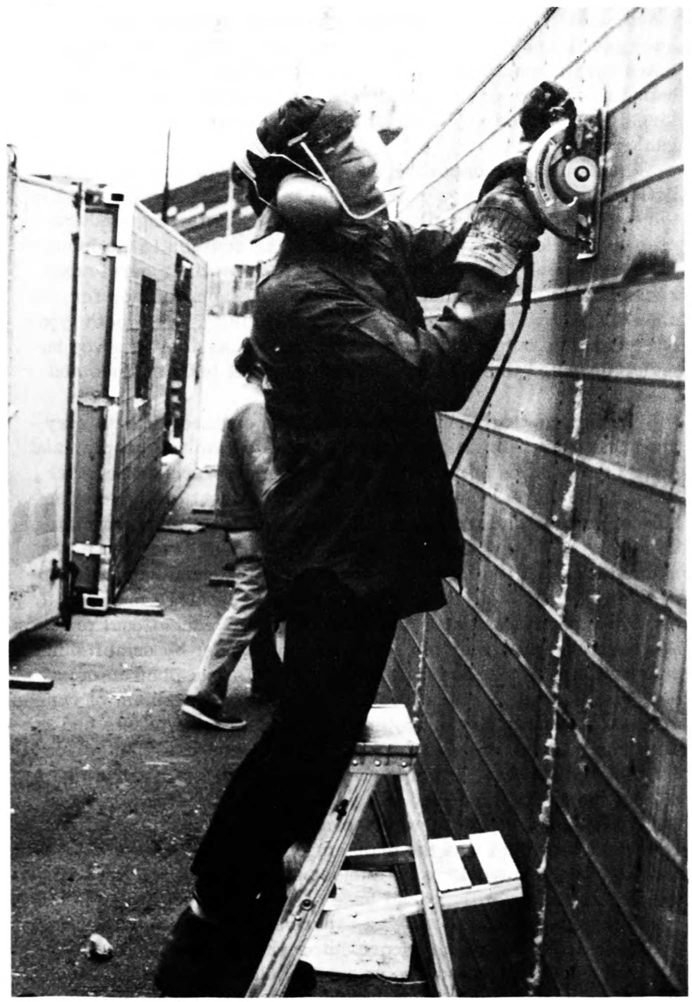

Fig. 4. Cutting Aluminum Walls

Flooring and Framing

A plywood floor was installed on top of the existing aluminum skid floor in the 35 foot units. No additional flooring was required for the 20-foot unit. Conventional framing was used for interior walls and for the end walls of the cargo containers. To make the floors the same height, the 20-foot unit was elevated 18 inches.

Electrical

The three units comprising the house were wired separately to permit final shipping of the house. Number 10 aluminum wire was used for all 110 volt circuits. The wire entered the house from the end and was channeled into the aluminum skid floor. For outlets, switches, and fixtures, it was necessary to punch through the wall and fish the wire vertically to the desired location. This was necessary since it was considered not worthwhile to remove all of the interior plywood walls to run the wire horizontally. A single 220 volt circuit was installed in the kitchen area. Each unit had its own separate 20 ampere circuit.

Fig. 5. Cutting Steel Members

Plumbing

Although the house had two "wet" areas, it was possible to connect them through one wet wall (the wall between the kitchen and bath). Since the 20-foot unit was elevated, water and sewer lines come into this unit. Plastic pipe was used throughout.

Doors and Windows

Exterior doors were conventional. Interior doors were of the cloth folding type. The windows were boxed in by plywood inset in the space occupied by the insulation.

Finishing

The house was finished with paint, wallpaper, tile, carpeting, and drapes. The units were joined, bolted together and provisions made for sealing the units (Figures 6-9).

Fig. 6. Master Bedroom

Fig. 7. Bathroom

COSTS

The total projected costs of the house were approximately $3500. The following represents the student manhours spent on the house.

Cutting	67 hours
Carpentry	125
Electrical	70
Plumbing	16
Windows/Doors	82
Finish	95
Misc.	31
Total	486 hours

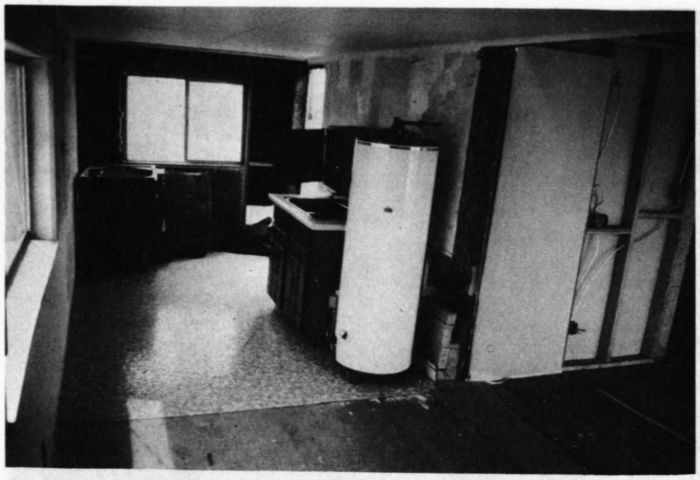

Fig. 8. Living Room/Kitchen

Fig. 9. Overall View of House

It must be explained that some of these basics took as especially long time because of the unavailability of power equipment and the inexperience of the students.

Adding a 10 percent factor to the man-hours and using a $2.00 per hour labor base, the labor cost was almost $1100. Using the wholesale price for all donated items, the cost of material and accessories was about $1500. This cost includes stove, refrigerator, cabinetry, fixtures, carpeting, and drapes. A $200.00 per unit acquisition cost was assigned to each cargo container and $150.00 allocated for shipment to the final site ($0.50/mile/unit). Approximately $150.00 was reserved for final power and water hookup on the site. The $3500.00 does not include the cost of the site nor the site preparation.

EVALUATION

The house has been donated to a Model Cities site for evaluation. It is planned that a follow-up will be made on the house at six month intervals to determine if it truly meets the social needs of the occupants.

CONCLUSION

It certainly appears, at this time, that housing constructed from dry freight containers can serve as lower-cost housing for both urban and rural areas. It is felt that the $3500 cost represents a maximum that could easily be reduced by more efficient construction techniques. The problem of shipping costs could be alleviated, in part, by shipping goods in the containers to some local organization; the housing industry could then acquire the containers from these organizations. This type of housing innovation can solve a critical housing need internationally as well as in the United States.

ACKNOWLEDGMENTS

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