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Kenneth P. Buchert

Professor of Civil Engr., University of Missouri, Columbia, Missouri

Walker W. Milner

Assoc. Prof. of Civil Engr., University of Missouri, Columbia, Missouri

Harry Rubey

Professor Emeritus, University of Missouri, Columbia, Missouri

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APPLICATION OF TURN-KEY CONSTRUCTION TO INDUSTRIALIZED URBAN HOUSING IN MISSOURI

Kenneth P. Buchert
Professor of Civil Engr.
University of Missouri
Columbia, Missouri 65201

Walker W. Milner
Assoc. Prof. of Civil Engr.
University of Missouri
Columbia, Missouri 65201

Harry Rubey
Professor Emeritus
University of Missouri
Columbia, Missouri 65201

ABSTRACT

Housing can be the answer to prayers for the declining technically-oriented aerospace industry.

According to Look magazine the Soviet Union is outproducing the U.S. two to one in new housing units for its people and nearly every country in Western Europe now outproduces us. It would be most unfortunate if we were first on the moon, first in defense, but last in housing. Industrialization and new financing methods for housing offer great opportunities to provide success for most groups which are often at odds. A 50 billion dollar a year business will produce profits for stockholders, hundreds of thousands of new jobs for labor including minority groups, an opportunity for young people to rebuild America, and a new, diversified area for investors.

INTRODUCTION

The decade of the 1970's will be greatly influenced by a combination of science, engineering, and management aimed at social synthesis. The professionals can no longer emphasize the most economical solution, or the most elegant solution, or the technologically best solution, or the systems engineering solution. The major goals will consider people and how technology can serve them better.

The amount of research done in the decade of the 1960's far exceeded that done in previous decades. About 7 billion dollars were spent last year on defense research. For every dollar spent on defense research, about 50 cents was spent on the space program, 9 cents on agricultural research and less than 1 cent on housing research. As the public and political opinion begins to change direction in Washington these figures could be reversed by the end of the decade. Housing is as much a crisis as is pollution.

The construction of the great interstate highway system had transportation and

economy as its major objectives. When a route was planned to run through an urban area, several alternate routes were studied and in too many instances the most economical route was selected. This criteria is no longer acceptable. Such major human factors as dividing school districts, church parishes and shopping areas, and relocating residents become major items that must be considered. Highway engineers that cannot develop a "social conscience" soon find themselves working at almost a technician or a technologist level.

The Congress has set a housing goal of 26 million units in 10 years. When considered in detail this is a goal that if vigorously pursued will drastically change the economy of the United States, and will challenge the engineering profession in such a manner that it will make the space program seem almost insignificant. It is estimated that the cost of this housing will be about 500 billion dollars or about 50 billion dollars per year. This amounts to about 10 space programs. It will result in an industry about the size of the automobile industry. The figure begins to approach the amount spent on defense each year. If about 200,000 of the country's 1,000,000 engineers were employed on the space program, about as many will be required for the housing program. Hundreds of thousands of technicians and skilled workers will be needed to even approach this goal. An analogous re-orientation must occur in financing. Perhaps the most important thrust for engineers in such a program is again that they must have a "social conscience". The engineer must quantitize and apply the social sciences as well as the physical sciences.

Urban reconstruction during the past decade can be viewed as progressing through pronounced stages. The first visible step after evacuation of the population is the destruction of the ugly old buildings which often disappear very rapidly. Then a relatively long period of apparent inaction on the site takes place, during which time architects plan and complete the

lay-out of the basic new structures, engineers design the basic elements, bids are requested, a contract is let, material is ordered and finally construction begins. It is not unusual that two or more years elapse from the time of evacuation to completion of a new construction. By this time the tenants are often different from those who originally occupied the old buildings.

One might ask "why can't the job be done in two days or two weeks instead of two years?" The answer to this question is not only that it can be done, but also, and perhaps more meaningful, that it has been done. Townhouses have been erected in Rochester, New York, in three hours. With the cooperation of Mayor Daley, the AF of L, and various manufacturers and contractors, several apartments in Chicago have been site built in two days. The Department of Housing and Urban Development has had houses erected in times from one day to four weeks. Almost all types of materials have been used such as wood, aluminum, plastic, asbestos cement, precast concrete, brick, concrete blocks, steel, and composites. The common mode of operation in these systems has been "turn-key" construction. Several companies in Missouri erect industrialized homes in one day.

These very fast construction times generally do not include such necessary items as site preparation, provision of utilities and roads, and sometimes construction of foundations. However, one could often plan the work and develop techniques in such a way that the occupants of buildings would suffer a minimum of displacement during this phase of the construction. With proper planning and turn-key methods, the inconvenience could be reduced.

Turn-key construction originally began with such projects as oil refineries and chemical plants. The procedures consisted of the owner writing a set of performance specifications such as the quality and quantity of output per day of the refinery instead of specifying the details of construction. A contract would be let and the engineer-contractor would be responsible for feasibility studies, engineering, procurement of equipment and materials, construction, and shakedown operation of the plant such that the performance or output of the plant would be met. When completed, the performance would be checked and the key to the gatelock would symbolically be turned over from the engineer-contractor to the owner-operator. The turn-key approach has been extended to almost all types of construction such as buildings, schools, houses, apartments, etc.

Often one of the secrets of this fast construction of buildings, apartments and

housing has been the very close cooperation of a mass-producer manufacturing company. Such firms as ALCOA, U.S. Steel, National Gypsum, and others are active or becoming active in the field and see it as a permanent growth outlet.

One of the new and critical factors of this new development is the absence of true performance specifications. Old building codes are based on very restrictive steel or concrete specifications or upon "rule of thumb" requirements that have evolved over centuries of practice. Such items as the spacing of wooden floor joists and wall studs as specified in the codes were determined by the "seat-of-the-pants" management technique. As a result, most organizations from Federal Agencies, to cities, to large owners have little information to make judgments on new techniques.

THE MISSOURI PROJECT

It appears that the so-called "instant" turn-key construction holds the promise to the urban resident for faster, cheaper, and better housing, with more abundant financing. More and better housing will broaden the tax base for cities, because of the more valuable housing and new industrial development.

The Construction and Management Group in the Civil Engineering Department of the University of Missouri-Columbia has received a grant to study "instant" industrialized urban housing.

The principal purpose of the project is to develop the general concepts and the performance specifications for turn-key housing in Missouri. Emphasis will be placed upon single-family houses, two or more low-rise family apartments and other low-rise group housing that can be site completed in periods of a few weeks. The study will include housing in all price ranges from low-cost to high-cost. Utility, road and foundation requirements, and construction methods will also be studied in detail. A secondary purpose of the program is to develop a report that describes the "state-of-the-art" of turn-key systems architecture, engineering, and financing for high-rise housing.

Since financing is often the crucial element in a successful program, it will be considered equal in priority to the technological parts of the study. Consolidations, mergers and conglomerates offer limitless possibilities.

It is not the purpose of this program to select a single system. It is anticipated that competitive systems using steel, aluminum, wood, concrete, asbestos cement,

masonry, plastic, and many others as well as hybrid systems, when properly developed, will meet the performance requirements. One of the most neglected areas in housing is the site planning and utility provisions. Every construction component represents an opportunity to speed construction and reduce costs, to reduce operating and maintenance costs, and to add or detract from the quality of living.

Earthwork and drainage construction can be minimized by selecting site, utility, and occupancy layouts that fit natural topography and subsurface conditions. Modern excavating techniques can cut excavation time by an order of magnitude. By the use of curvilinear sanitary and storm sewer alignment and by spacing manholes at the maximum length that available cleaning equipment can handle, it is possible to save installation, operation, and maintenance costs.

Utility rate advantages may result from master metering and billing through a central system rather than through individual meters.

Asbestos-cement and plastic piping material typically yields initial savings much greater than their possible added maintenance costs.

The design of house gas piping has been essentially devoid of engineering ingenuity. There is nothing sacred about certain pressures and pressure drops. Varying these two parameters can result in appreciable savings in piping installation costs for both materials and labor.

The production rate of housing can be increased by industrialization because much of the work would be repetitive, machinery could perform many construction tasks, and bad weather and other poor job conditions would not delay construction in a factory. While three to six months might be required to produce a finished house by conventional construction methods, only a few weeks or days would be required by using industrialized methods.

Cost savings can accrue by industrialization since factory labor can be employed at lower wages than construction workers demand. Indoor construction reduces the adverse effects of temperature extremes on worker efficiency, and provides other improved physical job conditions thus increasing labor productivity. Interim financing costs can be decreased since construction proceeds much more rapidly.

There are numerous commercial types of industrialized housing systems. Three of these are the skeleton, slab, and box systems. The skeleton system has a frame

of prefabricated beams and columns to which prefabricated walls and floors are attached. The slab system is composed of precast panels which bear the weight of the structure. The box system involves prefabrication of three-dimensional modules which are transported to the site for placement.

The increasing cost of housing is caused by such things as rising labor and material costs, high land costs, outdated property taxes, archaic building codes, poor zoning regulations, and the low-volume make-up of the housing industry itself.

Rising costs create two obstacles for the prospective house owner. Because of high costs even the simplest built home becomes too expensive for a typical, middle-income family. It is estimated that 70% of the American Public cannot purchase housing. Also, home builders are forced to find a larger supply of money to finance housing construction. More financing must be made available.

The main source of financing is the mortgage market. And the first thing that is hurt when interest rates go up and a tight money situation prevails, as it does today, is the mortgage market. Because of rising costs and a deflated mortgage market, the annual production of homes has drastically fallen off.

The housing industry provides an essential product for the well-being of every American. It is necessary that its problems be solved, and the space-oriented community may well turn its attention and effort in this direction.

CONCLUSIONS

A progress report on the Mizzou Project is scheduled for completion in August, 1970. One of the major parts of the report will be a performance specification for low-rise housing that can be site completed in periods of a few weeks. This short completion time will require automation and industrialization of the complete system from provisions of utilities and roads to the housing structure itself in all of its details. Attention will be called to the possibilities of large-scale financing.

The study is being carried out by the authors with the assistance of six graduate Civil Engineering students in the Construction-Management Program. The Industrial Referral Service of the University of Missouri Extension Division is assisting in gathering information. Other parts of the University of Missouri-Columbia, such as the Home Economics Department, are assisting in the Project.

