26 Apr 1972

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A MEANS OF RATIONAL COMPARISON BETWEEN VARIOUS TYPES OF LOWER COST HOUSING WITH SPECIAL REFERENCE TO THE EFFECT OF BUILDING CODES THEREON

by

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INTRODUCTION

This paper is based on research arried out by the author on the analysis of future draft building codes (1, 2, 3, 4) to study the simplification of their structure and increase their effectiveness for all types of housing. A supplementary component of the research was the performance/specification issue in building codes.

However, this discussion will begin with a brief examination of the sources of housing production costs and a conceptual decision making process to achieve the housing production process with the lowest cost. The relationship of lower cost housing to the structure of building codes can then be viewed more objectively.

THE COSTS OF HOUSING

The cost of housing is being considered as cost to the purchaser as a capital sum (or equivalent capitalization of rent from a period of time) of a house ready for use. The cost of various prerequisites such as land and financing are not being considered here. Stated conversely, this can be expressed as the producer's price of a house in the market place, at that location, at that time.

Examining what constitutes Cost in housing can be traced to two major aspects.

(1) The intrinsic aspects - minimum consumption of production resources, (labor, capital and management etc.) measured in money terms and

(2) The extrinsic aspects - factors which influence the choice of the most appropriate production process, e.g. number of houses in the project, the location of the project, the comparative degree of availability and price of labor and capital, etc.

As an example of the effect of the extrinsic aspects on the level of cost, it would be difficult to achieve low cost housing using highly industrialized, capital intensive factory production, in a situation where labor is plentiful and cheap and capital is scarce and costly. The converse is also true. (A decision on this issue may be different if the duration of production varies widely between the two processes and is being considered as a component of the making of that decision.) An example involving the more marginal decision of choosing between two types of industrialized housing probably will rest more on the estimate of the longevity of demand for a single type of product and the flexibility capacity of the different types of capital equipment, rather than the intrinsic cost of production of the houses. These examples show that the broad outline of the cost of housing production is set by these extrinsic aspects of the production process rather than the intrinsic costs of consumption of resources.

Thus, which Housing Production Process will give the lowest cost of housing will be based on what process consumes the minimum amount of resources, measured in dollars, within the context of the prevailing extrinsic aspects of the situation. This will be further qualified by the point of time of the decision and the conditions anticipated to prevail over the planned duration of the production process.

However, the extrinsic aspects and the intrinsic resources to be consumed are all part of the same economic environment in which production is to be carried out. In setting up the production process, the decision maker is attempting to minimize his costs by selecting the production process from the most appropriate available subprocesses. These subprocesses should be compatible with that existing economic environment and able to be linked together to form an overall efficient production process.

To facilitate the evaluation of various production processes, a conceptual all encompassing production process is required. Upon this framework, each individual production process is mapped and compared against the others and the prevailing economic climate.

HOUSING PRODUCTION PROCESSES

To categorize housing into types being produced today means classifying a considerable variety of end products. Classifying housing by its relationship to its degree of cost requires the use of the criterion of "Production Process", as it is there that the intrinsic costs are created by the consumption of resources.

As analyzed by the criterion of Production Process and for simplification of discussion there can be considered to be four major groups of contemporary types of housing in the United States. These are:

(1) Traditional Housing (Site Produced and Assembled Components)

(2) Industrialized Housing (Factory Produced and Site Assembled Components)

(3) Industrialized Housing (Factory Produced and Assembled Panels, Components and Modules) and

(4) Mobile Housing (Factory Produced and Completely Assembled Units)

These form the spectrum of Production Processes which are used for housing. Each process is a point on that spectrum. In reality, it is usual that any chosen production process is a blend of more than one of the above processes.

The conceptual all encompassing housing production process is now described and each of the above four individual processes mapped thereon.

This individual process mapping clearly shows:

(1) that the physical end product being consumed could be the same for all production processes.

(2) where the various production processes are similar

(3) where the various production processes vary and therefore may cause quantum changes in cost, one to another.

End Product In Use ie Being Consumed		Ga	Abstract Bundle Of Services				
Process In Creating End Products ⇩ \ Parts Of End Products			Site Infra Structure	Link To Site	Main Unit	Fabric	Services
			1	2	3	4	5
Site Development		Fa					
On Site Assembly	Process	Eb					
	Comp.	Ea					
Temporary Storage	After Transit	Dc					
	In Transit	Db					
	Before Transit	Da					
In Transit		Ca					
Off Site Production	Process	Bb					
	Comp.	Ba					
Materials		Aa					

Fig. 1. Conceptual Housing Production Process

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THE CONCEPTUAL HOUSING PRODUCTION PROCESS
(See Figure 1)

The conceptual all encompassing housing production process diagram has two axes. The vertical one displays the stages in the process of production and the horizontal one displays the groups of subsystems of the whole end product. It should be borne in mind that not all matrix core elements will be incorporated in each production process.

The stages in the process of production are:

Aa. Materials - Raw Materials and components at the supplier or wholesaler e.g. bricks, aluminum windows.

B. Off Site Production, Ba Components - The components bought in or made in the factory from raw materials, for incorporation in the factory built house e.g. timber stairs complete with treads, risers, stringers and blockings.

Bb Process - The putting together of components into large composite units e.g. panels or cubical modules which constitute either whole houses or parts of whole houses, e.g. a mobile home or section of a modules house.

Ca. In Transit - The transporting of raw materials, components and modules from the factory to the erection site, e.g. trucking or railing housing modules or raw materials.

D. Temporary Storage, Da Before Transit - Storage at the factory prior to transport to the erection site, e.g. mobile homes waiting for trailers.

Db In Transit - Storage en route to the Erection Site if the journey is of considerable length e.g. house modules or aluminum windows on flatbeds in a railway siding.

Dc After Transit - Storage on the Erection Site prior to erection and if other parts of the project are delayed, e.g. mobile homes being stored prior to completion of site services or bricks stacked on the site.

E. On Site Assembly, Ea Components - The components (1) bought in or (2) made on the site from raw materials for incorporation in the house e.g. bricks, aluminum windows, shingles.

Eb Process - The putting together of components and raw materials in the construction of the house, e.g. building brick walls.

F. Site Development - The process of creating all the necessary services for the house which are situated outside the house e.g. water services, sewers, roads, landscaping etc.

G. End Product in Use - The physical end product which expresses, provides and contains the abstract bundle of services e.g. privacy, warmth social status etc. which the customer desires and buys e.g. a traditional house or mobile home.

The group of subsystems of the whole end product are:

1. Site Infrastructure - The services and constituents of housing which are outside the physical house, e.g. water services, sewers, roads, landscaping, etc.

2. Link to Site - The part of the whole end product building which forms the link between the living accommodation and the site and which will vary for similar Main Units on different sites, i.e. the part of the building below the upper surface of the structural ground floor or its equivalent, e.g. the brick, timber or concrete substructure to modular housing.

3. Main Unit - The part of the whole end product which forms the usable living spaces situated above the upper surface of the structural ground floor or its equivalent, e.g. a mobile home.

4. Fabric - The parts of the Main Unit made up of the subsystems which form the physical enclosures and dividers of the usable living spaces e.g. walls, roofs, floors and

5. Services - The part of the Main Unit made up of subsystems which create, move and output the requisite services to each of the usable living spaces e.g. HVAC ducting, electric lighting outlets.

MAPPING OF INDIVIDUAL HOUSING PRODUCTION PROCESSES ON THE CONCEPTUAL MODEL

The four types of housing which are described above are illustrated in Figure 2. Note should be made of their similar End Product and the similarities and differences in use of production subprocesses.

(1) Traditional Housing

Ga 1	Ga 2	Ga 3		
Fa 1	–	–	–	–
Eb 1	Eb 2	–	Eb 4	Eb 5
Ea 1	Ea 2	–	Ea 4	Ea 5
Dc 1	Dc 2	–	Dc 4	Dc 5
Db 1	Db 2	–	Db 4	Db 5
Da 1	Da 2	–	Da 4	Da 5
Ca 1	Ca 2	–	Ca 4	Ca 5
–	–	–	–	–
–	–	–	–	–
Aa 1	Aa 2	–	Aa 4	Aa 5

(2) Industrialized Housing (factory produced and site assembled components)

Ga 1	Ga 2	Ga 3		
Fa 1	–	–	–	–
Eb 1	Eb 2	Eb 3	–	–
Ea 1	Ea 2	Ea 3	–	–
Dc 1	Dc 2	–	Dc 4	Cc 5
Db 1	Db 2	–	Db 4	Cb 5
Da 1	Da 2	–	Da 4	Ca 5
Ca 1	Ca 2	–	Ca 4	Ca 5
–	–	–	Bb 4	Bb 5
–	–	–	Ba 4	Ba 5
Aa 1	Aa 2	–	Aa 4	Aa 5

(3) Industrialized Housing (factory produced components and assembled modules)

Ga 1	Ga 2	Ga 3		
Fa 1	–	–	–	–
Eb 1	Eb 2	Eb 3	–	–
Ea 1	Ea 2	–	–	–
Dc 1	Dc 2	Dc 3	–	–
Db 1	Db 2	Db 3	–	–
Da 1	Da 2	Da 3	–	–
Ca 1	Ca 2	Ca 3	–	–
–	–	Bb 3	–	–
–	–	–	Ba 4	Ba 5
Aa 1	Aa 2	–	Aa 4	Aa 5

(4) Mobile Homes

Ga 1	Ga 2	Ga 3		
Fa 1	–	–	–	–
Eb 1	Eb 2	–	–	–
Ea 1	Ea 2	–	–	–
Dc 1	Dc 2	Dc 3	–	–
Db 1	Db 2	Db 3	–	–
Da 1	Da 2	Da 3	–	–
Ca 1	Ca 2	Ca 3	–	–
–	–	Bb 3	–	–
–	–	–	Ba 4	Ba 5
Aa 1	Aa 2	–	Aa 4	Aa 5

Fig. 2. Mapping of Individual Housing Production Processes on the Conceptual Model

BUILDING CODES AND HOUSING

In considering the impact of Building Codes on Housing the primary factor should be the principle of the function of Building Codes.

The Building Codes should provide a safety filter between each building and the community. This safety should be:

(1) Safety of the community from the building, which implies protection of
   (a) all the people in the community, including the residents in the building (even though those residents may own and have created the building) and their possessions and
   (b) all the other buildings in the community and

(2) Safety of the building from the community implies protection from
   (a) all the people in the community and
   (b) all the other buildings in the community.

In principle, this protection should state the safety standard required of each of the subsystems of each building to provide adequate protection from the functioning of that subsystem. When setting the safety standard for each functioning subsystem, consideration should also be paid to the degree of safety of each subsystem in a state of partial or complete failure. The effect of the juxtaposition and interaction of subsystems in each of these states should also be considered in setting of these safety standards.

A prerequisite of these safety standards for subsystems is an analysis of housing into meaningful subsystems as groups of subsystems.

On examination of Building Codes it is found that even in the most recently proposed draft national codes for the U.S. that there are two major and different documents

(1) for normal housing and
(2) for mobile homes.

This segmentation is made more complex by each document being (a) of a different composition of criteria and safety standards from the other and (b) a mixture of performance and specification type clauses.

This segmentation is unnecessary as each end product house provides the same abstract bundle of services, albeit in a different price segment of the market. This is analogous to the safety standards for automobiles being different, dependent on their particular production process.

The house that the customer buys and consumes is an abstract bundle of services e.g. privacy, warmth, social status etc. which is expressed, provided and contained in that single physical end product. The physical end product is created by the production process and it has been shown that similar end products can be produced by different production processes. The differentiation between production processes is caused by attempting to minimize intrinsic costs within the context of extrinsic cost aspects in an economic environment.

The production process is one thing but it should be only the end product which is the object of the Building Codes.

At a minimum, the existence of separate Building Codes for normal housing and mobile homes in an artificial segmentation, especially in the free economic market in the U.S.

This poses the question as to how the Building Codes should be presented and structured in order to provide the desired safety standard, for each geographic area, while minimizing its effect on the choice of production process.

Without a rational information structure relating (a) the building codes to (b) buildings and their costs, there cannot be a rational appraisal of the cost effect of building codes on buildings.

THE FUNDAMENTAL COMPONENT OF BUILDING CODES

The principal function for Building Codes has been stated above and points to a statement of the performance of the physical end product in comparison to a set of safety standards. This can be considered as the Fundamental Component of Building Codes.

The overall performance of the physical house is extremely complex. That physical house should be analyzed into parts whose physical performance can be measured and safety standards set. As a guide to this analysis of end product houses the above Conceptual Housing Production Process is useful as it provides a set of production processes from which can be synthesized any house.

The structure of an Overall Building Code now begins to emerge as:

(1) a clear and complete consideration of houses as a conceptual end product,

(2) The clear and complete analysis of houses as an end product structured according to the group of subsystems of conceptual housing because these are the major functional parts of houses, i.e. link to site, fabric and services (further analysis within each part will also be desirable) and

(3) requiring supplementary sections or clauses for use if the safety and protection of the community might be in jeopardy during a production subprocess, e.g. while in transit from a factory to a site. (Protection of the building or materials in such a situation is the problem of the producer and should be covered by the traditional insurance process.)

THE SUPPORTING COMPONENT OF BUILDING CODES

To have the Fundamental Component of Codes would be satisfactory for use in the Building Industry. However, the codes are a part of the laws of each geographic area and reflect not only the requirements of buildings, geographic and climatic considerations but also the socio-legal desires and procedures of the community as to type and degree of safety provided and means of administration and enforcement of the codes. These aspects of codes are essential to effective Building Codes and the required procedures should be spelled out within the code documents. Only if both the fundamental and supporting components are present can a Building Code be fully effective.

The parts of the supporting component of building codes can be considered as follows and each should be stated explicitly:

Power of Enforcement - Under which legal power or powers available to the community will the building codes be enforced.

- The extent of action available to the community to act in face of defiance of the building codes.

Relationship to Other Community Laws - The interaction between the enforcement of building codes and other community laws may be (a) a confluence of legal power or (b) a contradiction in legal power. In (a) the summed power and penalty may be too great to be desirable in such issues. In (b) a state of confusion will exist because a misdemeanor may be punishable under two or more legal powers and the penalty may be too great to be desirable in such issues.

Duties and Powers of Community Building Officials - The identification of the role and a clear statement of his scope of responsibilities, duties, powers and means of executing those powers.

Certification of Compliance with the Building Codes - How and by what means certification that a building complies with the prevailing building codes.

Notice of Non-Compliance with the Building Codes - The means and notice whereby a building does not comply with the building codes. This should contain what aspect of the building is in non-compliance and within what duration it must be corrected.

Appeals Against Non-Compliance with the Building Codes - The procedure to be followed by owners, builders etc. in the face of a notice of non-compliance with the building codes which they consider to be incorrect.

Process of Changing the Building Codes - The procedure to be followed in changing the building codes when they have become redundant in some part or upon the desire to introduce new standards of safety etc. for the future.

Other Documents to be Incorporated in the Building Codes - Each community need not have a full and complete building code. Each community may refer to other documents which may be generated for the whole nation or state, and need not be explicitly included in the community's building codes. Such documents should be listed as being part of the building code of that community.

These documents will tend to deal with means of testing and the certification of acceptable standard products. Also, the location and certification of testing stations which are acceptable to the community could be incorporated into their Building Codes in this manner.

It is probable that each of these documents could be produced by an appropriate level of central government, e.g. a state or federal agency and that the effectiveness of these documents and their policing be carried out at that same level of government.

CONCLUSIONS

The current consideration of Building Codes as being segmented one from another, dependent on the production process used, should be abandoned.

Building Codes should be directed at providing a two-way safety filter between the community and the end product building, with supplementary sections or clauses if the community safety is in jeopardy during any production process.

The structure of the fundamental component of Building Codes could be based on the analysis of the end product house in the Conceptual Housing Production Process and the required supplementary clauses based on the core elements of that same concept. To rationally appraise the effect of building codes on building costs, it is imperative to have an information structure which can relate one to the other. There should also be a supporting component to the Building Code which explicitly states the socio-legal and administrative aspects of the codes for that community.

The degree of costs of housing is derived from the choice of production process in relation to the extrinsic aspects of the prevailing economic climate and the intrinsic costs involved in the chosen production process.

To lower such costs of housing is dependent on choosing the most appropriate production process for the prevailing economic climate. The Conceptual Housing Production Process described facilitates such decision making.

ACKNOWLEDGMENT

The author wishes to acknowledge the advice and guidance of Professor W.H. Lewis, Department of Architecture, University of Illinois, during the research upon which this paper is based.

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