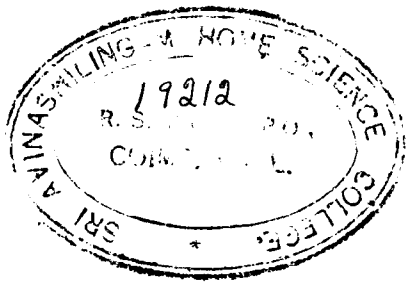
PROGRAM OF TECHNICAL COOPERATION OF THE ORGANIZATION OF AMERICAN STATES. INTERAMERICAN SOCIAL AND ECONOMIC COUNCIL. PAN AMERICAN UNION

developmental design in housing



RENE EYHERALDE F.

Drawings by Luz Amorocho
Translated by Cesar Garces

INTER-AMERICAN HOUSING CENTER
Technical Series No. 1 Bogota 1955

DEVELOPMENTAL DESIGN: The systematic development of design through research and use of three-dimensional models and mock-ups.

FIRST EDITION IN ENGLISH 1955
Translation of the First Edition in
Spanish - Bogotá 1953

81 Illustrations - Five Thousand Copies

IMPRESO EN COLOMBIA

Printed in multilith by SIC - CINVA in Bogotá, Colombia

INTRODUCTION

This publication is intended to serve the administrators of official and semi-official housing agencies, architects and engineers, and all those members of the construction industry concerned with the production of low-cost housing. All of these technicians share the common responsibility for building with economy and efficiency, irrespective of the sources of their funds.

It is hoped that this work may serve to guide and stimulate the development of a vigorous and efficient housing construction industry in Latin America, and that it may as well have some influence on the building industry in other areas of the world. As the magnitude of the housing problem is amply defined in numerous publications of the Housing and Planning Division of the Pan American Union as well as in various national reports, we shall not dwell on this subject. It is sufficient here to indicate that the problem is formidable. There is an urgent and immediate need to build or replace more than ten million homes in Latin America.

This need cannot be met solely by a construction program. By its very nature, the housing problem must be approached as part of the total problem of economic and social development, involving increased productivity, greater earning power, and basic education. Within this complex of human problems,

increased efficiency in construction methods is an essential tool. Those who believe that the easy answer to this problem is "prefabrication" or the invention of a miraculous new material are pursuing a phantasy. It is not my contention that prefabrication and new synthetic materials do not have an important influence on construction, but their use demands a high level of industrial development and easy and economical transportation. Now, and for many years to come, we must necessarily use local materials and labor to achieve economical housing.

The method of applying developmental design to low-cost housing, as proposed in this publication, appears to be extremely practical and immediately applicable under diverse conditions and is not predicated on the availability of any particular set of conditions as regards tools and materials. Neither does its success depend on a special level of development of the construction industry.

The importance of this method is the greater because it is not "revolutionary," but rather "evolutionary." The manner of thinking and the design philosophy inherent in the method is that which is now being followed by a small but growing group of the best and most creative of the modern architects and engineers. The procedures indicated are very much in accord with the design approach of rational contemporary architecture and can well be considered as a logical outgrowth of the contemporary movement.

Unfortunately, in no part of the world is the philosophy of contemporary design well understood by the large majority of architects and engineers. Nevertheless, the most advanced architects have instinctively adopted, to a greater or lesser degree, the basic principles outlined in this book. They develop their designs by stages with inquiring minds and without preconceptions; they make models of their buildings or parts thereof; they study their details in perspective sketches and through the use of materials samples. But

even this small group of more advanced practitioners are generally limited in their use of these principles because of lack of available laboratory facilities and, in the design of individual buildings, for lack of time. Large scale housing projects, by virtue of their size and their repetition of units, provide the opportunity and the necessity to invest time and equipment in the careful study of each element that goes into the dwelling unit.

It seems to me that the Developmental Design method introduced at the Inter-American Housing Center (CINVA) by the prominent architect, Howard T. Fisher, can best be considered as a contribution toward rationalizing, systematizing and popularizing the design and construction procedures that are in actual use by the most advanced professional firms. The method adds emphasis to the ever-present necessity of approaching technical housing problems objectively and systematically.

For me, the technique of Developmental Design holds real hope for the future in that it implies hard work, discipline, imagination, intelligence and systematic thinking. I am skeptical of solutions that appear too easy. In practice, the overly simple solutions of such complex problems as housing generally prove to be deceptive.

Mr. Fisher, of the firm of Howard T. Fisher and Associates of Chicago, first came to Bogota, Colombia in 1952 under the auspices of the Technical Assistance Administration of the United Nations, in response to a request made by the Colombian National Housing Agency (Instituto de Credito Territorial), for the purpose of helping the staff of the Inter-American Housing Center set up a laboratory program. For the first venture in teaching developmental techniques to CINVA's graduate students, Fisher used as an example the housing project of the National Housing Agency known as "Barrio Quiroga." One of the trainees, Renê Eyhêralde, a Chilean architect

who pursued the laboratory course with unusual application and enthusiasm was later sent by CINVA on a study tour to the United States and Canada. While in Canada, he assisted Fisher in directing a similar course which was offered jointly by McGill University and the Ecole de Beaux Artes of Montreal. Upon his return to Bogotá, Eyheralde joined the faculty of the Housing Center and authored the original Spanish Edition of the present publication. As Research Associate, he is now in charge of research and course work involving Developmental Design.

DEVELOPMENTAL DESIGN IN HOUSING forms part of the Technical Studies Series of the Inter-American Housing Center's Scientific Exchange Service. Other publications in the series, focusing on specific aspects of the housing problem, will be produced and distributed in the Spanish language. Selected works in the series treating subjects of wide-spread interest will be published from time to time.

in English

Bogotá — Leonard J. Currie, Director

November 1953 — Inter-American Housing Center

ADDITIONAL NOTE TO ENGLISH EDITION

Since publication of the Spanish Edition in 1953, the methodology described herein has become well established in CINVA's training program and is in the process of being adopted by several other institutions in Latin America and elsewhere. Because of the indication of wide-spread interest from other areas of the world in the original publication, we have decided to reach a greater audience through the production and distribution of the present English Edition.

The reader may be interested to know that the work started at CINVA in 1952 by Howard T. Fisher, is being followed-up by his associate, Robert L. Davison, who is currently a United Nations consultant at CINVA. The author, Rene Eyheralde, is temporarily in Europe on a United Nations Fellowship studying the building research methods of European institutions, and there informing the interested research people about the CINVA experience in the use of a construction laboratory as an educational tool.

Largely through the initiative of CINVA graduates, and with the cooperation of the Inter-American Housing Center and the United Nations, several building research and training laboratories are being established in Latin American Universities or housing agencies.

Bogotá — Leonard J. Currie, Director

July 1955 — Inter-American Housing Center

"..... An Inter-American Housing Center, the objective of which is to investigate construction problems and the use of materials, and to train technicians of all the Americas so that they may better serve their countries in the advancement of present and future housing programs."

(From the message of Dr. Alberto Lleras, Secretary General of the Organization of the American States, on the occasion of the Inauguration of the Inter-American Housing Center in 1952).

AUTHOR'S PROLOGUE

It has occurred to me that the readers of this work might be interested to know something of its history. The introductory words of Leonard Currie covers the general idea and the technical philosophy that the Center hopes to develop. However, I should now like to add the story of the more intimate aspects of the publication, during the process of its gestation. Perhaps in this way the work will be better understood.

In 1952 I had the opportunity to attend the first post-graduate training course at the Inter-American Housing Center (CINVA). As my experience in Chile as an architect and builer of low-cost houses had aroused my interest in housing problems, especially in the technical aspects, I followed with special enthusiasm that part of the Center's program which dealt with building materials and construction methods. This portion of the course was conducted by the prominent architect, Howard T. Fisher, who was at the time developing some interesting techniques in the systematic investigation of the design of mass-produced housing, and who allowed me to work as one of his student assistants.

As a result of this work, I undertook as my final project of the year a synthesis of the ideas expounded by

Mr. Fisher, trying to put these ideas into a methodical guide for the investigation of the design of any housing project. This task included the preparation of a resume of the various reports of my colleagues during the developmental design phase of the course. Later, thanks to the opportunity offered me by the Center to work as Technical Research Associate, I made a trip to the United States and to Canada to familiarize myself with the principal housing research institutions of those countries. In Chicago I was again in contact with Howard Fisher in whose office I spent a short training period. This permitted me to become better acquainted with Fisher's theories and to discuss with him several of the aspects of this report. At this time it was arranged for me to go with Fisher to Canada as his assistant in a course on Developmental Design which he was to direct at McGill University. Thus I was again able to apply the basic principles of the methodology which I was in the process of studying. Finally, upon my return to the Inter-American Housing Center, I conducted a similar technical training course of four months duration in the method which in Spanish we christened, "DESARROLLO PROGRESIVO." In this way, from my thesis and enriched by related experiences, this publication was born.

This work is divided into two parts. In the first part I have tried to sketch a picture, in a general way, of the housing problems and their relation to this methodology. In the second, the method itself is developed with the warning that this like all other systems must be used with sufficient flexibility to avoid the dangers of following a rigid routine.

In this regard, one should constantly bear in mind the philosophy of the method is more important than its form. The problems implied by housing shortages, especially housing for lower income groups, demand architectural concepts that evolve from the principles of Modern

Architecture. Le Corbusier, Gropius, Frank Lloyd Wright and other pioneers have upset the canons of traditional architecture with their ideas of functionalism and with the incorporation of constructure expression into the new forms of the art. At this time scarcely anyone would dispute the evident benefits that this revolution has brought to architecture, which is thus becoming an authentic expression of contemporary culture as it was during the great periods in history. Nevertheless, as in all revolutionary movements, the danger exists of not using intelligently the newly acquired values. Exaggerated plastic expressions, at odds with functional requirements, are all too frequent, are are especially dangerous when attempting to solve housing problems that are basically of a social nature. In this situation the architects and other technicians faced with these problems must work with sufficient criteria and discipline to achieve their social aims. Housing needs are so acute that if we do not establish realistic standards related to the demand and modify our usual standards of aesthetic design we will not reach our goals. Economy of construction and careful rationalization of the design are essential. Developmental Design can be an effective tool in achieving the desired results.

You will note that this publication contains many illustrations. It would be extremely difficult to explain this method solely by use of the written text. We have tried to illustrate the subject matter as much as possible with graphic examples as an effective means of presenting the different phases of Developmental Design. Most of these drawings and photographs illustrate the 1952 course of study at the Inter-American Housing Center. The original drawings were made by the trainees of that year. Most of the photographs were taken by Mr. Fisher. The investigation consisted of the analysis of a large housing project constructed by the principal housing authority in Colombia, the "Instituto de Crêdito Territorial." The

trainees were divided into teams with each team assigned a specific aspect of the project. One team studied the foundations, another the walls, still another the roofs, until one by one all the structural elements of the housing unit were analyzed. Even though time did not permit the application of Developmental Design to all the parts, very satisfactory results were obtained. These results were combined in a voluminous report with a wealth of graphic material, some of which has been utilized in illustrating this book. It is safe to say that this was the first experiment in Latin America in the systematic application of Developmental Design, even though it is possible that some Universities or research organizations may have developed to some degree three-dimensional studies of design problems.

This book could not have been prepared without the valuable collaboration of the Inter-American Housing Center staff who were my colleagues in this work. I also wish to acknowledge the substantial contribution of the trainees of the 1952 class whose work was the basis of the ideas developed herein. Howard T. Fisher deserves special mention; his ideas, council and suggestions were decisive in the production of this publication and he needs be considered as its spiritual author. To all of them, many thanks.

René Eyhéralde F.

Bogota, November 1953

CONTENTS

ILLUSTRATIONS

PART ONE

PART ONE

THE HOUSING PROBLEM

1. GENERAL

Because of its grave implications within the economic and social development of the community, inadequate housing constitutes one of the most serious problems of modern society. Much has been written about this problem, and many plans have been devised to attack it. Housing needs cannot be stated in terms of mere population growth, but rather as the result of a complex set of factors giving rise to much greater requirements.

To attempt the solution of any nation's housing problem without relating it to such problems as education, nutrition, and public health is of course unrealistic. The formulation of well coordinated plans for the gradual and simultaneous resolution of these problems is essential. It would be unwise to devote a nation's entire economic resources to the solution of only one problem, as other areas of public interest would necessarily suffer and the gains in the one field would not be lasting. A coordinated and simultaneous attack is indispensible in resolving the interrelated problems of mankind, even though each problem must also be studied intensively and separately. As

unsatisfactory housing arises from a variety of underlying causes and presents us with such complex considerations, our only hope for success is to develop an integrated plan for systematic study of the various causes and factors. Only after making a careful study and acquiring a full comprehension of the matter, should a plan of action be formulated. This investigation should be carried out by a technical team, and coordinated by a board that understands the complexity of the problem. Such a harmonious and coordinated effort is essential.

2. CAUSES

The basic factors in the over-all housing problem can be divided into two groups: socio-economic, and technological.

The socio-economic aspects include social legislation, existing living standards, the state of economic development of the country, public buying power, education, community organization, mortgage and loan policies, and others.

The technological factors comprise means of physical planning, construction methods, production of building materials, and labor efficiency.

These two basic groups of factors determine the cost and quality of housing, factors that we will deal with in the present work. When we speak of housing, cost and quality are generally considered indivisible; if we could reduce the cost of construction without lowering the minimum standards of quality we would make a major step towards solving our problem. If at the same time a program of economic and social improvement could be developed, we would then be on the verge of controlling this complex problem of modern society.

3. REDUCTION OF COSTS

Let us consider, in a general way, how the reduction of construction costs can be attempted without sacrificing the minimum standards of quality. We should bear in mind that cost is determined by direct and indirect factors.

Direct factors include materials, labor, design, building techniques and organization of the work. The house is the direct result of the orderly interplay of these factors.

Indirect factors, although generally not regarded as so intimately related to actual construction as those listed above, play an equally important role in the over-all costs. They include: land cost, interest rates, taxes, codes, and regulations, volume of construction, and profits. These factors offer a wide field for specialized research.

The houser must have a sufficient grasp of the over-all problem to encompass all of these aspects in his plan of action. A comprehensive attack on all factors will result in minor savings at many points. When these savings are summed-up, the result will constitute an important and appreciable saving in the final cost of each housing unit.

It is evident that the houser should have a oroad knowledge of his problem. His function is to organize and coordinate the search for the improved solution, leaving the detailed investigations to specialists. In his coordinating function, he must shape the over-all program, giving a stimulus to one phase of the work, modifying another, and so ordering the results that a final integrated solution is reached. This implies a great deal of work and the time necessary for its accomplishment. However, only by this laborious and

systematic process can we better present conditions.

If I have labored certain considerations, it is because I consider them essential to the understanding of the method which follows.

PART TWO

PART TWO

THE CONCEPT OF DEVELOPMENTAL DESIGN

1. SIGNIFICANCE

An architectural plan is a means to facilitate the construction of the building which has been conceived. The plan expresses the coordination of spatial interplay, the use of materials, and the consideration of the technical requirements for a rational and logical construction. It is possible that a project, simple in struction and function, can be built without plans, if it is conceived by someone with sufficient experience and imagination to keep in mind all the necessary technical considerations. This occurs frequently in the rural areas where the farmers erect their own houses which, in some cases, are models of architectural logic. This procedure, however, cannot be considered in large and complex projects where the technical problems are far beyond those which a man can keep in his head. It is evident that the architect must make use of plans to express to others the product of his imagination. An unusual imaginative capacity is often coupled with an extraordinary graphic ability. Most architectural schools include specialized courses in their programs for the development of the student's imagination and his means of expression.

In spite of such training, it is difficult for anyone to visualize all the details of a scheme. As some problems are usually overlooked in the design, complications and difficulties arise on the job. When these oversights are minor in nature, their correction may merely involve some loss of time or some waste of materials. When the omissions or oversights are serious, the results may be disasterous or at least costly. When this occurs in the erection of only one house, the problem is of importance only to the few persons involved, as the house is an isolated phenomenon and involves isolated consequences. But, if we consider a large-scale housing project, the need is evident to prepare extremely careful plans. (See Figures 1-3).

Being aware of such difficulties, some modern architects and engineers have considered the use of effective aids to the imagination thus enabling them to better anticipate the real problems involved. They have substituted for the usual two-dimensional process of the drawing of plans, a process of three-dimensional development. The method of Developmental Design presented in this publication is based on this principle. (See Figure 4).

The term "Progressive Development"* has been selected as these two words comprise the essence of this three-dimensional procedure. The design ideas are systematically improved through development, even those ideas concerned with the most minute details of the project under study. Such improvement is achieved through progressive stages, each an improvement on its predecessor, until an acceptable standard of quality is reached. This progress involves research in three-dimensions, utilizing models and mock-ups that simulate with a high degree of realism the various aspects of the

---

*In the original Spanish text, the title of this publication is El Concepto del Desarrollo Progresivo en el Diseño de la Vivienda, or Desarrollo Progresivo for short, a literal translation of which is Progressive Development.

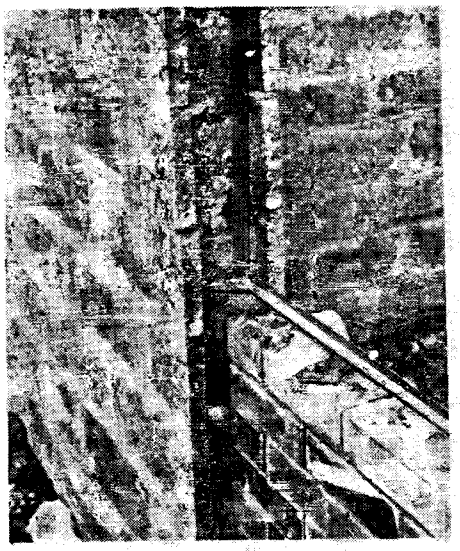


Figure 1

Figure 2

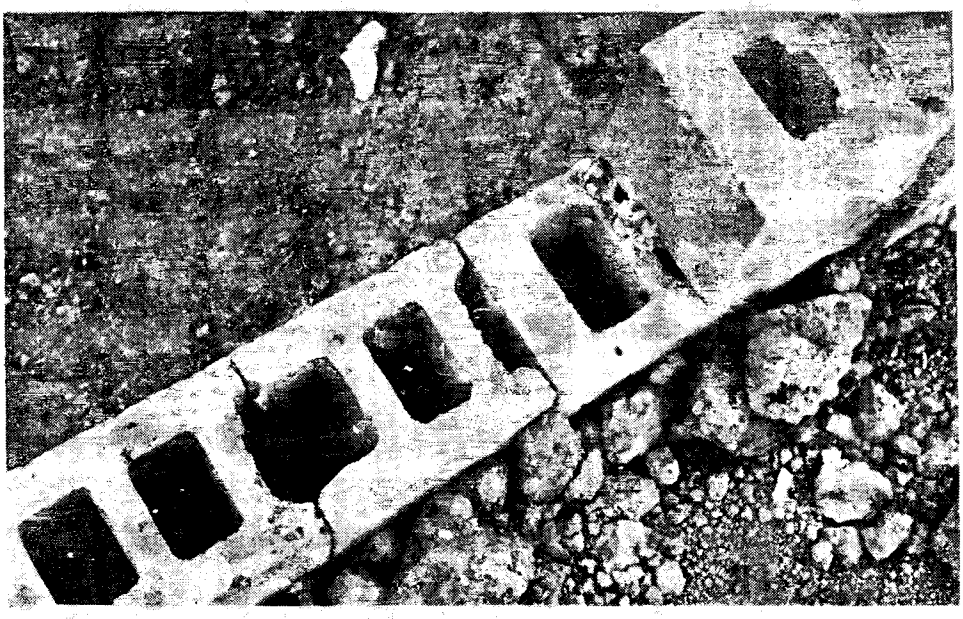


Figure 3

CONSTRUCTION PROBLEMS

Figures 1 and 2 - Lack of complete study of the design necessitates use of improvised methods to set a window.

Figure 3 - Effective modular coordination in the design would have obviated the breaking of blocks and consequent loss of construction time.

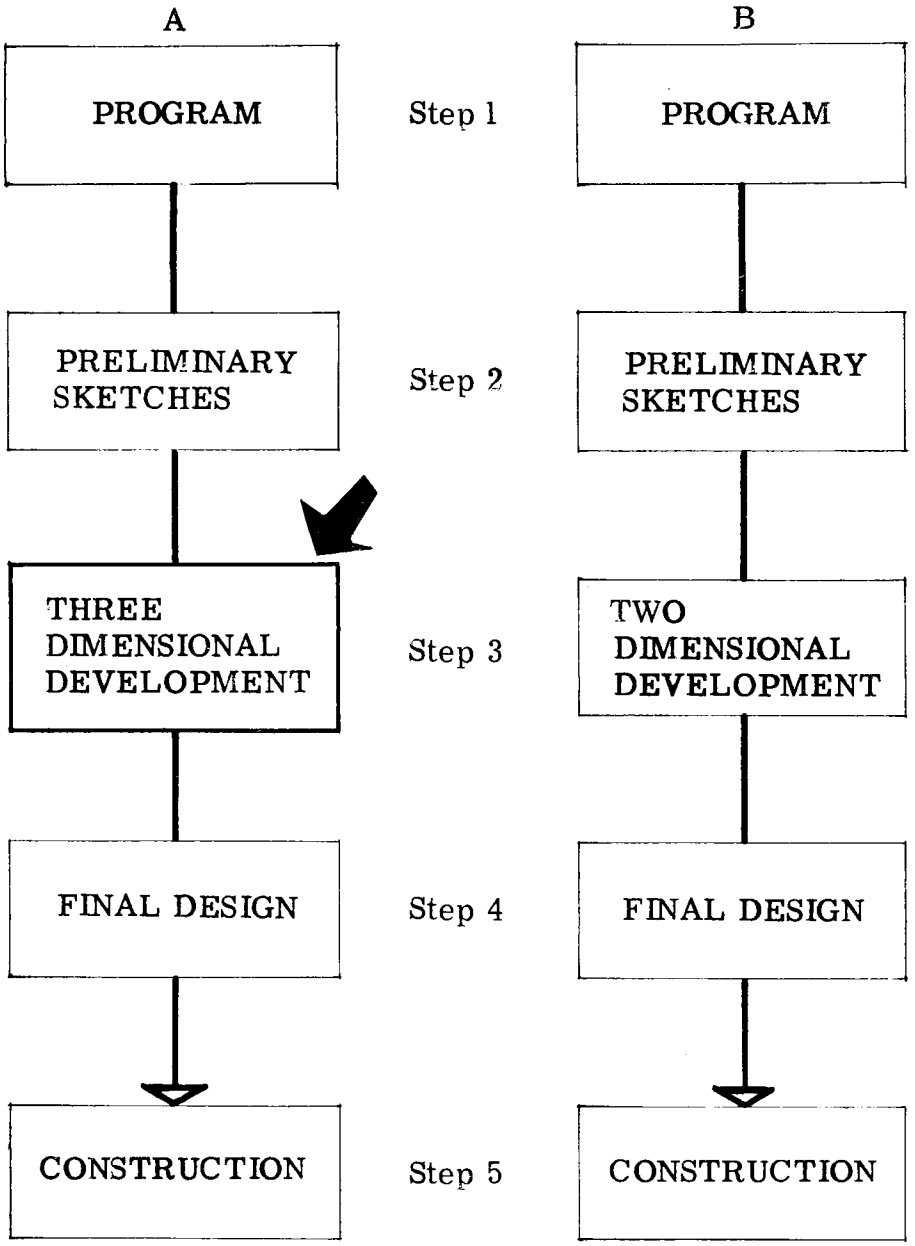


Figure 4 - Diagram indicating the difference between the "Developmental Design" process (A) and the design process commonly used (B). In (A), Step 3 has more importance and involves more time.

Figure 5

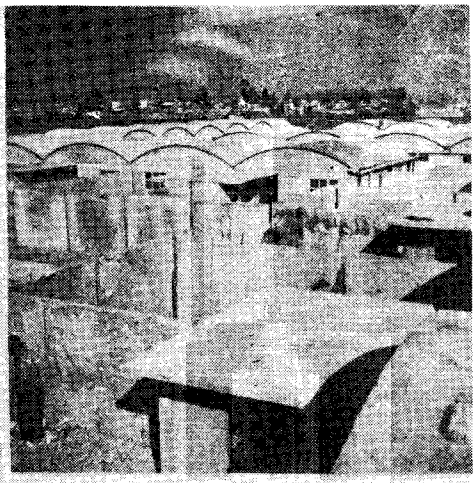


Figure 6

Figure 7

Figure 8

MASS PRODUCTION OF HOUSING UNITS

Figures 5, 6, 7, and 8 - Showing different aspects of a project involving mass production of housing units. Any shortcomings in the plans tend to be repeated ad infinitum.

study problem.

The basic philosophy of the method is well expressed by Howard T. Fisher, in a paper presented at the VIII Pan American Congress of Architects in Mexico City in September 1952:

..."The usual current method of preparing working drawings is probably satisfactory for the erection of one building, but it is evident that it is not adequate for the preparation of plans for a series of buildings, such as are currently being built in large scale projects throughout the Americas. . ."

"When we as architects are confronted with such projects, we must avail ourselves of the modern techniques of research and experimentation used by modern industry. These methods are more exact and place more emphasis on those small details which are of utmost importance in mass production. To achieve such results, I recommend working with mock-ups or full-scale models of the most important parts of the building."

"I understand clearly that this is a revolutionary idea in our profession and that it requires a more detailed and exact explanation. Unfortunately, sufficient time is not available, but perhaps the following example might illustrate my point."

"Let us think in terms of a project of 500 units. If each one of these units has 6 windows, the project will require 3000 openings with their corresponding windows, lintels, jambs, sills, locks, etc. The usual method in our profession is to work in the office with a two-dimensional design, select materials from Sweet's Catalogue, and draw the final result on paper. When convenient, the architect also examines one or two samples of the

ready-made products available on the market. This procedure is acceptable for one house or one building, but I do not consider it adequate for a housing project where three thousand windows are required."

"In the above example, it would certainly be worthwhile to build one typical window entirely and in three-dimensions and analyze the problems implied in its erection in a portion of wall. It would be even better to follow a developmental process of study and analysis to improve the element until obtaining the best possible product for reproducing three thousand times."

"No one would think of buying three thousand typewriters, or chairs, or handkerchiefs, or umbrellas, without first obtaining a sample. Nevertheless in our profession we frequently buy thousands of parts, or combinations of products and building materials, without previously inspecting samples of them. This is true in spite of the fact that large sums of money are involved and that our correct decision may mean success or failure for the project during the many years of its life."

Mr. Fisher's statement summarizes the essentials of the system. It may be observed that it involves the same general principles used by modern industry in the design for mass production of automobiles and home appliances. The product must be designed, tested, corrected and improved until the most satisfactory prototype is found to serve as a model for large scale production.

This method has limitless possibilities of application in the building industry generally, as well as in housing specifically. The feasability of its application can start with the design of a screw and end up with the

design of a large building, encompassing all categories of work between these two extremes. The system is, however, particularly adaptable to the construction of low cost housing.

2. EFFECT ON COST

In order to lower the cost of a house all the factors that determine cost should be attacked simultaneously. Within the factors that we have called direct, the design is of basic importance. Good design involves harmoniously relating the habitable spaces and coordinating the selection of building materials with construction techniques. Our objective is to create a working instrument whose degree of utility will be determined by the effectiveness of its execution. The Developmental Design method is suggested as a useful medium in the forging of this desired instrument.

Expanding our thesis, in the planning phase of housing the Developmental Design process will lead to a more efficient design by means of careful and detailed study based on the preliminary drawings. Through Developmental Design, the preliminary sketches will gradually evolve into final and complete plans in which all of the aspects of the problem will have been carefully considered. At the same time this procedure will eliminate those superfluous elements which usually pass unnoticed in the design and also in the construction. During the process, the basis for the preparation of clear, efficient and precise specifications will be established.

As regards building materials, Developmental Design can help to improve their form and proportion. In many countries large laboratories carry out extensive basic research in relation to building materials. These research programs are concerned with chemical and physical properties but they do not treat the problem of relating

the product to the adjacent conditions nor of its incorporation into the actual building. These vital problems are left to the product manufacturers who generally have neither sufficient time nor interest to carry out such studies. We at the Inter-American Housing Center believe that such building product development is essential and that the method herein proposed is clearly indicated for such development. We conclude that, in considering the development of a particular building design, we must necessarily be concerned with improving the form of the building materials which will in turn benefit the producing industries.

Concerning construction techniques, this method should contribute toward the establishment of simpler, more effective and more economical procedures in the enclosing and forming of the desired spaces. This end may be achieved by an analytical study of the human and mechanical means used in the building process, and especially by studying in detail all phases of erection and assembly of building materials and structural elements. Through such a study, we can simplify operations and save time and energy.

In summary, through the application of the Developmental Design technique to the improvement of a functional design, an effective economy and simplicity in housing construction may be achieved. The resulting structures will reflect a rational use of materials, simple and economical building methods, and greater return from invested capital.

3. PROCEDURE

We have presented in a general way the system of Developmental Design, indicating that it is based on the study of the structural elements of the design through

the use of a three-dimensional technique. We will now analyze the basic implication of the method.

In any type of research the following factors must be considered:

1. Background of the problem and proposed study.
2. Development of a solution.
3. Testing and presenting of the final solution.

These generally applicable considerations are essential in Developmental Design.

The initial problem is one of design, in our case the design of a house. The study will start with development of a preliminary sketch, with a separate analysis of the structural elements involved.

The presentation and testing of the final solution will consist of the construction of an experimental house. In this stage it will be quite evident whether or not the solution resulting from the research is a satisfactory answer to the original problem.

In each of the several steps in the investigation, the following points should be considered:

1. Data and background of the design problem.
2. Analytical three-dimensional development.
3. Synthesis.
4. Testing.

a) Data and Background of the Design Problem: We need go into no great detail in this respect as this point refers to the broad field of architecture in general. However, we should remember the need to follow four essential points in this process:

1. To develop a deep understanding of the nature of the problem.
2. To prepare a preliminary program.
3. To consider all the possible avenues of approach.
4. To familiarize ourselves in every possible way with the problem confronting us.

Sometime it will be necessary to do some prior investigation into other cases already solved to achieve this familiarity and to take advantage of research already accomplished. A preliminary selection of materials should be made, carefully analyzing the advantages and disadvantages of each in relation to the problem to be solved. This complete analysis should consider economy, durability, and physical properties.

b) Analytical Three-Dimensional Development: The program resulting from the previous study affords us a basis for making a well considered preliminary sketch solution. This sketch corresponds to the preliminary design in any work of architecture. From it we will develop our final solution after a minute investigation of all the detailed problems that we can discover in the preliminary sketch. By separately attacking these detailed and isolated problems we will arrive more easily at desirable solutions than if we should attempt to solve them all simultaneously, which is the common tendency in the planning of a house. Each selected problem will be studied carefully by means of perspective or isometric sketches until a satisfactory solution is reached.

These various partial and isolated examinations will of course lead only to partial solutions as we are not yet concerned with complete and final results.

c) Synthesis: The partial solutions obtained must now be assembled in a final scheme, making the necessary adjustments until they fit together to form a unified whole.

During this process of adjustment, we shall continue to make use of three-dimensional models, as the study of the union of all the structural components at full-scale helps us in correlating the various parts. During the unification process new problems may arise that could not be anticipated during the partial investigation, thus requiring the restudy and improvement of certain of the partial solutions.

When the final over-all scheme has been established, we may proceed to produce the working drawings, fully incorporating the conclusions of the study. This will complete our synthesis.

d) Testing: With exact drawings, the proposed solution can now be tested. Up to this point we have been concerned principally with problems of form and assembly rather than with physical and mechanical problems. We must now test the scheme for quality and resistance by building parts of a model house from actual materials and subjecting them to the weather. Leaving our work with models and mock-ups, we shall proceed to build the different structural elements in order to experiment with their actual physical behavior. We shall then wish to build and test a complete housing unit. Only at this point can we review and revise the working drawings, prepare the specifications, and make accurate cost estimates. With the investigation completed, mass production can be started with the assurance that the design is rational and that the housing units will prove to be suitable and economical.

4. ANALYSIS OF THE PROCEDURE

The foregoing describes in general terms the procedure used in Developmental Design. In actual application, each step of the investigation is further subdivided,

with the order and method adapted to the requirements of the specific case. It is therefore inadvisable to establish a detailed order and rigid procedure. Only after having thoroughly familiarized himself with the problems involved in his project, will a researcher be able to formulate an intelligent work program. In this regard, Architect Walter D. Burger, of Howard T. Fisher and Associates, Inc. has described the method used in their Chicago office in the following terms:

"No one set of rules of procedure can be inflexibly prescribed for any and every developmental project. Each project must be considered individually from the circumstances peculiar to it."

"Having established the objective and a course of procedure, the developmental engineer must nevertheless maintain a flexibility of mind at all times. He must be prepared to alter his course to take advantage of new ideas and changing circumstances. This is especially true in the preliminary stages of the work. However, progress is continuous and if tangible results are to be achieved, work must be directed in an orderly fashion toward ultimate crystallizing of ideas and freezing of the design."*

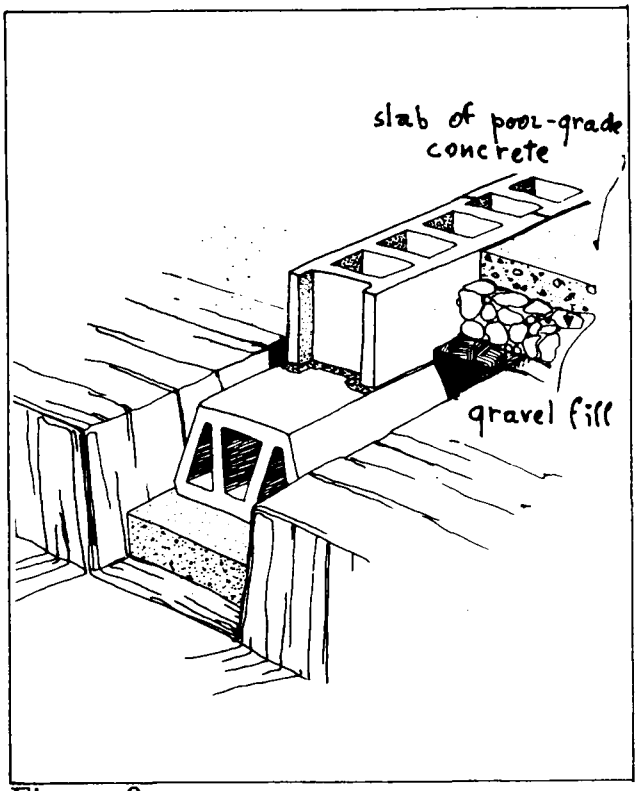
Nevertheless, based on prior experience, we can establish a certain logical order and sequence in the different stages for a normal application of Developmental Design in housing. This sequence includes the four essential steps of the investigation.

Accordingly, we may establish the following table:

---

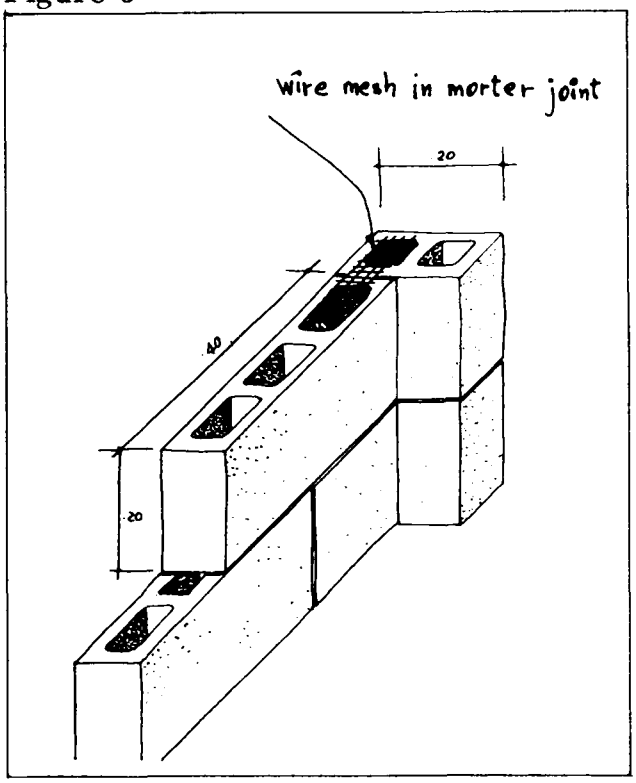
*Burger, Walter D. - WORK METHOD AND GENERAL PROCEDURE OF HOWARD T. FISHER & ASSOCIATES. Chicago, Illinois. Not published.

PRELIMINARY SKETCHES OF SOLUTIONS



Sketch of proposed solution for the foundation of a housing unit under investigation.

Figure 9



Proposed solution involving the juncture of two concrete block walls.

Figure 10

a) Data and Background of the Design Problem	I -	Programing
	II -	Investigation
b) Analytic three-dimensional Development	III -	Preliminary Sketches
	IV -	Sketches of sequence
	V -	Mock-ups
c) Synthesis of the Solution	VI -	Comprehensive Mock-up
	VII -	Working Drawings
d) Testing	VIII -	Testing of structural elements
	IX -	Building of a part of the structure
	X -	Building of the complete structure

I. Programing

Programing is the initial step, or starting point of the investigation. It implies the preparation of a working plan that considers in detail the procedures to use. In order to prepare the program the researcher must have a clear understanding of the study project and the objectives to be achieved. Since the researcher is necessarily working in the dark, he will find it difficult to arrive promptly at the most effective procedure. He must consider carefully, verifying and analyzing the problem requirements, trying to visualize the various paths which the investigation may follow. After due

deliberation an adequate working plan will develop. The time allocated to this phase is well invested as it is preferable to delay somewhat at this point rather than to lose more time later with obstacles that will result from a poorly conceived program.

II. Investigation

The work of this stage is closely related to the preparation of the program. At times it may even be necessary to start the investigation without a well-formulated program.

Background material must be collected as part of the investigation. If we are trying to develop a roofing system for a given building, we should investigate all conceivable roofing systems and the various materials that might be used to build them. Information regarding physical properties, costs, and other characteristics will help us decide on the most promising avenues of investigation.

Although research requires a certain boldness, we must insist on the need for critical, realistic thinking. A false hypothesis, adopted as the basis for future developmental work, will lead us to erroneous results and consequently to loss of time and money. In this respect, Architect Burger says, "The research and development engineer will make the utmost use of such information supplied by the client, but he would be derelict in his duty if he were not to question such information as well as his own conclusions at every step in the program. Frequently long established conclusions and practices prove faulty in the light of technological advancement and new approaches to the problem. Often, these are more evident to an outside engineer, because of experience gained in other fields and because he has not been too closely associated with the work to be prejudiced

by foregone conclusions."*

Research methods vary and their adequacy is conditioned by the degree to which they are adapted to the problem at hand. Reading of pertinent reports, analyzing charts and technical drawings, studying photos and movies may be very useful. If it seems advisable, physical tests should be made of the materials tentatively selected. These steps will help to assure the soundness of the preliminary decisions. After such study, we can begin the systematic development of a solution.

III. Preliminary Sketches

The place of Developmental Design in the sequence of investigation is between the phases of preliminary sketches and of final working drawings. Until the preliminary sketch is established, the architect attacks his problem in the customary manner. Upon terminating preliminary sketches, he is ready to begin the Developmental phase as he has before him a problem to develop. He must first establish the tentative structure through the previously mentioned process of investigation. With this accomplished the systematic analysis of the structure can begin. In commencing the analysis we will use a system of rapid free-hand sketches to produce numerous ideas for the solution of various details of the problem. (See Figures 9-12). We shall insist on the importance of minutely separating the various details of the structure, as the more we dismember the problem, the easier it will be for us to study and solve the parts. To define the points of study, we shall make an isometric or perspective sketch of the tentative structure. We shall call this a key isometric sketch. (See Figures 13-16). Complicated structures may require two or more

*Burger, Walter D. - WORK METHOD AND GENERAL PROCEDURE OF HOWARD T. FISHER & ASSOCIATES. Chicago, Illinois. Not published.

of these key sketches in order to clearly show all of the parts. For reference, parts should be marked with a conventional schedule of numbers or letters.

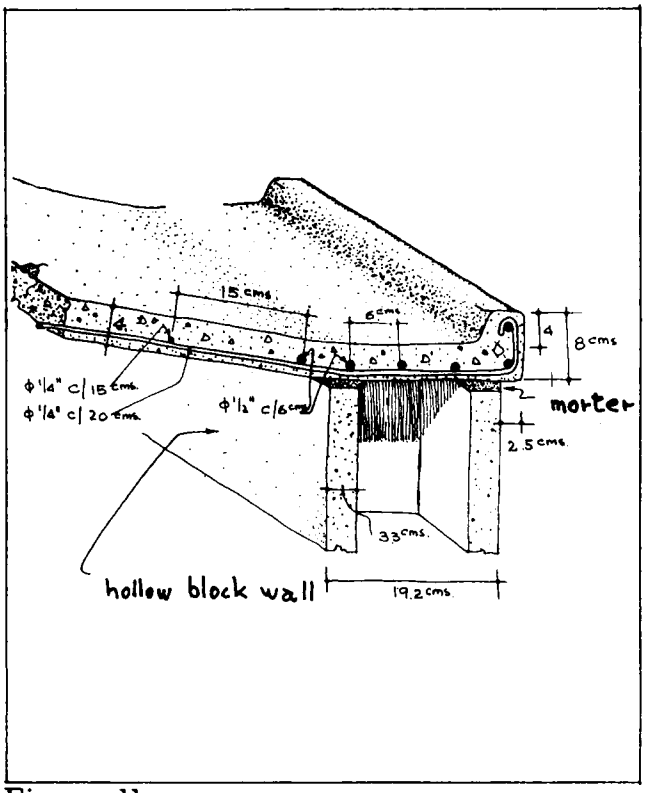
This process of graphical analysis is essential in developmental work. As previously noted, unit plans for repeated use are generally established without having carefully solved the many details. This results in construction difficulties with consequent loss of time, materials, and investment. Not infrequently partial demolition and reconstruction is required. The time spent in studying and developing rational construction details is well invested. In large-scale housing projects this study process is essential.

In some cases the analytical study may be of an existing project with the purpose of drawing conclusions for use in executing another project. In such a study the detailed structural aspects of the existing project will be those analyzed. The first sketches of details should reproduce the exact on-site situations without attempting to change or correct them. These sketches, along with the working plans, will constitute a record of the various aspects of the problem. By carefully sketching the existing conditions, the researcher will become thoroughly familiar with the qualities and defects of the subject of his study. (See Figures 17-20).

Once the existing conditions have been recorded, we will start sketching solutions of each one of the points established in the key isometric sketches. In arriving at these tentative solutions we will use the same sketch technique and procedure as before.

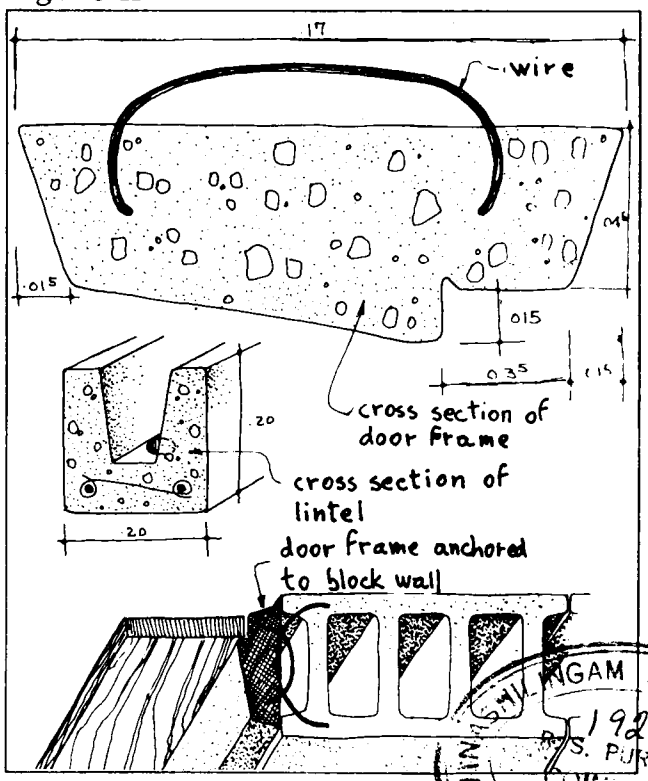
It must be emphasized that these drawings be executed as rapid sketches, as at this stage the researcher must concentrate on imagination and ideas rather than upon drafting. The best way to rapidly capture ideas

PRELIMINARY SKETCHES OF SOLUTIONS



Detail of edge of a concrete-vault roof.

Figure 11



Study of precast concrete door frame.

Figure 12

KEY
ISOMETRIC
SKETCHES

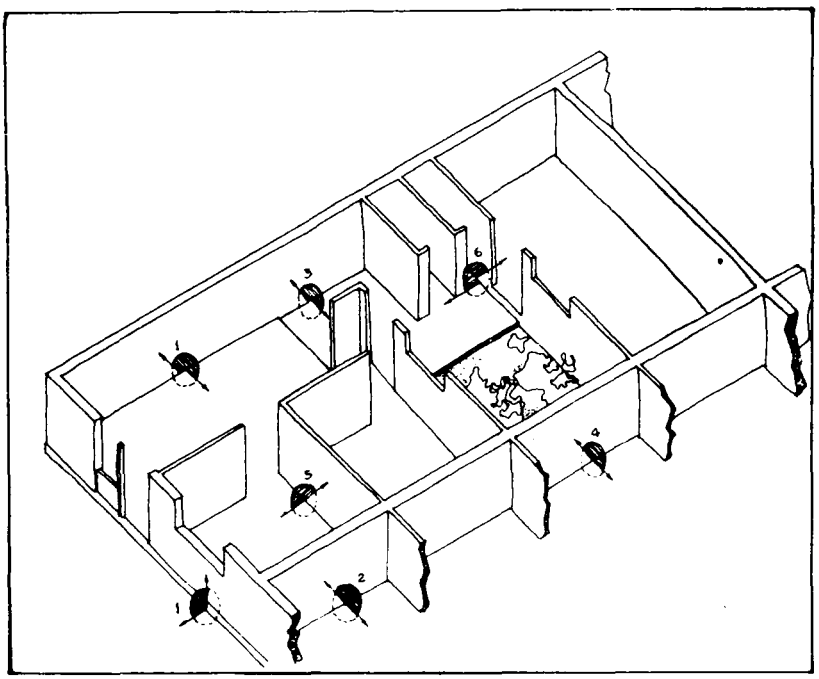


Figure 13 - Isometric view of plan under study, on which have been indicated the points of the foundation to be studied in detail.

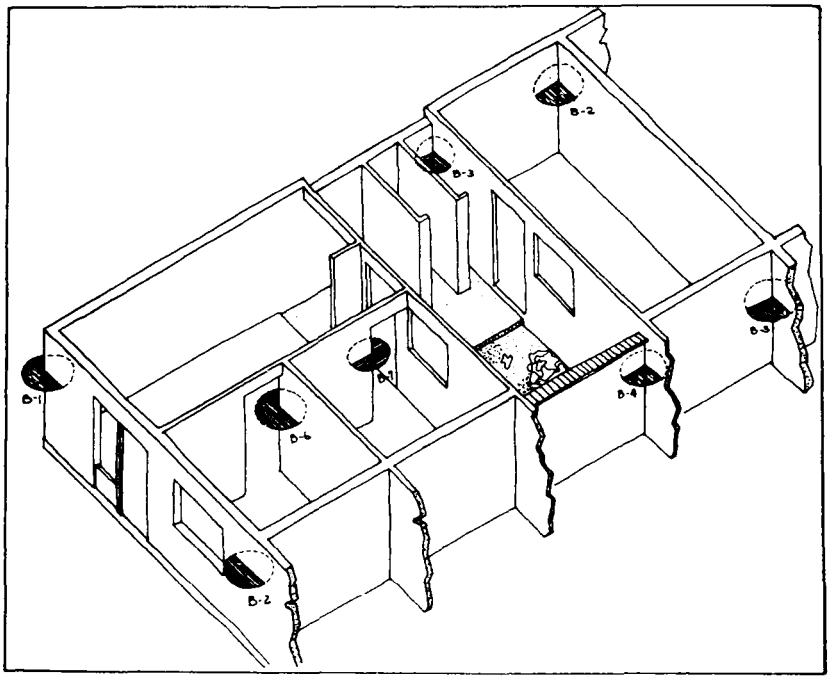


Figure 14 - Same isometric view, indicating points of walls to be studied.

KEY
ISOMETRIC
SKETCHES

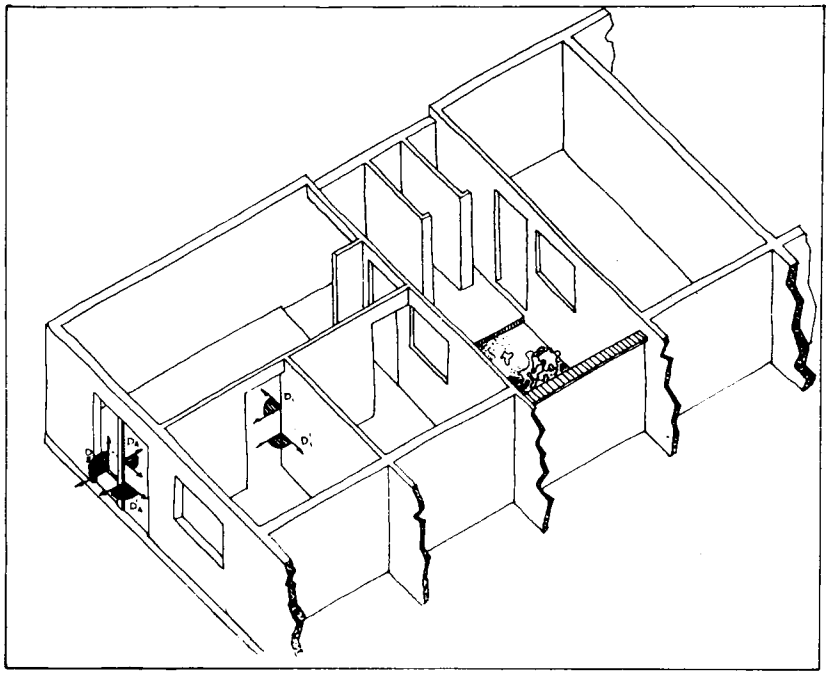


Figure 15 - Key to door problems.

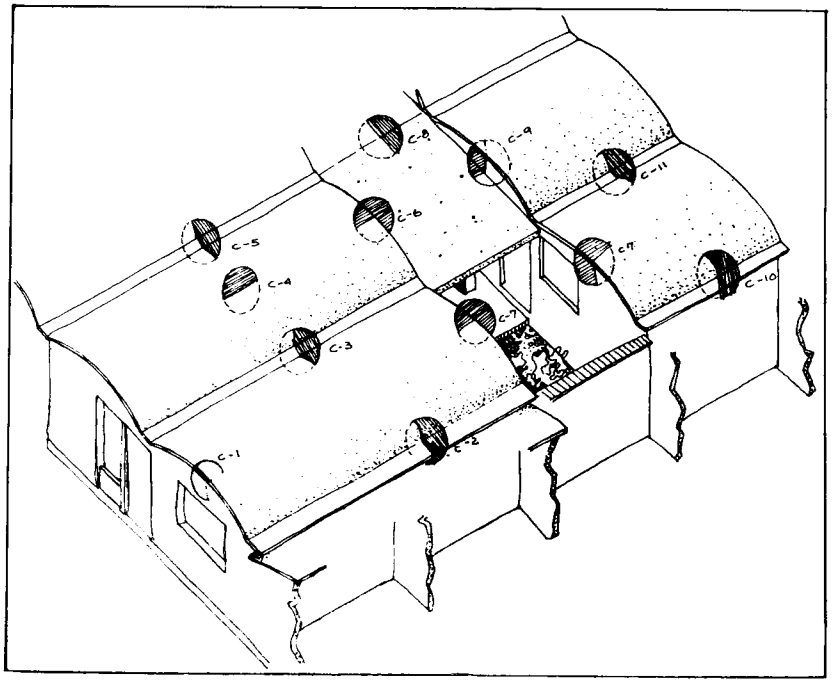


Figure 16 - Key to roof problems.

ANALYTICAL SKETCHES OF AN EXISTING PROJECT

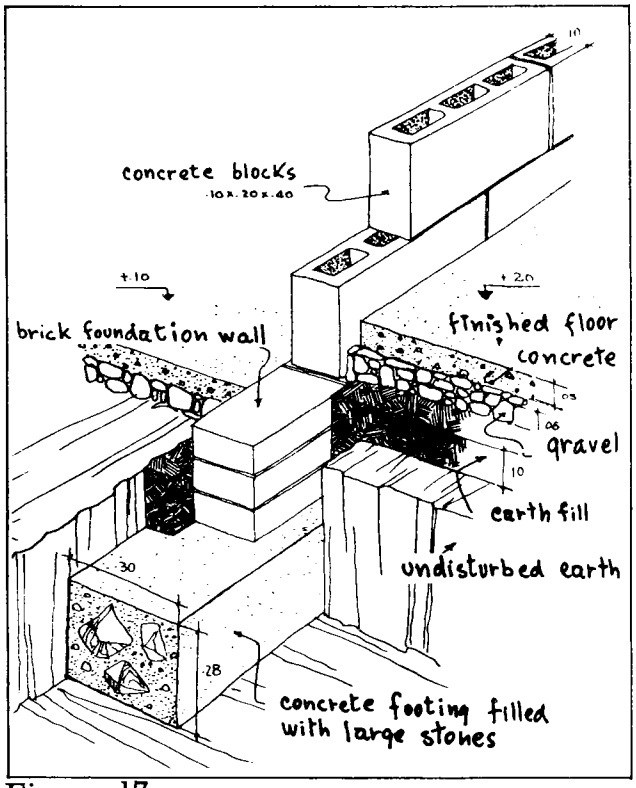


Figure 17

Detail of foundation as actually constructed.

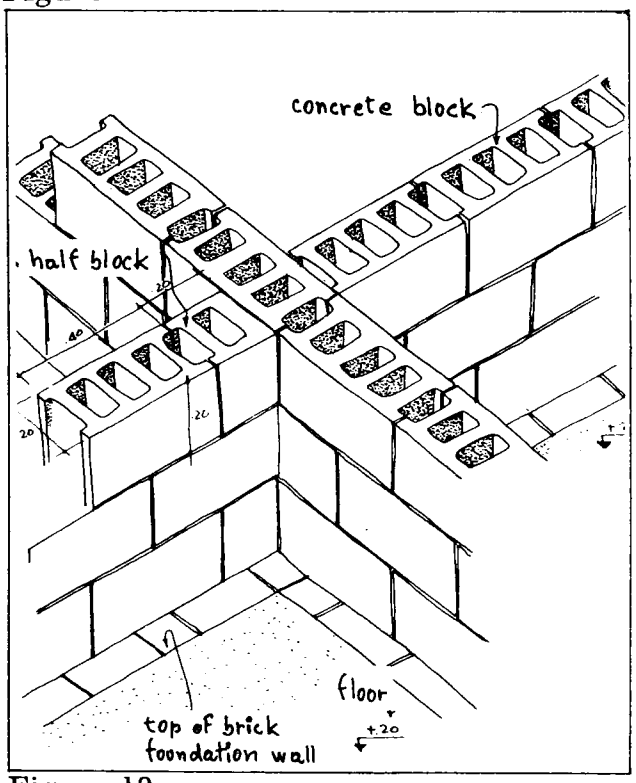


Figure 18

Analysis of intersection of two cement block walls.

ANALYTICAL SKETCHES OF AN EXISTING PROJECT

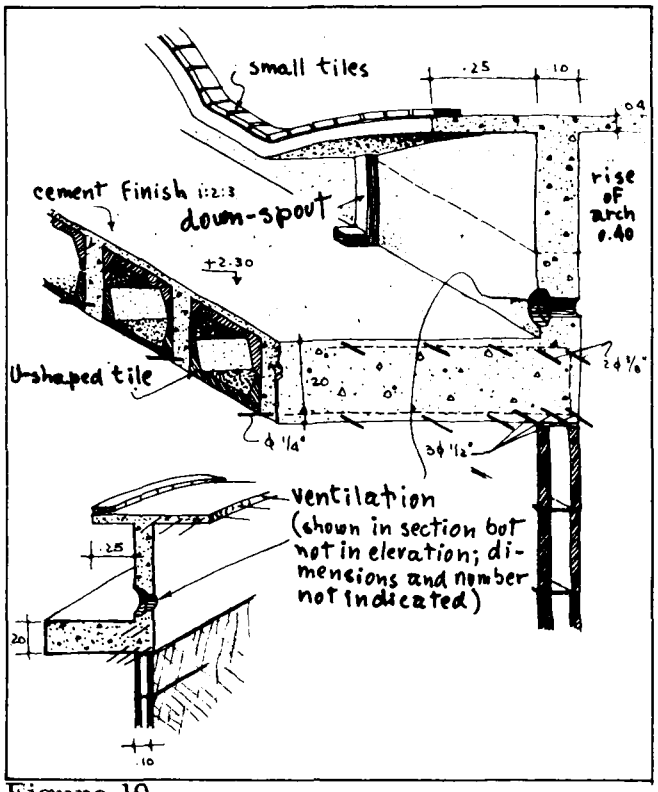


Figure 19

Detail of joining of two roofs as worked out on the job.

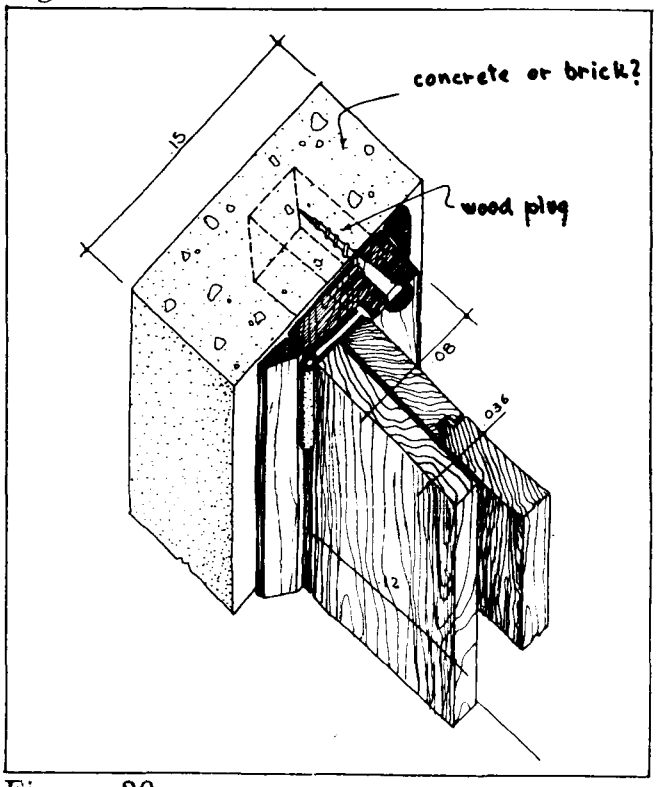
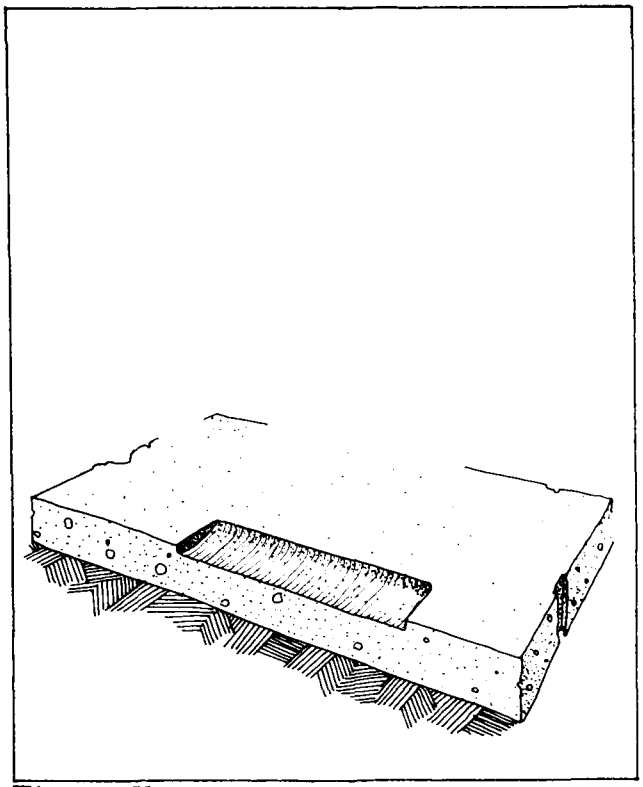


Figure 20

View of portion of door and frame.

SKETCHES OF CONSTRUCTION SEQUENCE



Demonstrating the process of installing a pre-cast concrete door frame.

Figure 21

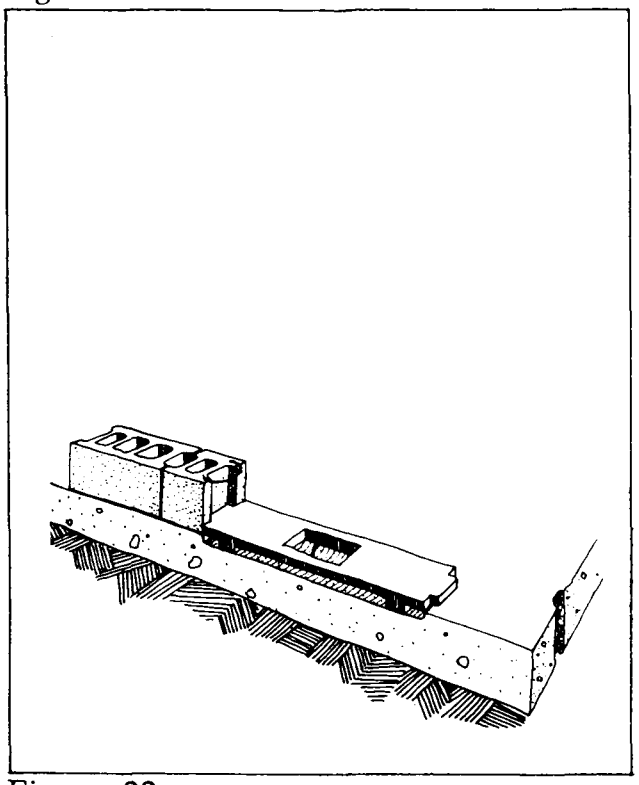
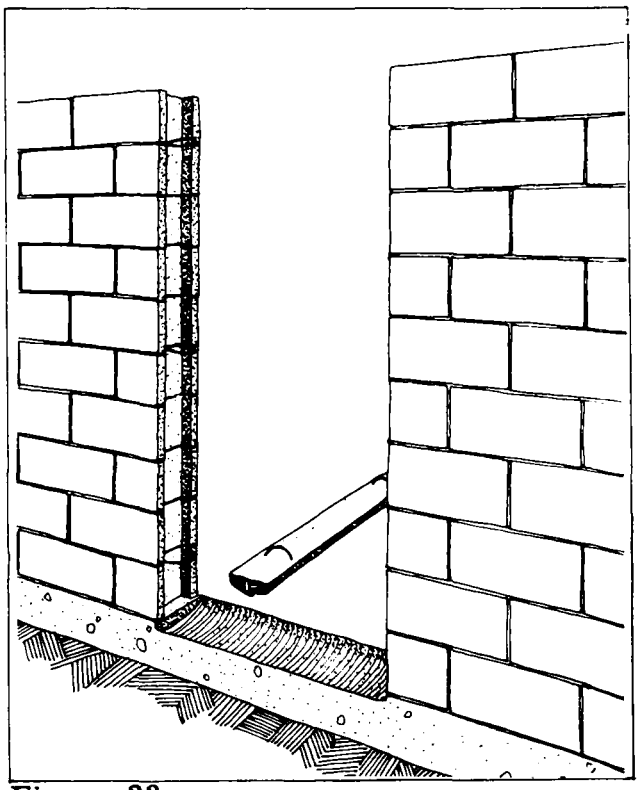


Figure 22

SKETCHES OF CONSTRUCTION SEQUENCE



Demonstrating the process of installing a pre-cast concrete door frame.

Figure 23

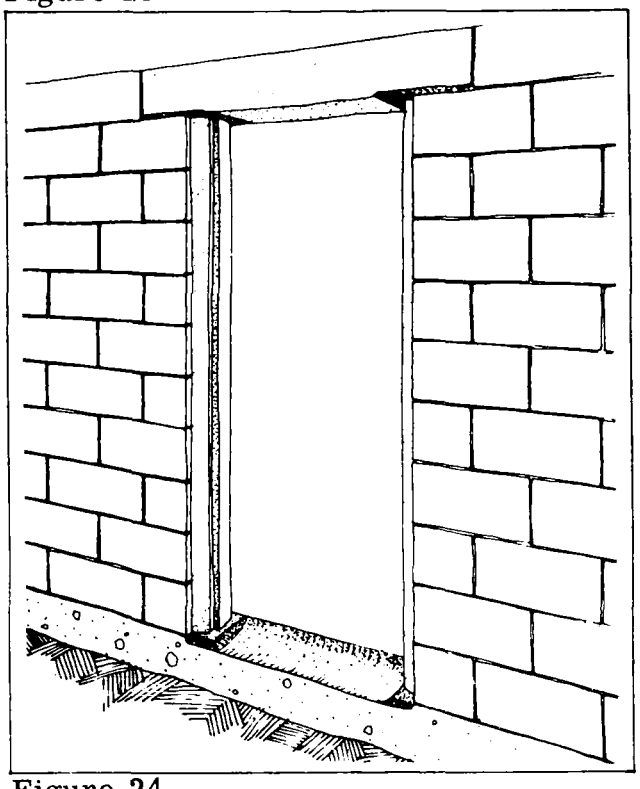


Figure 24

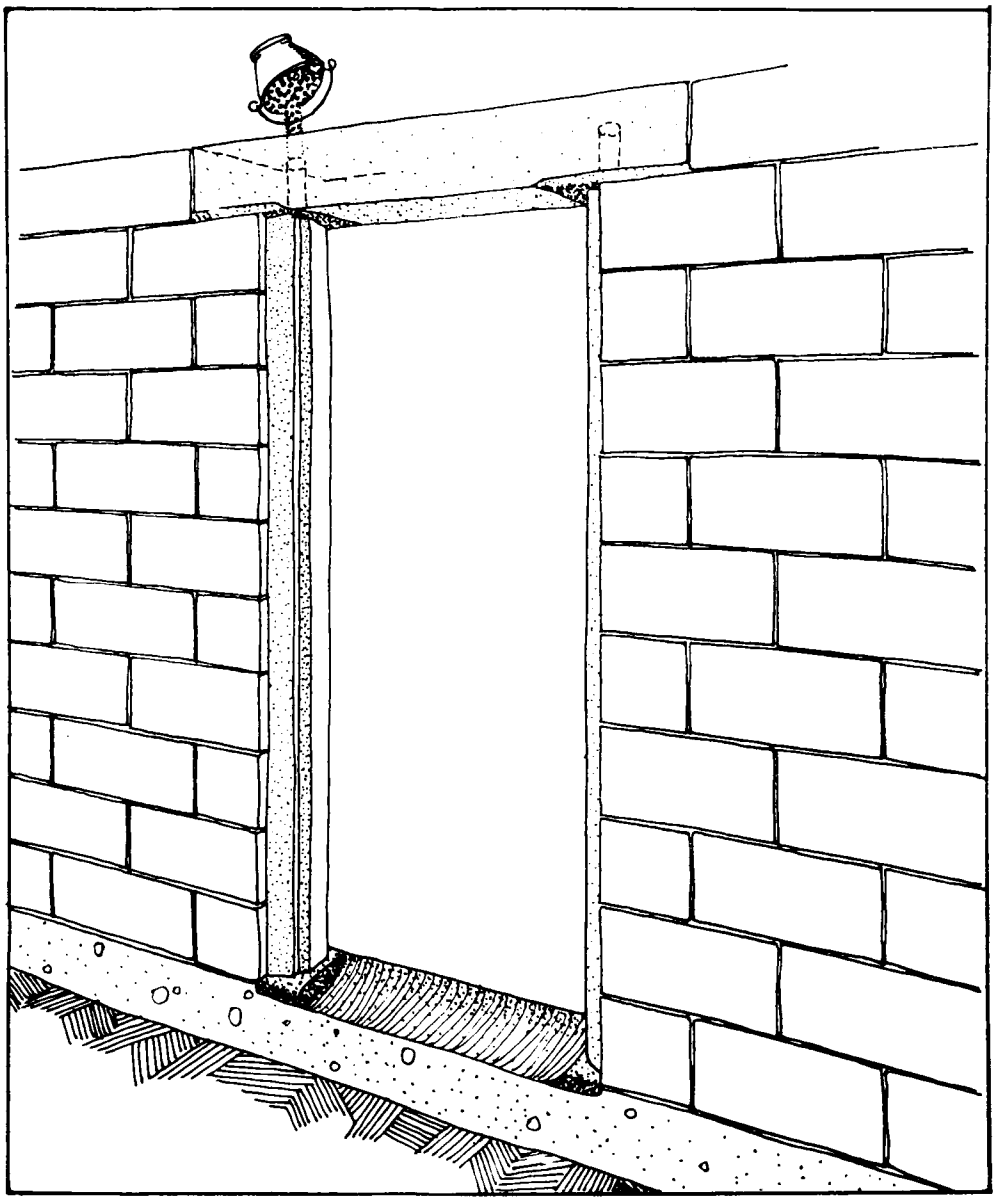
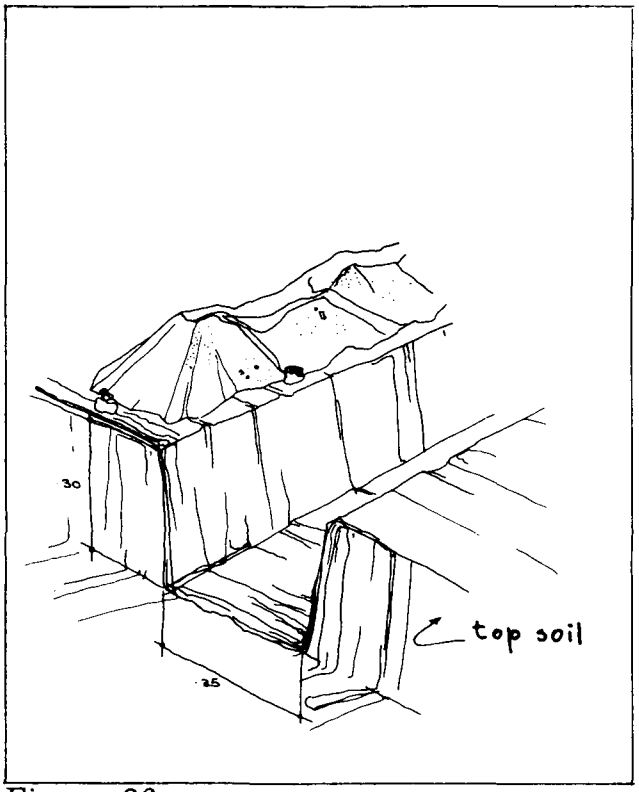


Figure 25 - Demonstrating the process of installing a concrete door frame.

SKETCHES OF CONSTRUCTION SEQUENCE

SKETCHES OF CONSTRUCTION SEQUENCE



Construction of a foundation type.

Figure 26

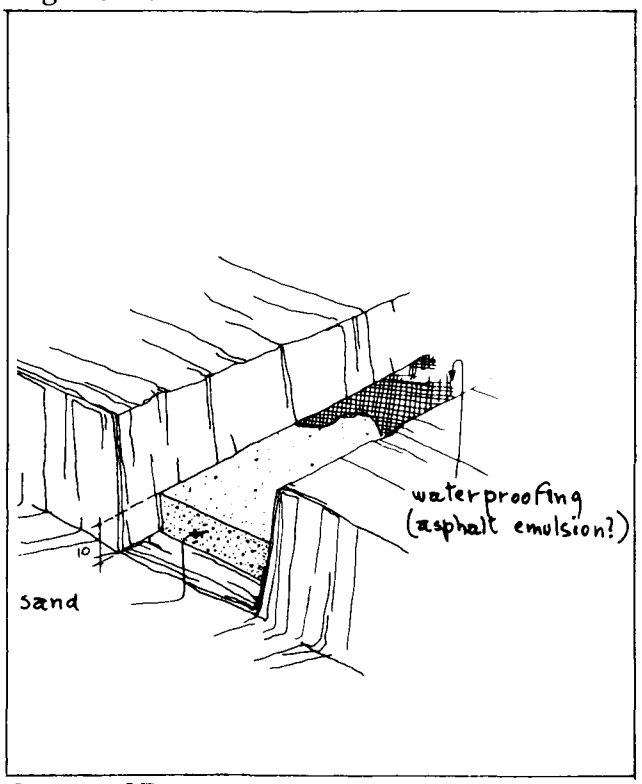
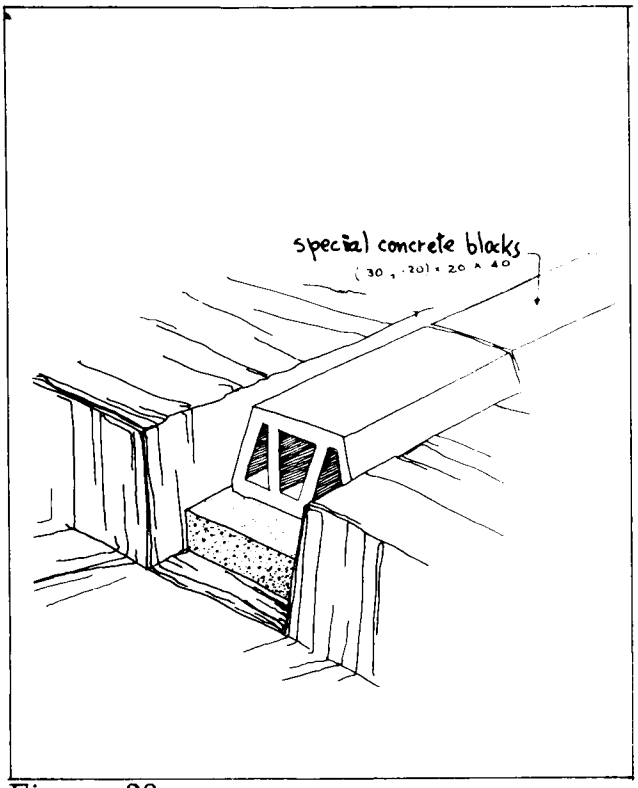


Figure 27

SKETCHES OF CONSTRUCTION SEQUENCE



Construction of a foundation type.

Figure 28

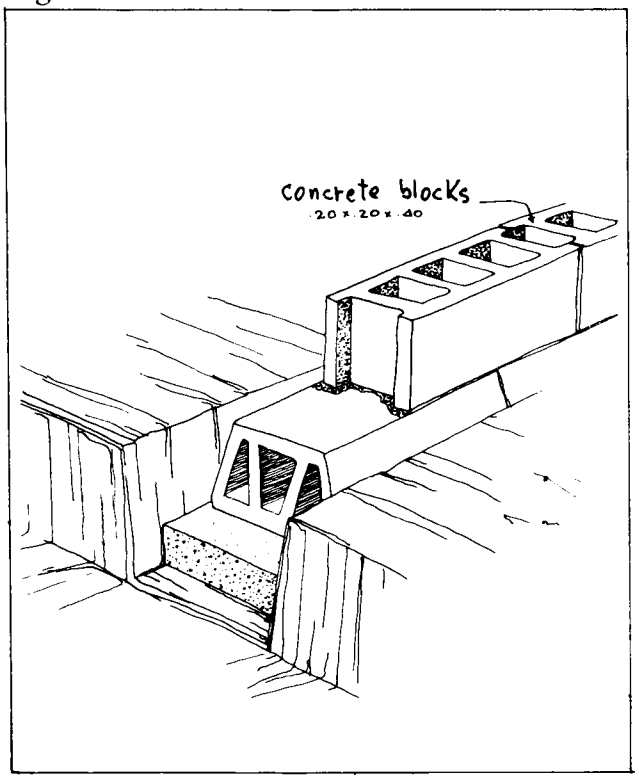


Figure 29

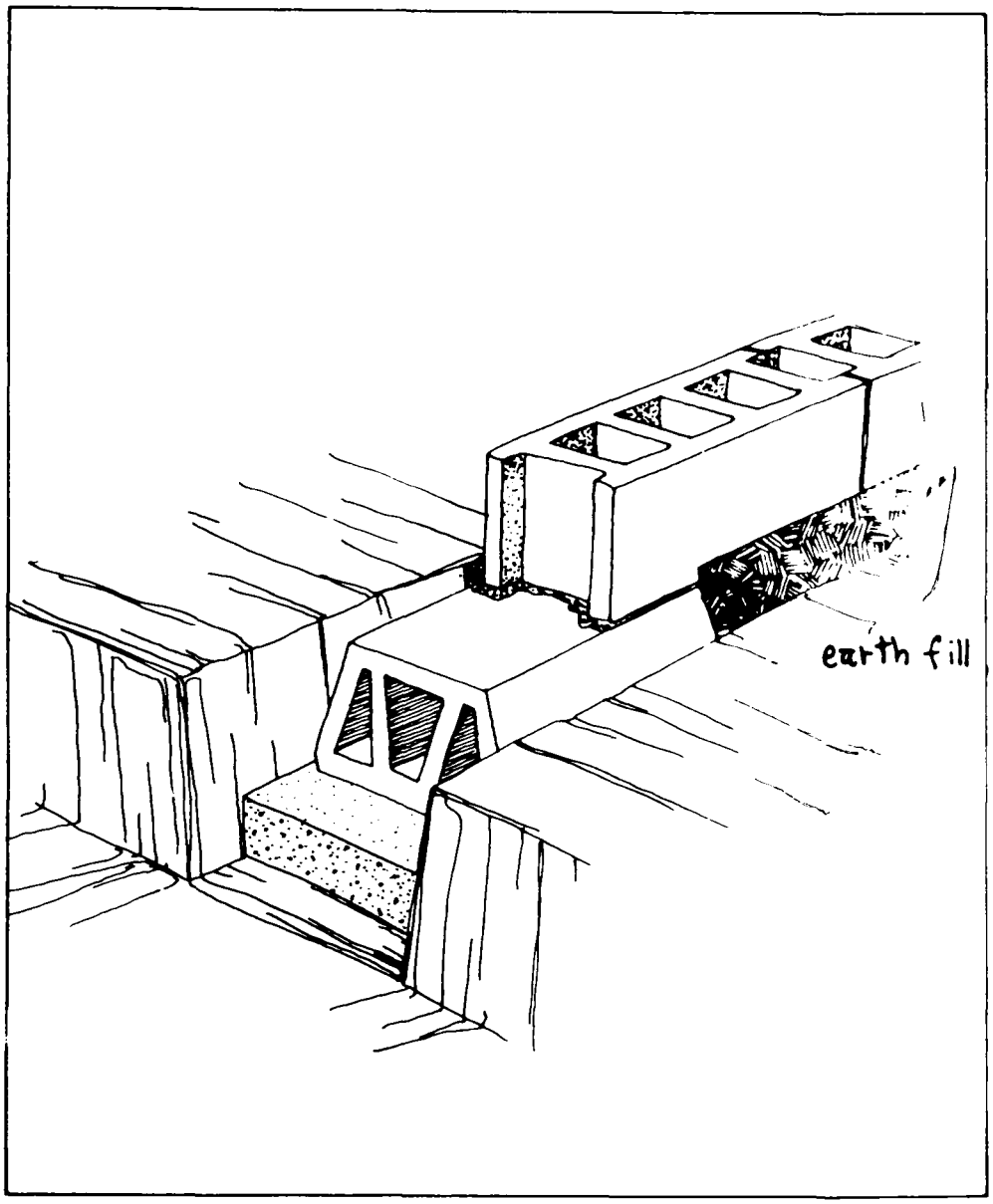


Figure 30 - Construction of a foundation type.

SKETCHES OF CONSTRUCTION SEQUENCE

SKETCHES OF CONSTRUCTION SEQUENCE

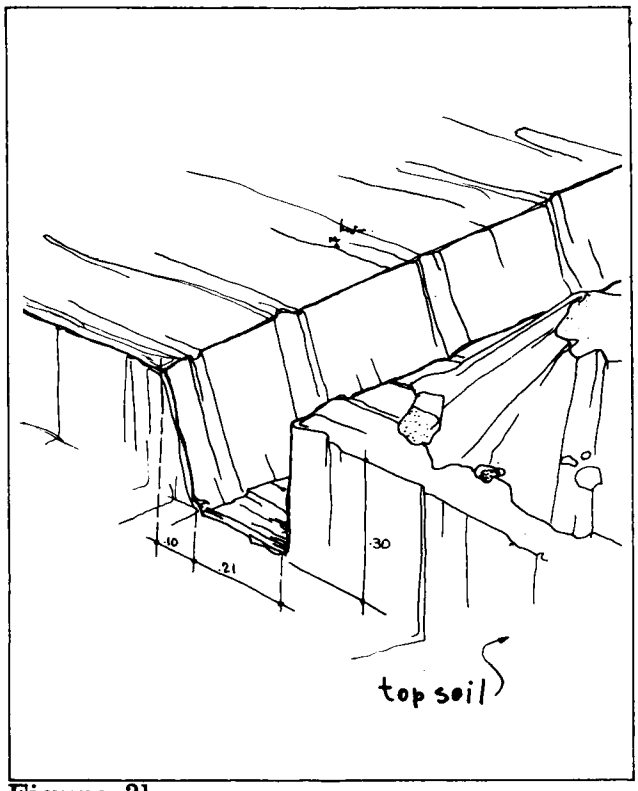


Figure 31

Showing detailed steps in the construction of a foundation type.

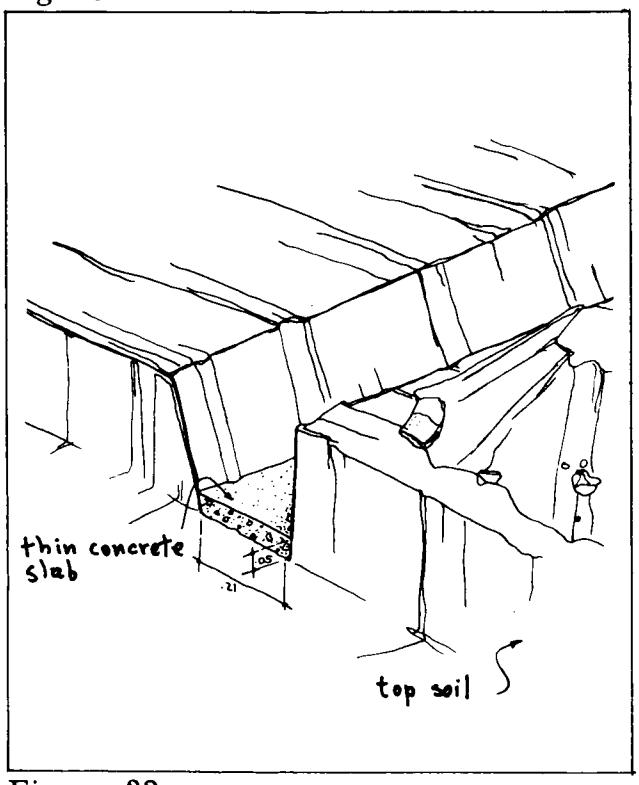


Figure 32

is to get them on paper with as few lines as possible before losing them. It is a waste of time to make elaborate drawings of ideas before submitting them to the refining process which is the essence of Developmental Design. After refinement we can make final and complete drawings.

The majority of our sketches should be in perspective or isometric to more nearly approximate the reality of three-dimensional work. Such sketches are most advantageous and efficient in analyzing the problem and in seeking solutions. A trial of this method will prove its effectiveness in calling one's attention to details that normally pass unnoticed in two-dimensional drawings.

In the study of detailed solutions for the various parts of the total structure, it is better to be not too concerned with the relationship of a particular detail to the entire complex. Efficiency will be increased by thus freeing the researcher from concerns other than those of his immediate problem. The correlation of the detailed elements will be accomplished later.

Although it is advisable to make rapid sketches, we are also concerned that they be truthful. The omission of a structural element in a sketch may lead to erroneous conclusions which may in turn result in faulty construction.

IV. Sketches of Construction Sequence

As a complement to the previous step, sketches should be made to demonstrate the several operations necessary to build the detail under study. For example, the erection of a door will be represented in as many different drawings as there are steps in

the process of erection. We will refer to these as sketches of construction sequence. This procedure allows us to better visualize the construction process and minimize possible errors. The problems that remain to be solved will be immediately apparent. (See Figures 21-37).

V. Mock-Ups

Once the sketches have been completed and the solutions are considered to be acceptable, full-size models can be made. Each model will represent one of the aspects or details investigated and the results can be checked much more thoroughly than in the sketches. The models should have a character somewhat similar to the sketches in their reality and rapidity of execution. They can be made of the actual materials to be used in the construction or of other more easily worked materials that simulate them in form, color and texture.

The purpose of the mock-up is to provide as realistic as possible a model of the problem being analyzed. As fragmentary details, they may be easily handled. If, as we have observed, the perspective sketches give a useful sense of reality, the mock-ups allow us to examine the problem with even greater realism. (See Figures 38-53).

The work with mock-ups indicates that we have arrived at an advanced stage in the research. Working in three-dimensional reality should be a decided stimulus to the researcher's imagination and creative sense. With details more clearly defined, the shortcomings should be immediately evident. At this point the researcher should sketch any new ideas that may occur to him for improving the construction. The process of sketching and then changing the mock-up should be continued systematically until the mock-up can no longer be improved.

SKETCHES OF CONSTRUCTION SEQUENCE

Showing detailed steps in the construction of a foundation type.

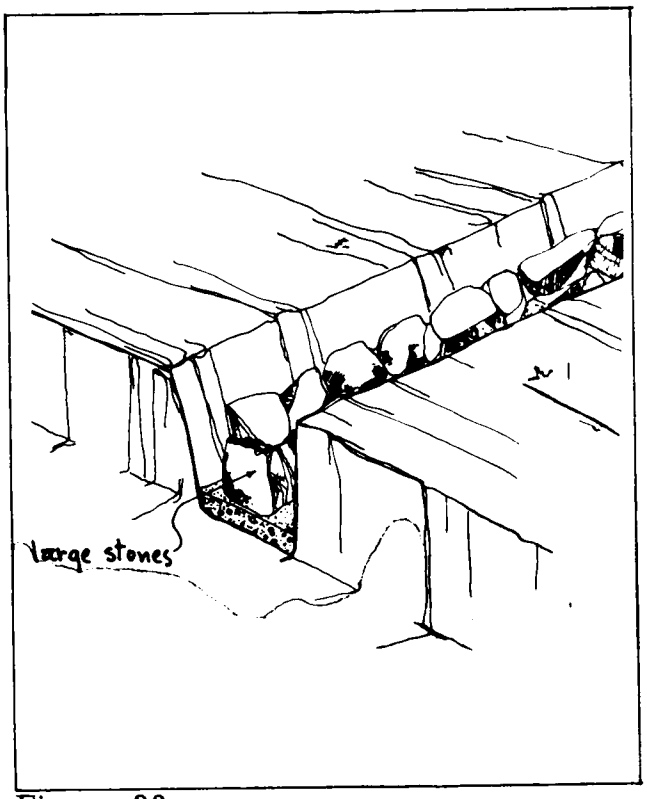


Figure 33

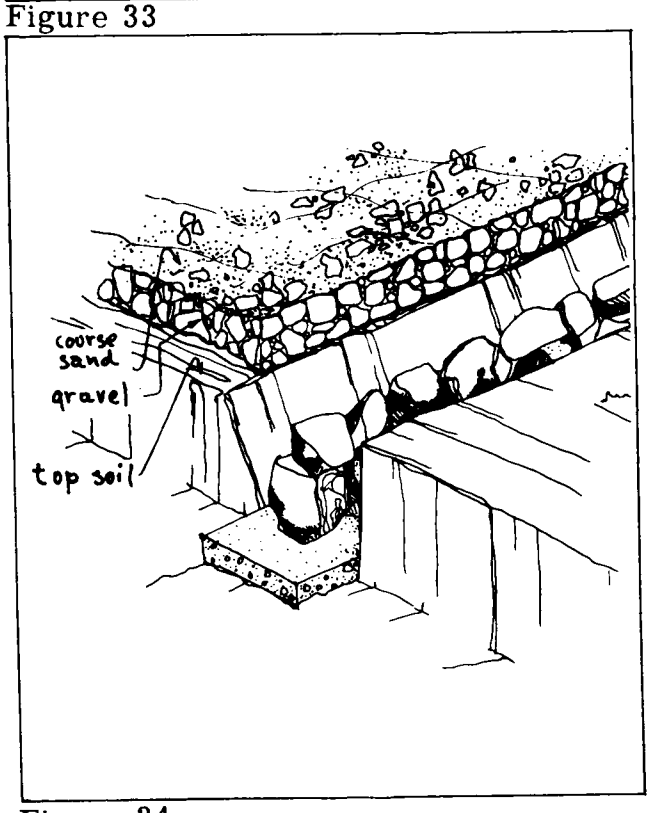


Figure 34

SKETCHES OF CONSTRUCTION SEQUENCE

Showing detailed steps in the construction of a foundation type.

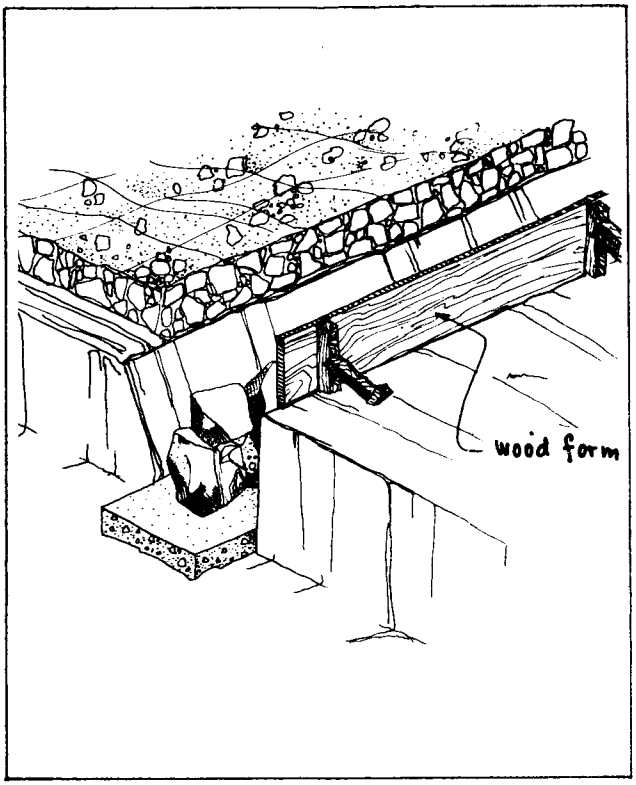


Figure 35

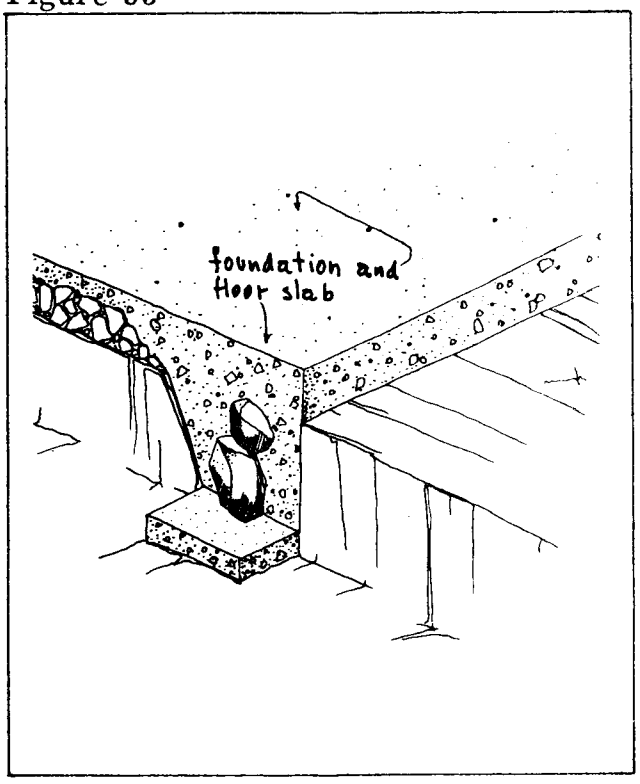


Figure 36

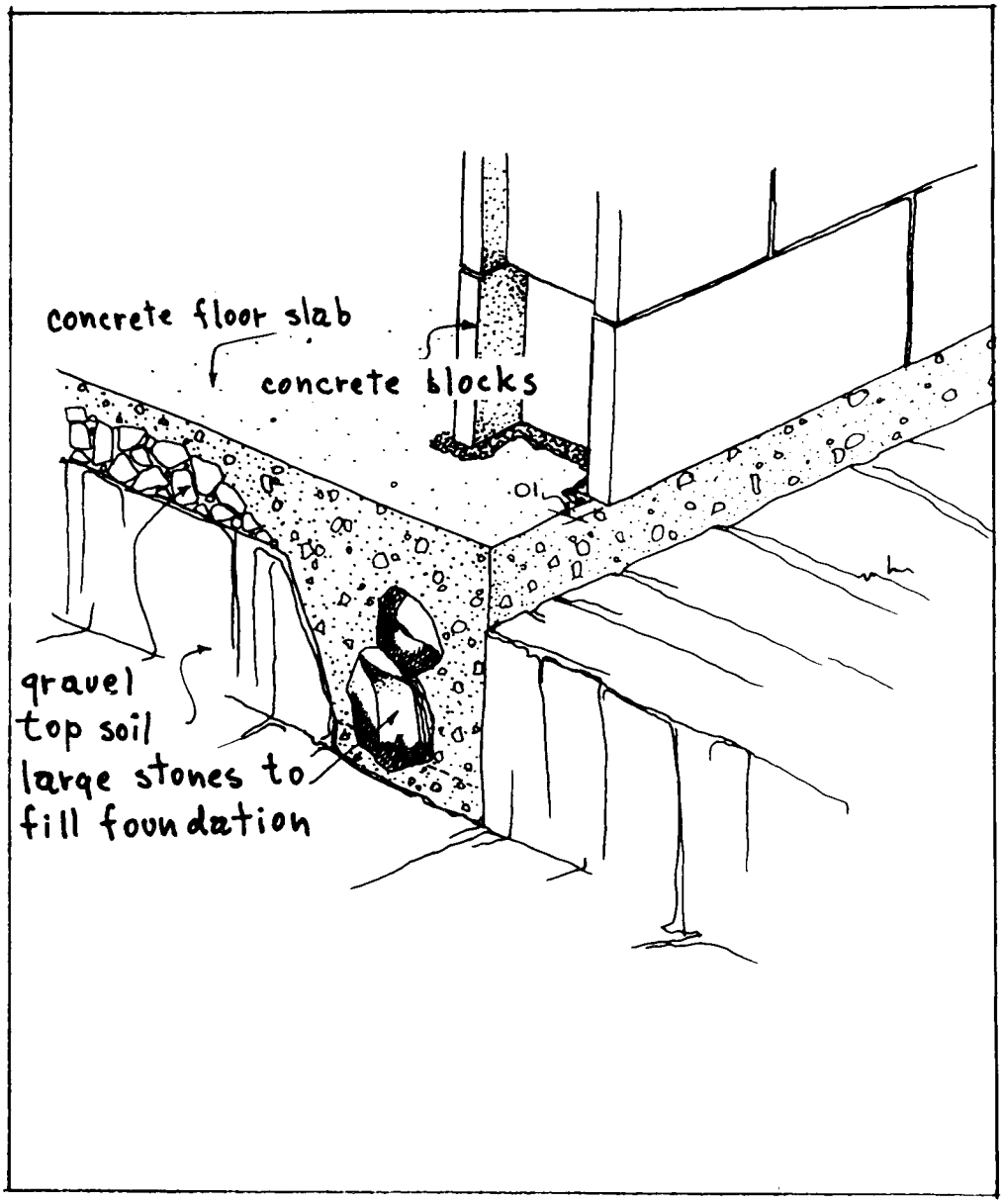


Figure 37 - Showing detailed steps in the construction of a foundation type.

SKETCHES OF CONSTRUCTION SEQUENCE

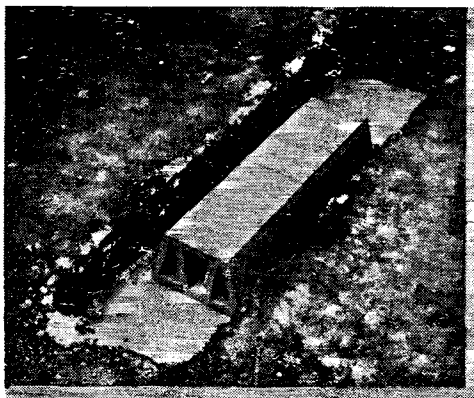


Figure 38

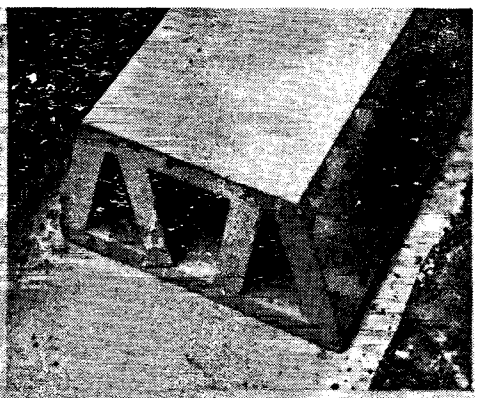


Figure 39

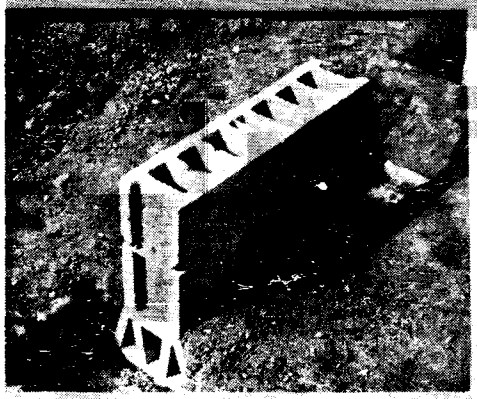


Figure 40

Figure 41

MOCK-UPS

Figure 38 - Study of a special block for use in prefabricated foundations. An appearance of reality is obtained by painting the model - which is made of wood - to simulate concrete.
Figure 39 - The same block in greater detail.
Figure 40 - To study its relationships to wall and ground, the mock-up is completed with a section of wall built of concrete block.
Figure 41 - Prestressing is indicated by using nut and bolt through fiberboard painted black to simulate steel.

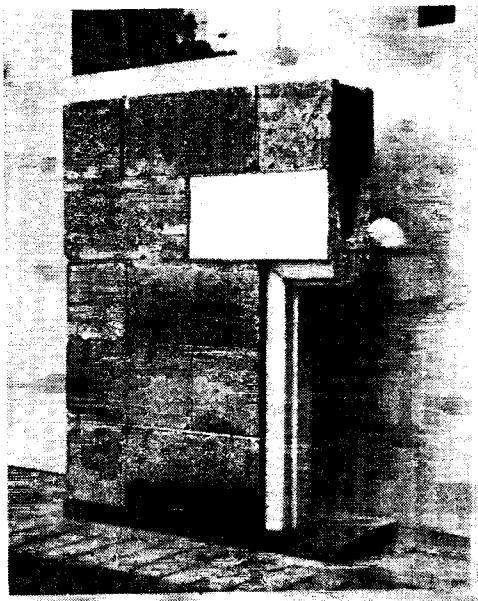


Figure 42

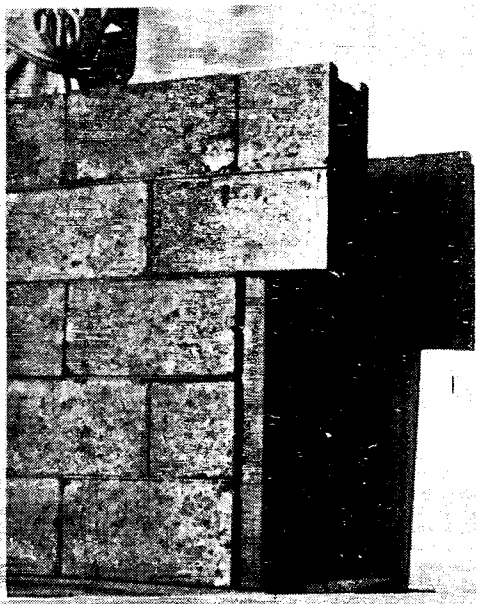


Figure 43

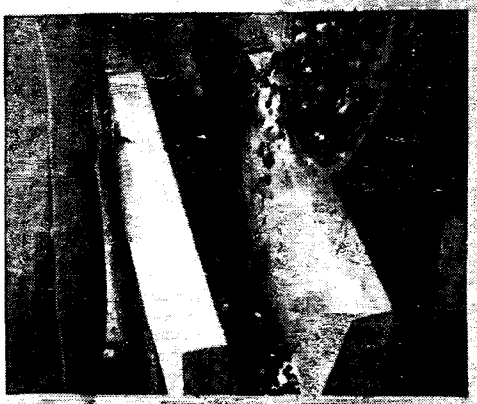


Figure 44

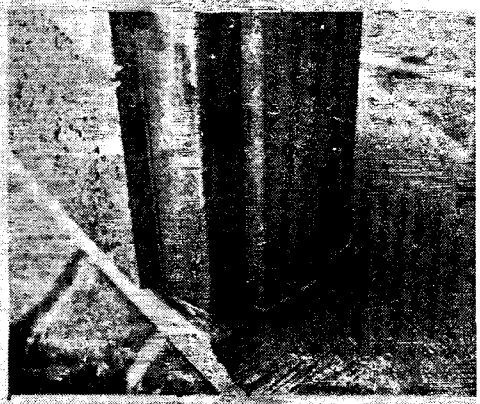


Figure 45

MOCK-UPS

Figure 42 - Mock-up of a precast concrete door frame and lintel.
Figure 43 - Study of a variation to the solution shown in the previous figure.
Figure 44 - With a bucket of sand and gravel, the task of pouring concrete through the hollow lintel, in order to join the frame to wall, is simulated.
Figure 45 - Detail of the mock-up, showing joint between the jamb and threshold.

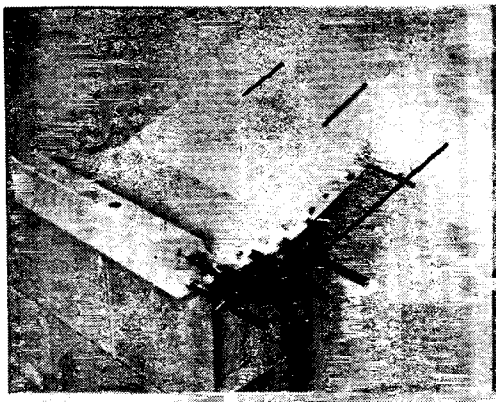


Figure 46

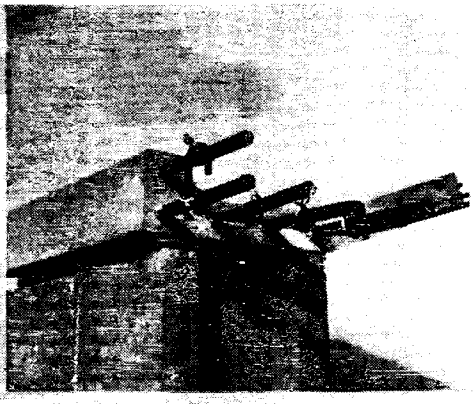


Figure 47

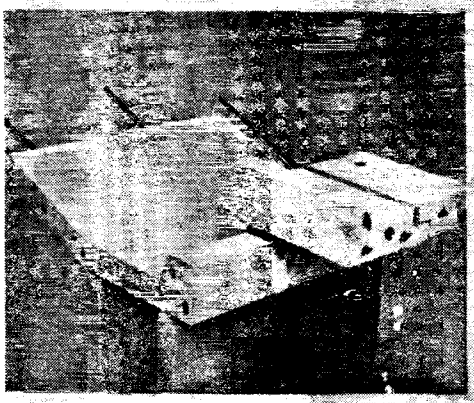


Figure 48

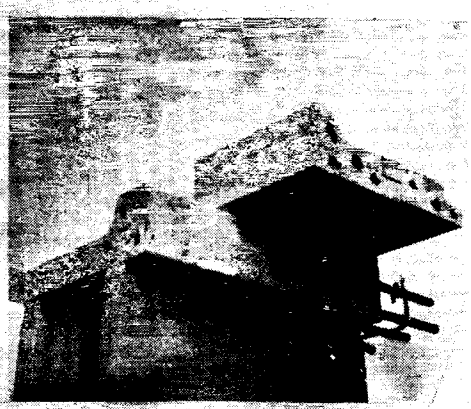


Figure 49

MOCK-UPS

Figure 46 - A section of a concrete gutter formed from the lateral edge of a precast concrete roof vault. After painting, a texture similar to concrete has been obtained. By inserting pieces of iron rod into the wooden model, the illusion of reality is increased.
Figure 47 - Same mock-up as in the previous figure, from a different angle.
Figure 48 - Study of the support of a sectional precast concrete slab on the edge of a vault roof.
Figure 49 - View of underside of the mock-up shown in Figure 48.

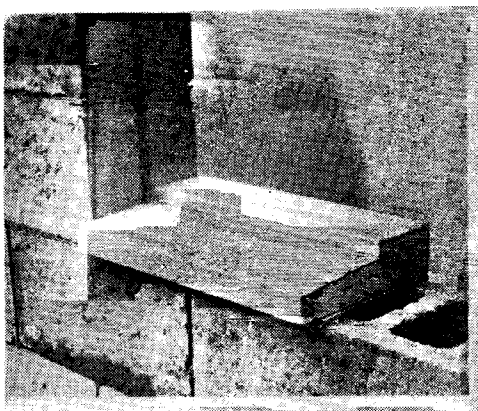


Figure 50

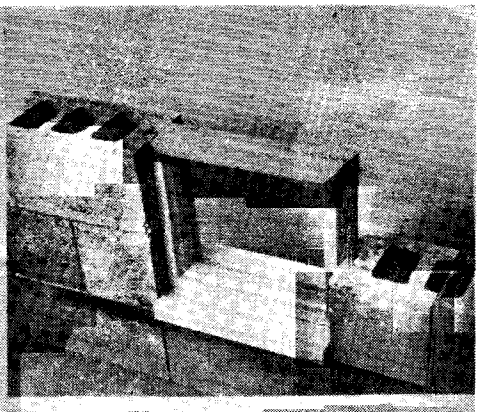


Figure 51

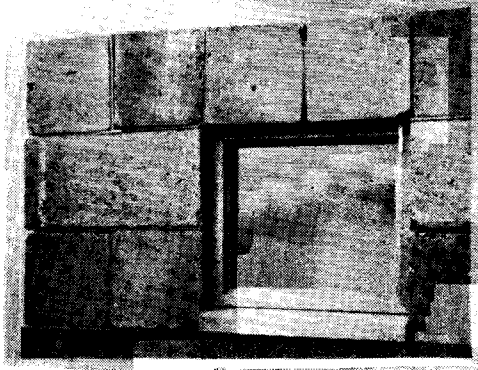


Figure 52

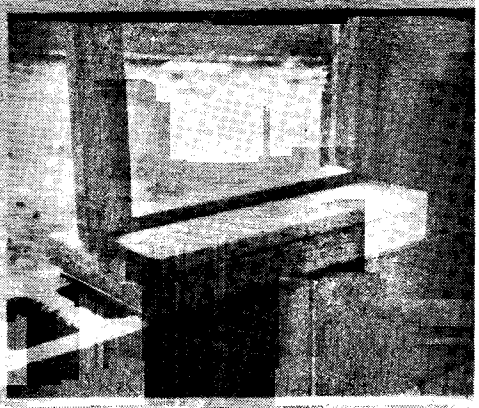


Figure 53

MOCK-UPS

Figure 50 - As part of the study of a prefabricated concrete frame to receive steel windows, a mock-up of a precast concrete sill is placed in wall opening.
Figure 51 - The second step consists of inserting the frame into wall opening and supporting it on the sill.
Figure 52 - The mock-up is then completed with a precast lintel of U-section concrete blocks with rod reinforcing.
Figure 53 - Interior view of same mock-up.

Figure 54

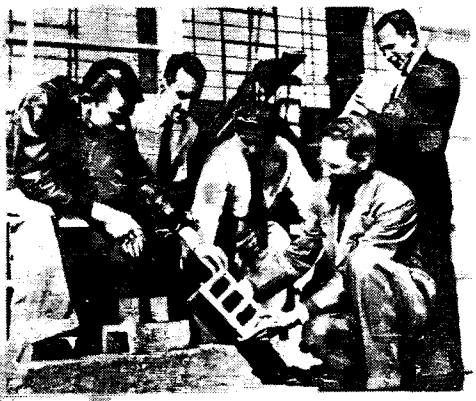


Figure 55

Figure 56

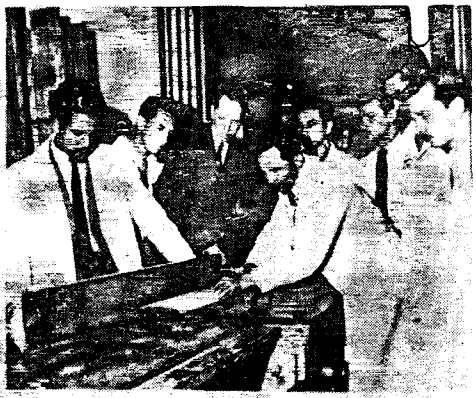


Figure 57

WORK IN THE SHOP

Figures 54, 55, 56, and 57 show several groups of trainees at the Inter-American Housing Center making mock-ups under the supervision of Howard T. Fisher. The direct contact with reality greatly stimulates the flow of ideas and at the same time reveals shortcomings in the design.

Figure 58

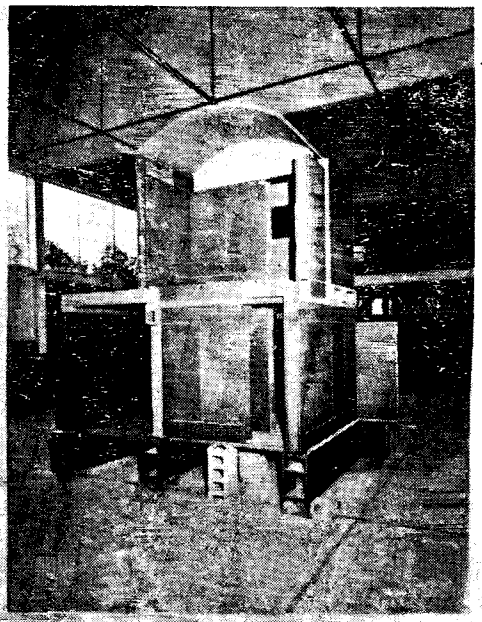


Figure 59

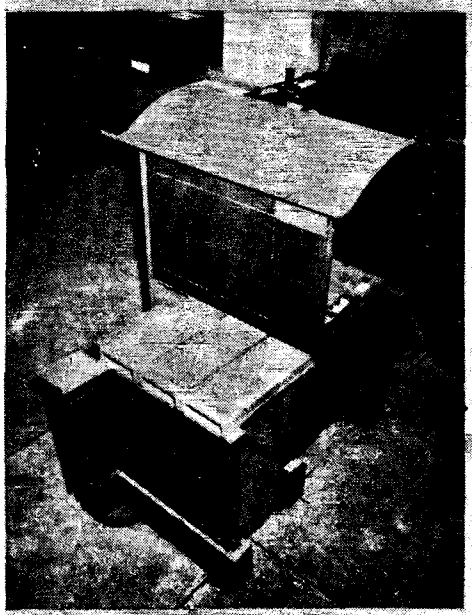


Figure 60

Figure 58 shows two students of the Inter-American Housing Center discussing with the author the details of a mock-up in which various fragmentary mock-ups developed during the investigation of the design of a dwelling have been integrated. The scale of this mock-up is evident in the photo. Dimensions in section are full-size while over-all height and width have been abbreviated. Figures 59 and 60 are other views of same mock-up.

Figure 61

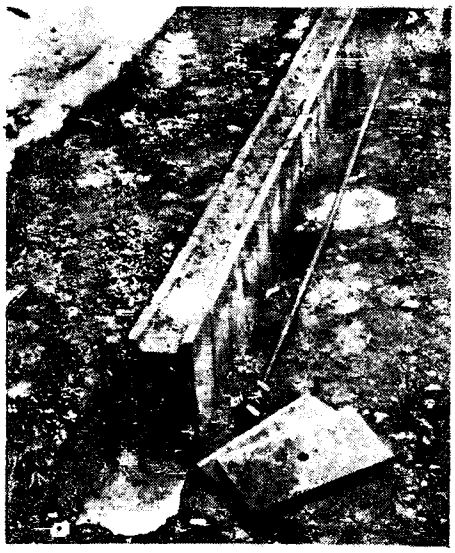


Figure 62

Figure 63

Figure 64

TESTING OF ELEMENTS

Figure 61 - Excavation prepared to receive a type of post-stressed foundation beam made with concrete blocks.
Figure 62 - Blocks placed in the excavation before being post-stressed.
Figure 63 - A steel rod is inserted in the blocks which are then post-stressed to form a beam.
Figure 64 - Detail of post-stressed system.

Figure 65 - The foundation beam is raised and supported at its ends while trainees of the Inter-American Housing Center demonstrate its resistance by standing on it. Foundation was part of a structure developed in study of the design of a housing unit at the Center.

TESTING OF ELEMENTS

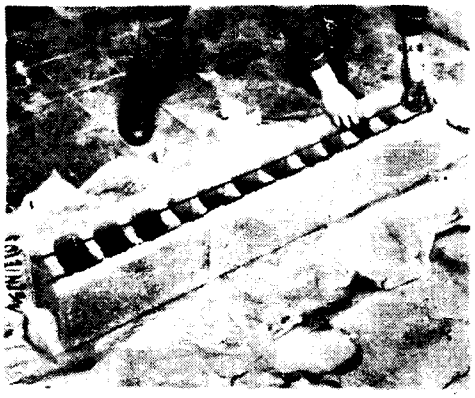


Figure 66

Figure 67

Figure 68

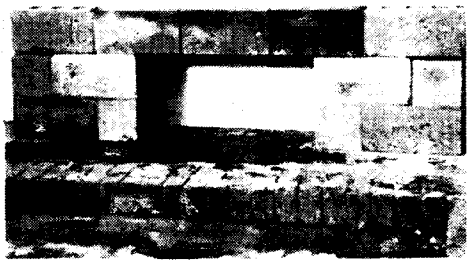


Figure 69

TESTING STRUCTURAL ELEMENTS

Figure 66 - Construction of concrete-block lintel with steel reinforcing.
Figure 67 - Covering rods with cement grout.
Figure 68 - Trowelling top surface which will become underside of lintel.
Figure 69 - Lintel in place, ready for testing.

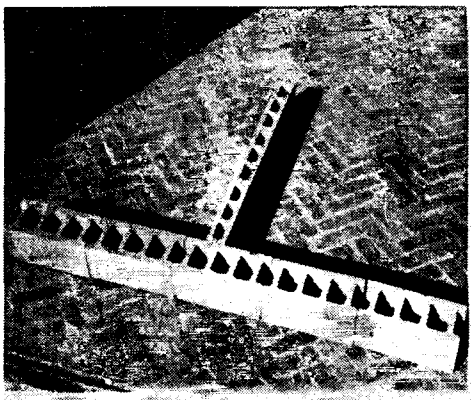


Figure 70

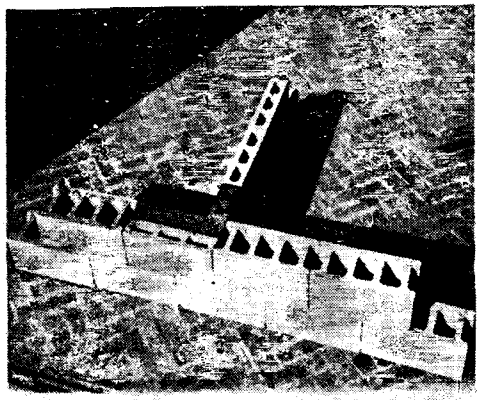


Figure 71

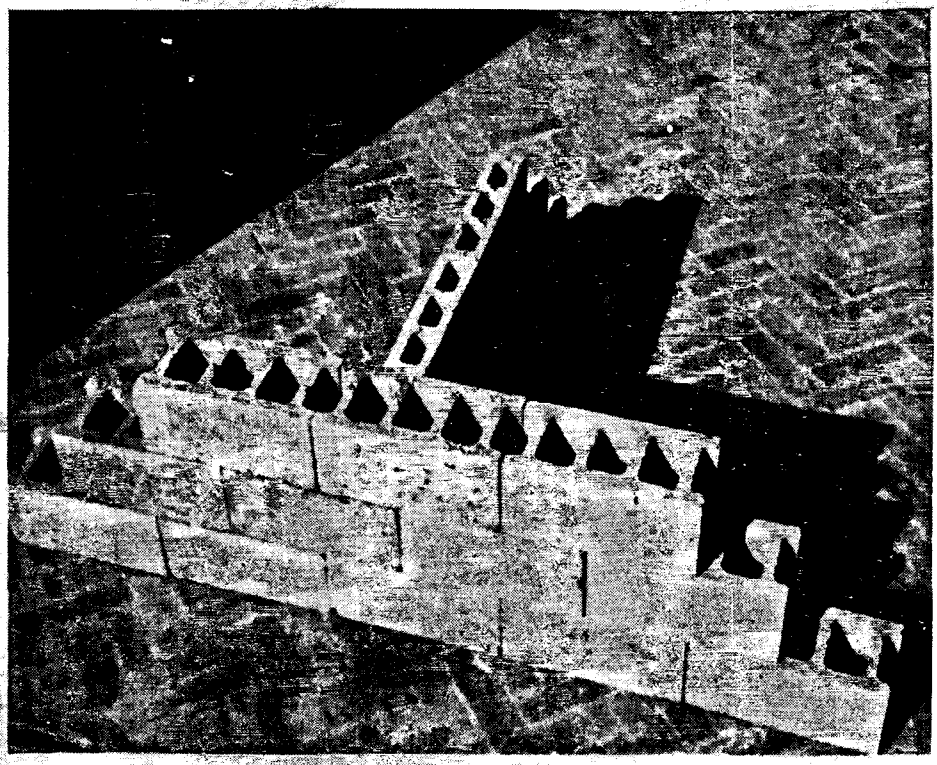


Figure 72

TESTING STRUCTURAL ELEMENTS

Figure 70 - Study of a portion of concrete block wall using actual blocks. Laying of first course.
Figure 71 - Layout of second course.
Figure 72 - With third course in place the fragmentary mock-up is completed.

Figure 73

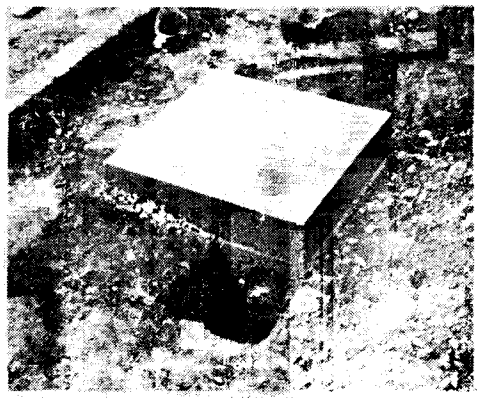


Figure 74

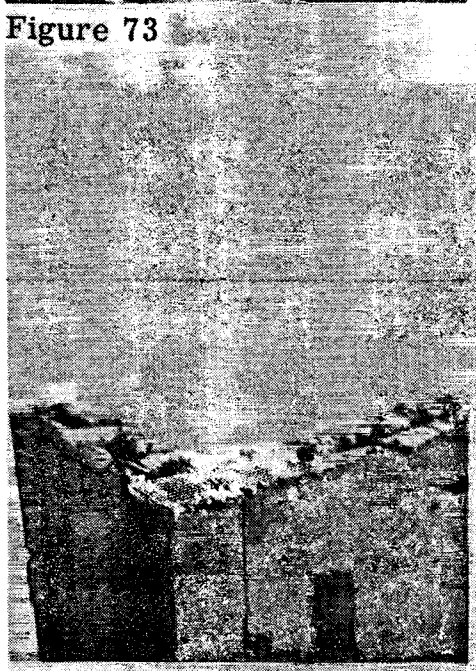


Figure 75

Figure 76

TESTING STRUCTURAL ELEMENTS

Figure 73 - Construction of a short section of foundation to study its characteristics.
Figure 74 - Completed portion of foundation.
Figure 75 - Study of corner of a concrete block partition.
Figure 76 - Building wall of concrete-block panels.

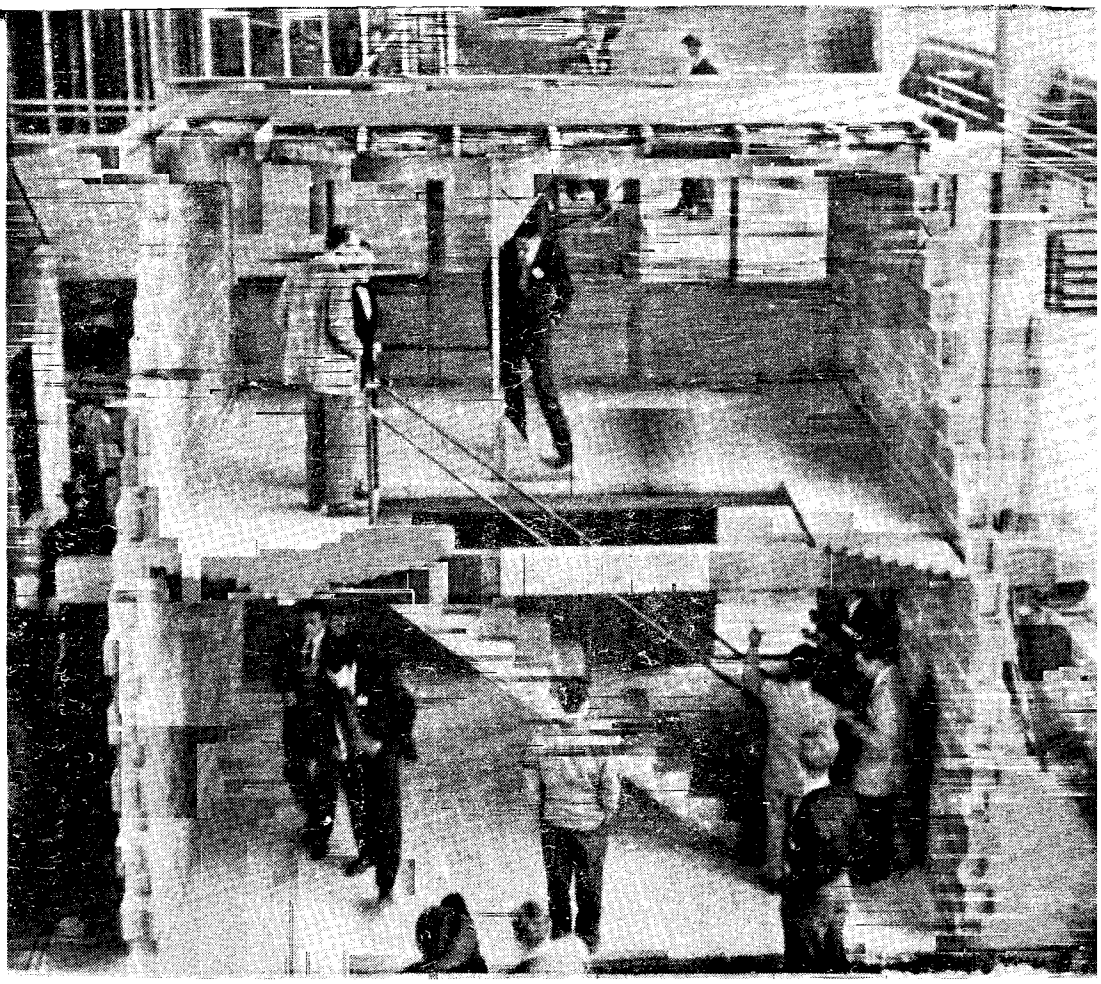


Figure 77 - Building a portion of a test house at McGill University, Montreal, Canada, during a course in Developmental Design conducted by Howard T. Fisher, with the assistance of the author.

CONSTRUCTION OF A PORTION OF A HOUSE

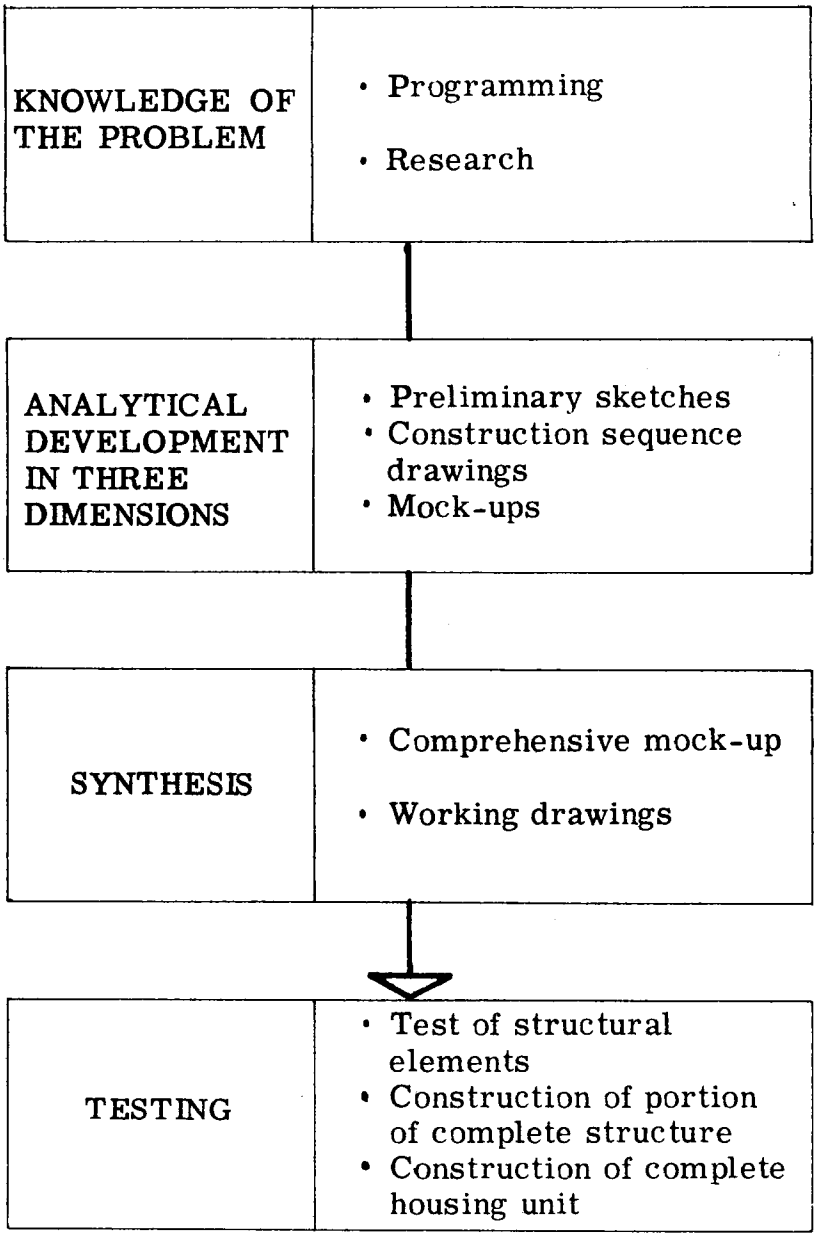


Figure 78 - Diagram indicating steps of the "Developmental Design" process.

It is preferable that the researcher should build his own mock-ups as many ideas will occur to him as he works. He therefore must have access to a small carpentry and mechanical shop. (See Figures 54-57). Experience indicates that positive results from the shop work more than compensate for the time invested in the manual work. This point should be stressed, as the more direct the participation of the investigator in the developmental process, the more complete will be his grasp of the problem under study and the more clearly will he visualize the most effective course to follow. While engaged in excavation or in carpentry he will observe difficulties that would otherwise escape his attention, and many new solutions will become apparent.

VI. Comprehensive Mock-Up

In order to study the assembly of the different parts of the structure under study, a selected portion of the structure should be built unifying the several previous fragmentary studies. As our concern is with the manner of assembling the various elements, it is not important to maintain exact dimensions of height and length. Elements may be shortened while maintaining the actual dimensions of the joints under study. We shall call such models Comprehensive Mock-Ups.

Before building the Comprehensive Mock-Up, we must study in sketch form the problems involved in assembling the several partial solutions. This study of assembly again demands the developmental process during which one or more of the partial solutions may necessarily require modification.

When the sketches indicate a satisfactory solution to the assembly, these sketches should be tested by making mock-ups of the junctures. When the mock-ups of the junctures appear to be acceptable, we may proceed

with accurate line drawings and then with the construction of the Comprehensive Mock-Up.

The importance of the Comprehensive Mock-Up cannot be over emphasized, as it constitutes the final model of the structure before trying it out in the actual materials. As with the partial mock-ups, it should be executed as realistically as possible. (See Figures 58-60).

VII. Working Drawings

When the comprehensive mock-up indicates that the assembly of the parts has been solved, the solution should be recorded in a complete set of working drawings. Since these working drawings are the result of a systematic investigation, success in actual construction should be assured. However this is not the end of the Developmental Design process. Even at such an advanced stage errors may appear requiring correction and modification of the plans.

Specifications should be written to complement the plans and should also be based on the results of the research. The specifications define the quality of the various materials to be used, and instructions regarding construction methods and workmanship. These specifications, along with the plans, should provide a synthesis of the results obtained throughout the research.

VIII. Testing of Elements

We now start the advanced stage of the investigation leading to the construction of a complete model house with its actual materials. We begin to test the various structural elements for strength, resistance, and suitability. The elements are no longer mock-ups, but are built of actual materials and in their true dimensions. In addition to testing for practicality, we must also check the elements for conformity with building codes. (See Figures 61 to 76).

In the proposed solutions we may contemplate the use of materials in forms not now available on the market. It will then be necessary to study ways of producing them, and also to design, with the aid of specialists, adequate machinery for their production.* Such machinery may serve for the production of the elements necessary for the verification tests, and also as a prototype for industrial equipment which will be required once the complete structure is proven and is to be produced in volume.

IX. Building of a Part of the Structure

In a previous stage we prepared an abbreviated mock-up of the principal elements of the structure; we will now build all of these elements full-size. If our project is the design of a house, we will build a corner with foundations, walls, roof, floors, doors, etc., in order to observe the junctures of the various elements at full size and with actual materials. If we find that some changes are indicated, the drawings and specifications will be revised accordingly. (See Figure 77).

X. Building of the Complete Structure

Here we arrive at the end of the design development. (See Figure 78). Based on the study, we can now build a complete test structure. The housing unit may then be submitted to all manner of tests to determine its practicability. Such tests should include all those normally required by local building codes. The test house may serve as a prototype for mass production.

The test house should be evaluated not only in terms of structural logic but also in terms of the ease and economy of its production and erection. Frequently, rational

*Translator's note: Latin American does not have an equivalent of a Sweet's Catalogue; the vast assortment of stock building elements as known in the United States does not exist; therefore, elements are commonly made to order and special equipment is sometimes devised to produce them.

structures require costly construction equipment or highly skilled labor. Such factors may vary greatly in the light of local conditions.

Upon completing the description of a representative developmental design project, it should be borne in mind that the norms established are not absolute, but merely illustrative. The researcher should adapt and modify the procedures to suit his objectives. What is important is to maintain the spirit of the method and to retain a general logical sequence. The reader may be assured that the results obtained will exceed his greatest expectations.

5. RECOMMENDATIONS FOR APPLICATION

The application of the method of Developmental Design involves carrying through a research project to its effective conclusion. This implies that the work be executed by experienced and capable technicians, as it is obviously impossible to carry out research by merely following a written procedure. The recommended norms and methods will be of little use unless applied by technicians with research criteria.

The well known Spanish scientist and writer, Ramôn y Cajal, recommends that the researcher should possess, among other qualities, an open mind, intellectual curiosity, and perseverance. His recommendations are applicable to Developmental Design insofar as it is a form of scientific research, involving the search for the unknown, and the refinement of a solution, sometimes with unexpected results.

An open mind allows us to discern the qualities and advantages in every possibility that presents itself. It minimizes the influence of preconceived notions and helps us develop a sense of self-criticism; to a degree we should question and be skeptical of existing customs. Each one of these principles, even though formulated by

persons of great technical and scientific prestige, should nevertheless be re-analyzed, as our conditions may be somewhat different. After an objective examination, we may feel free to accept or reject the principle involved.

As important as an unpredjudiced mind, is the quality of self-criticism. The human mind is generally filled with sub-conscious complexes that hinder the search for truth. Healthy criticism of each step in our work is essential in achieving our objectives. In carrying out developmental work, it is quite natural to become overly-intrigued with solutions in which we have put great time and effort. However, these solutions may be unsound or incomplete, and we must have the humility to recognize our errors and the will power to start over.

The quality of intellectual curiosity is essential as a constant stimulus in our study and to drive us to seek information and to follow new developments in the construction field. Through the diligent reading of technical literature, the imagination receives fresh stimulus.

Regarding perseverence, Ramon y Cajal has this to say:

"To carry a scientific research project to a successful conclusion, once the procedural methods are established, we should fix the terms of the problem clearly in our minds in order to stimulate strong currents of thought, that is, associations more and more complex and precise within the image received by observation and the latent ideas of our sub-conscious; ideas that can be drawn into our field of consciousness only through vigorous concentration. It is not enough to be receptive; one must become completely engrossed. Our investigation should profit from our every lucid moment, through the meditation that follows a long rest, through the intense mental effort produced only when our nervous cells are overheated by congestion, or finally

by the sudden inspiration that comes like a spark from a scientific discussion."*

A state of mind, similar to the trance recommended by the famous Spanish scientist for obtaining positive results from research, is advisable when applying the method of Developmental Design. During the process of our work, our imaginations must be alert to capture the smallest details that flit across our minds. Any lapse of attention may result in the escape of an important idea and hence the loss of a brilliant solution or at least the loss of much time. In such work we must maintain the highest possible level of concentration.

Finally, a research project must be thoroughly organized before work is initiated. In this organization, the advantages of effective teamwork should be considered. A coordinated group of technicians, with each understanding his role in the undertaking, can achieve integrated results with great rapidity.

The understanding and rational application of the principles presented in this publication should provide an efficient means to systematically improve construction and reduce costs. However, as in all human endeavor, the determining element is man himself. To paraphrase Anatole A. Solow, Chief of the Housing and Planning Division of the Pan American Union, Developmental Design is not a panacea and we do not regard it as the penicillin of housing.

---

*Ramôn y Cajal. "Los tônicos de la voluntad." 5a Edición, Espasa-Calpe, Buenos Aires, Argentina, 1946, page 49.

BIBLIOGRAPHY

Burger, Walter D.
Work method and procedure. Chicago, Davison-Fisher Associates. Not published.

Inter-American Housing Center, Bogotâ.
Estudios sobre materiales de construcción, Bogotâ, 1952. 5 v.

Inter-American Housing Center, Bogotâ.
Informe proyecto torcoroma. Bogotâ, 1953. Not published.

The Elmendorf Corporation, Chicago.
Final report. Project 13, by Armin Elmendorff and Howard T. Fisher. Chicago, 1948.

United States Department of Commerce. Office of Technical Services. Development of spandrel wall construction system, by Robert L. Davison and Howard T. Fisher. Final report. Washington, D. C., 1948.

United States Housing and Home Finance Agency, Division of Housing Research. The modular method in dwelling design. Washington, D. C., 1949.

Fisher, Howard T.
Prefabrication, what does it mean to the architect. (Journal of the American Institute of Architects, Washington, D. C., Nov. 1948).

Housing Conference, Cambridge, Mass., Jan. 1952.
Housing mass produced. Cambridge, Mass. Massachusetts Institute of Technology. Albert Farwell Bemis Foundation, 1952.

Kelly, Burnham
The prefabrication of houses. New York, Wiley, Cambridge, Mass., The Technology Press of the Massachusetts Institute of Technology, London, Chapman and Hall, 1951.

McGill University. School of Architecture. Montreal.
Report. McGill demonstration course. Montreal, 1953.

Massachusetts Institute of Technology. Albert Farwell Bemis Foundation. Housing, a national security resource [Cambridge, 1951].

Navarro, Hugo
Investigación experimental. Vivienda prefabricada con elementos de arcilla y hormigón, por H. Navarro y Hugo Pelliza. Bogotá, Centro Interamericano de Vivienda, 1953. Not published.

Ramón y Cajal, Santiago
Los tónicos de la voluntad. Buenos Aires, Espasa-Calpe Argentina, 1946. Colección Austral.

Rogers, Tyler S.
The construction industry, a promising educational opportunity. Washington, D. C., Producers Council, 1952.

Rubenstein, Albert H.
Research communication. (Industrial Laboratories, Chicago, Oct. 1952).