BUILDING
RESEARCH
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PROPOSALS FOR NEW BUILDING RESEARCH

National Academy of Sciences—
National Research Council
publication 831

PROPOSALS FOR NEW BUILDING RESEARCH

Two groups of proposals for new building research presented at the
1959 Fall Conferences and the 1960 Spring Conferences of the
N. R. C. Building Research Institute
Division of Engineering and Industrial Research

Publication 831
NATIONAL ACADEMY OF SCIENCES--NATIONAL RESEARCH COUNCIL
Washington, D. C.
1960

$4.00

The Building Research Institute gratefully acknowledges the contributions to building science made by the participants at these two conferences.

MILTON C. COON, JR.
Executive Director

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Inquiries concerning this publication,
the Conferences on New Building Research Proposals,
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Division of Engineering and Industrial Research
National Academy of Sciences--National Research Council
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Library of Congress Catalog Card No.: 60-60088

Price $4.00

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EDITOR'S NOTE:

Contrary to the usual practice of the Building Research Institute, the proposals included in this publication have not been edited for consistency in style, use of language and format. The special treatment of this publication is a result of the desire of the BRI Research Committee to demonstrate the actual manner in which typical proposals for building research are being made.

INTRODUCTION

By Leonard G. Haeger,* Chairman, BRI Research Committee, 1959-60
and Peter B. Gordon,* Chairman, BRI Research Committee, 1960-61.

In 1959, the Research Committee of the Building Research Institute started a program to encourage the undertaking of needed building research by sponsoring sessions at the BRI semi-annual conferences for the proposal of new research projects. The objectives of the Research Committee in this program are:

1) To bring to light important problems warranting investigation.

2) To provide information on the availability and desire of research workers to undertake new work.

3) To provide an opportunity for potential sponsors of building research to meet people interested in undertaking work and learn of available facilities for new projects.

4) To provide a forum for the discussion of the presentation of proposed research projects to assist new investigators in improving the organization of their ideas and proposals.

This report includes the proposals for new research presented in sessions of the Research Committee during the BRI 1959 Fall Conferences on November 18, 1959 in Washington, D.C., and at the BRI 1960 Spring Conferences on April 5, 1960 in New York.

The methods used by the Research Committee in the organization of these two programs differed considerably. At present, still another technique for the organization of this

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type of program is being employed by the Research Committee in connection with plans for future BRI Conferences. The variation in the techniques employed represents experimentation by the Committee to evolve the most satisfactory method.

Approximately thirty institutions were invited to participate in the program held in November, 1959. Of the proposals submitted, the Research Committee selected seven for presentation. The principal criterion employed in the selection of these proposals was maximum diversity of subject, methodology, and location of the institution. Following the oral presentation of the proposals and an informal discussion period, each of the seven proposals was submitted to a selected group of critics who provided written discussion and criticism. After receipt of the written criticism, the authors were invited to revise their proposals. Five of the seven proposals were subsequently revised. The authors of the remaining two, acknowledging the desirability of doing this, were unable to undertake revision because of circumstances involving commitments on their time. The proposals printed in this report are the revised proposals except in the case of the two indicated below:

An Analysis of Major Residential Building Features by Metropolitan Areas
Reinhold P. Wolff, University of Miami

Development of Solar Curtain Walls
Robert P. Darlington, Washington State University

Since most of the open forum discussion recorded at the Conferences is related to earlier versions of the proposals, this report includes just those general parts of the discussion which still remain pertinent.

In preparation for the session on the presentation of proposals for needed research in April, 1960, the Research Committee employed a more intensive screening procedure than previously. Members of the Committee worked with the four institutions presenting the selected proposals in advance of the conference. As a result of the greater advance effort, it was thought that the proposals presented orally before the Conference did not require subsequent review, and this procedure was not undertaken. The four proposals presented in April, 1960, are included in this report together with the open forum discussion which took place following their presentation.

The Research Committee believes that these programs have been worthwhile both from the standpoint of bringing to light needed investigations, and of the assistance provided to the investigators in formalizing their proposals. Several of the proposals are now known to be under serious consideration by potential sponsors. The Committee urges all organizations that are interested in supporting any of the proposed investigations to contact the authors directly; however, if desired, it will be most pleased to arrange introductions.

The Research Committee is still not fully satisfied with its own procedures in the conduct of this type of program, and intends to experiment further in the hope of improving the usefulness of its services.

RESEARCH PROPOSALS PRESENTED AT THE BRI 1959 FALL CONFERENCES

Session Chairman - Glenn H. Beyer
Director, Housing Research Center
Cornell University

AN EVALUATION OF THE INTERRELATIONSHIP OF PARAMETERS AFFECTING COMFORT IN DOMICILES FROM EXISTING LITERATURE

Richard G. Clarke,* Director
Division of Research, University of Hartford

A few years ago the Division was requested by a local manufacturer to formulate the scope of a major research project with the goal of identifying the significant parameters affecting the comfort, health, and well-being of the human family in its domicile. The task was to continue with an investigation of the problem of control of the important factors, with the ultimate purpose being the design of a "living machine" that would maintain the domicile environment within the acceptable limits of the important parameters.

The problem was put in the hands of the University's Department of Psychology and, with the assistance of the Biology and Engineering Science Departments, they assessed the problem and prepared the scope presented in Table I. The potential sponsor did not undertake the establishment of the project, primarily because of a change of emphasis in his manufacturing operations. Since the research program outlined seems particularly valuable, and is of importance to psychology and biology as well as to the construction industry, the Division of Research has continued to offer it to possible supporters.

It is immediately apparent that the program is a very large one, and lies in a field that has been well plowed by investigations of single parameters. If the goal were to determine a single parameter, such as the permissible air velocity maximum and minimum within various rooms of a domicile, assuming constant temperature and humidity, there would be no problem, for such a study has most probably been published. (It might have been made so long ago that it would be out of date, and require a recheck.)

All of the listed variables have probably been investigated rather carefully individually, not only for application to the domicile, but more especially to office, factory, and other working spaces. Any parameters that have not been satisfactorily studied could be worked out with relative speed and ease, compared to the problem of studying the interaction of the variables.

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Interaction effects have been studied to some extent. Temperature and humidity affect comfort profoundly, and the temperature optimum is a function of humidity. This interaction must have been thoroughly studied. Even the combination of temperature, humidity and air movement has been investigated, although in the instance known to the author the "subject" in the experiments was a robot that simulated the over-all thermodynamic response of the human body.

The scientific literature is full of published studies of environmental conditions and their effect on humans. In some instances limits of toleration were sought, but in general the efficiency and comfort of the human in the environment have been considered. There are probably no less than 10,000 published papers within the scope of this project.

The true problem lies not in the effects of the individual parameters, but in their interaction. At the present time an air conditioning system can provide temperature, humidity, and air movement that are better for the occupant of a space than the ambient conditions provided by nature. The contraption usually makes noise, and may be of dubious esthetics in the part that can be seen. Lighting fixtures give light at the work surface in a manner best suited to inspire the worker to his best effort, but they too may be noisy most of the time, they may be unwanted and very effective heat sources, and they are likely to be about as esthetically satisfying as a brass cuspidor. The esthetic value is not listed as a parameter, since it is probably not susceptible to scientific analysis, although certain minimum esthetic levels may be determinable if the component is rendered partially nonfunctional by decoration.

Are the secondary effects and interactions important? They probably are, although in some instances they may be negligible. This proposal was requested by the manufacturer on the assumption that they are not only important but crucial, and a first look at the problem supports that view. The conviction that the interaction of parameters affecting comfort is of the greatest importance in establishing the optima for a given living environment has led the Division of Research to continue its search for support of this project.

The first phase of this study of parameters affecting environment would necessarily be a literature search and analysis. In the usual research problem in science, the literature search yields a few hundred references, with perhaps no more than a hundred papers to be read in their entirety. Thus the search of the prior art is usually an incidental item in the budget for a project. Frequently, the sketchiest survey of the art demonstrates that experimental work can be undertaken without worrying about repetition of that done previously, so the detailed literature search and laboratory work go hand in hand.

In the problem under discussion the estimate of 10,000 pertinent literature articles is not likely to be an exaggeration. There may be that many in American publications alone. Probably only a thousand or so will be worth study, and a few hundred worth detailed analysis. It is certain that practically all of the parameters have been given some study, and a good many papers containing data on interactions will be uncovered. It seems unwise even to think seriously about experimental work until the literature has been well sifted.

The aim of the literature search is primarily to permit the formulation of a detailed research program. At the present time the existence of a major problem, both in magnitude and importance, is suspected, but its boundaries are unknown. There is the possibility that many of the parameters do not interact. It may be possible to determine lack of interaction from material already published, and so save eventual research time. The literature is sure to provide clues as to the most important interactions, so that priorities can be assigned within the program.

The research program proper is in the domain of psychology, so psychologists will be employed to head up both the preliminary survey and the experimental work. The standard procedures of psychological investigation and analysis of results are to be followed, but since physical and biological science are involved in the experiments, practitioners in those fields must be called upon for assistance. The eventual goal involves the design of hardware, so engineering personnel should also participate. Two of the University staff are Building Research Institute members, and will be deeply involved in the work. It is hoped that the BRI and the eventual sponsor will provide a considerable amount of the sort of advice and criticism that BRI has already offered in the development of this proposal.

The evaluation of the existing literature is being set forth as a separate proposal, with experimental work to be proposed later. Support of the survey implies that the subsequent experimental research necessary for development of data useful in the design of housing components is important and vital in the future of the construction industry. The project may be deeply rooted in pure science, but it is definitely intended to provide a source of future income for the applicable industries.

It will probably be possible, at the halfway point of the literature survey, to fix rather firmly the magnitude, procedures, and much of the detailed plan of the eventual experimental study. The time presently specified for the survey is one calendar year plus two or three months' notice that the project is to become active. The study team will be drawn from the University faculty, and will operate on a part-time basis. The direct supervision will be the responsibility of the Department of Psychology, acting for and with the Division of Research. The funding required amounts to $10,000 for the year. Of this about 60% would be expended for reimbursement of staff; 25% for library facilities, travel, and other direct costs; 15% for indirect costs.

The author is indebted to Messrs. Harold Horowitz, Ralph J. Johnson, Peter B. Gordon, and John E. Haines, for valuable criticism given during the preparation of the proposal.

TABLE I

Areas of Search
Preparatory to Research on Environmental Control

I. Independent Variables

A. Sound

Amplitude, complexity, frequency, intermittent or continuous. Masking effects, threshold and subthreshold reception.

B. Light

Hue, saturation, intensity, area of source. Contrast, direction.

C. Air

1. Temperature: Amount, fluctuation, location of source.
2. Humidity: Amount, fluctuation.
3. Movement: Speed, direction, fluctuation, part of body affected.
4. Odor: Amount, quality.
5. Purity: CO_2 concentration, dust, pollen, etc.
6. Barometric pressure: Amount and fluctuation.
7. Interaction of temperature, humidity, movement, etc.

D. Surround

Color, size, texture, material of ceilings, walls and floors.

E. Interaction effects of above variables.

II. Dependent Variables

A. Measures of comfort (for various activities: at rest, light manual work, heavy manual work, sedentary work).

1. Subjective preference measures.
2. Physiological correlates of preference measures.
3. Measures of emotional effects.

B. Measures of Work Efficiency

1. Amount produced in the various activities: Speed, accuracy, wastage, distractability.
2. Energy expended per unit work.
3. Fatigue effects: Physiological and psychological.

C. Physiological reactions: Pulse, blood pressure, respiration, galvanic skin reflex, allergic reactions, etc.

D. Acuity measures.

III. Controls

A. Subjects

1. Variability due to extraneous factors.
   a. Physiological Factors: Age, sex, body build, metabolic rate, etc.
   b. Psychological Factors:
      (1) Personality characteristics: rigidity, suggestibility, etc.
      (2) Previous environmental experience (habit).
      (3) Residual error variance.
2. Adaptation effects, immediate and delayed.

B. Methodology

1. Experimental design for study of large numbers of interacting variables, and statistical tools for handling.
2. Apparatus for producing and varying independent variables.
3. Apparatus for measuring and recording dependent variables: Comfort, efficiency, physiological reactions, acuity.

STUDY OF PRESTRESSED CONCRETE UNDER HIGH-RATE LOADING

By Michael Chi,* Associate Professor of Engineering
and Frank A. Biberstein,* Professor of Engineering,
Catholic University of America

GENERAL REMARKS

Prestressing is a technique for introducing a state of stress in a structure during its fabrication so that a more favorable stress condition would prevail under working loads than otherwise. Utilization of prestressed concrete has well begun to revolutionize concepts of structural design. In this discussion, it is presumed that the advantages of prestressed concrete construction are everywhere known and appreciated. Although knowledge and application of prestressed concrete have been concerned chiefly with static loading, considerable test data have been accumulated on dynamic effects of moving loads and fatigue effects of repeated loads, and design criteria have been formulated through analysis of these data so that safe and sound structures could be constructed. For each particular type of structure, however, the dynamic loading may be unique, and it is therefore desirable to study the fundamental behavior of members under pure dynamic loads. A clear understanding of the general phenomenon should make possible more general applications.

A "dynamic load" is taken to mean a load of moderate to extremely short duration. If a member endures a few cycles of loading, it should not sustain such damage as would impair its usefulness. Use of repeated loads of a large number of cycles is not contemplated.

THEORY

Energy absorption of a material may be measured by the area under its stress-strain curve; the area may be increased by increasing strength or by increasing ductility; if strength is increased, however, ductility may be adversely affected (Fig. 1).

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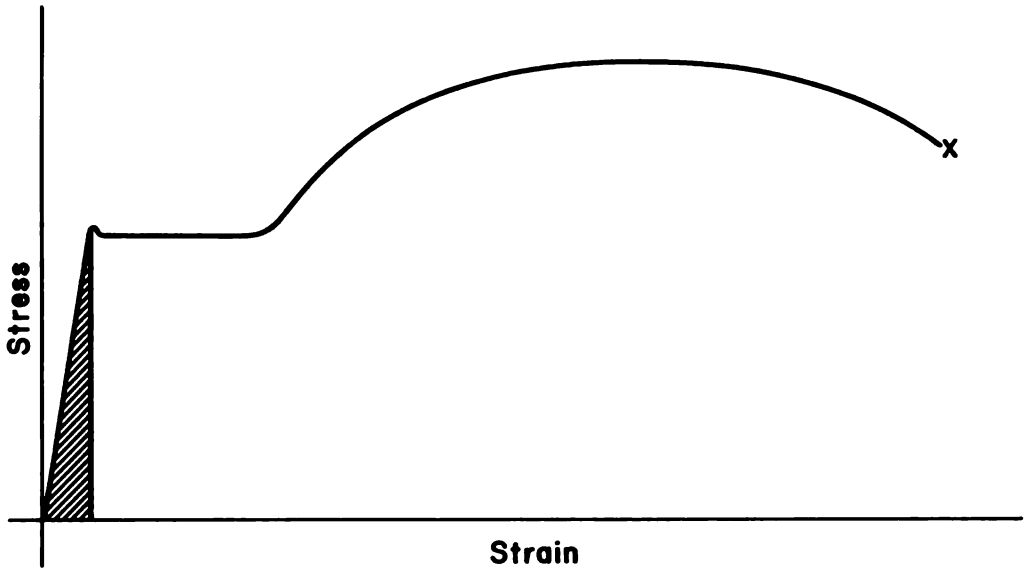

Figure 1

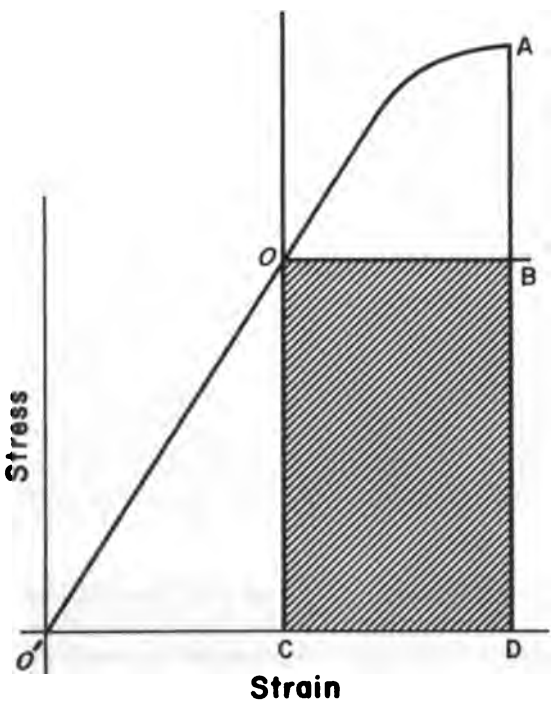

Figure 2

With modern technology, concrete has been readily obtainable having compressive strength higher than 8000 psi; strengths as high as 20,000 psi have been reported. Although extensibility decreases somewhat with increase of strength, nevertheless the compressive impact strength of concrete is considered to be adequate, without the help of reinforcement. Tensile strength of concrete is much lower than its compressive strength, and enhancement of strength is much slower for tension than for compression; for instance, the recommended relation of tensile and compressive strengths is given by

$$f' = 5.0 \sqrt{f'_c}$$

Increase of compressive strength requires denser, more uniform concrete, whose brittleness is also increased so that the tensile impact strength may be much lower and the growth of crack faster.

On the other hand, tensile impact resistance of concrete is quite a problem. Ordinary reinforcement helps very little. Extensibility of concrete is much smaller than the extensibility of steel so that the steel is only slightly stressed when concrete is near its tensile strength. On the other hand, long before steel nears its yield point, concrete is practically destroyed. Therefore, a suitable working alliance between concrete and steel is not obtainable in reinforced concrete under axial tension.

"Normal" expectancy for energy absorption under axial tensile loading for plain concrete is represented by an area under its tensile stress-strain curve shown as OAB in Figure 2. In the act of prestressing, the concrete is precompressed by virtue of which the "tensile stress" associated with maximum energy absorption is effectively increased, or the stress-strain curve is effectively shifted from 0 to 0'. Figure 2 shows that, by proper prestressing, the resulting total area is greater than the combined area representing energy absorption of nonprestressed concrete and the strain energy stored in the concrete due to prestressing. Additional area obtained in this way is indicated by the ruled area in Figure 2. Since both stress and strain are effectively increased in this way, impact resistance is about proportional to the square of the increase of stress. Therefore, by proper design a structure may be made to resist any amount of reversible loading.

Because structural steel has a relatively low yield point, its elastic impact strength is a very small part of its total capacity to resist impact--only about 0.1%, as shown by ruled area in Figure 1. In order to profit from its capacity for energy absorption, steel must be stressed beyond its elastic limit. However, if a substantial portion of its capacity is used, a nominal factor of safety on energy absorption would still permit the material to be stressed to the yield point. On this basis, however, the impact strength of a member would depend on its previous loading history and would be subjected to a progressive failure. On the other hand, because the static load depends on stress level only, a factor of safety of 2, based on yield point, would bring working stress to 1/2 of yield point and the member would last indefinitely. If sufficient margin of safety must be maintained under static load, it seems that it would be unsafe to leave no margin of safety under dynamic load.

Ultimate strength has little significance in both static loading and dynamic loading. Also, since static load depends on stress level, it is of little consequence whether, in design, one uses ultimate strength or usable strength. (Usable strength is defined as the maximum load which can be applied to the member without destroying its usefulness as a structural member.) Since material response to dynamic load, however, depends on the area under its stress-strain curve, it makes considerable difference whether one uses ultimate or

usable strength. It is the usable strength of concrete that is probably enhanced by prestressing. No claim is made that a prestressed concrete member might have a higher ultimate strength than a reinforced concrete member of the same static strength. Such a result, even if it is true, is of little significance.

PROPOSED OBJECTIVES

1) Superposition Effect in Impact. The beneficial effect of prestress on impact strength of ceramic materials was qualitatively confirmed by drop-weight tests[1]* for beams and slabs in flexure. On the other hand, Charpy tests conducted with steel having residual tensile stress and under moderate rate of loading proved[2] that ability of specimens for energy absorption was almost the same as for specimens without residual stress. The latter evidence seems to reject applicability of the principle of superposition. It is felt by some[3] that applicability of this principle would be substantiated if a higher rate of loading were used and if residual compression were employed. The first purpose of the proposed project is to clear up this confusion.

2) Hypothesis on Reversibility. Rather extensive dynamic loading tests have been made on plain and reinforced concrete [4, 5, 6]. Since concrete is much stronger in compression than in tension, nearly all tests were made for compressive or flexural loads, as the case may be. In tensile tests, the great difference between maximum strains of concrete and steel would cause a progressive failure in a nonprestressed member. With prestressing, concrete and steel may work together to a much greater degree in direct tension. It would be possible to make a structure having prescribed compressive and tensile strengths in a loading which can produce direct compression and then reverse to direct tension. Such a case may occur in a thin dome subjected to blast pressure and a subsequent suction. Confirmation of this hypothesis constitutes the second objective of the proposed project.

3) Criterion of Failure. Two series of flexural tests on prestressed concrete beams have been reported. Both series employed nonprestressed beams of equal static strength to companion prestressed specimens. In one series of tests[7], the nonprestressed beams had greater impact strength than the prestressed beams; in the other series[8], the reverse was true. Some explanations were offered[9] for this apparent contradiction, but more study is needed before clear conclusions concerning impact strength of prestressed beams can be drawn.

   Furthermore, it is recognized that correct criteria of failure in general should be based on "usable strength" rather than on "maximum strength." This is especially significant in impact loading where maximum strength perhaps exceeds usable strength by a much greater margin than in static loading; it is probable, moreover, that the margin for reinforced concrete is less than for prestressed concrete. Comparison based on maximum strength is probably meaningless. Further study along this line is our third objective.

4) Load Pulse. Finally, effect of dynamic loads depends on the combination of intensity and duration of load pulse. In a rigid member, full effect of load pulse is felt and intensity is brought up almost instantaneously, causing local failure. In a flexible member, initial acceleration of the member may be large enough to alternate the pulse, e.g., duration of pulse may be prolonged and its intensity, consequently, lessened. The new duration would enable the whole member to resist the load and

*Raised numbers in parentheses pertain to List of References at end of paper.

the new intensity may not be able to overstress the member. It is conceivable, therefore, that weaker, more flexible members can sustain greater energy than "stronger," more rigid members under blast load[10]. By this reasoning, over-designing a shelter structure by providing sheer mass is not only uneconomical but also unsafe. On the other hand, flexible, properly designed structures may be both economical and safer. It is believed that this criterion has not been adequately exploited. A thorough study of this phenomenon constitutes the last objective of the proposed project which, conceivably, could benefit aseismic design by providing better understanding of fundamental and comparative behavior characteristics of prestressed concrete in the presence of blast.

WORK PROGRAM

Following an adequate literature survey, extended theoretical analysis will be undertaken for high-rate axial loading and high-rate flexural loading; concurrently, special fixtures would be designed and fabricated for use in verifying tests which will be performed to provide observed data for comparison with results of the theoretical analysis. The test specimens will be small tensile bars for use in pendulum-type tests. Subsequently, long bars in both compression and tension will be tested by a Hopkinson-bar type of device. For short-duration loads applied on a slab, explosives and ruptured-diaphragm type of test setup will be used. Because of the nature of the study and the great practical difficulties in controlling the duration and intensity of the short-duration loads, it does not seem advisable to predict the number and dimensions of the specimens, nor to anticipate the test setup in elaborate detail.

BUDGET INFORMATION

In the preliminary study, $5000 will be required to make the literature survey and study of test fixtures. Theoretical study would run about $15,000 for one year. Subsequently, the test program, including equipment, will require as much as $25,000 annually over a a period of three years.

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RESUME OF PROFESSIONAL BACKGROUND

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Education

BSCE, University of Tientsin, China, major in Structural Engineering, minor in Hydraulic Engineering - graduated with honors, 1946

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Teaching Assistant, University of Tientsin, 1946-47
Research Assistant, Georgia Institute of Technology, 1947-48
Research Fellow, Louisiana State University, 1948-49
Designer and Deputy Group Leader with Preload Engineers, Inc., 1951-54
Structural Engineer (Project Leader) with Structural Engineering and Engineering Mechanics Sections of the National Bureau of Standards, 1954-58
Lecturer, The Catholic University of America, 1956-58
Associate Professor of Civil Engineering, The Catholic University of America, 1958 - present
Consultant, Building Research Advisory Board, National Academy of Sciences - National Research Council, 1959 -

Publications

Papers:

Study of Continuity in Prestressed Concrete Airfield Pavements (w. E. C. Molke) (Typewritten classified report, unpublished)
Tests of Prestressed Cellular Slabs (w. D. Watstein)
Effect of Type and Arrangement of Cellular Blocks on Strength of Prestressed Assemblies (w. D. Watstein)
Tests of Prestressed Cellular Slabs (w. A. F. Kirstein)
Punching Shear and Uniform Load Tests of Thirty-Six Module Segments of a Cellular Aluminum Drydock (w. L. K. Irwin)
Flexural Cracks in Reinforced Concrete Beams (w. A. F. Kirstein)
Elastic Deformation in Strip Loaded Through Pins (w. L. K. Irwin)
Stresses in a Strip Partially Loaded on Edges (w. W. D. Kroll) (to be published)
On the Design of Simply Supported Prestressed Concrete Beams (to be published)
On the Basic Assumption in the Flexure Formula (w. F. A. Biberstein) (to be published)

Discussion of following papers:

Tentative Recommendations for Prestressed Concrete
Strength of Concrete Under Combined Stresses
Strains in Beams Having Diagonal Cracks

Societies

Member, The Society of the Sigma Xi
Member, American Concrete Institute
Member, American Society of Civil Engineers

AN EXAMINATION OF THE SUITABILITY OF SCALE MODELS FOR PERFORMING HEATING AND VENTILATING STUDIES

By Rudard A. Jones,* Research Professor of Architecture and Director,
Small Homes Council-Building Research Council, University of Illinois

INTRODUCTION

There are a number of unanswered questions concerning the thermal performance of different materials in combination in residential structures under the usual condition of non-steady heat flow as influenced by varying temperatures, wind velocities, solar incidence, humidity, etc. Measurements taken in some of the experimental residences operated by the Engineering Experiment Station of the University of Illinois have indicated that the actual performance of portions of the house varies considerably from the performance that was predicted by the methods generally used. It has been difficult, however, to correlate this information with information gained from other research residences, since the residences differ in size, location, orientation, etc. When such discrepancies occur between actual performance and calculated performance of materials and constructions which may be considered more or less standard, it is obvious that similar deviations may occur when new materials are used in an actual structure. The discrepancies point up the desirability of obtaining experimental data for a wide variety of both new and old materials and assemblages under conditions that represent as nearly as possible actual in-use conditions. The obvious solution to this problem is to build full scale structures of all the varied combinations of materials that may be used in residential construction. Needless to say, the construction of such a number of full scale structures would be prohibitive in cost. The question then arises--can satisfactory data be obtained from tests of smaller structures than normal, and can a standardized procedure for model testing be developed?

PURPOSE

The purpose of this study is to determine the feasibility of using scale models to predict thermal performance and attic ventilation studies in residential structures, and to develop if possible a standardized procedure for designing test models which will give accurate performance characteristics of a given structure. The information particularly desired is the heat gain and heat loss through walls, roof structures, ceilings, etc., plus whatever

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additional information may be gained on the effectiveness of various ventilation schemes for attics. If feasible, the ventilation of the living spaces within the structure would also be studied.

PROCEDURE

The study will be conducted in two phases, the first of which will be a comprehensive literature survey and analytical study of the problem. If the first phase indicates that it is worthwhile to continue the study, Phase 2, which consists of the building of a number of different models and perhaps a full scale prototype for testing, will be carried out.

Phase 1 — Literature Survey and Analytical Study

This phase of the study would consist of a comprehensive examination of the literature now available on the subject of thermal model studies, followed by a careful analytical study which would result in the design of a model or models for the testing program.

The use of smaller structures in thermal testing is not entirely new. Valuable information concerning experimentation with model structures has been contributed by the Commonwealth Experimental Building Station of the Department of Works and Housing in Sydney, Australia. Duplicated Document No. 26 entitled, "Thermal Characteristics of Model Structures" by J. W. Drysdale, and Special Report No. 4 entitled "The Theory and Method of Construction of Thermal Models of Building" by L. J. Alexander, report the experiences of the Australian Building Station in a study of thermal models. It is understood that work along similar lines has also been done at the National Bureau of Standards and in the South African Building Research Station. Some studies have also been done at the University of Illinois. Test huts have also been used in some experimental work of the Division of Building Research, National Research Council, Canada, and some small structures have been used in the work of the Structural Clay Products Research Foundation in Geneva, Illinois. The information gained in these studies and experiments will be carefully evaluated, and will serve as a basis for further investigation.

Following the background study, Phase 1 would continue with complete dimensional analysis, the development of a model design procedure, plus the design of proposed models for thermal testing. Where possible these models would be related to existing experimental heating research residences now in operation at the University of Illinois by the Engineering Experiment Station.

If these studies prove fruitful, the project will be continued with Phase 2.

Phase 2 — Experimental Studies

The purpose of the second phase of the work is to test the validity of the model design procedures evolved in the preliminary study of Phase 1. A number of models on different scales would be built in accordance with the procedure devised, and these models would be thoroughly instrumented in order that complete performance records could be obtained. If possible, the models would be related to existing test residences now at the University of Illinois; however, since these residences are located in such areas that it would be difficult to construct the models adjacent to them, it may be necessary to erect a new prototype structure for purposes of the study. It may also be necessary to build a simple prototype structure for first tests

since the present test structures at the University of Illinois are of a more complicated nature. Complete data concerning both prototypes and models would be collected over a three-year period. This data would then be correlated and evaluated. If reasonable correlation between the model structures and the full scale structure does exist, then the procedure devised in the first phase may be considered proven, and may be used as the standard means for determining heat gain, etc., in lieu of full scale structures. If correlation is not reasonably exact, the study will, of necessity, include an examination of the necessary corrections which should be made to make the model testing method a suitable means of experimentation in thermal studies, if such adjustments are possible.

PERSONNEL

It is proposed that this project would be carried on by the Small Homes Council-Building Research Council, a research agency of the University of Illinois. A committee composed of representatives of the Council, the Department of Mechanical Engineering, and the Engineering Experiment Station, members of industry and other agencies would be formed. This committee would serve in an advisory capacity in the formulation of the detailed program for the study. The mechanical engineering aspects of the program would be directed by Professor S. Konzo of the Department of Mechanical Engineering of the University of Illinois and the architectural aspects by Professor Rudard A. Jones of the Small Homes Council-Building Research Council. Two full time research investigators would be employed as well as necessary hourly general and drafting assistants.

BUDGET

Phase 1 - One year

Personnel	University Contribution
Research Professor of Architecture	
1/5 time Research Professor of Mechanical Engineering	$ 3,000.00
Research Associate FTE	7,500.00
Research Assistant FTE	6,000.00
Wages (hourly)	2,500.00
Expense (travel, supplies, etc.)	1,200.00
Operating Costs	20,200.00
25% of operating costs= University Overhead	5,050.00
Annual Budget	$ 25,250.00

Phase 2 - Three Years

3 years annual expense as above	$ 75,750.00
Test Structures*	20,000.00
Instrumentation	8,000.00
Total Budget (Phases 1 and 2)	$103,750.00

*Includes allowance for prototype structure as well as models. If it proves feasible to use existing structures as prototypes, a corresponding saving will be made in the budget.

THE COMPILATION AND DEVELOPMENT OF SIGNIFICANT DESIGN AND PERFORMANCE CHARACTERISTICS OF BUILDING ELEMENTS AS RELATED TO BUILDING CATEGORIES AND TYPES AND ACTIVITY SPACE-USE

By Stewart D. Barradale, * Manager
Building Research Section, Southwest Research Institute

PROGRAM OBJECTIVE

To prepare a monograph which will assist architects, engineers and material or product manufacturers by presenting in a usable form pertinent building element characteristics. The resultant document would indicate the significant characteristics involved in the selection of material combinations or the design of proprietary material systems, according to building categories, types and activity space-use.

DISCUSSION OF THE OBJECTIVE

The multi-billion dollar building industry is composed of a great multitude of people and facilities from all walks of life. In fact, every individual entity, whether a person, family, company or corporation is involved to some degree. Thus, it is certainly fitting to increase the efforts in the architectural and building research area in order to provide the best that the arts and sciences can supply.

Several statements have been made to indicate the dollar value of the present industry-wide building research activity. One authority has stated that 1% or less of the total income is devoted to research with the major portion being allocated to specific manufactured products or materials.

Since it is logical to think in terms of an expanding research activity, and since science and technology are admittedly ahead of our employment of same, it is proper to look into those areas which will provide the industry with desirable tools and aids. The subject of this paper concerns the development of one of these aids.

Why should this research program be initiated?

> To provide a complete, comprehensive source of information which may be used by architects, engineers and products designers as a guide to evaluate which characteristics and properties should be required of and furnished by specific building elements.

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It is recognized that a major problem exists, i. e., the identification of the significant and desirable characteristics of building elements. For purposes of understanding, a building element is defined as any generic assemblage of building materials and/or components to form an enclosure of space--a more or less complex constituent part of a building having its own functional identity, i. e., a floor, wall, partition, ceiling or roof. Since the identity of each building element is individual and since there are a great many variations within each element category, it is obvious that the characteristics should be organized according to the requirements of the building category, the building type and the activity space for each of the functional elements.

To date much effort has been expended to determine the properties of individual existing materials or material systems and to develop information regarding particular simple or complex assemblages of existing materials. This information, which is presently available, concerns the physical and mechanical properties that are furnished by the given material and/or the assemblage.

In addition we find some data available which deal with the desired characteristics that must be met in order that a material or material system be considered acceptable. Here, however, the information deals with minimum requirements and usually encompasses a very limited number of characteristics.

Nowhere do we find a comprehensive, composite review, appropriately cross referenced, which indicates the design and performance characteristics and/or properties that should be furnished in order that specific building elements will provide the necessary and desirable features in such a way as to be sympathetic with the activity and the space. It is true that some of this information is available but until such an undertaking as is proposed here is initiated, there will be gaps between that which is desired and that which is furnished.

It is certainly fitting during the early stages of an emerging building science to initiate the basic work of compiling desirable design and performance characteristics of building elements. This will assist the architect, engineer and product manufacturer in judging the compatibility and acceptability of those characteristics that are furnished by a particular group of assembled materials in relation to those that are required by the activity space and function.

PROPOSED PROGRAM

The work involved in this proposed study concerns the preparation of a document which will aid building and product designers. It does not concern the development of a product or construction system, nor does it concern a historical review of material characteristics. No experimental work is contemplated as a part of this particular study. However, it is anticipated that as a result of this investigation many areas requiring laboratory experimentation will be disclosed.

The methodology to be employed will of necessity involve the phase or task approach since both the quantity and depth of available information is at this time an unknown. In addition, there is no preconceived answer regarding the end product of this effort in the area either of specific content or desired form. Thus, it can be said that this is a research investigation.

The over-all program should be phased in accordance with a logical separation of subject matter and work tasks involved in the accomplishment. In the interest of brevity and for the purpose of clarity in understanding, the total program effort is presented as follows:

Phase I - Investigation, Organization, Collection and Classification of Performance Data and Design Criteria

A. Initial Investigation

Review efficiently and rapidly the scope of the entire program to disclose the generic extent of work accomplished to date by others; to discover the variety of sources of material; and to develop a well-founded understanding of the complexities involved in the total study.

B. Detailed Program Organization

Develop the detailed program which will indicate the scope of effort of each portion of the study in accordance with the information collected during (A) above. Also develop the necessary additional technical and administrative procedures and/or methods required to produce the successful succeeding tasks.

C. Specific Collection and Classification of Data and Criteria

Perform a fact-finding search to disclose specific known data and prepare in a chart, tabular or other form all known information. Develop through studies such information as is necessary to lead to recommendations in significant areas where criteria are nonexistent.

The work to be accomplished here should be subdivided according to building categories, building types and activity space-use. The significant characteristics of building elements and subelements for each grouping should be separated and cross-referenced.

Task 1 - Building Category A
Building Type 1, 2, 3, etc.
Space-Use 1a, 2a; 1b, 2b; 1c, 2c; etc.
Building Element & Subelement
Criteria and/or Characteristics

Task 2 - Building Category B
Building Type 1, 2, 3, etc.
Space-Use 1a; 1b, 2b; 1c, 2c; etc.
Building Element & Subelement
Criteria and/or Characteristics

Task 3 - Building Category C
etc.

Phase II - Document Preparation and Finalization

Prepare and present a well organized monograph which will point out the important considerations or criteria in connection with the design of building elements. Two parts are contemplated:

A. Present characteristics and/or design criteria which are most applicable and are justified by the data collected and analyzed during Phase I.

B. Present recommendations for the selection of criteria where they are nonexistent or where existing data is insufficient to substantiate the selection of design criteria.

DISCUSSION OF THE PROPOSED PROGRAM

In general the proposed program is outlined in two primary areas. Both are necessary to accomplish the objective. However, the real substance of the problem effort, aside from organization, begins with Phase I-C where specific information is disclosed or developed.

At the expense of an oversimplified explanation, we might think of this program as the development of a master checklist of criteria for building elements. The following questions can be asked:

1) When Company X designs a new curtain wall system, what factors or values are considered as essential? desirable? marginal?

2) When Firm Y designs an interior partition to separate one space from another, what criteria are used? How is the priority set?

If the answers to these and many other similar questions were furnished in a readily usable form, two things would be accomplished:

1) Certain technical facts would be known and could automatically assist in the design of a building element.

2) Designers would have available more time for creative work, since routine items would become less cumbersome.

The general breadth of coverage of this program is best indicated by the following partial breakdown of building category, type and space-use. The building type and activity space examples shown are presented to suggest only one of many in each group.

Building Category	Example of Building Type	Example of Activity or Space-Use
Industrial	Manufacturing Plant	Assembly Room
Educational	Elementary School	Classroom
Commercial	Office Building	General Office
Institutional	Prison	Cell
Recreational	Theater	Lobby
Residential	Single Family Residence	Kitchen
Religious	Church Building	Sanctuary

It is obvious that there will be many similarities or identities in the use of space and therefore this division is considered as the key to the study. The building element characteristics and/or criteria will be organized and presented according to similar space-uses. However, the presentation will be sufficiently flexible to accommodate the variations that exist.

The construction outlook for the next decade has been forecast at $50-$70 billion annually. This represents a 48-50% increase above 1957-1958 spending for new construction and will make the next ten years the biggest in building history. Although the largest gain

will be in highways (88%), nonresidential construction, next in line, will be up 50% by 1967. It is anticipated that nearly $600 billion will be spent, compared with the $409 plus billion (in 1957 dollars) from 1948 through 1957.

On the basis of data collected from the Census Bureau 1956 housing inventory, the Bureau of Labor Statistics, U. S. Departments of Commerce and Labor, etc., the magazine, Architectural Forum, anticipates the annual rate of factory building to be greater than 70% in 1967 than now. By the same time commercial construction will have increased by some 43%, schools by at least 45%; and hospital and church building will both continue with outlays for such construction running into multi-billions in terms of 1957 dollars.

Although the order of gains expressed as percent in nonresidential building places hospitals and institutions first, social and recreational second, industrial buildings third, etc., the various building types should be viewed from the standpoint of anticipated dollar spending. Among the top five and in order of gross dollars are: 1) industrial buildings, 2) educational buildings, 3) commercial (stores, garages and restaurants), 4) hospitals and institutions, and 5) office buildings and warehouses.

Should the above predictions come true, even to the extent that only small increases are made over the 1957 figures, it is obvious that there will be great potential for many new buildings and building products.

It is fitting to initiate posthaste research programs that are broad in scope and that transcend specific and proprietary interests. This is in keeping with the over-all advance of the total building industry. Thus this program seeks sponsorship, from either an individual company, a group of firms or a large segment of the building industry, as a challenge to the sponsor and researcher alike to foster the advancement of the building science.

TIME AND COST ESTIMATES

Creative and technical personnel skilled in the areas of activity or space function, building construction, and research procedure will be required. The project team would consist of a Senior Research Architect as project leader, a Research Architect, a Research Engineer, an architectural draftsman, and scientific and engineering consultants in the many related fields.

Due to the very broad scope of this study and the variety of unknowns involved, it is not possible to determine at this time the exact time and cost involved in the total endeavor. However, it is proper to indicate approximate limits to provide the necessary planning and budgeting information.

It is estimated that this research team would require a calendar period of approximately 24 months to accomplish the total program.

It is further estimated the the program would require the following budget:

Staff Costs	$75,000	
Surcharge	75,000	
Direct Costs	30,000	
Total Estimated Cost		$180,000

It is also estimated that Phase I, Parts A and B, would require a calendar period of 5 months and a cost of $8,650 accumulated as follows:

Staff Costs	$ 3,325	
Surcharge	3,325	
Direct Costs	2,000	
Total Estimated Cost		$ 8,650

ADDITIONAL CONSIDERATIONS

The nature of this proposed project makes it mandatory that close liaison be maintained between the sponsoring organization and the research staff. Therefore, a high degree of cooperation and a frequent interchange of information will contribute substantially to the successful completion of this effort.

The Southwest Research Institute recommends that a steering committee be appointed by the sponsor to assist in organizing and evaluating the work performed. It is suggested that this committee consist of three members of the sponsoring organization and that the Institute provide two members. It is further suggested that meetings of this group be scheduled on a bi-monthly basis.

It is also recommended that the steering committee elect or appoint one of its (sponsor's) members to act as project coordinator. In this manner, the research project leader would have a single contact in the sponsoring organization.

It is intended that the sponsor's representatives will act in the capacity of constructive critics and, in addition, as working consultants to the research staff where their counsel will be of considerable benefit to the research effort.

The SwRI proposes to submit bi-monthly progress reports and a Phase I report in addition to the monograph. The former will summarize the project status for the subject period. The latter will disclose pertinent information and findings and will include all significant recommendations. The monograph will, of course, be the end product of the total program.

The Sponsors have full rights to any patentable invention, design or process developed in the process of the work. The Institute will respect any degree of confidence or secrecy requested by the sponsor in connection with this project.

In order to facilitate an orderly scheduling of staff efforts, this proposal will remain in effect for 90 days after the date of presentation. During this period the Institute will be glad to consider amending the scope of the proposal or to extend the effective date upon request.

The Institute will require approximately 30 days after receipt of a signed agreement before work can start on this project. This is necessitated by project workload and staff commitments.

APPENDIX

The Building Research Section of the Department of Structural Research consists of research architects, engineers, materials technicians, and consultants on special problems. This group conducts studies, investigations, evaluations, tests and designs of both general and specific problems concerning the building industry. The general scope of endeavor

involves city, regional and architectural planning; construction, building system and building material design and evaluation; building equipment and fire technology.

Following are some of the projects accomplished by the staff. These involved the study and/or consideration of construction systems; economic and trend surveys; building components; product and element designs, etc.:

1) Prefabricated Multipurpose Building System

2) Evaluation and Preliminary Designs for Improved DEW Line Structures

3) Design Survey and Market Potential of Plastic Products for Building Construction

4) Design of Curtain Wall Elements

5) Design of the Thor Missile Shelter System

6) Development of a System of Modular Coordination for School Building Design and Construction

7) Design and Development of the Techometric System of Residential Construction

8) Survey of Design Trends for Product Development in Merchant Builder Housing

9) Survey of Market Potential for Central Heating and Air Conditioning in Residential and Commercial Construction

10) Evaluation of Flame Spread Characteristics of Finish Building Materials

11) Analysis of Home Fires, Fire Hazard Characteristics and Methods of Control

12) Appraisal of Market for Steel Homes and Factors Affecting Their Marketing

13) Fire Safety Aspects of Plastics in Building Construction

14) Glazing Manual

Other groups and departments at the Institute have been developing new finishes, fungicides, resinous binders, and plastic and polymer techniques. Still others have been working in areas such as automatic and heavy equipment, thermal transmission, acoustical properties of surface finishes, strength and stiffness characteristics of materials, moisture and vapor transmission, nuclear magnetic resonance and electron paramagnetic resonance.

Although the above may or may not be directly applicable to the proposed program, it indicates the staff is working in associated fields, which offer both "know how" and perspective. The Institute provides the team approach where specialists in related disciplines are available to assist the pursuit of any of its projects.

CONTRACTUAL INFORMATION
SwRI Proposal No._____

Southwest Research Institute is a not-for-profit Trust Estate organized and existing under the laws of the State of Texas, with its principal place of business at 8500 Culebra Road, San Antonio, Texas. The Institute is tax exempt under Section 501 (C) (3) of the Internal Revenue Code.

Scientific research and development projects are conducted under contract on a best efforts basis. Prior to the start of any program, a written proposal for the work is submitted to the sponsor. If the proposal is satisfactory to the sponsor, the project can be initiated by executing a contract furnished by our treasurer's office. The proposal can also be modified according to the suggestions of the sponsor if such modifications will yield a program more satisfactory to the sponsor.

In order that the Institute will have some basis for the orderly assignment of research personnel, proposals are considered to be in effect for 90 days from the date given on the title page, unless otherwise specified in the proposal.

The Institute will at all times respect the requirements of the sponsor in protecting proprietary information furnished by the sponsor or resulting from research conducted in his behalf. Normally projects are treated as "Unclassified" or "Industrial Secret." In accepting our proposal, the sponsor should indicate the classification he wishes assigned to the project.

All data, reports, and design information developed during the course of a project are wholly the property of the sponsor. The same is true of any patentable ideas developed during a project. Employees of the Institute, as a condition of employment, sign an agreement formally assigning to the Institute all rights to any and all patentable inventions. The Institute's agreement with the sponsor likewise provides that it will assign such rights to the sponsor.

The Institute is not engaged in research for advertising or other publicity purposes. No advertising or publicity matter containing any reference to the Institute, or to any of its staff members, shall be made use of by the sponsor or anyone in the sponsor's behalf, unless and until the same shall have first been submitted to and received the approval of an Officer of the Institute. It should be understood that releases are never approved where approval implies or is otherwise equivalent to endorsement of a commercial product by Southwest Research Institute.

Charges against a project are accumulated in the following manner:

1) The hourly cost to the Institute of its scientific and technical staff members and carpenter and machine shop employees directly assigned to the project. This cost comprises direct base salaries and wages, vacation, sickness, holiday and other fringe benefits, and staff availability time. No direct charges are made to the project for time spent by senior scientific staff members on Institute administrative functions.

2) Surcharge--100% of the cost of services outlined in (1) above, to cover the costs of personnel engaged in executive, administrative, accounting, purchasing and

material handling, secretarial and general services. It also covers the cost of rent, utilities, general insurance, library, office supplies, personnel procurement, depreciation and maintenance of equipment and facilities, the cost of new equipment and facilities, and such other nondirect costs normal to operations of a not-for-profit organization.

3) Cost of materials, supplies, services purchased, telephone and telegraph, travel, technical services, and other items directly related to accomplishments of the objectives of the project.

4) If special equipment not already owned by the Institute is required for a project, such equipment, with the approval of the sponsor, shall be built or purchased or leased by the Institute and the cost thereof shall be paid by the sponsor.

The sum of the items listed above is the total cost to the sponsor.

It is clear that the total cost of a research project cannot be determined in advance of the work. Therefore, the cost quoted in the proposal is merely a best-estimate, based on the Institute's long experience. In over 90% of Institute projects, total costs have been equal to or less than the proposal estimate. Where the estimate has been exceeded, unforeseen difficulties in the research have been encountered.

For the protection of the sponsor, the Institute agrees that the cost figure quoted in the proposal will not be exceeded without the prior written approval of the sponsor.

It is a policy of the Institute to collect an advance payment. The first invoice will be presented with submission of the contract, and represents an advance payment of approximately eight weeks' expenditures which will be applied against expenditures of the final eight weeks of the project. The advance payment policy is used by not-for-profit research institutes in order to minimize the working capital necessary for maintenance of their services. Subsequent invoices will be rendered at least every four weeks and will cover actual expenditures as incurred. Invoices are payable within ten days from date of invoice.

METROPOLITAN AREA SURVEY OF MAJOR BUILDING FEATURES IN RESIDENTIAL CONSTRUCTION

By Dr. Reinhold P. Wolff, * Director
Bureau of Business and Economic Research
University of Miami

As you all know, the Bureau of Labor Statistics has for many years published monthly data on the number of housing starts, or more accurately on residential units authorized by local building permits. This so-called building start series has been lately taken over by the Bureau of the Census. Regional and area breakdowns of housing starts are available from a series which gives monthly data by permit-issuing authorities, i.e., the small and large municipalities who issue the building permits. In the Construction Review these data are expanded into states, divisions and regions on the basis of estimates for the non-reporting areas.

The industry uses housing starts data mainly for three purposes: first, as a basis of total construction estimates which in turn are important parts of the "Gross National Product," as they represent important indicators of cyclical changes of the economy; second, for the appraisal of demands for building materials, either nationally or regionally. In this respect the housing starts data provide important tools in sales management. They allow the sales manager of a building material supplier to check his sales staff's performance against those of his competitors. Third, housing starts data are used in budgets of the building material manufacturer or dealer. Budgets usually are based on three months or 12 months forecasts of total demand as derived from housing starts.

The use of housing starts data for these operational purposes has been limited by two shortcomings. One is the admitted inadequacy of coverage of housing starts of the BLS. The Government admits that because of lack of complete coverage, housing starts data are incomplete. This has seriously handicapped the use of the series on a regional and areawide basis, but the Government is now at work to extend the coverage. The second shortcoming consists in the lack of detail with which building starts data are released. To the firm which is engaged in the manufacturing of supplies for the home building market, it is essential to know the trends not only of housing, but also of its character, especially the trends in the use of specific materials. Obviously, more lumber is used in large houses than in small, more steel in apartment buildings than in homes, and so on. We have found from correspondence with members of the industry that the following

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features are especially pertinent to the practical housing analyst of a manufacturing firm: the number of apartments as compared with single homes; the material of the outside wall (wood vs. brick vs. cement block); the price class; the type of operator (project builder vs. custom builder); and the type of heat used. There are many more features, too numerous to mention here in detail, in which individual types of manufacturers are interested, but the ones enumerated seem to be of the greatest interest to the largest number of firms.

None of these features has been statistically covered in monthly reports, but as the Appendix suggests there has been some important research work done to get at least partial data for some of these features. This research should yield a better knowledge of one of the features mentioned before, the type of operator. Other features need exploration on a regional basis.

PROPOSAL

The proposal that I submit is designed to give an annual analysis of four important features for 15 sample city areas. The sample has been so constructed as to enable the market analyst to project the results to states, divisions, and regions of the United States.

1) Choice of Features

The features selected (apartments vs. homes, outside wall material, price class, and type of heat) were chosen because no other agencies seem to be engaged in this type of analysis and because of preferences expressed by the trade. The list is subject to discussion and could be broadened or narrowed.

2) Procedure

In order to gain a basis for practical uses of city breakdowns, the survey should be conducted annually. It is proposed to consider the first year's survey as a trial. During this year, we shall have, for each city area, sampled and estimated breakdowns of starts over a 12 months building period by type, wall material, price class. Experience gathered during the survey period may suggest changes in procedure, and possibly in the sample cities. The University of Miami would form a research team which would visit the sample cities and either perform the research work in those cities or delegate it to reliable and experienced housing research agencies in the sample cities. The analysis would be for current building status. An attempt would be made to obtain breakdowns of past experience to establish trends. Sources of information would be records of building permits, communications from builders' associations and builders' exchanges, interviews with appraisers and FHA and VA offices, and field sample counts. The University of Miami's Bureau of Business and Economic Research has already established a great many contacts with knowledgable individuals in many localities. These persons will form the nucleus for further investigation by the research team.

3) Sample Areas

The cities now considered as being most representative are New York City, Boston, Washington, D. C., Atlanta, Miami, Dallas-Fort Worth, Chicago, Detroit, St. Louis, Minneapolis-St. Paul, Pittsburgh, Denver, Los Angeles, San Francisco and Seattle. The list is subject to discussion.

4) Reporting

A report of the findings of the survey and statistical breakdowns should be made immediately after the research team has completed its work in a specific city. At the end of the year a comprehensive report will be issued.

BUDGET

It is estimated that the annual survey in each metropolitan area will cost $1,500 a year, or $22,500 for all 15 areas. Another $2,500 is budgeted for the analysis and dissemination. The annual budget of $25,000 includes travel and payments to subcontracting agencies. The University of Miami is prepared to undertake the administration of the project with an advisory committee in which the Building Research Institute and contributing firms should be represented.

EXTENSION OF THE PROJECT

The proposal is for one year only, but there is no reason why it should not be extended by the participants as long as the Government or other agencies do not undertake this type of research. Individual firms could add acceptable features to be explored at their own expense. For instance, the firm interested in the type of windows used may want to have this feature explored by the research team in all or selected sample cities.

To sum up, this project is one designed to fill a practical need of hundreds of organizations which lack detailed information on regional composition of the building market. It covers a small but very essential part of these needs, and it is the best that the University of Miami's limited resources can offer at the present time.

APPENDIX

Reports on Characteristics of Home Building

1) U.S. Bureau of Labor Statistics--U. S. Bureau of the Census

The Federal Government has published for the first quarters of 1954, 1955 and 1956 a report showing the same characteristics of home building which are proposed for the Building Research Institute project, except type of builder. The information is only shown by geographic regions and by metropolitan vs. nonmetropolitan location (nationally), not by areas. Later information is not available and as of the summer of 1959, the Government agency is not inclined to continue these.

2) F. W. Dodge Co.

F. W. Dodge Co. publishes a monthly report for each of seven regions of the country showing the value of residential construction and the number of dwelling units started. This information is broken down by state and metropolitan area within each region.

Twice a year, a national forecast of starts is released by Dodge, but no regional data are available.

3) Practical Builder

In 1957 Practical Builder magazine conducted a survey of its subscribers--800 returns were tabulated for the second quarter of that year. The results were tabulated by region and division for each characteristic our proposal considers, except type of builder.

4) National Association of Home Builders

The NAHB prepares periodic reports similar to those of Practical Builder. A detailed survey of builders is under way. However, building features as proposed in our survey are not included.

5) Miscellaneous

Special studies have been prepared by firms for individual areas including New York, Southern California, and Houston, Texas.

SOLAR CURTAIN WALL

By Robert P. Darlington,* Head
Architectural Research Section, Division of Industrial Research
Washington State Institute of Technology
and
Assistant Professor, Department of Architectural Engineering
Washington State University

OBJECTIVE

To develop the principles from which curtain walls for buildings may be designed which will intercept solar energy in winter for heating and in summer for cooling; to design and construct a working prototype solar curtain wall.

JUSTIFICATION

Great progress has been made in the past decade in the development of thin, lightweight, nonload-bearing curtain walls for buildings which can be factory-produced, are easily and quickly erected, have good thermal characteristics, and require minimum maintenance.

Much progress has been made, also, in the development of the heat pump and in utilization of solar energy for heating, cooling, power, and other purposes. A logical development would seem to be the integration of these facets of our technology to produce a building skin approximating the human skin in its ability to control the interior environment.

As our natural fuel resources continue to dwindle, more and more attention must be paid to developing new sources of power. The greatest untapped source is, of course, solar energy. More solar energy falls on the earth in two days than could be supplied by all of the remaining fossil fuels. Technology is only at the beginning of the development of this unlimited resource, but does possess some means, even now, of utilizing it.

A combination of building technology with the technology of the utilization of solar energy could create buildings ultimately requiring little or none of the traditional fuels or sources of energy for environmental control. Costs for this control would be drastically reduced, and the depletion of the supply of natural fuels would be sharply cut.

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*DARLINGTON, ROBERT P., B.A., Cornell University, M.A. in architecture, University of Illinois; formerly with George Fred Keck and William Keck, Architects and with Schmidt, Garden & Erickson; member of AIA and ASEE; published a number of reports on school building research and other subjects.

Also, buildings so constructed would be much more self-sufficient and less dependent on sources of supply and supply lines in cases of emergency.

COOPERATING ORGANIZATIONS

The facilities of the Division of Industrial Research of the Washington State Institute of Technology would be available for aid and consultation. Specifically, the project would be directed by the Architectural Research Section, Robert P. Darlington, Head. Other sections which could contribute materially are: Engineering Experiment Station, Hydraulics Research Section, Chemistry Section, Chemical Engineering Section, Applied Mechanics Section, Electrical Engineering Section and Design Section.

PROBABLE DURATION

Three to five years, with possible continuation depending on progress and developments during this period.

PLAN OF PROCEDURE

A thorough study of both curtain wall technology and solar energy utilization principles would precede specific studies of any assemblies. Following this, one early study would be based on the principles proposed in the solar curtain wall design submitted by Robert P. Darlington in the 1956 Alcoa-NAAMM (National Association of Architectural Metal Manufacturers) Aluminum Curtain Wall Competition.

This proposal called for hollow extruded aluminum louvers containing a circulating refrigerant on the entire building facade to intercept solar heat. A solar heat-to-water heat pump would operate an otherwise standard heating system. Heat storage would be in large basement water tanks. Resistance current through the extrusions on the exterior of the building would prevent frost formation.

Summer cooling would be accomplished largely through intercepting the solar heat before it reached the interior of the building and using it for domestic water heating and other uses, or dissipating it outside.

Insulation and transmission of diffused light to the interior would be accomplished through use of a translucent plastic wall panel behind the exterior collector extrusions.

With this initial proposal as a point of departure, studies would be made of the individual features of the project, such as absorption characteristics of collector metals, refrigerants, circulation speeds of the refrigerant, heat pumps, solar angles and others, with the ultimate goal of coordinating and integrating this information to produce a workable prototype.

One particular phase of the problem would receive special attention. This is the problem involved in environmental control of all parts of the building, especially when the sunny side of the building requires cooling and the shady side requires heating. The development of a skin, circulatory system and control system to balance the solar input will be a major objective of the project.

NECESSARY TRAVEL

Early inspection should be made of the major solar energy research centers in the United States, and elsewhere if necessary. Among these would be Massachusetts Institute of

Technology, Cambridge, Mass., and the Association for Applied Solar Energy, Phoenix, Arizona. There would be other travel during the project when required.

PRIOR AND RELATED WORK

1) Massachusetts Institute of Technology: long-term program in solar energy research; 65 publications of the Godfrey L. Cabot Solar Energy Conversion Research Project.

2) School of Architecture, University of Houston: research in solar radiation and thermal conduction of building materials; publication: "Interim Report on Experiments in Solar Radiation and Thermal Conduction of Building Materials at the University of Houston."

3) Engineering Experiment Station, Texas A. and M.: solar radiation and its effects on buildings.

4) Association for Applied Solar Energy, Phoenix, Arizona: association formed for the purpose of sponsoring and coordinating research in solar energy; in 1957 sponsored International Solar House Architectural Competition in which the winning entry provided solar energy collection area sufficient to meet all of the heat requirements of the house and the swimming pool during a normal Phoenix year, and sunshine control to minimize the summer cooling load.

5) School of Architecture, Princeton University: solar research program; publications by principal investigators:

   a. "The Temperate House," Victor G. Olgyay, Architectural Forum, March 1951: an analysis of the climate and the factors which produce climate, notably the sun, its mechanics and its effects.

   b. "The Theory of Sol-Air Orientation," Victor and Aladar Olgyay, Architectural Forum, March 1954: a new method of orienting buildings which includes time, air temperature and total effect, as well as the old maximum sun-heat gain calculations.

   c. "Environment and Building Shape," Architectural Forum, August 1954: The impact of thermal forces on buildings.

   d. "Application of Climatic Data to House Design," Housing and Home Finance Agency: report of research by Victor and Aladar Olgyay to find a method of approach for evaluation of existing weather data for one climatic region.

6) "Design and Performance of a Solar Collector Heat Pump," Gene Ambrose and Philip Sporn: paper presented before the World Symposium on Applied Solar Energy, Phoenix, Arizona, November 1955; describes in detail the idea of using the same surface for both heating and cooling cycles.

7) "The Solar Battery," Gordon Raisbeck, Scientific American, December 1955: a newly developed device to tap solar energy.

8) "Progress in Solar Power," Harry Tabor, Scientific American, July 1956: the search for ways to tap the sun's energy; emphasis on devices simple and cheap enough to repay their cost.

9) "The Curtain Wall," James Marston Fitch, Scientific American, March, 1955: the possibilities of designing a solar curtain wall to perform the control features of the human skin.

PROPOSED BUDGET

The budgetary figures per year are:

Salaries and wages (Equivalent of three full-time men)	$ 20,000.00
Supplies	500.00
Equipment and Materials	10,000.00
Travel	2,500.00
Film and publication	1,000.00
Total/year	$ 34,000.00

Note: Division of Industrial Research policy on sponsored projects calls for 48% overhead on in-state sponsored work and 100% overhead on out-of-state sponsored work.

STUDY OF AIR FLOW PATTERNS, SPEEDS, AND PRESSURES AROUND GROUPS OF BUILDINGS

By Ben H. Evans,* Coordinator
Architectural Research, Texas Engineering Experiment Station
A. & M. College of Texas

THE PROBLEM

Ever since World War II, the world has been involved in a mad rush to produce enough physical structures to house the expanding population, already crowded by wartime delays in construction. As a result of this rush program and other influencing factors, large multistory apartment buildings are being built at a very fast rate, particularly in areas where people are not able, financially or otherwise, to spread their housing over broader ground areas. In many cases the planners of these multistory, multibuilding, housing developments are attempting to take into consideration the effects of environmental factors on their buildings and occupants, but all too often fail to achieve significant results. Much of the necessary data on environment are readily available, such as the position of the sun, solar heat gains, probable temperatures, prevailing wind directions, and even some data on probable air flow patterns. However, planners too often do not understand how these data should be used, and frequently they even choose to ignore such data, for fear that it will inhibit their creativeness. The ridiculousness of ignoring the data seems obvious, but it continues to be done nevertheless.

Data on environmental conditions are tools, and very valuable ones, which can and should be used by all designers. What degree of emphasis is placed on the various aspects of environment is, of course, the choice of the designer and owner, based on their own feelings of what the occupants of their buildings will want and need.

Beyond those aspects of the environment already mentioned, what is needed now is a comprehensive knowledge of what happens to air flow around and through one building when that air flow is influenced by other buildings in the near vicinity. This kind of information is necessary and desirable, especially in the warmer climates, if housing units are to achieve any measure of warm weather comfort. In the absence of mechanical conditioning, (and we have not yet reached the point where all buildings are being mechanically equipped) air flow is necessary for maintaining body comfort in warm weather. Even where indoor conditions are controlled mechanically, a knowledge of air flow patterns is valuable, since the amount and extent of conditioning is dependent to a degree on the

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*EVANS, BEN H., B.A. in architecture, A. & M. College of Texas; postgraduate studies in design; Member of American Institute of Architects, Building Research Institute, Illuminating Engineering Society, U. S. Committee of the International Commission on Illumination.

dissipation of heat by means other than mechanical. Any surface will lose its heat faster if it has a good, free flow of air across it. This presentation is intended to point up the necessity for the aforementioned data and to offer a proposed method for collecting and disseminating the information.

RELATED RESEARCH

Some work has already been done in the area of research on air flow around buildings. Of course, considerable work on air flow has been done in relation to aeronautical considerations and this has provided much of the basic theory of aerodynamics which governs all air studies. However, most of the studies done in relation to buildings have been concerned with single buildings or with particular situations where the presence of nearby buildings was expected to have special significance. The problem of investigating air flow patterns with groups of buildings is extremely involved and time-consuming, and requires considerable special equipment and expertly trained personnel.

The Architectural Research Group at Texas A. & M. College has been involved in the study of natural ventilation since 1949. The original scope of the research was the investigation of the "Effects of Natural Lighting, Natural Ventilation, and Sound Upon Architectural Shapes." The program has since been expanded, but the simple idea of an integrated study (considering all of the environmental elements at once and the effect of each on design) is still the basic philosophy. The first step in the development of the program was the construction of a rotatable, flexible, demountable, experimental building, located in an isolated area so as to minimize any effects of surrounding buildings. Here was a building which could take on different shapes and orientations and which should "tell all" with regard to light, air and sound.

Weather conditions proved to be so erratic, even in this mild Texas atmosphere, that enormous amounts of time were required to accumulate useful data which could be compared. In the final analysis, it was decided that studies, to be practical, would have to be performed in the laboratory where, somehow, conditions could be held steady.

By bringing physicists and engineers onto the staff, it has been possible to develop facilities for studying light and air through the use of scale models. A simulated sky and sun lamp for studying the effects of natural light on models of buildings was developed, so that natural lighting conditions for any building, regardless of size, shape, or materials, could be determined prior to construction. Also, a slow speed wind tunnel was developed for studying the effects of air flow through and around models of buildings. The study of sound was found to be most feasible under the full scale situation even considering the problems of changing weather conditions.

The feasibility of using models for studying air flow in this wind tunnel has been pointed out in several publications by the research group. All such simulated systems, of course, have certain limitations, but if the limitations are known, they can be sidestepped or overcome. This is one of the only slow speed wind tunnels in the world used entirely and consistently for the study of buildings and their surrounding areas.

1) The first wind tunnel studies resulted in a publication called "The Measurement of Low Air Speeds by the Use of Titanium Tetrachloride". This presents the development of basic techniques for wind tunnel studies.

2) Next, came a research report on "Some General Considerations in the Natural Ventilation of Buildings." This report was a "primer" on natural ventilation and

was intended to point out ways and means by which architects might design better buildings.

3) "The Feasibility of Using Models for Predetermining Natural Ventilation", a third publication, was for the purpose of showing theoretically and empirically that these wind tunnel studies on models were valid and valuable.

4) "Air Flow Through Conventional Window Openings" came at a very opportune time and was instrumental in stimulating considerable interest across the country in terms of what windows were really doing to our architecture.

5) The postwar school building boom brought about a study of schools entitled "Geometry of Classrooms as Related to Natural Ventilation." Here, new and old schemes for ventilating and lighting schoolrooms were reported and suggestions provided as to what should and should not be emphasized in terms of these environmental factors.

6) Another phase of the wind tunnel studies was initiated with a study of the "Effects of Landscape Development on the Natural Ventilation of Buildings and Their Adjacent Areas." Surprising things were discovered about trees, shrubs, and fences and their relationship to buildings.

7) A number of very technical studies were performed under a contract with the Department of the Army, which considered the effects of air flow around fox holes, gas masks, and building entrance pressure chambers. Pressure distributions and air flow patterns on various types of buildings and tents were studied.

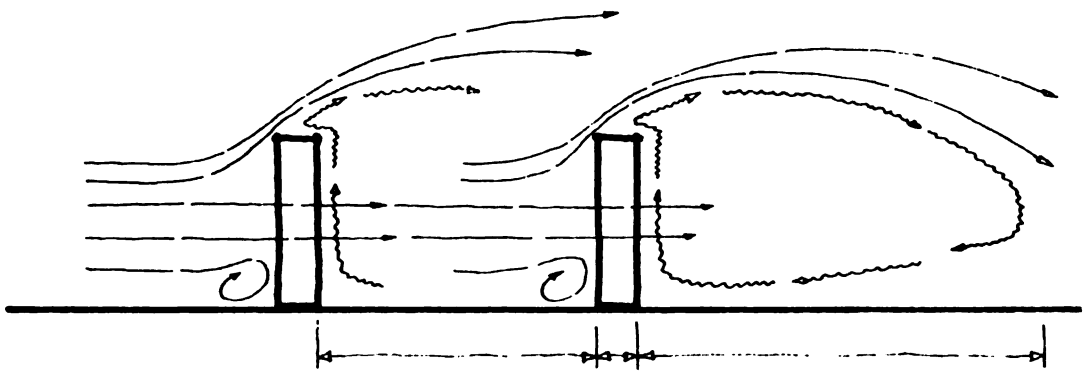
8) Under a contract with American Structural Products Company, a study of the "Natural Ventilation Characteristics of Glass Block Fenestration" was conducted. Again, this was a project directed toward improving ventilation conditions in American schools.

9) Research Report No. 59, "Air Flow Around Buildings," reported the results of studies on single buildings of various sizes and shapes. Because of the multiplicity of variables involved in studying groups of buildings, such studies were not undertaken at this time. However, through these earlier studies a tentative system for studying groups of buildings was developed.

PROCEDURE

This system involves the use of photographic techniques for recording air flow patterns and an electronic amplifier and oscillograph recorder for measuring and recording relative surface pressures. However, before any actual testing is done, a survey and analysis will be made of several existing and proposed multibuilding housing units, along with consultation with the planners, so as to determine the important planning aspects involved. This will provide a more thorough architectural basis for relating one building to another in terms of air flow.

The actual study of air flow will take place in the architectural slow speed wind tunnel, using models. All buildings will be rectangular in shape and of simple dimensions and patterns. The work will begin with a study of the relationship of two buildings of various sizes and spacings, and progress into three buildings, then four, and so on. It is difficult at this stage to determine just how many buildings can feasibly be studied under this



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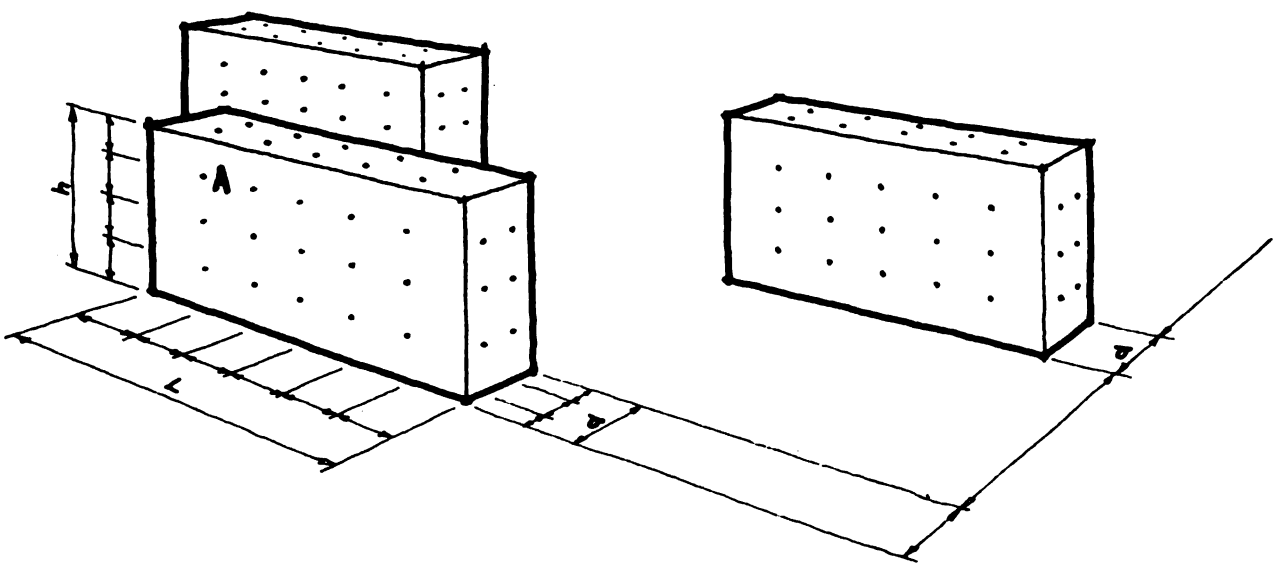

TYPICAL BUILDING TEST LAYOUT

"A"- POINTS OF PRESSURE MEASUREMENT

proposal or of what size and shape these buildings should be. This will depend on how each building affects its neighbors. This project will not deal with unusual building shapes, since the variables produced by the factor of unusual geometry would extend indefinitely the time and cost necessary for study. Specifically, each study will include a detailed analysis of the air flow patterns around the buildings with special attention given to the position, size, and flow direction of the eddy areas. Relative pressures will be measured at significant points on all sides of the buildings to determine the "potential" for air flow through the buildings. Previous studies have suggested methods by which the "potential" for air flow through a building may be determined by pressure analysis of all walls. This "potential" for air flow would provide an index for determining the speed and pattern of air flow through the building without involving the variables of window openings, partitions, etc., which could be studied separately from the other variables involved.

These studies will arrive at certain conclusions regarding the best placement and arrangements of buildings for maximum benefit. They will also provide pressure values for the building surfaces which, when converted to equivalent forces, will provide valuable knowledge for determining structural and wall design criteria. Curtain wall designers will find these data invaluable. While there are many, many variables involved, certain general characteristics will evolve which will indicate valuable design considerations applicable to all situations. The value of this research lies not in the elimination of further studies of specific situations, but in providing enough basic information to allow intelligent preliminary designing, even though subsequent testing may be desirable and necessary. This research will not attempt to evolve the perfect design, but will establish principles, guides, and suggestions which will assist planners in arriving at their own solutions.

Along with, and important to, any research project is the dissemination of the research results. Results must be disseminated in such a way that the information can be used by those involved, and in such a way that they will want to use it.

The results of the studies discussed here will be published in the form of a special Texas Engineering Experiment Station report, written, illustrated, and designed by the authors. The report will be written in a nontechnical form, insofar as is possible, being directed primarily toward architects and city planners whose background usually suggests graphic presentation as being preferable. The report will include diagrams, photographs, and sketches rather than technical formulas and graphs. The report will be distributed throughout the United States to college libraries, architects, and other interested agencies and persons, and to a selected foreign mailing list. Details of publication and other procedures can, of course, be adjusted according to the type of sponsorship obtained.

OBJECTIVES

The objective of this proposed research is to provide architects and designers with information which will help them to analyze proposed building designs, curtain wall designs, and multibuilding layouts with regard to natural air flow as seen in a clear perspective with other environmental elements.

PERSONNEL

The research will be carried out by personnel* of the Architectural Research Group of the Texas Engineering Experiment Station and the Division of Architecture of the A. & M. College of Texas.

FACILITIES

The following facilities are available for use in the proposed work.

A. The Architectural Research Laboratories:

1) The slow speed wind tunnel, consisting of a large 13' x 16' x 4-1/2' testing area; three variable-speed 42" fans which pull the air through the testing area; electronic controlling elements for the fans; and a large inlet "bell" for providing an even, steady flow of air into the testing area.

2) Electronic Sanborn low-level amplifier and oscillograph recorder, which are used in conjunction with low-level transducers to measure and record relative air pressures.

3) Electronic Flow Corporation hot wire anemometer and probes, for measuring very low air speeds.

4) Complete shop facilities for construction of models and maintenance of equipment.

B. Libraries:

1) Cushing Memorial Library, A. & M. College of Texas.

2) Library of the Division of Architecture, A. & M. College of Texas.

3) Texas Engineers' Library, A. & M. College of Texas.

C. The Texas Engineering Experiment Station's Publications Division with complete and competent editorial assistance for the preparation of final manuscript and publications.

D. Department of Photographic and Visual Aids.

E. The A. & M. College Press.

DURATION

The total amount of calendar time required for this project will be 18 months.

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*Qualifications data sheets of professional personnel concerned with the proposed project are attached.

BUDGET

Personnel

Principal Investigator (1/2 time, 18 months)		$ 6,750
Staff Investigator (1/2 time, 18 months)		6,000
Assistant Investigators		1,800
Supplies and Materials		500
Travel		800
Publication costs for final report		600
O.A.S.I. and Workmen's Compensation		576
Indirect Costs (40% of all expenditures)		6,810
	Total	$ 23,836

CONCLUSION

The proposed research, when carried out to the fullest measure, will provide data that are long overdue and which will contribute measurably to our basic knowledge of the environment. In the final analysis, building design, landscape design, furniture design --all the related arts and sciences--are simply efforts toward controlling environment for the convenience and comfort of human beings. The more we know about this environment, the more able we will be to control it for whatever purpose we choose.

QUALIFICATIONS DATA

Benjamin H. Evans, Assistant Research Architect
and Coordinator of Architectural Research
Texas Engineering Experiment Station, College Station, Texas

Education

Bachelor of Architecture (5 years), A. & M. College of Texas, 1952.
Graduate Studies in Architectural Design, A. & M. College of Texas, 1954-58.

Experience

Architectural Research, Texas Engineering Experiment Station, 1952--.
Assistant Professor, Division of Architecture, A. & M. College of Texas, 1954--.
Coordinator of the Architectural Research Program for the Division of Architecture, A. & M. College of Texas, 1958--.
General employment before and during undergraduate studies with architects, landscape architects, construction firms, power and light companies.
Planning and Consulting Experience with Caudill, Rowlett, Scott and Associates, Architects and Engineers, Bryan, Texas, and other architectural firms.
Private practice, controlling designer of several commercial, religious, and residential buildings in the College Station, Texas, area.
Military duty with the U.S. Army, 1945-46.

Research Achievements

Establishment of a program of Architectural Research with the Texas Engineering Experiment Station and the development of an architectural model testing laboratory with a specially designed simulated skydome and sun lamp for studying natural lighting, and low-speed wind tunnel for studying natural air flow.

Establishment and development of a model testing service, making the architectural model testing facilities available to the public, to the architectural profession, and to industry for the investigation of special problems, particularly as related to lighting and ventilation in the field of school buildings.

Fundamental research regarding the effects of architectural shapes on natural lighting, natural ventilation, sound, and other environmental factors.

In The Profession

Associate Member, Brazos Chapter of the American Institute of Architects

Member of the Daylighting Committee, the Illuminating Engineering Society

Member of the United States National Committee of the International Commission on Illumination (C. I. E.)

Member of the Building Research Institute

Publications

Daylight Survey Methods, E. E. Vezey, B. H. Reed, B. H. Evans, Illuminating Engineering, May 1954.

The Surrounding Landscape and Its Effects on Natural Lighting Indoors, R. F. White and B. H. Evans, Landscape, June 1955, and Texas Engineering Experiment Station News, June 1955.

Classroom Task Illumination As Affected by the Students and Their Attire, B. H. Evans, Texas Engineering Experiment Station News, June 1955.

The Study of Natural Illumination by Means of Models Under an Artificial Sky, E. E. Vezey and B. H. Evans, Illuminating Engineering, August 1955.

Architectural Model Testing Facilities, a leaflet describing the architectural testing services of the Texas Engineering Experiment Station, 1956.

Natural Air Flow Around Buildings, B. H. Evans, Research Report No. 59, Texas Engineering Experiment Station, March 1957.

Natural Lighting and Skylights, B. H. Evans, a booklet comprised of a Series of Talks, 1958.

Architectural Research, a three-color brochure describing the activities of the Architectural Research Group of the Texas Engineering Experiment Station, 1958.

Matthew A. Nowak, Research Assistant, Architectural Research Group
Texas Engineering Experiment Station, College Station, Texas

Education

B. S. degree in Physics, Southwest Texas State College, 1953.

Advanced Studies in Mathematics, University of Texas, 1953.

Advanced Studies in Mathematics and Physics, A. & M. College of Texas, 1954-58.

Experience

Research Assistant, Architectural Research Group, Texas Engineering Experiment Station, 1953--.
General consulting in the field of electronics.

Research Achievements

Establishment of a program in Architectural Research with the Texas Engineering Experiment Station and the development of an architectural model testing laboratory with a specially designed simulated skydome and sun lamp for studying natural lighting, and a low speed wind tunnel for studying natural air flow.
Establishment and development of a model testing service, making the architectural model testing facilities available to the public, to the architectural profession, and to industry for the investigation of special problems particularly as related to lighting and ventilation in the field of school buildings.
Fundamental research regarding the effects of architectural shapes on natural lighting, natural ventilation, sound, and other environmental factors.

Publications

Accuracy of Daylight Predictions by Means of Models Under an Artifical Sky, B. H. Reed and M. A. Nowak, Illuminating Engineering, July 1955.
Daylight Surveys Under a Partly Cloudy Sky, M. A. Nowak, Illuminating Engineering, August, 1956.
Miniature Light Cell Enables Smaller Models to be Used in Lighting Research for Architects, M. A. Nowak and B. H. Reed, Texas Engineering Experiment Station News, June 1957.
Architectural Research: Light and Air, M. A. Nowak, Progressive Architecture, July 1958.
A Sound Survey of the Geometric School Plant, M. A. Nowak, Research Report No. 64, Texas Engineering Experiment Station, September 1958.

William G. Wagner, Assistant Professor, Division of Architecture
A. & M. College of Texas
and Assistant Research Architect
Texas Engineering Experiment Station, College Station, Texas

Education

Bachelor of Architecture Degree, University of Texas, 1949.
A. & M. College of Texas, Graduate Studies.

Experience

Designer-Draftsman, Hulsey & Hall, Memphis, Tennessee, 1949-51.
Design and production in association with Leonard Lundgren, Austin, Texas, 1951-52.
Designer-Draftsman, Page, Southerland and Page, Austin, Texas, 1952.
Associate, Cameron Fairchild and Associates, Houston, Texas, 1952-54.

Experience (contd.)

Teaching Fellow, Design, University of Texas, 1954-55.
Instructor, Division of Architecture, A. & M. College of Texas, 1954-55.
Private Architectural Practice, 1954-58.
Assistant Professor, Division of Architecture, A. & M. College of Texas, 1955--.
Principal, Associate Design Consultants, College Station, Texas, 1958--.

Academic Distinctions

Teaching Fellowship, University of Texas, 1948-49.
Representative of Southwest Region Schools at A. C. S. A. Pilot Teachers Training Project, Cambridge, Massachusetts, 1956.
Foreign Study Travel, 2 months, 1946.

In The Profession

Registered Architect, State of Texas
Corporate member and President of the Brazos Chapter of the American Institute of Architects
Member, Engineering Advisory Council, A. & M. College of Texas, 1957-58

Publications

"The Campus Plan", College and University Business, 26 (2): 31-34, February 1959.

OPEN FORUM DISCUSSION

Moderator - Leonard G. Haeger
Architectural Research Consultant
Chairman, BRI Research Committee, 1958-60

(Editor's Note: Since most of the open forum discussion recorded at the Conference relates to earlier versions of the proposals, the following segment includes just those general parts of the discussion which still remain pertinent.)

Mr. Haeger: I would like to ask Prof. Theodore Larson of the University of Michigan whether he feels that the kind of program we are planning has a value to the schools.

Prof. Theodore Larson, Univ. of Michigan: I hesitate to speak on behalf of any school except our own, but I must say that I do have some reservations about seeing representatives of various schools put on what seems to be the auction block. This is a matter of policy which I suppose every college or university has to decide for itself, but I do know that within academic circles there is a division of opinion with regard to this. In some academic circles it is considered highly improper for academic people to seek support. That support should come from outside and it should be given to the institution without any strings whatsoever. If there's an attempted direction of the research activity within the institution, then this becomes rather questionable. I am not fully in accord with this position myself. I feel there is a great deal to be gained by more intimate cooperation between the academic world and the industrial organizations.

At the University of Michigan there has recently been established a unit called the Institute of Science and Technology. The State Legislature has appropriated $100,000 for the first year of operation of this Institute. This is something that even the Legislature and the Governor, who have been quarreling about other matters, have agreed on as a highly desirable activity. It is intended, quite frankly, to be an effort on the part of the University to promote the industrial development of the State, to bring about greater utilization of its natural resources. I don't think this is bad; I think it's good. I don't see any restriction of academic freedom; the intent of the Institute of Science and Technology is to have money available to bring in visiting researchers who are well known and established and who, because they are well known, will attract others in various fields of specialty.

In many ways, this is what BRI is attempting to do too, to bridge what has heretofore been a gap between the academic interests, the research interests and the industrial interests. This is what I think brings everyone together here--a desire to see a general advance in the frontiers of knowledge, to bring about a higher level of understanding. How can anyone disagree with this? But, to come back to my original premise, there still remains a doubt in my mind as to whether representatives of academic institutions should plead publicly for money. Another thing that disturbed me was that the sums mentioned were pretty high, in the aggregate, for each project. I should think most sponsors would be scared off by that. It's quite likely that the sums mentioned were on the short side, would undoubtedly be spent over a period of time, but to mention a lump sum right at the outset, before there's been any opportunity for performance by the individual institutions or by the group that would be handling the particular project, I think is very questionable. Each research unit or team would be better advised to proceed on a piecemeal basis, or perhaps break up the project into smaller parcels that are more modest in scope. Then perhaps, within a limited period of time, sufficient progress could be demonstrated to warrant further investment on the part of the sponsor, whether this be a manufacturer or a foundation. Many foundations seem to be well supplied with money these days and to be actually seeking places in which to invest their research funds. However, the officials in charge must answer to their boards of directors and they must have evidence that something is being done.

I think there's a progressive sort of development possible, with one accomplishment perhaps leading to larger accomplishments and larger investment of research capital. This is also a way in which an information service might be established that would feed back data to all those doing research, design, fabrication, etc. And now, having spoken from the academic side, I would like to put my good friend Charles Attwood on the spot. He has been a sponsor and he speaks from the industrial point of view. Perhaps he can talk about the relationship between industry and the academic institution as he sees it from his view.

Mr. Haeger: We would welcome Mr. Attwood's comments, but before he comments, may I say that I regret any feeling that we were putting anyone on the auction block yesterday. That was certainly not the intent. We regard this simply as an opportunity for people who would otherwise not have had a forum in which to present their ideas. Unfortunately, one of the problems is always money and a potential sponsor, whether he is in the audience or not, always understands the dollar sign and wants some way to measure the project. Mr. Attwood has, I believe, sponsored research at several schools. Is that right?

Mr. Charles Attwood, Unistrut Corp.: I have supplied plenty of materials for schools to play with and, if you consider that research, then I have sponsored research at several schools. I heard the discussion yesterday regarding the various research proposals, and I think perhaps I might differ a little from Prof. Larson in that I think the people who have these ideas need some means of placing them before those who might sponsor them. I question the advisability of placing a price tag on the project, because I think those who might sponsor it feel they should first become better acquainted with the people who are going to do the research, and it should

be done on a smaller, piecemeal basis, leading up to something better. I think Prof. Larson is right in saying that the research program should be broken up into small pieces, so that you can tackle a small part of it in the beginning to see how your research organization is going to function.

When I started in January of 1949 with the University of Michigan, I handed them a project, a rather small one, and I didn't know what to expect from it. As time went on we kept working, and you can't work without getting ideas --one thing leads to another. In the beginning my expected expenditure of money was very modest, but before we are through it will run into several thousand dollars. That's the way research goes, and when you divide it by eleven, the number of years I have been working at it, it doesn't come to such a staggering amount per year. But sponsors should be interested in these things from more than a money-making standpoint. The things that we've researched at Ann Arbor I have yet to place on the market. I have yet to make a nickel out of it, but I'm having a wonderful time doing it. Perhaps if other manufacturers looked at their research in the same light, there would be a lot of things uncovered that they never expected to see when they started. That's my experience with research, and we still aren't through. I've had four programs altogether in eleven years. The last one was producing the textbooks that will give engineers the privilege of knowing how to calculate stresses in space frame structures.

Mr. Haeger: Thank you very much Mr. Attwood. We've had a comment from a university man and an industrialist and we have another volunteer now.

Mr. Frank Comerford, Union Carbide Corporation: I am working with West Virginia University on a project which we selected and assigned to them. However, as I understand Mr. Haeger's question, he wanted to know what was thought about the general approach to this problem. As has been demonstrated earlier, there is a technological, or intellectual approach, an economic approach, and then relationships which are political. Fundamentally the strength of the country depends on all three of these and the proper relationship of one to the other. I don't think the universities should be too coy about going out and doing research. We have a new dean at West Virginia University who came via Oregon, Armour Tech., etc., and has been around quite a lot. He has instituted a slogan which is, "The University works hand in hand with industry," and I think they're off to a fine start. We have projects which have not broken the $100,000 mark yet, but we are just getting started. We have projects under way which we would never have attempted before, and even if the answer we get from them is "no," we feel the money is well spent. The university men come in and work with our men and we send men up there, and this seems to work to their mutual advantage.

Prof. James Lendrum, University of Florida: We have been accused of being coy twice now, and I assure you that this is the last thing we are. We do have one difficulty, however. I worked successfully and very happily with industry when I was at the University of Illinois. The only trouble is that you get a staff together, you have a sponsor, you do some work, and then you find that you've completed that particular job. (We don't all have sponsors that want to continue for eleven years--my respects to Mr. Attwood for that.) Then, you have a very serious choice to make; either you're going to break up a team, or you're going to exercise poor judgment in the selection of

projects. You find someone coming in with a string tied to a project, who wants certain work done and has it all lined up. So you either lose your team, or you do work you don't want to do. It's this lack of continuity that makes us, shall we say coy, about working with industry.

Mr. Joseph Kreuttner, Buensod-Stacey, Inc.: I'm going to confine my comments to the field of elementary and public schools. We have been making a survey for about three and a half years now, and we are shocked at the lack of uniformity in codes for environmental treatment of the pupils. Ventilation is my primary interest, but you also have to keep the atmosphere clean, to heat it properly, and possibly in certain parts of the country you have to cool it. But in the various states of the Union, there does not seem to be any attempt to arrive at uniform requirements for ventilation, for heating, etc.

Another thing that has made itself very obvious is that as regards lighting requirements, sound treatment, the maintenance and operation of mechanical equipment in schools, there is a great area where something should be done to establish at least a norm, some kind of average. Until that is done, we're going to have all kinds of messy situations in schools. This, to me, is a valuable research project--let's find out something about noise levels. I've looked at a number of specifications for schools in the last three-and-a-half years and have never seen one specification for an elementary school which mentioned the noise level. I've heard the opinion expressed that at low noise levels you cannot maintain the interest of the pupils. Now, that is something I think should be investigated. Lighting is another thing--there's never been any established lighting code that I know of for schools, certainly not a national one, although there may be some states that have some requirements for lighting. If we're talking about research projects, I think the schools are the place to start; that's where all of our children start anyway.

RESEARCH PROPOSALS PRESENTED AT THE BRI 1960 SPRING CONFERENCES

Session Chairman - James E. Lendrum
Head, Department of Architecture
University of Florida

DEVELOPMENT OF A LABORATORY METHOD OF STUDYING SOLAR ENERGY TRANSMISSION AND ABSORPTION IN GLASS

By E. R. Queer* and E. R. McLaughlin
The Pennsylvania State University
University Park, Pennsylvania

PRESENT METHODS

The usual method for making solar energy measurements on glass is to use a calorimeter behind a glass sample exposed to the solar radiation. Unfavorable weather conditions and a cumbersome calorimetric device limit seriously the number of valid measurements that can be made. The vagaries of the weather lead to many false starts. The early morning hours are very clear until about mid-morning when thermally motivated convection currents create clouds which interfere with the radiation. The cumbersomeness of the calorimeter does not allow it to follow the wildly fluctuating conditions under a partly cloudy sky. Only clear days, sunrise to sunset, provide the conditions which produce usable test results. It has been the desire of those needing these measurements to find a reproducible laboratory method that would simulate the solar energy source sufficiently to permit measurements on a more rapid and predictable schedule.

The duplication of the solar energy spectrum is not easy. There is no readily controllable energy source on earth that can duplicate the solar source in energy distribution throughout the spectrum. As the solar radiation passes through the atmosphere the energy at certain wave lengths is absorbed and the energy spectrum is modified. The extent of this modification depends on the composition of the atmosphere, providing a second very good reason for developing an artificial source. Dependence upon the composition of the atmosphere would be eliminated and the radiation would have a consistently uniform composition.

Glass and other translucent materials have selective properties for absorption and transmission of particular wave lengths in the ultraviolet, visible, and infrared bands of the sun's spectrum as well as radiation from sources at lower temperatures. It is desirable to maintain the quality of the radiation and not alter its characteristics lest the heat energy measurements and observations be misleading. For this reason it is deemed advisable to provide ultraviolet and infrared radiation as well as visible light. The total

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source may be several sources, each providing radiation in a specialized wavelength range. Where an excess is unavoidable, it can be modified with selective filters.

THE ENERGY SOURCE

It is proposed to use a high intensity electric light or combination of lights to produce the initial radiation. To reduce the nonuniformity of radiation from the several sources it may be necessary to rotate the combination so that the rapid cycling provides an apparently continuous source.

The solar radiation outside the earth's atmosphere is approximately 420 Btu/sq. ft./hr. In travelling through one standard atmosphere the energy is reduced to approximately 300 Btu/sq. ft./hr. This would be the radiation on a horizontal surface with the sun directly overhead. Glass is seldom exposed in this way so that the radiation must pass through more than one standard atmosphere and is reduced still further. To gain some concept of the electrical consumption required to produce 300 Btu/hr., this is the equivalent of 88 watts. However, the conversion from electricity to radiant energy is not highly efficient and much more than 88 watts per sq. ft. will be required. The energy concentration can be achieved.

THE CALORIMETER

Present calorimeters are large and cumbersome, primarily through an attempt to reduce errors by using rather large samples of glass. This requires considerable cooling capacity to service the calorimeter.

It is proposed to develop a small, highly responsive calorimeter that can make reliable measurements on laboratory samples of material. There is a need for a mechanism to indicate and perhaps integrate the mathematical product of the variable flow of small quantities of cooling liquid and the small temperature rise. Such a device will provide the service for heat removal that a watt hour meter provides for electrical heating. Such devices as are presently available are considered to be too large, with unsuitable ranges. The 300 Btu/hr. is considered to be a realistic load, as small samples not larger than 1 sq. ft. or 18" in diameter are contemplated.

The sample must be edge guarded to prevent extraneous energy from flowing into or away from the sample. If the radiation source is larger than the sample, the peripheral energy must be absorbed and removed by a separate cooling circuit. Such cooling must not be overdone. The guard control must be sensitive to the absorptivity of the sample and adjust the guard cooling rate accordingly.

The calorimeter arrangement should permit rapid changing of the glass samples. With such a device it should be possible to make measurements on a number of glass samples per day. This feature would also permit making observations on several samples during those infrequent clear days when suitable solar radiation is available.

The general pattern would be to compare proposed glazing materials or combinations of materials on the basis of results obtained from the calorimeter and the artificial radiation source. Of these a selected few would be compared in the calorimeter when exposed to direct solar radiation. In this way development work can proceed at a regularly scheduled pace and the days with suitable solar radiation can be utilized to the maximum.

Such a program will be useful in appraising materials for high transmission or high absorption or high reflection characteristics. The utilization of solar radiation as an energy source for immediate or delayed consumption will require the use of materials of known properties. The device described here will help provide the needed information.

For the design and construction of one unit, energy source and calorimeter, it is estimated that a budget of $15,000 and approximately one year's time will be required.

A TEST OF THE VALIDITY OF THE VALUES CONCEPT APPLIED TO HOUSING

By Alexander Kira,* Assistant Director, Housing Research Center
and Assistant Professor of Architecture, Cornell University

THE PROBLEM

Two points should be made concerning this proposal at the outset: (a) the proposal concerns one of the social science aspects of housing and (b) this particular aspect is a relatively esoteric one, human values. I say "esoteric" because not only is the application of values theory to housing new, but the concept itself is relatively new to the disciplines of sociology and psychology which originated it.

What are human or social values? Values have been defined as being... "Things in which people are interested--things that they want, desire to be or become, feel as obligatory, worship and enjoy." Values are modes of organizing conduct--meaningful principles which guide and pattern human action. They are based on the totality of a number of factors, such as an individual's ideals, motives, attitudes and tastes which are determined by his cultural background, education, habits and experiences. Values may be distinguished from preferences and attitudes in that these tend to be based on immediate experience and tend to change with some rapidity. Values, on the other hand, tend to endure and represent what is "desirable" rather than what is "desired." Values also have a strong element of "ought" and "should" about them and act as the very fundamental criteria against which goals are chosen.(1)

It soon became apparent that in this concept there might be an application to housing which could be as important as it was intriguing. The idea was very simple; if values are such a basic guide to our goals, and if certain of these values were to have application to housing design, then it should be possible to produce housing which meets a family's fundamental needs and desires on other than a trial and error basis. In essence, the hypothesis we are dealing with is central to the practice of architecture. Every architect, consciously or unconsciously, goes through a period of analyzing his client to discover just who he is and what his values are in relation to housing or building. What we are attempting to do for people in general is approach this analysis in a systematic and scientific way.

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(1) Raised numbers in parentheses refer to List of References at end of paper.

Several pioneering studies have since been made which have indicated that people do hold certain values with respect to housing.[2] From these studies, involving some 3000 families, nine basic value groups or "orientations" emerged. For convenient description these have been labelled: Family Centrism, Equality, Economy, Physical Health, Mental Health, Freedom, Esthetics, Leisure and Social Prestige. In each instance the label is indicative of the major orientation or emphasis of the persons holding the particular value. It should be noted, however, that few if any people are pure types; most persons have traces of some, if not all, of the other values, even though most people do tend to have certain dominant values. It should also be observed that although we have been speaking of people as individuals, there is some evidence that a correlation does exist between the values held by husbands and wives, so that we can also speak of a family's value orientation.

In the most recent study, it was discovered that although these nine orientations are all quite different in themselves, eight of the nine tended to fall into two general and opposed clusters or groupings, based on some common characteristics. On the one hand, we have a cluster made up of such values as Freedom, Mental Health, Leisure and Esthetics. People who hold these as dominant values tend to be more individualistic, more personal, more sensitive and more idealistic than those who do not. They are more likely to have whimsical demands, indulge in luxuries (whether they can afford them or not), and they are likely sometimes to disregard their basic physical "needs" in favor of luxuries and other demands. This group is generally motivated to buy things with an esthetic appeal. They are sensitive to design and color, and they want their homes planned to provide for leisure and privacy when they desire it.

On the other hand, we have a cluster made up of such values as Family Centrism, Equality, Economy and Physical Health. Individuals holding these values are more "group" oriented. They are more realistic and less sensitive to life in general than the other group. They tend to be much more practical in their demands. They emphasize necessities rather than luxuries, and they observe their basic physical needs. For these families the needs of children often stand at the forefront. They emphasize such matters as safety and physical well-being. They are careful not to "put on airs" for fear their peers will think them oversophisticated.

Social Prestige, the ninth of the value groups listed above, is the most difficult to identify clearly. Persons holding this value desperately want the social approval of their peers. To gain and hold this approval they will, in effect, take on the values of whichever group they feel gives them proper status. The house for these families serves largely as a role indicator. This group may also be highly receptive to appeals to the ego and be sensitive to fashion. They may seek to be conspicuous and perhaps gawdy, or sophisticated and tasteful or, in some circumstances, even dignified and anonymous if this can confer distinction or identity.

The thesis of these earlier studies is that value orientations have a direct influence upon our housing requirements. In some instances these requirements may vary sharply between the two groups mentioned and may even be in direct opposition to one another. In other instances the practical effect of these requirements in terms of design may be the same, but the underlying reasons for these requirements may be completely different. This suggests that a sound understanding of these basic value orientations and how they influence housing requirements may lead to new solutions that more nearly satisfy people's requirements for shelter.

In summary, it is generally conceded that the studies already made confirm the existence of human values as important factors in our lives in general, and show that these values can be identified. It is also clear that this identification can be sufficiently detailed to permit architectural or design recommendations to be made which satisfy these values. All of this, however, relates to theoretical considerations only.

PURPOSE OF STUDY

The purpose of this study is to make a field test of the concept that human values can provide a systematic and fundamental basis for making design decisions regarding housing in general.

PROCEDURE

This study would be undertaken at the Housing Research Center at Cornell University by an inter-disciplinary group composed of psychologists, sociologists and architects. The technique to be used is that of measuring the adjustment of a selected group of families moving into newly purchased houses having known value-design characteristics.

Two types of houses will need to be selected; a type generally suitable for each of the two basic value clusters mentioned earlier (omitting Social Prestige for purposes of keeping the research design to manageable proportions). It is recognized that "pure" house types probably will not be found, so that a system of evaluation and analysis will need to be developed which focuses the "adjustment scale" on those design and planning features most relevant to the research problem, and eliminates those which are most impure or irrelevant.

It is expected that these houses can be found within two or three carefully selected subdivisions or developments. If this should prove feasible, it would provide for economy of study and would furnish partial control over the variable of neighborhood influence. (While the difficulty of separating the influence of house and neighborhood is recognized, again, this study would be limited to the house in order to simplify the research design.)

After the necessary pretesting has been completed, a panel of approximately 200 families will be selected and studied. These families will be chosen with the cooperation of the builder, or builders, from among those families who have signed purchase agreements for new houses. The criteria to be used in selecting these families will include the requirements that the families presently own their houses, and that they are exercising a completely free choice in moving and in buying a new house.

An analysis would be made of the living patterns and existing housing situations of the families participating in the study. This would include such items as:

1) An analysis of their existing house to determine its value-design characteristics.

2) A determination of the dominant value orientation of the family.

3) The activities performed by the family; their household tasks, leisure activities, etc. in terms of whether they are active or passive, performed by individuals or by groups.

4) Where in the present house these activities take place and how satisfied the family is with their present accommodations.

5) The particular satisfactions and dissatisfactions with the house per se.

6) What leisure activities the family feels it would like to engage in which it does not now.

7) The nature of the intra-family social relationships.

8) The extent and nature of the inter-family socialization patterns.

Data would also be collected for control purposes on the existing neighborhood, its facilities, the distance to work, etc., and on the reasons for the family's moving, for its selection of the particular house it has just purchased, and on its expectations regarding the new house.

Analysis of these data on the family's existing situation will indicate how closely its present house matches its value orientation, and will furnish the benchmark against which measurements of the family's adjustment to the new house will be made.

In moving to the new house, four possible situations may result for any particular family. Some families may have been living in more or less a "wrong" house and, may either have chosen a "right" house or, may actually have chosen another "wrong" house. The same two possibilities exist for those families who may originally have been living in a "right" house. (It should be noted that the terms "right" or "wrong" are relative; some houses may be "righter" or "wronger" than others, thus affecting the degree of change which may be experienced between the old and new situations.) The extent to which changes may take place also depends on which of the four possible situations a given family falls into. We may expect the most pronounced changes to occur where a family went from a "wrong" house to a "right" house (and vice versa) and the least change to occur where the old and new situations were more or less similar.

After the families move into their new houses, their adjustment, in terms of both speed and degree, would be measured after three intervals...one month after moving, six months after, and one year after. Special attention would be given to those changes, if any, which have occurred in the various families' patterns of activities, socialization, inter-personal relationships, etc. as a result of living in the new house. Attention would also be given to how these changes might vary between measurement intervals and between the various value types.

Ease of adjustment would serve as the basic criteria used in determining the desirability of a specific housing type for a specific type of family. If ease of adjustment is experienced, for example, by those families among the 200 who change from a "wrong" house to a "right" house; or difficulty of adjustment is experienced by those families who change from a "right" house to a "wrong" house, then support would appear to be given to the basic theory.

If the basic premise is proven, that housing can be designed to satisfy the requirements inherent in various basic value orientations, then we will have made a significant step forward. It may well be that ultimately personal values will join price and number of bedrooms as major considerations in house selection and design.

DURATION

4 years

BUDGET

No budget has been prepared at this time. A detailed budget and work program will be prepared after the nature and location of the sample have been determined.

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COMPUTER TECHNIQUES FOR DAYLIGHTING DESIGN

By Philip F. O'Brien, * Associate Professor of Engineering
University of California (Los Angeles)

The prediction of luminous quantities within a room is an important aspect of lighting design. Both analytical and experimental approaches have been employed in this design effort. During the 1920's the analytical relationship for light transfer was recognized to be the basic integral equation of the second kind which in partial differential notation is the Poisson Field Problem. That is, the luminous flux or light flow as from the outdoors into a room may be pictured as occurring in a field in which the potential or driving force is luminance or brightness, and the resistance to flow is determined by the shape of the room and the luminous reflectances of the walls and other surfaces of the room. Light may enter the room at one or more locations, while light is absorbed or drained off the field or room at all locations.

Problems facing the designer of daylighting may be classified as "Analysis" and "Synthesis." In general analysis problems are concerned with the prediction of the luminance and illumination patterns in rooms whose location and strength of light source are specified as well as the room geometry and reflectances of the surfaces of the room. Conversely, synthesis of lighting systems involves the selection of luminous sources such as fenestration, geometry and reflectances that produce the desired luminance and illumination patterns in the optimum manner with respect to economy of men and materials. The daylighting designer often performs the synthesis process based on experience and without a conscious formulation of all the design parameters and relationships. Following the initial selection of luminous input, geometry and reflectance distribution, the designer must use some form of analysis to determine with paper and pencil that the design criteria of luminance and illumination patterns are met by this initial mind model of the real lighting system. If the analysis operation reveals some deficiency in the match between the first guess at the system and the design criteria, the paper and pencil model of the system is adjusted in some way and this process is repeated until a suitable system is obtained within some predetermined allowable tolerance.

EXPERIMENTAL METHODS OF DESIGN

Because the solution of the basic integral equation of light transfer can be accomplished by calculus only for the simplest shapes such as spheres and cylinders, the daylighting

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designer has been forced to rely largely on data based on experiment with full size or model structures. Some designers make measurements of completed daylighting systems which they have designed in order to discover the accuracy of their prediction and any discrepancy observed is employed to adjust the prediction method for following design problems. Other designers may construct a model of the structure and measure its performance in a range of lighting fields or inputs. In addition extensive bodies of data describing light transfer in a variety of rooms have been published by industrial suppliers and university laboratories. All of these methods based on experiment are limited by the great variety of luminous systems which the designer may wish to employ. Briefly, the published data describes only a small fraction of the systems used, while experiment with real models of each new system may not be practical.

ANALYSIS AND SYNTHESIS OF LIGHTING SYSTEMS BASED ON FINITE METHODS

As suggested above the infinite or classical calculus solution to the basic light transfer equation is not applicable to the daylighting situation because of geometrical complications. However, if the basic transfer equation is changed to a finite difference form the powerful tools of numerical analysis and the associated modern computing machinery may be brought to bear on the lighting design problem. "Finite-difference form" means simply that the equations are adjusted to describe a room composed of surfaces of any size, each of which possesses a uniform reflectance and luminance. Extensive data reveals that this approximation of the real system does not lead to significant errors and in the limit, as smaller or more numerous finite areas are employed the exact or infinite analytical representation is approached.

COMPUTER METHODS FOR DAYLIGHTING DESIGN

Although numerical analysis methods based on paper and pencil have been available for many years, these did not become attractive to the designer until computing machinery became generally available following World War II. Today computing machines are employed in almost every facet of technology and business. In this regard the group of engineers at the University of California, Los Angeles, under Professor Philip O'Brien have recently conducted research related to the applicability of computing techniques to radiative transfer in general and to daylighting design in particular. The list of references at the end of the paper reveals that both analog and digital computers have been employed. An analog computer, the first of its type, was constructed to aid the development of these methods. This Luminous Analog Computer is now being copied by several lighting organizations and should become a common tool for lighting design in a few years. It is the intent of the research proposed here to accelerate this adaptation of numerical techniques to the problem of daylighting design.

PROPOSED RESEARCH REGARDING DAYLIGHTING DESIGN WITH COMPUTERS

Many avenues of investigation in the area of daylighting technology have been opened by the introduction of finite analytical methods, but the following topics seem to be the most promising in terms of significant accomplishment within a minimum of time and effort:

1) Lighting Simulator--the concept of using the Luminous Analog Computer as a mathematical model or simulator of a lighting system is a powerful aspect of lighting synthesis. That is, the designer can observe the effect of changes in room shape, daylighting controls, sky light and direct sunlight conditions, room reflectances and room furnishings by simply adjusting the electrical resistances

of the Luminous Analog Computer. The effective application of this synthesis technique needs to be explored in a range of real design problems. It is proposed to set luminous design criteria for particular realistic room cross sections and develop a rational technique of employing the simulator to produce the required lighting system. These experiences will be formulated and made available to the lighting designer who will use the simulator.

2) Analytical Idealizations--all analytical descriptions of lighting systems depart from the actual physical conditions according to certain necessary idealizations. In the finite analytical method the principal idealization is the division of the room or space into finite regions of constant properties. This approximation gives rise to the truncation error. It is proposed to develop optimum methods of finite division of lighting systems by comparing the results of analysis with experimental results with prototype or real model rooms. The fineness of subdivision or the number of finite areas required to produce an analytical solution approaching the experimental data will be determined for a wide range of daylighting systems. Extensive experimental data is now available in the lighting literature and for this reason further experimental studies would not be required.

3) Development of Catalog of Transfer Matrices--as indicated in the reports of the research under Professor O'Brien at UCLA, the lighting conditions in a room can be predicted for any set of daylighting conditions by means of a set of numbers known as the inverse transfer matrix, or admittance matrix, in terms of electrical engineering terminology. Such a catalog of admittance matrices for symmetrical room lighting conditions typical of lamp lighting has already been prepared by Professor O'Brien (see "Lighting Calculations for Thirty-five Thousand Rooms" a paper presented at the Illuminating Engineering Society National Technical Conference at San Francisco during September 1959). Similar quantities for typical daylighting systems would be very useful for the lighting designer. The IBM 709 Computer of the University of California, Los Angeles will be employed for this work.

PROPOSED RESEARCH ORGANIZATION

Professor Philip F. O'Brien of the College of Engineering will direct these studies to be accomplished by graduate engineers who are candidates for the Master of Science and Doctor of Philosophy Degrees in Engineering. The computing and other facilities of the College of Engineering would be available without cost to the project as they are provided by the University for academic research. It is proposed that a Research Grant of $12,000 for the first year would be suitable to produce significant research results through the work of two graduate engineers with supportive staff. Undergraduate engineering students would be employed as project aids. A formal report of the work would be prepared at the termination of the activities.

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HOUSING IN RELATION TO HEALTH, ILLNESS AND THE USE OF MEDICAL CARE

By William A. Steiger,* M.D., Clinical Professor of Medicine
Francis H. Hoffman, M.D., Associate Professor of Psychiatry
H. Niebuhr, Ph.D., Assistant Professor of Psychology
Temple University

INTRODUCTION

For some generations now, we have been paying tribute to the idea that man needs to be understood in the context of his environment. Indeed, most of our social institutions, whether education, government or medicine, have been evolving on the basis of that generalization. In our own field, medicine, this viewpoint is in evidence in the sub-fields of comprehensive medicine, social psychiatry and the "new" public health. In the fields of housing, urban renewal and city planning, we detect as well new concepts emphasizing their psychological and sociological components. But we are still at the frontier. American medicine is still less occupied with the patient than with the illness. Similarly, as we rush to meet the needs of our exploding population, planning officials, township supervisors and eager developers fail to consider the potential long-range implications of the public housing units and the mass-produced suburbs, either on their inhabitants or on the structure and flow of American society.

In the past, as in the present, we live with too many panaceas. When the concept of public housing gained favor in the 1940's, it was presented as an almost magic solution for many of man's social ills. Disease morbidity, family disorganization, crime and delinquency were expected to fade from the scene; one rarely hears this prediction in 1960, for our social pathology is apparently as rampant in public housing as it was and is in the slums. Then, too, commentators on current American society talk about the quest of young people for security and stability, and their unwillingness to take risks; yet as the modern middle class family moves into the $15,000 split level house, they are already thinking about the next house five years hence. Can we promote anything close to the rootedness of the traditional European family where houses and land are passed down from generation to generation? Hardly. At the same time that we are seeking security and stability, we unconsciously order our lives in such a way as to minimize this through social and geographic mobility, planned obsolescence, short-term leases, no down payment mortgages, and leasing land on which to build rather than buying. At another level of analysis, the very concept of ever-upward social and individual progress

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penalizes various strata of our society. With the rise of mass media of communication, everyone who can afford a television set, even a second hand one, insures the reinforcement of his own material and social inadequacy; every night the magic tube of television takes him out of his house and informs him as to what he does not have, and in a telling sense (if he is from a lower social class) tells him what he will never have. The compensatory gratifications of being an integral part of a static neighborhood are less by comparison with the past.

Our comprehensive medical orientation at Temple University School of Medicine has led us beyond the narrow biological constraint of formal medicine. Initially we conceived that all manner of psychological, sociological and economic variables were important in the understanding and management of our patients. But even here, our major advance was in the blending of the biological and psychological conceptions of man; while we genuflected in the direction of the sociological and economic aspects of our patients' environments. There is little in the way of systematic knowledge correlating medical concerns and the various facets of these sciences. In our own limited way we have been exploring what appears to be a scientific no man's land. Out of our work with many patients, and out of a two-year follow-up study of former patients, we have come upon a number of facts and hypotheses which need to be explored.

The addition of "neighborhood conservation" to the urban renewal nomenclature has pointed us in a general direction. Not content with a philosophy of repair, we conceive our role to have more prophylactic emphases. As a medical center serving as physician to a lower class neighborhood, we are seeking new ways of relating ourselves to the neighborhood so as to serve a positive role in the preservation and conservation of the area and its inhabitants.

The implementation of this ideal will signify the blending of both the clinical and public health traditions of medicine, and mark the beginning of a new partnership with the social institutions concerned with the physical health of a city's housing. Before we feel ready to go on to this larger task, we need to explore in greater detail the relationship between our patients and their present housing environments. While we already have much anecdotal and some systematic data alluding to certain relationships, neither we nor anyone else, as far as we can tell, have focused on this particular area of relationships.

One of the few studies bearing on this question is in the process of being completed at Johns Hopkins[1,2,3]. Studying the effect of a move from slum housing to public housing in a controlled manner, the Hopkins investigators were able to report that disease morbidity did not change, but that satisfaction with housing did, and in a positive direction. While this study breaks the ground, the scope of the study and its survey design leave much to be desired. Nonmedical interviewers asking rather superficial questions suggest that a more intensive inquiry is necessary; indeed we judge that we are only at the hypothesis and methodology forming stage of investigation. For the rest of this proposal we shall describe three rather limited studies we should like to undertake. Our approach is conservative, extending as it does from the pattern of investigations already under way. Once these three studies are completed, we shall be in a better position to undertake more extensive explorations.

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(1) Raised numbers in parentheses refer to List of References at end of paper.

DESCRIPTION OF STUDIES

I. Housing Study of Comprehensive Patients

For the past five years, and continuing today, each senior medical student and every pair of juniors rotating through the Comprehensive Medicine Clinic selects patients, usually with multiple complaints, for special studies and treatment and for one or more home visits. He then writes a detailed paper on his understanding and management of these patients. Such patients have usually had marked psychological and environmental components which relate to their condition. We have found that a fair number of them get better and a fair number do not get better. Over the past two years, two physicians and a research assistant have been involved in making follow-up studies on these selected patients, and a number of interesting findings related to psychological and sociological variables have come to light. We plan to continue this study and, in the future, to study some of the home and housing aspects more extensively and intensively.

Methodological Considerations: For each population of "comprehensive patients" so studied, we plan to study a) the top 25% or "helped" patients and the bottom 25% or "not helped" patients with respect to a number of variables, and b) the 25% having the "best" housing and the 25% having the "worst" housing with respect to health variables. The housing variables will include:

1) Nature of neighborhood described in physical, economic and social class terms.

2) Nature of housing classed by rental, owned, private, multiple dwelling, and general physical characteristics.

3) Condition of housing, probably using an adaptation of the Twichell method of appraisal[4].

4) Care of and attitudes toward the home will need to be measured in a differentiated manner. It is in this area that substantial work on the development of assessment devices needs to be done.

On the basis of our knowledge of the "helped" and "not helped" patients, and on the basis of our data gathering in the housing areas, we ought to be able to establish certain correlations between the ability to profit from comprehensive medical care and the several housing dimensions.

II. Housing Study of Families under Comprehensive Medical Care

The study of comprehensive patients just described is useful in the sense that it allows us to examine extreme populations on the "helped-not helped" continuum and look for differences. The study has the weakness that it does not include other members of the family. For the past year we have initiated an expanding program of family care for families initially supplied by a neighborhood church. Thus our own data are augmented by data from the pastor who knows his families very well. The initial data were extremely surprising; in 15 ostensibly "healthy" families an amazing amount of disease was revealed. While we have come to know the family members as individuals and as members of the same social unit, we have yet to explore them purposefully in relation to their living quarters and the kind of "home" they have built for themselves.

Methodological Considerations: For a pilot study, it is our wish to undertake a case study of these 15 families in relation to their homes. Along with the kind of information described in the first study, this pilot study would describe the inter and intra-family uses of housing, attitudes toward housing, housing value systems, and housing aspirations. It would in effect be a socio-psychological approach to the family as a unit leading to an understanding of the family and home, the gratifications, tensions, problems soluble and insoluble inherent in the situation. A case study approach seems most desirable at the outset since it allows maximum flexibility and opportunity for following up the various leads uncovered. While we recognize the scientific limitations inherent in the case study approach, it offers optimum flexibility at this stage of hypothesis formation.

III. Housing Study of Current Patients

The completion of Studies I and II should allow the development of a more systematic relationship between patient variables and housing variables. Upon the basis of the data gathered in Studies I and II, specific hypotheses should emerge, and we should have completed the development of housing and attitude scales. Conceivably, for given classes of patients currently attending the Clinic, we would administer our assessment instruments and utilize the data in the evaluation of the case. This would move us quickly into the possible use of our new knowledge in the management of the patient. But, for more systematic reasons, we would gather data relevant to attitudes, uses, gratifications and problems inherent in the housing aspects of living and their relationship to total health. From Studies I and II, we ought to be able to have some basis for decision as to how we would categorize our samples. This could be by social class, nature of health problem, and a host of psychological dimensions. Again, while we envision Study III as being more systematic, it is entirely contingent on the earlier work.

FUTURE DIRECTIONS

As we indicated in the Introduction, we are interested in studying these questions and possible relationships in order to gain knowledge that would make modern medical care more effective. This obtains both on the level of the individual patient, and also on the prophylactic level of neighborhood conservation. We are action-oriented and make no apology for it. Therefore we envision the data from the three studies being used for developing more refined techniques of individual care, and for the development of new methods of community preventive health. Nonetheless we also feel that the present studies will be likely to open up a host of additional questions which we would be prepared to explore as well. A more systematic exploration of an individual's self-image and its extension into his material environment is just a step beyond the current studies. Similarly, another direction would be detailed exploration of psychological responses to the various building materials that go to make up a home.

PERSONNEL AND BUDGET

Co-Directors CMC	$ 2,000
Psychology Director	1,000
M. D. Director of Studies (1/4 time)	3,000
Psychologist (1/2 time)	4,500
Sociologist (1/4 time)	2,500
Consultants	6,000
Economist	
Authority on Housing	
Cultural anthropologist,	
Authority on Real Estate	
Travel and mileage	1,000
	$ 20,000
Overhead x 15%	3,000
	$ 23,000

List of References

1) Wilner, D. M., Walkley, R. P. and Tayback, M., How does the quality of housing affect health and family adjustment, A. J. P. H. 46:736-744 1956.

2) Wilner, D. M., Walkley, R. P., Glasser, M. N., and Tayback, M., The effects of housing quality on morbidity, A. J. P. H., 48:1607-1615, 1958.

3) Wilner, D. M., Walkley, R. P., Schram, J. M., Pinkerton, T. C. and Tayback, M., Housing as an environmental factor in mental health, A. J. P. H. 50:55-64, 1960.

4) Twichell, A. A., Measuring the quality of housing in planning for redevelopment. In Woodbury, C. et al. Urban Redevelopment: Problems and Practices, University of Chicago Press. 1953, pp. 3-98.

OPEN FORUM DISCUSSION

Moderator - James E. Lendrum, Head
Department of Architecture, University of Florida

C. M. Cutler, General Electric Co.: Isn't one of the most difficult problems that of determining the program to put into the computer?

Mr. O'Brien: The program for the digital computer is a standard program simply involving matrix inversion. They all have standard programs and all you need to do then is put the numbers into the matrix. The numbers are of two kinds, those that relate to properties and those that relate to geometry. Now where do you get the geometrical factors? For most shapes they have already been tabulated or plotted. There are very extensive tables available and one just looks in various catalogues and picks out the numbers. For certain cases where shapes are not reported in the literature, there are experimental and graphical techniques, some of them quite ingenious, that allow you to quickly come up with the numbers. For example, a complicated situation like some of the rooms that I discussed in my paper could be completely programmed, that is, all the numbers necessary to put into the matrix could be obtained in about an hour's work.

Mr. Lendrum: Could this analysis be extended to rooms of other than simple rectangular shape?

Mr. O'Brien: Yes, it can be extended to things as complicated as a chicken egg. We had a project not long ago supported by the Department of Agriculture. They wanted to know what the brightness distribution of a chicken egg was for light shining in one side, a process known as egg candling. We were able to predict rather accurately the brightness distribution as a function of the position of the yolk, the reflectance of the yolk, the area of the shell that was illuminated and things of this kind, which indicates that rather elaborate shapes can be treated by this technique.

M. H. Johnson, University of Florida: Are radiations other than those generating heat proposed to be incorporated in the solar energy source simulator, and would the incorporating of these other radiations, if not already considered, too greatly complicate the equipment?

Mr. McLaughlin: It was our hope to include as faithfully as possible the radiation throughout the entire spectrum. This would include the ultraviolet as well as the visible and the infrared.

Mr. Lendrum: We have three questions here directed to Mr. McLaughlin. They all pertain to details of the design and operation of your simulator, to the loads that you are going to use and the radiations, wind velocity, etc.

Mr. McLaughlin: This is envisioned as a comparison device and not as a total environment in which wind would play any great part. The thought is that by making certain factors constant, factors which are perhaps relatively unimportant in most of the exposures, we can determine the effects of certain things such as coloring within the glass or surface coatings, thicknesses perhaps, anything which would effect the absorption and transmission of the glass. I realize that the wind has some effect in carrying away the energy once it is absorbed, however, the simulator is designed to screen the effects of these other variables, and the effect of wind, etc., would be a job for the larger calorimeter. Such things as venetian blinds, for instance, certainly can't be made too small. That's where convection and wind are included. I believe the sample will still have to be large enough to give representative convection currents, but where the materials within the glass itself, or on its surface, are involved, the simulator and the small calorimeter would contribute considerable speed-up in the screening process.

C. M. Cutler, General Electric Co.: How would the first houses be designed or how would you decide on suitable designs?

Mr. Kira: We would try to select two house types that in effect would match the two value clusters. Now this, even in itself, may be difficult enough to do--to find two types of houses, each of which reflects the requirements and the characteristics of a particular group. They may not be "pure," in which case we would have to identify very clearly those aspects or features of the design or the planning or the layout of a house which we felt were appropriate to the particular group, and isolate or eliminate those that were extreme in this case.

G. C. Means, Clemson College: The auto industry allows a very wide choice, but this doesn't produce well designed cars. Since the builder builds for other persons, and people have to choose from what is available, how can these value studies encourage a wider range of choice?

Mr. Kira: The basic problem is very similar to the kind of situation Mr. Steiger discussed. The builder in most cases operates on the basis of incomplete knowledge with respect to the family he is dealing with. This is largely trial and error, the result of all kinds of factors--and what might be cheaper, or what might be on the market, what might be promoted by various magazines or other groups. There are a great many factors determining what the builder decides to build. I don't think that, in most cases, the builder today has really sound criteria for making design decisions. If we can postulate what some of the requirements might be for the various groups, then any builder could operate more effectively in producing housing which more nearly satisfies the requirements of various groups of people. By doing this we will probably end up with more choice. Presumably, then, if you can identify yourself with one of these groups, you can identify the house which is suitable for you.

C. H. Topping, E. I. duPont de Nemours & Co., Inc.: What about the personalities of the people that occupy houses? Some people are status seekers. How do you get these various groups to fit into the right types of houses?

Mr. Kira: Probably the builder can find a way of matching these families to the right houses. This idea could well become a selling device at some point, if it became sophisticated enough. Someone also raised the question of the relationship of neighborhood to income, and also the very interesting sociological question that every city planner and developer wonders about; mixing of the socio-economic types, etc. There is another factor involved here: Can you build a successful development that's full of one value type or full of another value type? This question we will certainly have to ponder in the future after we have discovered the basic information as to what would be suitable for a particular type of family.

Unsigned Question: Can housing situations cause illness?

Mr. Steiger: This fundamentally comes down to your concept of cause. In physics, for example, cause is a concept hardly used any more. There has been much philosophical meandering about cause and causality. We have come to view illness by what's called a field theory. Essentially it states that there are multiple kinds of forces impinging on everyone, both external and internal, some of these forces we are aware of, and some we are unaware of. Some we can measure and some we can't. We think that there is no such simple thing as the cause, whereas perhaps once it was said that the tubercular germ was the cause of tuberculosis. We know that everybody is exposed to that germ today, and not everybody gets tuberculosis, so while it is a necessary cause, it is not a sufficient cause. In other words I am saying there are multiple factors, social, biological and psychological, which impinge on individuals, and their housing must be a very significant factor. I would therefore have to answer your question in the affirmative.

Mr. Topping: This discussion also suggests the possibility that a good architect could try to create an improved environment to stave off the possibility of illness. Do you think this kind of study might eventually achieve this result?

Mr. Steiger: It sounds logical and it might, but of course we have really very few indications at the moment, in medicine, that would lead us to tell somebody to change his house. There may be a great deal more we could tell them to do if we studied the problem further. We sometimes tell the coronary patient to live on the first floor and not to climb stairs, or we tell the asthmatic patient to change his house furnishings, mattresses, etc. But, outside of the field of allergy and where cardiac work is involved, we have very few indicators. There certainly should be more study devoted to such problems as privacy, and what it means to individuals. One thinks about the impact of housing on something as remote as morals, for example. I would suppose that most of us were raised in a more cultured kind of family setting in which we didn't know that mother and dad had sexual relations until we were 12 or 14, and then only by implication, whereas in a significant segment of our urban society today, children sleep within 6 feet of their parents every night. This kind of economic condition, or housing condition, must certainly have an impact on how these people react. We know what impact it has on their health, and we think it probably has some impact on behavioral health.

I would think that a properly designed home might well be therapeutic. Curative is a strong word, but preventive therapeutics in this field is conceivable. This kind of a study might eventually lead to such a thing. We certainly are not at that point at the moment.

Glenn Beyer, Cornell University: What are some of the specifics with regard to the environment that you might investigate in this kind of a study?

Mr. Steiger: Of course, the prime answer to your question is that we are not sure what specifics are important. That's why we propose to do a pilot study along descriptive lines in order that from this study might emerge certain dimensions which we would find both relative and important. The things we can readily do are estimations of the neighborhood, the class of the house, and its condition, relative to the rest of the neighborhood. We can make subjective evaluations, consensually validated, as to the upkeep of the house and the pride taken in it. Certainly one can classify the types of families along educational lines, occupational lines and income lines. The number of people occupying the space involved, the number of rooms, bathroom facilities, indoor or outdoor, the working of the plumbing and the furnishings in the house, the presence of TV and radio, etc. By getting to know our families through interviewing techniques I think we can get some idea of their feelings about the place, their values, their aspirations for housing, the use they make of it, and the use that each member makes of it. Is this a family in which people are home at night, or is this an area in which everybody sits out on the front stoop, or is it an area in which dad always goes down to the corner saloon in the evening? These variables will be the things we will be looking at and looking into. We will be trying to isolate from these variables the ones that we should and could measure with more precision.

Mr. Hoffman: I would like to make a comment about this. We have observed, and I am sure that other people have too, that patients come to physicians for many reasons. We have known, for instance, that patients will consciously or unconsciously become ill in order to change not only a pattern of living, but sometimes the location where they live, or sometimes to move someone out of a house. I have seen several patients who moved their mothers-in-law out of the house by the simple process of illness. How much illness is the manifestation of the wish to change the pattern of living, we don't know. We do know that Alcoholics Anonymous, for instance, says that you have to hit bottom before you are going to change. Now maybe there are other illnesses where you have to hit bottom before you are going to change. Maybe there are other conditions about home and housing that have an effect. I can think of another patient who made her appointment to have her gallbladder removed because she was having a difficult time with her husband. Her daughter had moved out and they were living in a house that was now too spacious for them. They rattled around in the house and they did not have the daughter there as the arbitrator in their arguments; that's really the focus of it. So, she had her gallbladder removed in the process of working out this change in her pattern of living. Our interest is in the fact that illness does stem from such situations in many cases.

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PLASTICS IN BUILDING, 1955, 150 pages, ill., NAS—NRC Pub. No. 337, $5.00.

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FLOOR-CEILINGS AND SERVICE SYSTEMS IN MULTI-STORY BUILDINGS, 1956, 141 pages, ill., NAS—NRC Pub. No. 441, $4.00.

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NATIONAL ACADEMY OF SCIENCES—
NATIONAL RESEARCH COUNCIL

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