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PREDETERMINATION OF NATURAL ILLUMINATION BY THE MODEL TESTING METHOD.

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NEW EDUCATIONAL SPECIFICATIONS HAVE CAUSED ARCHITECTS TO USE NEW FORMS WITH THEIR RESULTING NATURAL LIGHTING PROBLEMS. THE PROBLEM CAN BE ENGINEERED WITH THE USE OF MODELS. PREDICTION OF LIGHTING PERFORMANCE IN A BUILDING CAN BE MADE EARLY IN PLANNING. THIS METHOD PROVIDES FOR THE TESTING OF A VARIETY OF TRIAL SCHEMES ECONOMICALLY AND RAPIDLY. MODEL TESTING IS THE ONLY METHOD WHICH ALLOWS COMPARISON OF ARCHITECTURAL FORMS BY VARYING SKY AND LANDSCAPING CONDITIONS. THIS METHOD ASSURES GOOD SEEING ENVIRONMENT IN NEW FACILITIES AVOIDING COSTLY MISTAKES. ACCURATE RESULTS ARE A PRODUCT OF HIGHLY DETAILED MODELS. LANDSCAPING MUST BE CONSIDERED AND IS AN INSEPARABLE PART OF THE DESIGN PROCESS IF ACCURATE NATURAL LIGHTING PREDICTIONS ARE TO BE MADE. USING THIS TECHNIQUE THE EFFECTS OF DESIGN ALTERNATIVES IN THE LANDSCAPE CAN BE EVALUATED IN THE SAME MANNER AS THOSE IN THE BUILDING ITSELF. THE TEXAS ENGINEERING EXPERIMENT STATION MAKES ITS MODEL TESTING FACILITIES AVAILABLE TO THE PUBLIC IN THE FORM OF A TESTING SERVICE SERVICE. THROUGH SUBMISSION OF PRELIMINARY PLANS, TESTS CAN BE MADE AT REASONABLE COST. INCLUDED IN THIS REPORT IS A DETAILED EXAMPLE OF THE TEST MODEL PROCEDURE USED IN CONJUNCTION WITH THE DESIGN OF A SCHOOL FOR GEORGETOWN, TEXAS IN 1951. AFTER THE ACTUAL BUILDING WAS COMPLETED IT WAS THEN TESTED IN THE SAME MANNER AS THE MODEL. THE COMPARATICE FIGURES SHOW THAT THE MODEL PREDICTIONS WERE REASONABLY ACCURATE. (RK)

RESEARCH REPORT 8

PREDETERMINATION OF NATURAL ILLUMINATION BY THE MODEL TESTING METHOD

by WILLIAM M. PEÑA

THE challenge of new educational specifications has impelled architects toward the use of new and untried architectural forms with their resulting natural lighting problems. Most of the technical problems involved in new buildings, including mechanical, structural and electrical lighting problems, are being engineered accurately. Until recent years, architects who experimented with new natural lighting forms were forced to rely on intuition rather than on engineering. Consequently, the results were never substantiated until the buildings were completed. Even then, there was no method for comparison.

Engineered Natural Lighting

Now, natural lighting problems can be engineered with the use of models. Model testing methods make it possible for architects to predict the lighting performance of a building early in its planning stages. This means that our clients can be given "lighting" insurance and that their school buildings need not be guinea pigs.

It also means that, as architects, we have a method at our disposal to try many, many schemes to solve the lighting problems created by new educational specifications. A testing model can be built very easily and very economically; the cost of an experimental full scale school building is prohibitive.

Model testing is the only method we know about which lets us compare architectural forms—varying sky and landscaping conditions make it impossible to com-

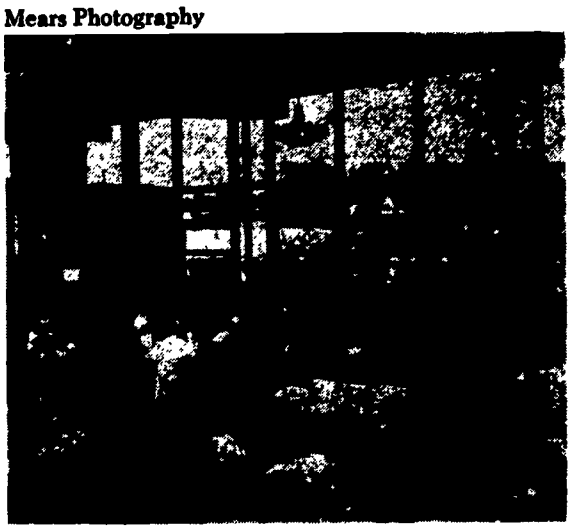
For Research Reports 1, 2 and 3 consult *American School and University* 1954–55, Volume 26, pp. 433–448.

For Research Reports 4, 5, 6 and 7 consult *American School and University* 1955–56, Volume 27, pp. 409–436.

THE PROBLEM:

Can the natural lighting performance of school buildings be predetermined before they are actually built? Or do we have to wait until buildings are completed before learning the outcome of our efforts to provide a good lighting environment? Can we take the guesswork out of new and untried natural lighting techniques?

Mears Photography



This report is based on pretests in model form and actual tests in full scale of this elementary classroom at Georgetown, Texas.

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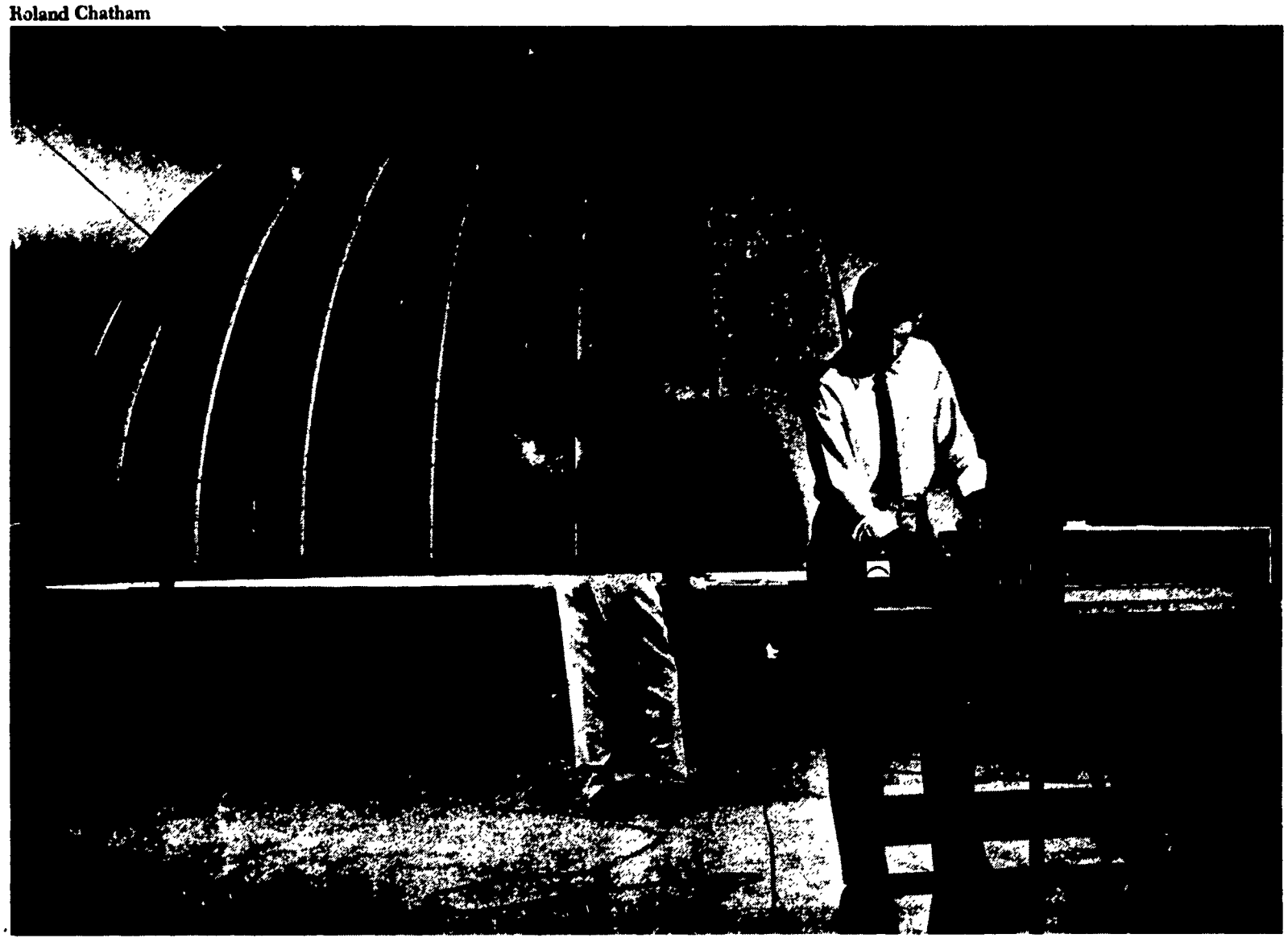
pare actual buildings, accurately. To us this means a freedom of design we never had before. And the use of models has given us the courage to try forms that we never dared to use before—and to compare them for lighting efficiency.

This scientific approach to natural illumination engineering puts lighting in its proper place. Where, before, we had to subordinate education, structures, heating and aesthetics to lighting, we now can treat the natural illumination problem merely as one of the many problems involved in the design of a school plant. Now the dog wags the tail.

Roland Chatham



This is the artificial sky under which models are tested to predetermine the lighting performance of classrooms before they are built.

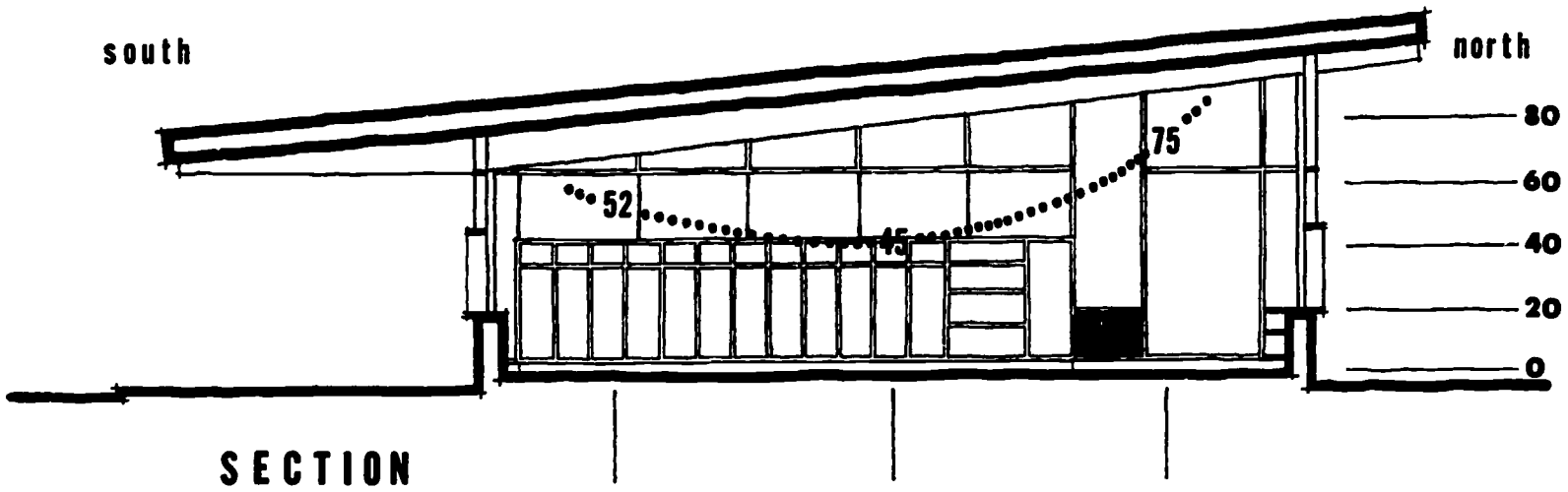
Here is one example of the use of models in predicting the natural lighting of a school building. In 1951, during the process of designing a school for Georgetown, Texas, we came up with a basic scheme having windows on two sides of the classroom and a sloping roof. The low projection of the roof formed the exterior covered corridor on the south and wa designed to keep the sun from entering through the classroom windows. This low overhanging roof made us doubtful of the natural lighting potentials of the scheme and the inclusion of skylights was considered as a third source of light. It was then decided to have the scheme tested in model form at the Texas Engineering Experiment Station, College Station, Texas.

The Model Testing Process

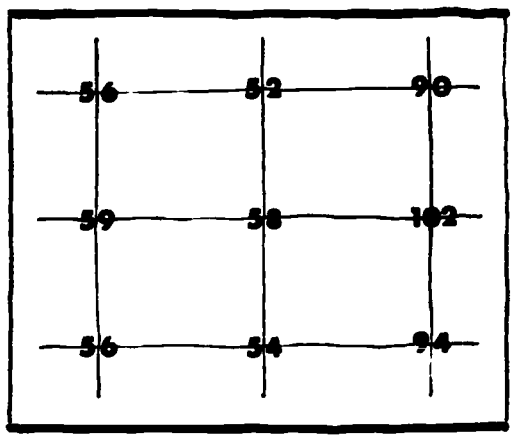
A classroom model was built at a ¾-inch scale, as nearly like the proposed building as possible. The model was then tested in the artificial sky dome with illumination valves based on a 1,000-foot-lambert uniformly bright overcast sky. Models are tested under these minimum light conditions since they represent the most critical conditions with which the actual building will be confronted.

Using light meters to read the intensities of light, two simultaneous readings were taken for each of nine locations inside the classroom model; one exterior reading on the vertical plane of the model's fenestration; and one interior reading at a scaled 30 inches above the floor level. The exterior reading always acts as a basis for comparing the series of interior readings.

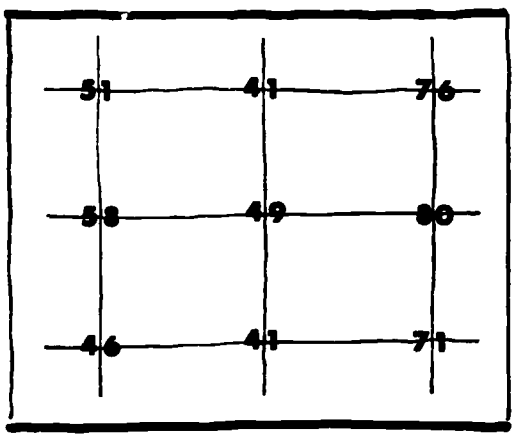
Numerous alternates to the basic scheme were also tested, including the use of skylights, an opaque wall over the north windows, exterior fixed louvers and translucent glass in the window areas. The skylights were found to be unnecessary, which was a relief to us and to Georgetown's pocketbook. The results of tests on the alternates provided valuable information on the merits of their use. This information is beyond the scope of this report; however, it is important to note that the alternate use of the variations on



SECTION



PLAN
MODEL



PLAN
FULL SIZE

The cross-section of the classroom tested is at top above. The intensity values, shown in foot-candles on the dotted distribution curve, are the average values for the full size building. A comparison of the above two plans will show that the predictions established by the model testing method are reasonably close to those of the completed building. The predicted intensities in foot-candles along the south windows are the most accurate, with an average difference of only 9 percent between the predicted and actual readings. The least accurate predictions occurred in the area near the north windows, with an average difference of 20 percent. Even though these predictions are considered satisfactory, more accurate results are now possible through the use of new and better techniques which have been developed since these tests were made.

the basic scheme was easily and economically evaluated in model form before the final solution was completely jelled.

The results of model-testing the basic scheme predicted that the classrooms in the proposed building would provide intensity levels far above the recommended minimum of 25 foot-candles for proper seeing. The lighting would have a good distribution throughout the classroom and be within the recommended maximum diversity, but it would have more excessive than desirable brightness ratios between the most poorly lighted tasks and the sky.

The quality of the light could have been improved through the use of one of the alternate schemes, but that involved decisions not directly connected with this report. It must be remembered that the quantity (intensities) of light alone does not provide a good lighting environment. The quality of light involving brightness ratios and the distribution of light requiring an even diversity throughout the classroom are equally important in good natural illumination.

After the actual building was constructed and occupied, it was then tested in the same manner as for the model, but under a real overcast sky of non-uniform brightness. The comparative figures show that the model predictions were reasonably accurate, although the predicted intensities were somewhat high near the north windows. It was felt that this discrepancy was due to the non-uniform brightness of the real sky at the time the tests were made. Tests are now made under a more realistic artificial sky of non-uniform brightness to correct this type of inaccuracy.

The landscaping of the actual building was very much like that represented in the model tests. The landscape has a considerable effect on the natural lighting performance of a classroom. This has led to the development of a new testing technique in which exterior reference readings can be taken independent of the landscape. Using this technique the effects of design alternates in the landscape can be evaluated in the same manner as those in the building itself.

Mears Photography

The elementary school for Georgetown, Texas, has a low roof projection which forms the exterior covered corridor on the south. It is designed to keep the sun from entering the building. Tests on a model of the classroom proved that skylights, as a third source of light, were unnecessary.

CONCLUSION:

Model testing of proposed buildings for natural lighting does work. It is a quick and economical means of assuring good seeing environments in new schools and sometimes helps avoid costly mistakes. It also gives an architect more freedom in design by providing a measure of assurance to what he can and cannot do with natural light.

In using these model tests, the more details that are incorporated into the model, the more accurate the results will be. Although the essence of using model tests is to evaluate a scheme in its early stages, preliminary plans from which models are to be made should be carried as far as possible in terms of the dimensions, structure, materials and other factors involved.

Landscape Is Also Important

These important details do not stop at the walls of the building. The landscape can have just as much and sometimes more effect on natural lighting as the building itself. The landscape can be man-made just as the building is and, in terms of natural lighting, is an inseparable part of the design process and must be considered if accurate natural lighting predictions are to be made.

In model studies, quick and inexpensive changes can be made in any variable both in the building and in the landscape, inside or outside the building, to determine the effect such changes will have on the natural lighting inside the building. Such variables as the dimensions of a classroom, the color of the ceiling, walls and floor, size and location of windows, location of trees and shrubs, and the color and location of screens, streets, walks and terraces may all have a bearing on the final results.

Services Are Available

The Texas Engineering Experiment Station makes its model testing facilities available to the public in the form of a testing service. Architects, school officials, anyone with a natural lighting or natural ventilation problem can submit preliminary plans and have tests made. And the charges are very reasonable.

Yes, predetermination of natural lighting is possible and greater degrees of accuracy continue to grow out of continuous development and improvement of model testing methods and techniques.

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