BUILDING
RESEARCH
INSTITUTE

The Design Potential of METAL CURTAIN WALLS

National Academy of Sciences—
National Research Council

The Design Potential of
METAL CURTAIN WALLS

Proceedings of a program conducted
as part of the 1959 Fall Conferences
of the Building Research Institute
Division of Engineering and Industrial Research

publication 788

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

The proceedings of this Building Research Institute conference on the Design Potential of Metal Curtain Walls were published with financial support from:

The Metal Curtain Wall Division
of the
National Association of Architectural Metal Manufacturers

Inquiries concerning this publication or the conference on the Design Potential of Metal Curtain Walls may be directed to:

Building Research Institute
Division of Engineering and Industrial Research
National Academy of Sciences-National Research Council
2101 Constitution Ave., N.W., Washington 25, D.C.

Price $5.00

Library of Congress Catalog Card No.: 60-60053

The opinions and conclusions expressed in this publication are those of the authors and not necessarily those of the Academy-Research Council units concerned.

Contents

ACKNOWLEDGMENTS

It is with sincere gratitude that the Building Research Institute acknowledges the thought, time and effort devoted to the planning and presentation of the conference on the Design Potential of Metal Curtain Walls by the members of a joint American Institute of Architects-Building Research Institute Committee. Those who served so ably in this respect were:

C. E. Silling - AIA Co-Chairman
C. E. Silling & Associates, Architects

Herbert F. Johnson - BRI Co-Chairman
Asst. Mgr., Building Product Sales
Aluminum Company of America

and

AIA Committee Members

Alfred S. Alschuler, Jr., Partner
Friedman, Alschuler & Sincere

Walter A. Taylor, Dir., Education & Research
American Institute of Architects

Francis R. Scherer, Architect

BRI Committee Members

H. G. Alm, Mgr., Building Products Div.
Adams & Westlake Company

Norman S. Collyer, President
F. H. Sparks Company

J. Fred Ingram, President
Ingram-Richardson Manufacturing Co.

William S. Kinne, Jr., General Mgr.
Kawneer Company

Charles S. LeCraw, Mgr., Bldg. & Constr.
Industry Sec., United States Steel Corp.

Ferd A. Leobach, Mgr., Architectural Sales,
Kaiser Aluminum & Chemical Co.

Jack Mozur, General Mgr., Architectural
Div., Benson Manufacturing Co.

Richard E. Paret, Research Engineer,
Committee on Stainless Steel Products

Robert Seery, Partner
Seery & Ward, Consultants

E. J. Tangredi, General Construction
Market Mgr., Reynolds Metals Co.

J. G. Terry, Development Supervisor
Armco Steel Corp.

The Institute extends to these committee members and to the speakers and participants in the discussion its thanks for their contribution to the advancement of the science of building.

Milton C. Coon, Jr.

Milton C. Coon, Jr.
BRI Executive Director

Abstracts of Conference Papers

MORTON SALT COMPANY BUILDING
T. Clifford Noonan, Graham, Anderson, Probst & White

Influence of the site on the design of this building is noted, and considerations which determined the choice of materials are described. Details of panels, windows and spandrel sections are given.

* * * * * * * * *

CONNECTICUT GENERAL LIFE INSURANCE BUILDING
Allan Labie, Skidmore, Owings & Merrill, Architects and Engineers

This paper discusses the reasons behind the selection of materials used in this building and the tests conducted to establish the validity of the choice. The problems connected with design, fabrication and erection are also pointed out, particularly as regards the necessity for developing a new method of handling the large lights of glass on the site. Performance experience is given and the author also comments on the matter of success in maintaining control over architectural intent in design during the fabrication and erection of the curtain walls.

* * * * * * * * *

NEW ORLEANS PUBLIC LIBRARY
Sidney J. Folse, Jr., Curtis & Davis and Associated Architects and Engineers

The original design concept for this building is described in terms both of the building and the site. Five design problems are listed and their final solutions detailed. Analysis of structural design problems in connection with the solar screen and experiments with the fabrication and finishing of the egg-crate structure are presented step-by-step. Shop fabrication problems in connection with the various components of the wall are also enumerated and methods devised to assure their satisfactory production. Performance experience is given, supplemented by an appraisal of the finished building in terms of aesthetics, psychological effect on the occupants, and the economics of the construction. An appendix describes the design and construction of a heliodon for the purpose of testing the solar screen designs.

* * * * * * * * *

SHERATON HOTEL, PHILADELPHIA
Robert C. Dean, Perry, Shaw, Hepburn & Dean, Architects

Design considerations peculiar to hotel buildings are discussed as they affected the planning and design of this structure, as well as the somewhat unusual site. Reasons for selection of grill and finish materials are enumerated and the details of panel fabrication are explained. Failure of the curtain wall during a severe windstorm is described, and also the causes of the failure as determined by subsequent investigation.

* * * * * * * *

LUTHERAN BROTHERHOOD BUILDING
John E. Starrett, Perkins & Will, Architects-Engineers

Attention is called to the discipline of a repetitive module as one of the factors in assuring the economy and quality of fabrication of curtain wall construction. Exploratory work by the architectural office including visits to factories and fabricators is mentioned as being highly valuable in subsequent cost evaluations. Performance experience over a period of four years is outlined, and the excellent performance obtained is attributed in part to prior agreement among all responsible principals on quality and performance required, and in part to thorough testing in a complete mock-up to establish the performance potential of the building. Attention is called to the cost advantages of factory fabricated components and adherence to the use of stock production modules. The author states that the secret of the successful metal curtain wall is the secret of joints and junctures honestly analyzed and thoughtfully solved.

* * * * * * * *

FABRICATION POSSIBILITIES AND TOLERANCES
J. M. Roehm, Kawneer Company

Recent trends in curtain wall building design are discussed and illustrated, and the author separates these into three different systems of metal grid design. Pan type and adhesively laminated panels are examined in terms of their various properties. Panel type walls, both custom built and those using stock panels of rolled or braked elements, are compared as to appearance and durability of various types of finishes, as well as factory control of tolerances, on-site fabrication, etc.

* * * * * * * *

DESIGN FOR EFFICIENT FIELD ERECTION
Norman S. Collyer, F. H. Sparks Company, Inc.

The related problems of tolerances and clearances encountered by the field fabricator of curtain walls are cited, with special emphasis laid on better control of the present amount of field cutting and fitting. The author points out that problems of tolerances and clearances occur not only in high-rise structures, but also in one and two story buildings where light, unbraced steel is difficult to keep plumb and in line. He cautions designers not to require sections too big or too heavy to be handled by a job hoist or four men. He also recommends avoidance of the use of scaffolds where possible, and that lines and grades be established, maintained and coordinated by the general contractor to lessen confusion on the job. Special problems of the field fabricator with joints and joint sealants are also discussed and the high costs involved when the erector must concern himself with the handling and matching of delicate finishes and colors.

* * * * * * * *

COLOR AND FINISH CONTROL WITH FERROUS METALS
J. P. Butterfield, Armco Steel Corporation

Four basic methods for control of both color and finish of ferrous metals are set forth in this paper: metallic coatings, organic coatings, inorganic coatings and stainless steel. Current work in development of porcelain enamel finishes and the control of color are described. The uses and properties of four types of stainless steel used in curtain wall construction, and reasons for preference in each type of application are detailed. The author recommends control of quality by specification and inspection, and urges architects and contractors to consider quality of past performance rather than low price in the evaluation of bids.

* * * * * * * *

COLOR AND FINISH CONTROL WITH ALUMINUM ALLOYS
C. J. Walton, Aluminum Company of America

The various types of coatings used to provide color in aluminum curtain wall components are described. It is pointed out that the combination of the use of special alloys with anodic coating of the surfaces has now produced at least 11 different colors for aluminum which can be reproduced with good color match. The pigmentation of porcelain enamels and organic coatings for use with specific aluminum alloys is also discussed, and the excellent weathering performance of finishes of this kind is illustrated by quotation of recent laboratory test results.

* * * * * * * *

NEW METAL CURTAIN WALL SPECIFICATIONS
Ralph L. McKenzie, Natl. Assn. of Architectural Metal Manufacturers

The rising need during the past ten years for an authoritative guide to metal curtain wall design and construction is described as a prelude to a discussion of the Metal Curtain Wall Manual recently issued by the Natl. Assn. of Architectural Metal Manufacturers. Contents of the Manual, consisting of sections on terminology, bibliography, specifications, reference standards, design principles and economics are discussed and explained, together with some of the reasoning behind the recommendations included.

* * * * * * * *

ARCHITECTURAL CONTROL OF FABRICATION AND ERECTION
Alfred S. Alschuler, Jr., Friedman, Alschuler & Sincere, Architects

This paper attacks the monotony of design which is beginning to creep into the newer curtain wall buildings. To achieve better buildings, the author suggests that more attention be given to varying the treatment of the large and prominent vertical and horizontal members of the structure; that they be shaped, varied in spacing, color, width, material, texture and length to give more interest and attractiveness to the structure. He also presents the idea of recessed or projected panels which might be round, spherical, diamond shape or free form. Likewise he urges variation in the basic form of the building away from the rectangular where possible. Closer association with the manufacturer is mentioned as one of the ways that architects can help influence production of more, and more varied, components and materials.

* * * * * * * * *

AN APPROACH TO ARCHITECTURAL DESIGN WITH METAL
Carl Koch, Carl Koch & Associates

This paper points out the need for each segment of the construction industry to take a much more responsible attitude toward the industry as a whole in the matter of research for better buildings. He also warns that if the industry does not work together toward its common goals, expansion of the industry in the future may be taken over by people not presently in the business of building at all, citing the fact that the house trailer industry accounted for from 12 to 15% of new housing starts in 1958. Architects are also urged to work with builders and city planners to give new form to our urban and suburban areas, and all concerned are counseled to bend efforts toward making urban renewal work faster, more effectively and with better imagination.

CASE STUDIES OF SELECTED BUILDINGS

Keynote Address

By George E. Danforth*, Conference Chairman
Director, Dept. of Architecture Department
Illinois Institute of Technology

In very simplified terms, the objectives of this conference on the Design Potential of Metal Curtain Walls are:

1) To consolidate recent experience with metal curtain walls and

2) To develop data which will permit architects to work in this comparatively new medium with the greatest possible latitude.

As many of us know well, the contributions of these Building Research Institute research correlation conferences become a productive source of information for those working with all aspects of the design, construction and erection of buildings. I am sure that you will find the proceedings of this particular conference no exception to that rule.

*GEORGE E. DANFORTH came to his present position from Western Reserve University, where he was for six years chairman of the architectural department. In addition, he has served as architectural consultant to United States Steel Corp. since 1957. Mr. Danforth did his undergraduate work at Armour Institute of Technology, and his graduate work at I. I. T. He is a member of AIA, the American Society for Aesthetics, and the American Society for Engineering Education.

Morton Salt Company Building

By T. Clifford Noonan*, Vice President
Graham, Anderson, Probst & White

On behalf of our firm, Graham, Anderson, Probst and White, I wish to extend our congratulations to the Building Research Institute for the notable contribution it is making to progress in the construction industry. The subject of this conference, "Design Potential of Metal Curtain Walls" is very challenging, exciting and provocative. The theme of my assignment is to investigate and probe the techniques of design, fabrication, and erection of curtain walls of stainless steel as they were used in the Morton Salt Building in Chicago.

This building, which houses the principal offices of the Morton Salt Company, is located on Wacker Drive between Randolph and Washington Streets and with frontage on the Chicago River. It is approximately 360' on Wacker Drive by 141' on Washington Street. Wacker Drive is a two-level street which permitted access to the basement level directly for car parking and service facilities. The grade elevation of the river and the elevation of upper Wacker Drive enabled us to introduce one additional story with outside exposure below street level.

The panel wall construction used on this building is entirely of stainless steel with the exception of the interior facing material on the inside. The stainless steel windows are of the pivoted type, and are installed after the stainless steel spandrel sections have been put in place. The spandrel sections are fastened at the side and the top. The inside face is carbon steel, of course, and the exterior face is stainless steel.

Figure 1 is the Wacker Drive elevation where four floors are visible. Figure 2 shows the river side which is more or less a duplication of the same module, except here we have picked up an additional floor by virtue of the difference in grade between Wacker Drive and the river level.

You may also be interested in some of the reasons for our decision to use stainless steel curtain wall construction. Our designers gave serious consideration to many types of facing materials for the curtain walls. Design criteria as well as a comparison between the wearing qualities and other properties of stainless steel and other materials were studied.

---

*T. CLIFFORD NOONAN is a graduate in architecture from the University of Notre Dame, a member of AIA, and a past director of the Illinois Society of Architects. He was recently active in the planning of the new State Department building in Washington, D. C.

THE MORTON SALT COMPANY BUILDING
Architects - Graham, Anderson, Probst & White
Photographs by Hedrich-Blessing

Before I indicate some of the things we learned, let me remind you of one important fact. An architect is an individualist. He wants to be remembered; he wants to be admired and respected. In this, he is exactly like every other human being. When he creates a new building, he makes certain that it can be identified as his, and only his, because it represents his creative ability.

But there are many architects--good ones, too--and very often the same ideas may occur to different architects simultaneously, just as playwrights, musicians and novelists get similar ideas simultaneously. So we in architecture are constantly on the alert for something that will serve as a catalyst to our design ability. We are always searching for a new, creative and challenging building tool. And in this situation we found one, the metal curtain wall.

What, then, are some of the advantages of stainless steel? And what are some of the characteristics of this metal which helped us decide to use it, as opposed to other materials?

To begin with, it is strong. Type 302, which is what we used, has a yield strength of 40,000 psi. Stainless steel is durable. It resists corrosion, because chromium is used as an alloy in the stainless steel. Thus we can say that this corrosion resistance is a characteristic of the metal itself. It is not merely a coating or plating treatment. Another factor in its favor is its availability. As far as we can determine, there are no mechanical limitations on design or construction of a wall, and any size which can be manufactured and handled is available. There seem to be no limitations in standard manufacturing techniques which can be performed on this material.

As to the design criteria, there are certain restrictions placed on the architect and also on the fabricator by this metal, but oddly enough, placed there by reason of its virtues. Because of its great strength and also because of its corrosion resistance, you don't need extra weight or extra thickness. Therefore, you are at liberty to use light, hollow sections. In fact, it is even possible to reduce weight in structural grids by the use of self-framing units.

To eliminate optical distortion which, by the way, is a problem when using any sheet metal, it is recommended that flat areas be minimized or eliminated. The use of concave panels is one method. We, however, used the fluted panel method. Other ways to do this are use of a small textured, pressed panel, or an over-all rolled-in texture panel.

Stainless steel can be obtained with a variety of mill surface finishes, ranging from rather dull to very bright. It is also available in a limited number of colors, but this technique--an oxide treating of the surface--has not been perfected to the point where colored stainless is commercially practicable.

After weighing all these things, it was finally decided to use sandwich panels of stainless steel as the most desirable medium. All sash, window mullions, spandrels and all detail in the curtain wall areas are of stainless steel.

The sandwich panels are 8'6" wide by 5'9" high, and are 2" thick. Exterior stainless steel is type 302 (18-8) fabricated from 20 gauge, with the vertical flutes approximately 16" on centers. Panel insulation consists of 2" of glass fibre.

Actual production of the spandrel sections of the 20-gauge material has proved that this gauge, if carefully fabricated and if proper consideration is given to shipping and installation, is most satisfactory and successful. And, of course, I need not remind you that rapid erection and economical construction, two virtues of curtain wall in any material, are always to be desired.

To summarize, our reasons for choosing stainless steel were:

1) Stainless steel has enduring beauty.

2) It can be erected with ease and with speed.

3) It permits more space in the enclosure because of the thin exterior wall.

4) It is relatively maintenance free.

New materials are developed to meet a need, sometimes to save money, sometimes to meet a specific structural problem. I am inclined to think, however, that these curtain walls were developed because the modern architect decided there was a better way of doing things. So that, instead of having 30 or 40 stories of masonry, brick piled on brick and stone upon stone, this new method was conceived.

This willingness to try new things is what makes for progress. Building techniques have made more progress in the last 10 years than in the previous half century. That's why I never despair about architecture. It has its ups and its downs, its fads and its cycles, but underneath it all is a pulsating, vibrant force that always moves forward. I believe that in designing the Morton Salt Building, we have been a part of that force. I further believe that in this design we have blended a number of things: art, science, technology, into something both beautiful and practical.

Connecticut General Life Insurance Building

By Allan Labie*, Associate Partner
Skidmore, Owings & Merrill, Architects & Engineers

Introduction

As far as humanly possible, we endeavored to select the most suitable combination of materials which would serve as the exterior enclosure for the Connecticut General Life Insurance Building with reasonable certainty that a durable exterior could be economically maintained in its original condition. During this development, we were fortunate in having the services of Professor Walter Voss of MIT who was engaged by Connecticut General to serve as a construction consultant. Since the owner felt it advantageous to select the contractor during the design phase to fill out the team, we were able to add the wide experience of the Turner Construction Company to the work at hand.

We dedicated ourselves to this task, supported by the owner's desire to construct a building embodying the most up-to-date technology, and as free from maintenance as practicable. This assignment took approximately one year for study and testing, not only of the materials used in its construction, but also of the interrelated problems such as heating, air conditioning and sun control.

Selection of Materials

Broadly speaking, we seriously considered only aluminum and stainless steel for the enframement. Other metals and finishes, such as chrome-plated bronze and painted steel and aluminum were reviewed in the early stages and not considered further, due primarily to high initial costs or problems of maintenance. Our analysis of air conditioning designs indicated the advantages of using heat-absorbing glass. The typical windows are 8' high by 11' wide. These rather large lights of glass were used in the design to take advantage of the beautiful view.

Before offering any recommendations to the owner, Professor Voss set up and directed a test program to corroborate the information we had received from manufacturers of the materials under consideration. The tests provided for an examination of the weathering characteristics of aluminum, stainless steel, synthetic rubber gasketing and sealants. They also determined the resistance of heat-absorbing plate glass to wind pressure and thermal shock. We also explored possible crazing and delamination of plate glass with

*ALLAN LABIE is a graduate of New York University, and holds membership in AIA. His firm is a member of BRI.

ceramic coated backing and the efficiency of cushioning and sealing the large panes of glass to provide relief during deflection and to provide for watertightness. Tests on flexing and watertightness of gasketing and sealants were conducted by Professor Voss in the laboratories of the Massachusetts Institute of Technology.

The materials were subjected to exposure in the Weatherometer and Fadometer, freezing and thawing, water immersion, salt sprays and ultra-violet.

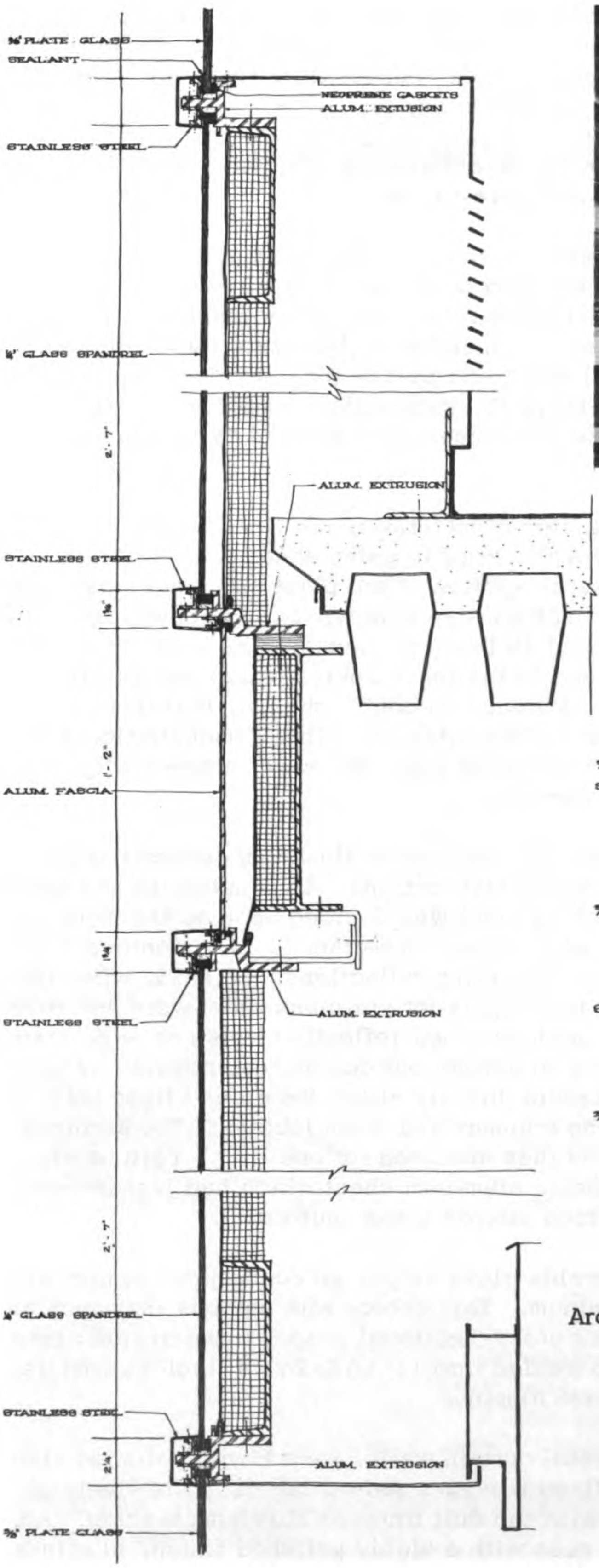
Although these accelerated tests were performed during a limited time and their evaluation is difficult, the tests, in combination with existing data from other sources, justified our belief that if the exterior skin was fabricated and built in the manner detailed on the drawings and with the materials specified for use, the metal and glass exterior would be durable, weathertight and readily maintained. I might add that in the considered opinion of Professor Voss this skin will have a life of 60 to 75 years without showing any excessive pitting or other corrosive effects. This expected longevity is favored by the rural location as opposed to an industrial atmosphere.

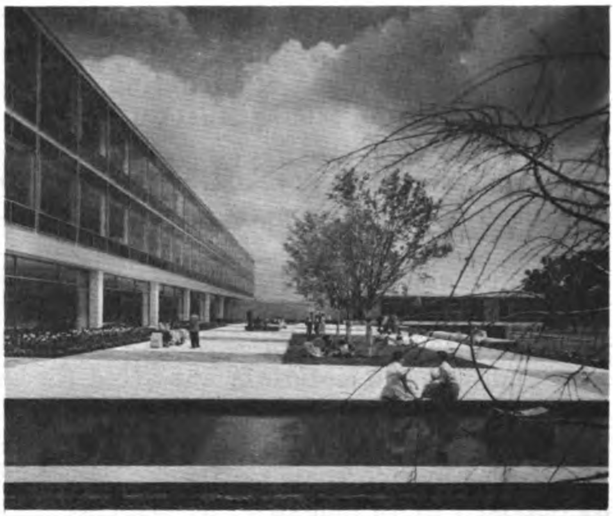
With complete data to substantiate our selection of materials, the final design was presented to the owner and received their approval. Prior to going ahead with the work, the sub-contractors for the wall erected a full-size section at the plant and ran a most rigorous dynamic test, exposing the sample panel to 120 mile an hour winds and heavy rain. The section deflected as much as 2" but developed no leaks or cracks. The value of dynamic tests has been criticized by many, mainly due to the inaccuracies which can be eliminated in static tests under laboratory conditions. No one can doubt, though, that this is a severe type of test producing vibrations and sudden stresses. This demonstration was the finale to many tests which preceded it, and served to show the owner dramatically that his building could take a beating from the elements.

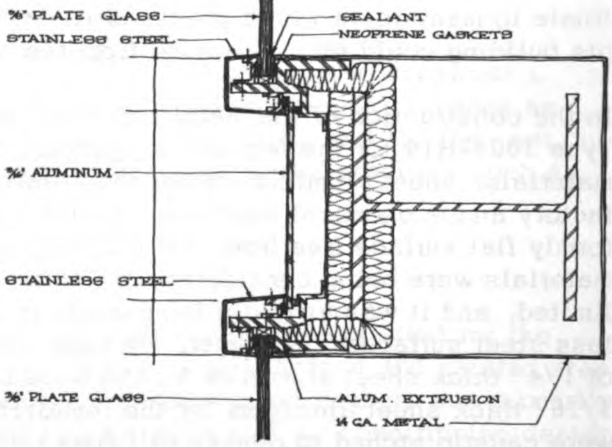
In the construction of the metal enframement, we used sheet aluminum designated as Type 3003-H14 for the facings of spandrel beams and columns. In considering the facing materials, sheet aluminum rather than stainless steel was decided upon as the more satisfactory and economical solution. Aesthetically, it was important to us to achieve a uniformly flat surface free from "oil canning" or disturbing reflections. In 1955, when these materials were being considered, finishing techniques for stainless steel were somewhat limited, and it was virtually impossible to produce a non-reflective finish on wide stainless steel surfaces. However, we were able to satisfy our design requirements by use of 1/4" thick sheet aluminum for the wide fascia directly above the ground floor level and 3/16" thick sheet aluminum for the remaining columns and beam facings. The surfaces were caustic etched to remove roll marks and then anodized for one hour. Fortunately, the manufacturer was able to furnish an anoclad aluminum sheet which had just become commercially available at this time, and which offered better uniformity.

For the supporting frame members and removable glass stops, an economical design was achieved using Type 6063-T5 extruded aluminum. This choice was obvious inasmuch as the extrusion process can produce a complex cross-sectional shape in one simple operation. These frame members were then shop welded into 11' wide by 14' high assemblies which fastened directly to the steel structural framing.

For a touch of elegance, often lacking in metal curtain walls, we added a polished stainless steel cover mold to the frames of the fixed windows and spandrels. The gleam of these trim moldings contrasted beautifully with the dull finished aluminum fascias. Aluminum moldings were also considered but, even with a highly polished finish, aluminum







THE CONNECTICUT GENERAL LIFE INSURANCE COMPANY BUILDING
Architects - Skidmore, Owings & Merrill
Photographs by Ezra Stoller

lacked the contrast achieved with the Type 302 stainless steel. This polished stainless steel treatment was extended to include frames between the marble covered columns of the ground floor level as well as of the dining room wing and the penthouse level.

The glass we recommended for windows, 3/8" thick heat-absorbing polished plate, had never before been mass-produced. About 600 lights were required for the job. While absorbing about 50% of the sun's heat, they also reduce glare 50%, a necessity in a building having this much glass.

Above and below the windows, the spandrel sections are of heat-treated glass, ceramic coated on the back. This ceramic coating, especially in the almost black color we chose, was visually a mirror. A 1/4" thickness was recommended and so specified, but the spandrel glass in this gauge warped during the heat tempering process, creating a distorted surface. Installed, we noted disturbing reflections. This was unacceptable to our office. Distortion was considerably minimized by increasing the glass thickness to 3/8".

For watertightness, the entire construction was cushioned in neoprene gaskets and sealed with a polysulphide material. This detail was applied to every field joint, metal fascias to frame, glass to frame and frame to flashings. The entire wall was free to expand and contract and deflect with the forces of nature, always remaining sealed.

<u>Problems of Design, Fabrication and Erection</u>

Initially, we were faced with the problem of achieving for the client his desire for a virtually maintenance-free enclosure. With the durability expected, the upkeep was to be limited to periodic washing of the wall, occasional repairs to sealants and possible replacement of damaged glass. In order to do this, means had to be provided to reach all exterior wall areas, including the four inner courts and the connecting passage.

Since the building was not situated on flat terrain and the perimeter was interrupted by covered walkways and ramps, the solution to the glass washing problem was to use a roof-mounted machine which would travel horizontally around the building on roof tracks completely free of the walls and stabilized against sway by use of a system of interlocking telescoping frames to form a rigid guide for a platform, free to raise and lower vertically. From this platform, two men can safely do the cleaning.

Fabrication of the component parts, to my recollection, posed no special problems which could be attributed to the design. I mentioned earlier that we had problems trying to obtain uniform color of the aluminum facing. Our field representative did not endear himself to the curtain wall contractor when he advised juggling the aluminum panels to minimize the mismatching. However, it did improve the appearance markedly.

Prior to the start of the erection, the lines and grades crew were baffled by the seeming impossibility of establishing working base lines and column centers. It was found that the building frame had a tendency to follow the sun, expanding and contracting as the sun moved over. By mutual agreement, everyone agreed to use the lines established at high noon. Once underway, the metal enframement proceeded quickly, each frame being fastened to clips welded directly to the structural steel. To carry the load of the glass and wind forces, a girt channel at the window head and sill was installed by the curtain wall contractor.

Locally, the code permitted the steel to be non-fireproofed and this too, simplified erection. Being able to leave the steel exposed allowed the enframement to be clipped directly to the steel members, and we did not have to cope with concrete or masonry usually out of proper alignment.

For thermal insulation of the wall, rigid foamglass 2" thick was used behind the spandrels and metal facings, positioned to allow for an air space between the face material and the insulation. Blocks were assembled into 2-1/2' x 5-1/2' panels and installed between frames.

To solve the prodigious problem of installing this vast expanse of glass, the manufacturer devised a special machine to do the job. For years, glass manufacturing plants had been using the suction cup principle to hold sheets of glass moving from one process to another. In this system, the glass is usually handled in a horizontal position. On the site, however, the glass had to be handled vertically, raised high in the air and held steady until the installation was complete. The specially designed rig was run on rails set along the building, enabling the crew to move this device sideways along the length of the structure.

At ground level, the cases of glass were leaned against the building. The suction cup machine was then swung against the glass and the vacuum pump started. A visual inspection made certain that all eight cups, each capable of lifting 500 lbs., had made proper contact. An electric winch hoisted the glass to the required level and a small hand crank allowed workmen to inch the glass exactly into position. The machine enabled an eight-man crew to set about 10 sections a day. This was the first use of suction apparatus to move glass on the exterior of a building under construction.

The polysulphide sealant posed special problems. The material had to be mixed on the site under controlled conditions, applied to joints that were free of dirt and moisture, and carefully ground into the joint. To insure a good job, an independent testing agency inspector, hired by the owner, was assigned to inspect every inch of the sealed joints. The 3/8" thickness of glass simplified this since it allowed good vision down into the rabbet. For neatness, we specified masking along all joints to be sealed. The problem of the protection of the metal during erection was not particularly serious since the concrete work was practically completed prior to the starting of the erection.

Performance Experience

The building has been occupied since the summer of 1957, and the curtain wall was completed six months before. This provides us with three years on which to base performance experience. I visited the job recently, mostly to get my own impression of how the wall is behaving. Much to my satisfaction, I found not a single sign of deterioration of any of the curtain wall components. The owner is pleased with the ease of maintenance and absence of repair work. The entire building seems as handsome and fresh as it did on the day of its completion.

Nothing has occurred that would indicate any modifications were we to duplicate the work today. The materials used appear to haye been suited to the job beautifully, and offer testimony to a careful approach to detail and design.

Control over Architectural Intent

Insofar as this particular project is concerned, we are discussing a custom curtain wall, specifically engineered for a given building, designed and detailed by a clearly defined set of working drawings and specifications. The fabricators who were to bid on the work were carefully screened by the owner's consultant, the contractor and our office to insure that only the most highly qualified would be allowed to do the work. Nothing was left to chance; the shop drawings were scanned in great detail, samples of actual materials down to the type of screws used had to be submitted for approval. The dynamic weather test included in the specifications as a part of the work had to be completed prior to starting shop work.

Our office maintains a high standard of field supervision to further provide for the desired control. Coupled with contractors equally anxious to do the best job possible, the outcome was most assuredly predictable.

New Orleans Public Library

By Sidney J. Folse, Jr.*, Associate
Curtis & Davis and Associated
Architects and Engineers

Design Concept

The curtain wall design for the New Orleans Public Library was generated by a single concept in the program of requirements furnished to the architects by the Librarian. That concept was.... "that the building should be a department store for books, whose showcases would be the walls of the building, with the interior of the library as the constantly changing display." This was an enlightened statement with strong foundations to support it.

The building is located within one square of the Canal Street shopping district which is the heart of retail merchandising in New Orleans. For the library to be successful in merchandising its "wares" and services, it has to display them as forcefully as the nearby shops and department stores. Secondly, the building is located at the intersection of two major thoroughfares, Loyola Avenue, a new north-south boulevard created as an artery into the new Civic Center, and Tulane Avenue, the principal east-west thoroughfare into the heart of the business district. With traffic moving at speeds of 25 to 35 miles per hour, anything less in the way of showcases than all glass walls would have lost its selling impact by not remaining long enough within visual range.

It is important to establish, here at the outset, the importance of this particular program requirement. Without it, the design we are discussing would probably not exist. It is almost certain, in deference to the external forces acting on the design of this building, that the firm would not have had the courage to design a library with all glass walls. These forces are, of course, the distraction of the boundary traffic, climate considerations in connection with air conditioning, and the problem of glare control from sunlight.

In view of this statement, it may be wise, before proceeding into the technical presentation of this design, that we take caution lest, in our technical research, we lose sight of the fact that true architecture springs from humanism, and that research provides us with the science, methods and tools for the expression of human philosophy. This is the element that distinguishes architectural approach from a purely technical approach.

*SIDNEY J. FOLSE, Jr., prior to his present affiliation was a member of the staff of Diboll-Kessels & Associates. Mr. Folse studied at University College, Tulane University, and is a member of the New Orleans chapter of AIA.

Design Problems

Faced with an all glass building, the problem of design resolved into one of finding a solar control device which would satisfy the following conditions:

1) Protect the glass walls from direct solar radiation during the summer months to reduce air conditioning load.

2) If possible, be an effective barrier against penetration of the sun at all seasons, obviating the need for interior control devices such as venetian blinds and drapes. To accomplish this, the solar device would have to be effective from 9:30 A. M. until sunset on three different orientations, at all seasons of the year.

3) Provide diffused light without glare.

4) Allow sufficient visibility to retain the openness characteristic of the design concept.

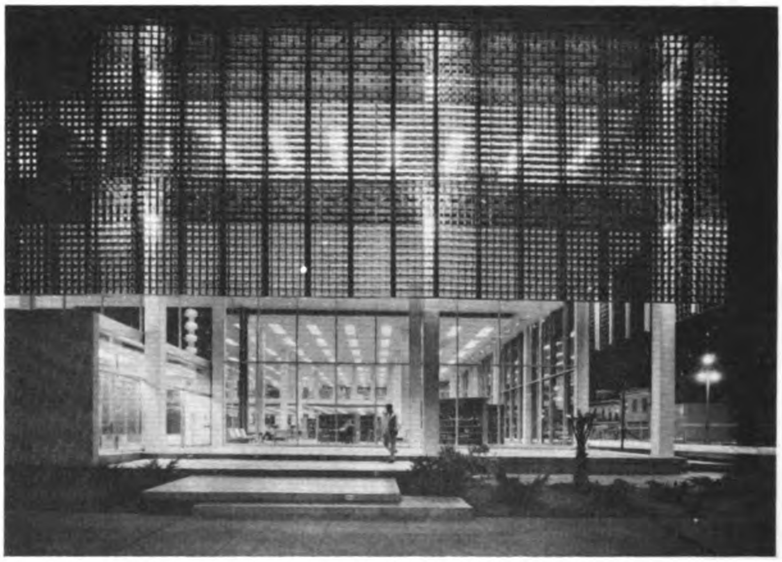
5) Be an esthetic solution to the facade design.

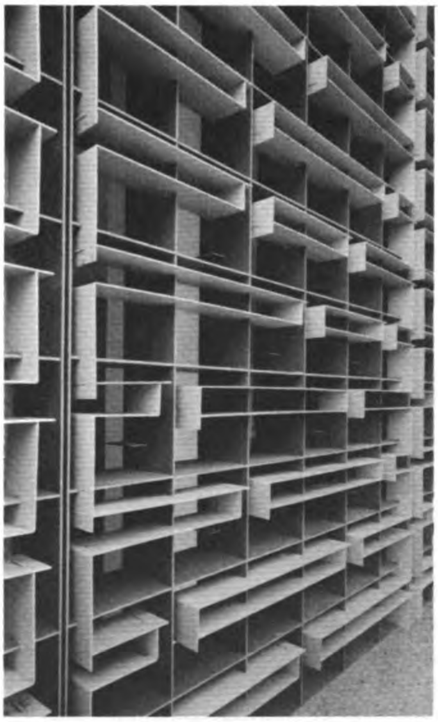
Research into available systems of solar control soon revealed that the desired function, plus the proper esthetic effect, could only be achieved in a custom designed product. Drawing on a local tradition of ornamental iron screens, it was conceived that a similar treatment in depth could be designed in the modern idiom, not only controlling the sun but also providing the desired aesthetic effect.

It was evident that the varied factors controlling the design would require many changes and adjustments during the design stage, and the use of the graphical method of projecting the sun's rays would be laborious and arduous. To assist in the design, a heliodon (a device to measure the shadows cast by a body for a given location and time) was constructed. (See Appendix I.)

Since the solar screen was to comprise the major portion of the facade, scale and visibility were the first considerations in fixing the aperture size and depth. For testing purposes, one-half size wood models were constructed for testing on the heliodon device. It was decided from the outset that an attempt would be made to satisfy conditions 1 and 2 of the design criteria established.

After several tests, a regular egg-crate of 8" squares, 6" deep, was selected. The egg-crate offered simplicity of fabrication and inherent strength. This unit was tested to determine the amount of sun penetration and it was found that the verticals were effective for all conditions, but the spacing of horizontals was too great. To correct this condition, and to provide a secondary rhythm in the screen, an overlay was designed to be mounted on the outer face of the egg-crate which, in effect, was simply two small horizontal louver blades crossing each of the 8" x 8" apertures near the top of the opening, resulting in a reduced spacing of the horizontals. To relieve the mechanical appearance of the system, the horizontal blades of the overlay were interrupted and several of them connected together vertically to form an irregular tracery over the surface of the egg-crate. Where the horizontals were interrupted, the penetrations of sun were trapped by small horizontal fins notched into the rear of the egg-crate. All of the sizes, spacings and depths of members were determined using the heliodon, which allowed all dimensions to be established accurately, with only small tolerances for safety factor. The accuracy of these





NEW ORLEANS PUBLIC LIBRARY
Architects - Curtis & Davis and
Associated Architects and Engineers
Photographs - Frank Lotz Miller

determinations naturally meant lower costs in pounds of metal. At this point, all of the desired design conditions had been met except to determine if light reflecting from the surface of the screen would be sufficiently diffused to provide uniform, glare-free daylighting.

It should be pointed out that on the west elevation, in the mid-winter season when the sun altitude is low, the solar screen is not effective in preventing sun penetration. To avoid the use of drapes on this elevation of the building, a special plate glass was specified, permitting 12% to 15% light transmission, which was sufficient to control this condition effectively.

On the remaining elevations, it was discovered by experiment under sunlight conditions that any color except a dull charcoal gray would cause reflections and produce hot spots with undesirable brightness contrasts. This was something of a disappointment, since the screen had been conceived in two colors, one for the egg-crate and one for the overlay. In the final analysis, this was achieved by making the screen of aluminum, anodizing the egg-crate charcoal gray and the overlay in natural aluminum finish.

To reduce to tolerable levels reflections from the satin aluminum finish of the overlay and from adjacent buildings, glare-reducing plate glass was used. This glass, also being heat-absorbing, assisted the air conditioning design from the standpoint of reducing diffused solar radiation which might penetrate the screen.

Materials

The total wall of the library consists of large fixed glass plates in a standard alumilited aluminum, puttyless, glazing bar system, with an aluminum solar screen suspended approximately 4'-0" in front of the glass wall. The 4'-0" module was used in plan layout and this determined the location of the solar device 4'-0" beyond the centerline of columns occurring in the exterior glass wall.

The glazing system was designed by the glass manufacturer and is puttyless except for the junction with concrete columns, where a polysulphide material was used as a sealant. Our office has adopted as a standard a five-year guarantee against leaks and other defects in factory designed systems. The guarantee was furnished for this system.

The reasons for selecting aluminum, both for the glazing members and the solar screen, was the desire to use only one exposed non-ferrous metal throughout the entire project. Aluminum was selected because of the large variety of standard architectural products available in this metal in controlled, matching finishes, from a large number of manufacturers. In the case of the solar screen, the advantages of aluminum's light weight, color possibilities, structural strength and ease of fabrication all served to reinforce this selection.

Structural Design

There were two problems of structural design involved in the solar screen: 1) the screen proper and 2) the structural system to support the screen 4'-0" in front of the glass wall.

The solution to the problem of support of the screen was found by searching for a structural unit which would act in two directions equally well; resisting the vertical static loads and, simultaneously, the horizontal and vertical forces of wind loads. These conditions suggested a triangulated space frame which was found to be feasible and was utilized in the final design. Aluminum was used in the space frames because of its permanence, and because the space frames were an integral part of the design, being visible through the screen. Because of this visibility, the open web construction of these frames was also desirable from an aesthetic viewpoint.

The frames were designed to span from column to column, a distance of 28'-0" on the front elevations and 22'-0" on the side elevations. They are supported by cantilevered aluminum brackets bolted to the columns, to which the frames are anchored at one end, and bolted with slotted holes at the opposite end to provide for expansion and contraction. The lower space frame (second floor level) is also utilized as a catwalk for washing the fixed plate glass wall. An aluminum grating was placed on the top horizontal surface. At the roof, the space frame was covered with ribbed aluminum sheet.

The design of these units posed no particular problem, except the education of structural designers in the properties of the structural alloys, and their modified characteristics after welding. This was quickly solved by utilizing the consulting services of the aluminum manufacturer, whose contributions throughout all phases of the design should not go unrecognized.

The solar screen was somewhat more difficult to analyze, and the problems more varied. We were faced with determining member thicknesses; the size of the unit to be fabricated; providing for expansion and contraction; designing splice connections; finishing of the screen, and erection methods. At this point in the development of the design, we called on the services and advice of the nearest fabricator in the region capable of handling such a project.

Sizing of a basic unit for fabrication was the first step, and this was limited by the size of anodizing tanks available. It was determined that tanks were available 4'-0" wide, 5'-0" deep and 24'-0" long. It was desirable to minimize field splices, so the largest possible unit was selected, 4'-0" wide (building module) by 13'-0" long (half of the height of the solar screen). The weight of this unit was approximated at 250 lbs., which could be easily raised by an electric hoist, so this size was accepted.

Engineering of the egg-crate structure was the next step. The obviously economical method of half-notching the verticals and horizontals was selected, with welding employed at the junction of the two notches along the center plane of the egg-crate.

The thickness of the egg-crate members was a function of the 4'-0" span and was determined to be 3/16" thick. Because each member was notched half its depth, 3" was assumed to be the depth of the spanning members. As a measure of added safety, the horizontal bearing bears were notched toward the front of the screen, so that when deflected under wind pressure the notches would close and tighten against the verticals passing through the notches. The vertical members banding the side of each 4'-0" wide unit were slotted, and the horizontals were dovetailed into these slots and welded continuously.

Since there was only one horizontal splice in the 26'-0" height of the screen, there were no structural problems, the vertical bars being considered as non-loading bearing. Splices were ship-lapped and bolted within an 8" aperture so that the appearance of vertical continuity was achieved. The size of the bolts was governed by expansion and contraction forces acting on the two plates in shear.

Each 4'-0" unit of width of screen was joined to the adjacent one by structural aluminum channels welded to the rear of the unit at each edge. When two units were placed adjacent, the two channels become an H-section, and the channels were bolted together so that they would act in unison. It should be emphasized that the 6" deep solar screen units in the plane in front of the channels were not joined--only the channels at the rear. This was the method utilized to compensate for expansion and contraction. One-quarter of an inch was maintained between the webs of the back-to-back channels, providing the same space between the screen units. The distance from the outer surface of the screen to the centerline of the bolts in the channels is sufficient so that temperature displacement at the heated outer surface occurs in an action similar to the operation of tongs. Expansion in the 26'-0" height of the screen was not considered sufficient to warrant special consideration.

The final problem to be solved was finishing. Our desire to have two colors at first presented a complication in the fabrication, since the two elements (the screen and the overlay) would have to be anodized separately and then fastened together. The aluminum industry solved this problem by making available for use in the egg-crate a high silicon alloy that was just ready to be marketed, and which when anodized, turned dark charcoal gray as a metallurgical reaction (rather than by the dye process necessary for other colors). The use of these two alloys allowed the entire unit to be fabricated and assembled, and then anodized in a single operation producing the two desired colors. At this point in the design, all of the problems involving architectural and engineering analysis had been solved. It is important to stress that all of the problems were solved in advance, in cooperation with the aluminum industry and, as a result, there were no modifications necessary when the contract was let.

Fabrication

The shop fabrication process had to overcome two principal problems:

1) welding procedures to avoid prolonged heat which not only changes the characteristics of the alloy, but produces "bloom" in the anodizing process;

2) an assembly and welding jig which would allow the welder to reach all areas conveniently and to maintain the screen without distortion.

For the first problem, the manufacturer utilized the services of an aluminum research laboratory, which advised the purchase of a filler arc-welding machine to introduce the weld metal through the nozzle of a welding gun. This method of welding, while performed at the same temperature as heli-arc welding, produces less heat and change in the base metal, because it is faster and deposits less metal without excessive puddling. This method also allowed the interior recesses of the egg-crate to be welded faster and more conveniently. It should be pointed out that the welds anodized a darker color than the base metal, but from a distance, the welds are not distinguishable because of the dark charcoal gray color selected. This is a problem to be contended with in welding where other colors are used.

The jig problem was solved by constructing a table with 32 perimeter clamps and mounting this table on a quadrant, so that it could be tilted to any desired position between horizontal and vertical.

The individual members were purchased already sheared to size, and slotted and notched with dies on a punch press. The egg-crate was then assembled, placed in the jig, clamped and welded. The overlay members were pre-assembled, and then welded to the egg-crate outer surface as a final operation.

The next step in the fabrication process was removing the grease and cleaning, and then to the anodizing tank for a one-hour treatment resulting in an 8-mil coating. The color range was held to a 3-point variation, although a 7-point variation is considered acceptable.

Of interest at this point is the fact that the recommended protective lacquer coating was omitted. This was done because of the sheen imparted to the surface, causing reflections from sunlight.

Shipment of the units was by factory trucks which avoided the cost of crating necessary if shipment had been by public carrier.

Erection

There were 276 units to be erected and they were installed at the rate of two units (or one full-height panel) each 30 minutes. The crew consisted of four men, one on the electric hoist, one on the ground and two men positioning and bolting. The final weight on each unit was 233 lbs.

The units were installed with practically no creep, although fabrication of the corner units had been withheld as a precaution until completion, so that field dimensions could be taken and adjustments made in the corner panels.

Performance

The total wall construction has performed in excess of expectations. The building has been occupied since November 1958, and has experienced seasonal differences in weather, expansion and contraction. The minimum winter air temperature was 29^{o} while the maximum summer temperature was 95^{o}, or a range of 66^{o}. The maximum rainfall intensity to which the wall has been subjected was 1.75" per hour, while we have experienced a total for the past year of 73" (10" above normal average).

With these exposures, there have been no leaks in the curtain wall, which is unusual for this high-intensity rainfall area. The advantage of this screen as an effective weather break cannot be ignored.

Daylighting was not originally computed, so a comparison cannot be presented; however, the measured data shown on the accompanying section through the building may be considered in evaluating the daylighting aspects of the screen (See Fig. 1, Page 21).

Appraisal

Aesthetically, there has been some comment regarding the color of the screen. While the screen is dull in color, we are not dissatisfied with the total results of the building. The unscreened first floor glass wall reveals bright primary colors used as decorating accents, which are very definitely in contrast to the screen, and provide a balance. The play of light and shade on the screen adds daytime interest, while at night the entire building comes alive as the high-intensity illumination reveals the total interior aspect of color and movement.

Our greatest concern prior to construction was the psychological effect of such a large mass of screen on the occupants (since the planning is predominantly open) and the restriction of view because of the cutoff effect of the egg-crate. These concerns proved unnecessary. From a stationary point 20'-0" away from the screen (assuming a 60° cone of vision), you are able to intercept visually approximately 23'-0" of width, and at the extremes of this intercept you still retain 60% of the aperture opening, since the angle of total cutoff is approximately 37°, requiring a 106° cone of vision. With some openness, the screen is not overpowering or dominant. In fact, we have discovered through personal evaluation, that in viewing an object beyond the screen the eye focuses to the plane of the object, and the screen in the foreground is minimized by being out of focus.

In appraising the wall, we should give consideration to the cost of the screen. Without accepting the glass wall as a basic requirement, the economic justification of the solar screen is not possible. However, in comparing the present design to an all glass building with drapes, the saving in air conditioning refrigeration equipment is 45 tons, and more than twice that amount in air handling equipment. Further, the control system serving the curtain wall of the building was considerably simplified in that no zoning was required for exterior walls. The air conditioning engineers were so impressed with the effectiveness of the screen (a full-size model was built) that sun load on the protected areas of glass was totally ignored. The monetary total of these savings was estimated to be $65,200. Add to this the cost of drapes, which was waived by the screen, and the savings are increased to $79,700. Finally, the saving in operating cost and maintenance annually is $2,200, which over a 30-year projected life of the air conditioning system amounts to $66,000.

The solar screen cost approximately $160,000, which is about 9% more than the estimated saving. Considering the aesthetic value of the screen, we feel it to have been economically justified.

In reviewing the design, the only modifications we would make in the light of experience would be to develop a splice detail having a better appearance and to stiffen the overlay members. Because of the 1/8" thickness of these members, they deformed when welded to the egg-crate. The warping is sufficiently pronounced to be observed, although it has not affected the sun control function.

In our judgment, we had extraordinary success in maintaining architectural intent during fabrication and erection. This is primarily due to early coordination with industry and the utilization of the knowledge and service it had to offer. Perhaps because of early familiarity with the limitations of fabrication and erection, we tempered our design thinking. However, this does not seem impractical when you consider that results can be achieved without last-minute modification or design compromises.

APPENDIX I

Heliodon

For the purpose of testing proposed solar screen designs for the New Orleans Public Library, an instrument was constructed which would allow the testing of models at one-half of full size. A moving light source with a fixed model was investigated first; however, this approach was discarded because of space requirements, and work began on a combination tilting and rotating table which could be set to any azimuth and altitude in relation to a fixed light source.

An 18" diameter rotating plate of 1/4" Masonite was covered with a 360° cardboard protractor and fastened to a 2'-0" square, 3/4" plywood table. This plywood table was then hinged to another fixed 3/4" plywood base and arranged to tilt forward from 0° to 90°. The pivot hardware was arranged so that the center of the hinge pin was in the same plane as the face of the rotating plate, and tilted about the center axis of the plate. On one side of this assembly, a 180° plastic protractor was mounted to the base with its center passing through the center of the pivot hinge. This allowed the angle of inclination of the tilting table to be measured by a pointer mounted on the face of the tilting table. One edge of the protractor was secured to the fixed base by a threaded bolt with leveling nuts so that the protractor could be calibrated.

Since it was desirable to have the assembly as compact as possible, it was decided to make the light source independent of the tilting-rotating mechanism, and to devise a method of calibrating the two. While light sources are available which provide parallel rays, they are expensive. It was determined that a standard slide projector would be sufficiently accurate if the measurements were taken on the model near the center of the light source and a factor of safety allowed in the final design to compensate for the divergence of the light rays.

The tilting-rotating assembly was clamped to one table and leveled, while the projector was mounted on another approximately 8'-0" away. A slide with a very small aperture in its center provided a 1'-0" square patch of light on the model and results were observed within this area. In order to calibrate the light source to the moving assembly, a 45° triangle was temporarily attached to the tilting table, with the hypotenuse in contact with the table. The table was tilted until the projecting point of the triangle failed to throw a shadow on the surface of the table. The leveling nuts on the protractor were then adjusted until the pointer on the tilting table read 45°. A gunsight type device was used to assure that the light source was perpendicular to the face of the model.

The accuracy of the device was tested by measuring the results on a model in the laboratory for a fixed time and date. The same model was then placed on the site and aligned by a surveyor. Measurements were observed in the sun at the same hour and date and the results were a remarkable corroboration of the laboratory results. This test allowed us to reduce our factor of safety, which means savings in material in the final design of the sun screen.

The use of the instrument is simple and rapid. The model of a proposed solar screen is clamped to the rotating plate with a clamping bar secured to stud bolts on the rotating plate with wing nuts. The model is fixed on the plate in relation to 0° (designated as

North) exactly as the building will be related to North on its site. When the light source has been calibrated, as previously described, the desired settings of azimuth and altitude are obtained from tables and the model set to these positions for observation.

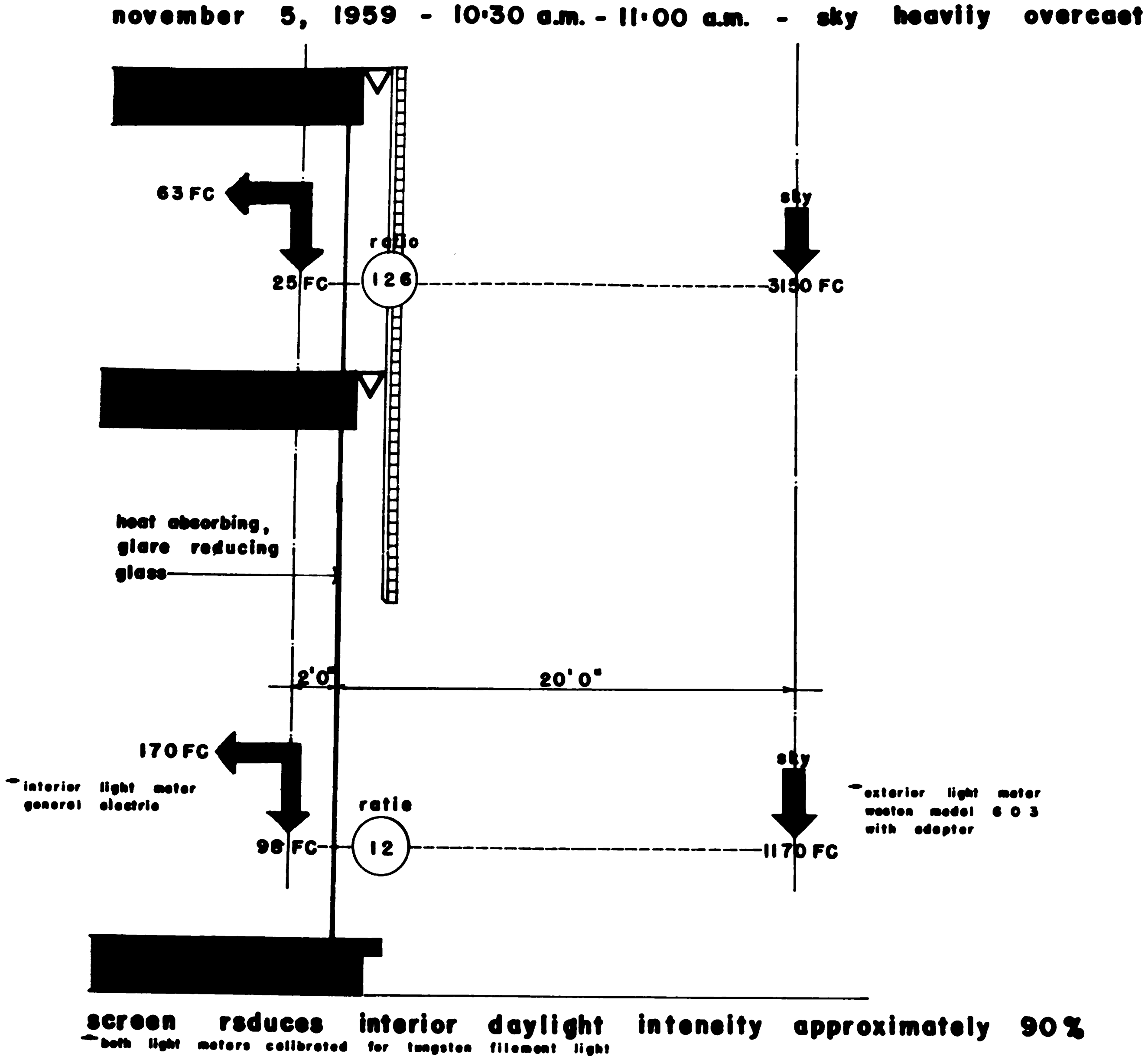


Figure 1

Sheraton Hotel, Philadelphia

By Robert C. Dean*, FAIA, Partner
Perry, Shaw, Hepburn and Dean, Architects

As we conceive the curtain wall, it is the natural outgrowth of the frame building. Once a wall is no longer weight-bearing, one of its traditional functions has disappeared. The remaining functions (i. e., the ability to resist wind, earthquake, explosion, to preserve desirable temperatures and to give security and privacy) can be met in other ways than by heavy masonry.

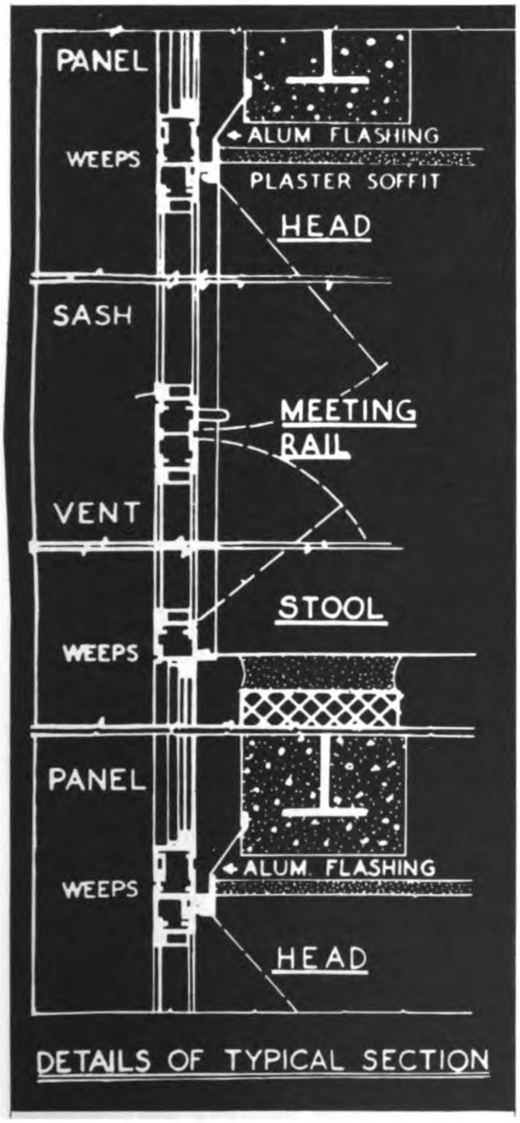
Much has been written on the reduction of weight and the saving of area by the use of a curtain wall, but it has been our experience that neither of these reasons is compelling. What has affected us most has been the philosophical or aesthetic aspect of the enclosure. We have been searching for a means of saying that this building has a frame, that it no longer is carried by its walls, that it is hollow and has a skeleton. One method of doing this is to cut away the base and expose the frame there. This somewhat explains the popularity of LeCorbusier's pilotis, which demonstrates this principle. We have attempted to emphasize the frame in many other ways. Some of our teachers, the critics of architecture, say we are creating a massless building but, to us at least, the mass is still there. We are but trying to demonstrate how the mass is created.

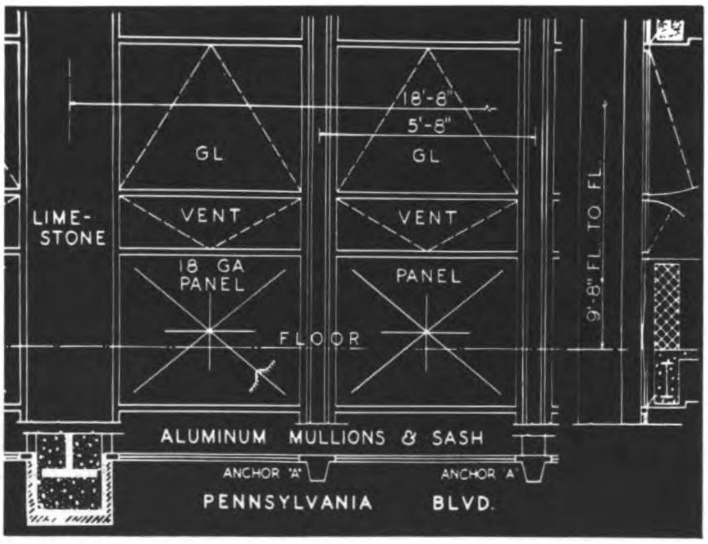
A curtain wall can be any wall meeting all the functions of a wall except its ability to carry any vertical load, and which encloses the space of the building. Such walls can be created in many ways but they all, to satisfy their fundamental aesthetic principle, must show clearly that they are suspended from the frame and that they do not carry a vertical load. A piece of canvas laced in a pipe frame would best illustrate this principle.

Design Considerations

At Philadelphia, the lot on which the Sheraton Hotel was constructed is long and narrow, 100' x 400', and is over the railroad tracks of the suburban station. An office building had been previously started on this site with a column spacing 18' 8-1/2" along the main direction of the lot. A height of 21 stories was thought necessary for commercial success. The most efficient plan of the bedroom complex called for a thin, slab-like block. This

*ROBERT C. DEAN joined his present firm after some years of teaching as assistant professor of architecture at Georgia Tech and as an instructor at M. I. T. He is a Fellow of the AIA, a member of the Boston Society of Architects and the Massachusetts State Assn. of Architects, and a member of BRI. Mr. Dean holds both Bachelor and Masters Degrees in architecture from M. I. T., and was their Travelling Fellow in 1928-29.





THE PHILADELPHIA SHERATON HOTEL
Architects - Perry, Shaw, Hepburn & Dean
Photograph by Ezra Stoller

form was also fashionable at the time. We demonstrated to ourselves that a steel frame would best support such a building, using end walls for wind bracing.

A curtain wall between these ends seemed to meet our needs best. Because the curtain wall lacks depth of shadow, it was decided to emphasize the vertical members of the frame on the south wall where shadows would count. Two types of curtain wall were used, one set into the frame on the south and the other applied to the frame on the north.

The main block of the hotel above the fourth floor is made up of bedrooms. Bedrooms require a special treatment not typical of office buildings. Privacy and the ability to look out, while others cannot look in, is the governing factor in the walls of a bedroom; therefore, the window wall chosen must provide this. Its windows should not go to the floor or, if they do, they should be protected by balconies. The occupant needs to feel that if he falls down, he won't fall into the street.

A fairly high window stool was adopted which had depth enough to cover the heating and air conditioning units. This high stool, and the bar-joist floor construction used, resulted in a wide spandrel which, according to the Philadelphia Code (since changed), had to be backed with 8" of masonry, the importance of which will be pointed out later.

There was another reason which led us to the curtain wall. A hotel is a meeting place, a temporary home, a place of festivities and in general should have a festive air. This can best be conveyed by flowers, gay colors, flapping pennants, awnings, lights and sparkle. To capture some of this in any urban setting, gay colors must be used in the walls. For this reason, a light mottled green panel with aluminum framing was chosen, the green being more of a typical metal color than others which might have been used, and one which also harmonized with the color of aluminum.

Aluminum was used for the basic grillage of the curtain wall, and either clear glass for windows or porcelain enamel fired on steel plates was used to close the spaces in the aluminum grid. As the wall had to have 8" of cinder block by law, heat loss was not a factor in this choice. Uneven surface reflections caused by an attempt to use a flat plane kept us from using structural glass, and lack of experience with the material kept us away from plastic. Expense ruled out thin slabs of slate or marble fitted into the frame.

Having decided to fill the grid with porcelain enamel, we still had to find some means of making the plates rigid against a 100-mile-an-hour wind. Philadelphia lies in the area of potential hurricanes. The manufacturer of the porcelain enameled panels tried many experiments. The largest size panel was mounted horizontally in the aluminum frame supported on all four sides. It was then weighted with nuts and bolts until its ultimate design load was finally reached. After many failures the final star design was evolved. This method of rigidizing panels is easy to do. Simple tapering T bars were fastened to one plate of the press; the other plate was covered with stiff rubber. The steel panel was formed by pressing the T bars into the rubber. The resulting rounded forms are most pleasing and very strong. They break up reflections so the surface does not have to be true, they catch the light, and they prevent flutter.

Glass, aluminum and porcelain enamel used in thin sheets, as they are in a curtail wall, build up heat very quickly as the sun strikes and lose it equally fast. There may be as much as 100°F difference in surface temperature between a cold night and a windless, sunny day in winter where the sheltered metal receives the direct rays of the sun. The resultant expansion and contraction present problems for the designer which must be met. Caulking must move, slip joints must slip, and both must be provided.

Having provided these joints, we raised another problem. They must be watertight. Not only must they keep the exterior water out but they must also let moisture out of the building from the inside, otherwise condensation will ruin the curtain wall. Rain not only runs down but blows up; often great, rising drafts may be observed flying up the face of the building, carrying water with them. A polysulfide rubber-like compound used as caulking proved to be the answer to this problem. It was used to caulk the panels into the aluminum frame and, when a part of the north wall failed in a heavy, tornado-like storm, the caulking held and pulled out the screws at the stop beads.

The aluminum grid, the basic element of the curtain wall, was fastened to the frame of the building by steel clips 3/16" thick fastened with T slots and bolts to the concrete fireproofing of the steel frame. Thus, the basic description of the curtain wall used at the Philadelphia Sheraton Hotel is an aluminum grid designed for expansion and contraction, fastened to the building frame with steel clip angles bolted to T slots anchored to the concrete fireproofing. In this grid were either aluminum sash filled with glass or porcelain enameled steel panels. The steel panels were rigidized by their shape, enameled both sides, and set in polysulphide caulking with stop beads screwed on. Weep holes drained condensate from behind the panels whenever moisture ran down and met a horizontal line of flashing.

For ease of installation, the grid was divided into one-story heights vertically, and into bays averaging 6' wide horizontally. They were installed from the outside and glazed after installation.

Failure Details

On June 26, 1958, a severe wind storm hit Philadelphia. It was sufficiently strong to sweep pedestrians off their feet and it emphasized for us a lesson which we knew, but which we had neglected to apply. The walls were designed to meet pressure from the outside but they also must resist pressure from the inside, since these great winds or explosions cause negative pressures as great as any positive pressure encountered. Experience in five hurricanes and in much bombing taught us that glass usually flies outward as a result of this negative pressure. This is just what happened here.

Two bays in from the west corner at the 6th and 8th floors, six steel clips holding the mullions of the aluminum grid to the concrete fireproofing failed dramatically. They had been cold formed at a sharp angle introducing a flaw in the metal and each sheared off at the bend as clean as if a hack saw had been used on them. This allowed the mullions to bulge outward, the steel panels pulled away from the grid and one flew across the street and punched a hole in a church roof. Others fell on our own roof. Fortunately, no one was hurt. The bottom rails of the windows bowed at the stool but no windows let go, and this failure was easily corrected by fastening the frames to the metal stools in the middle. The occupants of the rooms were saved from going into the street by the concrete block back-up, which had just been abandoned by the building code. Ironically enough, the evening paper which carried the announcement of the change in the law also carried the story and pictures of the failure, but the editors failed to notice the connection.

On investigation of this failure, we found the cold-formed steel clips which failed were Z shaped whereas the other clips in the area were U shaped. The U clips held; the Z clips failed. Only the U clips had been shown on the shop drawings, which we had approved, and no method of forming these clips had been shown or specified, although I doubt if we would have caught the fault in the method. We have examined, since this occurrence, drawings of curtain walls of four other major buildings, and in two of them we found the Z clips, probably cold formed, supporting the grid from the building frame.

The manufacturer manfully shouldered the responsibility and replaced the damaged section, took out the 56 undamaged Z clips remaining and replaced them with a stronger method of fastening.

Certain faults were noticed in the installation. When holes do not fit, they are sometimes enlarged by the workmen so as to weaken the surrounding metal. Porcelain enamel panels were forced in place by pounding with a hammer, and protective corrugated paper backers were allowed to fall down in the space between the backup and the panel and collect moisture and dirt. Our panels did not have enough tolerance to allow for poor workmanship in the frame and should have had more come-and-go in them so they might have been set more easily.

As for maintenance, we have requested the owners to wash the curtain wall, its aluminum grid and the porcelain enamel once a year. As the aluminum has a lacquered mill finish, we believe with proper care it will last as long as if it were anodized. When, in looking for signs of failure, we examined places where the panels had pulled away, we found no rust or any other sign of corrosion on them. The polysulphide material proved stronger than the aluminum screws and the aluminum stop bead. From what we saw, we believe we have a wall that will expand and contract and stay watertight. We believe that since the fault in fastening the curtain wall to the building has shown up and been corrected, there will be no further trouble.

Aesthetically we are not satisfied with the north wall. It lacks the depth which is given by the limestone piers on the south wall. Philosophically, the principle of the curtain wall is sound, but to us our handling of it is not satisfactory. Perhaps we should allow it to zigzag or undulate in order to give it more play of light and shade. However, several later attempts by our office to solve this problem have not been as successful as this, which we feel is our best result to date.

Lutheran Brotherhood Building

By John E. Starrett*, Partner
Perkins and Will, Architects & Engineers

I feel privileged to have an opportunity to describe the Lutheran Brotherhood Building, designed by Perkins & Will, along with such a distinguished group of buildings as are included in this conference. It is difficult to present anything that will be excitingly revealing, except insomuch as it will reinforce the thinking already expressed. When we were selected to design this building, it was because of the owner's belief that we as architects could produce an outstanding design with the courage to take full advantage of new materials and the design opportunities which they might afford.

We were fortunate that the piece of property available to us was adequate, and that the owner's program did not dictate massive coverage of the lot. They were as interested as we were in guaranteeing for the future an environment for their building with space around it to assure light and air. Although this was the first building of major proportions in the downtown (Minneapolis) area to depart from a masonry exterior in its design thinking, we nevertheless were supported by forward-looking leadership in the Lutheran Brotherhood. With that kind of backing, the architect is able to do outstanding work.

The way was clear to design a metal curtain wall structure, taking advantage of the intriguing possibilities of color along with the light and airy quality of the curtain wall design. These were the design considerations which led immediately to the challenging problem of design details, fabrication and erection.

Although not a design problem in the strict sense of the word, design necessarily has to acknowledge in the metal curtain wall the discipline of a repetitive module so that economy and quality of fabrication of the curtain wall can be assured. This by no means limits the design to a mechanical form in any sense of the word. Complete freedom of scale and pattern is available within a module which is determined in the first place by design considerations. I am an engineer, so I can only pass on to you the fact that the designers relished this opportunity, acknowledged the discipline and worked wholeheartedly to cooperate with the engineering and fabricating problems.

At the time this building was planned, there was very little material available on the production techniques of curtain wall, but there was a great deal of enthusiasm. However,

---

*JOHN E. STARRETT completed his Bachelor of Science degree at University of Michigan in mechanical engineering, and subsequently did graduate work at the University of Illinois in continuous frames. He is a licensed structural engineer in the State of Illinois and a member of the Western Society of Engineers, as well as of BRI.

many of those we talked to and sought advice from had little to offer except enthusiasm. There were just enough projects completed at this time to warn architects and engineers that curtain wall with its design possibilities was also replete with many headaches.

Specifically, those that relied on sealants to a large extent were encountering multitudinous troubles from expansion and other movements that repeatedly opened up joints. The conclusion immediately was that the design and fabrication of parts and the joining of these parts had to be done in such a way that there would be a minimum of dependence on sealants to accomplish weathertightness.

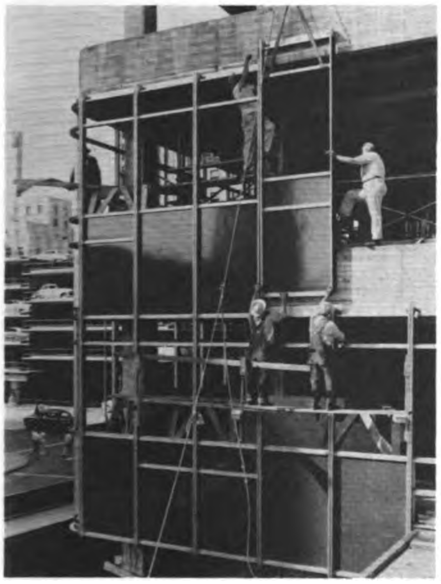
A team of us went to work and actually visited a number of factories where we talked to fabricators and watched their processes to see how the material we contemplated for the curtain wall construction was formed, and its limitations, stressing particularly the operations which were easily accomplished, so our selections would always lead us in the direction of an economical process for fabrication. We found this an interesting and rewarding experience. It proved invaluable later on when we were making some final cost evaluations, and because of what we had learned, we were able to reject suggestions for economies offered to reduce costs. We convinced our client this was short-sighted, and had occasion, before we finished our job, to find cases where unwise economies had resulted in leaks. Our client's confidence was reinforced due to the fact that such a problem never arose in his building.

Erection of the metal curtain wall proved to be an interesting problem, but not a difficult one. As our building progressed, we had to overcome the habit of doing things the same way they were done in buildings before we had metal curtain walls. The most important thing was insistance on accuracy and insistance on continuous checking to verify this accuracy. A curtain wall design perforce must have tolerances to permit variations in construction. However, because a metal curtain wall is prefabricated to exact dimensions, these tolerances can not be permitted to become accumulative. This we foresaw at the outset, and as we encountered variations in building dimensions and variations from true plumb, we insisted on corrections, floor to floor, so that we had plus and minus tolerances. Thus our building did not encounter accumulations that would force a "bulge" condition.

In the actual placing of the metal curtain wall units, the continued insistance on floor-to-floor rechecking and on holding tolerances to a plus and minus nature was effective and assured the success of the installation. It was also very effective in making the erection as economical as possible.

With over four years of experience and as many full seasons of operation, we have had extremely gratifying performance. The curtain wall maintenance has been economical and has been performed on a regular schedule, maintaining a crisp new appearance. Therefore, the building is as architecturally exciting as it was at the time of completion. Moreover, from my standpoint as an engineer, it has served its function of enclosing an air conditioned building and creating an outstanding internal environment with equal satisfaction measured both by technical standards and owner satisfaction.

This is a rather bold statement to make in the presence of this distinguished group, but appraising this metal curtain wall with the idea of possible modifications, it would be difficult to suggest any of a radical nature. There are, of course, things that have come on the market since we built this building that we could take advantage of, but primarily only because they are different materials.



LUTHERAN BROTHERHOOD BUILDING
Architects - Perkins and Will
Photographs - James Mulcahy and Hedrich-Blessing

At the time we received this commission we were deeply concerned with the responsibility of analyzing and providing a basically sound construction in the relatively new metal curtain wall field. We drew on our knowledge of the importance of adequate weathering, and everywhere we turned to study this further we noted the increasing importance of joint and juncture detailing. This we studied and re-studied in close cooperation at all times with not one, but several fabricators of the material proposed, to be sure that nothing, even a small detail, would fall outside the premise of the tools and techniques available. Expansion was also provided for and adequately measured. The resilient mounting necessary for glass and porcelain panels was analyzed and adequately detailed. Sealants were properly selected more with respect to control of infiltration than actual resistance to weather.

Because our designers, and this is most important, had acknowledged and worked within the discipline of a repetitive module, our engineering job of creating a successful metal curtain wall was greatly simplified. It meant we could devote more time to working out the details for this modular unit so it could be fabricated, checked and tested as a complete unit with an exacting amount of detail following each step. This end result of a thoroughly developed curtain wall unit was used over and over again many times in the building. I think that this last statement embraces the other point mentioned concerning our success in maintaining control over architectural treatment through fabrication and erection. However, this control included one other important consideration. With full agreement on the part of the owner, the fabrication was limited to firms whose record for producing quality results was outstanding and unquestionable. Competitive bids were of course taken on this work, but once the fabricator had been established, teamwork followed in which we cooperated mutually to effect minor modifications which would adapt details to the particular manufacturing facilities and techniques of the fabricator.

Before final production two important steps were taken:

1) Although in our contract plans and specifications we had established a single curtain wall responsibility, a meeting was called and attended by responsible principals of all contractors and suppliers to assure agreement on quality and performance, a sort of "speak now or forever hold your peace" meeting. This brought about outstanding teamwork.

2) The unit was thoroughly tested in a complete mock-up and its performance potential proven.

This initial major metal curtain wall experience, successfully reinforced by other buildings of curtain wall design, has left me personally convinced that the shop-fabricated curtain wall unit holds an important answer to quality work in buildings of the future. Having spent a lifetime in the construction business, with the eternally involved problem of weather, I am impressed with the advantages of controlled conditions of work inside a fabricating shop. No matter what we do in the field in design, we will always have some small awkward corners and important tight fits. All of those things can be overcome with success in the controlled conditions of a manufacturing plant; this in contrast to the same difficult operations which will at some time have to be performed on buildings under adverse weather conditions where the results will always be less certain. I am also impressed with the opportunity afforded for continuous and thorough inspection of a particular operation within the working area of a fabricating plant, as compared with a similar situation in a building where the area for inspection embraces the entire surface of the building.

The metal curtain wall as a building component, in strong and competent hands, is certainly an exciting contribution to building technology. On the other hand, many people will agree that there have been some very disturbing results in the curtain wall field due to the indiscriminate "plastering" of a curtain wall facade on buildings which are neither handsome nor utilitarian. These inappropriate uses are to be deplored, and constitute negative forces that could go far in their detrimental effect on the future use of curtain walls.

I think it is appropriate to observe that the Lutheran Brotherhood curtain wall falls into the custom range, where cost is balanced with architectural values and the long-range economy of using the very best quality materials.

The custom curtain wall is admirably suited to the multi-story building, with its concept of a light, airy, soaring structure expressed in planes and volumes suspended in air;

this in contrast to earlier concepts of a sculptured mass, pierced for window openings, carried out in masonry forms of solids and voids.

Owners have willingly paid premiums to attain these results. Within the last few years, the increasing familiarity of designers, manufacturers, and contractors with the curtain wall has modified and reduced these premiums, but nevertheless they stand at the moment as premium walls.

From our experience, we have found that the "low cost" metal curtain wall has resulted from the extension of metal window treatments to include wall panels in their most straightforward form. We have found these economical to use in limited height structures. Here again, however, our experience has shown that as we depart from stock production modules and elaborate on mullion treatments for architectural reasons, our costs mount. It is significant to mention this here, because at the present time it is our feeling that the metal curtain wall to date can only approach the cost of composite wall constructions, and cannot make a case for itself strictly on economy.

We are continually approached by manufacturers who "want to get into the curtain wall business." There are a few successful examples of companies which are doing a good business because they have a well-designed unit. These are accepted in their "catalog form," because the market in this country is vast and there will always be a demand for architectural products of quality and tasteful design, as in the case of storefronts and entrance-way architectural elements. However, we continue to caution people who ask us this question that the market for a mass produced, standardized curtain wall that architects will all grab and plaster on the front of their buildings does not exist. The history of architecture and buildings does not suggest that we will ever arrive at a unified exterior design, just because it could be bought in a mass production market. Buildings have in the past, and always will, express the egos of their owners and their designers, and will always call for individual characteristics.

In summary, it is useful to think of the exterior wall of a building as a filter, permitting those things from the outside which we want--sunshine, the sense of outdoors--to pass inside while at the same time resisting the passage of weather. From the inside, we wish it to confine us in as delightful and habitable a space as possible, permitting the pleasant things from the outside environment to enter in amounts controlled to the best of our ability.

The metal curtain wall, in its thoughtfully planned and designed large module with a minimum of joints, reduces care and maintenance, and assures the longest life at the lowest cost. The parallel to this axiom is found in exterior masonry, where the larger the joints the fewer the problems and, as with that type of masonry, skilled designers can handle the curtain wall module with equal aplomb.

There is now much technical information available on metal curtain walls. It has been helpful to all of us. After you have finished reading all the fine print, the secret of the metal curtain wall is the secret of joints and junctures. If those are honestly analyzed and thoughtfully solved, curtain walls will be successful. We can dream ahead to the day when a coating will be available that will allow us to build a building any way we like, of any material we like, and then have someone come along and cover it with an invisible transparent "goofite," which will solve all our nasty weather problems. However, until that day arrives, the architect, the curtain wall manufacturer and the contractor must rely on their respective skills and teamwork.

Discussion Period

Chairman - George E. Danforth

Panel Members - Robert C. Dean, Sidney J. Folse, Jr., John E. Starrett, Allan Labie, T. Clifford Noonan

F. R. Brant, General Services Administration: Do you have any bird problem with the screen on the New Orleans Public Library?

Mr. Folse: That's a very interesting question, and one that came to our attention immediately as we conceived that screen, because this is in an area where there are many trees and we have pigeons in New Orleans like everywhere else. We've used both masonry screens and steel screens on buildings, and to date have had no bird problems. This may be due to the high temperature of the material in the sun. However, we were prepared and had already gone to a bird control laboratory where we selected a chemical just in case the problem came up, but it has never arisen.

M. D. Folley, Sargent, Webster, Crenshaw & Folley: Do you have any problems with ice, dirt or climbing children?

Mr. Folse: Not in this particular instance; however, we've had schools at grade level, elementary schools in fact, with a masonry screen, where both the school board and ourselves gave serious consideration to the problem. To date, one elementary school has been in use a year and a half, and due either to proper administration or unimaginative children, there has been no climbing on the screens.

James C. Begg, Eastman Kodak Co.: Does dirt settle on the horizontal surfaces of the egg-crate screen? How are these surfaces, and the glass windows, cleaned?

Mr. Folse: The surfaces are not planned to be washed in any particular way. Actually, the color of this screen, dark charcoal gray, is such that a slight layer of dust may perhaps change the aspect of it, but it may add to the interest because of a little color variation in this very closely spaced aperture. The situation doesn't seem to be a problem aesthetically. Also, it doesn't get very dirty. We are not in a highly industrialized section of the city, and we also have 73 inches of rainfall a year, which washes the building quite regularly. In a year or so of operation, I have observed little or no dust accumulating on the horizontal surface.

R. Czaneck, Allied Chemical Corp.: Why didn't you put the glass and panels in the framing members before installing in place in the Connecticut Life Insurance Building?

Mr. Labie: The windows themselves weighed 500 lbs. apiece, so it would have created quite a problem in shipping and hoisting. It was a lot simpler to erect them on the site than to try to do it in the shop.

J. Reed, North American Aviation: How much glass breakage did you have during and after construction of this building?

Mr. Labie: There was some glass breakage early in the job, until the workmen got used to the new rig. It was a brand new item to them, and they did break a few lights initially. Once they understood the thing well they had no difficulty whatever erecting the rest of the glass. There were a few lights broken during construction by other trades, and since completion of the building, I believe they have replaced one light which they believe was cracked some time during construction and just didn't show up until after the building was occupied.

R. C. Kendall, Kimble Glass Co.: What was the cost per sq. ft. of completed curtain wall, including glazing?

Mr. Labie: I don't really know. It was somewhere between $4. 50 and $6. 50 per sq. ft. for the metal and glass work itself.

Jerome R. Salton, Caloric Appliance Corp.: Has Chicago done anything further regarding the building code; that is, the 2-hour fire rating problem? Do you still need a masonry backing?

Mr. Starrett: At the present time we still have that problem. It hasn't been too serious. We managed to solve the problem on a recent building with the use of gypsum because of its fireproof qualities. We got by with a 4" or 6" gypsum block behind the actual spandrel panel. We still hope this code provision will be rationalized and brought into line with other cities that have taken a more sensible attitude.

Kenneth D. Holton, Moper Chemicals Company: Other than foam glass and fiberglas cores have other core materials been used, approved or considered for curtain wall design?

Mr. Dean: As far as I know there have been any number of them. Some people have used paper honeycomb, others use aluminum honeycomb, there have been all sorts of materials used to stiffen and strengthen these panels. Some have been laminated over plywood. Wherever you are up against this question of the code, however, you don't need to worry about that at all. You just need to make your panel what you want, because the back-up is going to have to be masonry anyway.

Lt. Col. Segal, HQ, USAF: Is modular (4" module) dimensioning used in the design of buildings of curtain wall construction? Please comment, if used in any of the case study examples under discussion today, as to what problems were encountered and how were they resolved?

Mr. Labie: Well, when you start out with a module, the first problem is that a module has two dimensions, and a building has three dimensions. Very often in designing a building people lose sight of the fact that you do have to take care of different thicknesses of materials. In the Connecticut General building we had a building module which was adhered to rigidly. We set the module at the interior bases of all the walls, where we had to penetrate into the office space. These penetrations were also beyond the module line so that the module related only to the interior of the building. The exterior envelope was completely outside of the modular design of the building. This was one way we solved this problem of thicknesses.

Mr. Danforth: Mr. Starrett, would you like to make any comment about modular coordination in curtain wall construction?

Mr. Starrett: Well, the question of the modular dimensioning in architectural planning is one that's many generations old and there are still divided opinions as to whether it can be made to work or not. Interior planning is often done on a rigid modular pattern, but when it comes to the production of curtain walls I speak of the module as I spoke of it in our experience. In the designer's concept of the building, whether the module is 4', 6', 8', 9'6" or whatever it may be, he endeavors to pick a module that will be repetitive so that, as a production advantage in producing curtain walls, there will be repetitive sizes. It doesn't help the manufacturer to have to make different sized panels, just because there are 4" and 4" increments. When they make their panels a different size it poses a problem, whether it's a half inch bigger or a foot bigger. Modular dimensioning, as I see it, doesn't apply to what we have been talking about today, custom curtain walls. I feel that the module should be a consideration in repetitive production, particularly if you want to get good work and get as effective a cost reduction as possible.

Mr. Folse: I would like to comment a little, because the Library presented an interesting problem in modular control. We do like to follow a rigid module, and the 4' module was used in the planning of the Library in arriving at column spaces and using ceiling materials which were available in 1, 2, 3, or 4' increments. However, the rigid adherence to the 4" module I think is perhaps to be avoided. When we got to the exterior wall of the building there was just nothing in the 4" multiple that was the right proportion for what we wanted. We had a 28' bay, and 7 pieces of glass 4' on centers didn't suit us. So we changed it to 5 pieces at 5' 7-1/3" each, because this looked better. Yet, the 4' module penetrates this different module that's been established in the glass and gives back out into the sun-screen. So there are two different modules, one passing through the other, and yet we were able to keep them sufficiently separated so that there are no lines that mismatch in connecting these two different modules. I think you still have to keep some freedom of design, and therefore you cannot always stick to 4" module and use this in multiples and repeats.

Mr. Dean: We always seem to get stuck with the problem of somebody coming up with some previous columns all set up at 18' 8-1/2". Actually we've worked in a larger module, but we've never been able to adopt the 4" module as recommended. It has been very carefully studied but actually we have never been able to adapt it to our practice.

Mr. Noonan: The only thing I would like to add is on this question of a 4" module. We certainly didn't consider it on the Morton Salt Co. job. We started out that job on the basis of a flat slab construction with a module of 9' for a minimum single private office and let the repetitive results develop as they would. That was the key in the start of the design of that building. I might say that we had essentially the same problem in the Department of State Office Building in Washington. We were given the problem of laying out approximately 3500 private offices, a minimum of 12' in width, so that again developed a structural problem (and a car-parking problem within the building) to find a module that was going to be satisfactory to develop that kind of an office layout.

Kingsbury Marzolf, Architect: In your building there are horizontal bands of metal about 18" below the window sill in alternating pairs of panels. Are these simply for aesthetic reasons, or is there some other purpose for them?

Mr. Starrett: Those were put in our building strictly for aesthetic reasons, and yet they still acknowledged what I referred to as the modular discipline. They were very effective in carrying out the design motif of the building, and I think they relieved some of the monotony. It brought in that many more joints, but they all followed the same practice, so we didn't have any more trouble with the little panels than we had with the big panels.

H. R. Spencer, Jr., The Erie Enameling Co.: In the matter of permissible color variation on the sunshades for the New Orleans Public Library building, what units of measurement did you use in establishing three as your maximum variation?

Mr. Folse: Actually, I don't know how the scale is calibrated. This is a process which is licensed to fabricators by companies who have patents on these things, and I don't know whether the device is photo-electric or what it is, but the division of three to seven is relative to each other.

G. M. Johnson, Aluminum Co. of America: What is the frequency of cleaning of the metal components of the wall of your building?

Mr. Labie: The exterior of the building is washed once a month, the interior walls are washed about once every three months. At the entrances, of course, I think they're washed more often.

Mr. Danforth: You mentioned in your comments that the situation there relative to dirt in the air was fairly good as opposed to an urban area.

Mr. Labie: We've found, though, that even in New York City, once a month washing of the exterior of a building is usually adequate.

R. C. Kendall, Kimble Glass Co.: What was the area supported or anchored by one of the clips that failed?

Mr. Dean: The way I recall it there was about thirty square feet on each one of those clips, five to six feet wide and six feet high.

Harry H. Batchelor, Soc. of Residential Appraisers: Is there no problem of electrolysis between the aluminum and steel anchors with condensation present?

Mr. Dean: We expected we were going to have trouble with that, and you will find that we have inserted a small piece of ordinary roofing felt between the steel and the aluminum to put a stop to that. When I examined the pieces of the wall that came down, I found that there had been no corrosion at all from that source. We think that we're not getting any condensation inside this wall because the wall is sufficiently vented to the outside so that when the weather is cold the moisture in the air always tends to travel toward the coldest place. If the moisture can get out from behind this wall, it's not going to condense on the panels. The cold outside air dries the inside of this curtain wall and of course you can't get electrolysis unless there is moisture present.

Mr. Danforth: You mentioned when the wall was damaged that you found no corrosion or any other deteriorating factors. How long had that wall been in place at the time of the damage?

Mr. Dean: It had been in place about 18 months.

Lt. Col. J. H. Segal, HQ, USAF: Comment on advantages, if any, of curtain wall construction as compared to traditional materials (i. e., masonry, etc.) on points as to cost, working drawing production, multi-story compared to two- or three-story buildings?

Mr. Noonan: From the standpoint of cost, we believe that the metal panel wall is certainly a more interesting and a more challenging way to do things, and I'm certainly of the opinion that we're not approaching this problem strictly from economy. To evaluate it is a pretty complex process. We do know that unions and availability of mechanics have been one factor that has precipitated the development of these new materials. We haven't experienced any additional cost within our own organization that would place any emphasis on one type of construction over the other.

Mr. Danforth: Mr. Dean, relative to the rest of that question, have you any comment to make about the relative cost of curtain wall construction as opposed to masonry and other kinds; relative to working drawing production?

Mr. Dean: The design of this particular curtain wall, because the building was so large, didn't turn out to be very expensive for us. Actually, we ended up by making a little money on the job, so I guess we got the working drawings out fairly economically. It seemed to us that the amount of work we get into with the flashing of masonry walls, the working out of the window penetrations, etc., are at least as expensive to do as the design of the curtain wall.

Mr. Danforth: Mr. Folse or Mr. Starrett, do you want to make any comment about that? There's another point that hasn't been covered: "Make comments about the advantages of the two, relative to multi-story building as opposed to two- or three-story building."

Mr. Folse: In the area of New Orleans and surrounding country where the soils are very poor, almost nonexistent, every building, including residences, is on piling. We've recently had a site where we had to put the sidewalk on piling. Weight becomes quite a factor in that sort of a situation so I would say certainly, just on a direct cost comparison, you can find other materials that are less expensive, but a total evaluation must be made of space and weight gained, and savings in foundations. It requires a total evaluation; you just can't say this wall cost so many dollars and the next one cost $2 more, without taking the total building into consideration. In multi-story work in our area, there's just no question, we save on pilings and a good deal of foundation costs by going to a lighter wall.

Mr. Starrett: I would just like to reinforce what I inferred in my talk about the Lutheran Brotherhood building, and that is I am impressed with the possibilities of getting quality workmanship in factory produced units. Of course there are different opinions on that; some people like to assemble buildings more in the field than others. Our problem with skilled mechanics is that they can't operate without supervision individually the way they could a generation or so ago. We're moving into a mass production economy where the pride of the mechanic can not be relied on to the same extent that it was a while back. I think we gain by having units that are mass produced, tested, and you know how they will perform. Performance standards can be established and can be adhered to. In that respect, I think there's a tremendous field for the curtain wall if it isn't, as I said, fouled up by misuse, it's got a long, wonderful road ahead.

Mr. Labie: I agree with that. I think the curtain wall is a product of the times; it's a new tool that we've created by technology in this country, and if used properly it will enhance our cities, eventually.

Mr. Danforth: Would you like to comment about the influence on your firm of the speed of erection in making the choice of curtain wall?

Mr. Labie: I don't think there's any question about the time saved in erection, either on a tall building or a low building. Mr. Folse mentioned you have to evaluate the cost of an entire building rather than just the wall itself, and I heartily agree with that. Most of the people that criticize curtain walls just talk about the cost of the wall itself. A properly designed wall can save money in many other portions of the building; the air conditioning systems, the structural systems, floor area.

Mr. Danforth: What affect does metal curtain wall construction have on TV reception? Is the effect the same regardless of which metal is used, such as porcelain enamel on steel, aluminum, etc. ?

Mr. Labie: To my knowledge we've never investigated the problem. Usually when you're looking for good TV reception the way to get it is with an outdoor antenna. I know of no cases where the metal walls have reflected signals causing an interruption of good reception, but it could be handled by a properly designed antenna.

Mr. Danforth: Have any of the rest of you had experience on that?

Mr. Dean: We have the rabbit-ears TV antenna throughout this hotel and the hotel has a steel frame, bar joists and metal curtain walls on the outside; but I don't know whether this has any effect or not.

G. H. Ficken, Wm. H. Singleton Co.: Will you please describe briefly how the Connecticut General building was air conditioned; i.e., 1) low- or high-pressure ducts; 2) overhead or under window distribution; 3) heating under windows? Would you have done any of the methods of air conditioning differently?

Mr. Labie: The exterior system of the building was air conditioned with window induction units at the sill level. The interior zone was handled with, I believe, medium-pressure ducts, the single-duct system, with under window distribution of both heating and cooling through the same unit.

Mr. Danforth: Would you have done any of the methods differently?

Mr. Labie: I don't think so.

Eugene R. Ninnie, I. B. M. Corp.: What is the average cost per sq. ft. of metal curtain wall utilizing 1/4" plate glass?

Mr. Noonan: Well, at the risk of quoting some figures that we had on the Morton Salt Building, our panel construction cost us between $10 and $11 per sq. ft. These were stainless steel. Now, we had the benefit of a very interested subcontractor and manufacturer. To go out and buy that panel today would cost us more money.

Mr. Dean: We don't have 1/4" plate glass, we have sheet glass in the building, but those panels cost about $8.50 a foot.

Mr. Danforth: Let's run through the panel with some short comments about something which has occurred to me. Mr. Dean said that in his building they were not satisfied yet with the north wall, which I think is a very frank and refreshing admission. It occurs to me that certainly in any new technique the full realization of the design potential is not always possible because it seems to be hampered by many things. At one extreme there is the concept of the architect as to what it can do, the philosophy behind it so to speak, and it moves on down to the very practical side of the problem. Would you like to make some comments about your experience with the limitations of a full realization of curtain wall design potential?

Mr. Noonan: There has been one thing concerning the human element that entered into our job which may be of some interest. The windows are designed for 360° full pivot, and in the periodic window washing we found in a couple of areas that we were getting leaks. We couldn't find any difference in the condition that prevailed there from that which prevailed in other windows which were not leaking, and on checking further with the window washing people we found that the cleaners were not making a full 360° sweep of the window. They would turn it half way, and then bring it back, and this was just enough to tip the gasket in such a way as to produce a little leak.

Mr. Dean: My complaint about this wall has largely to do with the flatness of its surface. You've seen several examples here today where that flatness was beautifully handled. We have been trying to get a little more depth of design into our buildings and that is somewhat difficult with the curtain wall.

Mr. Folse: I'll let Mr. Labie talk about the sleek, highly intellectual type flat building which obviously he desired to have and has very successfully achieved. Then again, there's the desire for depth and sculpture. For the Library we have created a wall with depth. We think the total wall consists of the glass and the screen which is 4' deep. You see through it, and you have changing aspects of light and shade so that it's quite exciting. We may have another building which we would desire to be very sleek, with a plainer look to it, but in this one we were interested in this depth and the excitement of penetration of light and shade. You've got to decide which way you want to go in each particular design.

Mr. Starrett: I have great respect for the problems of flat surfaces in metal and I have observed installations where I know no expense was spared to solve them. When you have a highly reflective surface it's a very challenging, almost impossible, thing to come up with surfaces that don't have some of what's called "oil canning," but they don't have to have even that much. There's nothing as critical as a mirrored reflecting surface for showing up the slightest defects. In our design we are very careful to keep the flat surfaces to a minimum. Mr. Labie has pointed out that his office was conscious of that problem and purposely decided to work with a dull surface in the large areas. It's almost impossible to get a flat sheet out of metal because of temperature changes--it's just bound to move a little bit on you. It's a very very precarious thing, and I advise against it. People are funny; they look at a wall and if it was a foot out of plumb they wouldn't notice it, but they walk along the street and if they see something that's a thousandth of an inch off, they say, "Why that's a tinny looking job, it must be a cheap one!"

Mr. Labie: Well, our office has been accused of all kinds of ills. We do push manufacturers pretty hard sometimes, and we're always complaining about the limitations of size. Somebody once told me that S. O. M. stands for "somewhat over maximum." You just can't get people to change, even if you work continuously with them, the framework established by existing facilities. On several jobs we've had the opportunity to work with a manufacturer in the development of finishes on stainless steel. This problem, I think, is probably a little more critical on stainless because of its highly reflective nature, and they did come up with a very good finish. I hope someday that this will become commercially available.

Mr. Dean: My purpose today in showing you the accident at Philadelphia was to try and improve the design criteria for curtain walls; that is, the structural design. We had this accident very carefully investigated by several engineers, and they discovered that there's not very much in the literature as to what you can expect from wind pressure. Their final recommendation is that all people having to do with the design of curtain walls be certain that the wall will stand an inward pressure of 25 lbs. per sq. ft. over its entire surface, and an outward pressure of 20 lbs. per sq. ft. Now, this is a little more than the codes require in some places, but with the experience that we've had up and down the East Coast, and that others have had all over the country, we would do very well to pay attention to that recommendation: 25 lbs. inward and 20 lbs. outward. And, every clip, angle, joint that goes into that wall should be capable of meeting that kind of stress.

CREATIVE DESIGN
OF METAL CURTAIN WALLS

Fabrication Possibilities and Tolerances

By J. M. Roehm*, Vice President, Research and Development,
Kawneer Company

As most of you have observed, two general trends have developed in the design of curtain walls. The first trend, which is exemplified by the United Nations Building and Lever House in New York City, is the trend to emphasize the metal grid. Transparent glass areas make up about 80% of the facade in the typical building. The remaining 20% of the area consists of colored glass or other types of opaque panels. As of today, this particular type of curtain wall, because of its structural simplicity and clean design, has been the one most extensively used. The very excellence of this type of wall undoubtedly led to its extensive use, which in turn brought inexperienced architects and manufacturers into the act. This probably led to some of the monotony of design referred to by critics of some of the newer buildings. Good things are always copied, but not always copied well.

The second trend is towards walls made of formed metal panels in which little or no framing is visible. This type of wall is exemplified by the Alcoa Building in Pittsburgh. Where windows are used, they are generally punched in the panel itself. Buildings of this type have a panel-to-glass area ratio almost the inverse of the metal grid type. Formed panel walls have two possible advantages. First, the walls can be better insulated and second, three dimensional effects can be realized. Some walls have recently been built incorporating features of both of the foregoing types. (Fig. 1)

Referring to the metal grid type, most of these walls have been constructed from non-ferrous metals. The metal in largest use today is aluminum, although bronze has been used effectively in one of the more elegant monumental buildings recently constructed. These non-ferrous framing members are produced on extrusion presses. (Fig. 2) The ability to produce a shape by extruding it provides a number of advantages. In one piece many functions can be incorporated; for example, lips for glass holding members, slots for fastening members together, slots for inserting gaskets, built-in drainage systems, drips, flashings and a number of other things. With an extrusion it is a simple matter to put the metal where you want it and use as much metal as is required in various places to achieve proper structure, contour and shape as well as to accomplish the functions previously mentioned.

*JACK M. ROEHM holds an M. S. in electrical engineering from California Institute of Technology, and a B. E. in mechanical and electrical engineering from Tulane University. He is vice president of the Metal Curtain Wall Division of NAAMM, and chairman of its Research and Development Committee. Mr. Roehm holds memberships in ASME and American Institute of Electrical Engineers, as well as in BRI.

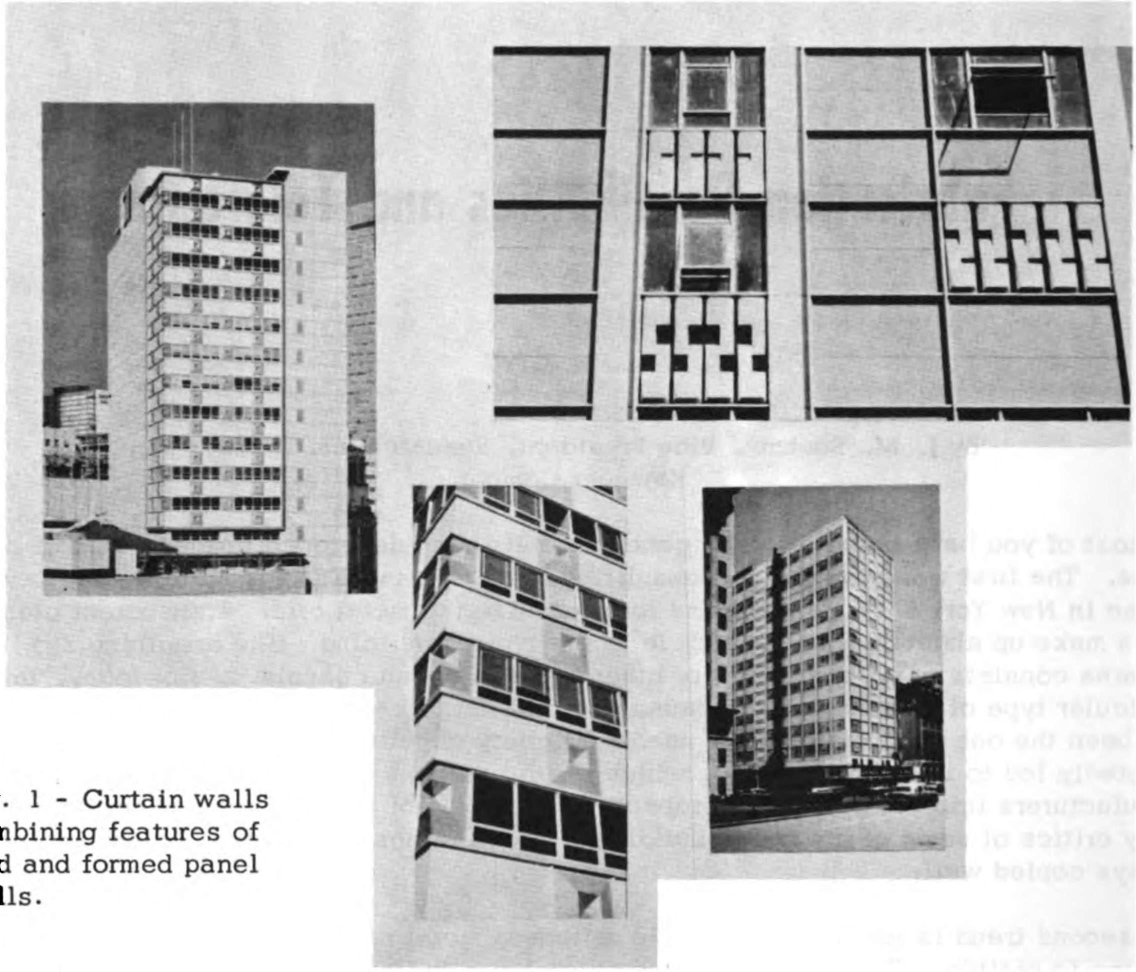


Fig. 1 - Curtain walls combining features of grid and formed panel walls.

Recently, however, we have seen the use of stainless steel come more and more into its own. Steel has its particular advantages. It has great strength and it has great resistance to certain atmospheric conditions which other metals do not have. Stainless steel must be formed on rolling machines or on brakes. While some functions can be incorporated by rolling or braking, the versatility of these methods is not as great as extruding, and other means must be taken to incorporate some functions. With stainless steel, therefore, the fabricating problem becomes different from that of non-ferrous members. Glass stops and other members must either be fastened mechanically to the steel by means of screws or rivets, or welded either by continuous seam or spot welding. This does not mean that there are any limitations in the use of stainless steel, it simply means that designs must take into account the material to be used.

There is also the possibility of combining non-ferrous extrusions with stainless steel to achieve an economy of design. This is done whether exterior stainless steel is applied to an aluminum substructure. The substructure, being an extrusion, can take advantage of all the properties offered by an extrusion, and the stainless steel provides the exterior properties desired.

In designing the metal grid, care must be taken to provide for the tolerances which occur both in the fabricated panel assembly and in the building structure to which this panel must be mounted. With extrusions one of the best ways to do this is through the split

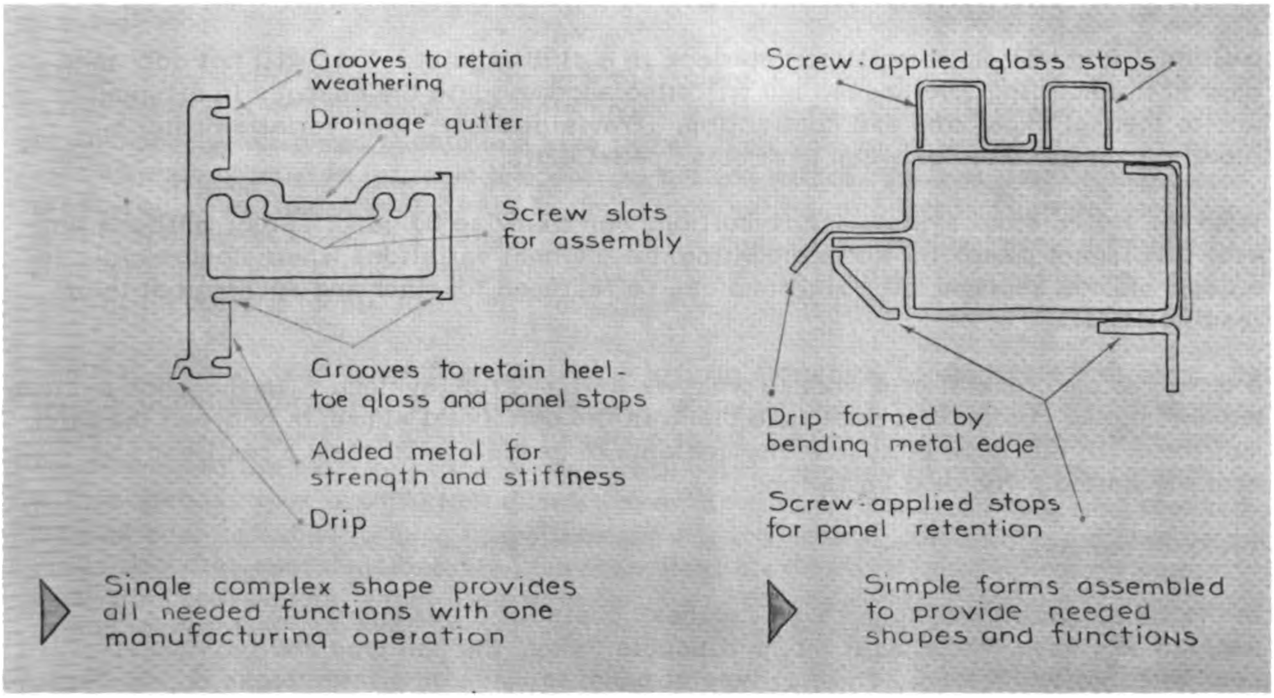


Fig. 2 - Comparison between extruded and rolled curtain wall members.

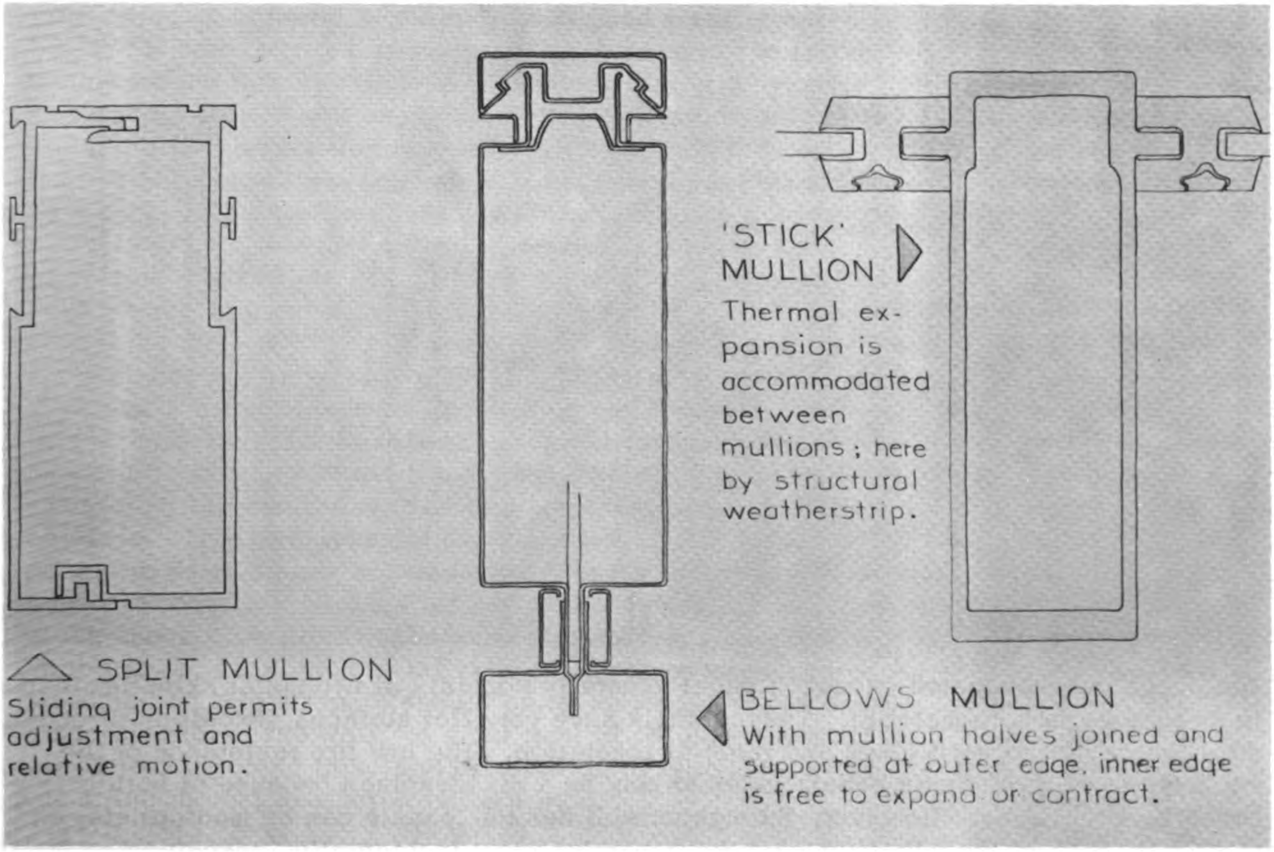


Fig. 3 - Methods of providing for building tolerance and thermal expansion.

mullion. (Fig. 3) Split mullions interlock in a sliding joint. This will not only take care of the building tolerances, but will also accommodate the changes in dimensions due to thermal expansion and contraction. Provisions for ± 1/8" variation can be readily accommodated between assembled panel units.

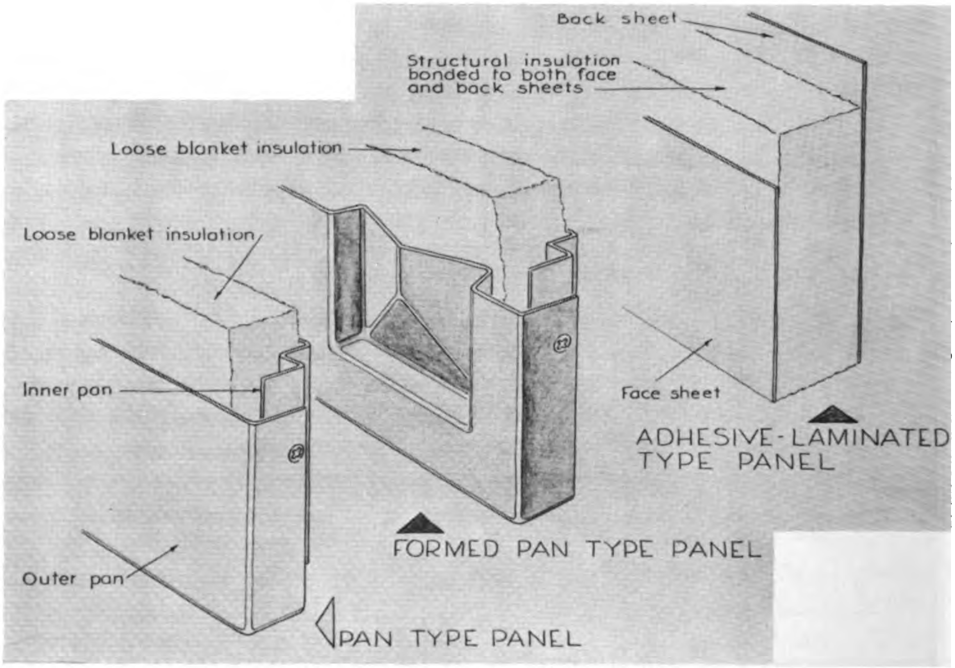
With the rolled steel system, split mullions can likewise be used. Steel mullions provide an elegant means for accommodating dimensional variations where design calls for a deep mullion section. The mullions can be fastened together and anchored at their leading edges.

A third system of metal grid work is what we call a "stick system." In the stick system, expansion and contraction must take place in the horizontal elements between the stick mullions. In this type of system the sealants or gaskets must have a resiliency to accommodate dimensional variations.

Types of Panels

In the metal gridwork system, most facades consist of a combination of glass and panels. We have two general types of panels today, the pan type and the adhesively laminated sandwich type. The pan type of panel is made on a large press or, depending upon the design, formed on a brake. The metal must be of sufficient gauge to maintain a reasonably flat surface, since in the flat pan type insulation, if used, is normally not used in a manner to contribute significantly to panel flatness. This type of panel has the advantage of being simple to make and low in cost.

Fig. 4 - Curtain wall panel types



The adhesively laminated sandwich panel generally consists of two metal skins laminated to an insulating core material. These panels have very flat surfaces, excellent strength, good resistance to wind loads and integral insulation. The low fire resistance of the adhesive used to laminate panels together may be a disadvantage because of building codes in some areas. However, through careful design, panels can be made to stay in place even though the adhesive were destroyed by fire. Incidentally, adhesives as well as core materials can be treated with certain chemicals and be rendered noncombustible. Such panels will adequately meet a number of building codes.

Adhesively bonded panels are made on a platen press under both heat and pressure, or on a roll press. New adhesives currently under development should advance the acceptance of adhesively laminated panels and also reduce their cost of manufacture. Some of these new adhesives provide for room temperature setting without the necessity of heat and pressure. Also under development in the laboratory are high-temperature adhesives which maintain strength above the melting point of the metals which they bond. I am sure the time will come when these adhesives will move into production and provide us with a fine answer for making highly fire resistant adhesively laminated panels.

There is another type of panel which I consider an extension of the basic pan type. This type of panel is formed on a large heavy press and can have contours of almost unlimited variety. Such panels are desirable to give a three-dimensional and more substantial appearance to the exterior of the curtain wall. It is possible to produce these panels without excess cost if sufficient quantities are involved. For small runs of a few hundred panels, provided forming operations are not too severe, zinc alloy dies can be used. Zinc alloy dies cost considerably less than steel dies. For a large job, with a great many identical panels, steel dies must be used. Formed panels, therefore, are a good means through which monotony of curtain wall design can be avoided.

<u>Types of Panel Walls</u>

By panel walls, we mean the large panels which constitute the wall itself without exterior visible framing elements. (Fig. 5) The manufacture of these panels is really quite simple. What is required is a large press, and a sufficient number of panels to achieve production economy. As is the case with the formed panels used in the metal grid system, these large panels can be produced in a variety of shapes and patterns. Insulation can be provided behind them in the form of lightweight aggregate cements which can be pumped in. The more recent development of foamed-in-place plastics should provide a simpler means for insulation, and, of course, our old standby, fiberglas, can be applied behind such panels to provide very good insulation.

Formed panels may be applied to a subframing system or directly to spandrel beams. The edges are so constructed that a certain amount of expansion and contraction can occur between them while at the same time good resistance to weathering through the proper incorporation of sealants is obtained. It is even possible to make large, flat laminated panels to do this same job and, with some developments now occurring in the laboratory, it appears possible to attach these panels directly to each other without the necessity of subframing. Laminated metal skin panels have tremendous strength and this strength should be taken advantage of through proper design of the wall. A great deal of redundancy could be eliminated by doing this, and elimination of redundancy means reduction in cost and better performance.

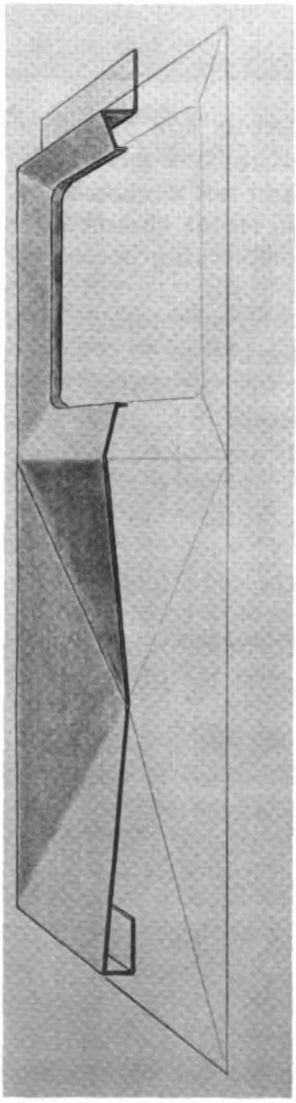


Fig. 5 - Large formed wall panel with punched window opening.

Another type of curtain wall which has met with great success and is widely used is one normally referred to as the industrial curtain wall. (Fig. 6) This type of wall generally uses stock panels of rolled or braked metal elements. These panels can be provided with or without insulation, and do an excellent job for the purpose designed.

Fig. 6 - Applications of industrial type curtain walls

Exterior Finishes

Let us now consider briefly some of the means by which these walls can be given an attractive exterior appearance; again, the thought being to make the walls interesting and not monotonous. First of all, in the rigidized metals, embossed patterns are applied to metal sheets by means of a roll press in which a pair of roller dies of the desired embossing pattern are installed. (Fig. 7) Finishes are then applied to these rigidized metals. Porcelain enamel is one finish available. It can be fired in two or more colors and, in connection with rigidized sheets, beautiful color and texture combinations can be achieved. Some of the most recently developed plastics are quite adequate for exterior exposure. The acrylics and the vinyls have perhaps reached a more advanced state than other plastics. These can be applied to the metal in a manner to achieve beautiful color effects. With porcelain or with plastics in combination with stainless steel for example, we can highlight the stainless by removing the porcelain or the plastic from the high points on the textured surface. (Fig. 8)

Ceramic finishes, mosaic tile and other materials can be added to the faces of laminated panels to give interest, color and variety. A special note here regarding mosaic tile; for it to perform properly, very good adhesives must be used and the sandwich panel must be designed for considerable rigidity.

We can also do a lot with simple flat sheets. For example, there are means by which different alloys of aluminum can be metallurgically bonded to each other. In other words, we can take thin strips of an alloy, apply them in certain patterns to a basic sheet of a different alloy, metallurgically bond the whole together, then put this through the anodizing process and come up with two or more different metallic colors in the final sheet.

In the basic anodizing process itself we are beginning to make progress. In the last few years, several new processes have been developed which begin to provide a variety of colors in the finished anodic coat. Up until recently, dyes absorbed in the pores of anodic coatings have been the principal means of providing color. Architectural results have not always been too happy. The new processes, however, use special electrolytes in conjunction with special alloys of aluminum to achieve beautiful, highly corrosion resistant finishes. Since the color is obtained through inorganic compounds, there is no noticeable deteriorating effect due to outdoor exposure. Metal still looks like metal when finished in this manner. New finishes, in themselves, should open up whole new vistas for architectural treatment of building facades.

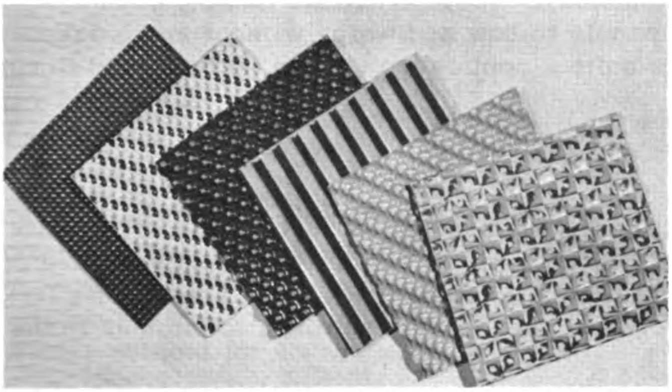


Fig. 7 - Rigidized metal sheet with wiped porcelain enamel finish

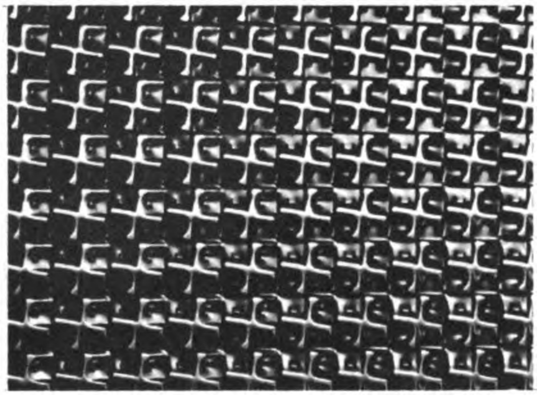


Fig. 8 - Blackened rigidized stainless steel sheet highlighted by buffing

As to the matter of tolerances, it is basic to factory fabrication that tolerances can be much better controlled in the factory than in the field. Tolerances add up from the individual members to the final assembly. Normal extrusion tolerances on elements commonly used in metal wall construction will run ± 1/64" to ± 1/32". Extrusions, of course, must then be cut to length, and cut lengths can be readily controlled through proper fixtures to something less than ± 1/16".

Approximately the same tolerances achieved with extrusions can be achieved with rolled shapes. Brake shapes, even though special dies and fixtures are made, will require somewhat larger tolerances than extrusions or rolled shapes. Angular tolerances are more difficult to hold.

With good practice it is possible to assembly a typical 5' x 12' panel unit to a tolerance on all dimensions of ± 1/16". However, I emphasize that this requires good jigs and fixtures. It can't be done with a tape, pencil and hand saw.

While we have made progress in the factory in controlling tolerances, I believe the construction industry (that is, those people concerned with the basic structure of the building in steel and concrete) has made even greater strides. One of the largest contractors in New York City advises me that they can hold structural dimensions to within ± 3/4" at critical points. Even if this variation were ± 1" at the points of anchorage, it's perfectly possible to accommodate this variation through well designed anchoring systems and panel joining systems, and come out with a very accurate curtain wall installation. The better metal curtain wall fabricators have started to use exact fixtures to locate anchor points, which is far superior to the old method of snapping chalk lines and measuring off distances with tapes, and is also less expensive.

Great progress has also been made in accommodating curtain walls to dimensional changes due to variations in temperature. Credit for this progress can be given mainly to advances made in sealing compounds. A variety of sealants and gaskets is available today which retain their resiliency over the life of the building and permit come-and-go of the elements within the wall without any breakdown of the sealing function. To name a few, we have the liquid polymers which include two-part polysulphides, two-part polyurethanes and one-part silicones; we have the preformed elastomers, primarily neoprene, which are available not only in solid state but also as a sponge; and, of course, we have preformed plastics made of vinyls. I would say, in fact, that improved sealants constitute one of the greatest advances in curtain wall technology. They permit the framing elements to expand and contract, and the glass and panels to bow and warp, without any breakdown in their weathering capabilities. This is quite a contrast to the old putties used in earlier years.

Summary

In the last few years tremendous strides have been made. We have learned about new materials; we have learned how to apply them properly to our curtain walls; we have developed better control of tolerances in our fabrication; our erection techniques are far superior and have been helped by the progress made in the control of tolerances in the basic building structure.

Today, as a result, any architect willing to take advantage of the best manufacturing techniques can design a curtain wall of outstanding appearance and performance. This is not the end; many more new things are just over the horizon which could well revolutionize the "revolutionary" curtain wall, so that there will be no valid reason to refer to this great advance in wall construction as "monotonous."

Design for Efficient Field Erection

By Norman S. Collyer*, President
F. H. Sparks Co., Inc.

It is rumored that the American Institute of Architects is changing its name to the "American Institute of Precision Parts Designers." This necessitates that we change the description of our own work from "Erection of Metal Curtain Walls" to "Erection of Precision Fitting Covers for Variable Structures." The need for these changes has been glaringly evident for some time.

The condition in which the structure to be enclosed is delivered to us and the manner in which we receive the materials designed to enclose the structure make it impossible for us to be efficient. Our hope is that we may be able to complete the installation in spite of all the obstacles. We may be successful, but we will never be efficient, with the designs being handed to us. Let us look at some of the problems which need solving if we are to have efficient field erection.

First, there are the related problems of tolerances and clearances. Tolerance is, of course, the variations that occur in the size and dimensions of various members of the structure. Clearance represents the distance allowed or needed between adjoining parts of the structure.

The word "tolerance" usually implies a permissible or normal amount of variation, although the actual may be more. Thus, the mill tolerances in a 5" x 5" steel angle may be about 1/4" in either direction and the actual variations more. It is therefore stupid to talk of attaching aluminum extrusions directly to such an angle and expect a finished product within 1/16" or 1/32". Yet, such details appear on drawings daily. An aluminum extrusion may be exact to dimensional size or thickness within a few thousandths of an inch. This same extrusion, however, may be twisted or out of line by 1/2" or more from one extreme to another in a 20' length.

Large extrusions on a recent job produced by one of our best companies were consistently 5/16" off square. Since they were used opposite hand in an opening, this alone lost 5/8" from the opening size. 1/16" had been allowed for clearance between the four pieces making up the opening. These four pieces varied by at least 1/16", which is

---

*NORMAN S. COLLYER is a licensed professional engineer in New York State, and a member of the Cornell Society of Engineers and the Engineers Club of New York, as well as of BRI. Before joining Sparks, Mr. Collyer was associated with Elwyn E. Seelye & Co. and prior to that with Turner Construction Co. of New York. He earned his engineering degree at Cornell.

reasonable tolerance. The adjoining stone was 1/8" oversize. By cutting, fitting, and juggling in the field, these precision parts were put together on the building--but would you call this efficient field erection? And, can you afford to pay for all this field cutting and fitting? When checking tolerances in any material, check not for the possible cross-section size variation, but for the total variation in both directions from any given plane for the full length of the member. This is tolerance as those on the job must work with it.

I have mentioned above one of the clearance problems; namely, that between adjoining members of the wall itself. In a brick structure I suppose this would be the cracks in the mortar. In a metal curtain wall, it is the space that must be allowed between members to: 1) allow for manufacturing size variations; 2) permit expansion and contraction of the members; and 3) permit the erector to make up for size variations in the structure he is covering. Bear in mind that manufacturing variations on any particular job are normally all in one direction. You must accumulate all possible variations including size, out of square, and out of straightness for the full length of the member. Whether or not you care about expansion and contraction later, the erector must work with materials and temperatures as he finds them on the job, and this affects size. Even the best field engineers make mistakes, but we don't tear down the building frame because it's too large or too small. The wall has to be adjusted to fit, and this needs clearance.

The other important phase of clearance is the distance between the face of the structure and the nearest point on the metal curtain wall. At previous BRI conferences, it was recommended that this should be a design minimum of 2". Structural steel may vary 2" or 3" in either direction on a 500' high building and yet a well-known architect on a recent 40-story job specified 1/16" from a vertical plane for the metal wall, where another specified 1/8".

A 45-story building we are now working on allows 3/8" from face of concrete fireproofing to the inside of the metal wall. The author of the previous paper indicates that he has been assured by one of the larger general contractors that they can keep the concrete within 3/4"--twice the allowance on our job. We might agree that they can, but not that they do.

Some of you will say that you don't have these problems because your jobs are only two, three or four stories. A three-story building now in progress details the aluminum work fitting tightly to the top and face of concrete on three successive floors. The concrete contractor has amazingly stayed within 1/4" in height except for one brief abberation of 5/8". This is perfection, but what do we do with the 1/4" or 5/8"? The concrete is only out of line 1-1/4" in relation to the building line, but since the building is on a curve, we can't relocate the wall which is a precision fit. Please note that fancy shapes may look good, but they complicate the field problems.

The one- and two-story schools with light framing and lack of contractor engineering and supervision are the worst. Light, unbraced steel is difficult at best to keep plumb and in line, but our precision designers regularly show the aluminum wall fitting directly to steel H columns or lally columns which are commonly an inch or two out of line and plumb. If the column happens to be back from the wall, they show a one-piece closure between wall and column.

The designer usually establishes the size and weights of the units which will make up the metal curtain wall when he finalizes his design. He may say that he is leaving the composition to the fabricator, but actually he has so established the ground rules that the fabricator has little choice. As a guide, don't require a section to be larger than will go on the job hoist or heavier than can easily be handled by four men. If the various portions of a job go up in sequence, be sure that sizes and weights will permit proper sequence without one operation being limited by another.

Avoid the use of scaffolds for the installation of the wall if possible. Scaffold work is slow, costly, somewhat hazardous, and subject to weather delays. Most jobs can be designed for installation from the building floors without outside scaffolding.

Connection of the curtain wall to the structure can best be made by means of a two-piece bracket with two-way slotted holes to permit adjustments in all directions. Portions of bracket should be bolted together and tack-welded after adjustment to prevent slippage. The bolts are important to the erector to hold work in place during setting and adjustments. We consider the welding good insurance and it should always be done. Connection to the building itself may be by electric arc welding, electric studwelding, powder driven studs, built-in anchor bolts, or bolts in slotted inserts, but should always allow for adjustments. Keep the attachment at floor level whenever possible.

It hardly seems proper to discuss the problem of lines and grades as part of design. The design, however, sets the need for accurate lines and grades. The manner in which the curtain wall ties into adjoining parts of the building such as stools, convectors, venetian blind pockets, air ducts, pipes and other wall items such as glass and masonry determines to a great degree the required accuracy of the wall for elevation and alignment. All such adjoining elements must be carefully coordinated and detailed to fit together with a minimum of trouble and maximum flexibility both of dimension and timing.

Since lines and grades are used by all trades, they should be established, maintained and coordinated by the general contractor. There is a tendency today to push this responsibility more and more onto the curtail wall contractor. Confusion and trouble on the job will inevitably result, if the general contractor does not maintain control of and furnish proper lines and grades to all trades.

No curtain wall discussion is complete or even plausible without something being said about joints and joint sealants. Joints are needed to permit field assembly of parts, and to allow for expansion and contraction. While it may seem sensible to make pieces large to eliminate field joints, I believe that within reason a small number of joints may cause more trouble in a given area than a larger number. The larger the number of joints, the less movement and the less variations we have to handle in any one joint. The size and type of joint to be used obviously must depend on size of sections and design. Careful thought should be given to the fitting together of the members during erection, and to the movement that will take place later. A joint whose members slide against one another is better than one in which the members pull apart with movement.

The joint sealant may be a gun type mastic or a preformed tape or gasket. Preformed gaskets of any type must be positively compressed at the time of installation by some mechanical device in the design. Joints or splices in preformed gaskets must have some special form of field sealing. Regardless of the sealant, interactions of members at field joints must receive attention by the erector. Special backing plates and sealants are required at these points. Whether or not an external sealant is applied at the time of installation, it seems good practice to provide a joint which will permit such an application at a future date without being unsightly.

Don't cheat on the sealant! The extra cost of using the best, properly applied in the beginning, will save money over the years. Remember, however, that the best sealant, carelessly applied, is no better than any other. Some of the best sealants are very difficult to apply, and dangerous in the hands of an inexperienced mechanic.

A vitally important part of any modern metal curtain wall, and probably the most frequent source of trouble, is the glass installation. Since the glass may represent almost 100% of the exposed wall area, and the joints around the glass may be far greater in extent than all other joints in the wall, it is evident that the glass should be treated as part of the metal curtain wall contract. Whether or not the curtain wall erector installs the glass, he is vitally interested in the glass installation. Frames, which are frequently quite flimsy, must be left square, plumb and true to receive the glass. On the other hand, the glass must be cut square and properly set and blocked or trouble may result with the frames.

The problems of sealing the joints between metal and glass are essentially the same as for metal-to-metal, and can be solved in essentially the same manner with the same materials. We will not go into these problems here except to say that the standard putties and glazing compounds--even the best--are not adequate for the sealing of glass in metal curtain walls. We, as glazing contractors, are now refusing to perform glazing with these materials on curtain wall jobs.

More and more special finishes and special colors are being developed and used to add to the attractiveness of metal curtain walls. This is one of the designer's finest tools and one which I personally feel has not been exploited to its fullest possibilities. The handling of delicate finishes and colors presents many new problems for the erector. It is difficult to avoid some marring or scratching. Color variations delay the work while all concerned decide what to do about the variations. Frequently, sorting and relocating has been necessary; jobs have been delayed. The manufacturer should be honest about the variations to be expected in commercial production and the designer should resolve to live with the variations if he wants that particular color or finish. If this is not done, installation costs will skyrocket.

Having successfully fabricated and installed these tight fitting, highly colored and polished materials, we have the problem of keeping them the way we put them in. This can be difficult and costly with other trades working all around and the elements adding their toll. Much damage is done maliciously or carelessly because of a "don't care" attitude on the part of all concerned at the job-site. In some cases protective coatings of some sort may be needed. Strippable coatings may be all right in some cases, but I have yet to encounter one that will stay on for months exposed to sun and weather and then will strip off without leaving a troublesome deposit. Mortar and plaster will stain most surfaces if special protection is not provided. A careful program of protection and cleaning for each particular job, with the full responsibility in the hands of the general contractor who alone can control the job, is the only solution. The curtain wall contractors cannot prevent others from getting careless with the wall materials. The cheapest time to buy cleaning is after the job has been finished under careful control by the general contractor.

The designer sets the pace for the entire job from beginning to end. It is essential that the designer give more attention to the erector's problems if we are to have efficient erection of metal curtain walls and avoid future problems.

Color and Finish Control with Ferrous Metals

By J. P. Butterfield*, Manager, Stainless Sheet Sales
Armco Steel Corporation

In discussing color and finish control with ferrous metals, we also are discussing corrosion control, inasmuch as practically all colors or finishes enhance the corrosion resistance of the metal to which they are applied. Relative to corrosion of sheet metals, one of the first questions invariably posed by architects is: "Does corrosion occur at the edges and cause failure by progressive attack proceeding into the sheet metal from the edges?"

The answer is "No." In more than 50 years of corrosion research on sheet metals our company has never encountered failure by corrosion horizontally from the edges. When corrosion occurs, it always is in the vertical direction from the flat surface of the sheet. We do not mean to suggest that edge corrosion is so negligible that it never could cause visual dissatisfaction but, as far as catastrophic failure of sheet metal panels is concerned, edge corrosion can be forgotten. Incidentally, this is true for any sheet metal, ferrous or non-ferrous.

There are presently four basic methods for control of the color and finish of ferrous metals. These four methods are:

1) Metallic coatings, either electroplated or hot-dipped.

2) Organic coatings, such as paint or plastic films.

3) Inorganic coatings, such as porcelain enamel fused to a base metal.

4) Stainless steels.

Metallic Coatings

Electroplated or hot-dipped metallic coatings have limited significance in metal curtain wall design because of the importance of the appearance factor. However, from the standpoint of protection against corrosion, either zinc coated or aluminum coated steel offers the most protection for the least cost. The life of these two metallic coatings in the atmosphere far exceeds the life of paints, at a fraction of the cost of painting.

*JOSEPH P. BUTTERFIELD graduated from Purdue University with a degree in chemical engineering.

Organic Coatings

Organic coatings such as paint or plastic films offer a virtually unlimited color range and continuing research has led to the development of plastic films that are quite resistant to atmospheric corrosion. The durability of these films is dependent on the composition of the plastic, the thoroughness of coverage, and the ability of the film to act as a barrier to attack by the elements.

The newer acrylic resin paints offer the prospect of a service life of eight years, or possibly even longer, on ferrous metals at a current cost somewhat less than twice the cost of standard paints.

A major research target of the vinyl plastic manufacturers is to develop polyvinyl chloride films that will withstand ultraviolet light, ozone and other atmospheric corrodents, and still retain their color, flexibility, and protection of the base metal. This development is in its infancy in the United States, but Belgian and Swiss architects have been using such films on storefronts and wall panels for the past several years with considerable success. Newer and more resistant films such as polyvinyl fluoride may offer more latitude in architectural applications than polyvinyl chloride, if manufacturers' tests are duplicated in actual service.

The other two methods of color and finish control of ferrous metals for metal curtain walls are by far the most widely employed.

Porcelain Enameling

Porcelain enameling is perhaps the oldest metal coloring method known to man. It dates back to the very early Chinese civilizations and to artifacts found in the Pyramids. The colors of these ancient porcelain coatings have endured through centuries and they still protect the metal to which they were applied. No known method of color and finish control on ferrous metals has a better proof of reliability than that offered by these ancient examples of the art of porcelain enameling.

By definition porcelain enamel is a substantially vitreous or glassy inorganic coating bonded to metal by fusion at a temperature above 800°F. For architectural uses, the fusion temperature is in the range of 1200°- 1500°F.

The range of colors available in porcelain enamel is limited only by the ability of the architect to discuss and convey his ideas to the enameler. There must, however, be mutual agreement on the color tolerance. All of us know that changes in humidity, temperature, cloud cover, and angle of viewing can result in slight changes in the appearance of the color. Since there are few, if any, color metering devices as critical as the human eye in the evaluation of an expanse of color, the architect must recognize the problem that is posed in securing true repetition, panel after panel, of delicate pastel colors.

For example, shades of pink may be both visual and color-metered equals at the same angle of viewing. When installed on a building, a cant or misalignment of a panel changes the angle of viewing for that panel and may make it appear almost gray instead of pink. Here, the control of color lies in proper installation, since all things were equal before the panel was placed.

To assist in control of color, members of the Porcelain Enamel Institute have established a series of 47 standard color chips. These colors are formulated and coded so that all members of the Institute are able to match them. We recommend the use of this color guide system, which was developed jointly by the Porcelain Enamel Institute and the National Bureau of Standards to assist in the control of the color variable in porcelain enamel finishes.

In addition to color control, the Institute maintains a technical committee for periodic review and up-dating of their Architectural Porcelain Enamel Specifications. Currently, studies are under way on flatness, weathering resistance, color retention, gloss, and image formation. As these basic studies are completed the findings will be incorporated in the specifications covering porcelain enamel surfaces.

The most recent advance in the control of architectural porcelain enamel occurred only last month, when the Porcelain Enamel Institute announced its Quality Verification Program. The manufacturers of architectural porcelain enamel have agreed to rigid specification control and to unannounced inspection of their products both in the plant and on the job to insure satisfaction for the architect and his client.

Stainless Steels

The remaining method for control of color and finish with ferrous metals is the use of stainless steel. There are many different alloys in the metallurgical family of stainless steels but only four have any architectural significance.

The American Iron and Steel Institute assigns identification numbers, known as Type Numbers, only to those stainless steels that are standardized as to alloy composition and are both in general use and in regular production by most of the stainless mills. The AISI Type Numbers to consider for architectural applications are: Type 301, Type 302, Type 316, Type 430. Use of these AISI Type Numbers controls the chemical composition just as effectively as any specification you may write.

Type 302 is by far the most commonly used architectural stainless steel. It is popularly known as "18-8", which refers to the 18% chromium and 8% of nickel that make up its nominal composition. Probably as high as 90% of all architectural stainless steel applications of the past 30 years are in Type 302 or 18-8.

Type 302 is fabricated into simple or intricate shapes by hundreds of metal fabricators. In earlier years, lack of experience with stainless steel fabrication limited its availability, but now many fabricators specialize in stainless steel and prefer it. It is the strongest and sturdiest of the architectural metals and nature in the form of chromium makes it carefree and beautiful.

Type 301 contains only a little less chromium and nickel--17% chromium and 7% nickel. It is a good choice where widths under 24" are required and a cold rolled finish is specified. If these two conditions are met, there is an appreciable saving, averaging about 7% in material cost, compared with Type 302.

A good illustration of intelligent use of Type 301 would be its selection for outdoor architectural sections that are fabricated by roll forming from cold rolled strip coils. The atmospheric corrosion resistance of Type 301 or "17-7" is fully equivalent to that of Type 302.

Type 316 is a molybdenum-containing version of Type 302. A molybdenum addition of about 2.50% considerably improves corrosion resistance, particularly in salt air. The architectural use of Type 316 is confined almost exclusively to locations such as Atlantic City and Miami, or similar exceptionally corrosive, salt air environments. Type 316 is not necessary in other locations.

Type 430 contains about 17% chromium--the alloy that makes stainless steel stainless--and no added nickel. Type 430 is the economical choice for many interior architectural applications and it also is suitable for metal curtain wall systems, providing two conditions are met. First, it should never be used in salt air environments such as Atlantic City or Miami. Second, it should not be used if weldments are exposed to atmospheric corrosion, because the metal immediately adjacent to welds may rust. Type 430, in sheets or strip, is approximately 20% lower in price than Type 302, thereby providing a worthwhile saving in many valid architectural uses, including metal curtain walls.

The natural color of stainless steel as it comes off the rolling mills is silver gray. There really are only two basic finishes of the metal that architects should know. The first is a dull, cold rolled finish (2D) that has found much favor in exterior metal panel construction. Examples of the use of 2D finish are the three Gateway Center Buildings in Pittsburgh and the new Socony-Mobil Building in New York.

We believe that the dull cold rolled finish used on all these buildings is ideal for metal curtain wall panels because there are no reflected images or reflected sunlight, the color is a uniform silver gray, the surface is the best for fabrication of any design patterns desired, and the cost is the lowest possible for stainless steel because there is no extra charge for a cold rolled finish.

The other basic finish of significance for metal curtain wall systems of stainless steel is No. 4 Polish. This is the long-established, standard polished finish that architects specify for building entrances, marquees, elevator doors, column covers, and many other uses calling for "dress-up" effects. However, we do not recommend the use of No. 4 Polish for metal curtain wall panels because of objectionable light-reflecting characteristics. On the other hand, No. 4 Polish is eminently suitable for trim, mullions, and any other small areas calling for contrast.

A recent innovation is the production of stainless steel sheets in color. Two new buildings have employed color-coated stainless sheets. On the American Society of Metals Building, near Cleveland, a soft gold coating is used on one side of the stainless steel sunshade on this ultra-modern structure. On Gateway Building No. 4 in Pittsburgh, a charcoal gray color coat on stainless steel panels will offset and accent the No. 4 Polish also used.

These colors are designed for outdoor exposure. It is reported by the producer that the thermo-setting acrylic coating fabricates well and can be drawn, bent, or roll-formed into any shape. Eleven colors are currently available, and the coating system permits easy field repair should damage occur during erection of panels.

Another coloring method for stainless steel in limited usage involves a simple chemical process that applies a black oxide finish which contrasts well either with the natural silver gray of a cold rolled finish or with No. 4 Polish.

Porcelain enamel can be applied to stainless steel with satisfactory adherence, and stunning color effects can be achieved on textured stainless by burnishing off the porcelain enamel from the high points of the textured pattern and leaving the porcelain enamel in the valleys.

In concluding this brief discussion, we depart for a moment from our main topic to suggest that there is another area of control by architects and contractors that often does not seem to receive the attention it merits. We refer to the control of quality by specification and by inspection. A loosely worded specification, rather than achieving the desired result, too frequently is an open invitation to downgrade. It is our sincere belief that reputation for quality and past good performance should carry as much weight as the low price in evaluation of bids. Architectural errors in metal, as well as in other materials, may result from too much of a squeeze on the initial cost, and may sacrifice the quality of the job.

Very few clients have unlimited resources and no job has an unlimited budget, but we have yet to find a client who is willing to buy trouble. We respectfully suggest that this is an area of control in which all segments of the industry--architects, engineers, contractors, builders, and material suppliers--should cooperate to educate the owner for the mutual advantage of all.

Color and Finish Control with Aluminum Alloys

By C. J. Walton*, Chief, Finishes Division
Aluminum Company of America

This discussion will be confined to finish and color control of aluminum alloys. The first large-scale use of metal curtain walls employed aluminum, and since then hundreds of buildings of varying sizes and shapes have been faced with aluminum as the primary or complementary material. From the inception of the metal curtain wall, it was recognized that its success and growth would depend on the use of durable and versatile metals, coupled with styling and color for aesthetic effects. It was also known from preceding experience that aluminum is ideally suited to curtain wall systems because of its availability in various products and shapes, and its ease of fabrication, as well as its ability to take and hold various types of protective and decorative coatings.

Considerable research has been focused on this general subject by the aluminum industry. This effort is being directed not only toward the finding of new finishes, but toward resolving those unforeseen problems that arise in any new market as large as this one. A great deal of attention has been given to methods and practices for controlling processes associated with aluminum architectural products. The result is that today there are more colored architectural finishes for aluminum with better control of finish than was the case several years ago. There is every indication, however, that new finishes with color will continue to come forth from the research and development now in progress throughout the metal industry.

ALUMINUM AS A SUBSTRATE

It would seem appropriate to preface further discussion with remarks on the merits and characteristics of aluminum as a substrate for finishes. In the final analysis, it is the nature of the alloy or metal that plays a major role either in forming the coating or in providing a stable base for it. The high resistance to corrosion of aluminum alloys is attributed to their natural ability to develop highly protective films when exposed to different environments. In addition, very protective and decorative films can be formed artificially on aluminum alloys by subjecting them to various chemical and electrochemical processes. The anodizing process is an outstanding example of a finish that is unique to aluminum alloys. Beyond this, however, aluminum can also be effectively coated and colored by organic and porcelain films. Finally, the inherent resistance to corrosion of

*CHARLES J. WALTON was educated at Carnegia Institute of Technology where he received his B.S. degree in metallurgical engineering. Mr. Walton is a member of American Society for Metals, ASTM, Natl. Association of Corrosion Engineers and the Scientific Research Society of America (RESA). His company is a member of BRI.

aluminum alloys as used in architecture is of a sufficiently high order that they have been used without any protection. Because of the good durability of aluminum alloys, their use permits developing the full life and potential of the applied colored coatings, whether they be anodic, porcelain, or organic.

WAYS TO COLOR ALUMINUM

Colored finishes for aluminum can be achieved in several ways. The coloring can be applied as a pigment in organic coatings or in porcelain enamels. In the case of anodized aluminum, color can be produced by using certain alloys where the oxidation products of specific elements or combinations of elements pigment the anodic coating during its formation. Anodic coatings can also be colored by impregnation with dyes or pigments. Certain chemical treatments produce colored and protective films on aluminum, and these have been of architectural value. The light-gray patina that develops by the weathering of unprotected aluminum may be considered as a naturally formed finish. All finishing methods have been adapted successfully to curtain wall systems.

The colored effects produced and the range of colors and finishes available vary with the type and thickness of coating used. On the basis that lightfast colorants are employed, the life of the color will be related to the expected life of the type of coating--anodic, porcelain, or organic--containing the colorant. The life of any coating and material of construction will vary with the nature and aggressiveness of the environment. The anodic coatings in the thicknesses recommended represent the most durable finish for aluminum for architectural application, followed closely by porcelain enamel and then by organic coatings.

ANODICALLY COATED ALUMINUM

Anodically coated aluminum has played a major role in metal curtain wall development. The first metal clad buildings of this type employed anodized aluminum because of its attractive appearance and excellent resistance to weathering in the absence of maintenance. Since then, hundreds of buildings have used anodized aluminum, alone or in combination with other metals or non-metallic facings. At first, anodized aluminum was offered in a light, natural aluminum finish and in a medium gray contrasting finish. This was followed by two darker shades of gray and by shades of gold, blue, brown, yellow and green. Before each of these finishes was exploited, it was thoroughly tested for durability and colorfastness.

The many buildings using anodically coated aluminum have been eminently successful and a tribute to the architects, engineers, and tradespeople associated with them. The problems that did develop in the past were chiefly concerned with the control of finishing treatments on such a large scale. These difficulties were analyzed and resolved primarily by instituting closer controls of metallurgical practices and surface processing.

Today durable colored anodic coatings are being produced by two basic approaches that may be classified as (1) integral colors and (2) impregnated colors.

Integral Colors

The term integral color designates simply that the color develops through the anodic process and results from pigmentation of the anodic coating by elements (or their oxidation products) present normally in the alloy or intentionally added to the alloy. Some years ago we found that whereas high purity aluminum produced transparent anodic coatings, the coatings formed from alloys containing certain elements were colored. At that time the desire was for clear anodic coatings that maintained the natural finish of aluminum. The dark cast produced by silicon additions, the yellowish cast from chromium, and the pink cast from manganese were not acceptable.

With the advent of the metal curtain wall and the demand for more diverse finishes and color shades, this method of producing color by alloy additions to the metal attained importance. The development of a uniform finish, and one reproducible from piece to piece and lot to lot for sheet and extrusions, has necessitated close control of metallurgical processes and of anodizing practices, because depth of color is related to the metallurgical structure of the alloy and to the thickness of the anodic coating. It is noteworthy, however, that the inherent difference in surface texture between sheet and extruded sections will usually cause a slight variation in surface appearance between these products.

Aluminum-silicon alloys yield anodic coatings that are dark, the shade varying with the amount of silicon used, the metallurgical practices, and thickness of anodic coating. This family of aluminum alloys has been the basis of four shades of gray ranging from a very light gray, natural finish, to a very dark gray. The metallurgical and processing technology for these alloys has been established so that good color matching within reasonable limits can now be effected for these achromatic finishes.

The integral-color gray anodic coatings have displayed outstanding durability and colorfastness in outdoor exposures that range up to periods of from 10 to 20 years for the light- and medium-gray finishes. The deeper grays have not been exposed as long, but their performance should be at least as good. These finishes have been used extensively in curtain wall applications.

Another approach to an integral color is by changing the anodizing conditions and process. One such process that has achieved commercial recognition involves the use of the hard anodizing process for coloring extruded 6063 alloy. The alloy is anodized under conditions designed to produce very hard and very abrasion resistant coatings (referred to as hard coatings). By applying such coatings in thicknesses ranging from 1 to 3 mils on 6063 alloy, metallic colors of a light, medium, or dark bronze are produced.

Impregnated Colors

The second basic method for coloring anodic coatings is by impregnation with various colorants. This method for coloring anodic coatings dates back many years and still represents an important method today. When formed, an anodic coating contains billions of submicroscopic pores per square inch of surface, and is therefore highly receptive to impregnation with colorants. After coloring, by a 1- or 2-step process, these pores are closed and the colorant sealed in by special treatments. By this process, it is possible to impregnate an anodic coating with mineral pigments, organic pigments, or organic dyes.

Many colorants have been investigated and only those that display good colorfastness in 1000-hour Fadometer tests and outdoor exposure are used for architectural applications. Three specific colorants--gold, blue, and yellow--have been found through exhaustive tests to have a high degree of colorfastness and are considered suitable for coloring anodic finishes for architectural uses. These colorants have been employed successfully in a number of architectural applications and are showing good color retention. This is exemplified by samples of gold and blue that have shown good color stability after five years' exposure to the industrial atmosphere at New Kensington, Pa. These three durable colorants have been employed in conjunction with the integral-color gray finishes to impart varying shades of blue, brown, and green. Here again, good color retention is being displayed in a three-year outdoor exposure of the architectural colors representing these finishes.

These findings emphasize the fact that good, colorfast anodic coatings can be produced by several approaches and that good color stability can be achieved both by the integral-color process and by the impregnation process. Presently, the number of colored finishes available for the anodically coated parts is limited, but the combination of colors now offered does include some of the more desirable architectural colors. To this can be added the potentialities of the integral-color gold and several shades of integral-color bronze.

Control

The technology for controlling the standard colored anodic finishes is rather well established and good color match and durability can be expected when these practices are followed. The final product can best be evaluated by measurement of such significant properties as thickness of anodic coating (ASTM B244-56), weight of anodic coating (ASTM B137-45), and effectiveness of sealing treatment (ASTM B136-45), since these properties influence durability and the ability of the product to develop the desired finish. The achromatic finishes, such as the integral-color gray finishes, can be appraised effectively by measuring the apparent reflectance to determine if they are within the range specified and agreed upon by the architect. The chromatic finishes are more difficult to evaluate and to match by existing instruments. For these as well as for the gray finishes, it is best to match the color and appearance by use of color standards and color range chips. The color and color range should be agreed upon prior to the processing of the materials. Close liaison is required, however, among the metal producers, the processors, and the architects. In this connection, at least one major aluminum producer employs an inspection service to assist all concerned to produce materials and finishes that will meet the architect's specifications.

PORCELAIN ENAMELED ALUMINUM

Porcelain enamel is one of the newer architectural finishes for aluminum. Since its introduction about 1953 as a curtain wall material, it has been successfully used to sheath and color a number of buildings of different types, including monumental buildings, hospitals, schools, and power plants. Most of the problems attendant to any new product have been resolved. Research and development have advanced the technology of porcelain enameled aluminum to the point where a product of high quality and durability can now be produced consistently.

To achieve best results, it is necessary to use certain types of aluminum alloys, surface treatments, and enamel formulations. Most difficulties with enamel adhesion in the past were related to choice of alloy or surface treatment. While unalloyed aluminum is an excellent base for porcelain enameling, certain elements that may be present in aluminum or added to it for strength considerations can adversely affect adhesion, whereas other strength-bearing elements are without effect.

Today the porcelain industry sometimes employs alloy 3003 where its strength and stiffness is adequate, but more often prefers the stronger 6061 alloy. Good results can be achieved with either of these alloys, especially when combined with the better surface treatments now available. However, better and more consistent results are obtained by use of aluminum alloys whose composition is controlled for optimum enameling characteristics. One metal producer now offers two aluminum alloy products that are designed specifically for porcelain enameling, and these develop strengths equal to 3003 and 6061 alloys. The indicated need for aluminum enameling alloys is analogous to the need and use of porcelain enameling stock in the ferrous industry.

The choice of aluminum casting alloy is also limited by alloy composition as it affects the melting point and porcelain enamel adherence. Such aluminum-silicon alloys as 43 and 344 satisfy both requirements and have been successfully employed for this service.

The surface treatment now commonly used in the enameling industry includes the use of an acid etch and a final surface conditioning in an alkaline chromate solution.

Porcelain enamels for aluminum are formulated to melt and fuse at about 1000°F (below the melting point of aluminum) and are applied in thicknesses of about 3 to 5 mils. The porcelain enamel bonds integrally with the aluminum surface and can undergo forming, drilling, sawing, without loss of adherence. Should the underlying aluminum be exposed for any reason, its high resistance to corrosion forms a protective film to stifle further attack, thereby minimizing the tendency for any color staining of adjacent enamel.

Porcelain enamels for aluminum can be offered in a wide range of basic colors and pastel shades with all but a few having good or excellent colorfastness. Some of the longest weathering data and service experience on porcelain enameled aluminum extend over periods of 10 to 15 years with good retention of color and gloss at the end of this time. Subsequent investigations on the newer porcelain enameling alloys extend up to 2 years on a wide range of colors and up to 4 years on fewer colors. In all cases, good adherence and good-to-excellent colorfastness was displayed. The former series includes both matte and gloss formulations, and these exhibited good self-cleaning properties.

Control

Several tests developed under the sponsorship of the Porcelain Enamel Institute can be used to evaluate porcelain enameled aluminum products. The ammonium chloride spall test is generally used to determine whether the alloy and surface treatment employed provide adequate enamel adherence, but there are some exceptions to its use based on the fact that this short-time test is not significant for some clad aluminum products. Other chemical tests are available to evaluate resistance of the enamel to acids. This correlates, at least qualitatively, with the inherent resistance of enamel to weathering.

Gloss measurements at 45° are useful to assure compliance with the degree of matteness or gloss specified. In this connection, it is the considered opinion of the trade that for best durability a matte finish should not have a gloss factor less than about 35, and that a range of from 35 to 85 for both matte and gloss finishes is preferred. Color and color control is technically a minor problem since the finishes are opaque and the enameling process can be adjusted to duplicate almost any given color. Color matches generally are made visually and by color-measuring instruments.

ORGANIC COATINGS ON ALUMINUM

Organic coatings will always represent an important finish for certain curtail wall applications, particularly where low cost and periodic alteration of the color scheme are important considerations. While organic coatings can be field applied, they can be applied most effectively and efficiently in the shop under controlled conditions. This also permits the use of newer synthetic formulations that require certain types of baking treatments for optimum results. There has been a progressive improvement, especially in recent years, in the quality and durability of organic coatings. These developments will undoubtedly produce more attractive colored organic finishes and greatly increase the prestige of this versatile finish for architectural applications. In this connection, considerable interest and activity is now being centered around the use of the new acrylic formulations for architectural application.

Substantially all organic finishes of the types now being used or advocated for architectural applications can be applied effectively to aluminum alloys. To receive these coatings, the aluminum need only be surface treated with an etchant such as phosphoric acid or, preferably, with one of the several proprietary chemical conversion treatments designed for aluminum and widely used throughout the paint finishing trade. Anodized coatings, of course, provide an excellent base for organic films but are not required.

Long and successful experience has been achieved with durable synthetic coatings when applied to aluminum, these including the alkyds, vinyl-modified alkyds, and vinyl coatings. Aluminum awnings, sidings, store fronts, and other architectural products with these organic films about 1 mil thick are providing more than 10 years service in many areas of the country. Aluminum alloy test panels with similar coatings are in a good state of preservation after 21 years' exposure to the industrial atmosphere at New Kensington, Pa. Even after this long exposure the paint film is substantially continuous. Other colored architectural finishes employing more recently developed synthetic formulations are now showing good durability and color retention in exposures of up to 4 years on aluminum alloy extrusions.

In recent years, the acrylic coatings developed initially for automotive applications have been modified for the architectural markets and can be applied by spray and roller-coat methods. The acrylic coatings, which are expected to provide even greater durability than previously employed organic coatings, are being used commercially on aluminum for residential applications.

Organic coatings do not require a primer and they are usually applied to aluminum as a single coat about 1 to 1-1/2 mils thick. The durability will vary with the severity of the environment and the thickness of the coating. Field experience indicates that commercially applied coatings of the alkyd or vinyl type in the thickness range mentioned above are giving 10 to 14 years of service in many areas; it is likely that the newer formulations and resins will at least equal and perhaps exceed these expectations, and also retain the original color to a greater degree. Longer coating life can be achieved by the use of the above-mentioned family of synthetic coatings in greater film thicknesses. Coatings in thicknesses of 2 to 5 mils have been used with success in special applications.

Control

The properties of organic coatings are usually evaluated by performance tests employing ASTM and Federal Specifications as a basis of reference. Included are such tests as film thickness (ASTM D1400-56T) and extensibility of coating using a conical mandrel test (ASTM D522-41). A Weatherometer exposure is frequently employed as an indication of colorfastness and durability. Color is usually controlled by specifying pigments that are known to be colorfast. Color matching is accomplished either visually or by color instruments that are now available.

Summary

The information summarized herein is but a small fraction of the accumulated technology and experience which the aluminum and metal finishing industries are now using to provide durable and colorful aluminum components for curtain wall applications. It is hoped, however, that this discussion will assist the architect by giving him up-to-date information on the basic characteristics of aluminum, its inherent ability to respond favorably to various coating and coloring processes and to develop the full life-expectancy of each type of coating, whether it be anodic, porcelain enamel, or organic. Aluminum alloys with these varied finishes can satisfy many of the needs for durable and aesthetic products for curtain wall systems.

New Metal Curtain Wall Specifications

By Ralph L. McKenzie*, President
Metal Curtain Wall Division
National Assn. of Architectural Metal Manufacturers

It is obvious that, while one man or a group of men may design a curtain wall, many minds and hands from many companies must cooperate to translate this design into a satisfactory wall. My portion of this program will be devoted to a discussion of one instrument which can enable all to achieve the desired result. With all of the mechanical and electrical contrivances man has devised to transmit thoughts and ideas, none can improve or correct faulty thought processes. We must depend on man-made guides of one kind or another. In the Specifications of the Metal Curtain Wall Manual of the National Association of Architectural Metal Manufacturers we have such a guide.

That a guide to metal curtain wall design and construction was needed has been very evident to those who must conceive them and those who must build them. The explosive development of an industry that was only in the crawling stages 10 years ago created many problems for both fabricators and architects. Fighting for position, fabricators wrote their own specifications and each tried to sell the architect his particular point of view. The architect, lost in a sea of claims and counter-claims, frequently accepted a particular specification only to find that after the bids were in the job had gone to someone else. The successful bidder then began to work on the "house-of-cards" specification created by his unsuccessful rival and the rest of the story is too familiar to all of us to need repeating.

Meanwhile, back at the architect's office, the specification writer was faced with the writing of a very complex section on a product with many kinds of materials for which architectural standards did not exist. This led to many kinds of specifications, some good, some weak. If a bad job resulted, the blame frequently was laid to metal curtain walls in general.

Realizing that only cooperative effort could bring order out of the incipient chaos, a group of individuals representing metal producers and fabricators in June 1957 organized the Metal Curtain Wall Division of the National Association of Architectural Metal Manufacturers. It was decided that the greatest service that could be rendered the architectural profession and the metal curtain wall industry was the creation of standards for the work which would provide a common ground for understanding.

---

*RALPH L. McKENZIE earned his B.A. degree at Centenary College, and subsequently did graduate work both at Louisiana State University and Kansas City Art Institute.

Specialists from producers, suppliers, and fabricators, some of the best brains in our industry, worked long and diligently as our Research and Development Committee, to write a curtain wall manual. In physical form this manual is loose-leaf, for this is an ever-changing industry. With its creation, our Association has assumed the responsibility for the continual maintenance and revision of the manual.

Contents of the manual are divided into:

1. Terminology
2. Bibliography
3. Specifications
4. Reference Standards
5. Design Principles
6. Economics

The specifications are designed for use by the architect. They are not intended for direct use as written, but will serve as a guide and a reminder to the architect to assist him in conveying his intentions to all concerned.

While the specifications are not wholly streamlined, an effort has been made to be as brief as is consistent with adequate coverage, at the same time providing a form appropriate for most requirements and supplying within the manual the information needed to fully implement it. It is recognized, however, that not all needs have been met, and that in some situations additional information or recommendations may be needed.

In order to better allocate responsibility and insure the best results, it is urgently recommended that the writer make these specifications a separate section of the building specifications, rather than scatter them among other trade sections.

A specification should be able to stand the close scrutiny of an expert estimator and answer all of his questions as to the architect's intention. Primarily, a specification is a categorical reply to the contractor's question, "What does he want us to do?" It should answer the familiar journalism queries of "who, what, when and where?" Elementary as this may seem, it is the failure to answer these questions that has caused confusion, misunderstanding, lawsuits, broken friendships, etc.

In Section 1, General, there are listed abbreviations appearing in the manual. Most of them, such as AIA, ASA, AISC, are familiar, but to some of you one may be a stranger. This is NAAMM, the National Association of Architectural Metal Manufacturers, parent body of the Metal Curtain Wall Division.

Where standards for materials or phases of curtain wall construction did not exist, the Metal Curtain Wall Division, in the name of the Association has brought together interested parties and established tentative NAAMM standards. We say "tentative" because they are subject to change and revision as are all parts of the manual.

In Section 1, General, there is also a part devoted to the curtain wall fabricator. It defines who he is and makes provisions for identifying him by name. An orderly procedure is established for approval of fabricators prior to bidding.

In the commentary text which will soon be issued to explain and amplify the specification further, we are recommending that a single sub-contractor should be responsible to the general contractor for the complete metal curtain wall installation, including glazing and all component materials and labor. Otherwise the blame for deficiencies which may appear are too easily shifted from one contractor to another; leakage may be ascribed by the metal manufacturer to improper glazing, and by the glazing contractor to the details of the metalwork.

The prior approval of contractors is a procedure recommended as a safeguard for the architect against submission of late, uninvited bids involving proposed substitute materials and details claimed to be equal to or better than those called for in the design. The requirement of approval 10 days in advance of the bid date, along with details and description of proposed variations, will discourage this while still permitting other contractors than those named to submit bids, if that is desired.

There are paragraphs to define the curtain wall contractor's responsibility in his relationship to the architect, general contractor, and other contractors; paragraphs to explain the information required in the shop drawings; and paragraphs to list the requirements for samples. Another paragraph provides for clarification of the subject of mock-ups: where they will be built, by whom, and who pays for them.

One of the most important paragraphs of the specifications is also found in this section: the guarantee. This makes the curtain wall fabricator responsible for materials and workmanship for a period of two years. Because of the extremely complicated interrelationship of metal components in a curtain wall, it was felt that two years of climatic changes are required to determine that all is well on the wall.

While such a guarantee seems to place the burden on the fabricator, it should also impress on the architect that the specifications must be carefully and completely drawn to provide for enforcement of the guarantee. Since it also makes the fabricator responsible for all material in his wall system, he must be sure that components other than metal meet the various standards as specified.

In some cases the custom type wall may be completely detailed by the architect, who thereby assumes much of the responsibility for compliance with code requirements, and for structural performance, air infiltration and leakage. In many instances, however, the architect may leave many decisions about details to the experienced judgment of the fabricator-contractor, and this is a commendable procedure. In any case, if the contractor is to be held finally responsible for guaranteeing satisfactory performance of the wall, he must be advised of the criteria governing the design, so that he may be guided accordingly.

<u>Section 2, Scope of the Work,</u> is practically a check list for the architect to assist him in clarifying what is and is not included in a curtain wall. A particularly valuable feature of the "Work Not Included" is the provision for listing the section of the specification where the item not to be included is specified. Too often this is overlooked and this paragraph will serve as a reminder to the architect to see that the item is covered.

<u>Section 3, Over-all Performance Standards and Tests</u>, gets down to the heart of the matter and avoids the vague references too often used for performance standards. Structural requirements for the wall are defined and proof, in the form of structural calculations, is required from the fabricator that his wall system meets these requirements. This should eliminate some of the borderline wall systems from installations for which they are not suited. Tests of the wall system for air and water infiltration are required under this

section, based on testing standards provided in another section of the manual.

The testing standards describe in detail the equipment and procedures for both static and dynamic load testing of metal curtain walls. Wind load data, explanations, and examples are given in the reference standard, "Design Criteria for Metal Curtain Walls."

Section 4, Materials, lists metals and finishes, glass, sealing, glazing, and insulation materials. Where standards exist, these have been given for each material, thus eliminating the need for lengthy descriptions. Where standards of architectural value do not exist, we have called attention to this by indicating that type, brand, or manufacturer must be specified. Panels and windows will be added to this section later.

Section 5, Workmanship, and Section 6, Fabrication, establish standards for protection of metals, the use of sealants, welding, cleaning and painting. The paragraph "Protection of Metals" saves considerable time for the specifications writer by listing all of the protective materials commonly used on metal surfaces in both concealed and exposed locations.

Section 7, Erection, is concerned with the final assembly of the wall components. One phase of erection, usually ignored in most specifications, is covered in this section. This is the postponement of completion of the erection in certain portions to facilitate moving material into and out of the building. Unless planned in advance, omitting wall units can lead to many difficulties in assembly.

As a final assist to the specifications writer, there is a list of over 40 reference standards: NAAMM Standards, Federal Specifications, ASTM Standards, Military Standards, and standards established by other associations. Each of these is identified as to the specification item to which it is related.

One of the most valuable additions to the specifications will be a commentary text now being processed by the Research and Development Committee of the Metal Curtain Wall Division. It not only explains the information required by many paragraphs but also tells the specifications writer the source of additional information. There are brief, but thorough, explanations of many of the factors sometimes overlooked in curtain wall design. It should be a tremendous time-saver to the specifications writer.

We have tried to make the Specifications as complete and practical as possible, useful to architects and fabricators alike for the protection of both. However, the specification is, in some respects, like any law; it is, for instance, only as good as its enforcement. Just as with laws, rigid and honest enforcement is usually rewarded with greater respect. In the case of the architect's specifications, this respect will result in better workmanship, both in the factory and at the site.

Well-written specifications, based on stipulated performance rather than on generalities, can be more easily enforced, because they affect all fabricators alike. It rests with the architect to see that the standards asked for are observed. It is he who establishes the quality level for his project and if he is lax in enforcing his specifications or in supervising the job, the building that results may be disappointing. A clear and complete set of specifications, on the other hand, developed with the cooperation of competent fabricators, followed by fair bidding, and implemented by careful supervision, can result in a building that faithfully reproduces the design concept and enhances the reputation of the architect. This is the result we are all seeking.

Architectural Control of Fabrication and Erection

By Alfred S. Alschuler, Jr.*, Partner
Friedman, Alschuler & Sincere

This paper will treat the subject of architectural control of fabrication and erection from a design viewpoint rather than a technical one, since the latter has so often been covered by other meetings, books, articles and papers. The design approach to the subject is of great interest to me and, I trust, to the manufacturers, construction and professional people here today. The matter of how to create curtain walls that have eye appeal is the principal subject I wish to deal with today.

Curtain walls are at least 70 years old and probably older. The present-day concept has come into popular use within only the past 10 years. Its total life will shortly be ended unless we do something drastic about the design.

A certain major building about to be perpetrated on the public has such a wonderful flexibility in its design that you could turn it around, backside forward, downside up, turn it on its side, or leave it as it is supposed to be and it would look just as monotonous in any position. A few more jobs like this and the public will clamor for the good old Colonial, Gothic or Greek temples; the only architects left will be those with an aesthetic sense, a conscience and no imagination, and there will be no more curtain walls. The public will inevitably rebel against buildings which look like apple crates.

Most of today's curtain walls are about as uninteresting to the man on the street as the back of a deck of cards is to a card player. If you turn the cards around, you get virtually unlimited, interesting possible combinations. Let's turn the cards around and start creating more curtain walls.

While we are aware that lack of uniformity in the panels adds to the costs, either the monotony of the design must be broken or the public, and the architects in particular, are going to revolt against and abandon them. The thinking in terms of curtain walls has been too rigid, too unimaginative. Some babies are not born because of sterility. Curtain walls may die of sterility unless we, the architects, work closely with the manufacturers to create a better solution than we have found up to now.

---

*ALFRED S. ALSCHULER, Jr., is a long-term member of the Building Research Institute, and is also a member of AIA, serving on its Building Products Registry Service Committee and on its Committee on Research. Mr. Alschuler studied for two years at Harvard University before taking his degree at Massachusetts Institute of Technology.

The picture is not all black and I would not be discussing the matter with you today unless I felt there was some hope--some approaches to making the curtain wall more attractive than most of them have been. I am the first to admit that the attractiveness of one building as compared to another is largely a matter of personal taste. However, this does not mean that there are not some basic principles which we might use as guideposts to lead us in the direction of better metal curtain walls.

First, they must be practical in all the usual ways, in terms of initial cost, durability, low maintenance, weathertightness, insulation, and so on. Second, the appearance of these buildings must be materially improved. One of the problems may be in the fact that we seem to employ large and prominent grids or vertical and/or horizontal members which become one of the main features of the exterior design. Actually, while these are the ribs of the structure, they are not as important as the backbone of the structure nor as beautiful as the skin should be. They certainly need not be exposed, or if they are, they can and probably should be reduced to their relative importance in the appearance of the whole structure. They can possibly be shaped, varied in their spacing, color, widths, material, texture and lengths to give interest and attractiveness to the structure. After all, it doesn't take a genius or anyone with talent to produce a building that looks like a piece of graph paper.

What about the skin itself? Up to the present, we have usually been dealing with endless numbers of relatively large identical units which contain anywhere from 6 to 40 sq. ft. or more. Because of the large scale it is difficult to create pleasantly varied, harmonious textures or colors on the face of the building that won't look like a blatant checkerboard. Some architects have recognized this problem and have tried to break up the large units into smaller spaces with varied shapes and colors. Another approach to a more pleasing appearance might be that proposed by at least one porcelain enamel manufacturer who is offering panels with a large variety of designs, patterns, colors and combinations of colors within the larger units that might help to create a more interesting appearance.

Another thought might be to have some panels recessed and others projected to give the building more sense of depth. Some panels or groups of panels can be sloped in or out, or could even be boldly bent in or out.

There is no law that says that panels cannot be round, spherical, diamond shape or free form. Consider treating different parts of a building harmoniously but differently. Combinations of the above can give endless possibilities. I am not suggesting the use of all varieties in one building, but I am reminding us all that it takes more than the design of one panel to design the entire building attractively.

Perhaps as important a factor in the appearance of the metal curtain wall building as the preceding, is to have the basic form of the building varied from rectangular flat faces to curved, slanted, sawtoothed and otherwise varied shapes. With varied forms given to the building, the metal curtain walls can still be utilized to enclose and enhance it.

Maybe the curtain wall manufacturers should be considering how to change the colors on the exterior of the building inexpensively by a re-coating process or a simple method of replacement of the exterior facing after a period of time. Perhaps plastic coverings or coatings would permit this.

As an advertising feature on some buildings it may become desirable to have the panels glow in the dark in one or more colors, and at a very low cost for electricity.

The windows in a curtain wall can vary in size, shape and spacing to meet different requirements inside the building and to give interest and a pleasing appearance to the exterior. Some attractive buildings have been designed utilizing curtain wall construction in combination with more conventional materials such as brick or stone.

With the interest that exists in the curtain wall, the size of the industry now and in the future, our ability to research and develop attractive, varied, low cost, weathertight, durable, fire resistant, well-insulated units is only a matter of time if we architects and manufacturers don't kill the industry by poor design, construction and materials in the meantime.

Now, how can an architect work effectively with the manufacturers to create more satisfactory curtain walled buildings? It is first of all necessary for architects to create attractive designs from which handsome, practical buildings can be built. However, it is up to the manufacturers to provide more flexible, attractive building enclosures which the architect should demand and can utilize.

If we fail in this joint effort, the short life of the modern curtain wall should and will be ended. One approach which I am recommending is to have many of the manufacturers of curtain walls and component parts employ an imaginative architect to design for them a tremendously appealing building of a different type each month. These solutions will show the potential development of the curtain wall. One month it could be a home and in succeeding months an apartment building, low-rise office building, hospital, school, industrial plant and others.

Another approach would be to have a competition between architects in accordance with the A. I. A. regulations, seeking the best and most interesting solution to one or several different types of buildings. Get an imaginative but capable jury to select the best designs and use the winning solutions in advertising literature of the manufacturer.

I would hope that this would serve as a stimulus to better curtain wall design by the architects and more interesting and varied products by the curtain wall manufacturers.

An Approach to Architectural Design with Metal

By Carl Koch*, Carl Koch & Associates, Architects

One of the most important facts about research in the building industry is the inter-relation of the many, many small parts and products which go to make up the whole. It is one of the few industries in which the largest corporations with the largest over-all concern for the industry's health have the least responsibility for the completed product which the consumer will or won't buy. This causes a lack of centralized responsibility that makes the industry behave like a tremendous centipede, an insect with a hundred legs, none of them coordinated, so that the unhappy creature has no method of propelling itself in a logical, consistent direction.

However, after many false alarms and excursions, a change at last seems to be on the way. In the coming few years we may well either find this monster working and moving in one direction or passed by some new creature evolved to meet one of the real challenges of our time. The tremendous new market of the 60's and 70's is causing many of the legs of this centipede to make a real attempt to work together to meet and satisfy this market.

There is a growing realization, too, that real innovation is a vital requirement for this job. We know now that we don't have enough skilled labor or material to continue to build as wastefully as we have. We know that the buyer is becoming more and more insistent on getting better value for his money. The pressure against outworn building codes, restrictive trade practices, waste in material and old fashioned methods is rising more rapidly. These are problems most of which cannot very well be tackled piecemeal on an individual company basis.

I believe very strongly that to obtain one's share of the market in the coming years it will be necessary for all of us to take a much more responsible attitude toward the whole industry. That the whole wall is no stronger than its weakest part is a lesson that has already been learned in the metal curtain wall business. We now know that if research is done only on a better building board by the building board industry, without relating it to the other parts of a building, this leg of our industrial centipede will be unable sufficiently to assist in the over-all progress that must be made in the coming years, to be sure it will be selling building board.

---

*CARL KOCH received his B. S. cum laude from Harvard University in 1934, and his Master of Architecture in 1937. He is a member of AIA, of BRI, and of the Boston Society of Architects, and is also a lecturer at Massachusetts Institute of Technology.

Innovation in the building industry--not only in individual products or components, not even in whole buildings, but in neighborhood planning, the planning of new towns and the renewing of our fast-decaying cities--is a vital area for innovation and research. If leadership and cooperation in innovation doesn't come from within the present industry, it will have to come from outside it. In fact, it is not unreasonable to assume that expansion of the new industry may very well be done by people not presently in the business of building at all.

Jay Forrester, Professor of Industrial Management at M. I. T., makes an interesting point regarding innovation relative to the electronics field, which seems to be already beginning to suffer from the "centipeditis" with which the building industry has been afflicted for some time. He points out that the future for most of the organizations presently in the field is not bright. He notes that we didn't get the electric razor from the safety razor companies and that, to a considerable extent, rockets, ballistic missiles and space vehicles have come from without the aircraft industry. Electronic computers didn't get their start 15 years ago from the calculating machine companies or the punch card machine companies.

Mr. Forrester analyzes this failure of companies presently in the business to adjust to innovations by suggesting that a leader with vision enters a new field. He personally builds a successful commercial enterprise and grows with his business. However, as the enterprise grows, functional decentralization sets in. Manufacturing, sales, advertising, research, development, design, all begin to fit into separate boxes, and staff functions emerge which further dilute responsibility and authority in the name of efficiency. The organization takes a form which repels and suppresses the kind of spirit that built the company. Leadership and the vision of the future are replaced by the organization chart, and the hope that a perfect textbook organization will in itself create new ideas. The functionally decentralized organization operates against innovation and a clear vision of the future.

There are exceptions, in the building industry, of course, to the trend which Mr. Forrester is suggesting, but it is an interesting commentary on the status of the house building industry that the trailer industry, which most of us thought would languish at the end of World War II, has grown until it accounted for 12 to 15% of the new houses started last year.

There is, to be sure, a more cooperative approach to building research already on its way. BRI is a testimonial to this spirit. Many of the companies represented in BRI are participating in or have instituted joint research projects themselves. Our office is working on several very interesting projects now involving a joint effort by at least a dozen major corporations.

This cooperative approach of industry toward research and innovation is new and it is often very difficult for powerful, individualistic companies to work together. Those who are attempting it should be highly commended for taking a longer view of the industry and their own part in it. This sort of approach is the way to make real progress and is, I hope, due for great and rapid expansion in the near future.

Our joint efforts, as they relate to curtain walls, must work toward providing the benefits inherent in a modular skin system at a square foot cost which will make it suitable for low cost, high quality housing. In "The House of Intellect," Jacques Barzun points out that as recently as the end of the last war it was almost unheard of for a business corporation to contribute to educational, artistic, and scientific establishments. He recalls a conversation with a famous corporation lawyer on V-J Day who insisted that the law, outcry of stockholders, and jealousies of directors with diverse allegiances would all require capitalism to be overthrown before such gifts could be authorized. Now, a dozen years later, most big corporations make regular gifts for the general welfare. It is certainly no more far fetched to expect building material companies to unite to conduct research and actual building operations on a cooperative basis.

And now we approach the role of the architect in design with metal. "Building, U. S. A." says: "An architect is a man who is willing to agree that the manufacturer is in the most intimate way a participant in design, that the design of our building parts must be made in the factory, that architecture in an industrial age is no longer an art built on handicraft. It deals with an assembly of ready-made manufactured products. How the individual product has been designed determines the character of the assembly. The connection between the architect and the manufacturer must therefore be more intimate than ever, since architectural design must move into the factory." And we know that when it moves into the factory it is more than apt to do it with metal.

On the other hand, an architect is apt to be a man who still agrees with Ruskin that "architecture is the art which so disposes and adorns the edifices raised by man, for whatever purposes, that the sight of them contributes to his mental health, power and pleasure." Many of our best architects are now confused in their efforts to reconcile these two points of view. Many machine-made buildings don't seem to add up to a contribution to our mental health, power and pleasure. We worry a good deal about the ancient values lost, the landscape plowed under, the ugliness created in the name of material progress.

Here's what architect Paul Rudolph says about the curtain wall: "... the present tendency is to reduce everything to a system of rectangles, both in plan and elevation. This is an outgrowth of the modular concept and machine process. One accepts this discipline, but one still longs innately for the old play of light and shade, for, indeed, something curved."

Some curtain wall manufacturers must be a little disturbed and annoyed with the article, "Monotonous Curtain Wall," in the Nov. 1959 issue of "Architectural Forum." I can hear some of you saying, "Can't these darn architects stand still long enough for us to get their crazy ideas to work before they change their minds and go off on another binge?" Personally, I think you have a point. A number of architects, perhaps subconsciously blaming the machine for our present miseries, are letting this misery show in their buildings. Some are escaping like birds into the sky--others less obviously are returning with Freud to the womb. And Edward Stone, as we all know, has taken the veil--though not that of a nun.

In this escape from the present architects have been led recently by our most revered progenitors, Wright and Corbusier, with buildings like the Guggenheim Museum, to recall an onrushing wave or a chapel like Ronchamps, borrowing heavily from a classic heritage of forms--no machines for living, they!

Fortunately, we can't all escape through form giving in this direct sculptural sense, and there are some of us who don't even want to. I personally find that building and sailing a real boat is a better escape, and as much fun as making a building look like a sail. Innovation in building may be provided by new forms but there are other important frontiers for architects besides new sculptural forms. The machines and our materialistic society have destroyed many values which need to be recreated. The machine can and must be an all-important servant in the recreation of these values. We don't have to let it master us.

A most obvious place to start is in our living neighborhoods--in our cities, through urban renewal--in our suburbs by building carefully and with imagination. This kind of form-giving is long overdue in America. A year or two ago Clarence Stein, one of our earliest and best neighborhood form-givers, in trying to bring up to date his book, "Towards New Towns for America," could find no better examples than Greenbelt (1934) and Baldwin-Hill Village (1941). The American Town Planning Exhibit in Moscow last year had no better examples of its town planning to show than the Los Angeles highway spaghetti pattern and Levittown.

If architects were able more often to think in terms of groups of buildings instead of single ones, they could spend less time worrying about infinite variety of surface treatment and obtain, with a standardized skin treatment, a much more useful and satisfying variety. Curtain walls in New York and Chicago are a unique sort of problem, but for most of us a less hectic environment requires less frenetic solutions. A wallpaper-like curtain wall, which in 20th Century terms does the same job that the early New England clapboard did in the 18th Century, can be just as satisfying and as economical a skin for today as the clapboard was then. None of us complains about the standardization of parts, colors, shapes and surfaces of the old Colonial village. The rightness of the architectural solution for its time shows clearly, and the surface treatment remains merely a harmonious part of the whole. We mustn't make the curtain wall take all the blame today for a growing addiction to an empty facadism that threatens to outdo the Beaux Arts approach at its worst.

We must give new form, not to curtain walls but to our neighborhoods made of curtain walls, by building standardized buildings with imagination, by stopping the wastage of land and multiplication of utilities, by planning our curtain skinned homes in better relation to the new curtain walled plants where we will be working, and the curtain walled community facilities, schools and shopping to which we must have easy access from our homes. We must do more thinking about how to cut down the tremendous waste of time we are building up in travel to and from our homes to reach everything by automobile. We need to study the effects and changes the new highway program will have on our communities and consequent living habits. Only by research and study now can we use this opportunity to do our building well, creating future assets rather than new suburban slums. If the bones, arteries, flesh, heart and soul of our buildings are well formed, the skin that covers and protects them will glow with health and beauty.

In urban renewal we should be working faster, more effectively and with better imagination. In all the half-dozen years or more that the renewal program has been in existence, less than 150,000 dwelling units have been programmed and I would hate to name the number that have actually been built. This whole program to date will account for housing no more families than the trailer industry did last year alone. While we discuss and confer, our cities--the heart of our civilization--continue to rot. We architects at least, while we wait, can be preparing better to tackle these problems of design.

There are, I hasten to add, some hopeful signs. I feel very fortunate to be part of a design team commencing work on a demonstration community in Pittsburgh where industry has already been working constructively to make the city a better place to live as well as to make steel. This project will make it possible, and indeed necessary, for the building industry to cooperate with municipal agencies, architects and planners to make a small area in the city work again for human beings. The aim of this project is to enable us to take a new look at our building and zoning, financing and labor regulations to see what the best of today's technical and organizational possibilities can provide in a living environment unhampered by any but reasonable performance requirements. I find this project a very hopeful sign for the future, but there are not many projects of this sort in view.

The other day, a good friend of mine said, "Carl, it seems to me that if you could use all the housing discussion panels you've participated in to build with, you'd have enough to build a couple of houses by now." That remark after I had recovered set me off into a daydream. In it my senator called me up and told me to stop talking and get working with some others that the President had called together to do something about our living environment here in America. I dreamed that he had persuaded top executives of one large equipment manufacturer, three basic materials producers, a national building construction company, Sears & Roebuck, the director of a newly-formed foundation for the preservation of our cities and countryside, and a news magazine publisher, each to make a large financial contribution and join the board of directors of a new non-profit town-building company. This new company was to bring into being a continuing series of new neighborhoods, both urban and suburban, to test and demonstrate new planning principles and an integrated construction system. My job as part of a planning and design team was to work on the technical aspects of this job while others were working out the minor managerial problems, raising long-term, low interest money, land assembly, tax write-offs, and what not. The physical aspects of the job, designing one or more component systems, and the problem of laying out specific examples of a physical environment "contributing to man's mental health, power and pleasure" were ours.

By the time I woke up we had all built a new town and rebuilt the bad parts of an old one with four different construction systems. In addition, we had been able to enlist the help, support and controls of local planning and building groups in 25 states and were licensing fabricators and distributors of these integrated components at the rate of a new one every week.

Like many dreams, this one seemed to leave out a few practical details when I analyzed it, but I have related it in the hope that some of the rest of you may be having daydreams too. In any case, I know we have the means and knowledge to translate this sort of dream into effective reality. There has seldom been such a magnificent opportunity for private industry to combine to such a degree self-interest, self preservation, even, with the public interest and perhaps even with the preservation of our civilization. This frontier can be crossed by manufacturers, public servants, business men and designers of courage and good will, if we work together and keep our eyes far enough ahead of the final objective--a civilized community--so that the obstacles in the way are kept in true perspective. I hope and believe it can be done by leaders in the present industry without the President having to knock heads together, and without having to suffer the indignity of standing to one side while newcomers, too naive to know how impossible it all is, go ahead and do it.

Discussion Period

Moderator - George E. Danforth, Director,
Department of Architecture
Illinois Institute of Technology

Panel Members - A. S. Alschuler, Jr.
J. P. Butterfield
Norman S. Collyer
Carl Koch
R. L. McKenzie
J. M. Roehm
C. J. Walton

W. S. Wieting, Perkins & Will: When--oh when--will aluminum producers agree on a standard nomenclature for the various alloys? What progress is being made?

Mr. Walton: There are at least one or two committees working with the Aluminum Association and with the American Society for Testing Materials to try to effect some unified system for nomenclature and finish. That work is progressing, but they are not nearly finished yet, so I do not see anything in the immediate future.

A. W. B. Watson, Vampco Aluminum Products, Ltd.: Please describe the ebonizing of stainless steel and comment on the availability, techniques, handling, protective coatings and cost.

Mr. Butterfield: Ebonizing is a very simple treatment. You put the stainless steel in a sodium dichromate bath at around 750°F and leave it in there for a short time. That converts the surface of the stainless steel to a black oxide finish. We have had samples that have been out on corrosion racks for 12 years, and there is no change whatsoever in the appearance, lustre or color of that oxide finish. We are confident that the corrosion resistance, if anything, might even be superior to the normal material. Now as to availability, I am very sorry to report that there are no commercial installations available for doing this treatment. We have been endeavoring to encourage companies to go into it, and there have been some limited sizes produced by ebonizing. The CIT Building in New York City is an example of the use of such a finish.

J. E. Starrett, Perkins & Will: Does an early meeting at the job by your superintendent, the general contractor and the structural steel erector, reviewing in detail and pointing out clearance and tolerance problems before the structure is built do any good? Do you ever do this? Do you advocate this?

Mr. Collyer: I think I would have to answer that "yes and no." I definitely would advocate it, and in most cases, on the larger jobs at least, we do it to some extent. I won't say it's carried through as well as it should be. I think that it would contribute much to the success of these jobs if not only the general contractor and the steel erector, but also the concrete arch man and our good friend the architect were brought into this picture. I think it would eliminate many of the problems which arise later on.

Anthony Jackson, The Canadian Architect: How can the smaller architectural firm, with smaller building projects get "consumer report" type independent information when research information and case studies are generalized away from specific products due to commercial support or financing both in research and by advertising in professional magazines?

Mr. Danforth: I think the case that was mentioned to me, when this question was turned in, was the instance of the Sheraton Hotel failure during the wind. Where can you get information on this sort of thing? Certain magazines apparently cannot publish this for obvious reasons of structure in their advertising and editorial policy. How can the small man, the small architect, get such information?

Mr. Koch: I think there are plenty of big men who probably aren't getting that sort of information the way they should. I was quite impressed to find that, as a small architect, I can join BRI for about half what it costs the BRI to process all the material I receive as part of my membership. An extension of the BRI program with the help of the industry is about as good a way as I can think of for the small architect, or the big one, to receive information and knowledge.

Mr. Alschuler: I would like to mention one of the projects we're undertaking at the AIA, that is the building products registry, which will be in print in the near future. One of the services it will perform is to list the failures that occur in various materials, systems and equipment. This will not be distributed to the public, but it will be given to the architects, large or small, upon request. Certain materials improperly used, or used in the wrong locations in some bad manner may be the cause of the failure, and this failure may not have been noted in the manufacturer's material. These failures are available however, to the architect who subscribes for this service. It contains a world of information about various different manufacturers' products of all different categories and will be available to architects, large or small.

Mr. Roehm: I would like to comment on what we are going to attempt to do through the Metal Curtain Wall Division of the National Association of Architectural Metal Manufacturers. We hope to set up performance specifications, and have done this already for walls and for materials that are used in walls. Now, it's all right to set up these specifications, but how is the small architect going to know that a given fabricator's product meets them? Well, there are a number of independent testing laboratories throughout the United States, Underwriters' Laboratory in Chicago, the Fire Testing Lab, Pittsburgh Testing Laboratory, and some of the universities run excellent services. We expect manufacturers to have these laboratories certify that their products will meet the performance requirements specified. This information will be available to people who have to specify products and be sure that they meet certain requirements.

F. A. Davidson, Harrison & Abramovitz: Do you ever inspect curtain wall units at the fabricator's plant before shipment?

Mr. Collyer: I could answer that question and simply say, yes we have on rare occasions. However, you have to realize that we are normally a sub-contractor to the fabricator in our position as erectors and as such we have to be careful how we criticize our customer's products. However, I think it would be a wonderful idea, and it would save a lot of trouble in the field later on, if there were more shop inspection by a representative of the architect's office or by some other assigned inspector. I know some of that is done, but I think more of it should be done.

John Talbott, Washington State University: Have studies been made of the reflectivity of anodized aluminum finishes in the infra-red and longer wavelengths, and if so where are the results available?

Mr. Walton: Some data like that are available. As to its ability to absorb or reflect solar energy, it has low emissivity, so it does tend to absorb solar energy. I would like to make reference to the research of Cyril S. Taylor and Junius D. Edwards in their paper, "Some Reflection and Radiation Characteristics of Aluminum", ASHVE Journal Section, Heating, Piping and Air Conditioning, January 1939. This article contains generalized information on anodically coated aluminum.

J. R. Golightly, Pittsburgh Plate Glass Co.: How does anodizing compare with other preparations as a base for organic finishes?

Mr. Walton: The anodic coating is an excellent base for organic finishes; however, generally speaking, there is no need to anodize aluminum simply to provide a base for an organic coating. A great deal of experience has shown that one of the chemical conversion coatings will give a completely satisfactory surface for an organic finish. If, however, someone wanted to apply an organic coating over an anodized surface, that could be done directly without any treatment other than to remove any soil or grease that might be on the metal.

Mr. Danforth: Is curtain wall usage virtually limited to large-scale custom design, or small-scale standard component design?

Mr. McKenzie: I think it's limited to neither. Most of the problems concerning curtain wall design are not so much with the materials as with the minds that use those materials. I feel that any limitations that exist in the use of curtain walls exist in the inability of manufacturers to change their manufacturing techniques as fast as design attitudes change, and in lack of knowledge by architects of what goes on in a fabricator's plant. Nothing will tell an architect more about the possibilities of curtain wall than learning something about how curtain walls are built. I would suggest that architects visit a fabricator's plant with the idea of finding out what goes on there, and from that they will probably learn more about the possibilities of design than they will by consulting an enormous stack of literature.

Mr. Danforth: Does your research indicate when we can expect to see the use of prefinished sandwich panels (laminated) for assembling complete portable small homes in quantity for people over 65 and mobile families? When can we expect to see the use of this in prefabricated sandwich panels for complete portable homes? Do you think it will ever come?

Mr. Koch: We already have complete portable homes in the trailer industry and I think we have the means right now for making complete portable, prefabricated panelized homes if enough people are convinced there is a market for them.

Mr. Roehm: It's a matter of market requirement. The techniques are available today. It can be done, and it can probably be done very economically. Again, you have tradition in home building and I don't think this sort of thing will move quite as fast as technology would allow it to move.

Unsigned question: Which do you prefer when the steel frame is fireproofed, to fasten anchors directly to the steel before the concrete is poured, or to fasten to the concrete after it is in place?

Mr. Collyer: We prefer to make our fastenings to the structure, whether we are fastening to the steel or to the concrete, after the fireproofing is completely applied, but with access left to the steel if we are going to attach to the steel. The reason for that is we find there's a tendency for the steel to move around and shift its position until there are at least five or six floors concreted above the floor we are working on.

Unidentified questioner: How long do you guarantee anodized aluminum against fading, discoloring, etc., particularly such colors as blue, yellow, and green?

Mr. Walton: There isn't any guarantee for something like that. We might, however, assure the customers that the colors we use for either the integral type or the impregnated type, if properly applied, can give very good durability for long periods of time. We have had the gold impregnated color on exposure for over 10 years and it's retained its color. That is the total length of data we have. The chemistry would indicate that this color should be durable and should last for an extremely long period of time. The blue now being used, and which replaces a blue that did perform inconsistently earlier, has been under exposure in a Fadometer test for 20,000 hours. There's been some change in the shade of blue but there's still good blue coloring left. It's very hard to say how long a color is going to last; it depends on where you want to set your goal.

J. H. Newman, Tishman Research Corp.: In your experience what are the causes for staining and/or discoloration of anodized aluminum?

Mr. Walton: The primary concern is discoloration that might.occur during construction where masonry materials, concrete, things like that, might be spilled accidentally, thrown onto the aluminum, or during storage at the curb it might come in contact with some of these thrown-out materials that stain the outside coatings. This is prevented by the use of a temporary protective coat of lacquer that resists these foreign materials very effectively, and then weathers off the surface slowly later on. As far as atmospheric corrosion is concerned, no basic staining occurs from weathering. Any change would be largely one of absorbing some soil that would accumulate over a period of time from the atmosphere.

J. R. Golightly, Pittsburgh Plate Glass Co.: What radii can be expected on 90° brakes on the four finishes and in the gauges from .040 to .125, especially in stainless steel?

Mr. Butterfield: About 90% of all the architectural applications of stainless steel in the last 30 years have been in Type 302 or 18-8, and that material you can bend flat on itself without fear of fracture in any thickness from .010 to the maximum thickness that you would use in sheet metal.

R. A. Wilson, Ellerbe & Co.: What is the life expectancy of vinyl or acrylic finishes on panels? How can the finish be renewed if it fails?

Mr. Roehm: Nobody knows the exact answer to the life of vinyl or acrylic finishes. There is a vinyl compound being used in a major building which is expected to last at least 40 or 50 years, and it's anticipated that the plastic will last that long also. What was the second part of that? As to how the finish can be renewed if it should fail, we don't know.

Representative of Burns & Roe, Architects: What is the relative cost of flat pan type and flat adhesive laminated panels.

Mr. Roehm: It all depends. The pan type is about the lowest priced. You can add about 25%, I would guess, and come out with a low priced adhesively laminated panel. There are some conditions where the adhesively laminated panel could be cheaper than the pan type, as in the case of large panel areas where you have to go to quite a heavy gauge pan to get the flat surface desired. In other words, these things overlap, so that you reach a point where a laminated panel would be cheaper than the pan. There's no exact answer to that question.

C. E. Loucks, Natl. Paint, Varnish & Lacquer Assn.: When are organic finishes on aluminum most advantageous?

Mr. Walton: That would depend on the end use and economy involved. The most durable, longest lasting finish for aluminum is the anodic coating, followed by porcelain enamel and organic films. The information we have today would indicate that you can get aluminum life in most areas of the country of around 10 to 15 years; it might exceed that with some of the modern coatings. You can also repaint it as you would repaint a home, by brush, roller coating or spraying, so that the choice of the organic coating depends a lot on the economy, the style of the building and what you intend to do with regard to color change.

E. L. Cairns, Trio Industries: Please comment briefly on color range and control of the finishes previously discussed.

Mr. Walton: With regard to the acromatic finishes, the grays, the best control is by measuring the reflectivity with a photovolt instrument, and the differences of grade can be controlled within fairly narrow limits of reflectivity. That, plus visual observation, is important. The anodic coating is actually transparent, so you see through it to the texture underneath. If you have a matte texture or a mechanically surfaced texture you can get different effects even though you have the same alloy and the same thickness of coating. Therefore the combination of reflectivity plus the visual is about the best way of doing that. On color, the most effective way today is to provide color chips showing what the color will be and the color range.

H. R. Spencer, Erie Enameling Co.: Do you recommend black anodized aluminum for architectural applications?

Mr. Walton: Black anodized aluminum as you know was offered several years ago. The impregnants used then were actually very stable when applied under laboratory and under controlled processing conditions. However, it requires very much closer control than the blue, the yellow, or the gold, so it is not offered today because of the lack of close control that can be effected on the black.

H. R. Spencer, Erie Enameling Co.: How can you laminate a sculptured panel such as you showed in your presentation without making press dies.

Mr. Roehm: You can't very well do it, I'm afraid. There are certain techniques becoming available, where you can foam a plastic into a sculptured panel and treat the panel skin, so that the foam plastic bonds directly to it. That way you have a bonded sculptured panel. There are also new adhesives coming on the market which cold-set (that is, set at room temperature without the benefit of heat and pressure), though I think perhaps some of those techniques should be used to glue together the skin and produce a good structural panel.

PREVIOUSLY PUBLISHED BUILDING RESEARCH INSTITUTE CONFERENCE PROCEEDINGS

PLASTICS IN BUILDING, 1955, 150 pages, illustrated, NAS-NRC Pub. No. 337, $5.00.

METAL CURTAIN WALLS, 1955, 190 pages, illustrated, NAS-NRC Pub. No. 378, $4.00.

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

MODERN MASONRY: Natural Stone and Clay Products, 1956, 163 pages, illustrated, NAS-NRC Pub. No. 385, $4.50.

WINDOWS AND GLASS IN THE EXTERIOR OF BUILDINGS, 1957, 176 pages, illustrated, NAS-NRC Pub. No. 478, $5.00.

ADHESIVES AND SEALANTS IN BUILDING, 1958, 160 pages, illustrated, NAS-NRC Pub. No. 577, $5.00.

INSTALLATION AND MAINTENANCE OF RESILIENT SMOOTH-SURFACE FLOORING, 1959, 146 pages, illustrated, NAS-NRC Pub. No. 597, $5.00.

FIELD APPLIED PAINTS AND COATINGS, 1959, 140 pages, illustrated, NAS-NRC Pub. No. 653, $5.00.

NOISE CONTROL IN BUILDINGS, 1959, 136 pages, illustrated, NAS-NRC Pub. No. 706, $5.00.

SEALANTS FOR CURTAIN WALLS, 1959, 82 pages, illustrated, NAS-NRC Pub. No. 715, $3.00.

BUILDING ILLUMINATION: The Effect of New Lighting Levels, 94 pages, illustrated, NAS-NRC Pub. No. 744, $5.00.

NEW METHODS OF HEATING BUILDINGS, 142 pages, illustrated, NAS-NRC Pub. No. 760, $5.00.

THE CURRENT STATUS OF MODULAR COORDINATION, 32 pages, illustrated, NAS-NRC Pub. No. 782, $2.50.

These publications are available on order from Publications Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N. W., Washington 25, D. C. A full list of BRI publications which includes a variety of technical reports from BRI study group and workshop meetings in addition to the list above is available on request from the Building Research Institute at the same address.

THE BUILDING RESEARCH INSTITUTE

The Building Research Institute is a unit of the Division of Engineering and Industrial Research of the National Academy of Sciences-National Research Council. BRI was organized in 1952 to meet the need of the construction industry for an organization which could focus the attention of the entire industry on building research and technology. It also acts as an information center and maintains liaison with building research agencies in other countries throughout the world.

The members of BRI are people interested in advancement of the science of building. Among those listed as BRI members are: architects, engineers, contractors, home builders, building owners, manufacturers of building products and materials, distributors, technical and professional societies, trade associations, research laboratories, financial, real estate and insurance firms, trade and consumer publications, professional consultants and technical experts from colleges, universities and government agencies in this country and abroad. Memberships are open to companies, associations, societies and individuals.

MEETINGS

Operating on the principle that the personal exchange of experience and ideas is the basis of the growth of a science, BRI conducts:

1) Research correlation conferences on specific design problems and the cross-industry application of building products. (open to the public)

2) Workshop, round-table and study groups on specific subjects. (open to BRI members and invited guests)

Beginning with the fall of 1959, research correlation conferences will take the form of multi-subject meetings and will be held twice a year, spring and fall. Programs on various subjects of interest to the building industry and its related professions of architecture and engineering will be presented in half-day, full-day, two-day or three-day sessions, depending on the field to be covered and amount of time necessary.

PUBLICATIONS

The Building Research Institute publishes and distributes to members the proceedings of its conferences, technical meetings and study groups. Building Science News, the Institute newsletter, reports monthly on Institute activities, as well as on building research news of general interest. Building Science Directory, founded in 1956, provides a comprehensive guide to sources of information on research and technical developments in the industry. Supplements to the Directory are issued quarterly with an annual index. BRI Abstracts of Building Science Publications are published quarterly. All of these services are provided to BRI members without charge. Non-members may purchase copies of published proceedings of public conferences and regular issues of the Building Science Directory at nominal cost.

NATIONAL ACADEMY OF SCIENCES— NATIONAL RESEARCH COUNCIL

The National Academy of Sciences–National Research Council is a private, nonprofit organization of scientists, dedicated to the furtherance of science and to its use for the general welfare.

The Academy itself was established in 1863 under a Congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the Federal Government in scientific matters. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency.

The National Research Council was established by the Academy in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the Academy in service to the nation, to society, and to science at home and abroad. Members of the National Research Council receive their appointments from the President of the Academy. They include representatives nominated by the major scientific and technical societies, representatives of the Federal Government, and a number of members-at-large. In addition, several thousand scientists and engineers take part in the activities of the Research Council through membership on its various boards and committees.

Receiving funds from both public and private sources, by contributions, grant, or contract, the Academy and its Research Council thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the Government, and to further the general interests of science.