FORMICA
CORPORATION

ARCHITECTURAL H P L APPLICATIONS

John Mclean

ARCHITECTURAL H P L APPLICATIONS

John Mclean

FORMICA CORPORATION

Contents

About the Cover

Subject: "Salon for Madame B of Dresden" (1921) by Piet Mondrian.

Piet Mondrian never lived to see his Salon executed. Most of a half century elapsed before it was built with Formica laminate.[1]

Mondrian's artistic estate was bequeathed to his artist friend Harry Holtzman, who felt that had Piet lived, he would have been working in laminates. The Pace Gallery in New York approached Wallace 0. Taylor, then President of Formica Corporation, and suggested that the company produce the laminate for the Mondrian Salon.

Taylor accepted and launched the company into the fine arts. A faithful reproduction of the Mondrian colors was made and the Salon was fabricated according to the original drawings.

The Formica Corporation later marketed the laminates used as the "Mondrian Collection".

The room has been an inspiration to this author who believes that laminate material should be used on many interior surfaces as well as for new structural applications yet to be identified.

The Author's Statement

An Introduction

This report and its enclosures summarizes my, and others' observations and discussions at the Architectural Applications Conference held in Evendale last year. As a practicing architect and industrial designer, I was invited to attend the conference and report on it from my professional laminate—user perspective.

In the last ten years, as plastics in domestic and industrial use have met with increasing acceptance and popularity, my interest in Formica laminate has grown. For the past two years, virtually every time I held a piece of laminate I asked myself: "Why couldn't more be done with this material"? *As* an architect, I find that the general perception of HPL is that of a high performance, high quality, color and finish coating system. It is used as paint. As an industrial designer, I see HPL, as an engineering material.

I wonder why only the decorative perception of HPL is encouraged, because it is clearly an architectural and engineering material as well.

The public's, and design community's image of FORMICA® brand laminate is influenced by their perception of Formica Corporation and vice versa. While this dual perception is positive[2], it is limited. It is potential. All of the company's operations appear to support this restricted view of their product.

The essential concept that I learned from the Conference, and the primary one which I wish to convey, is that laminate has broad commercial potential in applications. While some of these are known, (but not necessarily promoted) a great many applications are waiting to be designed by industrial designers, architects and engineers.

The product's overwhelming acceptance as an ideal decorative surfacing material has obscured other, perhaps even greater applications opportunities. Furniture makers, decorators, and kitchen dealers have dominated the shaping of the product's image. Now industrial designers and engineers must be given the opportunity to expand laminate's horizons.

I recommend that the Company:

1. Concentrate on developing structural and architectural HPL applications.

2. Communicate this information, and promote new design solutions to the architectural and engineering professions.

3. Establish an "Applications Library" containing reports, literature and samples of all applications, their history and current projects. Familiarity with contents of this library should be required of all marketing and design personnel. Suggestions for the types of materials that could be found in this library appear in the Appendix under the heading "Applications Library".[3]

Observations

This section expands on the following set of related observations:

1. HPL has a positive image and is growing in popularity with designers. This image, however, is essentially one of a decorative material, a "super paint". The physical characteristics of HPL and its structural attributes are largely unknown in the marketplace and to design professionals.

2. Structural applications hold tremendous promise for expanding the use of HPL. These engineered uses must be developed and communicated to a technical audience, which is presently unaware of HPL's structural potential.

Recent cultural and style-trend changes have brought laminate to the fore as a "legitimate" design material. Specific programs by Formica Corporation exploiting the renewed interest in ornamental decorative design, and

related activities in Europe by Abet Print, have further elevated laminate's design image.

Applications research must exploit this interest by continuing to explore every design possibility for hard, flat decorative surfacing, in flooring, walls and ceilings as well as in doors, cabinetry and furniture.

Of greater importance to the company, I believe, would be recognition by the engineering community of HPL's structural potential. The fixation with laminate as a decorative material has prevented the Company from identifying, developing, and communicating laminate's structural uses, which represent the potential for significantly larger square foot usages than do present markets.

Although HPL has been around for more than half a century, a man—made material, a member of the ubiquitous plastics family with a history equal to Bakelite, there remains much ignorance about it.

Possible reasons for the lack of public knowledge about HPL include the following:

1. Unlike Bakelite, Nylon and most other consumer plastic materials, laminate does not appear in free form. It is always glued to something else which carries the primary identity —— countertop, dinette, table, etc.

2. Laminate is a difficult material to carry and work with. Very few people have "hands-on" laminate experience.

3. Since simulation materials were considered second-rate or fakes, the uses of laminate received no attention in design schools.

Until recently, editors and publishers have seen fit to print little about laminate, thus compounding the public's unawareness. Since 1976, only two articles on HPL are referenced in *ART Index*, none in *Applied Science and Technology Index*. Both deal with HPL's high decorative quality.

HPL is listed, but only under "plastic laminates" —— a broad category. Result: The generic name, HPL, has not reached design or technical editors; Conclusion: an architect, or designer, curious about HPL, cannot rely on professional publications or on references. Furthermore, plastics journals do not recognize HPL as a building material. *Plastic Design Forum* ran in its 1981 November— December issue, a piece on structural adhesives. An adhesive selection matrix —— quick visual reference for designers on what adhesives to use for bonding materials —— included twenty-one materials in 441 combinations. None was HPL.

On display for one year at the World trade Center in Dallas is a model space with 1,600 sq. ft. of decoratively and functionally applied plastics. HPL is not a featured material in the Exhibit.

More investigation has brought more proof. ~1FL is an unknown in the plastics industry. A reference to *Material Engineering Material Selector* and *Modern Plastics Encyclopedia* does not mention HPL. Only by knowing its parts —— phenolic and paper —— can one find a reference to Industrial Laminates, but again, nothing on HPL. *Modern Plastics Encyclopedia* did run an article, on Web Impregnation, by a sales manager for Black Clauson Co., no mention was made that this is how HPL laminates are made.

Because it is so difficult to find HPL in journals and reference books, it is difficult to know its physical properties. If designers are ignorant of HPL, there is a high probability that except for the most routine applications, the product is underutilized. Most architects will not investigate whether a material can be applied, unless the knowledge is easily available and the application has been thoroughly tested beforehand.

HPL's properties must be fully documented, and published. If HPL Is to be used in construction, the engineering Information must be available. The applications portfolio can thereby be expanded accordingly.[4]

The lack of communications to the engineering—oriented specifier, (as well as to the architect or designer interested in non—conventional uses) Is particularly critical considering the fact that engineers specifically much more material than architects.[5]

Architectural designers are the sources for decorative design Innovations in the U.S. The construction industry, however, relies on engineers for design. According to *Engineering New Record* (1981) the top 400 design firms showed a total of $7.2 billion in construction design fees, shared among Engineers with in—house architects (RA), Engineers CE), Architects with in-house engineers (AE) as follows:

EA	E	AE	A
48%	29%	19%	4%

It is clear. Engineers lead. They must be informed about your products.

Others who need more and better information are architects who still see laminate only in its decorative surfacing role, and manufacturers or fabricators who need to know how different kinds of laminate can be used for structural components.

Many closely related industries could be tapped in developing structural applications. These industries —— transportation, construction, prefabricated building, exterior/interior signage, architectural metals, furniture/millwork, electrical, waste reclamation, aerospace, food —— would certainly use much more HPL if Information was available to them couched In familiar engineering specifications language and if they could see appropriate applications or demonstrations; And if the applications work visually as well as structurally. Joint industry development can be a real possibility.

Another important group to which technical communications should be directed are schools; all levels of architectural, engineering, design and vocational schools. Sponsor student programs, competitions and scholarships. Programs could involve experimental design and applications of HPL.[6]

Finally, consider a new name that perhaps includes the concept of a super strong—composite plastic, not just a decorative surface. New names must clearly relate to how the material is used. HPL, as a generic name, is not recognized by industry, or by designers. One architect when asked about HPL answered "high pressure laminate means formica bonded in a shop to a counter surface under high pressure". He thought low-pressure laminates were for the do-it-yourself market.

HPL's new name could become a potent tool. Its name would promote a new laminate consciousness and new uses. If the Formica Corporation, and its

competitors, refer to HPL as decorative surfacing, that is what it will be —— and nothing more.[7]

Formica Corporation leadership has been creative. The introduction of the DESIGN CONCEPTS® idea of laminate as laminate was a true breakthrough. At that point the simulation constraint was broken and new opportunities for laminate were created.

Once the "decorative surface material" constraint is broken, applications opportunities await laminates' new perception as a high grade, multipurpose structural material.

H P L Applications

An Opportunity

Many areas of potential HPL application are mentioned in this report, particularly the section on the Conference itself. But most of these are already known to everyone in the company.

What is most surprising is that there has been so little internationally coordinated applications research and marketing follow-up. There is no reason that I can see why many already developed applications are not universally marketable.

Perhaps the first thing to do is to get on the table —— which this report begins to do —— information on everything already accomplished and analyze the commercial potential of each product country-by-country.

Next, or perhaps at the same time, embark on an intensive applications research program, and then, as has been said, broadly communicate the

results throughout the engineering, architectural, and industrial design communities.

It is hard to assess the degree to which the total commercial potential of HPL has been inhibited by its pervasive association with decorative surfacing. There are two primary limiting conditions:

1. The designer is constrained in his initial consideration of applications possibilities. The "decor mindset" makes it difficult to conceive of technical uses where surface character is a subordinate consideration.

2. Applications research is similarly constrained. It is **limited in scope** to exploring areas where decorative character is the primary consideration. Perhaps even more importantly, it is **limited in character**, where the design of the structural character istics of the HPL/adhesive/core fabrication is dominated by consid erations of single face surface appearance.

The laminate material in engineering terms is a high tensile strength thin sheet (skin), relatively impact resistant, and chemically inert. Different face treatments make it particularly applicable to a broad variety of design solutions both where cost and functional considerations are most important and, more typically, where aesthetic considerations are primary. But this skin is only one element in the equation.

Future applications research, if it is to reveal and develop laminate's full potential, should focus on the whole HPL/adhesive/core assembly.[8]

Changing any one of the three elements alters the character of the fabrication and the assembly's performance characteristics.

If one begins with a vision of applications potentials for whole LAMINATE /ADHESIVE/CORE systems, then it becomes clear that not only must there be extensive thinking about the laminate skin in terms of function and appearance, but in terms of its structural performance characteristics when integrated with various adhesive/ core combinations.

This is obviously a large job, but one that offers the possibility of dramatically increasing the sales volume of HPL.

In terms of structural adhesives, there are many new technical developments available including those for high strength bonding used in the aerospace industry.[9]

An inexpensive core such as gypsum board that is compatible in terms of dimensional stability with TCL would open up an enormous market.[10] The KROYER process, I believe deserves accelerated development.[11]

Architectural panels of solid metals, bronzes, coppers, brass and white and black stainless steel have become prohibitively expensive.[12] Metal foils bonded to thick laminate could be widely used for exterior structural applications.[13] Laminates could be used for curtain wall systems, for mullions, and for structural subflooring possibly in combination with lightweight concrete. There are many needs throughout the construction industry for panel systems, which can incorporate various materials to meet special requirements. Laminates' dual decor/structural capability and its possible 5 feet by 16 feet size make it a uniquely qualified material. The manufactured housing industry represents a particularly attractive market for a comprehensive use of laminates in a broad variety of structural and decorative

applications.[14] Except for the glass windows, one can envision an entire house top to bottom, inside and out including the furniture and accessories being made with structural laminate composites. I believe the development of these structural applications should be a high priority for Formica Corporation.

The Architectural H P L Applications Conference

Objective: To review global experience in architectural applications in support of new application design research

Place: Evendale, Ohio

Date: Week beginning July 25, 1983

Participants:

Formica Corporation —
Michael J. Shannon,
Conference Chairman
Alessandro de Gregori
William Hershberger

International Group ——
Miguel Flores-FESA
Marie Fucci-CEMA
Brian Hamer-UK
Sami De Mizrahi-Cyanamid de Venezuela

Research and Development ——
Arthur Giddings
Gene Grosheim
David Messmer
Hugh Hanker (CAFE)

Consultant/Observer ——
John Mclean

HPL Design Applications:

Sami De Mizrahi D., Venezuela. Showed with slides and samples how he has used HPL with superb visual effect, for ceilings, walls, doors, and furniture; now he is experimenting with flooring.

Miguel Flores, Director of Design, Formica—Spain. Flores showed with photographs how HPL could be applied successfully to executive level commercial spaces. The applications, including exteriors, involve the whole architectural environment. Post-formed HPL has been used extensively in paneling and partition systems. He presented a partition and door mock-up.

He has raised the image and sales of HPL in Spain by introducing it to architects, designers and engineers, encouraging them to use it, catching their imagination. (The translation of his remarks relating to this effort are recommended for the Applications Library).

Arthur Giddings, Project Engineer, Research and Development. He noted that the Australians use HPL increasingly on outside walls. They have been doing this for fifteen years in spite of the fact that no one knows whether HPL will last five or twenty-five years. Ultra violet exposure remains a problem though Dupont and Scotch have developed coatings. It appears that long—term testing is required before entering the architectural paneling/curtain wall components market.

Gene Grosheim, Project Engineer, Research and Development. Computer room access flooring is solidly commercialized. Formica computer flooring is anti—static. Homes in the U.S. use about 20 sq. ft. of HPL. He presented perforated HPL sheets exhibiting a fine gossamer quality. The perforations have good acoustical properties.

Brian Hamer, Tynemouth, U.K.; Director, Product Applications, Design and Development. Hamer described applying Formica HPL on certain core materials noting in the U.K., it is common to apply HPL to gypsum wallboard. Although Formica Ltd. cannot guarantee the usage, it is popular, cheap, and fire rated. He showed Scandinavian Formica laminate bathrooms, built with moisture resistant chipboard, and prefabricated toilet compartments and toilet systems, fixtures included. He mentioned Belgium exterior applications, the *Homapal* joint venture, and *Trespa* thick laminates.

He noted that *Trespa* sells an exterior HPL in Germany and in Scandinavia. It includes an acrylic coating and a fifteen-year guarantee by Goldschmidt (Germany).

William Hershberger, Research Associate. Hershberger is a specialist in "do—it—yourself" techniques and HPL fabrication in both large and small shops. He discussed doors in all types of installations, fire—rated separations included. Venezuela, he noted, leads the field in fire-rated, two-millimeter thick lift ceilings. He also covered paneling systems for offices and bathrooms developed and

marketed by Formica. He presented Formica Corporation flooring research and showed samples in actual use. Price worksheets were developed.

Exterior paneling was developed and sold by Formica fifteen years ago. A World's Fair demonstration house exists in New Jersey, plus a storage shed on the Evendale site.

Hugh Manker, CAFE, Research and Development. Wide experience in the Far East, Central and South America. He stressed that applications technology must be developed to go with masonry, the world's main building material, residential and commercial.

Colorcore®, Metallics, Thick Laminates Applications

Art Giddings, said that more design guidance and product applications are needed for thick COLORCORE®.

Alex de Gregori, Manager, Product Design. Formica Corporation recently exhibited results of its COLORCORE® design competition. Mr. de Gregori presented slides, and a few actual designs from the invitational competition. (On display at EDI, a local fabricator.)

Gene Grosheim presented a history of COLORGORE. It was developed in response to the dark—edge of conventional HPL. One example, 3/4" thick, was shown. Non—pigmented, papers give it a translucent sheen (glow). Metallic-like COLORCORE®, also shown, looks like the metallic finish on a new car. Post—formable grade is being investigated. An embossed "tile" sample was shown.

Brian Hamer, in his written report, noted COLORCORE® fabrication problems, particularly its brittleness, and edge finishing difficulties. He also discussed expanding the use of metallic laminates through more application research.

Conclusion

Overall, the participants were impressed with the number of HPL applications, that are used successfully in various parts of the world, but which are not part of the U.S. design vocabulary.

Appendix

HPL Application Recommendations by Products

HPL	• Work with the gypsum wallboard manufacturers to create a compatible HPL product. Kroyer may be useful. • Harpsichords and other appropriate musical instruments. • Exteriors. • Flooring, walls, ceilings.
COLORCORE®	
a. **Standard COLORCORE®**	• Flooring and other wear-surface applications.
b. **Translucent COLORCORE®**	• A highly decorative application will he veil received by the furniture industry. Presently experimental.
c. **Thick COLORCORE®**	• Structural uses and sections. • Architectural translucent panels.
COREX (formerly TCL)	• Continuous laminate (COREX) production, width control, thickness control. • Work with Kroyer for continuous production in lieu of continuous feed of sheet paper. • Structural sections — see thick laminate.
KROYER (formerly called Corex)	• With polypropylene — see Union Carbides UNIPOL — a cold post—formable HPL, see Corex. • Structural sections.
THICK LAMINATES	• Structures, architectural interiors, built—up structural sections, furniture.
METALLIC LAMINATES	• Building cladding or architectural metals. • Curtain wall systems. • Furniture.
IMMEDIATE APPLICATION DEVELOPMENT	• Exterior cladding, flooring and ceilings.
SMALL SCALE CONSTRUCTION	• Manufactured housing —— thick laminates for walls, floors, ceilings, which provide both structure and finished surfaces.

Appendix

Applications Library Suggestions

Reports

1. Applications Bulletin, by the German Decorative Laminate Association, 7/26/83.

2. Formica Applications in Architecture, by Miguel Flores, 7/83.

3. Architectural HPL Applications, by John Mclean, 7/84.

4. NGM PROJECT (KROYER), by Brian Hamer, 1983.

5. TCL (COREX) Thoughts and Speculations, by Brian Hamer, 1983

Sales and Promotional Literature

1. Flooring

Unifloor — Placos para suelos
F.E.S.A. 1984

2. Panel Systems

Aqua — Elite, F.L. 1984

Formica Lifeseal Cubicles
F.L. 1984

Appendix: Notes

1. Mondrian in the 1920's designed his salon while the Formica Company was developing a new product for the electrical industry. Fifty years later Formica made the color palette for Mondrian's first Salon, from a material originated for industrial purposes.

2. Everyone knows the name Formica. The origin of the corporate name has been a testament to that success. The material was originally formulated "FOR" "MICA" applications, where an electrically insulated material —— mica, a mineral —— was needed. It was developed into industrial laminates, a material that has been used to make machine parts: gears and train wheels. Then the decorative applications were developed and taken to the current progressive and award—winning line of products known as DESIGN CONCEPTS, Color Grid, COLORCORE®, and the metallic laminates.

3. Technical specifications for HPL must be readily available. They are

not in the Plastic Industry Society, ASTM, or ANSI standards, the organizations to which architects turn.

HPL specifications standards are at NEMA, the electrical industry association.

4. While HPL is an established material, it remains unknown to professionals, seen by them only as decorative surfacing.

For example, I interviewed a metallurgical engineer, an expert on chemical formulations with building applications:

Question: "Do you know what Formica brand products are made of?"

Answer: No.

Question: "Have you heard of industrial or electrical insulating laminates?"

Answer: "Yes, I know what these are made of."

I then explained that industrial laminate with a decorative top sheet and a finished melamine surface was HPL.

If designers are ignorant of HPL, the consequences are that the product is underutilized because no one knows that they can design with it.

The metallurgical engineer offered documentation that a knowledgeable designer is important to a product's sales. The results of a questionnaire distributed to contractors to learn why sheet copper declined, prior to 1980, were, in order of weighting: 30% cited cost; **20%, architect's ignorance**; 16%, substitute materials (painted steel, aluminum).

A review of the *Cyanamid 1980 Annual Report*, coupled with the above interview makes one wonder if the designer's ignorance of Formica's HPL is affecting sales.

5. Publish the work of the designers who use Formica products. Encourage the designer to distribute these published reports. COLORCORE® was introduced well. Continue this approach with all Formica products and focus on the designer.

Keep designers informed about Formica Brand products. Deliver catalogues, technical reports and design applications finding. Distribute the summary findings of research and development.

6. This exists in England through Formica Limited.

7. The Formica Corporation has worked hard to assure that its trade name is not the generic one for the material. In the past, however, the generic name was plastic laminate, which meant any plastic material bonded to another substance or surface. (Architectural and design specifications still refer to the product as plastic laminate.) In industry, however, it is now called high-pressure laminate (HPL) or, high-pressure decorative laminate (NPDL). From a chemical or applications viewpoint, neither name helps. (Note the word "decorative.")

8. Basic to any application is the bonding of HPL to a core substance or structure. Clue, cement, bond, adhesive are terms for media that make materials stay together. HPL has been used, and continues to be, because it can be glued to other materials. To talk of architectural or building component applications of Formica brand products is to talk, automatically, of adhesives, or structural bonds. The weakest layer in a laminated assembly is its maximum strength.

It is precisely this point —— the bonding of HPL to a core material —— that should be explored. American Cyanamid, parent company of the Formica Corporation, is a major developer of structural adhesives. It supplies 45% of all adhesives used in the U.S. aerospace industry.

9. American Cyanamid's Polymer Products Division President, William Lee Berry, said: "...aerospace adhesive business ... [will continue] ... to be back on a growth path for the remainder of the 80's as both military and commercial production rates increase." Aerospace adhesive applications means glued together airplanes —— no bolts, rivets or welds, and, it is here already. These structural adhesives now exist: acrylic, novalac epoxies, vitrile phenolics and epoxy nylons.

10. Adhesives for use with masonry are available. No approved system, however, has been presented by the Formica Corporation. HPL should be developed in grades or formulations to assure its compatibility with popular and common construction materials. Gypsum wallboard in the U.S. and England, and concrete in the U.S. and throughout the world are two relied upon building materials.

HPL could certainly be used with the world's most popular construction materials. The Kroyer production system offers a solution. It offers an opportunity to use paper, and other fibrous wastes, as feedstock —— structural paper investigations have been done by 20th century architects and industrial designers —— and has the potential to place Formica brand materials in the building industry. Pulverized and recycled waste paper, textiles and metals, which are abundant, would be excellent for the Kroyer feedstock.

Other, new, materials technologies are out-stepping Formica Corporation's HPL materials applications. Consider the following questions on basic applications categories:

1. What are the (a) aerospace, and (b) civil engineering applications?

2. Is HPL an established material with unknown composite materials potential?

The answers: Unknown.

The fabrication techniques of HPL are casework factory methods. What about welding techniques? Weld bonding, a simple process developed by the Soviet Union's aircraft industry, which relies on the use of uncured paste adhesives could be used in HPL factory fabrication.

11. There are signs of new HPL technological developments: again COREX and Kroyer are two rising technologies. Through these processes, HPL, the material, is featured. But more applications work is needed, especially for thick laminates, and continuous formed sections of finished laminates.

The products thin, thick, COREX, Kroyer, COLORCORE®, DESIGN CONCEPTS, and metallic laminates should be viewed and presented as interrelated and compatible product formulations. For example, Kroyer material produced continuously can be a thick laminate formed into structural shapes, finished in a DESTON CONCEPTS finish and used in exposed structure for residential construction. Maximizing the resources of the manufacturing process, with the products unique properties, leads to more markets.

12. Architectural metals in sheet and plate thicknesses are rarely used anymore. The metal must look uniform in texture and in color increasing the cost tremendously.

13 sheet and plate thicknesses are used for buildings —— fine aluminum costs have also risen sharply —— and thin sheet aluminum has been used in composite panels because place and sheet material costs are so high. Foils are cheaper than sheets.

14. We are soon going to witness the full emergence of a prefabricated home as a product respected by the public, banks, zoning boards, unions, and home builders.

The industrial environment is alive and the applications for HPL are plentiful. Since the enactment, in 1976, of The Mobile Home Construction and Safety Standards (written by the U.S. Department of Housing and Urban Development) the factory built home has improved in quality, and become larger; as real property its value has appreciated. With these Standards, the path for conventional financing —— mortgages —— has been set. The home has been, and will continue to be, the focus of industrialized building.

In sum: HPL has tremendous opportunities for design application —— decoratively, structurally, and, as part of the manufacturing process —— in the factory built or mobile home and furniture industries.

For the moment HPL applications in these industries are meager. Close ties between the Formica Corporation, and them, are critical for the growth of HPL sales.

Appendix: Resources

1980 Annual Report, Board of Directors, American Cyanamid Company

A Testament, by Frank Lloyd Wright, Horizon

Beyond Habitat, by Moshe Safdie, MIT Press

Building for Tomorrow, by Martin Pawley, Sierra Club Books

Design for the Real World, by Victor Papanek, Pantheon

Design with Nature, by Ian McHarg, Natural Press

Design from Scandinavia, No. 11, World Pictures, Denmark

Engineering News Record, May 21, 1981, "Top 500 Design Firms"; April 28, 1983, "1982 Top 400 Contractors"

Experimental Architecture, by Peter Cook, Universe

God's Own Junkyard, by Peter Blake, Holt/Rinehart/Winston

High Technology, September, 1983, "The Glued—Together Airplane"; October, 1983, "Plastic Composites Fight for Status"

Industrial Design, May/June, 1978, Zero-stress columns can make buildings lighter and cheaper", by John Mclean

Industrialization in the Building Industry, by Barry James Sullivan, Van Nostrand Reinhold

Jean Prouve, by Huber Steinegger, Praeger

Materials Engineering, Mid—November, 1977

Modern Plastics Encyclopedia, 1981—1982

Mondrian: The Process Works, by Pace Gallery, Pace Editions

Operation Breakthrough, H.U.D.

Plastic Design Forum, November—December, 1981, "Structural Adhesives"; September—October, 1983, "Update"

Progressive Architecture, August, 1979, "High Impact Materials"

Rebuilding the Land of Israel, by Gershon Canaan, Architectural Book Publishing Co., Tat.

Residential Interiors, May 5, 1980, "Breakthrough in Laminates"

The Art of Design Management, edited by Thomas F. Schutte, The Tiffany/Wharton Lectures

The Deindustrialization of America, by Barry Bluestone & Bennett Harrison, Basic Rooks

The Modern Harpsichord, by Wolfgang Zuckermann, October House Inc.