

New Stone Technology, Design and Construction for Exterior Wall Systems

Barry Donaldson, editor



STP 996

***New Stone Technology,
Design, and Construction for
Exterior Wall Systems***

Barry Donaldson, editor



Special Technical Publication (STP) 996

1916 Race Street, Philadelphia, PA 19103

Library of Congress Cataloging-in-Publication Data

New stone technology, design, and construction for exterior wall systems/Barry Donaldson, editor.

(ASTM special technical publication; 996)

“Papers presented at the Exterior Stone Symposium 1987, which was held in New York City on 12 March 1987 . . . sponsored by ASTM Committee C18 on Natural Building Stones . . . [et al.]”—Foreword.

Includes bibliographies and indexes.

“ASTM publication code number (PCN) 04-996000-10.”

ISBN 0-8031-1164-9

1. Building, Stone. 2. Exterior walls. 3. Facades.

I. Donaldson, Barry. II. American Society for Testing and Materials. III. Exterior Stone Symposium 1987 (1987: New York, NY) IV. ASTM Committee C18 on Natural Building Stones.

V. Series.

TH1201.N4 1988 693'.1—dc19 88-2358

Copyright © by AMERICAN SOCIETY FOR TESTING AND MATERIALS 1988

NOTE

The Society is not responsible, as a body,
for the statements and opinions
advanced in this publication.

Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM.

Printed in Baltimore
March 1988
Second Printing, Baltimore, MD
July 1990

Foreword

This publication, *New Stone Technology, Design, and Construction for Exterior Wall Systems*, ASTM STP 996, contains papers presented at the Exterior Stone Symposium 1987, which was held in New York City on 12 March 1987. The symposium was sponsored by ASTM Committee C18 on Natural Building Stones, ASTM Committee E6 on Performance of Building Constructions, Tishman Research Corp., Internazionale Marmi e Macchine Carrara, and McGraw-Hill Publications. Barry Donaldson, Tishman Research Corp., served as editor of this publication.

Acknowledgments

The following benefactors have generously provided support for the symposium upon which this book is based:

Artex Precast Ltd.

P.O. Box 149 LAK 1B2
Concord, Ontario CAN

Cygnus Panel Systems

1580 Lincoln
Number 1200
Denver, Colorado 80203

Dow Corning Corp.

3901 S. Saginaw Rd.
Midland, Michigan 48686

Euromarble S.p.a.

Via Provinciale 160
54031 Carrara, Avenza, Italy

F.E.I. Limited Inc.

One River Street
Building 72A
Hastings-on-Hudson,
NY 10706

Henraux S.p.a.

Querceta—Lucca, Italy

International Quarries

A Div. of Ital-Fintex Corporation
9411 Wallisville Road
Houston, TX 77013

Laticrete International, Inc.

1 Laticrete Park North
Bethany, CT 06525-3498

PPG Industries

One PPG Place
Pittsburgh, PA

Testwell Craig Labs Italy

Via Capriglia
Al Logo
Pietrasanta, Lucca, Italy

Testwell Craig Berger Inc.

36-20 13th Street
Long Island City, NY 11106

Vistawall Architectural Products

P.O. Box 629
803 Airport Road
Terrell, TX 75160

Contents

Overview

Introduction

ANALYSIS AND TESTING OF STONE

- The New Stone Age: Overcoming the Structural Stumbling Blocks**—I. G. CANTOR
AND B. JUDA 3
- Some Field Problems with Thin Veneer Building Stones**—S. A. BORTZ, B. ERLIN,
AND C. B. MONK, JR. 11
- Design Considerations for Using Stone Veneer on High-Rise Buildings**—A. S. GERE 32
- Selection, Purchase, and Delivery of Building Stone—the Obstacle Course**—
M. HEINLEIN 47

DESIGN CRITERIA FOR THE USE OF EXTERIOR STONE

- Design Criteria for Thin Stone/Truss Wall Systems**—E. A. BENOVENGO, JR. 57

TRUSS SUPPORTED STONE PANEL SYSTEMS

- Truss Supported Stone Panel Systems**—S. GULYAS 69

PRECAST CONCRETE AND FIBERGLASS REINFORCED CEMENT (GFRC) STONE PANEL SYSTEMS

- Stone Veneer-Faced Precast Concrete Panels**—S. FREEDMAN 89
- Stone on Precast Concrete or Steel in Wall Design and Construction**—
G. KAFAROWSKI 105
- Posttensioned Panels of Indiana Limestone**—H. F. KLUESNER 119
- Stone Veneer and Glass Fiber Reinforced Concrete Panels**—M. LAFAYETTE, JR. 128

ADHERED THIN STONE VENEER SYSTEMS

Thin Stone Veneers—A Steel/Silicone Diaphragm System— W. LOPER AND T. OBERMEIER	137
Rediscovering Marble and Natural Stone— R. C. WOOD	141

CURTAIN WALL FRAMED SYSTEMS

Exterior Wall Systems Performance and Design Criteria: Should These Vary with Different Types of Cladding Systems—Glass Fiber Reinforced Cement, Stone, Metal, Glass—Panel, Frame, or Veneer?— G. H. SMITH	155
Structural Silicone Sealants Used to Adhere Stone Panels on Exterior Building Facades— L. D. CARBARY AND W. J. SCHOENHERR	160
The Marriage of Glass and Stone— D. S. SMITH AND C. O. PETERSON, JR.	166
Indexes	183

Overview

Today there is a strong emphasis on architectural eclecticism combined with technological innovation, and its expression is especially clear in the design and technology of stone facades. Curtain-wall structures continue to become much lighter and faster to install, and stone as a material unequalled for durability, richness, and color is replacing the minimal glass curtain-wall designs so popular during the 1960s and 1970s. The growth of new building methods and the renewed interest in the use of natural stone have led to many innovations in the way stone may be applied to the exterior of buildings. Numerous developments have occurred at such a rapid pace that there has been little information available for a better understanding of many new systems.

The application of today's most sophisticated building technologies to an age-old material such as stone poses many concerns about the quality and durability that had never existed before. The use of thin stone veneers on large, tall buildings in harsh climates and conditions imposes the need for close scrutiny and control throughout every step of the building process.

Recent developments in cutting and fabricating techniques allow the use of thin lightweight stone veneers supported by steel truss frames, precast concrete panels, glass fiber-reinforced cement (GFRC) panels, aluminum "stick frames," or diaphragm panel systems. In addition, the application of latex portland cements, structural silicones, and polymer gaskets to stone veneers is providing new opportunities for the fabrication of lightweight panel systems. The result is the availability of systems that are lighter, more economical, and faster to erect than conventionally anchored stone. Integration of various building components, reduction of labor-intensive hand setting, and acceleration of construction schedules have promoted greater use of stone even at a time when skilled stonemasons are fewer and construction costs higher than ever before.

Thin stone veneers are now available as a result of sophisticated fabrication equipment that uses laser-guided and computer-controlled diamond circular saws and gang saws which cut stone with less vibration and very close tolerances. This technology makes veneers available from 1 1/2 in. to less than 3/8 in. in thickness. Although thinner veneers mean greater economy, the stone specified for a building facade becomes structurally critical when used in veneers of 1 1/4 in. or less in thickness. Cutting kerfs for clip or disk anchors and drilling holes for blind-pin anchors or spring clips are much more difficult with thin stone, and especially with stone that has a great deal of veining or physical impurities that will affect its strength, or stone that has a crystalline structure with dimensions large enough to approach the thickness of the slab itself and therefore substantially weaken it.

Not surprisingly, a great deal of controversy has grown around the use of exterior stone veneers 1 1/4 in. and less in thickness. The concern is that there is neither sufficient evidence of the long-term durability of such veneers nor standard test procedures for measuring stone strength, especially in terms of flexure and modulus of rupture. Furthermore, international cooperation to support the sharing of information on stone availability and performance is inadequate. With the growing use of thin stone veneers, strength characteristics, factors of safety, design tolerances, and quality of workmanship have become much more critical to ensuring the durability of the system.

Many new stone systems involve fabrication of a number of individual stone slabs into larger panels that are attached to the building structure. Panelization allows for faster building enclosure and acceleration of the start time for interior trades, but requires that repetition of wall elements (spandrel panels, window panels, column covers, etc.) be distributed over a large enough volume to offset the costs of machining, formwork, or transportation associated with panel fabrication.

The Exterior Stone Symposium 1987 was organized with the objective of providing a forum for individuals with extensive experience in the use of new stone materials and methods for exterior walls to share their knowledge. The symposium focused on the experiences of architects, engineers, producers, and fabricators as illustrated by case studies of different projects. The presentations addressed specific building projects and described recommendations to insure good design and construction. Actual building projects were used to illustrate a history of performance in terms of the quality and durability of many systems or the deterioration and failure of other systems. Describing the successes and failures of different designs provides a valuable resource for designers, fabricators, and erectors. By emphasizing the application of stone in the context of total systems, it is possible to understand the relationship between different building disciplines (architects, engineers, fabricators, etc.) and their effect on the quality of the overall design. The one-day event covered topics such as analysis and testing of stone, design criteria, and discussions of different exterior wall systems such as truss-supported panels, precast and fiber glass-reinforced cement panels, adhered thin stone veneers, and curtain wall-framed systems.

The results of the symposium are intended to be useful to architects, structural engineers, fabricators, erectors, and standards organizations. Design details and performance characteristics are described for a variety of systems, different methods of fabrication are illustrated, and the advantages and disadvantages of different erection techniques are described.

Throughout the presentations there are references to the use of current standards as well as recommendations for further development of standards. Many of the overall conclusions and recommendations of the symposium are summarized below:

1. Develop design guidelines and details for thin stone veneer exterior wall systems. These guidelines and details should distinguish between different stone types and different panelization techniques.
2. Define appropriate design tolerances for thin stone veneer exterior wall systems including dimensional tolerances, anticipated movement due to moisture and temperature, joint treatment and size, panel span capabilities, deflection limits, bowing, and racking.
3. Develop test procedures which are more representative of actual conditions such as dimension, finish, and system performance. Tests for determining compressive strength, flexural strength, and modulus of rupture are defined by ASTM but may require modification to reflect actual stone thicknesses and finishes for a particular job.
4. Establish the actual range of physical characteristics for different types of stone and determine whether the mean or lower values should be used as the basis for specifications. Such a procedure would require defining standard sampling methods and commonly accepted safety factors.
5. Integrate the design guidelines and recommendations of different organizations representing exterior wall systems into common language and criteria.
6. Develop a method for the inventory and tracking of stone from the quarry to the site. The purpose of this is to be able to relate the performance of individual stone slabs to its specific source in the quarry.
7. Develop long-term weather testing procedures, especially as it relates to the performance of adhered systems and to the performance of these veneers under conditions of extreme freeze, thaw, and corrosive environments.

8. Initiate greater international cooperation between stone-producing countries to develop common language, format, and content for standards.

This symposium is the first in a series of lecture programs on new technology, design, and construction. Future programs will continue to focus on areas of innovation and controversy and where there is a clear need for more information. Also, there will be a continued emphasis on the experiences derived from actual building projects and from an understanding of the overall performance of building systems.

This symposium would not have been possible without the many individuals, companies, and institutions who contributed their financial and personal support toward its success. For their support, a special recognition is given to Artex Precast Ltd., Cygnus Panel Systems, Dow Corning Corp., Euromarble S.P.A., F.E.I. Ltd., Henreaux S.P.A., International Quarries, Latricrete International Inc., PPG Industries, Testwell Craig Labs Italy, Testwell Craig Berger Inc., and Vistawall Architecture Products.

In addition, many individuals gave enormous amounts of time and energy toward the Exterior Stone Symposium 1987. Many thanks to each and all of the friends and colleagues who were a part of this event. To Roberto Meini, Alberto Ricci, and Francesca Lofaro, who were enormously helpful in bringing our friends to join us from Italy. To Marco Tonelli, who was one of our greatest supporters from Italy. To Darl Rastorfer, who understood better than anyone the need to get more technical information out to the building community. To Michelle Albert, who handled all of the public relations and communications for the symposium. To Rose Saggio, for her patience and continued support on the computer. To Jinette Quinones, whose organizational skill, tireless efforts, and invaluable assistance kept the program running smoothly, and to Joseph Newman, whose leadership and guidance will always remain a source of inspiration, direction, and a great deal of fun.

Barry Donaldson

Tishman Research Corp., New York, NY
10103; symposium chairman and editor

Introduction

Opening remarks at the Exterior Stone Symposium, 12 March 1987, McGraw-Hill Auditorium, New York, New York.

A hearty welcome to the more than 500 members of the building community from near and far who have joined us today at this forum. I hasten to apologize to the more than 200 people who we had to turn away. This unprecedented demand tells me that what we suspected was true, namely, that holding this Exterior Stone Symposium was worthwhile.

This is the first such symposium addressing the actual experiences of architects, engineers, producers, and fabricators not only with regard to the individual aspects of stone technology but with respect to the total system. This symposium is unique not only because all the players are involved, but because they have come together with the realization that the best results occur when there is team cooperation and sharing of experience.

This symposium is unique because it examines developments that have occurred in a recent short span of ten years—a span of time when use of stone for exterior walls grew at such a rapid pace that there has not been an opportunity before this to review, assess, discuss, and summarize what has happened technologically.

This symposium is unique because of its four-party sponsorship: Tishman Research, the technological arm of a user and construction manager who has a proven record of introducing worthwhile new building technology; ASTM, the nationally recognized leader in promulgating voluntary consensus standards; Internazionale Marmi e Macchine Carrara, the Italian stone association with foremost knowledge in production and technology; and McGraw-Hill, renowned worldwide for its dissemination of technical and business information.

I would like to thank each of the sponsors as well as the benefactors who have made this symposium possible. I also wish to thank the speakers, moderators, and others working behind the scenes.

I would now like to set the tone for this meeting with a few comments. We are now witnessing a new age of buildings because buildings are better places in which to work, live, and interact. They are more durable, better designed, easier to maintain, and utilize higher quality materials and products. In this new age of buildings, owners are setting higher standards for the built environment and demand more value for this investment. Owners influence the final result more than ever before.

In this new age of buildings the emphasis is not only on improving productivity of the activities that take place within buildings but on giving more attention to alternatives and style. It is the era of better materials and improved design which I refer to as the “era of higher expectation.” This has helped the growth of the use of stone.

To help decisionmakers make choices there is more information readily available than ever before by voice, video, in print, and by computer, enabling the decisionmaker to be more knowledgeable about what’s available and what’s possible. This exposure to the rich variety of available alternatives feeds the expectation level of the decisionmaker. I hope this symposium enhances this exposure and that the Italian and U.S. stone industries will

develop adequate and useful information on a continuing basis, and that the spirit of international cooperation, evidenced here today, will grow.

We are also in an era of increasing individuality. This leads to more customization of product and service to meet the specific needs of users. Historically, as mass production grew, flexibility and freedom of choice were largely lost. Machines and assembly lines vastly improved speed and quality, but at the expense of much reduced flexibility. Economies of the past were economies of scale, and it just wasn't possible to make a fewer number of units of a specialized design at a reasonable cost. The challenge is to restore flexibility, and I believe that the stone industry has met this challenge in large part because they recognized the trend towards specialty custom high performance and upscale products and services, and understood that the decisionmaker is willing to trade bottom line dollars—particularly where it can improve his business—for individuality and freedom of choice. I am sure that each of you has your own views on individuality—but you can't escape the fact that today's and tomorrow's decisionmakers listen to a different drummer than yesterday's pacesetters.

Yes, today's goods and services cost more because we expect them to do more and, for the most part, users and consumers receive more value. They may fight to get the lowest price, but the auction is at a higher dollar level.

In the new age of buildings, there is a growing concern about improving maintainability and operation of buildings. This bodes well for the stone industry.

Decisionmakers want to know levels of quality available, price ranges, and expected performance. The owner's new desire to see a broader picture and to consider new alternatives, in my judgment, provides new opportunities that insure that technological progress will continue.

The time has come to recognize that, unlike many of the technological evolutions of the past, there is no single rallying point. Today, progress requires the involvement of more professionals, decisionmakers, and contractors than ever before. Therefore, bringing together the diverse interests, as we are doing today, to learn from one another—to make good things happen—makes good sense.

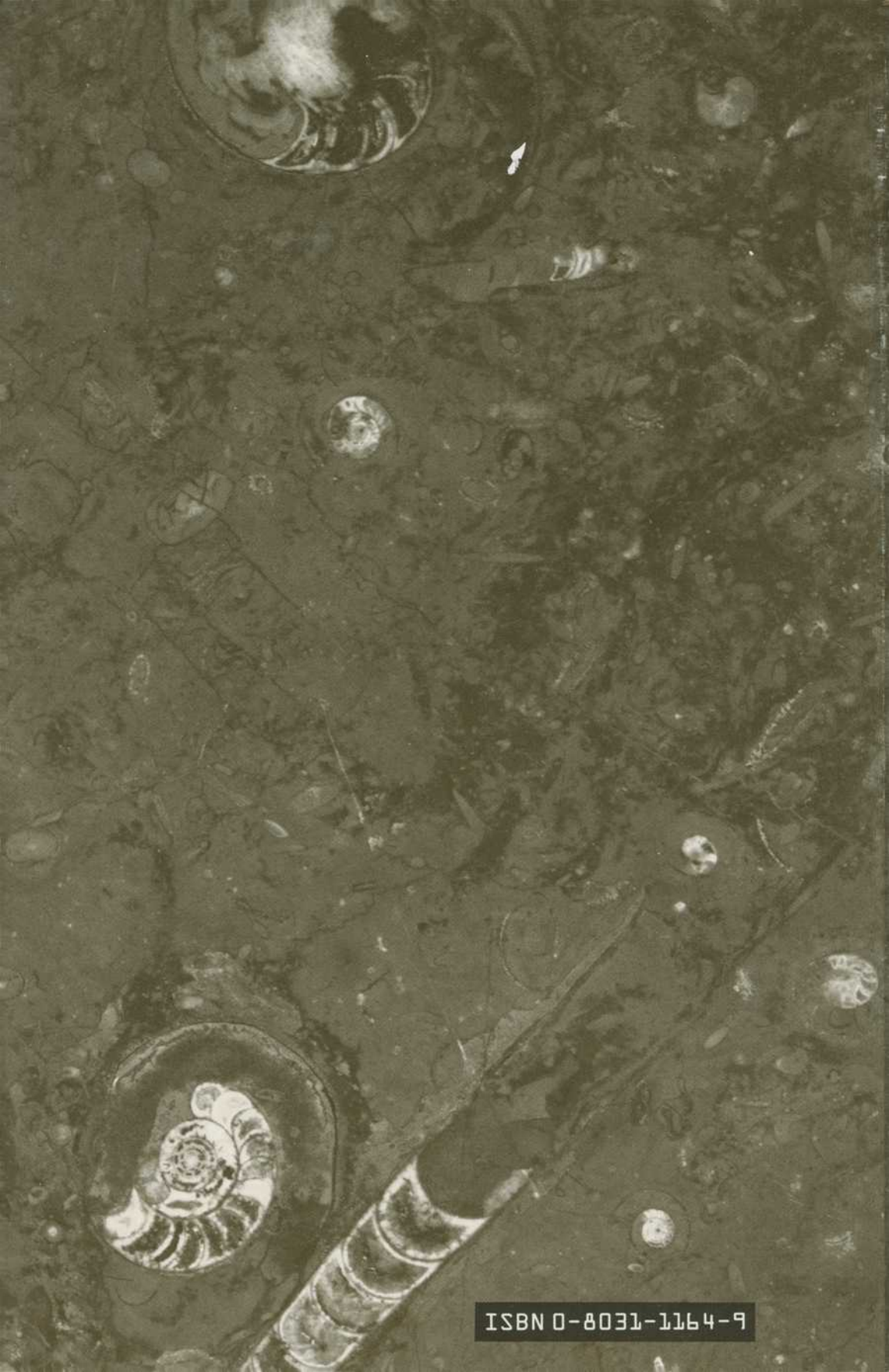
If the diverse interests in the building community cooperate and think more positively, more broadly, they can shape change more readily and for everyone's benefit.

I hope you will find this conference beneficial and take the opportunity to get to know one another better.

Thank you for coming, and, once again, welcome to Exterior Stone Symposium—1987, and to New York City . . . where as they say, "if you can make it here, you can make it anywhere."

Joseph H. Newman

President, Tishman Research Corp.,
New York, NY



ISBN 0-8031-1164-9