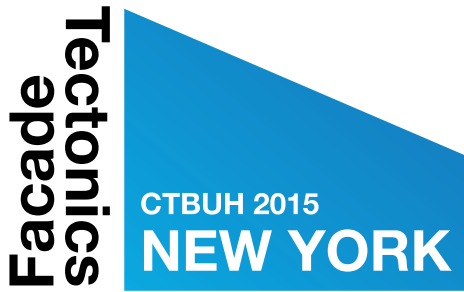


Framing the Future of Building Facade Technology

Skinning the Tall Building

Tectonics
Facade

CTBUH 2015
NEW YORK



Facade Tectonics started as a series of invited roundtable discussions at the University of Southern California School of Architecture in 2007; a strategic response to the escalating importance and complexity of building facade technology. The roundtables grew into a series of conference events that drew hundreds of participants with a broad range of interests in the building skin. The accelerating change of facade technology and the growing awareness of the facade as not only integral to, but the very fulcrum of holistic building design, has propelled Facade Tectonics to the forefront of the emerging dialogue of building skin. The facade system uniquely combines considerations of performance and appearance; it is, quite simply, the most interesting and vital aspect of architecture and urban habitat today.

The current milestone in the evolution of Facade Tectonics is the formation of the Facade Tectonics Institute, with the mission of carrying out progressive and broad-based research in building facade technology. The intent is to catalyze and foster a deep dialogue of collaborative research activity that bridges the fragmented market segments of the building industry, pairing industry, government, academia, the profession, and ownership. Integral to this mission is the dissemination of historical, theoretical and practical information derived from this research to the building marketplace, thereby acting as a conduit and facilitator for both learning and further collaborative research pursuits.

The Institute is an international member organization based at the University of Southern California School of Architecture. In addition to its research activities, the Institute conducts an annual conference, a series of half-day Forums, and similar events at venues local and regional. It publishes the Facade Tectonics Journal and produces various publications ranging from conference proceedings to technical guides, research reports, and books addressing diverse areas of building facade technology. The Institute also makes available to the public ever deepening technical resources online at FacadeTectonics.org, and the retrofit database FacadeRetrofit.org.

Visit FacadeTectonics.org to learn more about the Institute, to better understand its mission and activities, and to learn how you and your organization can participate in this dynamic enterprise.

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Acknowledgments

Ringo said it best a few decades ago: *we get by with a little help from our friends*. Nowhere is this truer than in the pursuit of independent research, the core business of Facade Tectonics. As a member organization, we are a band of friends supporting each other in shaping the evolution of building facade technology. We are quite simply one big collaborative network, enabling each other in implementing a shared vision of the building facade as an integral contributor to a resilient and sustainable built environment.

Thanks to the Advanced Technology Studio of Enclos, a very special friend of Facade Tectonics. Enclos first conceived of the idea of sponsoring a speaker program under the Facade Tectonics umbrella as part of the CTBUH 2015 International Conference in New York, what ultimately became the Facade Tectonics Room. Mic Patterson, with Katie Gould, Matt Elder, and his team at Enclos then took the lead in securing sponsors and assembling the stunning lineup of speakers for the program — each now a friend of Facade Tectonics. But they did not stop there. Recognizing the unique opportunity presented by this unprecedented event, they approached a publisher with the idea of documenting the event in the form of invited contributions from all the speaker and sponsor participants. They somehow managed to cajole these extremely busy people — the speakers and sponsors alike — to contribute the narratives and images that make up this book, *Skinning the Tall Building: Framing the Future of Building Facade Technology*. Enclos collected the material, produced the book, and paid for the printing, a copy of which will be handed out to each participant at the event free of charge.

A most special thanks to the speakers and sponsors that provided the content — the discourse, the narratives, the images — for what would only be a very empty container without them; this book is dedicated to all of you.

Lastly, we'd like to express a very special appreciation to our sponsors, who go beyond their participation as speakers and content providers to dig deep in their pockets and provide the cash flow that makes these events possible. Each was deeply involved in the planning and coordination for several months leading up to the event. Thanks to Steve Austin, Chris Enstrom and Erik Katchur with 3M, Eduardo Rosa with Interpane, Valerie Block with Kuraray, Derek Malmquist and Dr. Helen Sanders with Sage Glass, Attila Arian and Jaimee Sekelsky with Schüco USA, Karen Kensek and Doug Noble at the University of Southern California School of Architecture, Anne Alexander, Patti Harburg-Petrich, Greg Otto, and Sanjeev Tankha at Walter P Moore.

Skinning the Tall Building: Framing the Future of Building Facade Technology

This book is an experiment. It is a snapshot — the documentation of a unique moment in time. It is not a conference proceeding, it is not a collection of peer reviewed papers, it is not a journal, and it is not literal documentation of the Facade Tectonics host room at the CTBUH 2015 International Conference. It is, however, a derivative of that event, and a deliberate experiment, as was the speaking program itself. The program was the response to the question, what if we assemble a world-class lineup of facade specialists from various segments of the industry and feature them in succession in a small, intimate venue in the middle of New York City? Will the speakers agree to participate? Will an audience come? What might such an intimate and expressive dialogue yield? At the time of this writing we don't know the final outcome, but the engagement by the invited speakers was genuinely enthusiastic.

When we had assembled this remarkable program, nearly every invited speaker agreed to participate, and we recognized what a truly novel occasion this represented. We decided to attempt to capture the unique spirit of this event rather than merely document it. So we had the idea of asking all speakers and sponsors to contribute an informal narrative, with or without supporting imagery. The narrative could be loosely about their presentation topic, or have nothing at all to do with it; an opportunity, in other words, to carry on about whatever they wanted. We encouraged them to express their latest concerns, passions, ideas, musings; something more aligned with what you hear in casual — often animated — conversation over a drink, as opposed to an academic paper or lecture. What we got in return was all over the map, and remarkable in many respects. Arguably the most remarkable is that they very nearly all, as extremely busy as they are, found the time to submit to this rather unusual and somewhat annoying (I'm sure) request. We all heartily thank them for it.

We hope you enjoy these insightful and evocative readings; there are some real gems buried among them.

Thanks to Tectonic Press for facilitating the publishing of *Skinning the Tall Building: Framing the Future of Building Facade Technology*.

A handwritten signature in blue ink, appearing to read 'Mic Patterson', with a long horizontal stroke extending to the right.

Mic Patterson
President
Facade Tectonics Institute

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DAY 1 | MONDAY, OCT 26

11:15 - 12:45

SESSION 1

Materially Speaking: The Expanding Palette of Facade Materials and Systems

Chair: Silvia Prandelli, Werner Sobek

Charles Blomberg, Rafael Viñoly Architects

Bill Kreysler, Kreysler & Associates

Edward Peck, Thornton Tomasetti

12:45 - 1:45

LUNCH BREAK

1:45 - 3:15

SESSION 2

Myths & Tales of Transparency: Bringing Clarity to Emergent Facade Technology

Chair: Mic Patterson, Enclos

James Carpenter, James Carpenter Design Associates

James O'Callaghan, Eckersley O'Callaghan

Nico Kienzl, Atelier Ten

3:15 - 3:45

NETWORKING BREAK

3:45 - 5:15

SESSION 3

Performative Skins: Integrative Solutions to Multiple Performance Drivers

Chair: Peter Arbour, Vidaris

Stephen Selkowitz, Lawrence Berkeley National Laboratory

Lance Bischoff, AKRF

Deborah Moelis, Handel Architects

DAY 2 | TUESDAY, OCT 27

9:00 - 10:30 **STEERING COMMITTEE MEETING**
Facade Tectonics Institute

10:30 - 11:00 **FACE TIME**
Introducing Facade Tectonics Institute

11:00 - 11:15 **NETWORKING BREAK**

11:15 - 12:45 **SESSION 4**
Tall Tales: Framing the Future of Tall
Building Facades

Chair: Dr. Winfried Heusler, Schüco International KG

Peter Simmonds, Building and Systems Analytics
Peter Weismantle, Adrian Smith + Gordon Gill Architecture
Christoph Timm, Skidmore, Owings & Merrill

12:45 - 1:45 **LUNCH BREAK**

1:45 - 3:15 **SESSION 5**
Skin & Bones: Integrative Solutions
to Envelope and Structure

Chair: Greg Otto, Walter P Moore

Thorsten Helbig, Knippers Helbig
Sanjeev Tankha, Walter P Moore
Mic Patterson, Enclos

3:15 - 3:30 **NETWORKING BREAK**

3:30 - 4:00 **FACE TIME**
Introducing Facade Tectonics Institute

Session 1 – Materially Speaking

The Expanding Palette of Facade Materials and Systems

Great architecture is rooted in a deep understanding of material and process, and nowhere is this more evident than with the building skin. Emerging materials and diverging design practices are converging in an exhilarating exploration of facade applications. This material diversification is one of the dominant industry trends; it's not all aluminum extrusions and vision/spandrel glass any longer. Formed FRP and GFRC; cast glass, steel, stainless steel and bronze; ultra high-strength concrete; digitally fabricated plate materials; new architectural glass formulations; and robust textiles in a range of opacity are among the material solutions being applied in facade system applications. This session will explore recent material developments and design trends in building facade technology through a series of recent projects, but with an eye to the future trajectory of these material-driven trends and their implications for the facade practitioner.

Silvia Prandelli, facade director for the New York branch of Werner Sobek Engineering and adjunct professor at Columbia University, will moderate this panel of three leading facade practitioners. Charles Blomberg is a partner and facade specialist at Rafael Viñoly Architects with decades of experience including many high profile facade applications. Bill Kreysler, of Kreysler Associates, is the leading expert in the use of FRP as a facade material, most recently completing the unique FRP facade for the San Francisco Museum of Modern Art expansion by Snøhetta Architects. Edward Peck, a vice president and technical leader at Thornton Tomasetti for specialty glazing design and manufacturing, has worked with numerous design teams to integrate novel material technologies into high-performance buildings.

Speakers



Silvia Prandelli
COO, Facades Director at Werner Sobek

Prandelli leads the New York branch of Werner Sobek. Founded in 1992, the studio provides structural, facade engineering, and energy assessment services, with particular focus on lightweight structures, transparent facade systems, and sustainable technologies. She is an adjunct professor at the Graduate School of Architecture, Planning and Preservation at Columbia University, and holds a Master Degree in Building Engineering from the Politecnico di Milano.



Charles Blomberg, AIA, NCARB
Partner at Rafael Viñoly Architects

Blomberg has over two decades of professional experience in the design and construction of institutional, commercial and residential projects. At Rafael Viñoly Architects, he provides extensive structural and enclosure technical knowledge, overseeing all core and shell-related issues. Blomberg's responsibilities at the firm include overseeing project specifications, information management, and the implementation of execution plans.



Bill Kreysler
Kreysler & Associates

Kreysler is founder and CEO of Kreysler & Associates, a custom molder of fiber-reinforced products in Napa County, California. The firm has been awarded numerous awards for excellence in the manufacture of fiber-reinforced polymer (FRP) architectural products, industrial products, and large-scale sculptures. Kreysler is also a founding member and president of the Digital Fabrication Network, an international organization of cross-industry professionals working together to improve processes and accelerate the adoption of digital fabrication tools and techniques.



Edward Peck
Vice President, Facade Engineering at Thornton Tomasetti

Peck has devoted his career to the making of architecture, building facade technologies, and building systems. He specializes in projects involving sustainable and innovative building facades. Peck's professional experience includes roles as a design architect, technical consultant, and design technical leader of an ETFE design/manufacturing firm. He currently leads Thornton Tomasetti's Midwest U.S. facade engineering practice.

Session 2 – Myths & Tales of Transparency

Bringing Clarity to Emergent Facade Technology

The pursuit of literal transparency in the building skin has been a predominant driver in facade design since the first use of glass in buildings, dating back to the Roman Empire. Trends dating back to this time include the increasing percentage of window-to-wall ration, larger glass sizes, improved optical quality, and higher visible light transmittance. Glass has become ubiquitous in the urban environment, a near commodity material dominating the world's city skylines. Long-span applications have resulted in elegant exposed tensile structural systems and the development of glass as a structural material in beam and column applications. But the widespread adoption of glass has been a double-edged sword. Critics point to the poor acoustical and thermal performance of the material, and the problematic solar control issues inherent in its use. Advocates point to important potential energy consumption reductions resulting from skilled daylight design, as well as the health benefits provided by daylight and view. How are these factors influencing the current use of glass, and how will they influence the trajectory of this use into the future?

Three extraordinary practitioners with extensive and diverse experience in the use of glass each bring a unique perspective to this dialogue. Mic Patterson, author, educator, and vice president at the Advance Technology Studio of Enclos will moderate this panel comprised of renowned architectural artist James Carpenter of James Carpenter Design Associates, structural engineer James O'Callaghan of Eckersley O'Callaghan, and LEED Fellow Nico Kienzl of Atelier Ten, as they expound on the use of glass in their own work.

Speakers



Mic Patterson, LEED AP [BD+C]
Vice President, Strategic Development at Enclos

Patterson has concentrated his career on advanced facade technology and sustainable building practices. He pioneered the introduction of structural glass facade technology in the United States in the 1990s, implementing diverse and novel applications such as cable trusses, cable nets, grid shells and structural glass installations. Patterson has taught, written extensively, and lectured internationally. He is the author of *Structural Glass Facades and Enclosures*, published by Wiley.



James Carpenter
Principal at James Carpenter Design Associates

Carpenter has worked at the intersection of architecture, art and engineering for nearly 50 years, advancing a distinctive vision based on the use of natural light as the foundational elements of the built environment. Originally trained as a studio artist, he founded the cross-disciplinary design firm James Carpenter Design Associates in 1979, deploying these aesthetic principles on large-scale architectural projects. Applying a profound knowledge of materiality and craft, Carpenter has striven to integrate a collective experience of nature within the built environment.



James O'Callaghan
Director at Eckersley O'Callaghan

O'Callaghan founded the structural and facade engineering practice Eckersley O'Callaghan with partner Brian Eckersley in 2004. The practice is based in London with offices in New York, San Francisco, Paris and Shanghai. Acknowledged as an authority on the structural use of glass, O'Callaghan is best known for his highly innovative glass stairs, bridges and other structural elements in Apple retail stores around the world.



Nico Kienzl, DDES, LEED Fellow, ASHRAE HBDP
Director at Atelier Ten

Kienzl has over a decade of professional experience in advanced building analysis and energy performance. His expertise lies in building facade optimization, daylight and shading analysis, and building system optimization. A LEED Fellow, Kienzl has worked intensely on over 100 projects pursuing LEED certification through the use of innovative green design strategies and technologies. Notable projects include the first LEED Platinum condominium in New York, The Visionaire, LEED Platinum targeted 1800 Arch Street in Philadelphia, and LEED Gold targeted 220 Central Park South residential tower in New York.

Session 3 – Performative Skins

Integrative Solutions to Multiple Performance Drivers

The building skin uniquely combines attributes of both appearance and performance. Yet aesthetic considerations have been the predominant drivers of most of what we see built and under construction around us. What are the state-of-the-art facade technologies with respect to performance, and where does it need to be to support a sustainable urban environment? What role does the tall building play in such an environment? Is the very notion of a sustainable tall building an oxymoron? And what role can the facade play in the development of sustainable urban architecture? The building skin is the nexus of numerous and often competing performance considerations, challenging the most advanced building teams and accomplished facade designers. Daylighting and glare, view and noise, cost and durability, glass area and u-factor represent just a few of the considerations that must be balanced to achieve optimal performance. Key to accomplishing this is the concept of integration and holistic design process — no consideration can be omitted, all must be integrated into a comprehensive response to the nuances of a particular application.

Peter Arbour, facade designer, engineer, system innovator, and senior consultant with Vidaris in New York City, will moderate this panel of leading facade practitioners. Stephen Selkowitz, senior advisor with Lawrence Berkeley National Laboratory, Lance Bischoff, senior technical director with AKRF, and Deborah Moelis, senior associate with Handel Architects, will bring to the dialogue the immediacy of emerging facade technology and its application.

Speakers



Peter Arbour, Assoc. AIA
Senior Consultant at Vidaris

Arbour, Assoc. AIA, is a senior consultant with Vidaris, Inc., a leading facade and sustainability consultancy firm specializing in high-performance buildings. He has over fifteen years of experience in facade design and construction. Prior to joining Vidaris in 2014, Arbour was sales manager for Seele, Inc. in North America. He has a Master of Architecture degree from Yale University.



Stephen Selkowitz
Senior Advisor at Lawrence Berkeley National Laboratory

Selkowitz is a senior advisor for Building Science at Lawrence Berkeley National Laboratory, and leads the Windows and Envelope-Materials group. He is an internationally recognized expert on window technologies, facade systems and daylighting, and is the author/co-author of over 170 publications, 3 books, and holds 2 patents.



Lance Bischoff
Senior Technical Director at AKRF

Bischoff has more than 25 years of acoustical consulting experience, including project reviews, noise/vibration control, machinery noise/vibration control, testing, and custom transducer applications. In addition to detailed structural, architectural, and mechanical reviews, he is practiced in site approval work, including expert witness testimony and review of applicable noise codes and regulations. Bischoff holds a Master of Science in Acoustics degree from Pennsylvania State University, is a member of the Institute of Noise Control Engineering (INCE-USA) and Acoustical Society of America (ASA).



Deborah Moelis
Senior Associate at Handel Architects

Moelis is a founding member of Handel Architects. She is serving as Project Architect for Cornell Tech's new 26-story residential building on Roosevelt Island, New York, which will be the largest and tallest building in the world built to Passive House standards. Recently, Moelis served as Project Architect for Millennium Place, a 256-unit residential building in Boston, and Aire, a 42 story 315-unit residential tower on Manhattan's Upper West Side. She received her Master of Architecture from Columbia University.

Session 4 – Tall Tales

Framing the Future of Tall Building Facades

Tall buildings are a unique, distinctive and much celebrated building type. Large markets in the United States, Asia and Middle East are in the midst of a rather unexpected and breathtaking tall building boom. But as we begin the press toward sustainable urban habitats, what future does the tall building have past the current boom? What will the legacy of tall buildings be as humanity looks back a hundred years from now? Many claim that tall buildings are inherently unsustainable. As many claim that they are absolutely key to achieving a sustainable urban habitat. Others justify tall buildings as cultural icons. But what are the implications of having a city crammed full of such icons – how many can society afford, and just what is the cost to society and the environment? This session will address the role of the building envelope on tall buildings by asking the question: are we building solutions with today's building skins, or are we building tomorrow's problems today?

Dr. Winfried Heusler with Schüco International will lead this panel of tall-building experts, including Peter Simmonds with Building and Systems Analytics in Los Angeles, Peter Weismantle with Adrian Smith + Gordon Gill Architecture in Chicago, and Christoph Timm with Skidmore, Owings & Merrill in New York City, as they explore current tall building facade practices and their likely trajectory as we bridge the present to a sustainable urban habitat.

Speakers



Dr. Winfried Heusler
Senior Vice President at Schüco International KG

Dr. Heusler is the honorary professor at the Detmold School for Architecture and Interior Design at Ostwestfalen-Lippe (OWL) University of Applied Sciences, where he teaches facade design and technology. He studied engineering at the Technical University in Munich, and wrote his doctoral thesis on "The Use of Daylight in Buildings" at the Technical University in Berlin.



Peter Simmonds
Managing Director/Principal at Building and Systems Analytics

Simmonds is a recognized authority in the field of radiant systems and thermal comfort. He is co-author of the ASHRAE/REHVA Passive and Active Beam Design Guide, and author of the new ASHRAE Design Guide for Tall, Supertall and Megatall Building Systems. His publications led to the development of radiant systems in the United States, and are included in ASHRAE Handbooks. Simmonds has authored/co-authored more than 60 technical papers, articles and books.



Peter Weismantle
Director of Supertall Building Technology at Adrian Smith + Gordon Gill Architecture

Prior to joining AS+GG in 2008, Weismantle was an Associate Partner in the Chicago office of Skidmore, Owings & Merrill LLP, where he served as senior technical architect on several supertall towers, including Shanghai's 88-story Jin Mao Tower and the 162-story Burj Khalifa, currently the tallest building in the world. His current projects at AS+GG include Wuhan Greenland Center, Greenland Dongcun Center, Burj 2020 and Kingdom Tower, a project in Jeddah, Saudi Arabia, that will be the tallest building in the world upon completion. Weismantle is a registered Architect in the US and UK.



Christoph Timm
Associate Director at Skidmore, Owings & Merrill

Timm is an associate director at SOM's New York office. His portfolio ranges from small cultural projects to skyline defining work such as One World Trade. Timm's expertise lies in the design and execution of building enclosure systems.

Session 5 – Skin & Bones

Integrative Solutions to Envelope and Structure

Enclosure structures aren't what they used to be. The pursuit of transparency in the building skin, combined with the rapid escalation of geometric complexity in building form, has fueled the development of new structure and cladding strategies and digital processes that extend from concept design through design development, procurement, and into fabrication. The "skin and bones" architecture of Mies has morphed along several trajectories. While some building designers sculpt a formal envelope and rely on the structural engineer to define its support by whatever means necessary (often resulting in a conflagration of skewed beam and column elements ultimately hidden from view), others have focused on a high level design and process integration of structure and cladding systems that has produced some of the most interesting and unique work of our time. What are the materials and processes that enable this building form? What role are digital processes playing in the implementation of these structures? What are the practical issues and concerns for those interested in exploring these technologies? And finally, what are the latest applications, and to where does the future trajectory of these applications point?

Greg Otto, principal and west coast regional director of Walter P Moore in Los Angeles, will lead this discussion on emergent materials, technologies and processes, and explore their recent applications. Participants include Thorsten Helbig, partner at Knippers Helbig, Sanjeev Tankha, principal at Walter P Moore, and Mic Patterson, vice president at the Advanced Technology Studio of Enclos.

Speakers



Greg Otto

Principal, Regional Director - West Coast at Walter P Moore

With degrees in both architecture and engineering, Otto is strategically focused on collaboration between both disciplines. He has over 19 years of professional experience, including extensive knowledge of long-span structures, tensioned fabric/membrane structures, and building-facade design and engineering. His portfolio of work ranges from small, art-centric projects to large-scale stadiums and airports.



Thorsten Helbig

Partner at Knippers Helbig

Helbig is co-founder of Knippers Helbig Advanced Engineering. With offices in Stuttgart, Berlin and New York City, Knippers Helbig operates at the interface between the world's top architectural practices and specialized contractors in the European building industry. Active in North American and international markets, the practice centers on innovation in facade and structural design, synthesizing precise fabrication and performance parameters with structurally and geometrically complex designs.



Sanjeev Tankha

Principal, Director of Facade Engineering at Walter P Moore

Tankha is a Principal in Walter P Moore's Los Angeles office and Director of the firm's Facade Engineering Practice. He specializes in integrated facade design, implementing innovative ideas that bring value to clients. Tankha is skilled at developing elegant solutions that balance structure, aesthetics, constructability, cost, sustainability and occupant comfort. He has experience in a wide variety of projects, including aviation, civic, commercial, hospitality, transportation and sports.



Mic Patterson

Vice President, Strategic Development at Enclos

Patterson has concentrated his career on advanced facade technology and sustainable building practices. He pioneered the introduction of structural glass facade technology in the United States in the 1990s, implementing diverse and novel applications such as cable trusses, cable nets, grid shells and structural glass installations. Patterson has taught, written extensively, and lectured internationally. He is the author of *Structural Glass Facades and Enclosures*, published by Wiley.

Curtainwall: From Aesthetic Idea to Technological Straitjacket

Peter Arbour

Senior Consultant at Vidaris

My fascination with the facade has everything to do with it being that zone of a project that is defined by both the technical and the aesthetic, by both the architect and the engineer. It can be a harmony and a battleground and a paradox; all of the above. It is integral, integrating, and always something that could and should be becoming more integrated.

The evolution of function and material that one sees in nature's systems, and the sense of strange beauty it invokes in us, is rarely achieved in design. But in the development of the built environment, and in the design of facade systems specifically, we are given the chance to try – to attempt to meld characteristics and appearances, function and form. In my estimation, it is a challenge worth rising to, and a peculiarly special challenge in the time in which we live.

Insofar as we are modern, we've been raised on the architectural dream of invisible buildings and transparent cities. The technologies we employ,

the glass curtain wall most especially, are directed towards that image, and we have largely succeeded in achieving the goal. Mies van der Rohe might be proud. And yet the further we've gone towards perfecting that vision, the further we have gone from a holistic sense of building performance. The acrobatics involved in the heating and cooling, controlling the environment, blocking the sun, maintaining the view, and cleaning all that glass have rather spoiled the simplicity of the idea: a building is a crystal for living in.

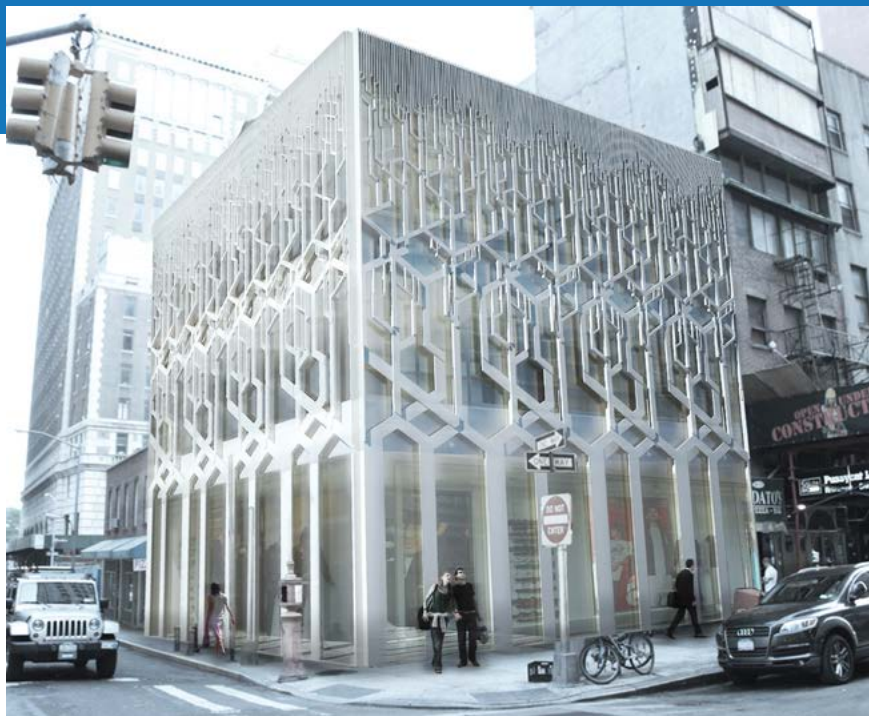
Having begun with this beautiful concept, we have configured a whole

array of industries and professions in a way that has left us with remarkably few choices. This is a world where it makes the most economic sense to enclose our buildings using, almost exclusively, construction materials that are by far the most energy intensive to produce. Even more perplexing, primary among these materials is aluminum, one of the most thermally conductive materials on the planet. We build our building envelopes out of these same materials and in the same ways regardless of whether we build in the desert or the jungle, in the arctic or on the equator.

Amidst these difficult facts, one surprising result of the ubiquity of aluminum and glass curtain wall technology is its lack of versatility for architectural expression. Extrusions and flat infill materials offer a very lim-



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ited number of moves to the designer. As a facade consultant, I have seen both architects and engineers spend countless hours struggling to achieve simple geometric effects made impossible by the constraints of straightness and flatness required by these materials and their assembly. After designing to the fabrication technology and adding in the required performance enhancements, even calling this all glass exterior a facade is kind of a reach, as if we discarded the features of the human face in exchange for a pair of mirrored sunglasses and somehow kept calling it a face. Over time we might forget the difference, not remembering that the facade was once an incredible means of expression.

From an aesthetic idea to a technological straitjacket, where do we go from here? There is genius in curtain wall: its isolation of and adaptation to movements found in every building

and every material, the integration of enclosure and structure, the controlled assembly and efficient installation of exterior walls. The curtain wall is a construction system that is conceptually durable and technically suitable to its purpose. And yet the pendulum must swing back. The aesthetic component that has too soon been abandoned cannot be underestimated.

I developed my project, the Liquid Wall, as a way of exploring this problem. To take the best of curtain wall technology and re-inject it with cultural purpose. The loss of architectural expression in the face of successful construction technology is simply not acceptable. What began as a search for a viable alternative became an exploration of material, which led to experiments in methods of fabrication. And these discoveries brought new possibilities: the making of a curtain wall in which straightness

and flatness are not such domineering requirements. It is a system able to express what it does, able to embody its own performance, to meld characteristics and appearances.

The Liquid Wall system is a way of bringing the strange beauty of nature back to the facade while retaining all of what curtain wall technology has given us. The principles of engineering, new composite materials, and digital fabrication create the DNA for a new generation of building enclosures.

An alliance of surface, structure and architectural form, the Liquid Wall turns the tables — it empowers design through technology. The system offers solutions to the escalating demands of the building facade: transparency, high-insulation value, fire resistance, interior daylighting, reduced energy consumption, beauty, and a fresh invitation to build what could once only be imagined.

Performative Skins – Acoustical Design

Lance Bischoff

Senior Technical Director at AKRF

Proximity to highways, railways, aircraft, HVAC equipment, and industrial facilities in densely populated urban environments can result in stringent building facade acoustical performance requirements.

Whether a code mandated requirement (e.g. Zoning, E-Designations, LEED, Facility Guidelines Institute, etc.) or design goal oriented, facade acoustics is prevalent in the design and construction industry. However, due to the complexity of facade acoustical design, it is a technical area often misunderstood.

“Acoustical design is an iterative process, as there are visual, energy, weight and cost implications associated with upgrades.”

Every development site and facade system is acoustically unique. Therefore, for projects that require acoustical design of its facade, an experienced acoustical consultant is an important team member in the design process. The first step is to document development site noise levels to aid facade acoustical

performance requirement determination. An experienced acoustical consultant understands the acoustical performance capabilities of various exterior wall systems (e.g. curtain wall, window wall, punch window, etc.), can perform acoustical modeling for design recommendations, and estimate facade system acoustical performance. This is an iterative process, as there are visual, energy, weight and cost implications associated with acoustical upgrades. Experienced acoustical consultants can also provide in-field acoustical testing and client-representation for laboratory testing of various facade elements to ensure compliance with acoustical design goals.



ACOUSTICAL TESTING HAS EXPANDED TO INCLUDE AUDITORY TRANSFER BETWEEN FRAMING SYSTEMS IN CURTAINWALL.



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3M™ VHB™ Structural Glazing Tapes are durable, high performance two-sided pressure sensitive acrylic foam tapes for the bonding of glass or metal panels into curtain wall, commercial window or door systems, and architectural panel systems. They have been proven in thousands of international buildings since 1990 as an alternative to structural silicone and spacer tape for glazing in curtain walls.

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Laminated Glass: Safety Glazing & Beyond

Valerie L. Block, CDT, LEED® AP

Americas Market Development at Kuraray Interlayer Solutions

I have spent the better part of fifty years in the glass industry, and for me, the building facade's story is one of laminated glass. My family owned a company that made laminated glass — stock sheets of annealed glass bonded with a polyvinyl butyral (PVB) interlayer. Things changed in the late 1970s when the Consumer Product Safety Commission standard 16CFR 1201 was adopted for safety glazing. Laminated glass became one of two glass products suitable for use in hazardous locations, such as doors, bath enclosures and glazed panels. In the 1990s, laminated glass experienced another quantum leap when Miami-Dade County adopted regulations for wind-borne debris protection. The only way to keep windows, glass doors, skylights, curtain wall or storefront systems intact was with laminated glass.

Besides safety and impact resistance, PVB interlayers offer a number of key benefits. They are formulated with UV blockers to minimize fading of interior furnishings, as well as valuables, such as books and artwork. While laminates with PVB have been known to provide sound attenuation superior to monolithic glass of the same nominal thickness, specially formulated sound control PVBs



THE ALICE TULLY HALL RENOVATION BY DILLER SCOFIDIO + RENFRO AND FXFOWLE IN NEW YORK CITY FEATURES A ONE-WAY CABLE NET STRUCTURE SUPPORTING OVERSIZED GLASS PANELS WITH AN IONOPLAST INTERLAYER.



THE TKTS BOOTH BY PERKINS EASTMAN IN NEW YORK CITY WAS THE LARGEST LOAD-BEARING GLASS STRUCTURE IN THE WORLD AT THE TIME OF ITS COMPLETION. IT FEATURES AN IONOPLAST INTERLAYER FOR STRUCTURAL ENHANCEMENTS.¹

now offer even better performance, sometimes enabling designers to use thinner, lighter glass within insulating glass units. From a decorative perspective, colored PVB interlayers and digital printing have enabled designers to customize the appearance of glass, expanding options for interior as well as exterior glazing.

From a structural perspective, the real game changer was the introduction of ionoplast interlayers. Enhancements in this interlayer's mechanical properties, such as strength, creep, post-glass breakage, coupled with enhancements in durability and materials compatibility, extended the performance of laminated glass well beyond established PVB limits.

The key mechanical property differences between an ionoplast interlayer and a PVB interlayer is the modulus and viscoelastic behavior. At temperatures below 0°C, the Young's modulus for both polymers converge. The PVB polymer softens rapidly and goes through glass transition at room temperature. The ionoplast

polymer goes through glass transition at around 55°C. As a result, the ionoplast polymer maintains a significant stiffness advantage over PVB for a large range of temperatures (room temperature to 80°C).

A further advantage of the ionoplast interlayer is the improved mechanical performance of a laminate in case of accidental glass breakage. The stiffness of the interlayer results in a more robust condition if the laminate is broken. One such application of this performance feature is in point-supported glass systems, where laminates made with ionoplast interlayer have been shown through testing to survive glass breakage with minimal tendency to tear free from fittings.

The strength of laminates with ionoplast gives designers the ability to optimize glass thickness, creating facades that are thinner and lighter than they would be with PVB laminates. Oversized glass panels, glass fins, embedded attachments, even structurally laminated glass beams

have become a reality because of this interlayer. Projects around the world give testimony to the unique structural capabilities of the ionoplast interlayer: the iconic all-glass box at Apple's Fifth Avenue flagship store, the TKTS booth in Times Square, and the elegant point-fixed facade at Alice Tully Hall are but a few project examples in New York City alone. But even larger facade projects can be found outside of the United States, including the Shanghai Tower, the Cleveland Clinic in Abu Dhabi, and the Foundation Louis Vuitton in Paris.

Whether laminated glass is made with a PVB or ionoplast interlayer, it is clear to me that the technology will continue to grow based on concerns for safer glass facades, skylights and railing systems, the need for quieter interior spaces, and the aesthetic preferences of customers.

¹<http://www.popsci.com/technology/article/2009-12/looking-back-100-best-innovations-2009>

Challenges to Building Facade Design

Charles Blomberg, AIA, NCARB
Partner at Rafael Viñoly Architects

The changes that happen in the delivery of building facades today are not so much related to architecture as they are related to how it is procured. Developers are far more educated with the latest construction methods, materials and regulation. Preconstruction begins with a preferred construction method and determines a budget even before the design is established. Once the zoning volume is fixed, the role of the architect has been more or less reduced to how to decorate the box with a predetermined budget. As building codes and performance criteria become more stringent, they become tools for the architect to maintain a higher level of quality.

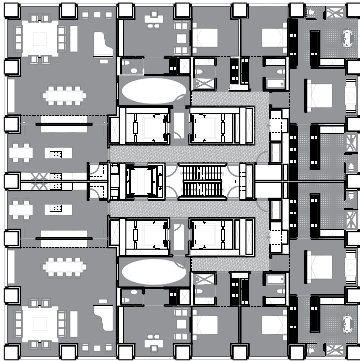


FIG. 1: 432 PARK AVENUE PLAN. © RAFAEL VIÑOLY ARCHITECTS

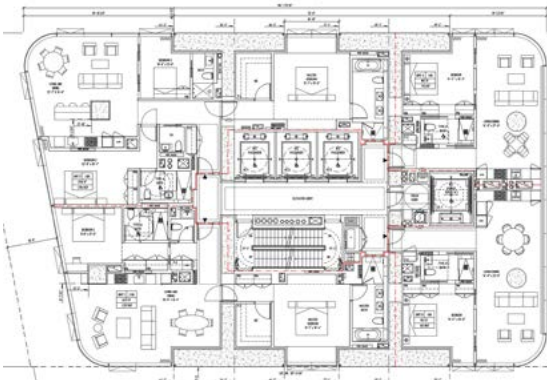


FIG. 2: BUILDING ONE PLAN. © RAFAEL VIÑOLY ARCHITECTS

In a high-rise building, the exterior skin is a major component in achieving aesthetic aspirations, performance criteria and economic constraints; after the structure and core it is what defines the building. Depending on the scale of the building, a dollar saved in unit cost could result in a million dollar reduction in total cost.

But before you get to the facade you need a structure. With the current development of the pencil-thin high-rise residential tower, the resolution of the structure is critical to the development of the building exterior.

Looking at 432 Park Avenue in New York, the plan arrangement (Fig. 1) and the final exterior of the building is driven by the definition of the structure. As urban sites become smaller, the clarity of the structure becomes even more important (Fig. 2). The form of the building becomes the resolution of the maximum moment of inertia for the core and the maximum surface area for views and daylight.

Another major factor in developing high-rise facades is how it is installed. In a very competitive market, the curtain wall industry has developed more and more efficient methods of installation – nearly a one-size-fits-all approach; if it's not six to seven feet wide and floor-to-floor in height, it's too expensive.

After years of facades with solid panels and ribbon windows (Fig 3) because curtain walls were too costly, slick curtain walls with structural glazing is the cheapest method to use today. This method of cladding grew out of years of perfecting the commercial office tower. But how does this change when the box is now a residential tower?



UNIVERSITY OF CHICAGO MEDICINE - CENTER FOR CARE AND DISCOVERY.
IMAGE © TOM ROSSITER, COURTESY OF RAFAEL VIÑOLY ARCHITECTS

Residential towers give the opportunity to explore different combinations of materials. For years the standard residential building in NYC was a flat slab masonry building with punched windows. These gave way to the slick modern tower that could be used for office or residential purposes, such as the John Hancock Center in Chicago. To meet new energy codes, curtain walls get in-filled with a larger area of shadow boxes, hiding bathrooms and slab edges, but also to reduce the window-to-wall ratio.

Challenging these assumptions has led to the development of a series of towers where the orientation of the glazing has been changed to horizontal, maximizing the size of the construction lift, and creating unparalleled panoramic views.

Pushing Performance-Based Design

Greg Goldfinch

CEO at Goldfinch Bros., Inc.

Facade Tectonics talks with glazing contractor Greg Goldfinch, CEO of Goldfinch Bros., about the partnership that clad the greenest office building in the world, the Bullitt Center in Seattle, Washington.¹ Goldfinch worked alongside door, window and facade specialist Schüco USA to deliver an integrated building envelope that is critical to the project's net-zero program.

What was the motivation for Goldfinch Bros. to get involved in such a challenging project?

We were first introduced to the project in the architect's office while looking at other work. Every once in a while you see something that is a stretch, and you tend to back away for something more mainstream. Not here. I recognized that Schüco would be a great fit, and after review, we built a great partnership.

What was your firm's scope of work on the project?

Goldfinch Bros. was responsible for the glass and glazing for the building exterior. The project was, to a certain extent, a straightforward stick-built triple-glazed curtain wall, but also included large motorized vents, skylights (both fixed and operable), entrance and manual sliding doors.

Did you engage with the design team in a design/assist role?

Yes, we were asked to join as a member of the design/assist team. There was a process of understanding what was proposed, an evaluation of the system's expected performance and cost. This is where we were able to explain the benefits of Schüco's integrated product, and the design team realized that our competitors couldn't meet the same level of performance — which was critical for the project to achieve net zero building standards. I believe any time you're building a sustainable building of this nature, a collaboration between the design teams is essential to achieve the net result.

Describe the project's schedule.

The schedule was not too much of a challenge due to the fact that we were brought on early in the design phase. This helped us communicate to the team that complex projects like this take time, and facilitate scheduling. We were able to effectively set goals, have materials delivered to Goldfinch Bros., and fabricate on time. Because we were not only the local installer of the project, but also the fabricator of curtain walls, windows, and doors, we had quite a bit of control over the finished product.

Tell us about the building envelope design and its operable vents?

For a net zero building, the design requires taking advantage of conditions unique to the project site. You rely on climate, orientation of the building, and the dynamics of the building for heating and cooling. The operable vents were approximately 4.5 to 5 feet wide by 10 feet tall, and triple-glazed. Due to size and weight, the only way to operate them was to motorize them. It became evident that motorization of the vents was the right thing to do: they were integrated into the building management system and needed to open when the building was unoccupied to flush air. Their large size allowed for some architectural freedom without having to interrupt the large lite openings with mullions. They were key for this project's success by providing an efficient and cost-effective way to control the building's climate.

What challenges did you face?

There certainly are a lot of challenges

in a project of this complexity, but as we broke the project down and addressed each challenge individually, we were able to overcome each of them. While we had experience working on other living building challenges, it wasn't long before we recognized that Schüco understood the red-listed products far better than others we had worked with. We found this to be a struggle with other companies in the past, trying to understand how their products met the red-listed items. Schüco not only had a solution, but the solution was part of the deliverables within their system. In the end, the contractor reviewed our report and information and determined that they would use our submission as the standard for presenting red list items for all the other trades on the project.

What would you do differently, given the chance to complete the project again?

One of the biggest challenges that we had involved all of the automation that went into the building. With motorized operable events and motorized exterior venetian blinds, the UL rating and wiring was a fair amount of work for us to coordinate and work through. What we came to realize was that we needed to hire an electrical engineer or consultant to draw the diagrams and help the electricians on-site understand how to integrate them into the building management system. I think we realized that a little too late, paying a little money upfront. Getting a fairly complex system broken down into a very manageable piece of work would have made much better sense, looking back. But since the Bullitt Center's completion, we have completed other projects that integrate systems into the management system, and have proactively used consultants to help understand electrical requirements.



Are you up for another challenge like the Bullitt Center?

I think it would be great to take the experiences we've had on the Bullitt Center and apply what we've learned to another project. Because of the increasing need for energy efficient buildings, the owner was intent on trying to create an understanding that could be carried over to future projects.

About Goldfinch Brothers

Goldfinch Bros., Inc. is a well-established glazing contractor and known entity in the Seattle market. The company was founded 123 years ago, and is currently managed by CEO Greg Goldfinch. Greg is an entrepreneur with a clear vision, who has been able to build a business that is highly respected by both the architectural and building community. The commercial division of Goldfinch Bros., Inc. specializes in design, engineering, fabrication and installation of high performance building envelopes with an impressive portfolio of completed projects.

¹ <http://www.millerhull.com/html/non-residential/bullitt.htm>



Towards Differentiation and Integration: Why Do We Still Design Like Henry Ford?

Thorsten Helbig

Partner at Knippers Helbig

Why are the majority of new building designs still based on the 20th century Fordism principle: the use of repetitive elements of standardized products? For example, a typical tall building facade is still designed in a way that a unit could be placed anywhere on the building, instead of being adjusted to the final position — a unit placed 10 feet above street level is basically designed to meet the same physical requirements as if it was placed 1000 feet above street level. The availability of highly automated and computer-based production facilities used by the facade industry, along with advanced parametric design tools, already allow for more differentiated facade solutions. A building skin can be developed based on the specific local requirement of each single unit and finally composed into a system that allows for automatized production.

In recent years we have used such approaches mainly for realizing geometrically and technically complex building envelopes based on non-repetitive units, such as free-formed grid shells or to clad irregular and curved surfaces. But this approach does not only enable us to achieve macro systems based on individually optimized or adjusted micro units. Rather, it offers possibilities to

implement many more aspects into a building skin's behavior and purpose — the transmission/exchange between the outside and inside of a building. This interchange is highly influenced by in-stationary transient conditions such as light, wind, temperature, and more, so specific facade units could be designed to respond and react based on adaptive strategies. Such facades would

perform much differently than the conventional (passive) protection layers we are accustomed to designing so far.

From such a perspective, integrated facades would mean much more than just the integration of facade and structure. It is not just about "skin and bones," but about the interplay of the whole organism. This moves facade design towards the notion of localized variation — be that in material properties, performance parameters, or programmatic/user response. Such multi-performance, highly-differentiated systems and potentially adaptive building envelopes could offer new architectural expressions underlining the increased awareness of the interaction of our buildings with the outside world.



THE ARTISTS FOR HUMANITY EXPANSION BY BEHNISCH ARCHITEKTEN IN BOSTON UTILIZES AN INNOVATIVE FACADE THAT WILL OPTIMIZE DAYLIGHT, MAXIMIZE THERMAL PERFORMANCE, AND CONTRIBUTE TO THE ENERGY PRODUCTION REQUIRED BY AN ENERGY POSITIVE BUILDING. © BEHNISCH ARCHITEKTEN.

AGC INTERPANE



Interpane is one of the major European glass manufacturers and offers a wide range of functional glass. The company's product range includes float glass and low-iron float glass, high-quality coated insulation glass, soundproofing glass, solar control glass, safety glass, glass for design and decoration.

AGC and Interpane have been working together since mid-2012, resulting in a bigger network, more locations as well as an exclusive and diverse product range. The alliance produces oversized glass sheets – called "Giga Lites" – for exclusive projects. AGC and Interpane are European leaders in glass design and aim to be trendsetters in interior design and architecture.

Framing the Future of Tall Building Facades: High Tech, Low Tech, Smart Tech?

Dr. Winfried Heusler

Senior Vice President at Schüco International KG

Sustainable buildings are elementary for a healthy built environment. The basic question is: do we need high-tech facades and mechanical systems or low-tech facades and mechanical systems for that purpose? To answer the question I would like to introduce to you some personal experiences gained in advanced projects as a facade engineer.

In a passive building concept, passive facade components seal off the interior from external factors as much as possible. Contemporary mechanical systems ensure a comfortable interior environment. Conversely, in active building concepts, dynamic facade components respond specifically to changing internal and external conditions. In cognitive building concepts the facade and mechanical-system components with dynamically adjustable functions are connected to each other through an intelligent building automation system (Fig. 1). By this the cognitive building is capable of reacting to varying conditions that are in many instances predictable and calculable, such as the case with annual or diurnal swings in meteorological

conditions (i.e. solar altitude angle), or the times of a building's operation. However, non-predictable weather and operational aspects — such as variations in cloudiness and spontaneous presence of users — should be included by means of appropriate sensors or weather reports.

According to our experience, purely passive building concepts are only advantageous if the location, height or use of a building excludes natural ventilation, as well as the use of solar energy and daylight for at least two-thirds of the year. In tall buildings, natural ventilation through conventional windows and external solar shading installations is pushed to

its limit by high wind loads. For this reason, many tall buildings have been constructed with passive facades and operated with year-round energy and maintenance-intensive mechanical ventilation equipment (mainly air conditioning). For a number of years — at least in the high-end European market — there has been a trend towards double-skin facades. Double skins consist of a highly thermally insulated inner facade behind a single-glazed second facade with ventilation openings protected from the rain (Fig.1). In conjunction with the interspace, the external facade reduces wind loads and the negative effect of gusts of wind. In this way, conventional solar shading installations can be used effectively. In many cases this allows the ventilation or AC system to be significantly smaller and its operating time to be reduced by more than 50%. The investment and operating cost savings thus made often cover the additional costs of a



FIG. 1: DYNAMIC DOUBLE-SKIN FACADE AS PART OF A COGNITIVE BUILDING CONCEPT (SHANGHAI TOBACCO BUILDING, CN-SHANGHAI (2005), HUANG FANG / SHANGHAI PAN-PACIFIC ARCHITECTURAL DESIGN CO. LTD.).

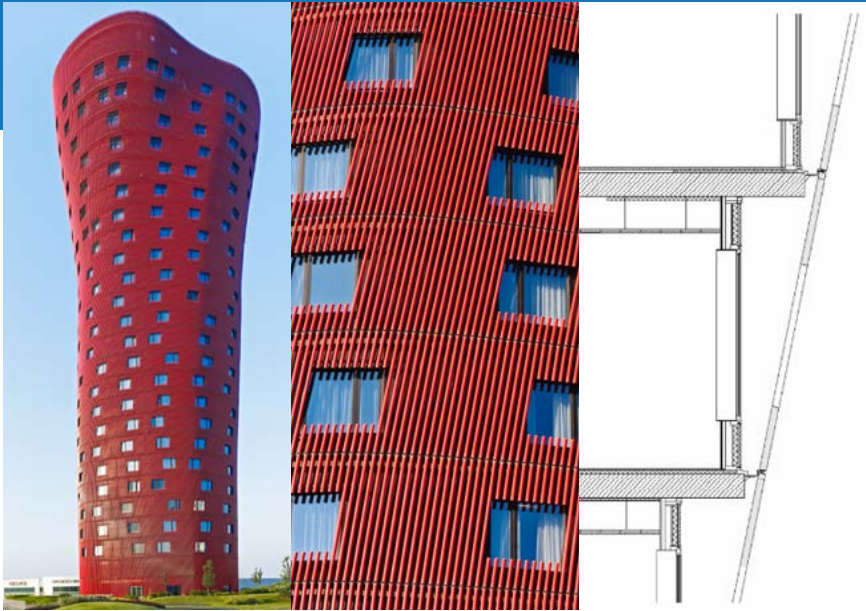


FIG. 2: PASSIVE DOUBLE-SKIN FACADE AS PART OF A PASSIVE BUILDING CONCEPT (HOTEL PORTA FIRA, ES-L'HOSPITALET DE LLOBREGAT (2009), TOYO ITO ARQUITECTOS, L'HOSPITALET DE LLOBREGAT).

double-skin facade. The alternative is a temporary cognitive twin-wall facade whose external facade consists of glass-louvre blades operated by computer-controlled motors.

Many new tall buildings will be built in locations with tropical climates, such as the highly populated Hong Kong, Guangzhou and Shenzhen areas. One solution for that specific climatic zone is the passive building concept. The alternative is to return to the traditional cooling method of natural ventilation and to create building zones with different levels of comfort in accordance with the onion peeling principle. The core zone has to be sealed off (airtight and well insulated) from the naturally ventilated surrounding buffer zones. Courtyards, atria, loggias and sky gardens can be part of these concepts. The outer layer should not be glass, but instead a rigid, partially transparent solar shading installation that allows the permeation of air (Fig. 2). Movable and motor-driven components in such regions are only suited to buildings whose owners have a positive attitude towards maintenance.

Circling back to whether we need high or low tech facades and mechanical systems for a healthy built environment, from my point of view, the answer is neither: the smart tech concept is the answer. Smart tech uses only as much technology as necessary for facades and mechanical system. It follows the principle to diminish or even eliminate the unnecessary and useless consumption of energy, materials, time and money. Following the bioclimatic design strategy, the aim of this concept is to minimize the use of mechanical systems by means of natural ventilation as well as the use of solar energy and daylight. It has to be designed for specific boundary conditions. The first step forward is a holistic design approach that takes into account environmental, economical, social and cultural aspects. It is subject to a detailed, step-by-step analysis with respect to the following factors: cost-efficiency (investment, operating and maintenance costs), design considerations (practical, formal and symbolic aspects), energy requirements (heating, cooling,

ventilating, lighting, etc.), as well as room comfort (thermal, visual, acoustic, etc.). Analysis has to consider the entire lifecycle of a building, from design, planning and construction, through operation and usage, updating and upgrading, up to demolition — with possible reuse or recycling of building components or materials. In the end we have to remember the fact that building techniques and methods are to be tailored to the people for whom the building is intended rather than matching the tenants to the newest possible techniques and methods.

Visual Programming for Building Skins

Karen M. Kensek, LEED AP BD+C

University of Southern California School of Architecture

An exciting development in the profession has been the increase of visual programming languages (VPL) for the design and analysis of buildings, including their facades. Visual user interfaces for programming allow users to create customized, flexible, and powerful form-generating algorithms without having to first learn how to write code. Visual programming is a type of computer programming where users graphically interact with program elements instead of typing lines of text code. Nodes are created; they can be numbers, sliders for adjusting values, operators and functions, list manipulation tools, graphic creators, scripts, notes, “watch” nodes, customizable nodes, and other types depending on the tool. They are virtually wired together, and the program is resolved from left to right.

Brief Overview: Grasshopper, Dynamo, Marionette

VPLs have been used in other disciplines for many years. Simulink (originally Simulab - 1984) developed by MathWorks is one powerful example that uses a graphic representation of objects to produce a block diagram. In 2007, Grasshopper (originally called Explicit History) was released by David Rutten at Robert McNeel & Associates. It is an add-on to Rhinoceros, a popular 3D software program. Since its original inception, the functionality of Grasshopper has grown tremendously, and with the development of third-party plug-ins

there are numerous components providing new functionality for algorithmic modeling, environmental simulation, optimization, structural form finding, paneling, physics simulation, etc., in addition to other components that allow users to generate map and topographical surfaces — and even tap into social media. Grasshopper has given the building industry a powerful stepping-stone into design computing and visual programming.

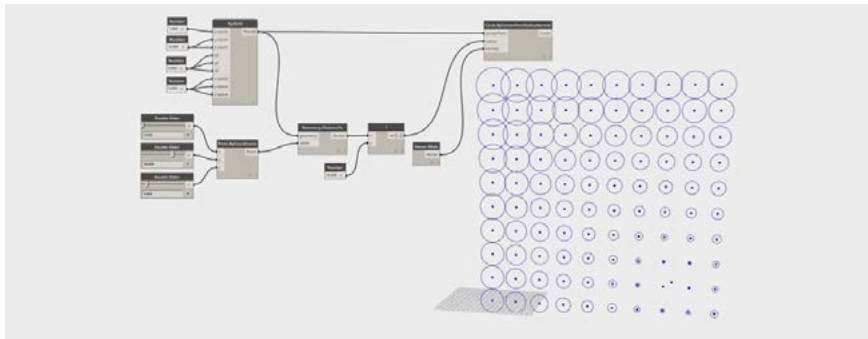
Whereas Grasshopper works with Rhino, Dynamo was developed as a visual programming environment for Autodesk Revit, a building information modeling (BIM) software

program. Dynamo's look and feel was influenced by a number of visual programming interfaces that have come before including MaxMSP, the Maya Hypergraph, and LEGO MINDSTORMS NXT. Dynamo also takes inspiration from Bentley's GenerativeComponents and McNeel's Grasshopper for Rhino. First released in 2011, Dynamo is undergoing some “re-packaging” and has announced a new version (Autodesk Dynamo Studio) that will include functionality for users who do not use Revit.

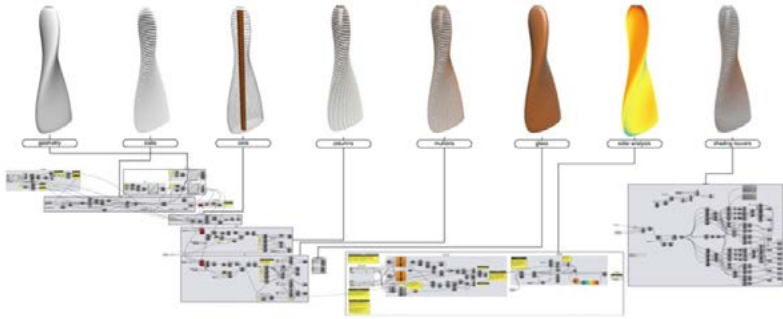
Another VPL for the building industry has been disclosed: Nemetschek recently announced the release of Marionette for Vectorworks 2016.

Applications

Users of VPLs can use the basic functionality provided by the software companies, draw upon a large and growing community creating components and packages, and even write their own for internal use or public release. Three figures are shown to illustrate how firms are currently using these tools.



THIS SIMPLE DYNAMO SCRIPT CREATES A GRID OF CIRCLES. THE USER CAN MOVE THE SLIDER TO CHANGE WHERE AN XZ POINT IS LOCATED. THE DIAMETER OF THE CIRCLES IS BASED ON THE DISTANCE OF THE CENTER OF THE CIRCLE TO THAT ATTRACTOR POINT. IMAGE COURTESY OF BHATTACHARJEE AND BURKHART.



HIGH RISE TOWER EXPLORATIONS IN RHINO WITH GRASSHOPPER (2010). IMAGE COURTESY OF JEFFREY VAGLIO / [HTTP://THEIMPROVINGGROUND.WIKIDOT.COM/JEFFREY-VAGLIO](http://theimprovingground.wikidot.com/jeffrey-vaglio). WEBSITE ACCESSED 26-AUG-2015.

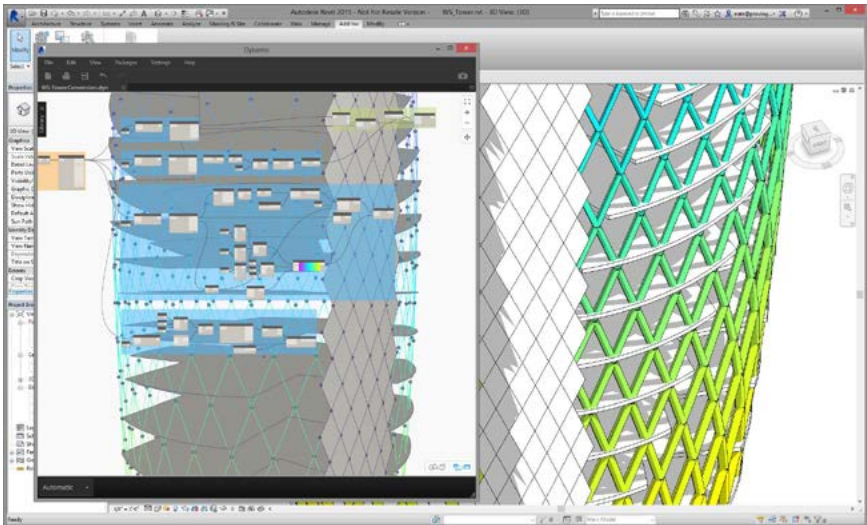


FIG. 1: USE OF ADVANCED GEOMETRY AND RHYNAMO INTEROPERABILITY TOOLS TO MANAGE THE FLOW OF FACADE DATA FROM DESIGN TO BIM. IMAGE COURTESY OF MILLER, THE PROVING GROUND.

Summary

Hopefully these notes have provided those unfamiliar with visual programming with some motivation to learn more about how it can be added to a practitioner's workflow. It is not all about making complex forms, although this can be done. It can be used for creating time-saving scripts such as renaming all rooms on a sheet based on an Excel spreadsheet, doing daylight analysis for

conceptual massing models, calculating the amount of concrete that the building's pilings will take for different site locations, and anything else one can think of. Creative people will use visual programming for innovative solutions to real problems.

Acknowledgments

Thank you to Nathan Miller, Daniel Segraves, Erik Narhi and Ron Elad, some of the presenters at the Ninth

Annual USC BIM Symposium (2015): Visual Programming for the Building Industry, and thanks to three of my former students: Shinjini Bhattacharjee, Kelly Burkhart, and Jeffrey Vaglio for supplying images!

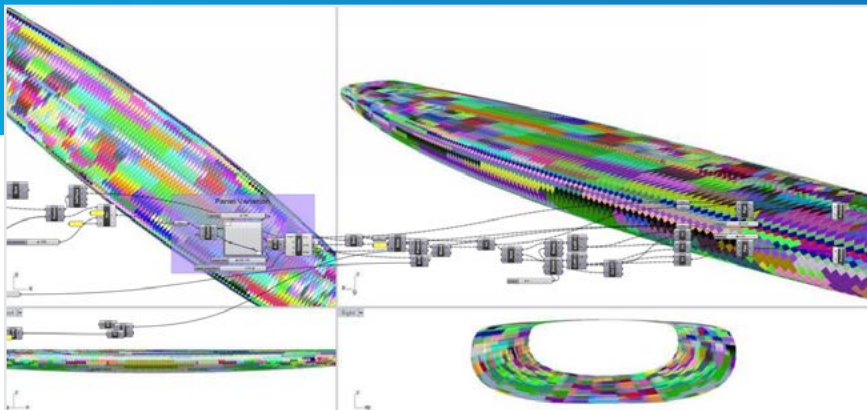


FIG. 2: PANEL VARIATION ANALYSIS OF A METRO STATION ROOF. THIS SCRIPT COMPARES THE GEOMETRY OF EVERY PANEL AGAINST EVERY OTHER PANEL TO SEE WHICH ARE SIMILAR ENOUGH, WITHIN A TOLERANCE, TO BE CONSTRUCTED AS IDENTICAL PIECES, THUS REDUCING EARLY MACHINING COSTS. IMAGE COURTESY OF SEGRAVES, THORNTON TOMASETTI.

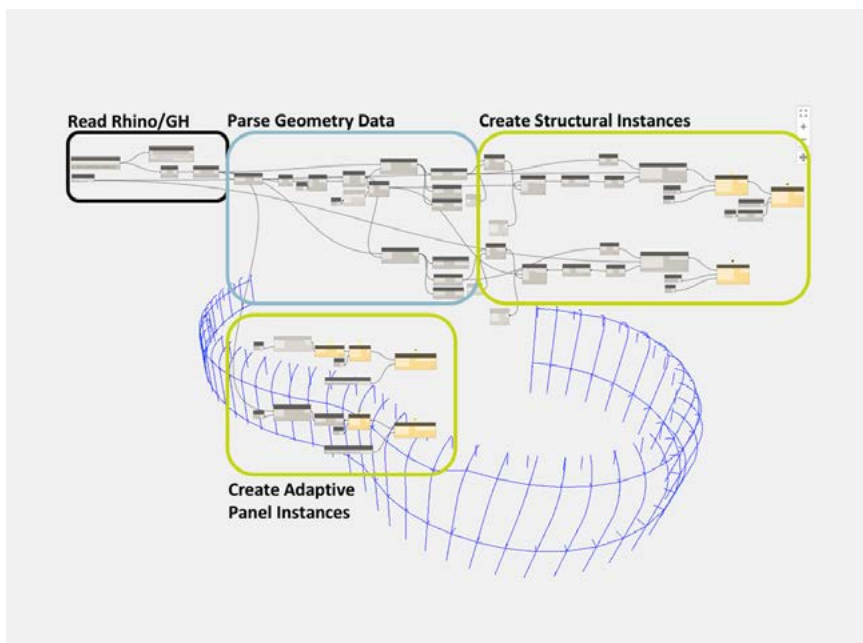


FIG. 3A: DYNAMO READS RHINO/GH FILE, IMPORTS GEOMETRY INTO DYNAMO INTERFACE, AND THEN PARSSES EACH PIECE OF GEOMETRY BY NAME AND ASSOCIATED OBJECT DATA. ONCE EACH PIECE OF GEOMETRY IS PARSED, IT IS TURNED INTO ITS CORRESPONDING REVIT FAMILY (I.E. PANEL CORNER POINTS CREATE AN ADAPTIVE PANEL, VERTICAL CENTERLINES CREATE FRAMING WITH THE STRUCTURAL SECTION ASSIGNED IN GRASSHOPPER, ETC.). IMAGE COURTESY OF NARHI AND ELAD, BUROHAPPOLD ENGINEERING.

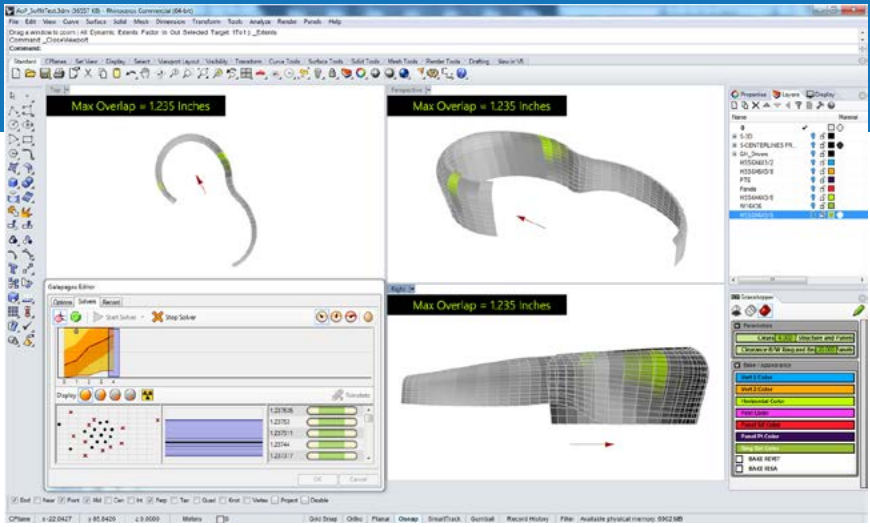


FIG. 3B: JOINT SIZE ANALYSIS IN GRASSHOPPER. IMAGE COURTESY OF NARHI AND ELAD, BUROHAPPOLD ENGINEERING.

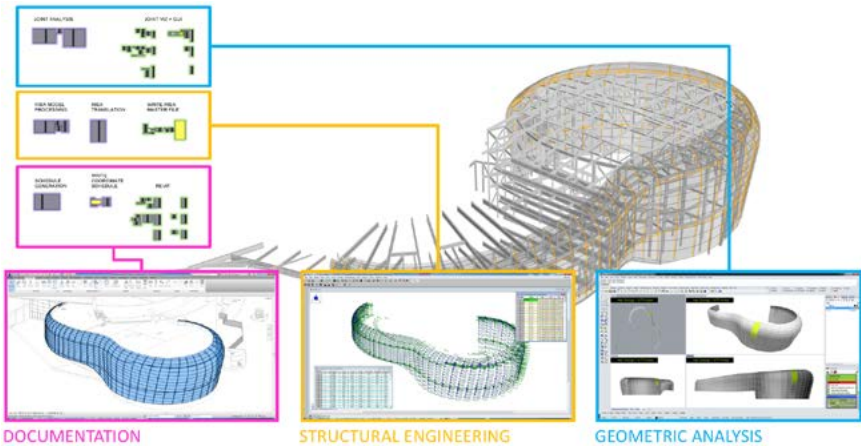


FIG. 3C: DATA TRANSFER FOR GRASSHOPPER, RISA 3D, AND REVIT WORKFLOW. IMAGE COURTESY OF NARHI AND ELAD, BUROHAPPOLD ENGINEERING.

Is Your Tower Facade Future Proof?

Nico Kienzl, DDES, LEED Fellow, ASHRAE HBDP

Director at Atelier Ten

When designing towers, conventional wisdom holds that the thermal performance of the building enclosure has a relatively small impact on overall building energy use. In tall buildings with larger floor plates, internal loads typically drive energy consumption. For most climate zones, improving the performance of the facade by incorporating high performance glazing, adding external shading, or employing other innovative strategies leads only to low single-digit percentage savings in energy use.

Given the significant first costs of higher performing facade systems, design and engineering teams often focus on improving HVAC/energy systems, controls, and lighting systems to achieve code compliance or added energy savings. After optimizing these systems, the development team will address the facade – generally focusing first on cost, then aesthetics, then thermal and visual comfort. To increase transparency, the team will maximize the window-to-wall ratio, often resulting in fully glazed facades with poor thermal performance. These buildings do not meet prescriptive energy code requirements.

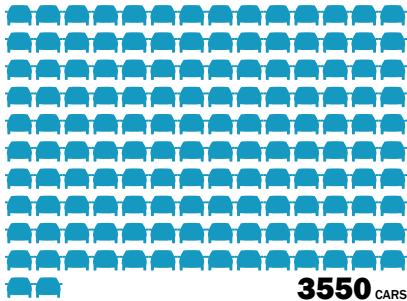
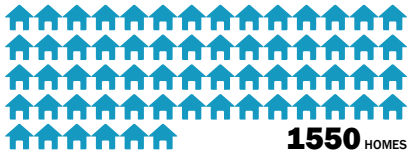
This conventional approach ignores two important considerations. First, emphasizing relative impacts on overall energy use hides the fact that these large buildings still incur massive energy penalties in absolute terms due to underperforming building enclosures. The size of this energy penalty is simply obscured by the magnitude of overall energy consumption, but the added greenhouse gas emissions associated with underperforming building envelopes are still quite large.

The second, and perhaps more interesting consideration, is that these facades will quickly become outdated, as regulations require higher levels of energy performance. Energy codes are becoming much more stringent as efforts to reduce greenhouse gas emissions accelerate. In New York City for example, the current target for greenhouse

gas emissions reductions is 80% by 2050. How will we reach this target? For HVAC and energy systems in tall buildings, there are few opportunities for further optimization, with a limited set of new technologies on the horizon to improve energy performance.

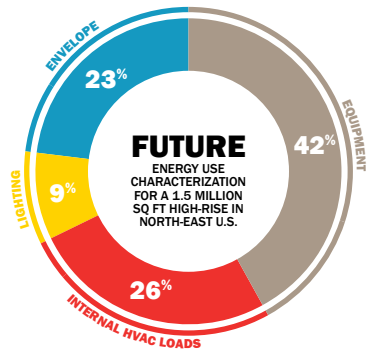
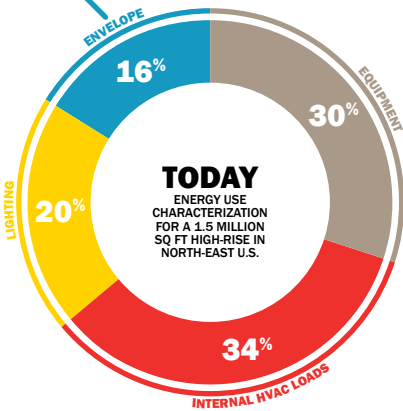
In terms of lighting energy, we can incorporate LEDs and advanced lighting controls, but will similarly approach a point of diminishing returns with current technologies. As for equipment loads, developers often hesitate to impose restrictions as this would compromise the commercial appeal to potential tenants, although we will need to seriously address this issue in the future. Therefore, improving envelope performance will play an increasingly important role in helping tall buildings meet and surpass even more stringent energy codes.

EQUIVALENT ENERGY USE AS

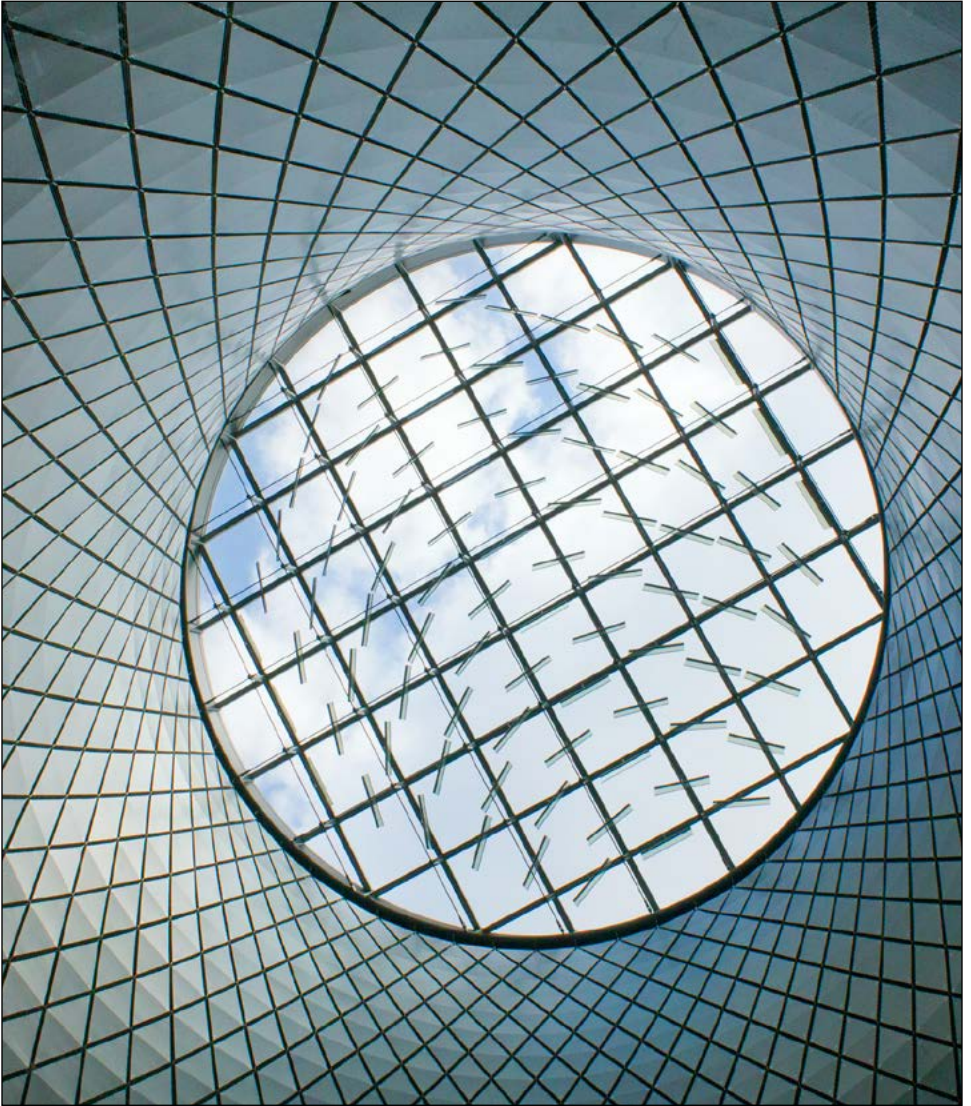


As a result, we will likely see more innovative and higher performance facades in the coming years. This shift towards high performance facades in tall buildings will transform market expectations of thermal comfort, visual comfort, aesthetics, and energy use. It is unreasonable to assume that tall buildings with underperforming facades can adapt to these new expectations, as the building envelope, especially for tall buildings, is difficult and costly to replace.

Developers who wish to create long-term value for their projects must stay ahead of this market transformation by designing facades for the future, with a special focus on performance. It is therefore advantageous to future proof tall building projects by starting to invest in higher performing facades today.



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Enclos is a leading facade technology firm, providing comprehensive design, engineering and strategic implementation services for custom facades and curtainwall cladding systems. With over 800 people and 16 office locations, the firm self-performs a spectrum of services while managing a sophisticated global supply chain.

Enclos has been a leader in facade system development since the advent of contemporary curtainwall systems, and today is consistently ranked as a leading facade contractor by national industry surveys. Many of the most prominent buildings in the world's great cities showcase Enclos' innovative approach to design, engineering and construction.

See *The Visible Difference* at enclos.com.

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Kuraray is a leading supplier of laminated glass interlayers, including Butacite® and Trosifol® PVB and SentryGlas® ionoplast interlayers. The PVB portfolio includes ultra-clear products, a color palette from opaque white to black, as well as interlayers designed to provide enhanced acoustical properties, UV-ray blocking or natural UV-transmission.

SentryGlas® ionoplast interlayers can expand laminated glass performance in facades, skylights, and other architectural applications like the Louis Vuitton Foundation Museum in Paris. The interlayer's exceptional strength and stiffness often enables the use of thinner glass, resulting in an overall weight savings. In addition, ionoplast interlayers provide excellent edge performance in exterior, exposed edge conditions. More information at www.sentryglas.com and www.trosifol.com.

FRP Composites – Something New in the Facade Toolbox

Bill Kreysler

Kreysler & Associates

First let me say that I am not a facades expert. I'm not yet familiar with the wide variety of options available, their pros and cons, nor am I an expert in thermodynamics, waterproofing, or environmental issues. What I do know is composite materials, and by that I mean fiber reinforced polymers (FRP), the most common of which is fiberglass (that's a bit of a misnomer, by the way, since fiberglass is only half the materials found in FRP; the other half is the resin matrix, not unlike steel fiber in reinforced concrete). It takes both these components, glass fiber or fiberglass and synthetic resin, to create what we know today as advanced composites.

Since its introduction during World War II as an alternative to aluminum in aircraft, FRP has swept through many industries rapidly. The pleasure boat industry was first to feel its influence, replacing almost completely hand-crafted wood with molded materials that were stronger, lighter and required essentially zero maintenance, as composites do not rot, corrode or deteriorate over time. Most properly built fiberglass boats are still in service, many for well over 60 years. Truck and automotive bodies were next, followed by motor homes and a vast array of industrial products. Because of its corrosion resistance, a large segment of the composite industry supplies chemical storage tanks, cooling towers and ducting for highly corrosive environments such as those found in semi-conductor fabrication facilities. Intel uses FRP ducting in their factories, replacing their stainless steel predecessor, whose lifespan is sometimes only a few months. The composite material's lifespan is yet to be determined after 20 years in service. Aerospace has used FRP for decades, where advanced composites have saved thousands of pounds. Perhaps more significantly, molded FRP has replaced sometimes thousands of assembled parts. Wind energy would not be commercially viable without FRP blades, which represents nearly 100% of all wind turbine production.

So why, after so much acceptance in such a wide array of industries, has FRP taken so long to find itself applied to buildings? To my knowledge, the first use of FRP on a building exterior is a cornice on a New York hospital installed in the 1940's. It's still there by the way, and appears to be doing fine. It was not until the International Building Code



PHOTO BY ETNOY



SAN FRANCISCO MUSEUM OF MODERN ART EXPANSION BY SNØHETTA.

(IBC) adapted section 2612 in 2009 that FRP was recognized in the code. This exclusion dramatically limited its use, particularly on large-scale applications, in spite of the fact that many companies had for years made a living providing FRP components to builders — our firm has fabricated FRP building components for over 30 years, for example. With the IBC adoption of section 2612 however, the added insurance of building codes made the use of FRP much more appealing. This recognition by the codes greatly reduces the risk that a code official or fire marshal would challenge the use of an FRP product and holding up a project at great expense. Provided it carries the proper label and is certified to meet the use intended, FRP is now a recognized and accepted product in construction with the same rules that apply to other materials. Today, fire is the material's main issue. FRP above 40 feet is required to

meet the same code other materials meet, most significant of which is passing the NFPA 285 test. Passing this test, which our firm did in 2014 for a rainscreen application at the San Francisco Museum of Modern Art expansion, has given architects, engineers and builders access to yet another facade material.

FRP carries with it unique advantages and disadvantages. On the plus side it is light weight, durable, has extremely low thermal conductivity, and can be molded into a wide variety of shapes of unlimited size. On the negative side, it is not non-combustible, is difficult to keep flat (making it less attractive for use on planar surfaces), and has a low modulus of elasticity (making stiffness the controlling factor in its design, as opposed to strength, which often ends up exceeding requirements). The material also requires different connection designs, which, although

much lighter than other systems, are sometimes foreign to traditional means and methods. Understanding these pros and cons and exploiting them reliably and efficiently is the challenge we face today. The American Composite Manufacturers Association (ACMA) is currently writing a design guide including CSI standard specifications for the use of FRP in construction. Information on the status of this guide, which should be published by early next year, is available by contacting the ACMA in Arlington, Virginia, or going to their website at www.acmahq.org.

Facade Technologies

Deborah Moelis, AIA

Senior Associate at Handel Architects

The global urban population has grown to surpass the rural alternative. This is good news for the environment, as we have known for decades that density is imperative to a sustainable future. Multifamily high-rise construction must become a significant part of this urban solution. When tall buildings are designed and constructed properly, greenhouse gasses and energy input can be drastically reduced, and dependence on non-renewable fuel is alleviated. Residents can benefit from improved indoor air quality, constant fresh air ventilation, acoustical separation from busy city streets, and monthly financial savings due to the potential 90% reduction of energy usage.

The design guidelines set forth by the Passive House Institute can provide a path leading to this necessary design revolution. The guidelines afford architects the flexibility to push and pull/add and subtract — to design buildings hand in hand with engineers to meet previously impossible energy efficiency requirements. One must be extremely aggressive to design and implement this rigorous design methodology.

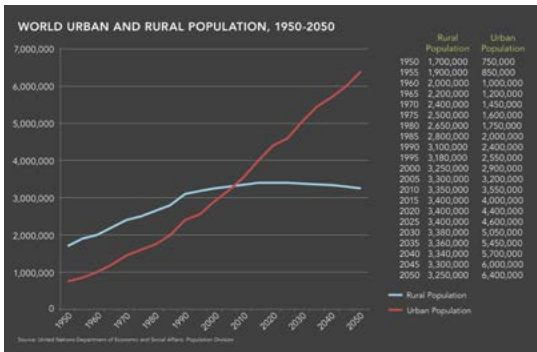
With regards to facades, the critical components to achieving Passive House goals are:

- continuity of substantial insulation
- air sealing
- elimination of thermal bridging
- coordination of specifications
- careful selection of products
- careful architectural detailing

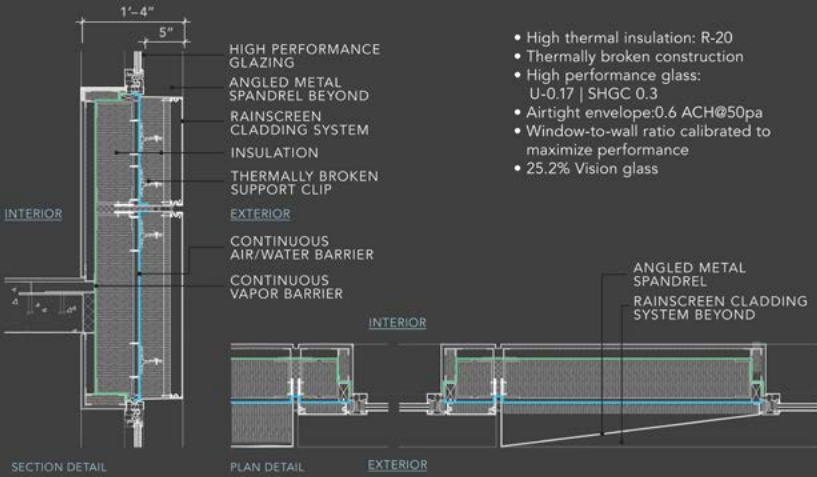
Handel Architects is planning to realize these goals within the Cornell Tech Residential Building on Roosevelt Island in New York City. The facade design has been an extreme collaboration between Hudson Company, Related Companies, Monadnock Construction, Eastern Exterior Wall Systems, Vidaris, Steven Winter & Associates, and Handel Architects. Collaboration and a willingness to rethink standard construction methodologies is an ongoing and intense effort.

Early on the team determined that a panelized, shop-assembled exterior wall could achieve the project's aesthetic and technical goals. Within a controlled environment, the metal outer layer is first backed with insulation and then tied back to the outer waterproofed sheathing with thermally broken clips. Inboard

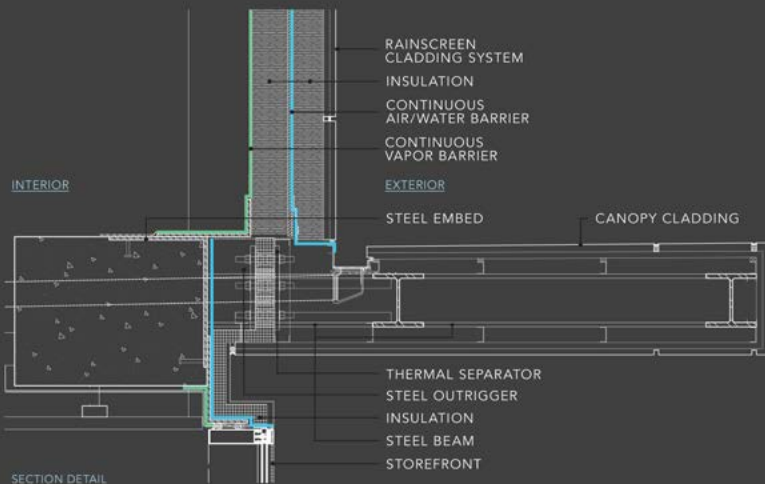
of the sheathing is another layer of insulation that is faced with a continuous vapor barrier and taped and taped, affording a continuous vapor barrier facing the interior of the building. The windows are installed and sealed in the shop, which ensures strict quality control. The average 10'x36' panels will then be hung off the slab, allowing approximately 9" of insulation to pass by the edge of the building. Each of the panel joints needs to be carefully taped and inspected on site to assure that the panel-to-panel joints are tightly sealed. This fabrication and installation method yields an overall facade that allows an air infiltration of no more than .01 perms — nearly 10 times tighter than standard facade construction.



EXTERIOR WALL DETAILS



BUILDING CANOPY DETAIL



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Detailing for proper taping and thermally separating the facade has thus far been arduous. Air sealing at the windows alone is expected to use over 3 miles of high performance, vapor-impermeable tape. Neoprene gaskets, thermal isolators and aluminum extrusions are all incorporated into the panel system.

Additionally there are some areas of the building envelope, specifically

at the structural steel support of the building canopy, where structural isolators are employed. Here the isolators serve to reduce thermal bridging by separating structural steel from the body of the building.

One simply cannot overstate the critical component of communication. The development and design team needs to be in constant communication with the construction manager.

This has proven to be a vital aspect to every step in design and construction, from identifying trades to proper field execution.

As these design methodologies become second nature to the drawing, specifying, pricing and building process, we expect that the building industry will transform and do its part to save the planet.

Building Envelope Research Collaborations: Engaging Industry and the University

Douglas Noble, Ph.D., FAIA

University of Southern California School of Architecture

New processes, materials, manufacturing methods and construction techniques for building envelope design and delivery are nearly unrecognizable from just a decade or two ago. Though often seemingly driven by energy and sustainability goals, the increased interest in improving the envelope pervades the broadest spectrum of built-environment professionals. Knowledge and technology have expanded at rates that challenge our abilities to keep up. Professionals find themselves needing constant continuing education.

In many fields outside of architectural disciplines, universities have powerful roles in research and development. University-based research outcomes in medical, scientific and engineering disciplines are key to progress in countless arenas. This collaborative engagement has traditionally not been a dominant mode in architecture and its related disciplines, especially in the United States. The unfortunate research chasm between the university and architecture, engineering and construction (AEC) professions limits opportunities for advancement of both groups.

The built environment industry and professions do not have a history of powerful relations with university research, and often do not know how to begin the conversation about serious research. This disconnect is

compounded because many university faculty carry out design projects as research as opposed to the more traditional kinds of research and development that occur on campus in medicine, the sciences, and even engineering. We are at an important moment for AEC expansion into research and development, and vigorous action should be taken to set the foundations for collaboration between the building envelope industries, professions and the academics.

Strong links have been established in some cases: Berkeley, Georgia Tech and MIT, for example. The list of universities with some town-and-gown connections is longer than this, and we risk offending colleagues if we attempt a comprehensive list and overlook an important one. But these examples are generally exceptional

cases, and usually represent relatively modest collaborations. Some universities may not be actively seeking these opportunities, but most are making serious efforts.

The School of Architecture at the University of Southern California (USC) has staked out a leadership position in building envelopes. USC has hosted dozens of conferences, and established an envelope oriented doctoral program nearly a decade ago. New courses have been created, special faculty designated, and broad enthusiasm has been generated. Extraordinary efforts have been made to guide faculty research agendas and coursework throughout the curriculum from freshman year to Ph.D. Deep research is being conducted in areas such as facade retrofit, intelligent skins, double-skin facades, facade acoustics and more. Some of the work will have esoteric-sounding titles involving things like “agent-based pareto-optimization,” while other studies might involve directly practical subjects such as “backpan detailing for rainscreens.”



The Facade Tectonics program was founded at USC to promote these kinds of collaboration. The Facade Tectonics Institute outgrew the scale and scope of USC, and is being transformed into an international organization that will host conferences, events, and publications globally. This is a great success story, but the success of Facade Tectonics masks the underlying gap of research collaboration between the envelope industry and universities. This gap must be aggressively bridged.

The building envelope industry and professions must take firm steps towards establishing research and education connections to universities. This will help the missions of both groups, but also impact the larger architectural communities in the schools.

This is a call to action. Industry, the profession and the university need to reach out to each other and start discussions. We may start with small projects or opportunities with budgets of just a few thousand dollars, but that can be enough to engage a faculty member and a grad student.

At the other end of the spectrum, firms and industry groups can sponsor doctoral students for some very serious research that might cost \$100,000 or more.

Some universities may have testing labs, others will not. Some will be able to work on post-occupancy evaluations and human-comfort testing adjacent to a facade. Each university will have unique capabilities and interests. The range of possible research is broad: materials analysis, in-situ testing, prototype development, thermal and energy studies, computing methods, design processes, and many more types of studies can be carried out.

Some firms will not have an immediate research need, but might be interested in sponsoring a design studio to expose students to a specific facade type or material system. For example, the Precast Concrete Institute (PCI) Foundation sponsors studios across the nation as a way of introducing architecture students to precast concrete, and newer precast technologies such as glass fiber reinforced concrete (GFRC).

Industry representatives and professionals have often been surprised at the range of possibilities, and some just never realized how eager the universities are to work with them. For those that their preliminary idea might not fit the university research model, you can contact me directly for a quick review before reaching out to your local university. Schools and firms may have guidelines and rules about interaction and finance strategies. It takes just a little extra time to sort these out for a first time collaboration.

Many faculty, professionals and industry representatives will not know exactly how to proceed. Each participant will assume that there is a well-established protocol for interaction, and that there exists a type of "menu" of opportunities, costs, and policies. This might be true in other disciplines, but it is not yet true in architecture. All participants must be bold and step forward to start the dance.



Glass for Building Skin – Size Mattered. Now Energy Governs.

James O'Callaghan
Director at Eckersley O'Callaghan

Clients and designers have defined glass as a key component in the design palette for contemporary architecture. Together, we have created demand for innovation — the criteria for evolution — as a challenge to those who make. The application of glass technology has exponentially advanced over a relatively short period of time, despite difficult economic conditions and industry inertia. The pursuit of perfect transparency drove industry to produce larger and larger panels of glass with connection details that can be entirely embedded.

Bigger is better. Less is more. And we have succeeded.

Today, we face a new reality. Size mattered, now energy governs.

At the same time as glass panels have grown in size, the codes that determine energy requirements have become ever-increasingly stringent. Their trajectories were inevitable — the limits on size and energy converged a few years ago. This moment challenges the extent that we can use glass as a building skin and still be energy compliant.

There is simply no benefit in growing the largest glass panels beyond the 50' x 10' that is possible today until we navigate the energy impasse. We must refocus our attention.

“It is our responsibility to temper the scale of our ambitions and firmly prioritise energy as our concern.”

There are two ways forward. The first is for code writers to develop the means of assessment, which recognises the nuances of different building types and typologies. We must engage in this process. We

must determine how best to accurately measure energy performance goals for every specific situation and environment. We must elevate this science. In tandem, industry must realise the application of energy management technologies for glass. There are several schools of thought here, ranging from dynamic systems to coatings. We must also engage with this dialogue to drive their development and find the right path. It's an exciting and new epoch.

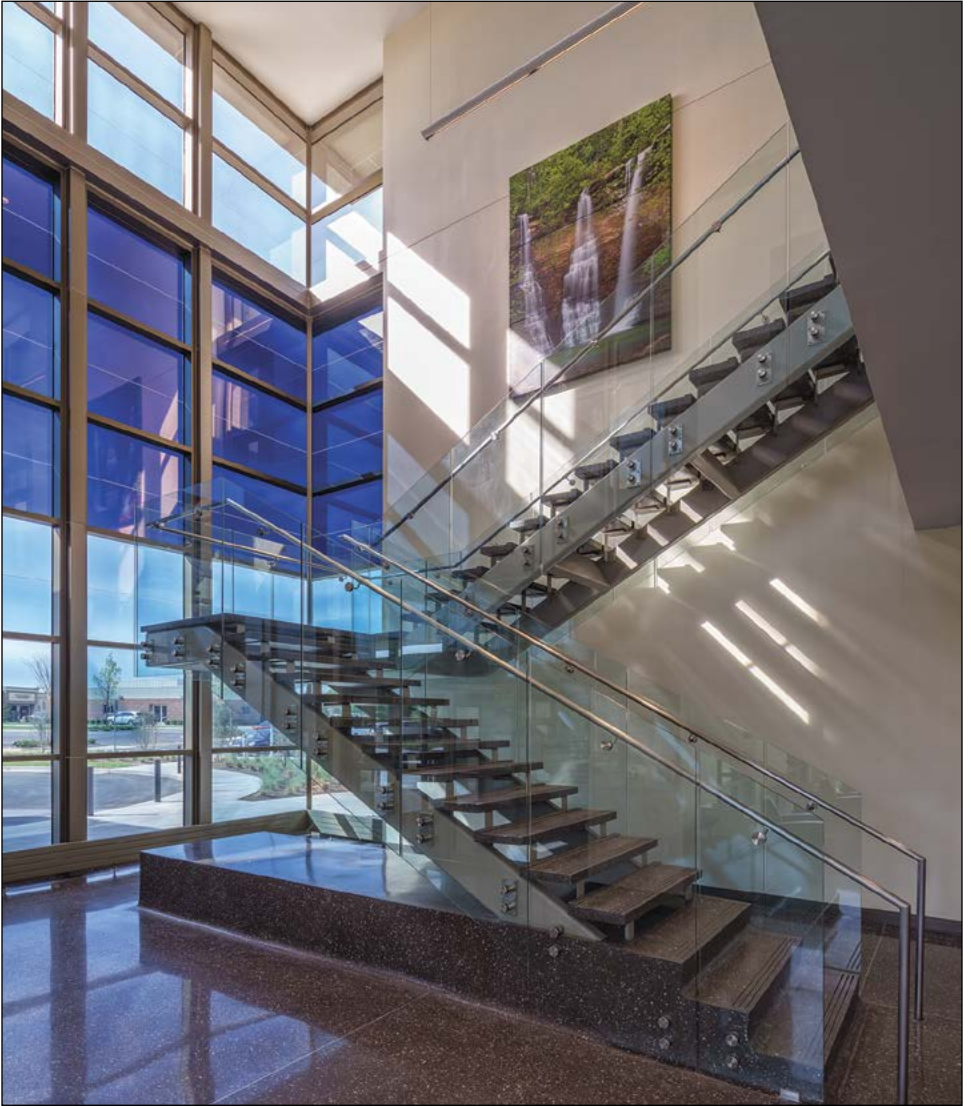
As designers of the built environment, it is our responsibility both professionally and morally, to temper the scale of our ambitions and firmly prioritise energy as our concern. In the same way that we created demand for large format glass, we must be unequivocal in supporting industry along the next steps in meeting energy performance criteria.



IMAGE © ROY ZIPSTEIN

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Skin Deep Durability: How Long Should Building Facade Systems be Designed to Last?¹

Mic Patterson, LEED AP [BD+C]

Vice President, Strategic Development at Enclos

Contemporary curtainwall systems fail to support service life duration and quality consistent with sustainable building performance. Enhancing curtainwall system durability can extend service life and quality, thereby amortizing embodied energy over a longer period and resulting in a significant reduction in environmental impacts, with subsequent contributions to the sustainability of the building sector.

I have been involved for some years in an investigation of various curtainwall practices and the extent to which they support sustainability of the built environment. The focus started with an investigation of curtainwall retrofit practices in tall buildings. But many of the problems identified were rooted in the original facade system design. The scope of the investigation thus broadened to include opportunities for improvements to facade technology for either new or retrofit applications, opportunities that could contribute to improved sustainability at the scales of facade system, building and urban habitat.

Sustainability is a complex consideration that first requires the identification of appropriate evaluation factors in the context of the building skin. One of these factors is durability as it relates to the weathering and service life of a material, product or system. This line of inquiry led to the question, how long should buildings and their facade systems last, for which I was surprised to find no consensus answer, which is perhaps not that surprising after all. More surprising, however, was finding that service life is very rarely explicitly defined as part of a building program (even on LEED Platinum projects), much less their facade systems, this despite the massive investment in resources these buildings represent.

In my line of work, curtainwalls are typically regarded as zero-maintenance systems; building owners do not want to hear about maintenance (beyond annual cleaning)

on their 40-story building facade. Nonetheless, I began to consider the implications of an ongoing process of facade renewal involving planned maintenance and partial renovation cycles as a strategy to extend service life. I found that, at least conceptually, the service life of the curtainwall system might be dramatically extended through such a strategy, and much of the cost, impact and disruption of facade replacement on a 40 to 60 year cycle eliminated. While facade renovation practices are no longer the singular focus of my research, I find them to be central to the exploration of opportunities to improve key sustainability attributes of curtainwall technology.

Sustainability goals in the built environment require that the service life of buildings be reconsidered. Building construction is highly resource consumptive, especially for large commercial and multi-unit residential structures. It is imperative that these buildings be durable enough to support a lifespan well beyond today's expectations, and to provide a standard of service throughout that lifespan consistent with sustainable performance.

Longer lasting buildings and facade systems must also be designed with adaptive capacity — the flexibility to change in response to accelerating social change, and the capability to adopt emergent materials and products that can improve facade system performance. It is impossible to say how the buildings of today will be used 50, or even 30 years hence.

In addition, the technology required to render the tall building facade energy neutral may be close, but is not yet available. But even this is not enough. Net-zero energy performance in urban habitat will require the activation of the facade systems of tall buildings, enabling them to become energy producers. Again, this will require the retrofit of future technology to these existing buildings. This means that buildings under construction currently and into the foreseeable future will require adaptive facade retrofits in order to meet already defined future energy consumption goals for the building sector. Despite this, I have yet to come across a facade design that anticipates this need and accommodates these requirements in the system design.

With current curtainwall practices, we are building problems for the future at the same time that we are trying to deal with the legacy of the past.

This is the problem that we face today in retrofitting facades of the early tall curtainwall buildings. Typically, the most feasible — and often only workable — facade renovation strategy is reclad: the complete removal and replacement of the facade system. The process is both expensive and highly disruptive to ongoing building operations. The building owner is faced with the prospect of vacating the building for the 2-year duration of the renovation, or keeping the building operational throughout the renovation while implementing complex strategies to mitigate disruption to tenants. Either are expensive propositions. Owner-operators faced with the loss of lease revenues and owner-occupiers faced with outside leasing options both tend to choose the latter strategy of



BUILDINGS WILL REQUIRE ADAPTIVE FACADE RETROFITS IN ORDER TO MEET ALREADY DEFINED FUTURE ENERGY CONSUMPTION GOALS FOR THE BUILDING SECTOR.

completing the renovation while the building remains occupied.

The widespread need for facade retrofit is ultimately an infrastructure problem with the potential to compromise the resilience of our urban environments.

A facade system designed to support a continuous renewal process through a strategy of planned cyclical maintenance and partial renovations would eliminate this problem entirely; the facade system would have a continuous and unlimited service life. At the end of its service life, however long that may be, there may not be a single original component or material left in the assembly, yet the system has been in continuous service for the duration. The facade system design focus then shifts from zero-maintenance to ease of maintenance: how do we design the system to accommodate renewal strategies with minimal resources? It presents an entirely different way of thinking about the building skin, a different way of thinking that, I have come to believe, is a fundamental requisite to even

beginning to approach sustainable performance in the building sector. It brings to the forefront questions like:

- How do we design the system so that every material and component can be fully recycled (not down-cycled)?
- How do we design the system so that all maintenance requirements can be performed from inside the building with no disruption to the occupants?
- How do we design the facade system weather seals so that they are easily inspected, repaired or replaced as necessary?
- How do we change the appearance of the building without ripping the entire facade from the building and replacing it with a new one?

It becomes clear that these questions drive design solutions that look quite different from what we are building today (we would have to consider

methods to avoid burying the weather seal deep in a channel that cannot be inspected, repaired or replaced for the entire lifespan of the system, for example.) My earliest design training included lessons in the critical importance of asking the right questions. I think when it comes to current design practices, even when we attempt to integrate sustainability considerations, we have yet to get around to asking the right questions. Among them is:

How long should a building and its facade system be designed to last?

I'm coming to the conclusion that a viable and compelling answer may be forever.

'Excerpts taken or derived from in-process dissertation work by the author in pursuit of an advanced degree at the University of Southern California School of Architecture.

Rethinking Energy Efficiency Through Integrated Building Facade Forms and Materialities

Edward Peck

Vice President, Facade Engineering at Thornton Tomasetti

I am interested in architecture that advances holistic performance through the design and integration of innovative building skins. Historically, vernacular buildings were “high performing” with multi-layered skins and passive concepts for ventilation and solar control. By the mid-twentieth century, the widespread use of mechanical systems, coupled with the drive to create ultra-thin and highly transparent building facades, resulted in the building industry parting ways with responsible environmental stewardship.

Today's building design culture supports a movement toward high-performing architecture. Building and facade designs are being challenged by designers and clients to reach high energy efficiency while integrating complex ideas about form and materiality. This challenge encompasses both the rethinking of traditional building materials and the development of novel applications for new and innovative materials. Architects and engineers must adapt to these developments and perform advanced analytics to model the resulting performance of these systems.

The idea of single-layer skins consisting of traditional materials is diminishing as the demand for energy efficiency drives the building skin to

be re-thought. The skin needs to be a system of materials layered together, inclusive of both static and active components. Active components in building skins can be responsive to the environment or have the capacity to harvest energy. These types of skins will be responsible for modulating daylight, reducing solar gains, mitigating glare, redirecting light, controlling thermal transmission and infiltration, while maintaining occupant comfort and direct connections to the exterior.

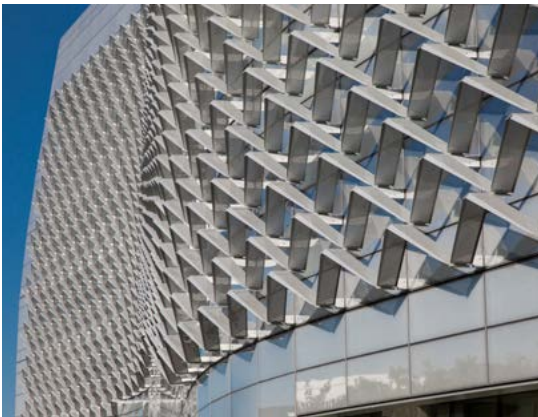
Complex skin systems composed of diverse and active components will require new modeling methodologies to be fully realized. The designer must consider not only individual performance, but also the holistic

performance of the total system, while factoring the skin's performance directly into the building-energy model. Furthering the complexity of this task, the process needs to be interactive and parametric to refine the system composition and performance. These interactions should persist from preliminary design investigation to final resolution.

To be at the forefront of this type of architecture requires the ability to participate in two major avenues of investigation. First, the knowledge of materials and technologies, and second, development of analytical tools that will allow design teams to explore, model and evaluate ideas in real-time — informing their designs and providing energy and performance monitoring prior to construction investment.

The interactive process goes beyond the knowledge and explorative capacities of a traditional design team, requiring tight collaboration of a multi-disciplinary team, integrating programmers, material and building scientists, environmental consultants, architects and engineers. This team will need to work together to develop performance targets and challenge the design from concept to construction.

We require the development of project-specific tools that can consider multiple elements contributing to a building's performance within a single model. The goal is always to provide immediate feedback that is useful in the continuation of the building's design, and ultimate energy solution.



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Silvia Prandelli, COO
Werner Sobek

The necessity for efficient enclosures, as well as the increasing complexity of building-skin geometries, has aimed the facade consultant's focus towards the optimization of cladding materials and systems, production and site installation. Members of multiple design teams need to work closely together to identify and craft suitable solutions within each project's unique constraints.

The latest energy requirements, combined with today's sculptural architectural designs, are reflected in the research initiatives and enhanced capabilities of the construction industry; new materials, as well as advancements in traditional technologies, allow current facade systems to achieve improved performances. For example, the first installations of vacuum insulated glazing systems are proving that the window-to-wall ratio argument can be challenged, and that highly transparent facades can still be explored. Our buildings are also being asked to achieve longer lifespans, and systems should be designed to be replaceable for this purpose. An example of this integration is the housing prototype B10 by Werner Sobek in Stuttgart (Fig. 1). This self-sustainable project can be installed and dismantled in twenty-four hours, and produces more than double the energy required for its use thanks to a highly efficient envelope that includes vacuum insulated units.



FIG. 1: B10 ACTIVE HOUSE IN STUTTGART, GERMANY.
IMAGE © ZOOEY BRAUN.



FIG. 2: MARITIME MUSEUM IN LINGANG, CHINA.



FIG. 3: HEYDAR ALIYEV CENTER IN BAKU, AZERBAIJAN. IMAGE © HELENE BINET.

The construction market is increasingly recognizing the valuable impact of these innovative designs and technologies in the built environment, and is initiating studies on how to achieve more cost effective productions. Essential to the success of this development is the collaboration of designers with research institutes and manufacturers to translate hypothetical designs into feasible products.

Material and system innovation does require careful consideration of project budget. When this is of importance, the use of materials currently available from the building industry can be explored with a pioneering approach. For example, the introduction of cold bending in glazing systems may help to reduce the quantities of hot bent units in systems accommodating variable rotations, while metal rainscreens can follow smooth curvatures without the need of producing custom-made molds.

A holistic design approach can impact the selection of materials or systems. This is the case of the Heydar Aliyev Center in Baku (Fig. 3), where glass reinforced plastic panels are used to reduce cladding weight and deflections of the optimized steel spaceframe substructure.

Finally, designers should also consider that performance improvements are not necessarily linked to the exploration of new technologies. Customary materials can be engineered to suit new purposes and challenge current regulations. This aspect becomes particularly interesting when the manufacturing industry is progressive and willing to investigate new process and methods to advance production techniques.

Push + Pull: Performance Drivers and Glazing Technologies

Eduardo Rosa

Architectural Specialist at Interpane

Facade Tectonics interviews Eduardo Rosa, architectural specialist at Interpane, about the future of glass materials, technologies and their implementation.

When did you start your career-long involvement with glass?

I got to understand glass as material during my stay in the Czech Republic 30 years ago. At that time I was helping a well known artist. I took her molded glass piece to a glass fabrication facility to polish the excess material on the edges. The sculpture broke just seconds after the polishing started. I was devastated, but as I looked around I noticed that no one else even blinked an eye. That day I learned that glass breaks, and also that it can be recycled. But much mystery remains with the material, much yet to be explored.

The glass industry has had several decades of innovative product development that have resulted in significant improvements in areas of solar and thermal performance, yet energy considerations continue to pressure the extensive use of glass in the building skin. Do you ultimately anticipate a general reduction in the window-to-wall ratio (WWR) in buildings?

I think there will definitely be a reduction in the WWR. It will not have an immediate effect, as glass is still among the cheapest materials to be used on a facade. Energy remains cheap in areas like the United States and Middle East, mitigating the push towards greater efficiency. This is especially important with tall buildings. Nonetheless, energy consumption is a major concern of the building sector, with widespread impacts that affect us all. The environment requires more care than we give it.

Reduction of WWR takes you back to vernacular architecture. Traditional or vernacular architecture shows us how much we can learn from the past, a time when efficient mechanical systems were not available. Breathing buildings are something of a trend today, but they have always been there. Orientation and ventilation are two important factors to take into account to reduce the WWR. Contemporary ventilated facades are not as common in the United States as they are in other parts of the world, particularly Europe.

What are your thoughts on non-energy problems, like the limited durability of insulated glass unit (IGU) products, and the fact that post-consumer architectural glass is not recycled?

Durability is always a major concern, not just for glass and their products, but also for the building itself. The glass industry and all other building supply industries have made great efforts to improve the longevity of their materials. No material has unlimited durability, and that is a fact that we have to live with. It has been shown that IGUs endure longer than expected. Poor manufacturing process reduce IGU durability. There are many examples of quality IGU products in service for far longer than expected. Sealants have improved, but there has been little development in the basic seal strategy, nothing in the way of viable alternatives. Vacuum IGUs are a future trend, but still in the very early stages of development.

Glass is one of the easiest and most effective materials to recycle, yet

architectural glass may be one of the least recycled post-consumer products in the building industry. The cost of recycling the glass on a facade reclad or retrofit project is so labor intensive and expensive that few building owners can justify the cost. Economic considerations drive the building industry, and without some form of incentives in place, building developers are unlikely to embrace recycling practices with architectural glass products. It is also a matter of education and social consciousness that the value of recycling practices is recognized, that recycling becomes a profitable trend in the medium and long term because society is willing to pay for it. Europe is generally more conscious about recycling than the United States.

Triple glazing has become relatively common in many parts of Europe, with competitive, high-quality products available from multiple suppliers. In contrast, the uptake in North America has been quite slow. To what do you attribute this, and how do you expect this to play out in the future? Do you expect demand to ultimately increase in North America?

Triple glazing is close to a commodity product with widespread application in northern European countries, where there is an elevated consciousness about energy saving and environmental protection. These countries have long been energy dependent, with high energy prices, and have sought to develop solutions to reduce operating cost. Triple glazing has been widely adopted in the residential market, but less so in the commercial market. Some unexpected problems have occurred with the use of these products, which has tempered some of the initial enthusiasm about striving



PROJECTS SUCH AS THE CUBE BY ALFONSO MILLANES MATO IN MADRID UTILIZE HIGH-END GLAZING TECHNOLOGIES FOR LOW ENERGY TRANSMITTANCE, THERMAL INSULATION AND HIGH TRANSPARENCY.

for a better performing wall. Triple glazing may be more of a trend or fashion than a real asset in better performing buildings. Again, energy remains too cheap in the United States compared to other geographical areas with similar climates. The widespread adoption of triple glazing must be implemented through new standards, code requirements and incentives, or the demand for triple glazing is unlikely to increase.

What can you tell us about the future of glass in architecture?

What do you see ten years out in terms of glass products and their use in the building skin?

Glass is a material with a bright future in the building skin, as at present there is no comparable material, nothing even close. There have been efforts by the transparent polymer industry to make inroads into the architectural glass market with little success to date. There are too many problems yet to be solved with polymers before these materials can compete with glass. So, glass will remain a primary product in the building facade into the foreseeable future. There remain a lot of opportunities for

growth through new product development with architectural glass, but the investments required are expensive.

I think that the glass industry must continue the hard work of developing higher performing products, as well as process improvements like recycling. Thermal performance is a key focus. Photochromic products are viable for the future, but still in very early stages of development. Thermochromic properties are another interesting possibility, or various combinations of these dynamic behaviors. New coatings are needed for use on laminated glass. Vacuum insulated glass requires much development before an affordable product can be put into the market, but it holds potential as a game-changer. Glass is heavy, a factor that limits its use in some applications. Vacuum products hold the potential to improve the performance-to-weight characteristics of glass products.

The Sustainable Design Challenge: Providing Healthy, Comfortable & Energy Efficient Buildings

Helen Sanders, PhD.

Vice President of Technical Business Development at SAGE Electrochromics, Inc.

There is now indisputable evidence of the positive benefits of access to daylight on human health and well-being [1]. Access to daylight has been shown to significantly improve productivity and reduce absenteeism in office settings, increase student achievement in schools, and increase healing rates in healthcare environments [1]. Over the past decade it has become clear that the human eye is not just for “seeing”. It is designed to “use” light to control many of the body’s important functions. In fact, light processed by the eye is used to trigger the activity of more than 50% of our genes, and is key to many of the body’s circadian driven functions, especially hormone production, the immune system and metabolic processes. Disruption to circadian rhythms can have a significant impact on human health, so much so that night shift workers who suffer significantly from body clock disruption have a significantly higher risk of hormonal cancers, mental health disorders and obesity [2].

According to Deborah Burnett of Benya Burnett Consultancy, a leader in epigenetics, daylight is a drug critical for human health, and nature is the “dispensing physician.” Nature provides the ideal dose (intensity of light) of the right type (wavelength) at the right time of day [3]. Exposure to daylight has also been correlated to quantity and quality of sleep [4]. Studies have shown that those with little access to daylight have insufficient sleep and suffer from higher rates of depression. The combination of lack of sleep and misaligned circadian rhythms can result in fatigue, poor performance and safety issues in the work place, and in the long term can cause diseases and impaired cognitive function. It is no wonder that studies are showing the link between exposure to daylight (and darkness) at the right times of the day and improved productivity and well-being.

It turns out that views to the outdoors may be even more important for human health than daylight (although hard to separate). In fact, views of nature have been shown to reduce stress levels and improve mood [5]. The World Health Organization says that mental health disorders will be

the number two illness worldwide by 2020, and stress can be a major contributor [6]. Based on all the evidence, providing views of nature and access to daylight within the built environment would therefore seem to be a critical design factor.

Twenty generations ago we spent most of our waking hours outside, and we were very much in tune with the day’s light/dark cycle. The proven human need for daylight and views of nature underscores that even after thousands of years of evolution, we are still outdoor animals. However, today we spend more than 90% of our time indoors and in environments that, because of cheap electric lighting and our ability to construct larger, deeper buildings, have increasingly isolated us from these critical needs. Nick Baker of the University of Cambridge calls the buildings of the late 20th century “the dark ages of fluorescent lighting”. Moreover, the 300-500 lux design points of electric lighting systems which have been designed first and foremost for task illumination, is not sufficient to trigger a circadian response in humans. Much higher intensity levels (1000s of lux) are required to create a non-optical response in the eye.

This indicates that the standards and priorities of lighting design should be adjusted to meet the needs of the human: non-optical physiological needs for light, as well as the simpler requisite to see what you are doing.

In recognition of the growing evidence, there has been a movement in recent years to increase the availability of daylight in buildings through market-leading standards such as the U.S. Green Building Council’s (USGBC) Leadership in Energy and Environmental Design (LEED) rating program, the International Green Construction Code (IgCC), and ASHRAE’s Standard 189.1. These standards require a certain level of daylight admission and views to the outside. Providing sufficient daylight to meet these criteria creates a significant challenge when balancing the competing needs of energy efficiency and occupant thermal and visual comfort.

The provision of more glazed area to provide daylight and views usually comes with unintended consequences for occupants in the form of thermal and visual discomfort. This is often due to the fact that the solar heat and glare that accompanies daylight are not effectively managed — primarily because the conventional static building envelope can’t respond to the ever-changing exterior environment. For example, a number of LEED-certified buildings, while theoretically providing good access to views, in practice have been shown to have no better energy performance than non LEED-certified buildings. With large expanses of glass, they also have the potential to cause significant thermal and visual discomfort if there is insufficient solar control and no planned dynamic response



FIG. 1: WHILE MANUAL BLINDS ARE USED TO CONTROL GLARE, THEY ARE OFTEN LEFT DRAWN LONG AFTER THE GLARE CONDITION HAS PASSED, NEGATING THE BENEFITS OF DAYLIGHT AND VIEW.

for glare. In fact, studies have shown that the presence of glare and thermal discomfort completely negates any of the positive benefits of daylight and views [7, 8]. Even if manual blinds are used to control the glare, they tend to be left down long after the glare condition has passed, blocking views and daylight admission, and negating the positive benefits of the window. You only have to walk down the street in any city and look at the buildings around you to understand the extent of the issue with using manual blinds on the inability to provide building occupants with good daylight and views (Fig. 1).

The challenge for designers is to manage heat gain and glare in a building where the exterior environment is dynamic, with the sun position and exterior illumination changing hour by hour, day by day, and month by month, and to do so without obstructing the intended views, admitting sufficient daylight to deliver the desired health benefits for occupants, as well as superior energy performance. Electrochromic (EC) glazing has the ability provide such a solution because of the ability

to tune its visible light transmission (VLT) and solar heat gain coefficient (SHGC) in response to the external environment and/or occupant needs. In this way, heat gains and glare can be controlled, as needed, while the view through the window is maintained continuously. The wide dynamic range of EC glass (60 to 1% visible light transmission and 0.41 to 0.09 solar heat gain coefficient) provides architects with unprecedented performance and the ability to use more glass, creating daylight spaces without compromising either energy performance or occupant comfort (Fig. 2).

The ability to tint the glass down to 1%T is crucial to delivering the needed glare control (such that blinds can be eliminated), and by using automated control the glass is un-tinted to admit more daylight when the glare condition has passed. Just like more open weave shade material, dynamic glass with transmissions of 3%T or even 2%T is not sufficient to control direct sunlight glare [9, 10].

In addition to downsizing HVAC systems by reducing peak loads as

well as overall energy use, EC glass can also enable the adoption of more efficient and more comfortable heating and cooling systems, such as radiant heating, cooling and chilled beam systems.

The current generation of EC glass provides even more freedom to architects through improved color aesthetics and choices to complement various design schemes. The first generation of EC products on clear glass have a green/yellow/red exterior aesthetic, whereas the new generation has an attractive, slightly reflective blue-green aesthetic that complements a number of the standard low-e and solar control products available (Fig. 3). Moreover, additional color choices are available, such as green, blue, gray or bronze to provide more architectural design freedom.

As EC glass size availability has increased to provide panes that extend fully from floor to ceiling without mullions (5'x10'), the ability to segment the pane into up to three independently controllable zones has become essential to ensuring the

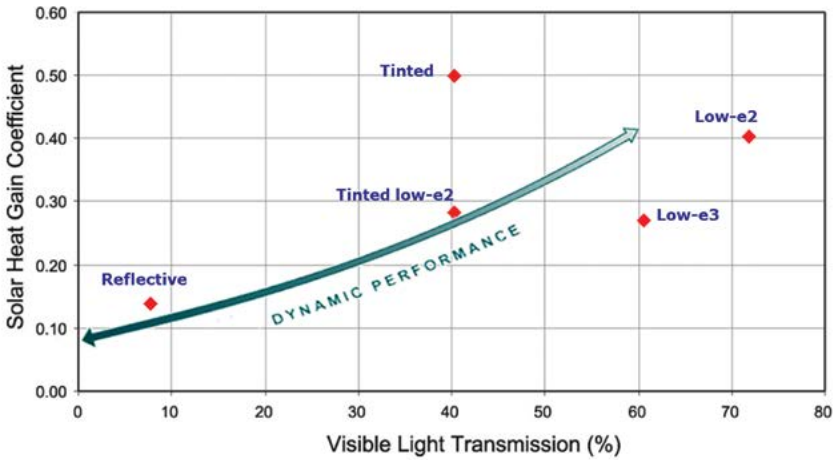


FIG. 2: EC GLASS PERFORMANCE COMPARED TO STATIC PRODUCTS.

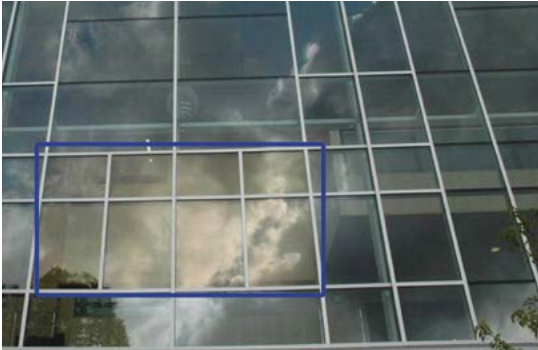


FIG. 3A: GENERATION 1 EC GLASS WITH YELLOW/GREEN/RED AESTHETIC (INSIDE THE BOX) WITH TYPICAL LOW-E AND BLUE REFLECTION ELSEWHERE ON THE FACADE.



FIG. 3B: GENERATION 2 EC GLASS WITH IMPROVED BLUE/GREEN EXTERIOR AESTHETIC, MORE TYPICAL OF LOW-E GLASS PRODUCT.

optimum balance between controlling glare (1% visible light transmission required), achieving sufficient daylight admission, light color quality, and energy performance (Fig. 4).

For example, if the whole pane from floor to ceiling had to be tinted to 1% visible light transmission to control direct sunlight glare, the interior space would be too dark, and the light color rendition would be too blue. If a small amount of the EC glass (~10-15%) is held in the clear state a neutral light color rendering can be achieved even if the remainder of the glass is fully tinted. For this reason it is very important to zone the EC glass appropriately to achieve the desired occupant comfort.

Electrochromic glazing has a surprisingly long track record in construction window markets, with a proven 12-year history and installations dating back to 2003. With the availability of larger sizes, higher volumes, improved exterior color aesthetics, non-rectangular shapes, wirelessly powered and controlled products for retrofit applications, and enhanced daylight management features, architects are finding it increasingly easy to design with. The photographs in figures 5 and 6 illustrate the scale of buildings now being glazed with dynamic glazing technology, and the



FIG. 4: EXAMPLE OF IN-PANE ZONING OF EC GLASS, WHICH IS NECESSARY TO APPROPRIATELY BALANCE THE COMPETING NEEDS OF GLARE CONTROL, DAYLIGHT ADMISSION, ENERGY PERFORMANCE, AND LIGHT COLOR QUALITY.



FIG. 5: A LARGE-SCALE INSTALLATION OF EC GLAZING AT BUTLER COUNTY HEALTH CARE CENTER IN DAVID CITY, NEBRASKA. THE APPLICATION FEATURES A COMPLEX CURVED FACADE WITH GLAZING SLOPED OUTWARDS. THE ARCHITECTS CHOSE EC GLAZING BECAUSE OF ITS ABILITY TO CONTROL HEAT AND LIGHT, AND ITS ABILITY TO MAINTAIN VIEWS OF NATURE FOR PATIENTS IN THE REHABILITATION CENTER. PHOTO COURTESY OF DAUBMAN PHOTOGRAPHY.



FIG. 6: A LARGE-SCALE INSTALLATION OF TRIANGULAR-SHAPED EC GLAZING AT THE FROST SCHOOL OF MUSIC IN MIAMI. NOTE THE ARCHITECTURALLY FAVOURED BLUE EXTERIOR REFLECTED COLOR. PHOTO COURTESY OF MORIS MORENO.

enhanced exterior aesthetics that can now be achieved.

Architects and owners are choosing dynamic glazing solutions because of the design freedom it gives them in applications ranging from schools and colleges to office and healthcare applications, and beyond. By providing flexibility in using more glass, even on the more challenging east and west orientations, architects have more freedom to design with glass, yet still meet the challenge of designing a well day-lit, comfortable and healthy building that does not compromise energy performance. Given the imperative to reduce our impact on the planet and make our buildings healthy places in which to live and work, providing solutions to this challenge has huge significance.

References

- [1] "Health, Wellbeing and Productivity in Offices," World GBC Report 2014.
- [2] P. Bhatti et al. (2013). "Nightshift Work and Risk of Ovarian Cancer," *Occup. Environ. Med.* 2013;70:231-237.
- [3] Deborah Burnett, Benya Burnett Consulting, "First Do No Harm: Practicing Lighting Design or Medicine...", Presentation given at VELUX Daylighting Symposium, London, 2015.
- [4] Arne Lowden, Stockholm University, "Daylight Exposure in Relation to Sleep, Wakefulness and Health", VELUX Daylighting Symposium, London, 2015.
- [5] The Economics of Biophilia: Why Designing With Nature in Mind Makes Financial Sense (2012). Terrapin Bright Green LLC.
- [6] http://www.who.int/mental_health/advocacy/en/Call_for_Action_MoH_Intro.pdf
- [7] Heschong Mahone Group (2003), "Windows and Offices: A Study of Worker Performance and the Indoor Environment" (technical report) for California Energy Commission.
- [8] O. Seppanen et al., "Effect of Temperature on Task Performance in Office Environment," LBNL report 60946.
- [9] CEC-500-2006-052 Advancement of EC windows, PIER Final Project Report, April 2006 by LBNL
- [10] DETAIL Green, 2014, 1; John Mardaljevic et al, Electrochromic Glazing: Properties and Design Guidelines.

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High Performance, Sustainable Building Facades

Stephen Selkowitz

Senior Advisor at Lawrence Berkeley National Laboratory

"You can't always get what you want. But if you try sometimes, well you might find, you get what you need." – The Rolling Stones

The design of building envelopes and glazed facades is intrinsically a compromise between the tensions that drive conflicting goals and functions: view, daylight, comfort, structural integrity, aesthetics, thermal performance, peak electric impact, energy and carbon use, air and water leakage, acoustics, security, and more. The "final" as-built solution is influenced by the skill of the design team in translating a concept into final design, by the ability of the supply chain to deliver products and systems that meet the designer's specs, and by the ability of contractors to faithfully execute the design. The experience of occupants in the space, and the resultant energy and environmental impacts, are then further influenced by the facility managers, and by the occupants themselves. Given this complex process, when comparing design intent to the measured performance of the occupied space behind the facade, it is not surprising to see and experience wide discrepancies between design promises and occupied realities.

While immediate effects may impact the comfort of an occupant or utility bill paid by an owner, the broader long term consequences of excessive energy use and carbon emissions are now widely understood as far more serious. The building sector is responsible for about 40% of all energy use and over 70% of all electricity, so any national, regional or local energy and carbon goal (e.g. reduce carbon emissions by 80% by 2050) must address the design and operations of our building stock. If we are not successful in meeting targets such as these, the adverse consequences of climate change are likely

to be even more costly and highly disruptive over the coming decades. While better buildings alone will not solve the problem, it is also true that without aggressively addressing building energy performance, the problem is unlikely to be solvable.

Glazed facades in large buildings represent both extraordinary challenges and enormous opportunities. Over the last 50 years, highly glazed facades have been the poster child for inefficient and uncomfortable building environments. That underlying notion continues today and drives prescriptive codes that seek to "protect" occupants and owners from discomfort and cost. But several decades of innovation, and the opportunity for new advances, provide the potential to negate that view and to produce facades that can outperform the best insulated walls in terms of energy efficiency and comfort. These may not be simple, cheap or easy to accomplish today, but they are technically possible, and that alone should encourage us to envision an alternate future for high performance, sustainable building facades. The challenge then shifts to motivating the desire for these solutions and ensuring that the skills, products and resources needed to achieve them are readily available across the building industry.

To further explore this argument, we frame the discussion on sustainable solutions for advanced facades around 12 issues, trends and opportunities.

1. "Zero Net Energy" or "Energy Plus" facades are technically feasible and can be key elements in the push

toward a carbon neutral building sector.

2. The underlying component technology for glazing, framing, shading and daylighting continues to provide higher performance enabling options (e.g. R10 IGUs), light redirecting coatings, electrochromic glass, and more.

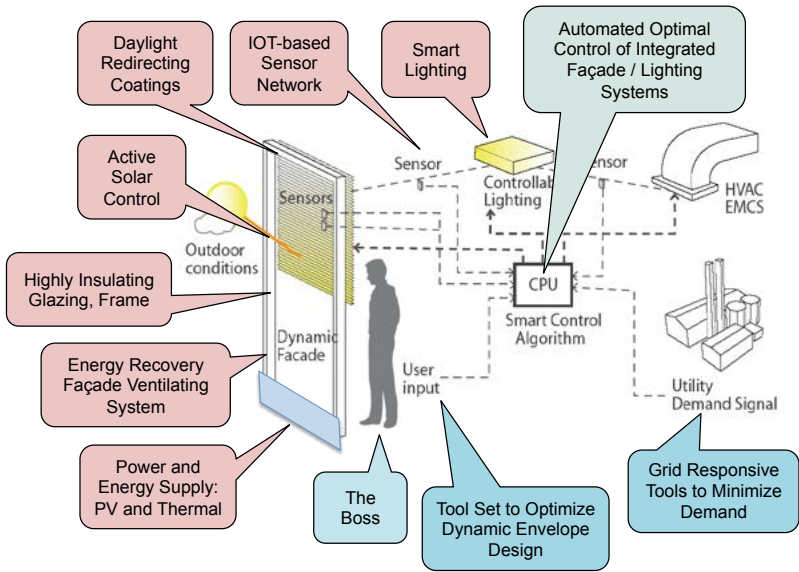
3. Facades are intrinsically "integrated systems" that address structure, life safety, weather tightness, view, appearance, and more. Within the "energy performance" realm, facades must also operate as integrated systems with respect to management of light, glare, solar gain, heat transfer, ventilation, power generation, energy storage, and more.

4. The view of the optimal building envelope as an "impenetrable barrier" should transition to the perspective of a "dynamic filter" admitting, rejecting and enhancing light, heat and energy flows based on occupant and building needs.

5. Integrated performance, as outlined above, must address both the "local" comfort and performance needs of the occupant living and working behind the facade as well as those of the building owner in terms of supplying reliable, efficient and cost effective support services.

6. Facade operation will begin to be influenced and/or optimized as part of a larger energy network by integrating power generated in the facade with local microgrids and larger scale systems to supply reliable, low carbon electric power.

7. Smart, dynamic, responsive controls for facades can be implemented via alternative pathways. Occupants can pull shades or activate coatings for solar control and glare management, turn lights off, and open



windows for ventilation. Alternatively, a new generation of sensors and actuators can “invisibly” determine and then implement “optimal control”.

8. The proliferation of these “smart” control solutions will cause more confusion and frustration in the short term (Do I need to call the building IT manager to lower my shades?). The “Beta vs VHS” challenge will be multiplied 100 fold unless the industry rapidly settles on open, interoperable protocols and standards to facilitate the implementation of low cost envelope/lighting/HVAC solutions that work out of the box. The “Internet of Things” is providing the low-cost technology and infrastructure to enable this — the building industry needs to get on board with appropriate protocols and standards.

9. Complex façade solutions do not spring fully formed from the minds of architects or engineers, but are conceived, nurtured, refined and implemented over long periods of time. The underlying data and design tools that support that process have been evolving rapidly, allowing degrees of virtual design and parametric exploration not envisioned only a decade ago. These tools now allow evaluation of some qualitative

aspects of performance in the design phase and begin to connect design to fabrication, assembly and operations.

10. Façade mockups should take on an expanded role to become “performance mockups.” On larger projects visual mockups are built to test “appearance,” and air/water/structural testing may be done. Numerous issues can be resolved while still in design by outdoor performance mockups that focus on technology integration issues under real climate conditions, occupant comfort assessment, and more. New test facilities, like FLEXLAB, make this approach more practical and affordable.

11. Elegant designs and platinum ratings make good press, but measured performance is a better indicator of real achievement. Outcome based codes, city and statewide disclosure laws, owner demand for performance guarantees are all trends that are spreading rapidly. Once energy and comfort expectations for overall building performance are created, they will migrate to the major building systems like façades. The façade industry ought to be thinking ahead about these operational performance issues.

12. Innovation is a driver in manufactured products (e.g. electronics, automotive, appliances, aircraft), and there are new businesses and collaboration mechanisms to drive these innovation processes. Progress appears to be much slower in the building sector — what can be stolen and adapted to accelerate progress, and what new frameworks, programs and initiatives might be implemented to address this need?

Epidermis / Hypothalamus

Peter Simmonds

Managing Director/Principal at Building and Systems Analytics

Exploring the design potentials of the building envelope as a factor controlling occupant thermal comfort for tall, supertall, and megatall buildings is a subject of paramount relevance.

In contemporary architectural discourse, the importance of the exterior wall systems is both environmental and cultural. The traditional function of protecting occupants from the elements has been enriched by a better understanding of how to respond to the climatic challenges for each particular region, while each urban context demands respect for the unique local, cultural and construction traditions. But with tall buildings we have additional climatic challenges associated with temperature, humidity and wind velocities that vary with the buildings height. We have a different set of conditions for every 50-100m of vertical height. So for a 600m building we could have 12 different exterior climatic conditions, while for a 1000m building we may have 20 different climatic zones.

While many look at the facade as just a haute couture, the opportunity is to investigate the building enclosure system rather as an epidermis — the building skin — the mediator between inside and outside, and the body's major barrier against an inhospitable environment, but also a systemic layer organically integrated with the rest of the building body. The function of a hypothalamus - the sensory organ that controls an occupants perception of comfort, is influenced by the performance of the building epidermis. The ability to predict and control the dynamic performance of the systems, both passive and active, is evolving through an ongoing series of novel and inventive applications — such as the Harbin Bank Building in Beijing — and supported by the development of standards such as the revised ASHRAE Thermal Comfort standard.



IMAGE © SKIDMORE, OWINGS & MERRILL

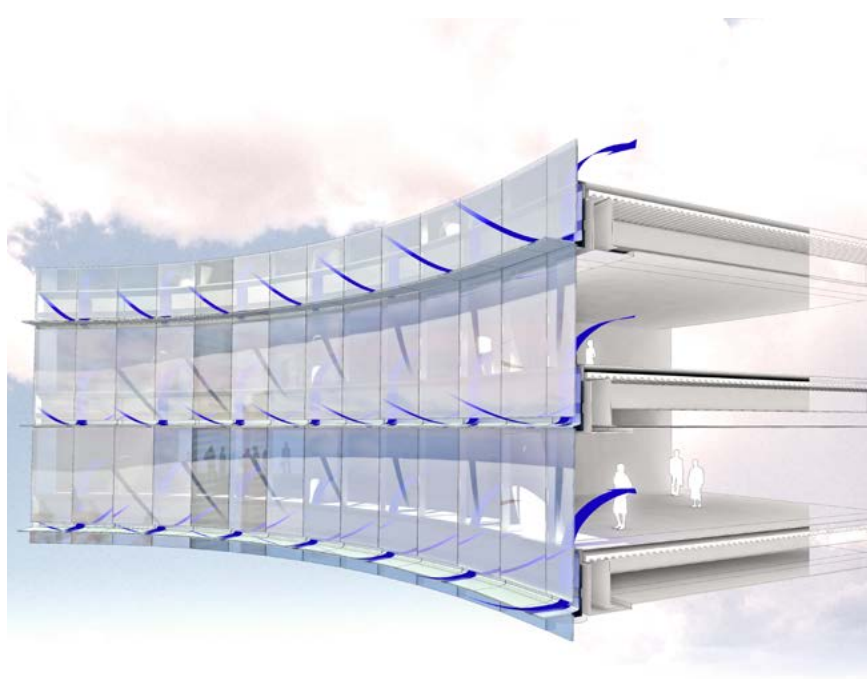


IMAGE © SKIDMORE, OWINGS & MERRILL

But it is not simply a matter of design. The design process of exterior systems is deeply influenced by the integration between design and building technologies, and emerging methods of project delivery are equal in importance to design innovation. A digitally integrated design-assist/build-build process that engages all parties involved in the design, construction and building management of a project from the beginning influences the entire life cycle performance of a building.

The design challenge is found in how building enclosure development balances requirements for energy preservation, ventilation, and daylight, while providing thermal and moisture protection appropriate to the specific climatic conditions of a site, all without compromising the uniqueness of the architectural intent. A compelling

question being addressed in recent high-performance enclosure applications, at projects such as the Phare Tower in Paris, is just how much intelligence must be integrated into a facade to provide this balance, thereby achieving optimal performance over an extended building life cycle that will see the buildings of today into the next century.

Optioneering an Integrated Solution

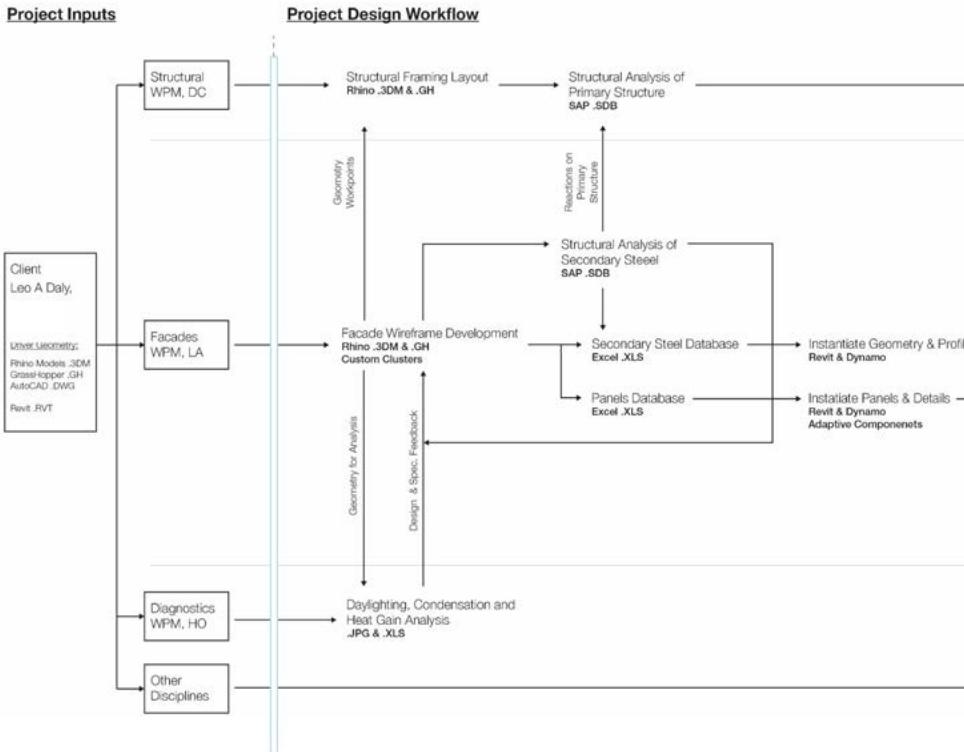
Sanjeev Tankha

Principal, Director of Facade Engineering at Walter P Moore

Building skins that integrate critical performance criteria such as structural, environmental, aesthetic, material, cost, fabrication and installation are generally known as high-performance facades. The building industry often views high-performance facades as expensive skins that typically do not have a reasonable return on investment, and thereby tends to value engineer these carefully crafted designs. This leads to uncomfortable discussions, overall team stress, and often the collapse of carefully crafted design intents. This scenario is repeated on project after project, much to the dismay of owners and architects. This process — value stripping to save cost — can be avoided by utilizing the process of optioneering.

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Workflow diagram



AN EXAMPLE MULTI-DISCIPLINARY WORK FLOW CHART DESIGNED TO DELIVER INTEGRATED SOLUTIONS.

value engineer these carefully crafted designs. This leads to uncomfortable discussions, overall team stress, and often the collapse of carefully crafted design intents. This scenario is repeated on project after project, much to the dismay of owners and architects. This process — value stripping to save cost — can be avoided by utilizing the process of optioneering.

For our projects at Walter P Moore, we strive to use a multi-disciplinary design approach where the architect, structural engineer, facade engineer, and mechanical engineer all use a common integrated workflow to derive appropriate solutions. This holistic approach to performance-based design leads to optimized skins with integrated environmental systems, reformed structural systems, and architectural design criteria's fully integrated into final designs.

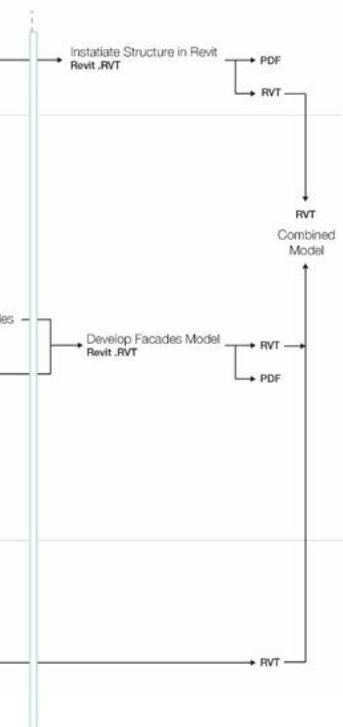
Optioneering is collaborative, freeing the design team to explore, iterate and arrive at a logical performance based solution for any project. The optioneering process looks at an integrated holistic building solution, is design performance centric, and has construction and fabrication intelligence built in. One of the key elements is that it is utilized early on, allowing for detailed development and construction later without the value engineering process unraveling the project.

To achieve this complex integration of a performance-based design solution, we utilize the digital platform and a digital toolbox. The digital process is highly data centric and provides the opportunity to iterate and generate feedback loops for informed decision making. It allows for integrated performance-based design in a very powerful way. Using this platform allows the design team to have a much more interactive, engaged, effective and robust impact on solutions, engineering and performance embedded into the design.

Why does optioneering and integrated solutions matter? The early optimization of engineering options provides the ability to visualize an engineered solution in real time, which then allows the freedom for designers to design and engineers to engineer towards a common goal.

The feedback loops of the digital workflow allow iterative and incremental development at a very fast pace. This inevitably leads to the right solution — the appropriate solution — a performance based building skin that is finely tuned to all aspects of the design parameters: structure, environment, aesthetics, cost, fabrication and construction. Optioneered performance solutions are linked multi-dimensionally and responsive to complex building requirements. They embody engineering principals, performance values, and aesthetic decisions that are cost effective and optimized.

Project Documentation & Delivery



More (and More): Architects and Environmentalists Alike Require More From Glazing Manufacturers

Christoph Timm

Associate Director at Skidmore, Owings & Merrill

Facade Tectonics interviews Christoph Timm, associate director at Skidmore, Owings & Merrill's New York office, about the current state of glass manufacturing and technology.

You've made aggressive challenges to the glass industry in past addresses regarding size limitations, distortion and technologies, in addition to performance issues such as thermal and acoustic insulation. Has the industry responded?

It certainly feels like the industry has responded to some. For example, I hear from many sources that bigger glass dimensions are available, or will soon be on a more widespread basis. This includes float manufacturers as well as downstream glass processing companies. Even offshore markets are beginning to produce jumbo sizes locally, which we find particularly intriguing.

Another area I see a lot of movement in is the chemical tempering process to strengthen glass. Available bath sizes are getting bigger everywhere, and I'd imagine architectural companies are specifying its use more and more often – we certainly are. One of the reasons for this is the supreme optical quality that chemically strengthened glass has compared to heat-treated glass. Another is the increased use of hot-bent glass that traditionally has limitations when it comes to the heat-treating of more complex shapes. Chemical strengthening can also come in handy in these applications.

A third example of the industry really progressing is the effort to reduce quench marks. Standardizing quench marks is being discussed, and new offline technology is already available to allow for objective quantification. This emerging technology of quenchmark quantification needs to

be brought on line so that continuous quality control can be executed. New heat-treating technology with air glass floatation has been developed, and will hopefully be widely implemented by glass processors over time. The design community must continue to demand equipment improvement and standardization in line with the overarching effort of improving the aesthetic quality of glass on buildings.

There are still ongoing quality, performance and aesthetic issues that need to be addressed.

It's hard for me to believe that argon retention inside an IGU is such a difficult subject. We need insulation improvement in glass products if we want to continue their widespread use in the building skin. Such use must be accompanied by energy use reductions.

Why do we still need to edge delete a lot of coatings?

The intimate knowledge of glass processing companies needs to progress. Heat strengthened laminated glass, for example, can be edge polished after lamination per ASTM if the manufacturer recommends this. Unfortunately, in reality, it is difficult to find a processor that is willing to edge polish laminated heat strengthened glass and make an exposed edge really beautiful with this post-lamination finish. More knowledge and experience on the processor's side could greatly contribute to the architect's strivings for beauty.

In regards to new products, or the refinement of products, I am impatiently awaiting improvements and wider spread market implementation

in the areas of BIPV, organic PV, and dynamic glass. I would also like to learn more about embodied energy and end of life recyclability of products we are using: can I recycle coated glass, for example? I have not yet heard a clear statement from the industry that this is possible, or if post-consumer recycling is being used on a regular basis.

The future will definitely bring more complex shapes to architecture. This is a trend that started over ten years ago, but is here to stay. The repertoire of form and shape of architecture that we see in the mainstream today encompasses a much wider range than 20 years ago. What was once cutting-edge and rare in regards to design will become more prevalent. More three-dimensional shapes in buildings will likely also mean more hot bent, laminated bent, and cold-bent glass applications.

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A World Class
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The Challenge: Enclosure systems influence the look and performance of a building more than any other system. Too often, performance considerations take a back seat to aesthetics. Just as importantly, supplier fragmentation and proprietary technology conspire to leave designers with a shortage of objective design information and ideas.

Our Solution: Walter P Moore offers a world-class team of experts to provide comprehensive enclosure engineering consultancy to our clients. Leveraging our expertise in structural engineering and building diagnostics, our enclosure engineering team assists designers with best-in-class and tailored advice on the design, detailing and procurement of today's complex facade systems.

Design and Deliverability of the Kingdom Tower's Building Facade

Peter Weismantle

*Director of Supertall Building Technology
at Adrian Smith + Gordon Gill Architecture*

On any architectural project, the exterior wall represents a significant portion of the total initial investment. In a supertall building like the 3,280 foot tall Kingdom Tower in Jeddah, Saudi Arabi, that cost can run upwards of one hundred million dollars. It follows that every client is interested in economy — something designers usually interpret as simplicity, efficiency and constructability. From the start of the 30-day design competition of Kingdom Tower in June 2009, it was agreed that there would be only one primary, unitized wall type on the tower, composed of flat, rectangular panels to maximize repeatability and minimize the number of panel type variations. Using these principles, the building massing was essentially finalized in a couple of days, and the wall, as it currently is configured, was essentially designed in the same amount of time.

The following Q&A discusses Peter Weismantle's experience on the Kingdom Tower.

What do you perceive as the dominant trends in building facade design and delivery?

It may not be so new anymore, but the application of modeling programs by the younger generation of designers has had a big impact on pushing designs to more indeterminate geometric forms. Although challenging geometry was not a major issue on Kingdom Tower, what became an issue was the fact that the original massing was established in Rhino, but the overall project was documented for construction in Revit. The interoperability of those two programs is somewhat tricky even today, let alone six years ago.

Although designed in only a couple of days, it took significantly longer to work out the actual details of the wall. Essential in that work was the application of THERM software, used for heat transfer modeling of the wall assembly. What it pointed out was that while we have seen a marked improvement in glass performance due to advances in coatings, inert gas fills and triple glazing, we have not seen the same level of improvements in the thermal performance of the unit

framing members. Of course we were dealing with temperature extremes in Jeddah, however, the impact of increasingly stringent

energy standards and green codes will require more detailed analysis at earlier stages in a projects development.

How is the link between material and fabrication process relevant to your design practice?

Without a level of understanding of material science and fabrication processes, designers will waste a significant amount of time designing a wall that is uneconomical, underperforming, or quite simply ugly. Starting with the principles of simplicity, efficiency and constructability, we were





disciplined enough to provide the client with economy, performance and beauty throughout the process.

What is the future of window-to-wall ratio (WWR) for the building skin?

As long as codes continue to allow for performance-based solutions, we will still see all-glass buildings. The drive for transparency in the building skin is not a new phenomenon, but leaps in technology have allowed for the development of structural glass facades, and larger and better performing glazing units. This drive is especially true in tall buildings. After all, why live in a high rise if you cannot relish the view? That was certainly a significant factor in the design of Kingdom Tower.

What is the relevance of bridging art and architecture? What are the challenges thereof?

A beautiful wall can also be a well performing wall. The problem is defining art as pertaining to aesthetics only.

Is aesthetics or performance the predominant driver in facade design today?

Aesthetics predominate without a doubt, however as architects we still must remain true to the three fundamental values outlined by Vitruvius 2,000 years ago: Firmness, Commodity and Delight.

Sponsors Lead the Way

What have you sponsored lately? What about your company?

There are many reasons to consider sponsorship, and many companies have discovered the powerful potential of sponsorship as a far more effective alternative to advertising. These include:

- highly targeted and efficient marketing
- raise brand awareness and recognition
- foster brand loyalty
- manage brand positioning
- create positive PR
- enhance credibility
- access to new contacts
- lead generation
- media exposure
- formation of new business partnerships
- tax deduction and write off

But let me add another reason for sponsorship: doing the right thing! Our industry has been negligent over the years in investing in R&D. Budgets are as tight as ever, meaning we continue to be tight-fisted with our marketing dollars. There is a great deal to be accomplished in the building facade industry, and individual companies within the context of fixed-price projects can only do so much of it. Funding collaborative research initiatives like those facilitated by Facade Tectonics is an excellent strategy to make your marketing investments provide greater value. The branding benefits alone can more than justify the investment, with the technical enhancement the icing on the cake.

We are selective in our sponsors. Our events are not pay-to-play proceedings like so many others. Our sponsors know that they are not necessarily best served by taking the speaker's podium themselves. They rely on us to engage speakers that will, in turn, engage our audience and our membership in the most meaningful manner.

Our sponsors are industry leaders, and this is another reason that sponsorship is so important; it's the dynamic of the push and pull in the marketplace. Our sponsors are leading the way to a resilient and sustainable built environment by developing and bringing to market products in support of this objective. In spite of the escalating pressure for higher performing buildings and facade systems, the industry continues a decades-long trend of pushing product solutions forward faster than the building profession can adopt them.

But we can't simply build this sponsorship base on the backs of fabricators and material suppliers. Sponsorship and membership, like the facades dialogue itself, must bridge the market segments of the profession, industry, academia, and ownership. Development, architecture and engineering firms must also step forward and engage at the deepest levels of mind and wallet.

We honor our sponsors. You will note that their individual contributions in this document with the rest of the practitioners and academics. Their voice is a vital and integral part of this dialogue.

Facade Tectonics expresses its most sincere thanks and deepest appreciation to our fabulous sponsors for their committed support of the Facade Tectonics host room at the CTBUH 2015 International Conference.

A handwritten signature in black ink, appearing to read 'Mic Patterson', with a long horizontal stroke extending to the right.

Mic Patterson
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