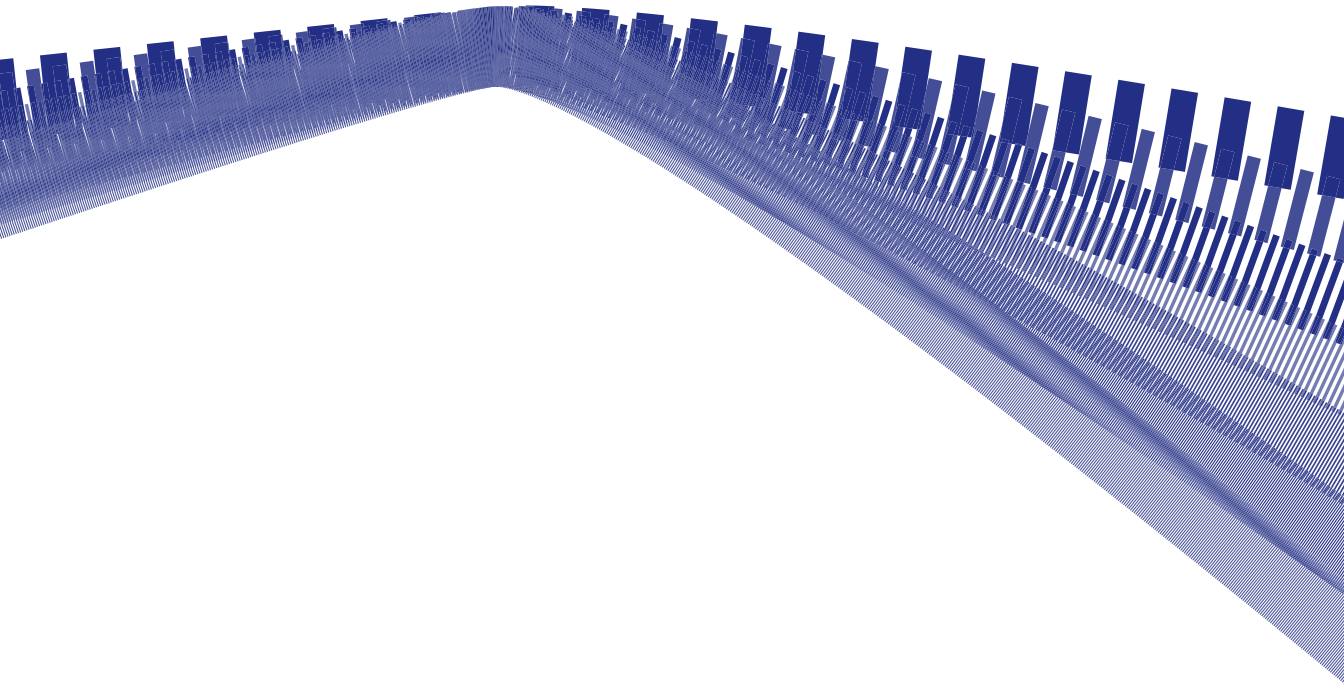
POST DUCTILITY

Metals in Architecture and Engineering

The Third Columbia Conference on Architecture, Engineering and Materials

September 30—October 2, 2009



1 glass 2 concrete 3 metal 4... plastic

The Columbia Conference on Architecture, Engineering and Materials explores the boundaries between architecture, engineering and materials science by mobilizing symposia, studios, exhibitions, books and films in an intensely focused investigation. Bringing together a wide range of leading architects, engineers and scholars, the Columbia Conference on Architecture, Engineering and Materials is a multi-year project to explore the dramatically changing limits of known and new materials in an era of rapid urbanization and within unprecedented forms of technical measurement, coordination and production that increasingly blur the boundaries of professions and of materials. Do contemporary means of structural and material analysis suggest a way of modeling material attributes such that analysis itself might produce a new material and new practices? Do new techniques create a virtual strain or quasi-alloy, leading to a new realm of coordinated material action and conceptual action? How is a new generation of professionals and manufactures fusing engineering and architectural practices, and how do new materials and material concepts change our professions?

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Professor, Escuela Técnica Superior de Arquitectura, Madrid

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Director of Industry Development, Steel Institute of New York; Ornamental Metal Institute of New York

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Chair and Professor, Department of Civil Engineering and Engineering Mechanics, Columbia University

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Mark Wigley
Dean, The Graduate School of Architecture, Planning and Preservation, Columbia University

Michael Bell
Professor, The Graduate School of Architecture, Planning and Preservation, Columbia University, Conference Chair

POST DUCTILITY
Metals in Architecture and Engineering

The Third Columbia Conference on Architecture, Engineering and Materials

The Graduate School of Architecture, Planning and Preservation

September 30, 2009: Keynote Lecture
October 1—2, 2009: Conference

CONVENED BY
The Graduate School of Architecture, Planning and Preservation, Columbia University
Mark Wigley, Dean
Michael Bell, Professor, Conference Chair

IN COLLABORATION WITH
The Fu Foundation School of Engineering and Applied Science, Department of Civil Engineering and Engineering Mechanics, Columbia University
Christian Meyer, Chair and Professor

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The Architect's Newspaper

The conference will be accompanied by the installation
METALSMYTHS
Rosana Rubio-Hernandez, Curator
Alejandro de Castro Mazarro, Assistant Curator
On display in Avery Hall, 200 Level, September 30—October 9

POST DUCTILITY
Metals in Architecture and Engineering

PREFACE: LIMITS OF CHANGE

Few concepts are as central in structural engineering as the ability of a material to sustain plastic deformation under tensile stress. The standardization of historically known deformation limits or ductile properties in most materials allows architects and engineers to keep the analysis of structure within known parameters of finite element analysis rather than materials science. If the material behavior is known, the statics equations for its organization are predictable. If the new material is new or the organization is unique, naturally, the risk is less clear, but it is rare for architects and engineers in practice to encounter new material performance quotients. If the goal is avoid fracture, the boundaries are set and the limits of ductility are observed.

Post ductility refers to the literal aspects of material behavior—in this case of metals—but also to aspects of architectural and urban space that are measured by less verifiable but nonetheless real quotients of stress. These include both aspects of plasticity that are common to architectural discourse for centuries such as concepts of the plastic arts, and also literally up to-the-minute entities such as sprawling cities that exceed historic limits of plastic or formal coherence. In both cases it is the reciprocity of tension and compression of space that provides form or gives coherence to form. In the case of engineering and quantifiable limits—or of architecture and cities and less quantifiable spatial limits—it is clear that formerly daunting degrees of risk often seem to have been diminished. New levels of sophistication in calculation seem to lower the risk tolerance for fracture in structural design, while more metaphoric readings of limits in architectural and urban space seem to have been long surpassed, at times with outright abandon. What does ductility mean today if you seek material or spatial limits; how do you measure limits and to what degree do historically stable measurements of ductility still enable spatial organizations in architecture, in engineering or in cities? Are there spatial innovations in new materials; have we charted the limits of known materials leaving architecture to find its significance in other realms?

PART 1: INDUSTRIAL CHANGE—IMAGINED AND REAL

During the first half of the 20th century real and imagined transformations in industrial capabilities and means had immense impacts on the aspirations of architecture and engineering, impacts that remain central today. The rationalization of construction processes, of techniques and standards—of labor and the subsets of professional practices and materials in building—reached levels of efficiency, analysis, control and subsequent spectacle that still persist as both empirically real and alternately imagined in scope. The elastic distance between the imaginary and the real has been the zone in which architectural and engineering aspirations are often founded; its qualities changing or motivated by way of received or even false memories of the past. The cleft is the zone of opportunity for much of where we innovate and actual material capacity is leveraged as much as an image of material capacity.

But the radical aspects of these changes have nonetheless reinforced the discrete or finite terms of architecture's and structural engineering's impact within social or economic realms. Architecture in this scenario causes change and then is left behind by it—or the material work manages a sustained new form of a-material social life in which architecture struggles or fails to take part. The terms of architectural and engineering practices themselves seem to have stayed within and have often reinforced disciplinary boundaries as rapid changes in the actual economics, geography, politics and media forms of contemporary life change. A key aspect of this divide remains significant today as we reengage and escalate both the real and imagined aspects of our technological and material aspirations, both in terms of the tools we use and the world in which our realized works are made. The wide range of computation, design and delivery means rapidly gaining use in practice (BIM, IPD, etc.) are linking localized small-scale practices across globalized sites: materials and practices, newly networked within architectural and engineering protocols, are reconceptualized and imagined, and are indeed newly "real" in what is literally and conceptually believed possible. In this regard the term *ductility* is an attribute of material limits, but also of material's conceptual and economic limits. The extensive diagram of materials and practices as sites and zones, as areas of engagement, is changed by pushing boundaries previously thought closed. Material in this regard is a component in a diagram of money, time and delivery. Perhaps more than an origin for engineering advances, this mode of material can be considered an immediate spatial engine as well as an extended form or potential.

If the site of today's architectural and engineering work is the latter-day *sprawling* world city, how does one construct a value for materials today? What is the ideal relation of engineering and architecture in this milieu? Is the city and its sprawling context an out-of-control economic (yet still material) engine that threatens the discrete terms of architectural and engineering practices, or does the city constitute a new form of material practice—a condition that is the source of new conceptions of material in which the gaps between the imagined and the real are the zones where a new form of urban life will emerge?

Is this a post-ductile era—one in which the elastic values of material are inextricably lost as determinant values? Is this a newly formed arena of dramatically new material limits and orchestrations in which the material work is to recover the logics; to decipher the mathematics of its allocation—to intuit the resulting space, the aftermath, of money and material and to testify to its potentials rather then diminish its damages?

PART 2: THE DISTRIBUTION OF METALS—BEYOND ARCHITECTURE AND BUILDING

For most of the 20th century the automobile industry in the United States deployed metals in greater quantities than were used by architecture and building. In terms of distribution, the use of steel in construction was highest between 1955 and 1965,

accounting for more than 25 percent of the total production. However, that still left approximately 75 percent to other industries. Today plastic production per capita in the United States exceeds that of steel. Metals are indeed still everywhere, but the architectural and engineering histories that sustained them and provide historical importance to metals have never fully engaged the real-time logics of finance and political action that sustained and gave rise to the work. The complexity of materials in historically important architectures is still an underexplored project if viewed in empirical terms. One could say that metals, and steel in particular, created modern space — if we are discussing spanning capabilities and indeed the urban distances and space of the postwar city. Yet these expansive tendencies are frequently portrayed as having inverse procedures that foreclose distances — that exact the tedium of daily life and instrumentally track or construct our behavior patterns. The physical limits of daily life are wide but frequently narrow in terms of how attention is parceled or how time is organized.

For practices in architecture and engineering a question that has become central is, how do we measure building arts and their material allocations against wider circumstances such as the allocation of material and its value in other industries? To what extent has the precise territorial equation of discrete measure been irreversibly changed today—such that the measure of statics, of components and the relationship of part to assembly are able to be located within the wider de-territorialized aspects of material trade, emerging economies and finance? These are not new questions, but as materials and development become inevitably global today, we must consider how our work addresses the manufacturers and the markets that capitalize them. In this realm is there a new form of frame, of structure, of enclosure—a new means of measurement? Or are these terms now malleable but not fundamentally changeable? Material is, of course, still everywhere and increasingly the barometer of its meaning is the absence of its limits or finite formations rather than its ductile properties or the logics of its engineering. Space is at times radically unconstructed and almost randomly produced at urban levels while its borders are just as often defined and driven by contravening social or economic constraints. There is a strong consensus that we are well into an era of increasing material and fabrication logics again; if so, what are the parameters and how do we construct the value of materials in the equations of practice, of urban space and of economic or social life?

As social life has been increasingly portrayed as untethered from the strife of immediate production — from city life's material density, from prewar factory life and labor relations — materials have not ceased to be a determining factor in the spatial or economic engine of urban or suburban life. Yet when conflated within wider urban worlds, the industrial production of commodities such as cars, domestic equipment and products merges with infrastructure such as freeways and bridges, and the limits of either material performance or coherent social space become impossible to calculate. The dimensions, and discrete form,

of professional practices fail to offer coherence to the wider experience of urban life. A measurement of raw steel as a benchmark commodity in the United States in relation to the gross national product shows a rapid and steady rise during the pre- and postwar era, even as it simultaneously registered a persistent decline as a percentage of the overall economy. From the very origins of steel production's massive run-up during and after World War II and until 1970, steel was actually declining as a benchmark commodity in the United States and in Europe. Steel and metal production grew but not within necessarily architectural terms — or within our professional arena — and not within the wider economy. How should we accommodate prewar histories of immediate and present material significance in design to postwar forms of urban and economic territories?

The efficiencies of construction and engineering that produced new forms of architectural and subsequently social space on the cusp of the 20th century operated within and were perhaps commensurate with the advances in economic production — efficiency in design was arguably on par with emerging forms of economic practices. In this realm material engineering innovations were often coupled with known forms of architectural language: a column, a beam, a wall, etc., sustained their nomenclature as they achieved new levels in spanning, in lightness, in speed of construction. The architectural elements maintained an operational value as they gained material and economic qualities. Yet the material science that lies behind these renewed elements seems to have rarely been correlated to the new forms of social space these innovations instigated. How do we look at these issues today: do the nomenclatures hold — are the architectural and engineering terms commensurate with the material processes, with the economics of global material practices?

Architectural and urban theory has persistently struggled to give material quality to the sprawling world of the postwar city, giving predominance to economic or social dimensions. From Tafuri to Koolhaas — post-Utopia to Junkspace — there has been at times what seems to be an abandonment of material value or material goals. Yet architectural nomenclatures survive today despite the massive transformations in the substrate of our practices. The result is a divide between what are imagined as capable material practices and what is witnessed as a debilitating, even reckless city that disallows material qualities in most building as it nonetheless consumes material in widening detritus. Does the divide circumvent a comprehension of often nonetheless deeply organized processes of urban space and of urban life? How do we construct material's value in this realm? What is the level of ambition, what is imagined versus what is real and where do we try to locate, or if necessary, create the boundary?

—Michael Bell, Conference Chair

WEDNESDAY
September 30

6:30—8:00 PM

WELCOMING REMARKS AND INTRODUCTION TO CONFERENCE

Mark Wigley
Dean, GSAPP, Columbia University

Gary Higbee
Director of Industrial Development
Steel Institute of New York; Ornamental
Metal Institute of New York

Louis Geschwinder
Vice President, Special Projects
American Institute of Steel
Construction

KEYNOTE LECTURE

José Rafael Moneo
Architect, Madrid,
and Professor, Graduate School
of Design, Harvard University

THURSDAY
October 1

10:00—10:30 AM

INTRODUCTION TO THE CONFERENCE

Mark Wigley
Dean, GSAPP, Columbia University

Christian Meyer
Chair and Professor,
Department of Civil Engineering
and Engineering Mechanics,
Columbia University

Michael Bell
Professor, GSAPP, Columbia University

10:30 AM—12:00 PM
12:00—1:30 PM

DUCTILITY: MATERIAL LIMITS AND TERRITORIES
BREAK

Ana Miljacki *moderator*
Professor, Department of Architecture, Massachusetts Institute of Technology

David Benjamin
Professor, GSAPP, Columbia University

Keith Kaseman
Professor, GSAPP, Columbia University

John Fernandez
Professor, Department of Architecture, Massachusetts Institute of Technology

Hilary Sample
Professor, School of Architecture, Yale University

Is a new generation changing the way material operates in the nexus of architectural production? How do you situate material, and in particular metals, in the range of territories that constitute their uses, production, value and life span? How do designers and engineers place material in the production, design and life cycle?

Metals, as surface or structure—as structural generators of space—play a role in nearly every strain of modernization in architecture, but they are also benchmark commodities that are central to labor and employment contexts before and after World War II. Metals define complete geographies of work, production and political life (Bethlehem Steel and Allentown, for example). Non-architectural metals delivered in automobiles, and hard goods (from AEG to General Electric to General Motors) in the United States and worldwide have all been sourced as the engines of the sprawling late-20th century city in all of its registrations and forms. But in the received aspects of architectural history, metals, and in particular steel, remain something more segregate and less diluted; they are presented as intrinsic to key terms of the profession. Metals as a material precede architectural concepts—they are instigators and carriers of architectural meaning.

The divide between what metals are as commodities and what they signify architecturally seems to be immense, but this imaginary is rapidly changing. As every material is increasingly seen as a component in a delivery and control chain, it is situated within a deeper set of organized techniques and seen less as an origin than as a conductor. Does the process replace the material's centrality in architecture and engineering, or diminish the component's significance as it replaces this with forms of production and performance?

By their nature, metals have differing limits of ductility, but they all inevitably recover more easily and with greater limits than other major building materials such as glass or concrete. Is ductility still an issue in your work and if so, how does the nature of material limits affect design? What aspects of your work exceed the nature of material limits or determine how you see material value as affecting your work? Is there an aspect that is essential to metals that has added qualities, such as ductility, in your work today? What replaces structural performance or what quality in metals does your work rely on, extend or demonstrate when performance at an immediate level is not the singular goal? How do you work with material limits and with aspects of material behavior? How does the material life cycle affect its meaning today?

1.5 AIA CES

1:30—3:00 PM

DISCRETE STRUCTURE: STEEL FRAME

Phillip Anzalone *moderator*
Professor, GSAPP, Columbia University

Christoph Kumpusch
Professor, Department of Architecture, Cornell University

Rory McGowan
Engineer, Arup, Beijing

Jesse Reiser
Professor, School of Architecture, Princeton University

Heiko Trumpf
Engineer, Werner Sobek Engineering and Design, Stuttgart

Nanako Umemoto
Professor, GSAPP, Columbia University

How does one discuss the significance of the steel structural frame today? How does your work conceive of structure in relation to framing, to surface, to enclosure—to other modes of efficiency and implementation; to new relations between structural framing and enclosure?

Architectural and engineering systems predicated in construction efficiencies have since the middle of the 19th century been founded in rationalized structural systems. Nomenclatures of structural frame and subset building systems such as curtain wall coordinate aspects of enclosure and volume to subsets of interior divisions—structure's essential mathematics forms a substrate against which smaller divisions are made. All of these systems have been modulated by varying degrees of detail and connection to structure, forming tributaries that lead back to the essential stable and grounding frame.

If metals, and steel in particular, have been conceptualized within architectural and economic metaphors of material strength, of factory strife and economic destiny, they also signify all manner of labor and legal aspects of economic equity. Yet it is the architectural metaphors and the facts of frame and enclosure—steel as structural frame and metals as surface enclosure—and curtain wall that have been predominant in architectural schools, and that to a large degree have been presented as free from wider constituencies. Frame and enclosure sustain a form of autonomy, despite their cultural histories, within a wide swath of architectural education. The frame here is usually segregate and neutral within social actions—it enables them but social aspects of building are presented as choreographed by other systems.

In the United States steel's architectural history is often geographically substantiated in Chicago architectural history—the late 19th-century "Chicago Frame"—but the true separation of surface and structure as pedagogically efficient and segregate has also suppressed the wider discussion of metals in the very economy that produced new office buildings, new curtain walls and new forms of assembly. The formation and subsequent rise of corollary economic machines prior to and during World War II redistributed metals on a global scale and introduced them to an indexical financial value that architectural histories have rarely dealt with. The material aspects of engineering and architecture, and in particular the ductile and static properties of metals, offer a discrete and workable repose against the wider liquidity and distributed nature of finance and aspects of construction indexed in buildings, cities, automobiles, etc. Measuring these matrices—the history of architecture and its local histories—against the mobility of materials and monies establishes territorial relations and in some sense exacerbates attempts to see construction in discrete terms. From the outset of steel's rapid rise in the 1940s, elastic limits have been set for metals within markets but also for labor and a deep investment in the value and sourcing of material within new financial territories and new methods of construction.

Has your work in structure been affected by wider changes in the social or urban aspects of where you work? The profession is increasingly engaged in broader and more reflexive forms of computation and management of construction. Do you find new directions or evolutions in the significance of structural framing today that renew the discourse of structural framing?

1.5 AIA CES

3:15—5:00 PM

STRUCTURE AND PROGRAM: CLEAR SPAN/LONG SPAN

Toshiko Mori *moderator*
Robert P. Hubbard Professor in the Practice of Architecture, Graduate School of Design, Harvard University

Lise Anne Couture
Professor, School of Architecture Yale University

Laurie Hawkinson
Professor, GSAPP, Columbia University

Ronald Mayes
Engineer, Simpson, Gumpertz & Heger, San Francisco

Galia Solomonoff
Professor, GSAPP, Columbia University

What are the significant innovations within clear-span or long-span structure in architecture and engineering today? What are the current conditions, tendencies and potentials of long-span and clear-span capacity in the architecture and engineering of metal structures? Do structural and spatial innovations still merge to create new social potential in architecture today as they have at key historical moments such as the design of Bibliothèque Sainte-Geneviève by Henri Labrouste (1834–50) or the Neue Nationalgalerie by Ludwig Mies van der Rohe (completed 1968)?

In clear-span or long-span structures varying degrees of integration between framing and enclosure means that volume, mass and structure are often unified and undivided. Structural engineering, in this realm, takes on social aspects of what could only incrementally be called architectural space. In long span or clear span structures a threshold is passed that indicates that space is fundamentally derived from engineering as much or more then architecture. Its social meaning is derived or understood within the tributaries of both fields but at a scale that was often virtually infrastructural. Within the evolution of metals and in particular of steel framing, the nature of a clear or long span structure has also been a continually evolving project in which spanning capacities reveal new functional potentials; new spaces that preceded use.

Is structure's relation to expansive forms of space and use still a driving factor in design today?

As either a pragmatic foundation, or a conceptual device, the structural frame segregate from and as a datum or foundation for space — not as closure or volume, but as its matrix — has often maintained a tight perimeter that keeps social aspects of use apart from overtly structural or material concerns. In the normative *modern* structural paradigm the structural frame holds the building up as non-load-bearing walls, and subsequent programming, affect social life and use. The stability of structure assures a datum for a segregate organization of social life — in this realm a concrete office building essentially functions as a steel office building would. As a subset of structure the social aspects of architectural space could occur as a concurrent or parallel project. In clear-span structures, or spaces where structure and space are synonymous, however, the degree to which social aspects of occupation were related to the very means of construction — to overt use of materials — meant that structure was a social entity. It was capable of instigating use. In other words, the social was overtly tied to material and to engineering, even as space was often cast wide open and made to seem a-material in its newfound expansiveness. Quasi-endless interiors made by clear-span systems fascinated architects and engineers, but also engendered counter movements and caused trepidation in other realms where the freedom became a source of anxiety.

To what degree have we often seen counteracting tendencies to the capacities of spatial and structural extension — toward new models of privacy, intimacy and interiority as antidotes to the tendencies of expansiveness in clear-span experiments? Are examples such as the cellular nature of space in the Whitney Museum galleries by Richard Gluckman (which created permanent rooms out of former office space in the otherwise open plan of the building) or the wide range of aedicular spaces common in postmodernism, or even within new forms of networked communities and communication? What are the technical aspects of clear-span today; what aspects of spatial specificity versus universality affect its organization today?

1.5 AIA CES

FRIDAY
October 2

9:30—11:00 AM

ENVIRONMENTS, AIR, OXIDATION: FINAL FINISH

Felicity Scott *moderator*
Professor, GSAPP, Columbia University

Anna Dyson
Professor, Rensselaer Polytechnic Institute

Mark Malekshahi
Engineer, Buro Happold

Jorge Otero-Pailos
Professor, GSAPP, Columbia University

George Wheeler
Professor, GSAPP, Columbia University

What role does oxidation play in the conceptualization of design? Are there advances in material such as Cor-ten® or changes in how we see a metal's stability in light of weather and change? What alternate meanings of reflectivity are critical in metals today?

The oxidation of metal occurs when the material loses electrons: the atoms of the metal move from a neutral state and become positively charged. The result is the formation of what we commonly call rust and what is routinely addressed as a fact of maintenance. The concept of decay in metals dramatically changed during the rise of Cor-ten® and other metals that controlled oxidation as a protective final finish. The visual result was a dulled surface — a darkened, rough patina. Cor-ten® allowed the temporal affects of weather to merge with the universal or timeless aspects of material in modernism. Coupled with landscape orientations in design by Roche and Dinkeloo, Cor-ten® was part of a naturalization of the modern office, and an invocation of weather in material maintenance.

Compared to architectural metals that were highly polished, or finished in work by Mies van der Rohe and others, Cor-ten® was a radical shift. In Mies's work, aspects of material, light and optics deeply affect the work's complex presence; the metals bridged retinal aspects of work in the visual arts by Man Ray and others where reflective materials were critical. Is it a mistake to see aspects of polished and highly reflective or refracting metals as contrary to the opacity of Cor-ten's® controlled oxidation? Rosalind Krauss describes a kind of opacity in the work of Duchamp as an "arrêt à la rétine" — a stopping of analytical process at the retina. The production of meaning is found in the interactions between the subject's nerve endings — the retinal aspects of the art instigate what is ultimately a physiological production of meaning. The optic aspects of reflectivity in the art are experienced as coordinated innervations of the retina; what Krauss called a "self-sufficient or autonomous realm of activity." Was Cor-ten's® matte, but still complex finish relatable to theories of surface and opacity in art? Was its chemical work a kind of optic work and far more intertwined with art than we have often imagined?

How are buildings understood environmentally today? Is there a visual effect of our contemporary capacities to control or manage thermal and environmental aspects of metals?

1.5 AIA CES

11:15 AM—12:30 PM

INFRASTRUCTURE OR ARCHITECTURE: STRUCTURAL PERFORMANCE AND ITS VISUAL QUALITIES

Christian Meyer *moderator*
Chair and Professor, Department of Civil Engineering and Engineering Mechanics, Columbia University

Kenneth Frampton
Ware Professor of Architecture, GSAPP, Columbia University

Steven Holl
Professor, GSAPP, Columbia University

Hans Schober
Engineer, Schlaich Bergermann & Partner, Stuttgart

Marwan Nader
Vice President, Project Director
T.Y. Lin International, San Francisco

Man-Chung Tang
Engineer, T.Y. Lin International
San Francisco

How does your work in structural engineering and control of forces change the end result in visual and social terms, safety, serviceability, and economy? Can you discuss the qualities of your work as they are affected by new technologies, in the design of repetitive versus unique structural components, in the control of production and on-site verification of performance?

New aspects engineering in the structural design of bridges has led to new crossover works and a new architectural aesthetics of infrastructure. Coupled with recently developed computational tools that have allowed high levels of customization in structural design without compromising essential requirements of serviceability and economy, we are seeing a wide range of new forms of infrastructure as new forms of quasi-architecture. The professions of engineering and architecture merge in unique ways as new means of structural analysis open new visual and aesthetic forms.

A case to consider is that of the cable-stayed bridge: the delicacy of the balance and the linear-planar control of forces reflect a mechanical invention that creates new forms of structure, but also new forms of visual monumentality. Unprecedented levels of precision in the routing of forces enable reductions in material weight in cable-stayed bridges: while the towers or pylons carry primarily compression loads the cables are arrayed in a way that essentially cantilevers the deck surfaces. The deck's ability to resist the horizontal components of the cable forces has the consequence of eliminating the need for heavy buttresses or anchorages. There are uncanny visual results as the historically expected visual mass of the suspension bridge's massive anchorage is absent: the structure resolves itself internally. The concrete deck acts as a prestressed element and the structural composition becomes a visual matrix of linear and planar elements. It is visually light—the taut cables replace the parabolic form used in the suspension bridge.

Does your work on structure engage design in new ways? Does your work in architecture engage structure in new ways, and are we seeing a new moment in the bridge-like structures that opens new social or cultural potentials?

1.5 AIA CES

2:00—3:15 PM

NEW METALS EQUAL NEW SPACE

Michael Bell *moderator*
Professor, GSAPP, Columbia University

Sanford Kwinter
Professor, Graduate School of Design, Harvard University

Theodore Prudon
Professor, GSAPP, Columbia University

Craig Schwitter
Engineer, Buro Happold, New York

Werner Sobek
Engineer, Werner Sobek Engineering and Design, Stuttgart

Does architecture have the capacity to instigate change in material science or is it bound to be a recipient of these changes? It is possible to detect in the early decades of the 20th century a coincidence of material being organized within previously unimagined matrices of engineering, industrial coordination, political and economic propensity and will. What is inherited from this era in regard to metals in architecture and engineering?

In the case of metals, what are the concepts that serve to outline the material for our work today? Is metal now simply one material among many in a leveled field; does it hold a central position as it might have with the work of Walter Gropius or Mies van der Rohe (as frame or curtain wall), or in work by Renzo Piano (as infrastructural scale or as cast components) or even Frank Gehry (as spline-based skin or shingle)?

Aspects of high modernism often are received as a story of rationalized or discrete production yet the steel and glass towers of this early period were never isolated from wider parameters. Political or social action could not be separated from material even as new forms of urban, social and financial life emerged that increasingly relied on dispersed and bucolic forms of suburbia and media-based modes of social life — forms of private life that insulated subjects from overt forms of production. Yet production, by many accounts, has permeated the postwar suburban sprawl as fully as it has the prewar city.

Prior to the end of World War II, the goal of full employment in a postwar United States was understood to require a dramatic rise in manufacturing and material exports. Metals were key to this equation at the heart of the expansion of the U.S. economy and its territorial expansion. At the Detroit Economic Club in 1944, then Secretary of the Treasury Henry Morgenthau pledged that the formation of the International Monetary Fund, as part of the Bretton-Woods Treaty, would secure for Detroit the exports needed to secure full employment after the war. Producing automobiles to meet that goal could only occur against a stable exchange rate between the United States and Europe. The World Bank and the International Monetary Fund, set into motion by the Bretton-Woods Treaty signed by forty-four nations, fueled a new urban landscape worldwide. Driven by the dual mechanisms of production and finance, material commodities were never to be understood as discrete again. As they found their way into buildings as much as automobiles and airplanes, and into consumer products worldwide, metals became distributed and complex commodities.[1]

Where in this explosion of growth are the known terms for our fields? The postwar city and its wildly expansive and often predicted collapse has usually been presented as having humiliated the local aspects of building, and material craft or control, but in this new moment of material logics, do we return to the real or imagined aspects of architectural and engineering history of engagement?

1. The percentage of consumption for the automotive and construction industries remained fairly similar over the course of the last century. Although there are high points in both industries—for example, in 1935, 25 percent of steel production in the U. S . went to the automotive industry and 14 percent to construction; while in 1958, 21.4 percent of steel went to automotive and 31 percent went to construction. Today the automotive industry's reliance on steel is smaller in comparison to global construction: 6 percent of steel now is used in the automotive industry, while approximately 74 million tons a year are used to make cars and light trucks. World steel production totals 1.3 billion tons.

1.5 AIA CES

3:30—5:00 PM

PRECIOUS METALS: ABSTRACTION AND RATIONALIZATION

Mabel Wilson *moderator*
Professor, GSAPP, Columbia University

Juan Herreros
Escuela Técnica Superior
de Arquitectura de Madrid

Sylvia Lavin
Professor, Department of
Architecture and Urban Design, UCLA

Paola Antonelli
Senior Curator, Department
of Architecture and Design,
Museum of Modern Art

Matthias Schuler
Engineer, TRANSSOLAR, Stuttgart

To what degree is the cleft between real and imagined, rational or abstract, material or a-material critical in architecture today? Do new material logics driven by computation diminish themes of abstraction in design via greater forms of computational control, and higher forms of engagement with production?

Metals have been both the epitome of the rational and pragmatic aspects of building as well as the denominator of modern architecture's more rarefied or a-material aspirations. The imagined terms of production and its broader territories and their impact on architecture during first half of the twentieth century frequently linked issues of rationalization with parallel themes of abstraction or programming and use. By seeking forms of structural and material rationalization that were simultaneously carriers of social change, or transcendental experience, the boundary that separated empirical work and less quantifiable imagined aspirations did not present a divide; indeed it was a constituent aspect of much of what still forms core educational values in architecture programs today. Is abstraction an aspect of modern conceptions of materials that seem less valued in the emerging aspects of material today; for example, in relation to contemporary digital controls, or the modeling and choreography of project delivery?

During the Bauhaus era the simultaneity of empirical work and transcendent aspirations allowed and perhaps even perpetuated a divide between what architecture and engineering may be capable of versus what its aspirations were. Today it seems we have entered a new realm of technical work in architecture and engineering that is decidedly less abstract in how it relates to broader issues of economy and money—of its place in the spectrum of building. Issues of speed in realization, not as leitmotif or zeitgeist of cultural experience, but as a denominator of management of monies, time and ultimately profits are common in architectural discourse today.

How have we constructed the imaginary and literal aspects of our work, and how does this revise what we have come to expect as standard appreciations and procedures for the role of materials in practice? From what basis do we engage materials today and how is our thinking still affected by the social and technical aspects of the previous centuries' origins—from all its vantages, whether quasi-religious, secular, mystical, technically based or socially driven?

In the writings of Mies van der Rohe, the drive toward the factual aspects of building is parallel with a renunciation of forms of mysticism; the search for a renewed form of the building arts in Mies's work is founded in an "enthusiasm for the immediately real." Yet Mies's work is based in an "understanding of life" as having "become more profound." Mies's iconic nickel-plated cruciform column and its optical qualities under light stand as both the figural and empirical signifier of a rationalized world yet it of course was famously abstract and even a-material. The column is demonstratively "real" even as its visual qualities and color give it a saturated sense of flow. Nickel is both hard and highly ductile—that hardness is as evident as the sense of flow is palpable.

How is the relation between abstraction or rationalization constructed today—or have these arguments been displaced by new relations between material and production—between function and use, between image and...?

1.5 AIA CES

5:00—6:00 PM

CONCLUDING DISCUSSION: ARCHITECTURAL SURFACE AND STRUCTURE TODAY

Mark Wigley
Dean, GSAPP, Columbia University

with

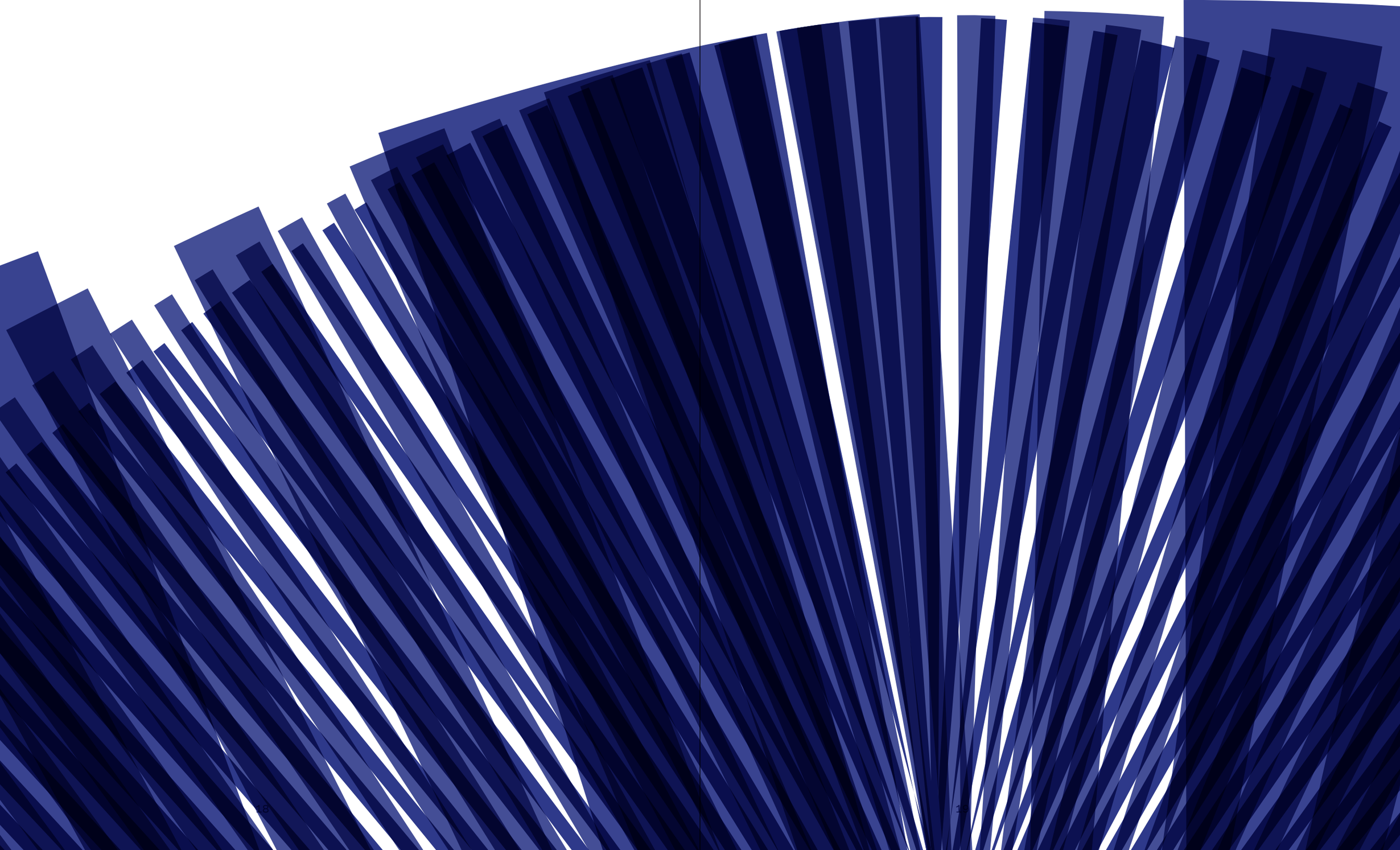
Werner Sobek
Engineer, Werner Sobek Engineering
and Design, Stuttgart

Steven Holl
Professor, GSAPP, Columbia University

Matthias Schuler
Engineer, TRANSSOLAR, Stuttgart

Is it possible today to create new terms that conflate surface and structure? Are these out of date terms? Are new concepts of materials and industry needed in order to reinvent the role of material aspects in design—in social life?

1.5 AIA CES



PARTICIPANTS

PAOLA ANTONELLI

Paola Antonelli is senior curator of architecture and design at The Museum of Modern Art in New York (MoMA) where she has worked since 1994. Before joining MoMA, she curated design and architecture exhibitions internationally and worked as a contributing editor for *Domus* magazine and as design editor of *Abitare*. She has lectured on design and architecture worldwide and her articles have appeared in publications ranging from *Seed* and *Nest* to *Harvard Design Magazine*. Antonelli is the author of a number of books, including *Workspheres* (2001), *Objects of Design from The Museum of Modern Art* (2003), *Humble Masterpieces* (2005) and *Design and the Elastic Mind* (2008).

PHILLIP ANZALONE

Phillip Anzalone is Director of the Building Technologies Sequence and the Avery Digital Fabrication Laboratory at Columbia University's Graduate School of Architecture, Planning and Preservation (GSAPP). As director, Anzalone leads research and curriculum related to applied and experimental building science and technology, digitally based design and fabrication and assembly techniques, as well as numerous creative constructed projects at GSAPP. He also teaches classes related to computer-based fabrication, building structures, advanced material studies, industry collaboration and architectural detailing and graduate-level design studios. Anzalone is a registered architect with experience as a curtain wall consultant for R.A. Heintges & Associates and an architectural designer with Greg Lynn FORM, and is currently a partner at Atelier Architecture 64, a firm with built projects in New York, San Francisco, France, the Netherlands and Korea. He holds an M.Arch from Columbia University and a B.P.S. degree in architecture from SUNY Buffalo.

MICHAEL BELL

Michael Bell is an architect practicing in New York and a Professor of Architecture at Columbia University's Graduate School of Architecture, Planning and Preservation (GSAPP) where he is director of the Master of Architecture Program Core Design Studios. Bell is also coordinator of the school's housing design studios and chairs the Columbia Conference on Architecture, Engineering and Materials; a GSAPP collaboration with The Fu Foundation School of Engineering and Applied Science.

Bell's architectural design work has been exhibited at The Museum of Modern Art, New York; The Venice Biennale, the Yale School of Architecture, the University Art Museum, Berkeley, and at Archilab, France. Bell has received four Progressive Architecture Awards and his work is also included in the permanent collection of the San Francisco Museum of Modern Art. His recently completed Binocular House is featured in Kenneth Frampton's *American Masterworks: Houses of the 20th and 21st Century* (2008). Books by Bell include *Solid States: Concrete in Transition* (2009); *Engineered Transparency: The Technical, Visual, and Spatial Effects of Glass* (2008); *16 Houses: Designing the Public's Private House* (2004); *Michael Bell: Space Replaces Us: Essays and Projects on the City* (2004) and *Slow Space* (1998).

Bell has taught at the University of California at Berkeley and Rice University, and been a visiting professor at Harvard University, Graduate School of Design and at the University of Michigan where he held the Saarinen Professorship in Architecture. Michael Bell Architecture was established in 1989 and specializes in housing and urban redevelopment where housing is a key component. In 2001 Bell led a team of architects who provided research, planning and design for 2,100 units of housing on a 100-acre parcel of oceanfront land owned by the New York Department of Housing Preservation and Development (NYHPD). The project was commissioned by the Architectural League of New York and the NYHPD as a research proposal to help shape city planning.

Bell is a partner in the design firm Visible Weather with Eunjeong Seong.

DAVID BENJAMIN

David Benjamin is Director of the Living Architecture Lab at Columbia University's Graduate School of Architecture, Planning and Preservation (GSAPP) and principal of the firm The Living. Recent projects include Living City (a platform for buildings to talk to one another), Amphibious Architecture (a cloud of light above the East and Bronx Rivers that changes according to conditions underwater), Living Light (a permanent pavilion in Seoul that displays air quality and collective interest in the environment) and Proof (a series of design studios at Columbia that explore testing as a design methodology and multi-objective optimization as a software technique). Benjamin received an M.Arch. from Columbia GSAPP, and a B.A. in Social Studies from Harvard University.

LISE ANNE COUTURE

Lise Anne Couture is a principal of Asymptote Architecture, the award-winning, New York-based practice that she co-founded with Hani Rashid in 1989. In 2004 Couture and Rashid were chosen as the design architects for the 9th International Venice Architecture Biennale and awarded the prestigious Frederick Kiesler Prize for Architecture and the Arts in recognition of exceptional contributions to the progress and merging of art and architecture.

Among Asymptote's recently completed projects are the Strata Tower, an innovative, forty-story residential tower, and a luxury hotel adjacent to the Formula 1 racetrack, both in Abu Dhabi, UAE; the award-winning HydraPier Pavilion in Haarlemmermeer, the Netherlands; the Guggenheim Virtual Museum; the New York Stock Exchange Advanced Trading Floor and the design and creation of new brand identities for clients such as BMW and Alessi. Asymptote's work has been widely published and exhibited and is included in various private and public collections, including The Museum of Modern Art in New York, the Pinakothek der Moderne in Munich, the San Francisco Museum of Modern Art, the Centre Pompidou in Paris and the Frac Centre in Orléans, France.

Lise Anne Couture is a visiting professor at the Yale School of Architecture and has held visiting professorships at Princeton University, Harvard University Graduate School of Design, the Southern California Institute of Architecture (SCI-Arc), the University of Virginia, l'Université de Montréal, the Berlage Institute in Amsterdam, the University of Michigan and MIT. Couture received an M.Arch from Yale University in 1986.

ANNA DYSON

Anna Dyson teaches design, technology and theory at the School of Architecture at Rensselaer Polytechnic Institute. She is Director of The Center for Architecture, Science and Ecology (CASE), which hosts the Graduate Program in Architectural Sciences, offering a concentration in Built Ecologies. Dyson has worked as a design architect and product designer in several offices in Canada, Europe and the United States. Her work has been exhibited in the MoMA Young Architects Series, and she was a finalist in the international Next Generation Design Competition.

Dyson holds multiple international patents for building systems inventions and is currently directing interdisciplinary research sponsored to develop new systems for on-site energy generation.

Dyson received a Baccalauréat Général from Université Laval and an M.Arch. from Yale University.

JOHN FERNANDEZ

John Fernandez has been a member of the faculty of the Department of Architecture at the Massachusetts Institute of Technology since 1999. His interests are related to the physical world: materials, resource flows, the built environment and the diverse discourse that ensues. He practices architecture in Boston and his work can be found in California, New York, Virginia and elsewhere. He is currently writing a book titled *Designing Urban Metabolism: Material Flows in a Resource-Constrained World* and is the author of *Material Architecture* (2005). Fernandez received an M.Arch. from Princeton University's School of Architecture after earning a BSAD degree from MIT.

KENNETH FRAMPTON

Kenneth Frampton trained as an architect at the Architectural Association School of Architecture, London. He has worked as an architect and as an architectural historian and critic in England, Israel and the United States. He is currently the Ware Professor of Architecture at the Graduate School of Architecture, Planning and Preservation at Columbia University, New York. His books include *Modern Architecture: a Critical History* (1980), *Modern Architecture and the Critical*

Present (1980), *Studies in Tectonic Culture* (1995), *American Masterworks* (1995), *Le Corbusier* (2002), *Labor, Work and Architecture* (2002) and the updated and expanded fourth edition of *Modern Architecture: A Critical History* (2007).

LOUIS GESCHWINDER
Louis Geschwinder is vice president of the American Institute of Steel Construction (AISC) and Professor Emeritus of Architectural Engineering at Pennsylvania State University. As vice president, he was responsible for the development of the standard specification for steel buildings, ANSI/AISC 360, as well as all technical activities of the Institute. He currently is working on special projects, including the development of a unified approach for all AISC education activities and several technical publications.

He received his bachelor's degree in building science from Rensselaer Polytechnic Institute and both his M.S. degree in architectural engineering and his Ph.D. in civil engineering from Pennsylvania State University. He is a registered professional engineer and was a faculty member at Penn State for more than 40 years where he taught and conducted research in building structures. He continues to teach in the architectural engineering program.

Geschwinder is past chairman of the Committee on Design of Steel Building Structures and the Committee on Metals and co-chair of the Tension Membrane Structures Standards Committee, of the Structural Engineering Institute of the American Society of Civil Engineers (SEI/ASCE). He is a member of the AISC Committee on Specifications, is Chair of its technical committee on Member Design, TC-4, and is a member of the editorial committee, TC-2.

LAURIE HAWKINSON
Laurie Hawkinson is a partner of Smith-Miller + Hawkinson Architects—a New York City-based architecture and urban planning firm. Projects include the expansion of the Corning Museum of Glass, the Wall Street Ferry Terminal at Pier 11, the Outdoor Cinema and Amphitheater at the North Carolina Museum of Art in Raleigh, North Carolina, and the firm was a finalist for the Olympic Village Design Competition sponsored by the NYC 2012 Olympic Committee. Currently the firm is designing the U.S. Land Ports of Entry at Champlain and Massena, New York, for the General Services Administration and recently completed a house in Sagaponack, New York. Laurie Hawkinson is Associate Professor at Columbia University's Graduate School of Architecture, Planning and Preservation.

JUAN HERREROS
Juan Herreros is Senior Professor and Head of the Thesis Program at the Escuela Técnica Superior de Arquitectura de Madrid. He has taught at Columbia University's Graduate School of Architecture, Planning and Preservation, the Ecole Polytechnique Fédérale de Lausanne, the Architectural Association in London, and the School of Architecture at Princeton University. He has conducted numerous lectures, courses, and international seminars as well as research workshops. In 1984, with Iñaki Abalos, he founded the Madrid-based practice Abalos & Herreros; in 1992 he established the Multimedia International League LMI; and in 2006 founded his current practice, Juan Herreros Arquitectos, which encompasses both professional and pedagogical activity. His work has been widely published and exhibited, and among his other theoretical books, *Tower & Office* (2003, in collaboration with Iñaki Abalos) remains preeminent as a primary resource for students and architects around the world. In 2008, Herreros was awarded the International Fellowship of the Royal Institute of British Architects and his office is currently working on projects in Spain, Norway, Panama and Mexico.

GARY HIGBEE
Since 2002, Gary Higbee has been director of industry development for the New York City-based Steel and the Ornamental Metal Institutes of New York, where he promotes the work of the institutes' 400 members to the architectural, engineering and building communities by conducting technical seminars and conferences, and by publishing the associations' magazine *Metals in Construction*. An architect by profession, he is an expert in building codes and serves as the governor's architect appointee on New York State's code-making council.

STEVEN HOLL
Steven Holl has realized cultural, civic, academic and residential projects both in the United States and internationally. Among the notable work produced by his firm, Steven Holl Architects, founded in 1976, are the Kiasma Museum of Contemporary Art in Helsinki, Finland (1998), Sarphatistraat Offices, Amsterdam (2000) and Chapel of St. Ignatius, Seattle, Washington (1997). Most recently completed are the Linked Hybrid mixed-use complex in Beijing, China (2009), the Knut Hamsun Center in Hamarøy, Norway (2009) and the Herning Center of the Arts in Herning, Denmark (2009). In June 2007 the highly acclaimed addition to The Nelson-Atkins Museum of Art in Kansas City, Missouri, opened to the public.

Recently the firm has won a number of international design competitions, including the Glasgow School of Art (Scotland), LM Harbor Gateway (Copenhagen, Denmark), Cité de l'Océan et du Surf (Biarritz, France; with Solange Fabião), Sail Hybrid (Knokke-Heist, Belgium), Meander (Helsinki, Finland) and Vanke Center (Shenzhen, China).

Steven Holl is Professor of Architecture in Columbia University's Graduate School of Architecture, Planning and Preservation. He has lectured and exhibited widely and has published numerous texts, including *Anchoring* (1989), *Parallax* (2000), *Idea and Phenomena* (2002), *Luminosity/Porosity* (2006), *House: Black Swan Theory* (2007) and *Architecture Spoken* (2007).

KEITH KASEMAN
Keith Kaseman received a B.S.D. degree in Architecture from Arizona State University in 1995 and an M.Arch. from Columbia University's Graduate School of Architecture, Planning and Preservation (GSAAP) in 2001. In June 2003, Keith and his partner, Julie Beckman, launched Kaseman Beckman Advanced Strategies (KBAS) upon having their scheme selected as the winning proposal in the Pentagon Memorial Design Competition. Currently based in Philadelphia, KBAS operates under the premise that, at its best, architecture stands as a cultural declaration of collaborative intelligence. Keith is an adjunct associate professor of architecture at Columbia University's GSAPP, where he lends his expertise to both advanced design studios and technical workshops.

CHRISTOPH A. KUMPUSCH
A professor in the Department of Architecture at Cornell University, Christoph A. Kumpusch, C.D.-IVCL.A. Ing. Mag. Arch., is a recipient of the Leonardo da Vinci Fellowship and Grant, launched by the European Union and the highest honor of its kind; and is a Rudolf M. Schindler Scholar, USAA Scholar and National Collegiate Engineering Award winner for outstanding commitment to academic excellence. Kumpusch has previously taught at the Irwin S. Chanin School of Architecture at The Cooper Union, Pratt Institute, Ohio State University, Southern California Institute of Architecture (SCI-Arc) and Guangzhou University, China. He recently became the research director for the Ludwig Wittgenstein estate and the Wittgenstein Haus. In 2006 Kumpusch became the youngest architect to be accredited as engineer by the European Union, Federal Ministry for the Economics, Austria Section. Current projects include a community embassy in Kenya, Africa; a council estate development at the Costa del Sol in Marbella, Spain; an atelier for an actor partnership in Beverly Hills, California; a technology pavilion in Chengdhu, China; and a social housing tower in Budapest, Hungary.

SANFORD KWINTER
Sanford Kwinter is a Professor of Architecture at Rice University's School of Architecture and currently teaches at Harvard University Graduate School of Design. He is the author of *Far From Equilibrium: Essays on Technology and Design Culture* (2007), *Architectures of Time: Toward a Theory of the Event in Modernist Culture* (2002) and the forthcoming *Requiem: Meditations on the Metropolis at the Turn of the Millennium*. Kwinter was co-founder and editor of the journal *Zone* and Zone Books from 1984 to 2001.

SYLVIA LAVIN
Sylvia Lavin is a Professor in the Department of Architecture and Urban Design at UCLA, where she is Director of Critical Studies and M.A./Ph.D. programs. She has been a visiting professor at Harvard University Graduate School of Design, Princeton

University's School of Architecture, Columbia University's Graduate School of Architecture, Planning and Preservation and other institutions. Lavin is the author of the forthcoming books *The Flash in the Pan and Other Forms of Architectural Contemporaneity* and *Kissing Architecture*. She recently curated two exhibitions: *Craig Hodgetts, Playmaker*, opening at Ace Gallery, Los Angeles, in October 2009; and *Take Note*, at the Centre Canadien d'Architecture, Montreal (2009).

MARK MALEKSHAHI
An associate principal at Buro Happold Consulting Engineers in New York, Mark Malekshahi serves as the key member for communication between the MEP team and the architect's design team. He has worked for more than 15 years in engineering design and project management on a variety of multi-disciplinary and specialized building projects, including cultural, institutional, corporate, health care and retail projects. His responsibilities also include developing HVAC design schemes. He holds a B.S. degree in mechanical engineering from the City College of New York and is a member of ASHRAE, and ASME.

RONALD MAYES
Ronald Mayes received his Ph.D. in structural engineering from the University of Auckland, New Zealand, in 1972. He is the past Secretary/Treasurer of the Earthquake Engineering Research Institute (EERI) and a former Technical and Executive Director of the Applied Technology Council (ATC). Mayes formed and became President of Dynamic Isolation Systems, Inc. a firm that pioneered the use of base isolation technology in the United States. He joined Simpson, Gumpertz & Heger, San Francisco, in June 2001 and is the firm's in-house expert on the application of innovative technology. He has been project manager on an extensive research program funded by the Army Research Laboratory on the use of high-strength steel in long-span structures.

RORY MCGOWAN
Rory McGowan is currently Director of the Beijing office of the global engineering firm Arup, where he oversees development of the firm's practice in China. Among his current projects in Asia are the Bangkok Residential Tower (OMA), JiangXi Museum (MADA), Shenzhen Stock Exchange Headquarters (OMA) and the CCTV building (OMA), which he has led since the competition stage. He has also worked on a number of development projects, including the Lotus Children's Center in Mongolia, the Ladakh School in India, the Korup Bridge Project in Cameroon, and primary health care research in Tanzania, sponsored by Arup.

Born and trained as a structural engineer in Ireland, McGowan joined the Arup Dublin office in 1986, and later moved to London. Until early 2005 he directed a building engineering group in Arup's London office where he led a variety of high-profile international projects, including the Kansai Airport (Renzo Piano), Congrexpo Lille, ITT Chicago, Whitney Museum of American Art, Universal Studios (OMA), VPRO Headquarters in the Netherlands and Serpentine Mountain (MVRDV) and Fundación Caixa Galicia, La Coruña, Spain (Nicholas Grimshaw and Partners).

McGowan lectures frequently and has served as technical tutor at several architectural schools, including the Berlage Institute Rotterdam, the Architectural Association and Bartlett London.

CHRISTIAN MEYER
Christian Meyer is Professor and Chair of the Department of Civil Engineering and Engineering Mechanics at Columbia University. He completed his undergraduate studies at the Technical University Berlin and obtained his M.S. and Ph.D. degrees from the University of California at Berkeley. He then spent eight years in engineering practice, first working with Albert C. Martin and Associates in Los Angeles on earthquake-resistant design of tall buildings, then with Stone and Webster Engineering Corporation in Boston on analysis and design of nuclear power plant facilities. Since 1978 he has been on the faculty of Columbia University. His primary interests are related to analysis and design of structures, particularly concrete structures. In recent years, his interests have shifted toward concrete materials science and technology. He and his co-workers are focusing particularly on the beneficiation of recycled waste materials for the production of concrete, such as waste glass, carpet fibers and dredged material from New York Harbor. This work extends from basic scientific research through technology development to technology transfer by closely working with concrete producers. Meyer has written almost 200 technical articles, including a textbook on the design of concrete structures. He is the recipient of the prestigious research award from Germany's Alexander von Humboldt Foundation.

ANA MILJACKI
Ana Miljacki is a Professor in the Department of Architecture at Massachusetts Institute of Technology. She has previously taught studios and seminars at Columbia University, City College in New York and Harvard University Graduate School of Design. She holds a Ph.D. (2007) in history and theory of architecture from Harvard University, an M.Arch. from Rice University and a B.A. from Bennington College. Her research interests range from issues in contemporary discourse, through the articulation of the role of architecture and architects during the Cold War, to, more recently, the ghosts of utopia that haunt the architectural discipline throughout its history of envisioning the future.

Miljacki is a partner, with Lee Moreau, in the interdisciplinary practice Project_, which was one of the recipients of The Architecture League of New York Young Architects award for 2008.

JOSÉ RAFAEL MONEO
José Rafael Moneo is the first Josep Lluis Sert Professor of Architecture at Harvard University Graduate School of Design. He was chairman of the Department of Architecture from 1985 to 1990. Before joining the School of Design, Moneo was a fellow at the Spanish Academy in Rome and taught in Barcelona and Madrid. His numerous articles and lectures have been published throughout the world. His projects in Spain include the Bankinter Building in Madrid, the Museum of Roman Art in Mérida, the L'Illa building in Barcelona, the Pilar and Joan Miró Museum in Palma de Mallorca, the Kursaal Auditorium and Congress Center in San Sebastián and the extension of the Prado Museum in Madrid. He has also designed the Davis Art Museum at Wellesley College, the Houston Museum of Fine Arts and the Cathedral of Our Lady of the Angels in Los Angeles. Moneo has been awarded the Gold Medal by the Spanish government, the Arnold W. Brunner Memorial Prize by the American Academy of Arts and Letters, the Prince of Viana Prize (Spain), the Royal Swedish Academy of Arts Schock Prize for the Visual Arts and the Royal Institute of British Architects Gold Medal. In 1996 he received the UIA Gold Medal and the Pritzker Prize.

TOSHIKO MORI
Toshiko Mori is the principal of Toshiko Mori Architect, in New York City. She is the Robert P. Hubbard Professor in the Practice of Architecture at Harvard University Graduate School of Design and was chair of the Department of Architecture from 2002 to 2008. In 2003 Mori was awarded the Cooper Union Inaugural John Hejduk Award. In 2005 she received the Academy Award in Architecture from the American Academy of Arts and Letters and the Medal of Honor from the AIA New York Chapter. She has edited a volume on material and fabrication research, *Immaterial/Ultramaterial*. A monograph of her work, *Toshiko Mori Architect*, was published in 2008.

MARWAN NADER
Marwan Nader is a vice president and project director at the civil and structural engineering firm T.Y. Lin International in San Francisco. He earned a Ph.D. from the University of California at Berkeley, focusing on the seismic performance of steel structures. He has more than 20 years of experience in the design and construction of long-span bridges. A member of ASCE, AISC, AWS, IABSE and SEOANC, Nader is the 2004 recipient of ASCE's Arthur M. Wellington Award.

JORGE OTERO-PAILOS
An architect, historian and theorist specializing in experimental forms of preservation, Jorge Otero-Pailos is interested in rethinking preservation as a powerful countercultural practice that creates alternative futures for our world heritage. He is the founder and editor of the journal *Future Anterior*, the first American peer-reviewed scholarly journal to be devoted to the history, theory and criticism of historic preservation. His forthcoming

book, *Architecture's Historical Turn: Phenomenology and the Rise of the Postmodern*, traces the intellectual origins of postmodern architectural theory to the 1970s turn toward history and historiography. His current research project probes the manner in which the advent of large-scale environmental pollution changed how architects understand the nature of architecture and its history. His experimental preservation installations have been exhibited at Manifesta 7: The European Contemporary Art Biennial (2008), and at the 53rd Venice Art Biennial (2009). An Assistant Professor of Historic Preservation at Columbia University's Graduate School of Architecture, Planning and Preservation, he holds a Ph.D. in architecture from the Massachusetts Institute of Technology.

THEODORE PRUDON
Theodore Prudon is a Dutch-born architect and principal of Prudon & Partners, a firm specializing in restoration. As the founding president of DOCOMOMO/U.S. (The Documentation and Conservation of Buildings, Sites, and Neighborhoods of the Modern Movement), Prudon leads the U.S. chapter of the international organization dedicated to preserving modernist structures. Prudon also is a DOCOMOMO International board member and an Adjunct Associate Professor of Historic Preservation at Columbia University. He holds a master's degree in architecture from the Delft University of Technology in Holland, a master's of science in architecture from Columbia University and a Ph.D. in architecture from Columbia. Prudon is the author of *Preservation of Modern Architecture* (2008).

JESSE REISER
and
NANAKO UMEMOTO
Jesse Reiser and Nanako Umemoto have practiced together in New York City since 1986. Reiser + Umemoto, an internationally recognized architectural firm, has built projects at a wide range of scales, from furniture design to residential and commercial structures, up to the scale of landscape design and infrastructure.

Jesse Reiser received his B.Arch. degree from The Cooper Union in New York and his M.Arch. from the Cranbrook Academy of Art. He was a fellow of the American Academy in Rome in 1985. He is an associate professor in the School of Architecture at Princeton University.

Architect and landscape architect Nanako Umemoto graduated from The Cooper Union following studies at the School of Urban Design at the Osaka University of Art. In addition to teaching at Columbia University, both Reiser and Umemoto have taught and lectured throughout the United States, Europe and Japan.

HILARY SAMPLE
Hilary Sample is an architect and Assistant Professor at the Yale School of Architecture. She is a founding principal of MOS, an interdisciplinary architecture and design practice based in New Haven. Projects designed by MOS have been showcased in numerous publications and exhibited at the Venice Biennale, Scottsdale Museum of Contemporary Art, The Museum of Modern Art, and the Art Institute of Chicago. The firm was the winner of the 2009 MoMA/P.S.1 Young Architects Program and has received numerous awards, including a Design Award from Progressive Architecture, and selection as part of The Architectural League Emerging Voices series. Current projects include a villa for Ordos 100, Inner Mongolia, China; Ballroom Drive-In theater, Marfa, Texas; an inflatable factory in Newfoundland, Canada; and a Teen Center, Lowell, Massachusetts. Sample's research focuses on both the physical and conceptual aspects of maintenance and their intersection with architecture and urbanism. Her forthcoming book, *Sick City: A Global Investigation About Urbanism, Infrastructure and Disease*, explores cities in trauma. Sample received a B.Arch. from Syracuse University and an M.Arch. from Princeton University.

HANS SCHOBER
Hans Schober is a Partner with Schlaich Bergermann and Partner, Consulting Engineers in Stuttgart, Germany, which he joined in 1982; he established the firm's New York office in 2005. He studied civil engineering at the University of Stuttgart from which he earned his Ph.D. in 1984. His numerous completed projects include specialty structures and innovative projects in the field of glass structures, cable and lightweight

structures, as well as railway, highway and pedestrian bridges. Among his most recent projects are the New Trade Fair Milan with Massimiliano Fuksas Architecture; in New York, the cable net walls for Time Warner Center and 7 World Trade Center, the glass roofs for the new Moynihan Station with James Carpenter and David Childs, the antenna structure and glass walls for 1 World Trade Center with David Childs and the glass structures for Eleven Times Square with FX Fowle; the Transbay Transit Center In San Francisco with Pelli Clarke Pelli; and the YAS Hotel in Abu Dhabi with Asymptote Architecture. His areas of expertise include materials such as concrete, glass, timber, fiber-reinforced plastics, steel, and cables and membrane systems.

MATTHIAS SCHULER
Matthias Schuler is a Managing Director of TRANSSOLAR Energietechnik in Stuttgart. Trained as a mechanical engineer at the University of Stuttgart, in 1992 he founded the firm TRANSSOLAR Climate Engineering. The firm's focus is on new energy-saving and comfort-optimizing strategies that take an integral approach in building design. With the master plan for the world's first carbon-neutral city, Masdar Development, in collaboration with Foster Partners, Transsolar expanded its concepts to the urban scale, identifying the necessary boundary conditions for such a challenging approach.

Today, with 45 employees in Stuttgart, Munich and New York, Schuler works on national and international projects with architects including Kazuyo Sejima, Frank Gehry, Steven Holl, Jean Nouvel and Helmut Jahn. Since 2001, Schuer has taught as a visiting professor at Harvard University Graduate School of Design; he became Adjunct Professor for Environmental Technologies in 2008.

CRAIG SCHWITTER
Craig Schwitter has more than 17 years of experience in the engineering design of complex buildings, including educational, performing arts, stadium, transportation and cultural projects. Schwitter founded the first North American office of Buro Happold in 1998. Since then the branch has grown to encompass more than 200 staff members based in multiple office locations including New York, Los Angeles, Boston and Toronto. The North American offices offer a full spectrum of engineering services, including structural, MEP, and facade, special projects engineering, lighting design, sustainability consulting services, and geotechnical services. With a focus on integrated engineering and the use of appropriate technology, Schwitter has played a hands-on role in to ensure a high level of quality in Buro Happold's projects and breakthrough innovations for the firm's recent high-profile engineering commissions.

FELICITY SCOTT
Felicity Scott is Assistant Professor of Architecture and Director of the Program in Critical, Curatorial, and Conceptual Practices in Architecture at Columbia University's Graduate School of Architecture, Planning and Preservation. She is also a founding co-editor of *Grey Room*, a quarterly academic journal of architecture, art, media and politics published by MIT Press since Fall 2000. Her articles are included in numerous journals and anthologies, and she is the author of the books *Architecture or Techno-Utopia: Politics After Modernism* (2007) and *Living Archive 7: Ant Farm* (2008). She is currently finalizing a manuscript titled "Cartographies of Drift: Bernard Rudofsky's Encounters with Modernity."

WERNER SOBEK
Werner Sobek studied architecture and structural engineering at the University of Stuttgart in Germany. In 1991 he became full-time professor at the University of Hanover. One year later he founded his own engineering consultancy, Werner Sobek Engineering and Design. In 1995, Sobek took over directorship of the famous Institute for Lightweight Structures at the University of Stuttgart as successor to Frei Otto. In 2001 he also assumed the chair of structural engineer Jörg Schlaich at the University of Stuttgart's Institute for Construction and Design, fusing the two institutes into the new Institute for Lightweight Structures and Conceptual Design (ILEK), which specializes in research into new materials and new concepts for lightweight and adaptive structures.

Werner Sobek Engineering and Design is one of the leading engineering consultancies in Europe, with

offices in Stuttgart, Cairo, Dubai, Frankfurt, Moscow, and New York.

A particular focus is special structures in steel, glass, titanium, concrete, textiles and wood.

The works of Werner Sobek have been awarded numerous awards and distinctions, including the DuPont Benedictus Award, the European Gluelam Award, the Fritz Schumacher Award, the iF Design Award, the SEAOI Structural Engineering Award, awards of the American Institute of Architecture, the Hugo Haering Award, the Fazlur Rahman Khan Medal and the UIA's Auguste Perret Prize.

GALIA SOLOMONOFF

Galia Solomonoff is principal of SAS/Solomonoff Architecture Studio in New York. SAS provides architecture for art-related clients and artists, including DIa:Beacon. Solomonoff was a contributor to the book *Latin American Architecture: Six Voices* (2000), edited by Malcolm Quantrill. Solomonoff is currently an Assistant Professor of Architecture at Columbia University. She holds an M.Arch. from Columbia University's Graduate School of Architecture, Planning and Preservation (McKim Prize for Excellence in Design, 1994), and a B.S. in architecture from City College, City University of New York (1991). A native of Argentina, she has lived in New York since 1987 and works to foster recognition and knowledge of Latin American architecture.

MAN-CHUNG TANG

Man-Chung Tang is the Chairman of the Board of T.Y. Lin International, a consulting engineering firm with headquarters in San Francisco. He received his Doctor of Engineering degree in 1965 from the Technical University Darmstadt, Germany, and has since been working as a structural engineer. He is an honorary professor at nine universities, a member of the U.S. National Academy of Engineering, a foreign member of the Chinese Academy of Engineering and an honorary member of the American Society of Civil Engineers.

HEIKO TRUMPF

Heiko Trumpf is a principal of Werner Sobek Engineering and Design in Stuttgart. He studied civil engineering at the University of Hanover, became an International Welding Engineer (IWE) and received a Ph.D. in structural engineering from RWTH Aachen in 2006. Since 2007 he has also been a lecturer at the University of Stuttgart. Among the major projects he has worked on are the extension for O'Hare Airport, Chicago; Bukhatir Headquarters, Sharjah, UAE; Swarovski Corporation, Männedorf, Switzerland; University of Chicago Utility Plants; and DC Towers, Vienna.

GEORGE WHEELER

George Wheeler is Director of Conservation in the Historic Preservation Program at Columbia University's Graduate School of Architecture, Planning and Preservation. He joined the program after 25 years at The Metropolitan Museum of Art as a Research Scientist. He has published extensively in the field of conservation, including his book *Alkoxysilanes and the Consolidation of Stone*, published by the Getty Conservation Institute (2005). Wheeler is a Fellow of the American Institute for Conservation, the International Institute for Conservation and winner of the 1997 Rome Prize in conservation. He holds a Ph.D. in chemistry from New York University, a Graduate Certificate in Conservation from the Institute of Fine Arts and an M.A. in Art History from CUNY.

MARK WIGLEY

Mark Wigley is Dean of Columbia University's Graduate School of Architecture, Planning and Preservation. An accomplished scholar and design teacher, he has written extensively on the theory and practice of architecture and is the author of *Constant's New Babylon: The Hyper-Architecture of Desire* (1998); *White Walls, Designer Dresses: The Fashioning of Modern Architecture* (1995) and *The Architecture of Deconstruction: Derrida's Haunt* (1993). He co-edited *The Activist Drawing: Retracing Situationist Architectures from Constant's New Babylon to Beyond* (2001). Wigley has served as curator for widely attended exhibitions at The Museum of Modern Art, New York; The Drawing Center, New York; Canadian Centre for Architecture, Montreal; and Witte de With Museum, Rotterdam. He received both his Bachelor of Architecture (1979) and his Ph.D. (1987) degrees from the University of Auckland, New Zealand.

MABEL WILSON

Mabel Wilson, Associate Professor at Columbia University's Graduate School of Architecture, Planning and Preservation (GSAPP), navigates a multidisciplinary practice between the fields of architecture, art, visual cultural analysis and American studies. Her design research and scholarly work investigates space and cultural memory in black America, race and visual culture and new technologies and the social production of space. Her collaborative design practices (KW: a and Studio 6Ten) have produced speculative and built projects. Her practice has been a competition finalist for several important cultural institutions, including lower Manhattan's African Burial Ground Memorial and the Smithsonian's National Museum for African American History and Culture (with Diller Scofidio +Renfro.) The Wexner Center for the Arts, the Cooper Hewitt National Design Museum's Triennial, the Storefront for Art and Architecture, and SF Cameraworks have featured her installations. She is currently completing the book *Progress and Prospects—Black Americans and the World of Fairs and Museums*, which examines the ways in which ideologies of race, social uplift and nationalism shaped black American sites of memory. She is compiling photographic research for the book into an experimental exhibition and database as part of the *Visible History Project* and is also developing an urban history database for use through mobile technologies by residents in African cities. Wilson directs GSAPP's program for Advanced Architectural Research and the HBCU Design Leadership Project.

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ACKNOWLEDGMENTS

Post Ductility is the third in a series of conferences on architecture, engineering and materials. The series originated as a plan to collaborate; Mark Wigley, Dean, GSAPP, and Christian Meyer, Chair, Civil Engineering and Engineering Mechanics, began discussions to host a joint conference as a new model of exchange between architecture and engineering. The first conference in the series, *Engineered Transparency*, on glass, was held at GSAPP in September 2007. The second, *Solid States*, on concrete, was held at GSAPP in October 2008, and the fourth conference, on polymers, will be held at GSAPP in autumn 2010.

Post Ductility: Metals in Architecture and Engineering would not have been possible without the energy, good will and intellectual rigor of the conference chair, Michael Bell, who has been supported by a group of dedicated advisers and collaborators including: Christian Meyer, Mark Wigley, Gary Higbee, Louis Geschwinder, Jean-Louis Cohen, Steven Holl, Laurie Hawkinson, Juan Herreros, Jacques Lukasik, Antoine Picon, Jesse Reiser, Werner Sobek, Diana Darling and William Menking; and Benjamin Prosky, Craig Buckley, Devon Ercolano Provan, Phillip Anzalone, Bridget Borders, Julian Pancoast, Ravi Raj, Victoria Benitez, Luke Bulman, Stephanie Salomon, Gabriel Bach, the GSAPP AV crew; John Ramahlo, Lou Fernandez, Kevin Allen; Rosana Rubio-Hernandez, Alejandro de Castro Mazarro, Mark Wasiuta and the GSAPP exhibitions team and especially Annie Kurtin.

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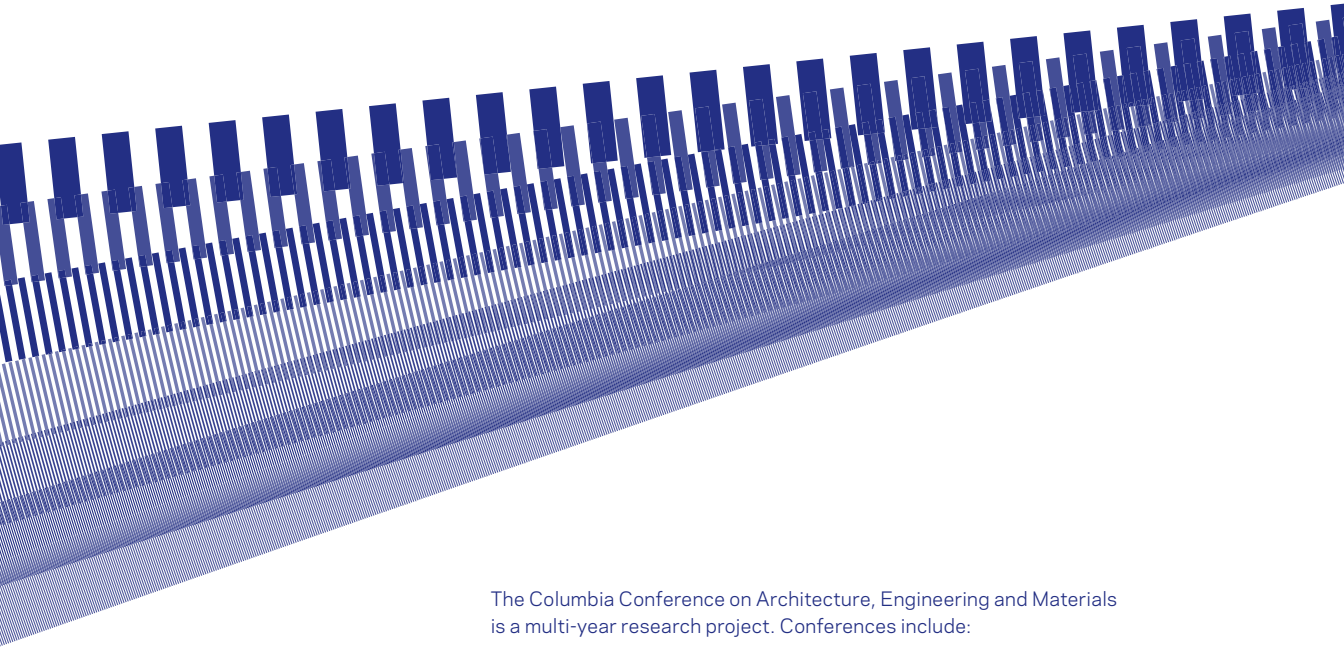

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1 glass 2 concrete 3 metal 4... plastic