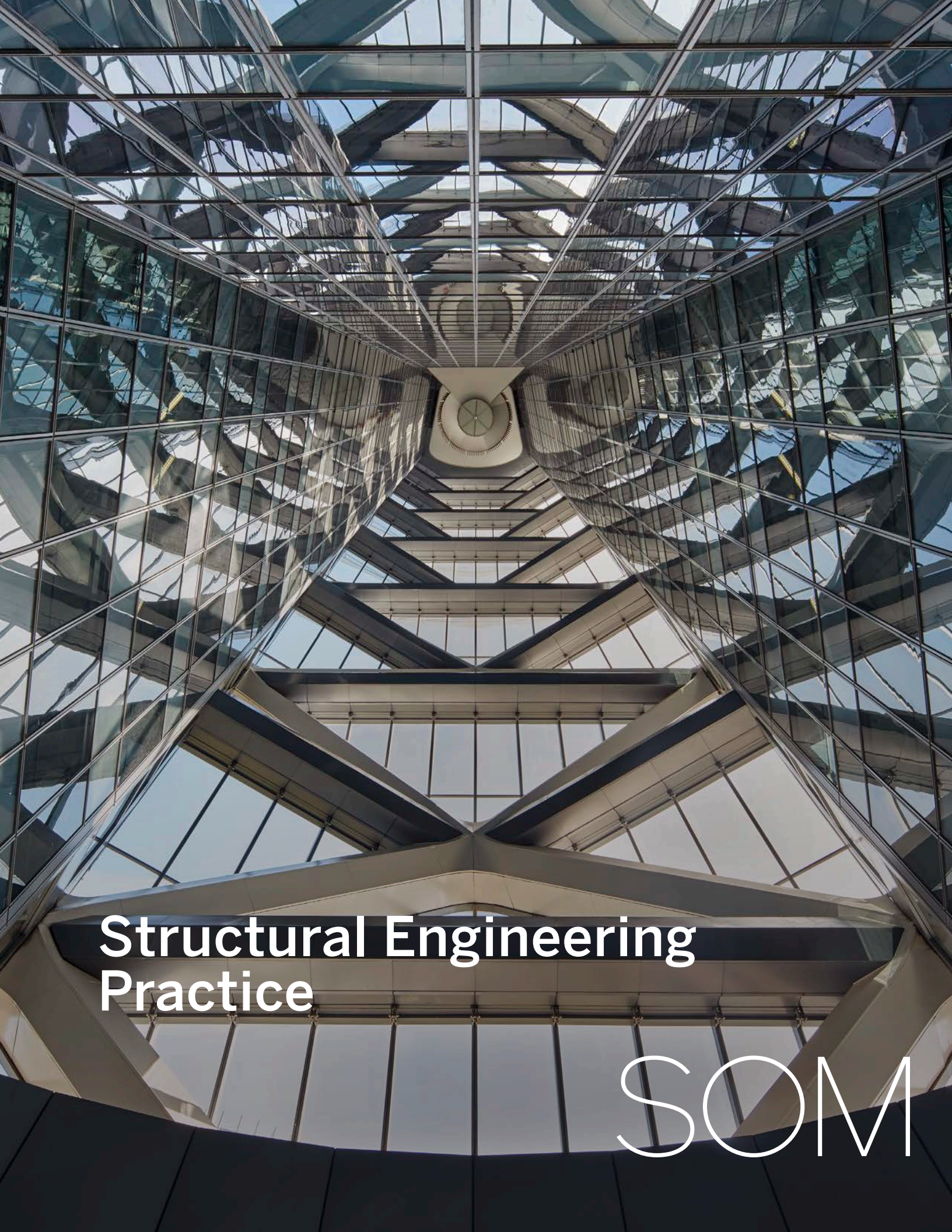
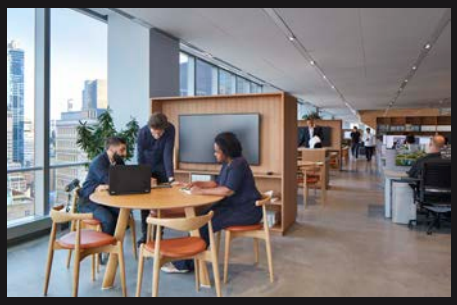


Structural Engineering Practice

SOM

We are a collective of engineers, architects, designers, and planners building a better future.





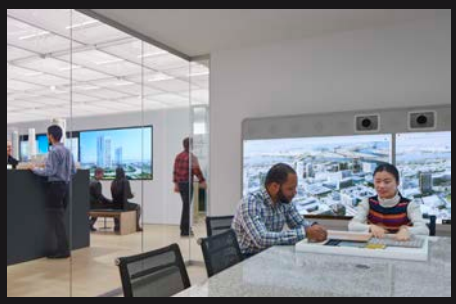






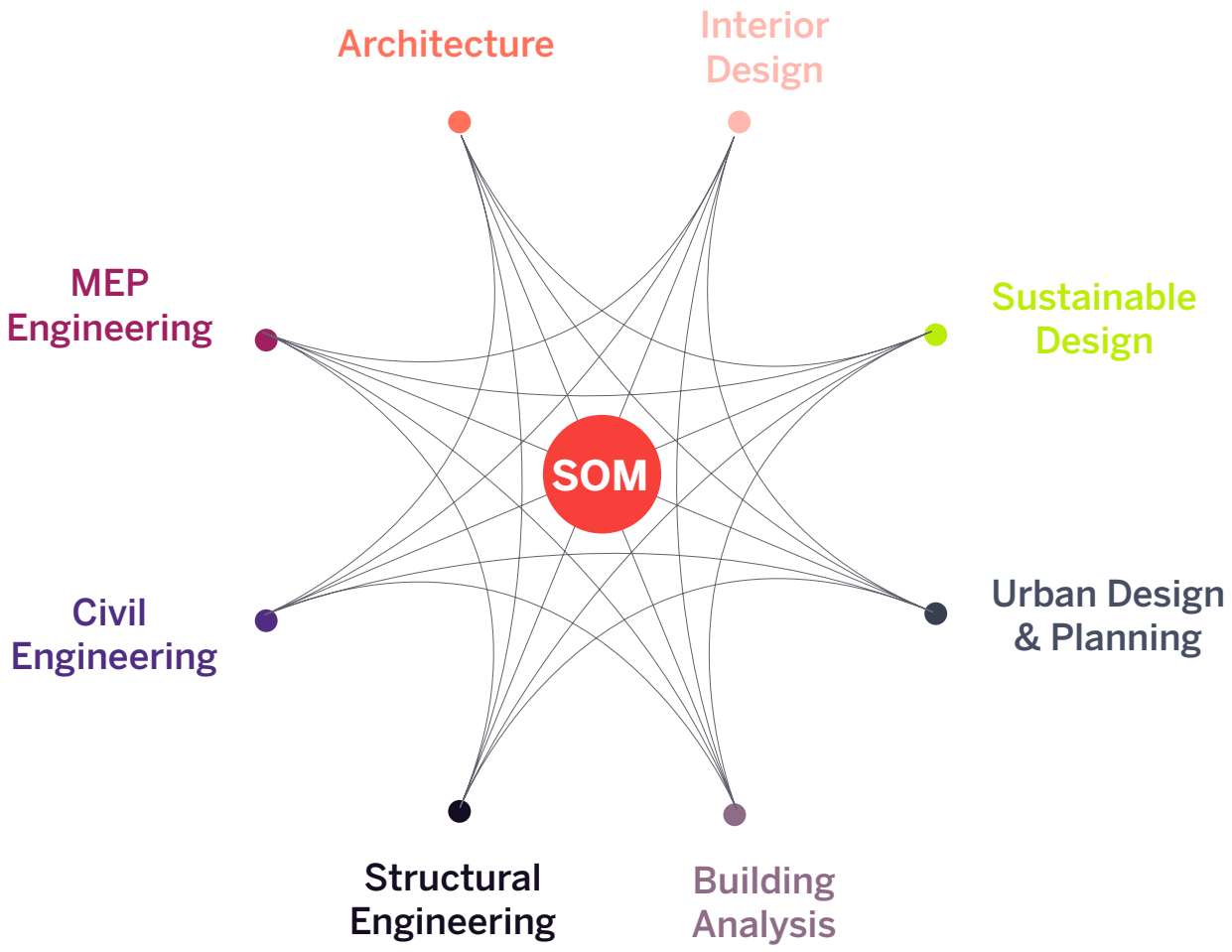



Los Angeles Federal Courthouse
Steel Topping Out | March 12, 2015
SOM



Our Firm

As an interdisciplinary firm, SOM fosters a collaborative environment. The interdisciplinary approach—one that SOM helped pioneer—has allowed us to develop new and unique solutions in our designs.




San Francisco Studio

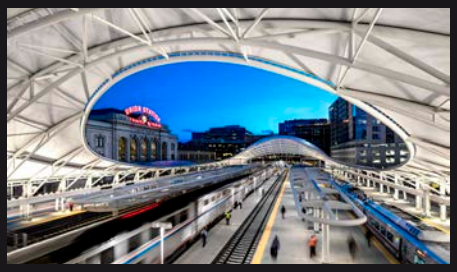
Our firm, Skidmore, Owings & Merrill is responsible for some of the world's most technically and environmentally advanced buildings and significant urban spaces. Our portfolio extends from a strategic regional plan to a single piece of furniture; we design spaces that anticipate new ways of living, working and learning and bring lasting value. Our approach is highly collaborative and our interdisciplinary team works from a global network of creative studios, harnessing our international expertise at a local level.

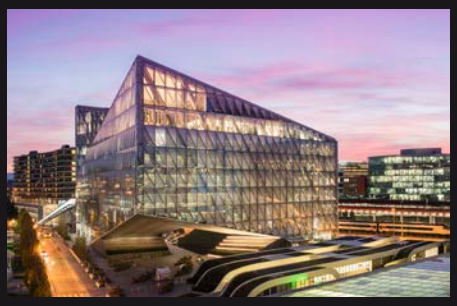
Skidmore, Owings & Merrill believes that great buildings come through a dialogue between engineers and architects, working as a design collective with the shared aspiration of achieving simplicity, structural clarity, and sustainability. Our engineers work at all scales, from adaptive reuse to the world's tallest building, and our talented team has a unique breadth of expertise and depth of experience. This puts us at the forefront of research and innovation, and enables us to create structures that are practical, efficient, economical, and elegant.

SOM has established a significant record in the design and completion of projects large and small, local and global. We have developed an unsurpassed reputation for our ability to mobilize resources to manage the design of complex projects. We have been responsible for the design of over 400 million square feet of space located throughout the world. Our experience in spearheading projects that span disciplines and geographies is unparalleled and is supported through the use of well-established management tools that enable SOM to complete projects on schedule and within established budgets.

Through research and proven innovation, our interdisciplinary approach to structural design turns visionary ideas into reality.

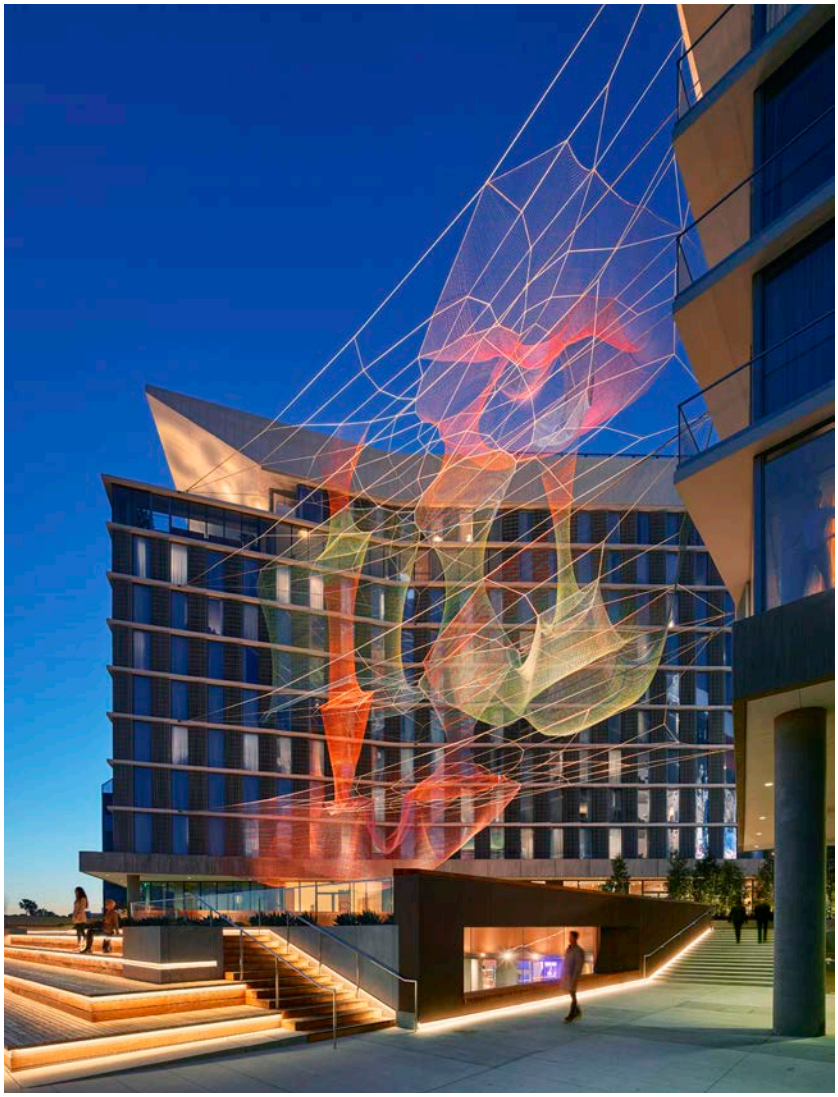

ONE MANHATTAN WEST





SOM Structures

We believe that great buildings come through a dialogue between engineers and architects, working as a design collective with the shared aim of achieving simplicity, structural clarity and sustainability.



Opposite: One Steuart Lane is an exclusive LEED® Gold building located in downtown San Francisco. An 8" thick post-tensioned flat slab complemented by sculpted coulm capitals creates an open floor plan a flexibility of unity layouts.

Left: SOM engineers collaborated with artist Janet Echelman to integrate a public art installation titled "Dream Catcher," a 65–foot–tall net sculpture held in tension and suspended above ground between two boutique buildings in West Hollywood,

Our engineers work at all scales—from an art installation to the world's tallest building. Our talented team has a unique breadth of expertise and depth of experience. This puts us at the forefront of innovation and research, and enables us to create structures that are practical, efficient and elegant. We bring in design expertise in conjunction with adapting to local standards and construction materials.

Structural Engineering Practice

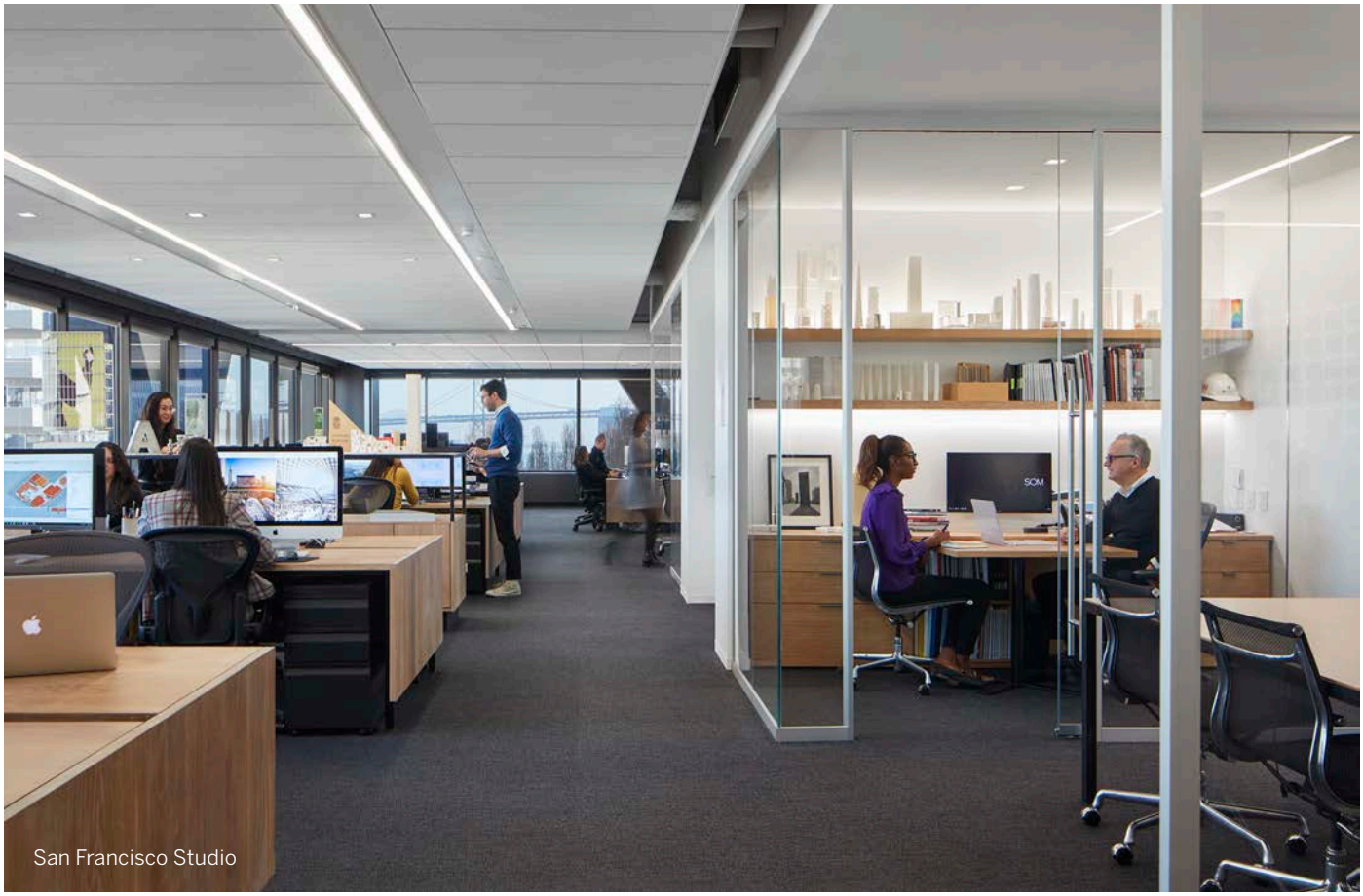
Innovation, creativity, and design excellence are principle aspirations for our structural engineering practice. We believe that the best engineering solutions result from a close collaboration with our clients and our multi-disciplinary approach to design. Simplicity and structural clarity drive the architectural and structural design ethos of each project to result in distinctive and timeless structures.

We believe that a refined science of structural engineering leads to the most efficient solutions, resulting in least materials, and least cost. We have designed over 30 projects incorporating performance-based design methodologies to achieve various design goals; from structural efficiency and least cost to buildings being continuously operational after an extreme seismic event. We perform structural material quantity estimates from the onset of the project and maintain close collaboration with the design and construction team to realize material quantity targets and control costs.

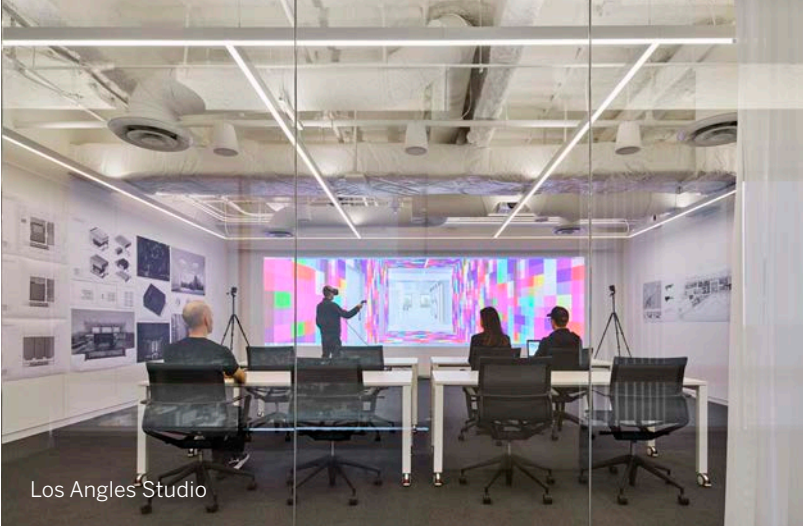
Through our project work, our structural engineering practice leaders have developed close relationships with clients, building officials, peer reviewers, contractors, and other industry leaders. We contribute to the advancement of structural engineering through service in committee work such as Council of Tall Buildings and Urban Habitat (CTBUH), the Structural Engineers Association of California (SEAOC), American Concrete Institute (ACI), American Institute of Steel Construction (AISC), and American Society of Civil Engineers (ASCE) and through teaching at well respected Universities across the nation.

Our Team

Our experience as proven innovators of elegant, efficient structural systems at all project scales is represented by our award-winning portfolio.



San Francisco Studio


Los Angles Studio


San Francisco Studio

SOM Structures' commitment to pioneering research and the pursuit of creative solutions results in innovative, cost effective ground-breaking design solutions and ideas that influence structures yet to be imagined. As an interdisciplinary firm, we look at each project as a whole, rather than as the sum of many parts. We are concerned with both the immediate and long-term value of our work—we create places that endure, perform and are treasured.

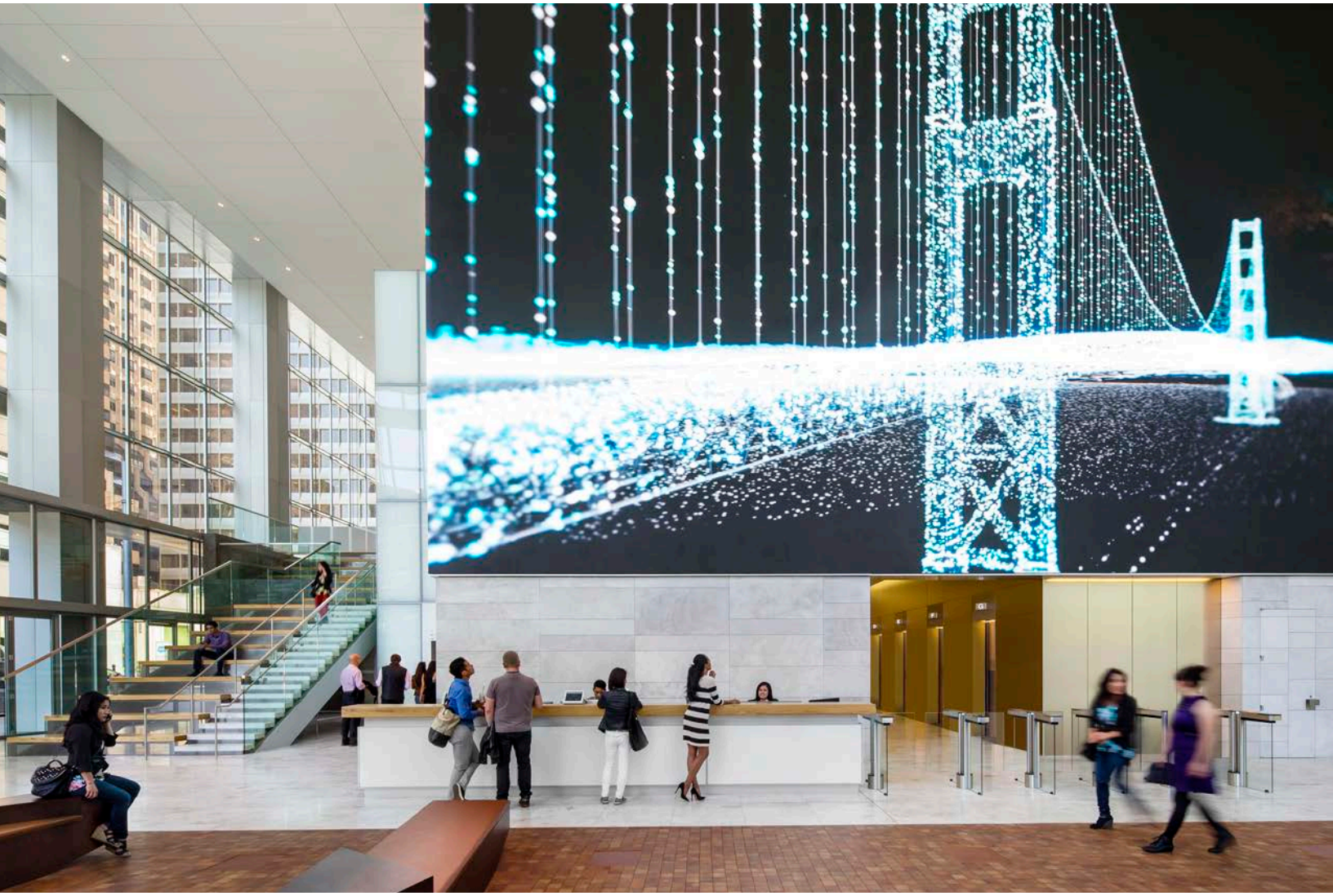
Our portfolio embraces a wide range of building types, from residential, commercial and hospitality projects to cutting-edge research facilities, transportation hubs, and civic and cultural landmarks. We are inspired by the opportunities presented by a site, a brief, a problem. We are also inspired by each other, and by the talented network of people we work with. The issues facing our cities in the future are complex, and we have built a practice with the depth of resources to address them.

We consistently strive to forge unique solutions to complex problems through an inclusive, analytical, empirical and data-driven process. Our practice maximizes synergies between building design and structural systems design, creating inspiring and stimulating places for living, working and interaction. As a research-based practice, we integrate a diversity of disciplines—to spur innovation.

Our firmwide structural engineering teams are located in New York, Chicago, San Francisco, Los Angeles, Washington, D.C., London, Shanghai, and Hong Kong. The SOM structural engineering West Coast practice with our studios in San Francisco and Los Angeles works corroboratively with all SOM studios around the world. The West Coast practice leads seismic designs across the firm, with in-house expertise in performance-based design, seismic isolation, resilience and life-cycle analysis.

Integrated Design Approach

Our structural engineering team works seamlessly with the architectural, planning, interior, and MEP teams to incorporate efficient structural systems for any building design.



Opposite: Rigorous performance-based design methods were used to prove equivalency to prescriptive code design procedures for 350 Mission Street in San Francisco.

Above: : Supported by a central buttressed core, a structural system developed by SOM engineers specifically for Burj Khalifa in Dubai.

We are a design think tank. At SOM, we understand that innovation is a result of interdisciplinary exchange—both in design and research. We integrate multiple disciplines from the start of every project to advance design innovations.

State of the Art Techniques

Technological innovation drives the creation of new structural solutions. Research into new technologies, typologies, and materials is central to SOM's ethos and essential to the continued evolution of structural systems.

Above: A seismic isolation system was designed to support each of the ten art house towers with the dual intent of preserving the building's architectural vision and providing the Los Angeles County Museum of Art (LACMA) with a high level of seismic protection for their invaluable art collection.

Right: Responsive Tendon Patterns, a new design methodology that addresses irregular support conditions. The proposed innovative design methodology enhances structural designers' understanding of gravity framing through the employment of topology optimization.

Iterative Early Design
SOM's integrated practice brings architects and engineers together at the very start of the project to test as many buildi configurations as possible. The structural efficiency and performance of the building are considered at every step of the design process, ensuring a cost-effective result.

Value Driven Solutions
The structure of the building can do more than support the program, it can also define the character of the space. Our team looks for synergies between building systems to maximize value to our clients, including interior space layouts. We seek to find added value solutions on every project.

Material Savings Through Optimization
The first step in our design process is to develop an efficient structural solution that is integrated with the architectural design concept. The structural solution is then refined through a wide range of optimization techniques to reduce material quantities - from simple floor framing layouts to bracing systems of super-tall buildings.

Sustainability
We look beyond LEED and the basic structural engineering contribution of cement replacement and recycled steel content through the use of our own Environmental Analysis Tool to estimate equivalent carbon dioxide emissions embodied in structures. We analyze embodied carbon for a variety of building types, materials and construction methods with consideration of deconstruction, material replacement, and reconstruction after use or a hazardous event and use the data to inform the design process and reach the highest levels of sustainability.

Efficient Design Approach

Before we design, we listen. Our structural engineering team seeks to fully understand the different needs of a project, and develop innovative ideas tailored to our client's unique challenges.

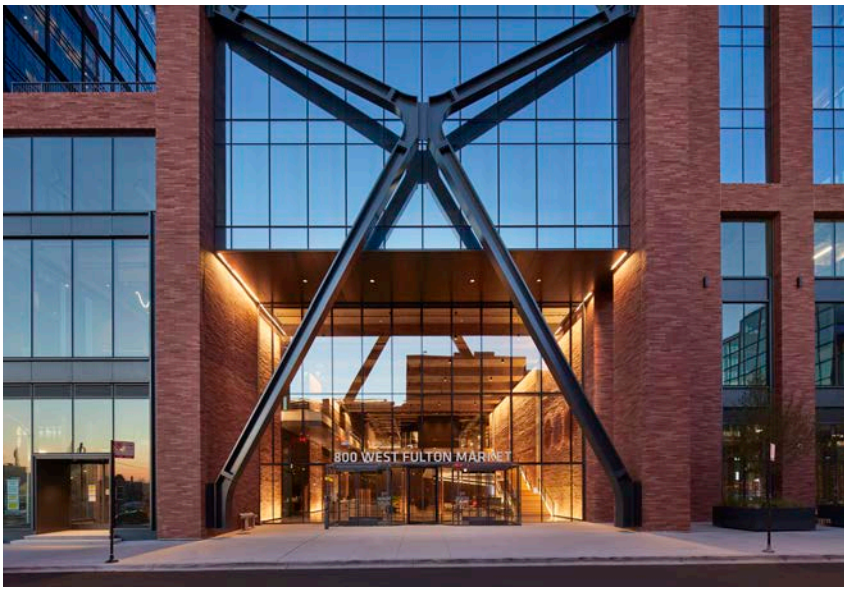
High-Rise Buildings
Fundamental principles of structural engineering are used as the basis of our tall building designs. We continuously search for new system solutions that increase performance while considering specific site conditions. We carefully study the behavior of these structures in their wind and seismic environments to optimize their shape, orientation, and structural properties considering energy principles. We embrace sustainable design concepts to minimize structural materials and integrating structures with the architectural and mechanical systems. Our goal is to develop solutions that are elegant, well integrated, readily constructible and are cost-effective.

Long-Span Structures
We have found a great deal of flexibility in materials and systems that are appropriate for structures requiring large spaces absent of vertical support. These systems use light weight structural components with geometries refined to accommodate spans and, in some cases, incorporate pre-stressing layouts to alter initial conditions with an anticipation of future loads. Special considerations are required for construction, including tensioning sequences, temporary stress states, and final long-term conditions.

Right: The design for 500 Folsom in San Francisco incorporates the latest performance-based design methods to verify seismic performance and inform the most efficient placement of structural materials.

The Chhatrapati Shivaji International Airport in Mumbai, features a **long-span roof** covering 70,000 square meters, making it one of the world's largest roofs without an expansion joint.

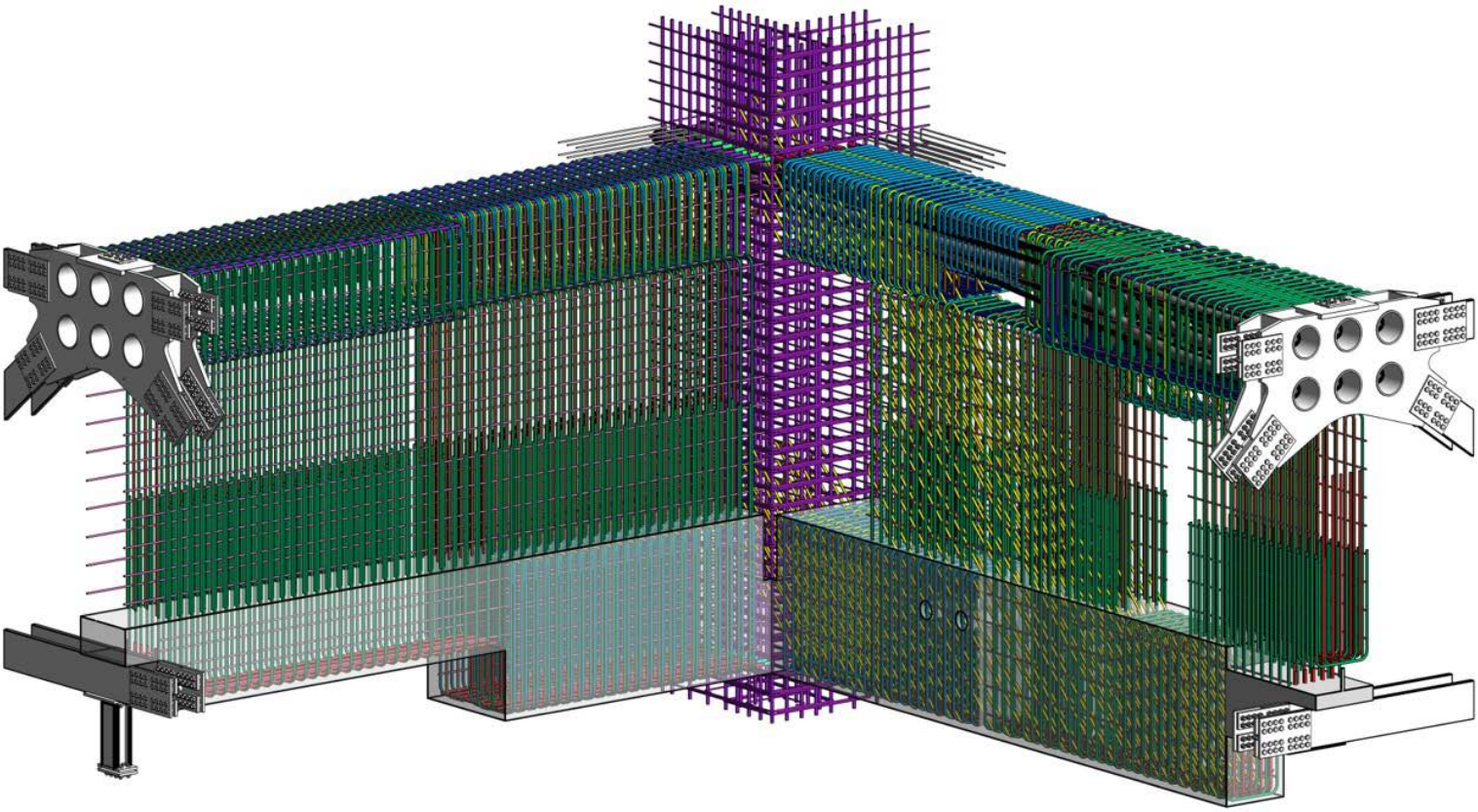
The COB3 building will redefine the San Mateo County Government Center with an iconic, forward looking design that reflects the values of the community. With a **mass timber/CLT structural system**, ultra-low carbon footprint, and net zero energy goal - the design will set a new standard for a sustainable, generational, civic building beyond the Bay Area.



The combination of steel bracing and concrete columns required careful detailing to compensate for the long term movement/shrinkage of the concrete columns for 800 Fulton Market in Chicago. The resulting **composite frame** is expressed as part of the architectural design, and lateral loading codes.

Advanced Project Delivery Tools

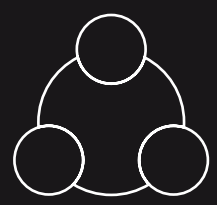
SOM engineers and digital design specialists utilize integrated Building Information Modeling (BIM) as an inherent part of our design and project delivery process.



Comprehensive Coordination, Detailing & Documentation Process

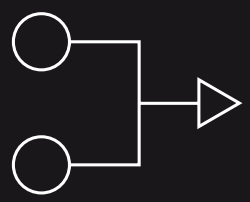
Schedule reduction through accelerated take-of, pricing, and shop drawing production, review and approval

Earlier and more accurate steel quantities and order placement



Creation of cloud-based tekla environment to facilitate SOM and contractor collaboration

Material cost and labor savings through optimized engineered connection design and detailing



Streamlined construction scheduling, erection, sequencing, and material tracking

Facilitating early-release packages

Integrated Project Delivery | BIM & TEKLA

SOM was one of the first firms to embrace BIM in early 2000. Our teams continue to be a key participant in defining the role of BIM in the industry in order to dramatically improve the efficiency of traditional design, documentation production, and the collaboration efforts of participating members of design teams. We utilize BIM technology to facilitate communication of design intent, collaboration between the design team and fabricator, and shorten the overall project schedule and cost.

The combination of our technical expertise, extensive materials research and imaginative structural solutions has resulted in award-winning, cost effective world-class projects. As industry leaders in the development, implementation, and advanced use of computational tools, SOM uses BIM as a fundamental part of our creative design and project delivery processes. We have a rich, 40-year legacy of computational design, being one of the first firms to embrace modern BIM, and we continue to define its role within the architectural and engineering industry.

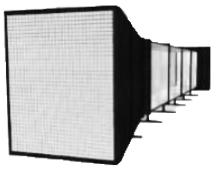
We use BIM to dramatically elevate the efficiency of traditional design, documentation production, design team collaboration, and construction administration coordination. Our engineers collaborate with some of the world's top structural engineering universities, to perform pioneering research in structural system optimization. Starting from the conceptual design phase of a project, SOM applies advanced research findings utilizing structural topology optimization and advanced mathematical principles to inform the architectural aesthetic and structural system design of projects. These efficient structural systems reduce the cost of structures, and facilitate their constructability.

For complex steel connections, our TEKLA Integrated Delivery Process presents an optimal solution to ensure quality and precision through integration. SOM is implementing innovative project delivery methods that considerably shorten the time from conceiving complex geometry, to documentation, and to the completion of construction.

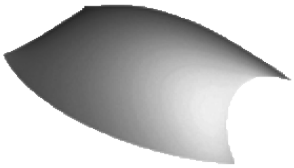
SOM is leading the industry by creating the 3D Steel Detailing Model simultaneously with the production of construction documents. The Detailing Model is then used during the bidding process to give all parties a more accurate scope of the project, with better understanding of quantities and design.

SOM Tool Set + Knowledge

SOM has developed several advanced structural analysis tools in-house to assist in better project understanding and solutions. SOM has the ability to adapt and further develop these tools as required for each specific project.



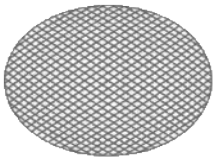
WIND TUNNEL
Exclusive Hardware



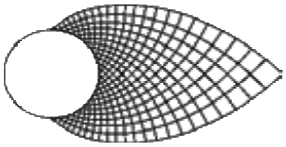
SURFACE OPTIMIZATION
Exclusive Software

POLYTOP
Academic Software

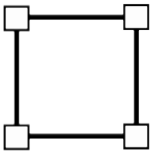
TOP3D
Exclusive Software



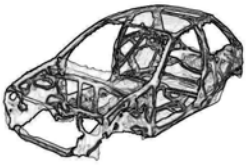
GRID OPTIMIZATION
Commercial Software



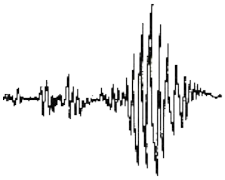
MICHELL TRUSS
SOM Knowldge



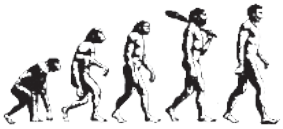
BUILDING FOOTPRINT
SOM Knowldge



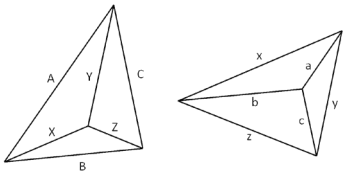
ALTAIR
Commercial Software



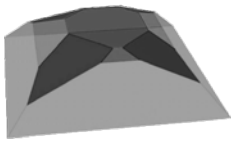
SEISMIC DESIGN
SOM Knowledge



GENETIC ALGORITHMS
Common Software



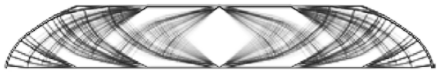
GRAPHIC STATICS
SOM Knowldge



AIRY'S STRESS FUNCTION
SOM Knowledge

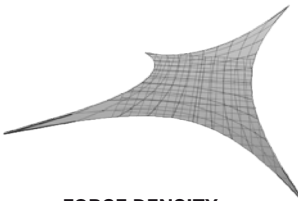
TIMBER
SOM Knowledge

PRINCIPAL STRESS
SOM Tool

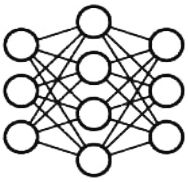


GROUND STRUCTURE
Exclusive Software

3D PRINTING
SOM Knowledge



FORCE DENSITY
Common Software



MACHINE LEARNING
Exclusive Software

Commitment to Sustainability

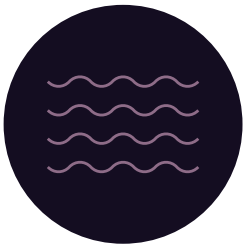
Structural engineers have an important role to play in mitigating climate change by reducing the impact the built environment has on our planet. We are committed to working towards a Net Zero Carbon Future and actively support the SE 2050 Commitment to eliminate the built environment's carbon emissions within the next decades.

10 Design Principles for Sustainability and Wellbeing

ECOLOGY
Leverage and Protect Nature

ECONOMY + EQUITY
Provide Low Carbon Urbanism for All

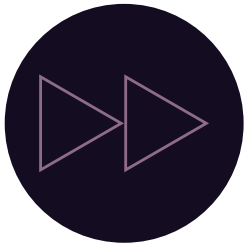
ENERGY + CARBON
Design and Deliver Net Zero Carbon Built Environments



WATER
Value Every Drop

RESILIENCY
Adapt for Climate Change

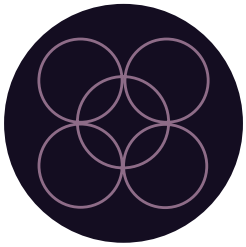
LIVABILITY + WELLBEING
Design Places where People Thrive



MOBILITY
Promote Sustainable Connectivity

MATERIALS + RESOURCES
Specify Responsibly and Prioritize Efficiency

WASTE
Do more with Less



HERITAGE + IDENTITY
Cultivate Authentic Connections

Above: Structural optimization has been a core means by which SOM has achieved sustainable buildings. The pioneering work of Fazlur Khan in the 1960's and 1970', seen with the braced tube system of 875 N Michigan Avenue and the bundled tube system of the Willis Tower allowed incredible heights to be reached with remarkable material efficiency.

Left: The LEED® Platinum certified Billie Jean King Main Library in Long Beach, utilizes timber construction and features rooftop photovoltaic cells, daylighting strategies, controlled air ventilation systems, and extensive glazing with architectural overhangs for solar protection.

Research and Innovation

Technological innovation elicits the creation of new architecture and efficient tools. Structural engineering research has been integral to SOM's practice, whether on a project basis, as an individual effort, or within a dedicated team, the firm's research processes are continually evolving.

Technological innovation drives the creation of new types of architecture. Research into new technologies, typologies, and materials is central to SOM's ethos and essential to the continued evolution of our profession. Importantly, this research is not undertaken in an isolated department, but by the architects and engineers that are engaged in projects—the people who can see an idea's potential. We are continually expanding the tools we can draw on; by harnessing the potential of computers and human ingenuity, we can explore completely new ways of thinking about sustainable design. We address a wide range of issues, from using artificial intelligence to quickly assess earthquake damage, to finding new ways to design efficient, enduring buildings, which use resources economically and provide inspiring places to live and work.

We collaborate with artists, manufacturers and academic and research institutions, including Princeton University, Massachusetts Institute of Technology (MIT), University of Cambridge, the University of Pennsylvania's Building Simulation Group, Virginia Tech Center for Design Research, University of Illinois, Georgia tech, Army Research Laboratory, Oak Ridge National Laboratory and Harvard's Graduate School of Design. These partnerships enhance our understanding and ability to advance new technologies throughout the design process.

Moon Village

SOM is working with the European Space Agency to design a concept for the first permanent human settlement in outer space. The visionary project brings experts from government, academic institutions, and private industry together to create a holistic vision for development on the lunar surface. Everything to support human life on the Moon will be designed—from a master plan for the settlement, to the habitat modules for its first residents.

Timber Vault

The Timber Vault installation part of our traveling strucutral exhibibtion seeks to revive this ancient masonry construction method, by applying advanced engineering techniques, creating an exceptionally efficient shell structure. The concept proposes a return to traditional building methods that can provide a solution for sustainable, low-cost construction alternatives.

SPLAM Timber Pavilion

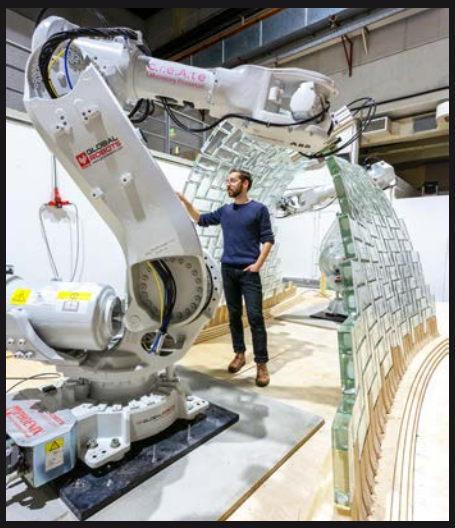
Exploring Future Construction Methods SPLAM is the result of a multi-year creative collaboration between SOM and University of Michigan Taubman College. The pavilion showcases the potential for prefabricated timber framing panels using robotic technology to advance more sustainable and efficient methods of design and construction.

Stereoform Slab

Steroform Slab is an exploration of the intersection between digital form-finding and advanced digital fabrication and robotics to expand the possiblities of what is possible in building construction. The result is 20% less concrete and a 20% carbon reduction than that of a conventional system.

AMIE 1.0

The Additive Manufacturing Integrated Energy (AMIE) demonstration project is a research and design collaboration of SOM and the U.S. Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL). Highly energy efficient, the 3D-printed building was designed by SOM to produce and store renewable power and to share energy wirelessly with a 3D-printed vehicle, which was developed by the



Glass Vault

The Glass Vault is one of our latest demonstration projects, using automated robotic construction techniques. The project is a joint effort between SOM and Princeton University c.r.e.A.te lab and Form Finding Lab, with advisement from the TU Delft Glass & Transparency Research Group.

Kinematic Sculpture

This morphing, 27-foot-long pavilion hovers above the landscape on the grounds of Los Angeles's Schindler House. Suspended from aluminum trusses and braced with steel wires, the double-curved kinematic structure is made of hinged and stiffened wood panels. The form of the pavilion is inspired by the mathematical relationships between force and motion: it can be expanded or contracted into a version of the original geometry with minimal effort.

Art Collaborations

SOM's structural engineers have developed tools, techniques, and approaches that have enhanced the impact of public art installed around the world.

From the monumental Picasso sculpture in Chicago's Daley Plaza, to Isamu Noguchi's Red Cube in Lower Manhattan, SOM's history of integrating iconic artworks into a wide variety of building sites is well documented. Perhaps less known, however, is the role that engineers have played in helping to realize various works of art. In some cases, SOM has developed structural engineering solutions for executing the artist's vision. In others, an exploration of technical issues has led the artist to refine or expand their ideas.

Some notable work includes collaborations with:

- Pablo Picasso
- James Turrell
- James Carpenter
- Inigo Manglano-Ovalle
- Janet Echelman
- Jaume Plensa
- Richard Serra
- Isamu Noguchi

"Weather Field No. 1," Iñigo Manglano–Ovalle

SOM used an advanced wind engineering approach to account for turbulence caused by the stepped arrangement of the poles, as well as for strains at the connection point between pole and base. Close collaboration between artist, engineer, and fabricator was key to the creative development and successful installation of this memorable piece of public art.

"Chicago Picasso," Pablo Picasso

Picasso's first monumental sculpture in America—known simply as the Chicago Picasso—designates the plaza in front of the Chicago Civic Center as a public gathering space. The sculpture stands 50 feet tall on a base of granite, and is constructed of the same Cor-Ten steel as the building behind it.

"Hope Tower," James Carpenter

SOM's work on the structure allowed Carpenter to focus on the tower's relationship to light. The steel panels are designed to reflect sunlight and atmosphere at different times of the day; by night, internal illumination transforms the tower into a lantern. Since its installation, "Hope Tower" has become a beacon on the campus and a gathering place for students, faculty, and visitors alike.

"Santa Monica Linear," Phillip K Smith III

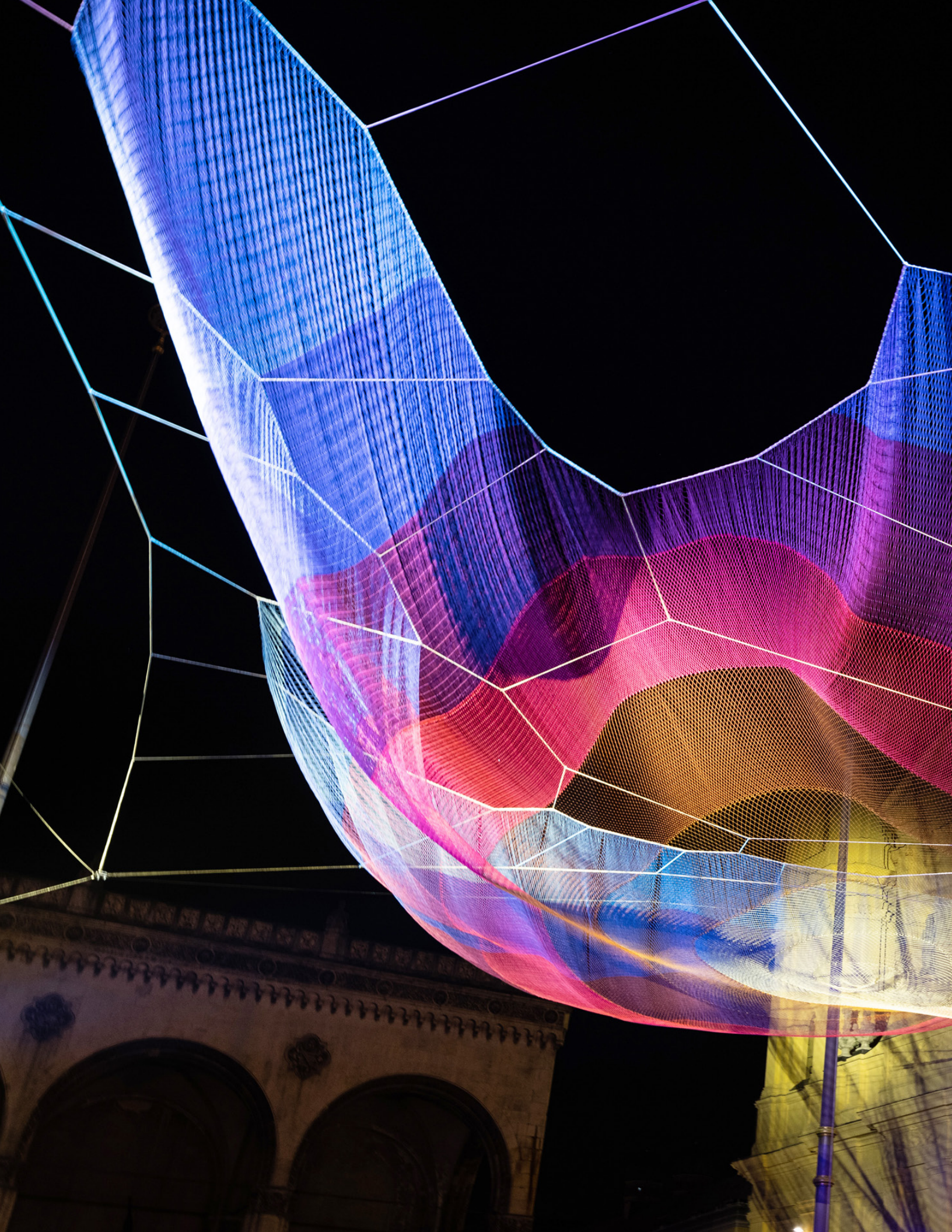
Santa Monica Linear is a site specific work commissioned by Dallas Price and Bob van Breda for their Santa Monica home and private collection. To help realize the artist's vision, our structural engineering team worked closely designing the 30-inch-long linear line of reflected sky inserted into a 110' wall of green. This SOM's first collaboration with artist Phillip K Smith III.

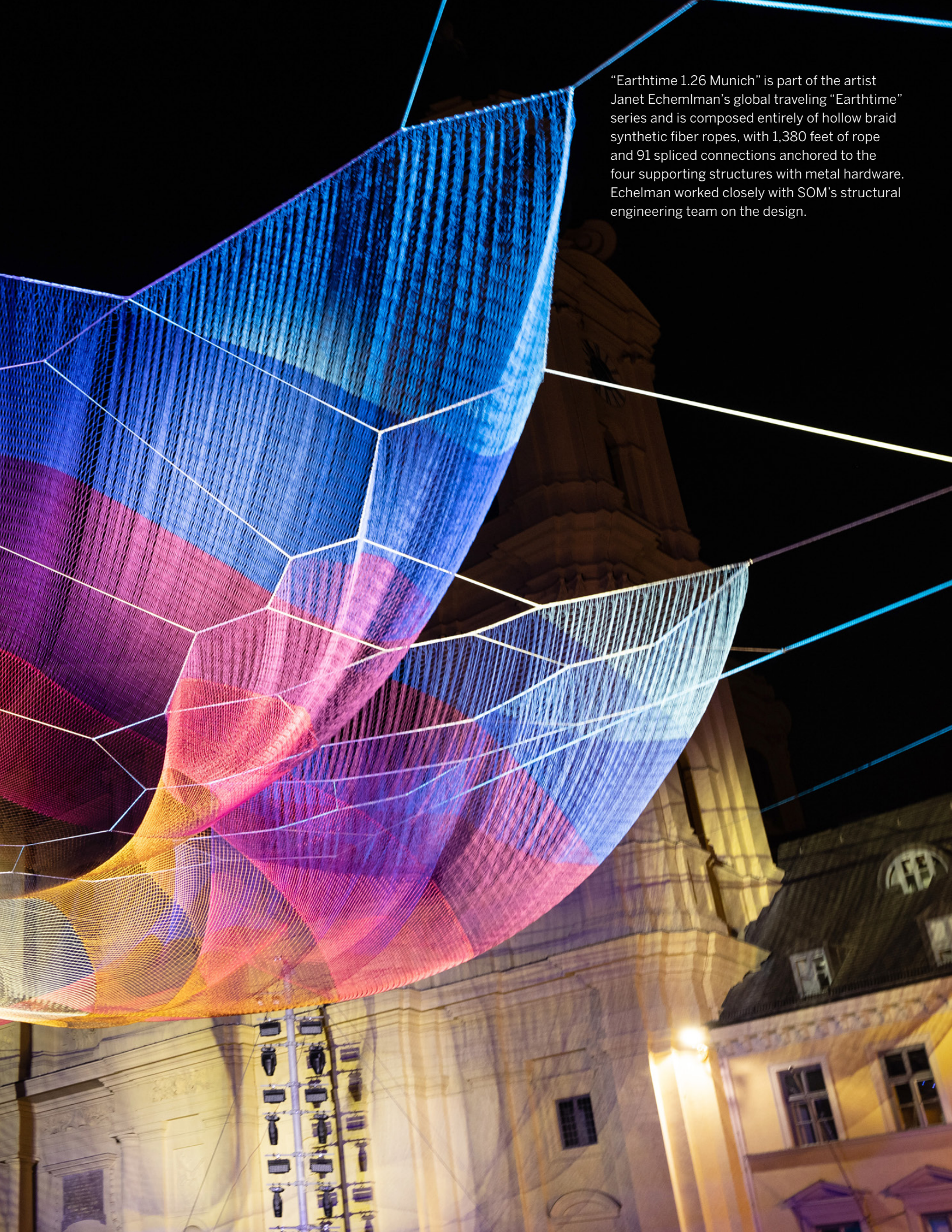
"Twilight Epiphany," James Turrell

The team created a supportive structure that allows for a gentle, imperceptible slope, which continues to taper off several feet beyond the primary steel until it meets at a knife-edge with the surface. The hidden frame creates a perception of the roof as a two-dimensional object, nearly floating above the mysterious earthwork and viewing chamber below.

"World Voices," Jaume Plensa

SOM worked with Plensa to perfect a structurally sound base (invisibly submerged within the poolvs), as well as the design of the tubes themselves. Staggered throughout the height of the lobby, the 196 cymbals of "World Voices" represent the number of countries in the world: a symbol of international collaboration befitting the Burj Khalifa's status as a global icon.





"Earthtime 1.26 Munich" is part of the artist Janet Echemlman's global traveling "Earthtime" series and is composed entirely of hollow braid synthetic fiber ropes, with 1,380 feet of rope and 91 spliced connections anchored to the four supporting structures with metal hardware. Echelman worked closely with SOM's structural engineering team on the design.

SOM

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