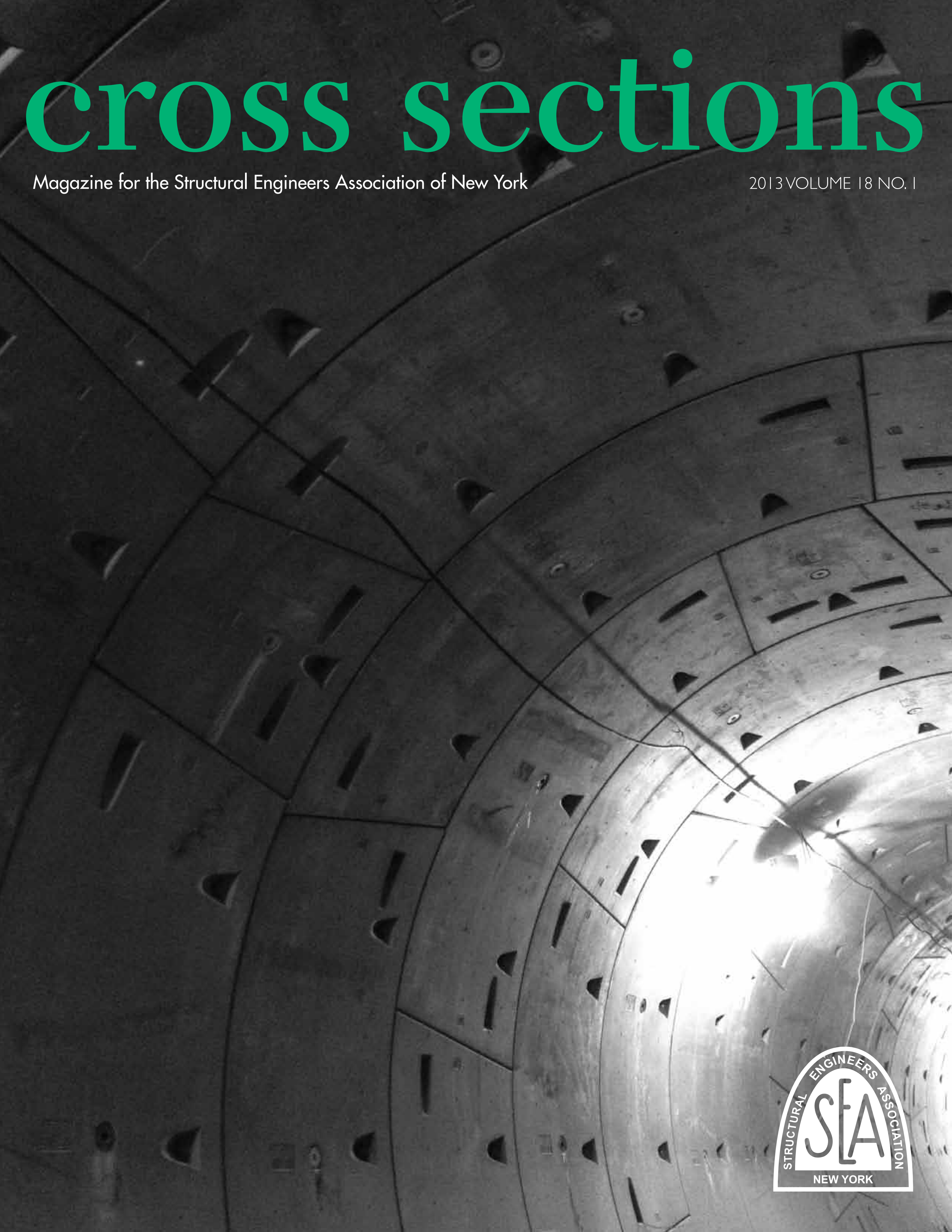
cross sections

Magazine for the Structural Engineers Association of New York

2013 VOLUME 18 NO. 1



STRUCTURAL ENGINEERS ASSOCIATION
SEA
NEW YORK

cross sections

2013 VOLUME 18 NO. 1

SEAoNY
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New York, NY 10012

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ON THE COVER

Interlocking precast panels line the inside surface of one of the new tunnels for the 7 train beneath Manhattan's West Side.

Photo: Allan James Olson

President's Message

Once again the New York/New Jersey region has had adversity thrust upon it. This time it was Hurricane Sandy, which made landfall over two days between October 29 and 30. While there is still a long way to go, the region is making progress towards recovery. And once again, the structural engineering community is leading the way. In our May 2010 issue of *Cross Sections*, we discussed ways in which structural engineers could get involved in responding to natural disasters. It appears many structural engineers in and around New York took advantage of the resources described in that issue, as the response to calls for assistance in the days and weeks following Sandy were truly overwhelming. On behalf of the SEAoNY Board as well as the New York City Department of Buildings, thank you all for your tremendous generosity and continued service to the community.

I would like to take this opportunity to welcome our newest Board members: Brian Falconer of Severud, Jonathan Hernandez of GMS, and Brad Kiefer of GACE. The Board is looking forward to another year serving the membership. One goal over the next year will be the continued implementation of the strategic plan created in 2011. Within this issue we have included some of the results of the survey that was sent out to the membership in 2011 and that helped inform the strategic plan. Please take a moment to learn more about the make-up and interests of the membership. In the next year we also hope to increase the number of social events for the membership to gather with colleagues from other firms. If you have ideas or suggestions for the organization, please contact a Board member or join a committee. And in the meantime, enjoy another excellent issue of *Cross Sections*.

Scott Hughes

Editor's Message

As we emerge from the wake of Hurricane Sandy, all of us at *Cross Sections* sincerely hope this Issue finds you well and safe. As civil engineers in the root sense (literally, those who engineer the built environment), we have a responsibility to protect the public from environmental hazards through our designs. We also have a responsibility to aid in recovery efforts when possible, as many of us helped to inspect the thousands of homes damaged by the storm. As we continue to assist in the aftermath, let us do all we can to safeguard the public through suitable design and sound advice.

In this Issue, we present highlights from last year's SEAoNY Member Survey as well as review the latest SEAoNY Strategic Plan. We discuss the infrastructure projects that have shaped our city both above and below ground, including the 7 Line Extension below Manhattan's West Side and the Lower Manhattan Expressway (which was never built, but influenced the city nonetheless). We then finish with a discussion of bridges, first a glimpse of the future with an overview of parametric design methods, and then a nod to the past with the latest installment of Structural Profile featuring the Hell Gate Bridge.

I would also like to welcome Justin Den Herder who will officially begin his tenure as the Editor-in-Chief starting with the New Year. As outgoing EIC, I'd like to thank our volunteers for a diligent and thoughtful two years. We have made great changes to the magazine since 2011, and I know Justin will continue to find ways to elevate what was, only 10 years ago, our humble community newsletter.

We hope you enjoy this Issue. If you have any comments or suggestions, or if you would like to write for us, or simply come to one of our monthly meetings to share ideas, please feel free to contact us at publications@seaony.org.

Very best,

Allan Olson

ADDENDUM

In our previous issue (Volume 17 No. 1), we omitted to mention that the base for the bird nest described in the "Nest Engineers" piece was designed by (human) engineer Liviu Schwartz, P.E. of Robert Silman Associates.

UPCOMING EVENTS

March 19 — **T.R. Higgins Lecture: Steel Plate Shear Walls**
Speaker: Dr. Michel Bruneau • Registration @ 5:45 | Lecture @ 6:15

March 22 — **SEAoNY Excellence in Structural Engineering Awards – Submissions Due!**

April 17 — **Post-Tensioned Concrete Core Walls**
Speaker: Steven Tipping • Registration @ 5:45 | Lecture @ 6:15

Visit **www.seaony.org/programs** for additional information!

SEAoNY's Three Year Master Plan

Aspirations for Future Growth and Development

Summarized By Justin Den Herder

In 2011 SEAoNY constructed a three year master plan that involved an introspective look into the organization with the purpose of determining how the various aspects of SEAoNY were functioning and how they could be improved. This plan was thoughtfully crafted amongst board members and was based largely on the results received from the SEAoNY membership survey completed in 2011. Some of the relevant results of that survey have been included in this issue. The board members, committee leaders, and volunteer membership are striving to see that this plan is successfully enacted.

One of the top priorities of the plan is concerned with increasing membership amongst younger engineers by having informed members continue to spread the word about SEAoNY within their firms but also to raise awareness of PDH-providing lectures to professional engineers in the region. The plan also hopes to improve the average attendance at presentations and lectures each year, and to increase their frequency and relevance to crucial industry related topics.

Another priority is SEAoNY's involvement in the city building code, a resolution that certainly carries weight in the wake of the most recent natural disaster. This precedence pushes for an Existing Building Code in New York City, hopes to include recommended industry practices into the code, and promises to continue providing proactive feedback for current and future code revisions.

SEAoNY is only as effective as its core group of volunteers and therefore encourages the continued support and volunteerism necessary to execute its ambitious plan, a plan that, when implemented will help improve the organization and allow it to continue to be a successful beacon for the industry of Structural Engineering here in the greater New York Region.

Justin Den Herder is a senior engineer at Robert Silman Associates in New York City.

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Contact us at **publications@seaony.org**
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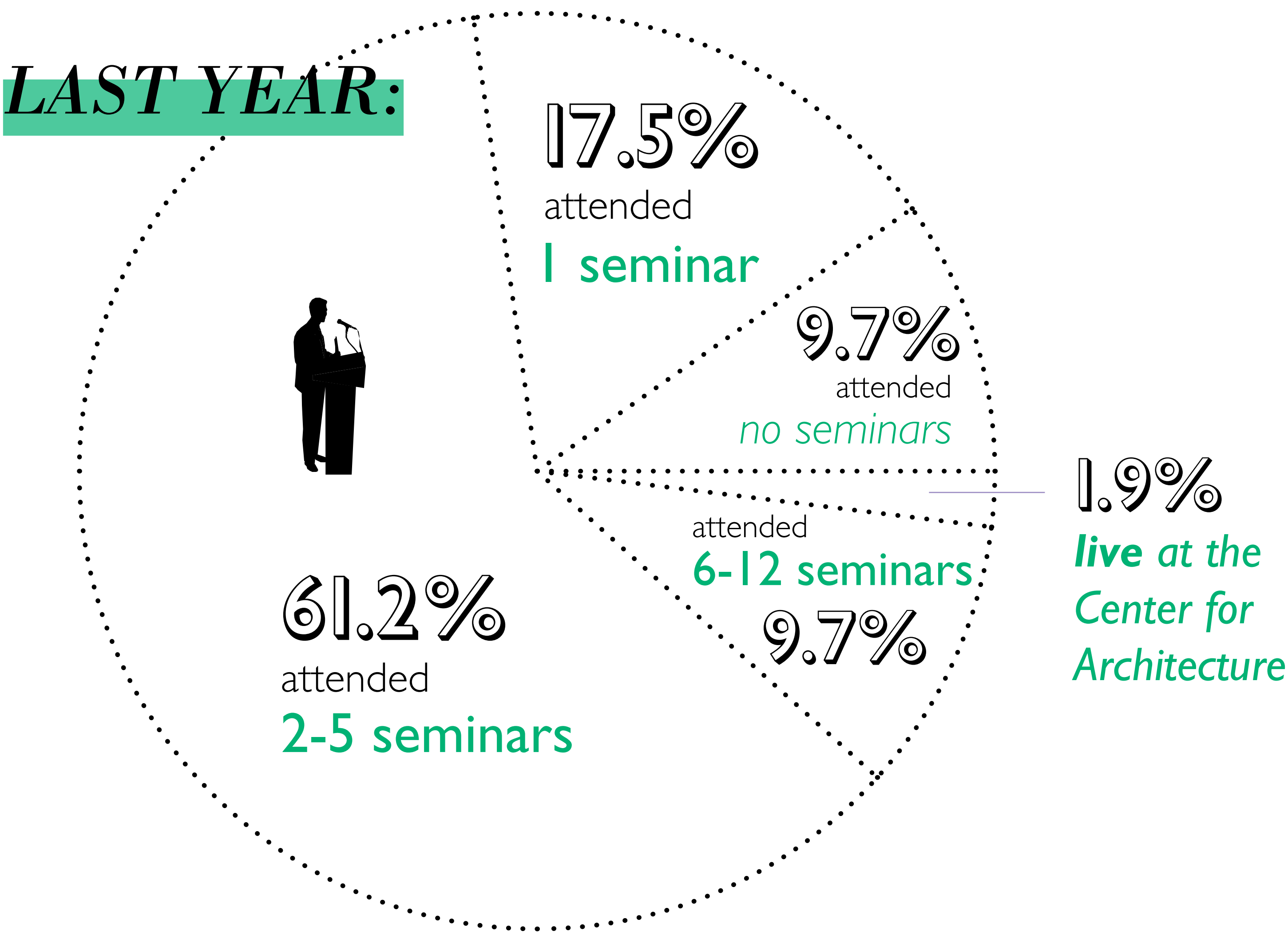
Highlights from the SEAoNY Survey

Compiled By Justin Den Herder

In conjunction with the SEAoNY Board's Three Year Master Plan, a survey was created and distributed to all members. The goal of this survey was to glean useful information about member demographics and to learn what needs the organization currently fills for our industry and in what aspects SEAoNY can better serve those needs. 106 members submitted responses to this questionnaire. Below, we have extracted some of the highlights from the survey results. Thank you for participating!



72.3%

find

TECHNICAL SEMINARS

most useful

62.5%

WORK AT

firms that pay for SEAoNY memberships

68%

WORK AT

firms that pay for SEAoNY seminars

55.9%

ATTEND SEMINARS

for

PDH credits

70.6%

ATTEND SEMINARS

to

keep up with the industry

41.6%

ATTEND SEMINARS

to

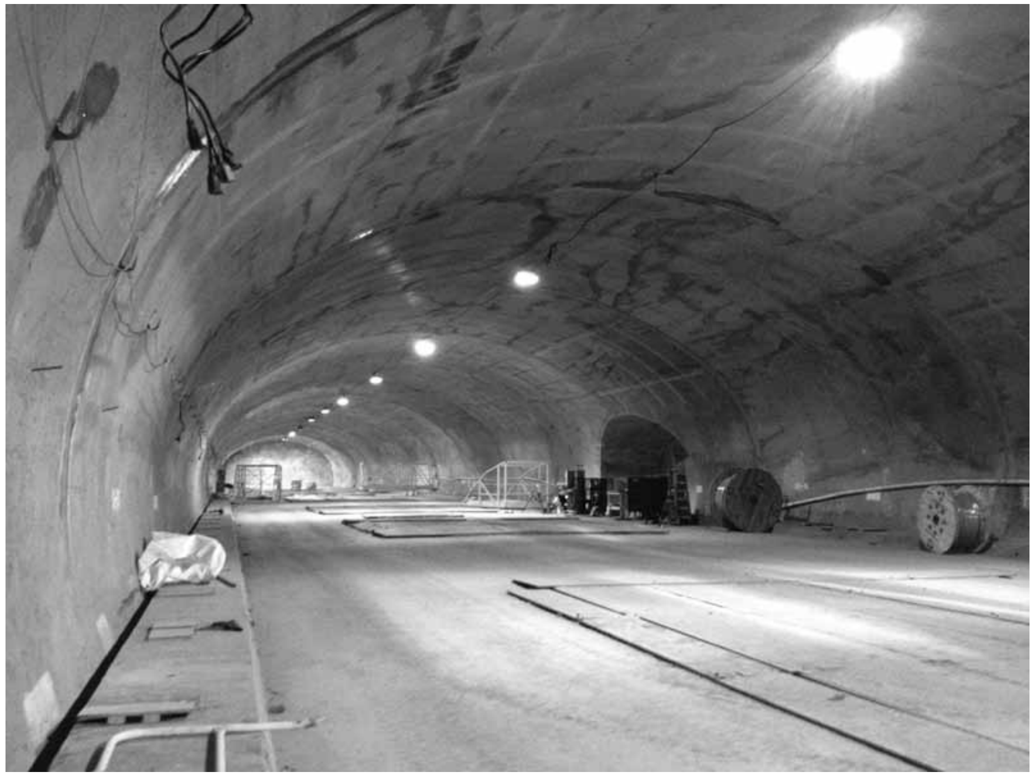
network with colleagues

MEMBERSHIP HISTORY

12.8%	19.1%	33%	35.1%
≤ 1 yr	2-3 yrs	4-8 yrs	> 8 yrs

BELOW LEFT
SEAoNY members began the tour at an access shaft at 34th St and 11th Avenue.

BELOW RIGHT
The first 1000 ft of the tunnels, including the entrance concourse pictured above, were created using the drill and blast method.



7 LINE EXTENSION TOUR

A chance to see what lies beneath

BY SARAH FITZMAURICE

IN DECEMBER 2011, the MTA generously guided an eager group of SEAoNY committee members through the newly-bored tunnels of the 7 Train subway extension, entering through the 70 foot deep pit near 33rd Street and 11th Avenue and emerging again at the Port Authority Bus Terminal. The $2.1 billion project, which kicked off at the end of 2007, will add one new station at 34th street and 11th Avenue, near Hudson Yards. The tunneling itself was recently finished, though there is still much to be done before the extension will officially be completed.

The 1.5 mile extension project includes 7,000 feet of tunneling, comprising two parallel tubes. The first thousand feet of tunnel near the future station at 34th and 11th Avenue were formed using the drill and blast method. The remaining length of tunnel was created using two tunnel boring machines, which lined the tunnel by installing interlocking precast panels.

LEFT
The portions of tunnel created by tunnel boring machines were lined with interlocking precast panels. SEAoNY members proceed north to Times Square through a recently lined tunnel.

ABOVE
The current end of the 7 Line tracks with the new trackbed pictured beyond. This portion of the tunnel passes directly beneath the tracks of the 8th Avenue line and required permanent underpinning of the existing tracks above.

Photos: Allan James Olson

The project has proven to be a unique challenge, given the proliferation of underground obstacles in this area, including numerous tunnels used by Amtrak to access Penn Station, as well as the Lincoln Tunnel itself. The tunnels had to be drilled deep enough to avoid these obstacles. At the crossing with the ACE line at 8th Avenue, the new tunnels pass so close beneath the existing tunnels that permanent underpinning was required.

The construction team had to take into account concerns over public safety and security, given the densely populated area, and worked closely with the city and with the MTA to ensure that the safety of New Yorkers was never compromised, even as work was going on just meters below their feet. Often, NYPD officers were stationed within the Port Authority Bus Terminal, tasked with remaining calm and appearing at ease in case any vibrations or noise from the construction were to send people into a panic.

This seemingly simple extension project creates the potential for future extensions, perhaps across the river to New Jersey. With the imminent construction of the Hudson Yards Redevelopment, the new station will certainly help to connect it to the larger transit grid of the city and further boost development in the area.

At the end of the tour, the group was taken up to the last stop of the 7 Train at 8th Avenue. On the walk over, I imagined how interesting it would be to see a real "cross-section" of the city, with all its interwoven tunnels hidden below ground. As I pondered this, a train rushed into the station, full of New Yorkers heading to work and tourists out for a leisurely stroll, people who are able to get where they needed to go thanks to projects enabled by innovative engineers.

Sarah FitzMaurice is a structural engineer at Robert Silman Associates in New York City.

How SoHo Survived

Preservation by way of near destruction

BY EYTAN SOLOMON

LEFT AND BELOW RIGHT
Soho's streetscape today.

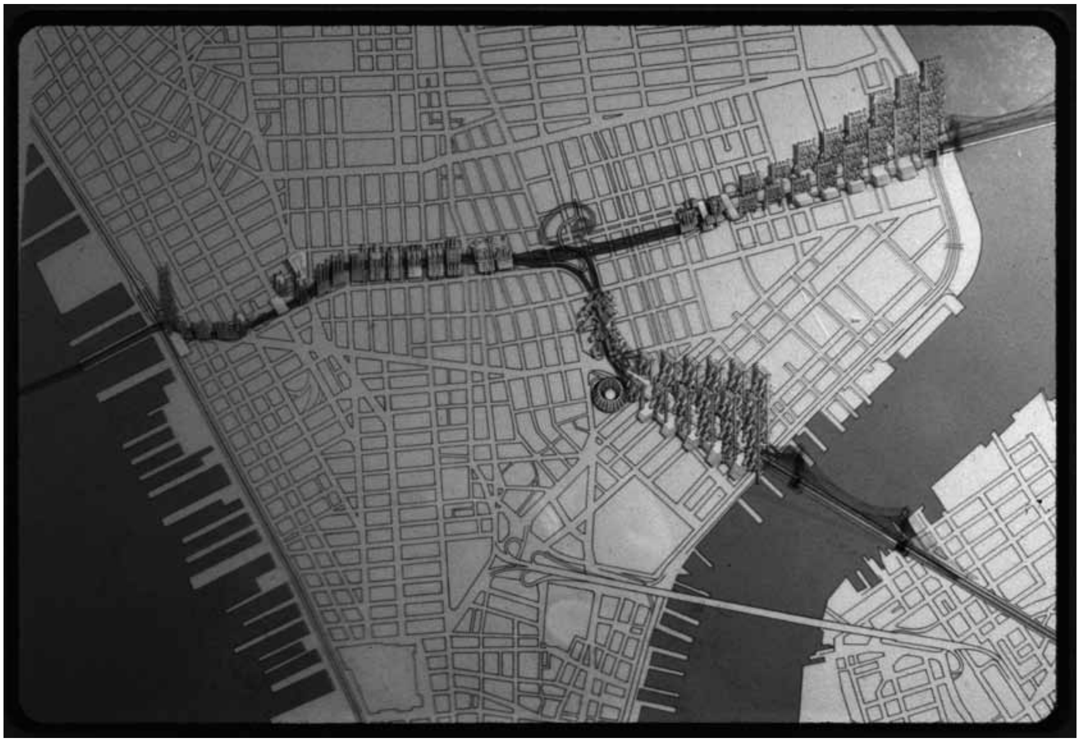
Photos: Adam Kirk

SOHO, the chic Manhattan neighborhood named for its location south of Houston street, today is famous for its trendy retail and art scene, cobblestone streets, and unrivaled collection of historic cast-iron architecture. Of the approximately 250 cast-iron buildings in New York City, more than half are in SoHo. The neighborhood stands as a testament to preservation of historic structures; though interestingly, the very reason it could survive is that for many years it was under threat of destruction.

Cast-iron as a structural material was pioneered in 19th century America, touted at the time as cheaper, stronger, safer, and more able to be artistically crafted than wood, brick, or stone construction. Architects, engineers, and builders dreamed that they could create just about any shape and detailing with cast-iron, and use it either as load-bearing elements, or as pure façade features, or as combined structure and architecture. However, a series of structural and fire failures, due to the material's brittleness and lack of tensile capacity, sobered these dreams. Still, properly built and protected structures were able to last, especially in SoHo where a thriving economy in the mid to late 19th century saw many sizable and ornate buildings constructed.

Around the turn of the century, SoHo experienced what we might call the bursting of its real estate bubble, as the city's economic center moved uptown and abandoned several downtown neighborhoods. After the world wars, much of the textile and manufacturing industries left the inner cities, and SoHo's buildings become occupied by warehouses, sweatshops, or unoccupied altogether. By the mid 20th century the neighborhood had taken on a nickname – Hell's Hundred Acres – reflecting its declined state and unsafeness. Because the area saw so little development during this time, most of SoHo's buildings were left alone in a virtual time capsule, though some were demolished to make way for gas stations and parking lots: This was a time when people in power focused their attention on the automobile as the future of transportation.

In the 1950's and 60's, with Robert Moses ruling New York City's urban planning, SoHo was eyed as



LEFT
1967 rendering of the planned route of the Lower Manhattan Expressway.

Image: Courtesy Library of Congress (http://www.loc.gov/pictures/item/2010647103/).

The "Lower Manhattan Expressway" mega-project was devised to connect the Holland Tunnel, Williamsburg Bridge, and Manhattan Bridge via elevated highways lined with new construction: the historic blocks of SoHo would be collateral damage.

a tantalizing potential link between the Holland Tunnel, the Williamsburg Bridge, and the Manhattan Bridge. This "Lower Manhattan Expressway" mega-project was devised to connect the three river crossings via elevated highways lined with new construction: The historic blocks of SoHo were to be considered collateral damage. With the neighborhood's economic poverty, and the threat of direct destruction by the impending Expressway, the lack of development continued and SoHo's buildings remained largely unchanged from the 19th century. As the highway plans took shape, no one with any influence felt the need to protect SoHo.

That is, no one but urbanist scholar Jane Jacobs, and the artists who had begun to move into SoHo's abandoned buildings. The nascent preservation movement within the city, still reeling from the loss in 1963 of McKim, Mead, and White's original Penn Station, rallied around the cause of protecting SoHo from through-highways. Mayor John Lindsay, initially a supporter of the Expressway, eventually changed his position, and the mega-project was shelved. In 1973, the neighborhood received landmark designation as the SoHo Cast-Iron Historic District.

Today the public can enjoy the cobblestones and cast-iron of SoHo, thanks to its curious survival through passive neglect and active preservation. Architectural designers, and structural engineers in particular, can appreciate the building technologies – innovations of their own time – that made possible its beauty.

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Eytan Solomon is a structural engineer at Robert Silman Associates in New York City.

Parametric Design

CREATING ADAPTIVE GEOMETRY

BY LANA POTAPOVA

WHAT is parametric design?

Modern information technology has drastically changed the way engineers visualize, model, and analyze their creations: three-dimensional modeling and analysis are common tools used by many leading designers. The next big wave is parametric definition of geometries and data. Parametric definition of calculations has caught on through the use of software like Microsoft Excel and Mathcad, but parametric definition of geometries has been much slower to develop. Nonetheless, the principle is the same, and that is to enable a flexible approach to design.

In basic applications, the parametric definition of geometries entails drawing the model through the use of coding language and a set of rules, as opposed to drawing static lines in a standard CAD package.

How can parametric design be used?

A parametric approach can be used for various aspects of design, such as rationalization of complex geometries, optimization, panelization, real-time visualization, and construction staging. One of the key reasons parametric tools have proved to be vital instruments of design is their ability to interact with design inputs and swiftly respond to changes.

Every project is a collaboration — every phase of a project has inputs that affect the design and drive the geometry of the structure. These inputs can constitute field data (from a geotechnical or site survey), data from other design disciplines (road alignment from a highways engineer), or data from an existing structure.

Creating a structural and visual 3-D model adaptable to input changes

The examples below demonstrate how a parametric approach to defining geometry provided the ability to easily respond to frequent changes by linking geometry to common design inputs.

The steel arch shown in Figure 1 was one of the alternatives considered for the Gateway Arch Project (project location not disclosed currently). The single arch that hops over the deck bridge form resulted as a means to mitigate views from the main highway to the bridge above with a severe skew. It provided an elegant solution; however, ensuring that it works with multiple constraints such as clearance and right-of-way limits could not have been achieved quickly without parametric definition of geometry (Figure 2).

The logic used to draw the geometry of this roadway bridge associates the deck and cable elements with the roadway alignment

Parametric tools have proved to be vital instruments of design by their ability to interact with design inputs and swiftly respond to changes.

and locates the arch anchor points flexibly (Figure 3). Due to a clash at the abutment with the existing road during construction staging, the alignment of the new bridge was shifted. New alignment 3-D strings, generated by InRoads, was imported and the bridge geometry regenerated within minutes.

In the same way that the designers could quickly generate multiple 3-D models of this bridge with different arch span-to-depth ratios (and correspondingly different cable arrangements), it was just as easy to produce 3-D structural models of these alternatives, as shown in Figure 4.

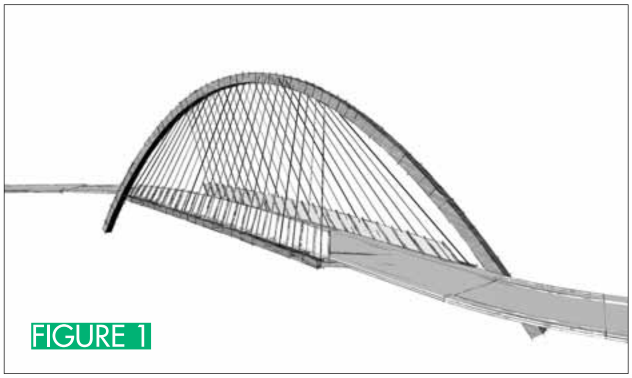
Upgrading the existing Milwaukee Avenue rail bridge into a trail for pedestrians (Figure 5) as part of Chicago's Bloomingdale Trail provided an opportunity to create a unique structure spanning over existing rail girders. One of the alternatives involved a structure that curves in plan and elevation, creating a unique individual shape for each rib supporting the trail deck. The ribs would not be difficult to fabricate once the schedule of shapes was supplied to the contractor; however, drawing a new schedule every time a change occured would have been time consuming.

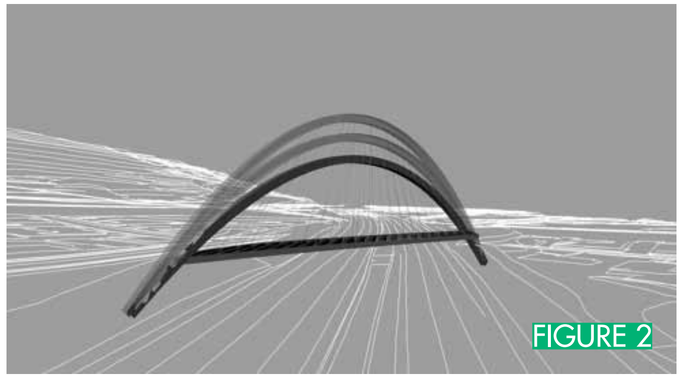
The code used to generate the 3-D model of the ribs at schematic design involved linking them to locations of existing girders and the proposed trail alignment. The shape would then be projected and mapped, creating a schedule (Figure 6). This would allow for an easily generated rib schedule following receipt of the final survey and determination of the alignment.

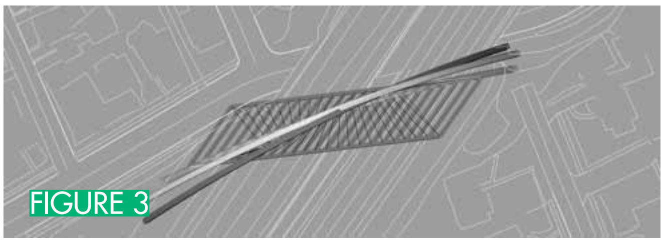
Conclusion

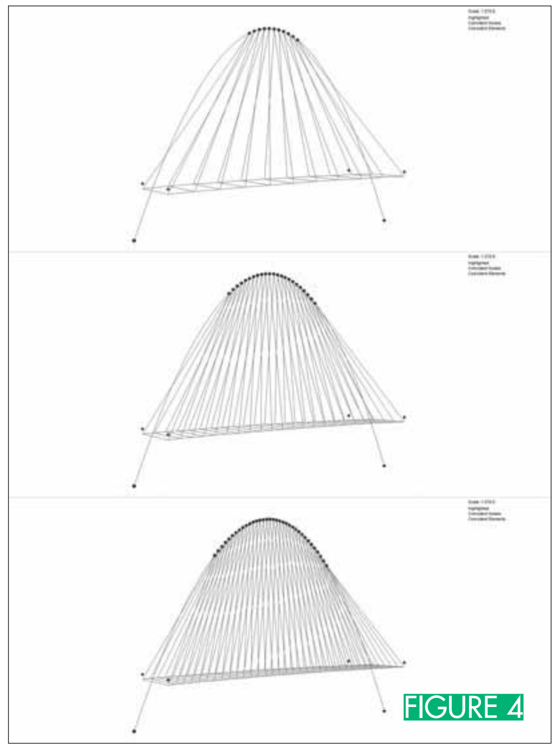
In new construction as well as additions to existing strucutres, the information technology revolution allows us to visualize, optimize, analyze, and build structures with more speed, efficiency and accuracy. Embracing this change in our industry encourages creative geometries and unique solutions that were unrealistic with our old approaches.

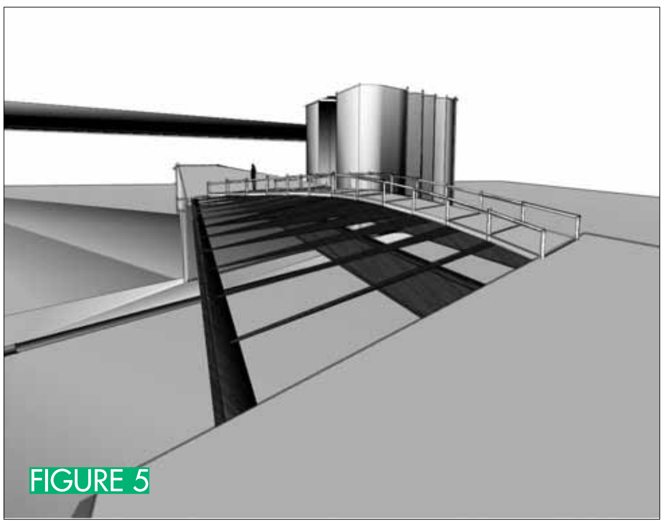
Lana Potapova is a structural engineer at Arup in New York City.











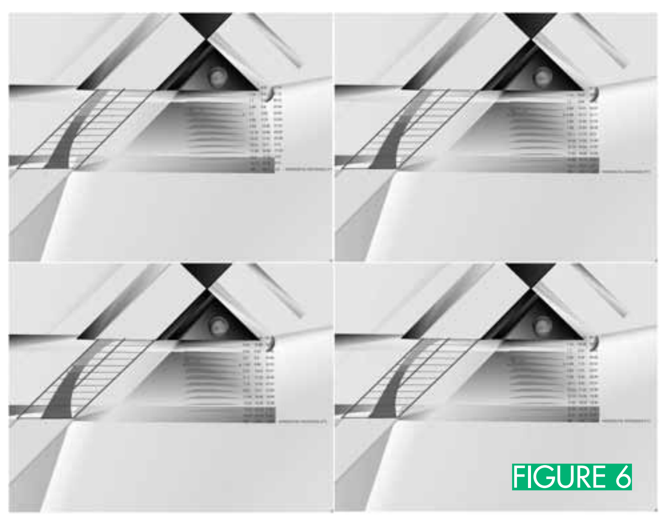


FIGURE 1
Gateway Arch Project, undisclosed location, USA

FIGURE 2
Various arch span-to-depth ratios are explored by regenerating the same model with different inputs

FIGURE 3
Flexible arch anchor points are shifted around to fit around the new alignment

FIGURE 4
Parametric definition extends beyond a 3-D visualization model; a flexible structural model is created through a plug-in linking analysis software to parametric code, thus allowing an update in the structural model as various cable spacing is explored

FIGURE 5
Bloomingdale Trail concept, Chicago, Illinois

FIGURE 6
Linking construction drawings showing shapes and a schedule of dimensions to a 3-D model eliminates the need to update drawings as design changes occur or field information, such as existing girder location, is verified.

RIGHT
The massively graceful trussed arch profile of the Hell Gate Bridge has carried railroad traffic across the Long Island Sound for almost 100 years.

Photo by Adam Kirk

A MONUMENT TO THE GOLDEN AGE OF THE RAILROADS

The Hell Gate Bridge

BY ALICE OVIATT-LAWRENCE

RAIL TRAFFIC around the soon-to-be-created New York City was booming; the Pennsylvania Railroad wanted to expand, and it needed bridges to do so.

Gustav Lindenthal, by 1885, working from his homebase in Pittsburgh, had developed into a leading national bridge engineer. Seeking even wider recognition at the level of the brand new Brooklyn Bridge [Roebling, 1883], Lindenthal confidently submitted proposals to the Pennsylvania Railroad and unsuccessfully sought municipal funding for several visionary New York City river-spanning bridge ideas.

One such river pass, the Hell Gate channel, had been excavated in the 1870s by blasting away 9454 cu. yd. of rock to provide capacity for growing river traffic.Lindenthal knew by 1890 that the Pennsylvania Railroad was considering a bridge over the deep, 850 ft. wide hazardous Hell Gate waters to connect trains from New Jersey, through Manhattan, and northward.The proposed bridge would span between Queens and New York County's Ward's and Randall's Islands, then into the Bronx, and there connect with tracks to Long Island and New England.

Lindenthal worked to convince the Pennsylvania Railroad to use one of his designs for the rail bridge at Hell Gate. Competition from other engineers includedOliver Barnes' proposal fora cantilever bridge in 1892 and Alfred Boller's 1900 cantilever design.

Lindenthal moved to New York City and between 1902-1904 served as Commissioner of Bridges. In his tenure he would finish the Williamsburg Bridge [L. L. Buck, 1903], and oversee the start of what would be a slow-going Manhattan Bridge design and construction, among other bridge projects.

At his term end, he was appointed to direct the Hell Gate bridge project as Consulting Engineer and Bridge Architect in 1905. With the Pennsylvania Railroad financing the project, and after first considering a three-span continuous truss and a three-span cantilever design, Lindenthal presented two steel-arch designs: one, a "crescent" arch design (with the top chord of the arch termini converging into a point) and the other a "spandrel" arch design (with the top chord of the arch termini splaying apart).

ABOVE
In the 1990s, the rusting Hell Gate was scraped and repainted for about 45 million dollars, the scraping alone being a third of the expenditure. This fact speaks to the inefficiency of the design in comparison to bridges of similar span and function.

Photo © Dave Frieder, all rights reserved. www.davefrieder.com

The Hell Gate Bridge was the longest and most heavily loaded railroad bridge in the world when it opened in 1916.

Once Lindenthal's design was chosen, he faced futher challenges: it was mandated that there would be no piers or falsework in the water to avoid blocking the water traffic under the bridge's 135 ft. vertical clearance. To aid in meeting these challenges, Lindenthal hired Othmar Ammann (a Swiss bridge engineer and future designer of a number of New York City's major river crossings including the Verrazzano Narrows and George Washington Bridges) and David Steinman (also a notable future bridge designer) for engineering assistance, Henry Hornbostel (architect of the Williamsburg Bridge and other notable structures) for the masonry tower design, and a staff of 95.
The resulting length of the continuous,two-hinge arch bridge is 977 ft. between towers, and 1017 ft. long including the 2 end towers. Today, some assert that the towers provide no structural support for the bridge, however Lindenthal believed and stated that they were necessary "for the thrust of the arch to be properly resisted". The lower chord of the bridge is hinged at the abutments where the force equals 28,652 kips, or 94.4% of the total chord force. The overall length, including the approaches, is 2.5 miles [16,900 ft]. The 100 ft. wide bridge has four rail tracks with a loading capacity of 24,000 lbs/sf.

More steel [20,000 tons] was used in the Hell Gate than in the Queensboro [Lindenthal, Hornbostel, 1909] and Manhattan Bridges [Moisseiff, Carrère & Hastings, 1909] combined. Some steel members used were 'double weight' of those previously used, to ensure support for locomotive live loading.

In 1914, when construction began, Lindenthal's 1907 original plans showing steel girders and piers in the viaducts were changed to concrete, after authorities balked that inmates from the two state institutions located on the islands beneath the bridge might be able to escape by climbing up the steel truss piers.

With the foundations finished in 1914, two steel ends met in the middle over the Hell Gate waterway in 1915 and during the next year the viaducts and the arch bridge were finished. It was the longest and most heavily loaded railroad bridge in the world when it opened in 1916, accomplished for $20 million dollars.

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