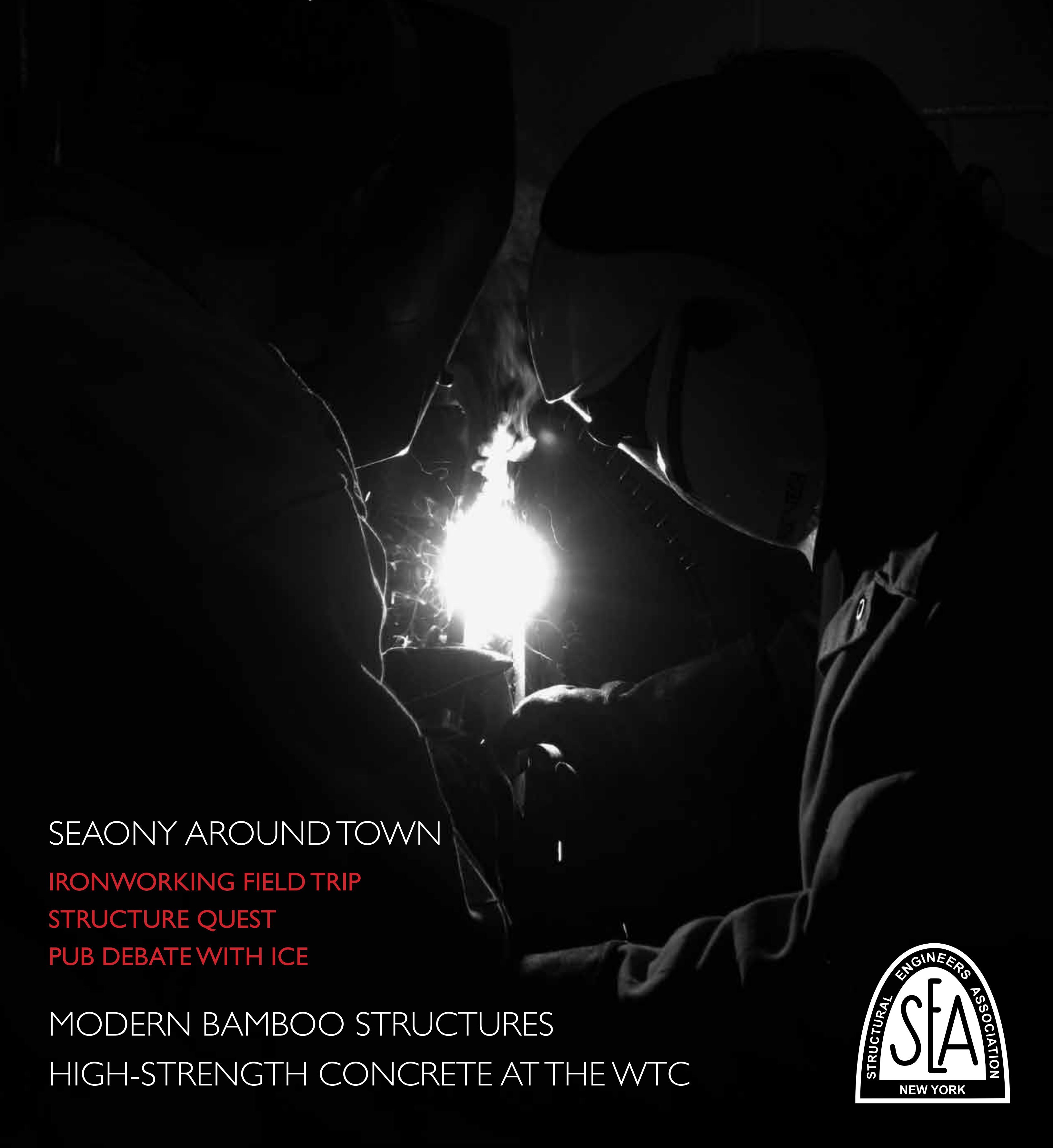
cross sections

Newsletter for the Structural Engineers Association of New York

SUMMER 2011 / VOLUME 16 NO. 2



SEAONY AROUND TOWN

IRONWORKING FIELD TRIP

STRUCTURE QUEST

PUB DEBATE WITH ICE

MODERN BAMBOO STRUCTURES

HIGH-STRENGTH CONCRETE AT THE WTC

STRUCTURAL ENGINEERS ASSOCIATION SEA NEW YORK

cross sections

SUMMER 2011 / VOLUME 16 NO. 1

SEAoNY
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CONTENTS

ON THE COVER

An ironworker from Local 40 & 361 teaches proper welding technique to a local engineer.

Photo: Eytan Solomon

President's Message

How can SEAoNY better serve you? How can we push the boundaries and offer programs that appeal and engage? These are the questions that we have been asking at the Board as we enter into the summer months. Soon we will send out a survey to ask you for your input.

Over the past few months, SEAoNY has offered varied programs and initiatives aiming to achieve a balance of the technical and social, keeping events fun and lively while offering opportunities for professional growth and collaboration with fellow engineering societies. In this edition of Cross Sections, we recap the debate at a local pub with the Institute of Civil Engineers, a welding workshop with ironworkers, and a scavenger hunt with the Met Section of the American Society of Civil Engineers and two local universities. Although not included in this newsletter, Tim Lynch also presented in May to an audience of engineers, contractors, and property owners a seminar on building facades and the Department of Buildings. In addition, we had our first Honorary Member Lecture, in which Richard Tomasetti discussed the limiting design factors for tall buildings. Earlier this month, a panel from the Forensics Group of the ASCE Met Section probed into the potential causes of a wind-induced structural failure and discussed the subsequent investigation. We also cruised in New York Harbor and dined in style while the winners of the Excellence in Structural Engineering Awards were announced. Finally, we finished this month with the SEAoNY Golf Scholarship Outing that took place on a beautiful sunny day in Mahopac and raised funds for three scholarships. As you can imagine, SEAoNY volunteers have been busy, and I thank all of you who have worked hard to make these important events happen.

Where do we go from here and how do we get better? We ask you not only for your support and energy but also for your ideas. Please participate in the survey or send me email. Together we can build a better future for the New York structural engineering community.

- Kevin Poulin

Editor's Message

It is sometimes lamented that structural engineering is an overly specialized profession. As engineers we often find ourselves fighting the stereotype of the bean-counter in a cubicle; someone who only sees what's on paper, or a computer screen, and does not grasp the workings of the real world which is rich in diversity of viewpoints and opinions. How do you fight the stereotype? By constantly pushing the boundaries of your own experience, pushing yourself to communicate effectively with engineers and non-engineers alike, and continually finding new means of self-education within and without the office - and not just for your PDH count.

And so in this edition of Cross Section, we showcase three recent "extra-curricular" activities, and two more articles at the technical boundaries of the industry. Jennifer Pazdon, George Hummel, and Victoria Ponce de Leon recap three fascinating SEAoNY events from the last few months, all of which collaborated with other industry groups: A spirited public debate about the technical and cultural legitimacy of skyscrapers (with the Institute of Civil Engineers), an exciting hands-on workshop at the Ironworker 40/361 training facility (with the Steel Institute of New York), and the "Structure Quest" scavenger hunt for local college students (with the American Society of Civil Engineers Met Section).

In our extended feature on the topic of bamboo structures, we exhibit three manifestations of this timeless and timely construction material: Rebecca Buntrock describes the work and recent lecture by Simon Velez, Scott Hughes guides us on a photographic journey through the sensational Big Bambu installation on the roof of the Metropolitan Museum of Art, and Rob Otani shows us an intriguing project called the Transformative Kayak. And in a topic near the heart of all New Yorkers, Marco Pirozzi takes us up close and personal with the latest ultra-high strength concrete techniques at the city's most famous construction site.

Finally, I would like to formally welcome Allan Olson as the new Editor-in-Chief of SEAoNY Cross Sections and chair of the Publications Committee. It has been my honor and pleasure to serve this role for the last two years, and I look forward to staying involved under Allan's leadership. I encourage everyone to join the efforts of our "Pubs" group, or any of the other committees, as SEAoNY marches on to become an even stronger presence in the industry.

- Eytan Solomon

call for writers *(and nonwriters!)*

Interested in writing about our profession?
Do you have great ideas, but no time to write?

Contact us at **publications@seaony.org**
Check out previous issues at **seaony.org/publications**

*Our next content deadline is **August 31st.**

Pub Debate with ICE

Are tall buildings an extravagant waste?




LEFT
From left to right: Zak Kostura, Chris Cerino, Linda McKenna, and Daniel Urrutia.

BELOW
Audience members join the debate.

Photos: Richard Giffen

IK Brunel's Great Western Railway operated with a "broad" rail gauge of 7' ¼" beginning in 1838. Meanwhile, the first main line railway, George Stephenson's Liverpool and Manchester, ran on a 4' 8 ½"' "standard" gauge. The mismatch meant that passengers and goods were forced to transfer when traveling between the North and the south-west. It was not until 1855, through an act of Parliament that the Gauge War was ended and rail gauges standardized throughout the modest-sized country.

One might say it was only a matter of time before the descendants of these opinionated British engineers would meet with the similarly discursive structural engineers of New York. On March 29th, meditative engineers from SEAoNY and the Institute of Civil Engineers (ICE) gathered at the 12th St Bar to debate a modern issue in engineering: Tall Buildings are an Extravagant Waste.

Two volunteers from SEAoNY, Zak Kostura and Past President Chris Cerino, were paired respectively with two ICE members, Linda McKenna and Daniel Urrutia. Kostura and McKenna argued for the motion, while Cerino and Urrutia argued against. The debate was moderated by current ICE Chairman, Richard Giffen.

- Jennifer Anna Pazdon





Welding Seminar with Ironworkers Local 40 & 361

Learning the nuts and bolts of steel work

LEFT
Attendees tried their hands, and the rest of their bodies, at plasma-cutting (far left) and column-climbing (left) among other activities.

Photos: Eytan Solomon

On March 10, SEAoNY joined the Steel Institute of New York for an engineers' field trip to New York City's training facility for ironworkers. After a brief introduction about the history and functions of the Local 40 & 361 Ironworkers Union, we split up into small groups and rotated between various stations, where experienced welders demonstrated the use of their tools of the trade.

Willing volunteers were able to try their hand at shielded metal arc welding (stick welding), gas metal arc welding (auto-wire-feed welding), using a plasma cutter, and climbing a wide-flange column. Some were surprised to find they had natural talents, while others… not so much.

- George Hummel

"Structure Quest" with ASCE Met Section

Scavenger hunting with local engineering college students

FAR LEFT
Cooper Union students pose in front of the Brooklyn Bridge.

NEAR LEFT
Manhattan College students pose with the Flatiron Building.

The SEAoNY Education and University Outreach Committee, in conjunction with the ASCE Met Section, the Cooper Union for the Advancement of Science and Art, and Manhattan College organized and sponsored the first "Structure Quest" event on April 2, 2011.

Students from the Metro-Area universities were invited to participate in this structural scavenger hunt throughout Manhattan. Each group of students was given a series of clues about structurally and historically significant buildings and bridges in Manhattan. The groups had 5 hours to visit the structures, take required photos, and find examples of various engineering feats such as "Built-Up Columns" and "Link Beams." Each group was escorted by a SEAoNY member to help answer the tougher questions.

When the groups completed their hunt, they gathered back at the Cooper Union's Rose Auditorium where pizza and refreshments were waiting. Points were tallied, and Cooper Union's group was hailed the winner of the first Structure Quest!

The Committee plans on organizing another Structure Quest this fall. This time, all SEAoNY members will be invited to compete against or with the universities. If you are interested in getting involved with the event or attending, please email seaonyeducation@gmail.com.

- Victoria Ponce de Leon

Simón Vélez's Bamboo Structures

By Rebecca Buntrock

Simón Vélez, an architect who has pioneered the use of bamboo as a structural building material, presented and discussed his work at a lecture at the Cooper Union moderated by SEAoNY member Nat Oppenheimer. Vélez, a native of Bogota, Columbia, first began working with this locally available material nearly 40 years ago and today is regarded as one of the foremost experts on bamboo architecture. His completed works encompass a wide range of typologies, from low-cost housing to long-span bridges to temporary structures. Signature projects include a bamboo pavilion for the Expo Hanover 2000, the Zocalo Nomadic Museum in Mexico City, and the Crosswaters Ecolodge in the Guangdong Province of China. The Crosswaters Ecolodge was notably the first bamboo structure in China, a country known for using bamboo for everything but buildings.

Vélez opened his lecture by implicitly stating that he does not consider himself to be a bamboo architect; very simply, he is an architect that happens to occasionally work with bamboo, amongst other materials. Despite this claim, it was clear that Vélez is dedicated to making bamboo a fashionable and viable building material, due in part to its critical importance as part of a sustainable future. As a building material, bamboo is uniquely strong in both tension and compression, up to eleven times the strength of steel. Bamboo is also rapidly renewable, with some species growing up to one meter per day. Interestingly, the strength of bamboo varies considerably based on location; Vélez commented that the bamboo in Columbia is significantly stronger than that in China.

Simon Vélez's success with using bamboo as a structural material began as collaborations with engineers and builders and was largely a result of trial and error over the course of his career. Since there are no standards for the structural performance of bamboo, load testing is typically necessary to confirm structural capacity and obtain building permits. Nat posed the question, is bamboo as a structural material being researched from a purely analytical perspective anywhere? No, according to Vélez, which is a hindrance for newer engineers and architects, as this necessitates years of practical experience rather than gaining an educational foundation early on in one's career.

Vélez's philosophy is to consider "aesthetics, statics, and ethics" as the driving force behind any and all designs. As such, the form of his design typically reflects its structural function, keeping most of the members efficiently in tension or compression with minimal zero-force members. He has developed a mortar-filled joinery system, where bolted joints are filled with mortar to keep the bolts from crushing the walls of the bamboo. Vélez keeps his drawings simple, typically freehand and color-coated on letter-sized graph paper, which his experienced team of builders can easily interpret. Drafters and computer renderings are only engaged when absolutely necessary for building permits.

His works have brought bamboo into the public eye and have inspired a new generation of architects and engineers; it will be interesting to see how bamboo as a structural material continues to progress.

> " Bamboo is uniquely strong ... up to eleven times the strength of steel.

RIGHT
Simon Vélez (right), and moderator Nat Oppenheimer (left) discuss Vélez's work.

Photo: Rebecca Buntrock

Bamboo is one of the oldest known structural materials on Earth, yet people are still discovering (or rediscovering) novel uses for it in today's world.

"BIG BAMBÚ"

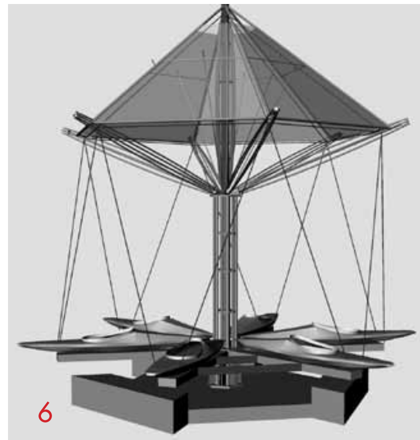
THE "TRANSFORMATIVE KAYAK"

1 + 2
Big Bambú on the roof of the Metropolitan Museum of Art was a sculpture created by twin brothers Doug and Mike Starn of Beacon, NY. It is made entirely of bamboo poles lashed together with mountain climbers' rope. There are several different types of bamboo, all shipped from bamboo farms in South Carolina and Georgia. There is a trail winding through the piece that is open to the public, and load tests were performed to verify structural adequacy. The sculpture was constructed by as many as 17 mountain climbers at a time, and was also not a static sculpture. During the time of its exhibition at the Met (April to October of 2010), the climbers continued to add to the piece until the final day of the exhibit, when it was subsequently disassembled.

Photos: Scott Hughes

Bamboo Structures: H

5



6

BAMBOO SCAFFOLDING

7

3 - 6
The superstructure is comprised completely of wood and bamboo with primarily only rope lashing (thousands of feet of it) for the connections. The super light skin-on-frame kayaks (about 15 lbs each) made with western red cedar, bamboo plywood, and raw bamboo are connected with wood dowels and artificial sinew lashing with a ballistic nylon skin. The base platform is configured with benches filled with about 2,500 pounds of sand ballast to resist wind overturning. The roof is an extruded polycarbonate on lashed bamboo poles to provide some shade in the summer and to keep the kayaks dry. Hammocks complete the sculpture. It will be on display along with 15 other projects at Governor's Island through September 25, 2011.

Photos: Rob Otani

7
Bamboo scaffolding is an age-old construction technique, still in use today in Beijing, China (above) and other parts of the world.

Photo: Eytan Solomon

ere, There, and Everywhere

High Strength Concrete

at the World Trade Center Site

10,000 PSI AND MORE, AT THE WORLD'S MOST FAMOUS CONSTRUCTION JOB

By Marco Pirozzi

The Port Authority of NY & NJ has ownership of many of the construction projects in progress at the World Trade Center Site. Their knowledge and experience of concrete has been an important resource for the success of the many concrete structures being built there. The design engineers for the WTC Memorial, Tower 1 and WTC Transportation Hub specified structural elements that require high strength concrete (over 10,000 psi). A trend in the design community has been to specify concrete structures with a high modulus of elasticity, over 7 million psi, to reduce wind loading effects and column and core shortening due to creep. The Port Authority has been specifying concrete mixes that require pozzolanic substitutions for cement for over 20 years and realizes that these substitutions are the key to producing high strength concrete.

Low cement factors typically are a necessity to reduce the heat of hydration and in-situ temperature rise. The truth is counterintuitive when considering the constituents for high strength concrete in that high cement and cementitious contents are detrimental to high strength and durable concrete. Shrinkage and high curing temperatures are important issues that are associated with high cement contents and these need to be properly addressed in order to achieve high strength concrete. These substitutions will also produce higher in-place strength, less cracking, and eliminate potential for delayed ettringite formation. The low cementitious (paste) content and higher aggregate volume using aggregates with high specific gravity are the key elements which enabled us to achieve a concrete mix with a compressive strength over 14,000 psi.

The basis for consistent production of high-strength concrete starts with the proper concrete mix proportions, especially a good blend of cementitious material, cement, fly ash, slag and silica fume. The chemistry and particle packing of these materials is important since water demand and workability of the concrete is dependent on their interaction. A suitable blend of coarse and fine aggregates will facilitate easier placement, less segregation, and reduce the quantity of water and High-Range Water Reducer used. Finally, good quality control from the concrete producer provides assurance that the materials being used are not changing from those originally tested and approved.

Traditionally, concrete compressive strength has been specified at 28-days; however, with the high supplementary cementitious substitutions being used in high strength concrete, the specification age should be 56-days. This allows proper hydration of the fly ash and slag that typically do not gain strength as quickly as cement does.

As with any real life situation, issues arise where an adjustment may need to be made to the mix to enhance workability or extend set time. These changes should be done by the concrete producer, not the contractor since the producer has an intimate knowledge of his materials, and ultimately the performance of the concrete is his responsibility. The addition of water should only be done with proper testing before the start of the job. In the field, AASHTO T-318-Water Content of freshly mixed concrete using Microwave Oven Drying is the best test to determine how much water is in the concrete. For high strength concrete, air content should be kept under 2%, since for every 1% of air present in the concrete the strength will be reduced by 7%. Many high strength concrete mixes are being designed as Self-Consolidating to maneuver around the large volume of reinforcing bars present in the cores and shear walls of the structures. The difficulty of SCC is the tight envelope of flow that must be achieved to allow the concrete to travel within the forms without segregating and leaving stacked layers of aggregate and paste. Finally, some high-strength concrete sections are large enough where the temperature of the concrete is an important factor in determining ultimate strength. In these cases, temperature probes should be installed in the middle and surface of the elements to monitor the overall temperature rise and gradient between the core and surface.

As stated in ACI Committee Report 308 "Guide to Curing Concrete" -Section 1.3, "The key to the development of both strength and durability in concrete however, is not so much the degree to which the cement has hydrated, but the degree to which the pores between cement particles have been filled with hydration product. The degree to which the pores are filled, however, depends not only on the degree to which the cement has hydrated, but also on the initial volume of pores in the paste, thus the combined importance of the availability of curing water and the initial water-cement ratio."

The pore volume is reduced with low water content and better packing of cementitious materials. This allows the hydration product to

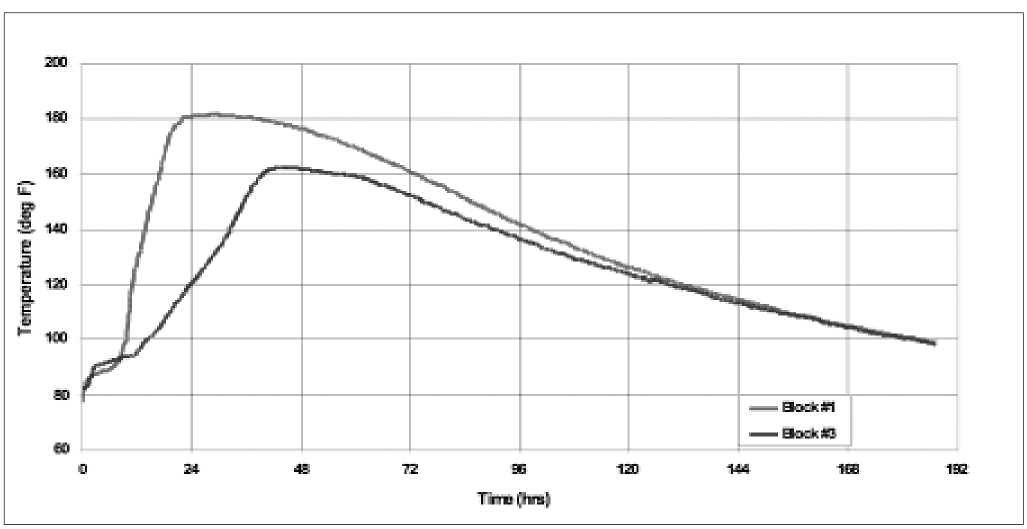


Chart 1
Internal Temperature of Mock-Up Blocks

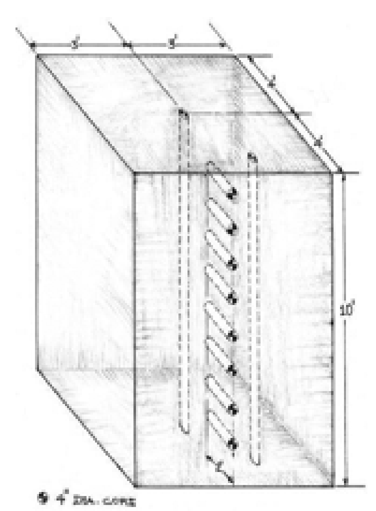


Figure 1
Sketch of Mock-Up Blocks and Coring Locations

LEFT
Rebar being laid out at the WTC site.

Photo: Timothy Schenck

> “ The average compressive strength at 56 days was 16,160 PSI.

fill the remaining voids thus creating a concrete paste with lower porosity. Compressive strength is also increased by reducing the water content and achieving a better packing of cementitious materials. Dense packing of the cementitious paste quickens hydration, decrease porosity and creates a more homogeneous microstructure, which in turns increases strength and durability.

The proper cement is important when creating a high strength mix design because not all cements will produce high strength concrete. Just because a cement is categorized as Type I/II does not translate into equal compressive strength results. The reaction of a cement with a specific fly ash, slag cement or silica fume for producing high strength concrete will be different. The Port Authority ran an internal study on which cements could produce the compressive strength needed with a given design.

For the 14,000 psi concrete mix that was specified for the core of One World Trade Center, The Port Authority required the contractor and concrete supplier to demonstrate pumping methods and consistency of the material by producing a mock-up section. The mock-up sections were instrumented to measure the core and surface temperature. Concrete cylinder samples were taken as well as cores from the mock-up to compare in-situ vs. cylinder strength. Numerous mock-ups were done with different mix designs to ultimately arrive at a mix that met all the performance criteria. Figure 1 details the coring of the mock-up blocks while Chart 1 shows the internal curing temperature comparision between block 1 and block 3, the highest and lowest cementitious contents respectively. Tables 1 & 2 compare the core and cylinder data from each mock-up block.

The concrete mix that was finally approved and used for the 14,000 psi core of Tower One contained a total cementitious factor of 873 lbs with only 300 lbs of cement. This quaternary mix includes cement, fly ash, slag and silica fume. The design water to cementitious ratio was 0.25 with an average field value (measured by the microwave test) as 0.29. The average compressive strength at 56-days was 16,160 psi with a coefficient of variation of 6.25%. The Modulus of Elasticity was 7,500 ksi after 90 days. The air content averaged below 2% with a spread measuring 25 inches. Due to the heavy rebar congestion in some of the shear walls, this mix was designed to mimic self-consolidating concrete. The goal here was to achieve enough fluidity for the concrete to move around and through the rebar yet remain cohesive without any bleeding or segregation.

When all of the above issues are addressed and taken into consideration, high strength concrete is readily achievable.

Mock-up Block # 1 – Total Cementitious = 1,029 lbs

	Vertical		Horizontal	
	Edge	Center	Edge	Interior
Number of Cores	10*	10	7	6
Avg. Compressive Strength (psi)	12,320	12,880	12,560	12,870
Coefficient of Variation (%)	6.70	6.00	5.60	2.80

Average Core Strength – 12,640 psi @ 221 days *Tested at 173 days
Average Cylinder Strength - 18,140 psi @ 56 days
Maximum Curing Temperature - 182°F @ 30 hours
Percent Reduction in Compressive Strength - 30%

Table 1

Mock-up Block # 3 – Total Cementitious = 820 lbs

	Vertical		Horizontal	
	Edge	Center	Edge	Interior
Number of Cores	8	9	7	7
Avg. Compressive Strength (psi)	15,780	15,570	16,380	15,470
Coefficient of Variation (%)	5.7	3.80	4.2	5.4

Average Core Strength – 15,780 psi @ 205 days
Average Cylinder Strength - 17,290 psi @ 56 days
Maximum Curing Temperature - 162°F @ 42 hours
Percent Reduction in Compressive Strength - 9%

Table 2

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