



## Sunshine Skyway Bridge Closes the Gap

**W**hen the last segment in the middle of the main span was lifted into place on August 23, 1986, the new Sunshine Skyway Bridge fulfilled its promise as the longest precast prestressed concrete segmental bridge in the world. The 4.14 mile (6.7 km) long Skyway links St. Petersburg and Bradenton (on Interstate 275) across lower Tampa Bay on the west coast of Florida. The skyway will carry two lanes of highway traffic with full width emergency lanes in each direction.

The new bridge, which was designed to withstand hurricane wind forces, has a main span of 1200 ft (366 m) with a clearance of 175 ft (53 m) above the Tampa Bay ship channel (see diagram on page 170). These features give the new bridge a

longer main span and higher clearance over the water than the original twin truss bridge which lies adjacent to the new structure.

The closure of the superstructure was marked by colorful ceremonies which were attended by dignitaries, highway officials, bridge engineers and the press. Florida's Secretary of Transportation, Thomas E. Drawdy, spoke eloquently about the bridge as an engineering triumph — one which will have a profound influence on future bridge construction.

Planning for the new bridge began in 1980 after a ship rammed the original bridge, destroying much of the southbound span and taking 35 lives. To maintain the alignment of I 275, the 21,878 ft (6673 m) long Skyway is adjacent to the old bridge,

where the undamaged north roadway has been used for two-way traffic since the accident six years ago. Next year the center portion of the old bridge will be dismantled, leaving the approaches on both sides to be used as fishing piers.

There were basically five major operations involved in the construction of the bridge.

**1. Substructure** — The substructure consists of piles and 606 match cast box pier segments rising from 26 to 135 ft (8 to 41 m) above sea level where the structure transitions to single piers. The segments were manufactured at a casting yard in Port Manatee about 4 miles (6.4 km) from the bridge site. They were barged to the site where they were assembled and post-tensioned vertically in place.

**2. Trestle approaches** — Low level north and south twin trestles of 4281 and 8736 ft (1306 and 2664 m) spans, respectively, consist mostly of 100 ft (30.5 m) spans of Type IV AASHTO precast prestressed I girders with 8 in. (203 mm) thick cast-in-place reinforced concrete decks. There are 256 such spans with five girders per span for each roadway.

**3. High level north and south approaches** — These 2430 ft (741 m) spans lie on each side of the main span. They were erected using the now well established span by span method of construction. The sections change from I girders to twin trapezoidal box girder segments. There are 584 such precast segments making up 18 spans of 135 ft (41 m). The spans rise at a roadway grade of 4 percent.

The units are made with epoxy coated, reinforcing steel grade 60 and 5500 psi (38 MPa) concrete. Three tendons of four 0.6 in. (152 mm) diameter strands are immediately tensioned to keep the wings of the decks compressed. Each span consists of pier segments and seven intermediate segments. Generally, the post-tensioning consists of three tendons of 19, 24 and 25½ in. (12.7 mm) diameter strands in 4 in. (102 mm) polyethylene duct.

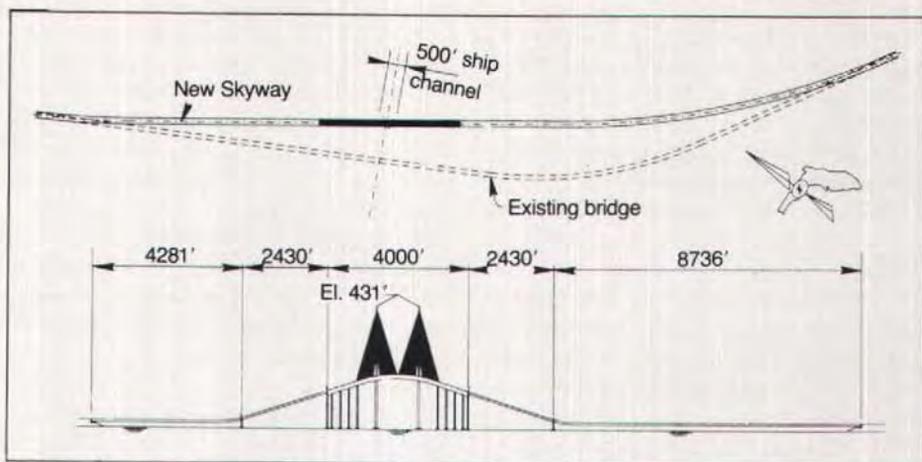
Initially, the seven intermediate segments are loaded, aligned and temporarily stressed together on the barge mounting lifting frame at the casting yard. The barge is then floated to the bridge site where the entire unit is lifted into position between the two piers with the aid of a steel gantry. Once the unit is set in its final position, a closure pour of 6 in. (152 mm) is made at each pier. The unit is sequentially stressed and then the gantry moves to the next span. The same procedure is repeated span by span.

**4. High level balanced cantilever spans** — The twin roadway sections transition to one structure for 4000 ft (1220 m), including two 140 ft (43 m) spans, six 240 ft (144 m) spans, then two 540 ft (165 m) spans and finally the 1200 ft (366 m) main span that is erected with the cable stays.

There are 333 large roadway segments of 95 ft (29 m) width to accommodate both northbound and southbound spans. Due to



The last precast segment of the Skyway was placed on August 23, 1986.



Plan and elevation of Sunshine Skyway Bridge. Observe that the elevation drawing is exaggerated in order to show clearance. (Note: 1 ft = 0.305 m.)

the relatively large width of the segments, internal inclined struts are necessary to properly support the top deck. These struts are precast separately ahead of time to facilitate mass production. Diagonal post-tensioning is also provided to cable stay anchor segments in order to distribute stay forces to the webs.

The transverse deck post-tensioning consists of 0.6 in. (152 mm) diameter strands in 1 x 3 in. (25 x 76 mm) flat polyethylene duct. Also, the base slab is tensioned after the concrete has attained a strength of 2500 psi (17 MPa).

The large segments are match cast to each adjacent segment using the short line method. A freshly cast segment is moved to the match cast segment. Using an adjustable pallet to the bottom slab, the whole segment is aligned both horizontally and vertically so proper geometric control can be achieved.

The balanced cantilever method requires an erection sequence to start at a pier and extend equidistant both ways with a maximum imbalance of one segment thus explaining the first span of 140 ft (43 m) transitioning to the span by span piers, then a series of 240 ft (73 m) spans.

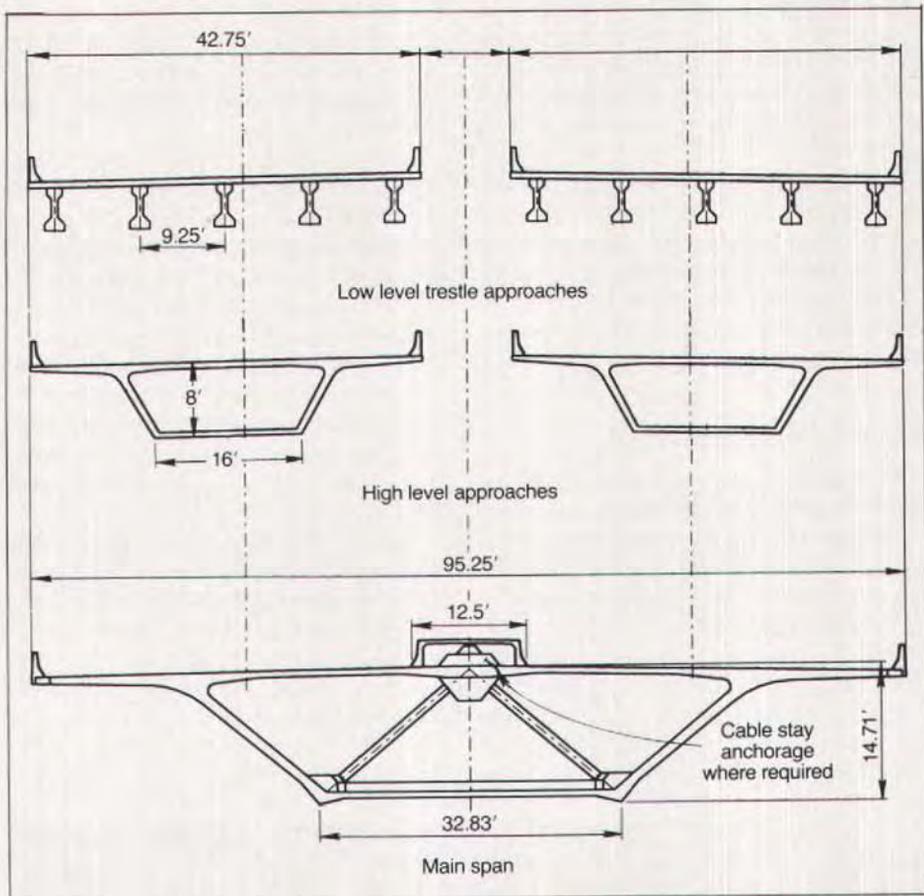
To facilitate erection, a two-plate girder assembly is used. Initially, the travelling hoisting crane alternately lifts segments for

the first two positions on either side of the pier; then the remaining eight segments on the backward side of the pier. Two beam and winch assemblies cantilever off the leading segments and counterbalance through the previously erected segments to provide lift on the forward side of the pier.

As the cantilever advances, so do the beam and winches in sequence with the backside where the lifting crane provides the lift. The backside cantilever closes to the tip of the previous forward cantilever to complete the span. The whole process then repeats itself with the lifting of the next pier segment and the moving of the plate girder assembly.

A special lifting beam assembly is used with the segments to ensure proper distribution of stresses. The web shear keys on the segments are used to guide them together. Epoxy is spread over the web and bottom slab mating faces. Threaded bars in both the top and bottom slab are connected and stressed to hold the segment temporarily in place. The top slab closure pour is formed and completed. When this concrete attains 2500 psi (17 MPa), the lifting frames can be released.

The permanent post-tensioning consists of multistrand tendons, each seven wire strands in plastic duct, encased in con-



Precast segmental box girder sections for various portions of Sunshine Skyway Bridge.  
 (Note: 1 ft = 0.305 m.)

crete for the top slab and exposed. The only exceptions are the pier segment saddle and deviation blocks for the draped cantilever tendons which are needed for each pair of segments. When this post-tensioning is completed, the whole erection cycle is repeated for the next two segments, and so on until the whole span is completed.

**5. Cable stayed spans** — To achieve a main span of 1200 ft (366 m), two main pylons of reinforced concrete, 435 ft (133 m) above the water or 240 ft (73 m) above the road surface, provide the vertical support.

The cable stayed spans were erected entirely with winches on self-advancing

beams, with the stays replacing the longitudinal post-tensioning required in the shorter spans. After closure, the internal continuity strands were stressed to carry their final suspended loads.

Each pylon carries 21 stays, anchored in every other segment [every 24 ft (7.3 m)] but passing freely through individual saddles in the pylon. Made up of multiwire strand and ranging from 38 to 82 high strength steel strands, the cables are encased in 6% and 8% in. (168 and 219 mm) steel pipe, grouted after final stressing.

The pipe was erected first, then the cables were pulled through. The 1700 ton (1542 t) rams and other equipment needed for the pulling and stressing were set up

inside the segments. After initial stressing, the next non-stay segment was lifted, closure pours made and the cycle begun again by advancing the beam and winches.

Part of the cable stay design is a provision for removing and replacing any one cable. If necessary, the pipe and grout system will be decompressed by removing a series of shims to bring the anchorage back down until it rests against its bearing plate.

## Concluding Remarks

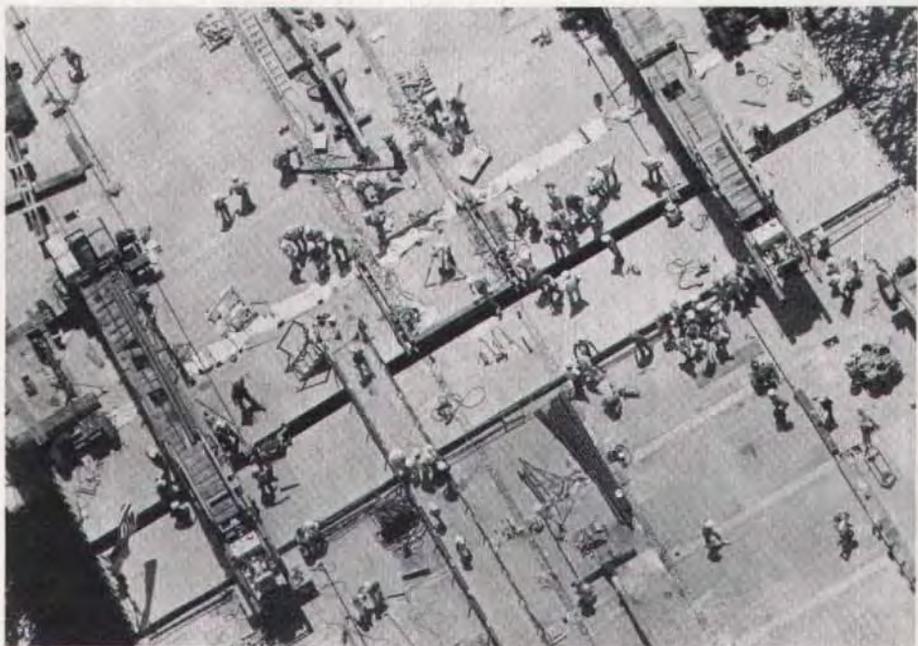
In retrospect, the various precast prestressed segmental phases and especially the cable stayed portion of the project proceeded very efficiently. In particular, the geometry control proved to be excellent. Only a very few joints had to be shimmed.

The two massive twin piers provided good rigidity during construction of the balanced cantilevers, but have sufficient flexi-

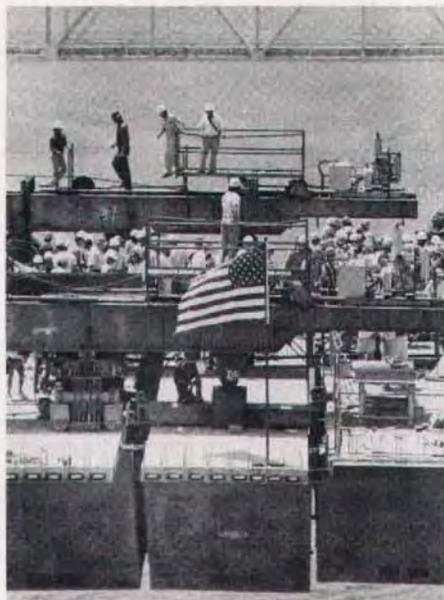
bility to accommodate thermal expansion under highway traffic. As a result, the bridge structure has exceptionally good stability.

The construction of the bridge caused little or no interference with the ship traffic. Closely spaced cable stays allowed the bridge to be built by the cantilever method without any falsework. The close spacing of the stays also gives the advantage of allowing stays to be replaced easily, if necessary, without causing major traffic disruption. The cables are located on the centerline of the structure which will allow motorists an unobstructed view of Tampa Bay. It will be opened to traffic in early 1987.

The cost of the Sunshine Skyway Bridge is estimated to be \$220 million. This figure includes design, construction and inspection of the bridge, pier protection islands and dolphins and a motorist warning system, plus refurbishing the old bridge for recreational fishing.



Placement of final deck segment closed the world's longest precast prestressed concrete segmental bridge. The main span is 1200 ft (366 m) long.



To celebrate the placement of the final precast segment on the superstructure, an official ceremony was held on August 23, 1986.



Aerial view of 4.14 mile (6.7 km) long bridge with last precast segment in place. The bridge will be opened to traffic in early 1987.

## Credits

The bridge is owned by the Florida DOT which also was involved in the planning and design aspects of the bridge. In addition, the FDOT Bureau of Structures Design played a key role in checking many elements of the design.

Figg & Muller Engineers, Inc., Tallahassee, designed the 8800 ft (2684 m) high level approach and main span. The low level approaches were designed by Parsons, Brinckerhoff, Quade & Douglas, New York City, and the FDOT Bureau of Structures Design.

Construction inspection is being handled by SKYCEI, a consortium called Skyway Construction Engineering & Inspection Consultants. Participants include Parsons, Brinckerhoff, Quade & Douglas, New York City; DRC Consultants, New York City; Kissinger, Campo & Associates, Tampa; and H. W. Lochner, Inc., St. Petersburg.

Contractors are Hardaway Constructors of Georgia and Michael Construction Co., Tennessee, main pier foundations; Paschen Contractors, Inc., Chicago, American Bridge, Chicago, and Morrison-Knudsen, Boise, high level approach and main span; Ballenger Corp., South Carolina, low level trestle spans; Meisner Marine Construction, Tampa, main pier dolphins.

Construction Technologies Laboratory, Skokie, Illinois, instrumented the bridge; VSL, Los Gatos, California, engineered the prestressing. LoBuono Armstrong & Associates, Tallahassee, were structural consultants to Paschen Contractors for erection of the segmental and cable stayed sections.

The pier elements and the box girder segments were manufactured by POMCO (as a subcontractor to Paschen Contractors) at its plant in Port Manatee.

The photographs for this article were furnished through the courtesy of Figg & Muller Engineers, Inc.

served as the company's executive vice president and chief operating officer.

Mr. Danciger, president since the company's formation in 1958, will remain as chairman and chief executive officer.

## **Mark W. Huggins (1911-1986)**

**Mark W. Huggins**, professor of civil engineering at the University of Toronto, Ontario, Canada during the past 35 years, has died at the age of 75. During the past 10 years he was emeritus professor. Pro-

fessor Huggins obtained both his undergraduate and graduate degrees from the University of Toronto, where he developed an early interest in the work of Eugene Freyssinet. Upon graduation he joined the firm of E. P. Muntz, engineering contractors, an association which greatly influenced his future interest in prestressed concrete.

In 1946, he became a partner in Morrison, Hershfield, Millman & Huggins, Consulting Engineers. In this capacity, in 1952, he participated in the design of prestressed concrete roof joists for the Hydro

## **Podolny, Jr. Wins 1986 T. Y. Lin Award**

**Walter Podolny, Jr.** has won this year's T. Y. Lin Award from the American Society of Civil Engineers. The award, a handsome plaque and a \$500.00 check, was given to Dr. Podolny in Boston, Massachusetts during the Society's annual convention.

Dr. Podolny received this prestigious award for his paper "The Cause of Cracking in Post-Tensioned Concrete Box Girder Bridges and Retrofit Procedures," which was published in the March-April 1985 PCI JOURNAL.

This marks the eleventh time in thirteen years that a paper published in the PCI JOURNAL has been selected by the American Society of Civil Engineers to receive the T. Y. Lin Award.

For each 12 month period ending in June, the American Concrete Institute, Prestressed Concrete Institute, and American Society of Civil Engineers are invited to nominate a single paper from their respective publications. The three papers are then reviewed by a committee and a grand winner is named.

Dr. Podolny is a structural engineer in the Bridge Division, Office of Engineering, Federal Highway Administration,



Dr. Walter Podolny, Jr.

Washington, D.C. He is the author of more than fifty publications and coauthor (with Jean Muller) of the book "Construction and Design of Prestressed Concrete Segmental Bridges." Dr. Podolny has served on several technical committees of the PCI and other professional organizations and has also served as a juror on the PCI Awards Program. He received PCI's State of the Art Award in 1985 for the same paper that won the T. Y. Lin Award.

Electric Power Commission of Ontario. At the same time he, jointly with E. P. Muntz, produced a prestressed concrete runway design. Since then, he designed many prestressed concrete bridges and was responsible for numerous prestressed concrete structures.

Professor Huggins was chairman of the committee charged with developing the first Canadian Standard for the Design of Prestressed Concrete. He was also coauthor with L. G. Cazaly, in 1962, of the Canadian Prestressed Concrete Institute Handbook, the first in North America. He was a founding director of the Canadian Precast Concrete Bureau which has since become a CSA Plant Certification Committee.

A lasting legacy of his life's work was the eloquent article he wrote for the PCI JOURNAL on "The Beginnings of Prestressed Concrete in Canada," which was published in the November-December 1979 PCI JOURNAL and later republished in the volume "Reflections of the Beginnings of Prestressed Concrete in America." For this article Professor Huggins received a Special Award of Recognition from the Prestressed Concrete Institute.



Professor Mark W. Huggins

sible for all production facilities in the company's pits and quarries, ready-mix plants, marine department and Lockport, Illinois repair shop. Formerly president of a Material Service subsidiary, El Paso Sand Products Corporation, Mr. Levy will also serve as the Texas company's chairman of the board.

### Harris Retires

Texas Industries, Inc., Dallas, Texas has announced the retirement of **Phillip H. Harris**, vice president of cement planning.

Mr. Harris began his career with the company in 1965 as president of Creole Corporation, a wholly-owned subsidiary. In 1967, he became president and general manager of the south Texas region and for several years prior to his retirement was vice president-cement marketing and planning.

Mr. Harris is expected to keep a continuing, consulting relationship with the company.

### Moore Relocates to Texas

Wiss, Janney, Elstner Associates, Inc., Northbrook, Illinois has announced that **Mark Moore** has recently relocated to the firm's Dallas area office. He had been associated with WJE's Princeton area office since 1982.

### Material Service Corp. Announces Promotions

Material Service Corporation of Chicago, Illinois recently announced the promotions of **Morris Lauwereins** and **Richard E. Levy**, two long-time company employees.

Mr. Lauwereins has been named senior vice president-operations and will be responsible for the company's aggregate operations, ready-mix and precast concrete products, engineering and real estate. Formerly vice president of operations, he has been with Material Service for 33 years in various capacities, including serving on the company's board of directors.

Mr. Levy will step into the position of vice president of operations and will be respon-

Mr. Moore has been involved with the analysis of prestressed concrete bridge girders and seismic monitoring of structures subjected to blast-induced vibrations. Recently, he has been involved in testing precast bridge deck panels in conjunction with a FHWA study.

### Swiss Joins CONAC

Concrete Accessories Inc. (CONAC), Port Jefferson, New York has announced the appointment of **Steve Swiss** to the position of regional manager for the Northeast, Mid-Atlantic, and Midwestern states.

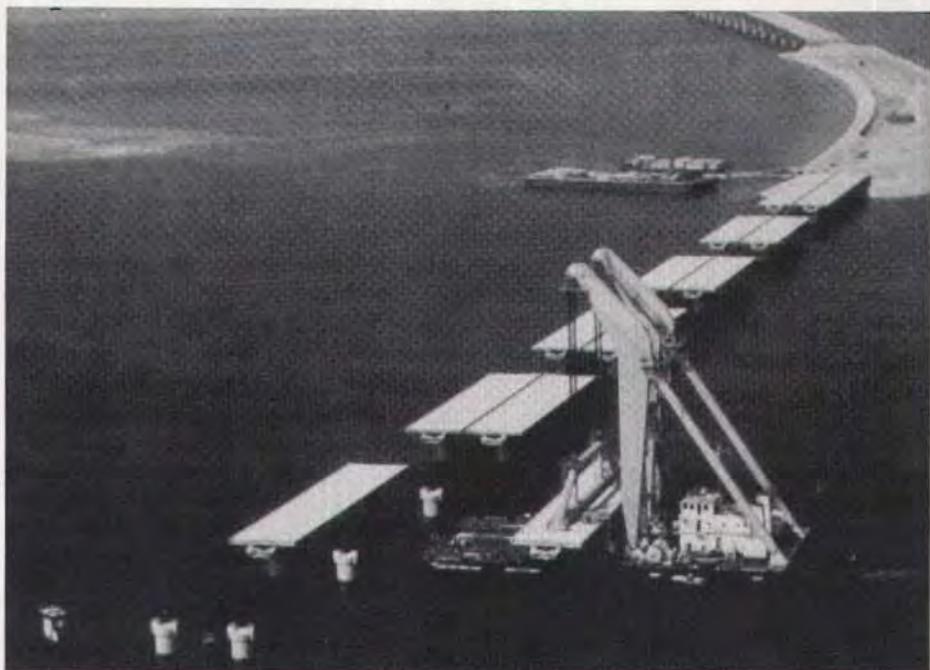
A graduate civil engineer from the University of Massachusetts, Mr. Swiss has worked in the engineering and sales departments for a major United States pre-caster. He also has several years experience in the sales of accessory products to the precast prestressed concrete industry.

### Tindall Concrete Elects New Officers

Tindall Concrete Products, Greenville, South Carolina recently elected **Richard Blumberg** as president of the company and **William Lowndes IV** as vice chairman of the board.

Mr. Blumberg joined the company three years ago as general manager of the prestress division and will retain responsibility for the management of that division. A 35-year veteran in the construction industry, he was most recently president and chief executive officer of Paterson-Leitch Steel Company of Cleveland, Ohio, a position he held since 1979.

Mr. Lowndes joined Tindall Concrete Products in 1977 and was named general manager of the utilities division in 1983. He will continue to manage that division, as well as serve on the company's board of directors.



The 15½ mile (25 km) Saudi Arabia-Bahrain Causeway is being built using innovative products from Preco Industries Ltd., Plainview, New York. (A more detailed look at the project appeared in the September-October PCI JOURNAL on pages 179-180.)