Highlights

- **Shanghai's Inner-Loop Bridges, in 20 years, lead population from 8.5 to 21 million**
- **Western experience on the Nanpu converted to Eastern practice on the Yangpu**

SPANS

Hillsborough County Florida

Public Works Department
Bridge Team

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SANGHAI'S SIAMESE TWINS

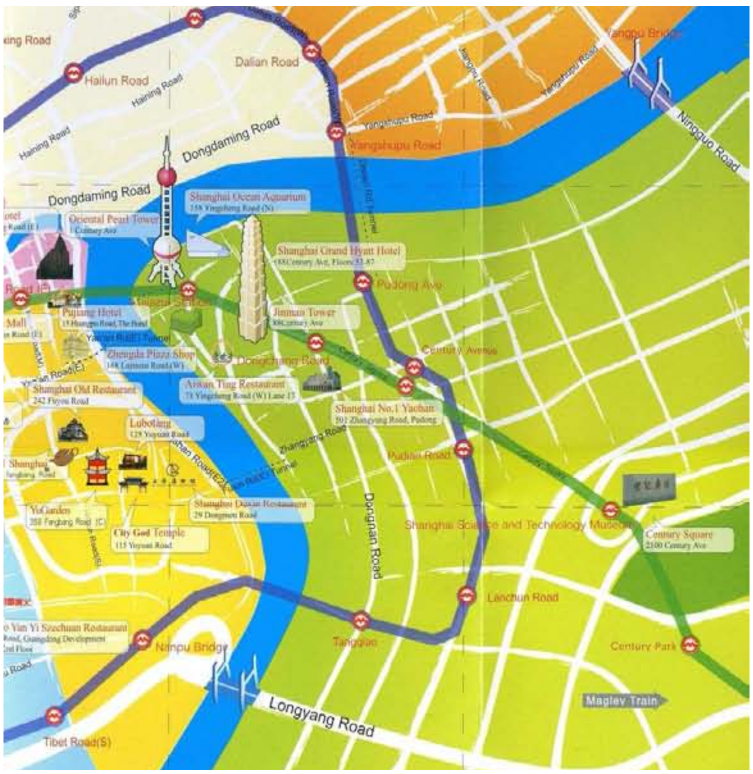

FIGURE 1: East Bank, Oriental Pearl Tower between the Huangpu Bridges

The business of developing work for a Professional Engineering Company requires a great deal of energy, a large degree of confidence and a very strong constitution, nevertheless, without a strong product, none of this will matter. The New York City based firm of DRC Consultants Inc. was heavily endowed with great engineers who were attracted by the growing reputation of doing challenging work. The Technical leader of this company (founded in '79) was the President who also organized the corporation and established the position of Vice President, Director of Business Development.

Meeting the potential client was critical in putting a face and attitude to the image portrayed in the promotional media which made all firms seem the same - perfect. Regardless, there were

FIGURE 2: View south with Nanpu Bridge reaching to east shore beyond

FIGURE 3: South view of Yangpu Bridge with new, city skyline beyond

certain prequalification matters that needed to be done with governmental agencies and the VP spent time in Washington D.C. with the IMF, AID, World Bank, Ex-Im Bank and the Asian Development Bank (ADB). The ADB was headquartered in Manila, Philippines and the VP developed a telephone relationship with an ADB operative by the name of Bruce Murray, a Canadian ex-patriot.

Mr. Murray was able to balance a very personable manner with the appropriate business-like responses. He was a pleasure to do

SANGHAI'S SIAMESE TWINS		
FEATURE	NANPU	YANGPU
OPENED	DECEMBER, 1991	OCTOBER,1993
LENGTH	2,775 FEET	3,844.16 FEET
MAIN SPAN	1,387.44 FEET	1,974.56 FEET
WIDTH	99.55 FEET	99.55 FEET
VERTICAL CLEARANCE	MAXIMUM 150.88 FEET	MAXIMUM 157.44 FEET
TOWER HEIGHT	492 FEET	682.24 FEET
PRINCIPAL DESIGNER	SHANGHAI MUNICIPAL ENGINEERING DESIGN INSTITUDE	SHANGHAI MUNICIPAL ENGINEERING DESIGN INSTITUDE
DESIGN CONSULTANT	BUCKLAND AND TAYLOR LTD.	HOLGER S. SVENSSON
CHECK ENGINEER	DRC CONSULTANT INC.	DRC CONSULTANT INC.
GENERAL CONTRACTOR	SHANGHAI HUANGPJISIANG BRIDGE ENGINEERING CONSTRUCTION COMPANY	SHANGHAI HUANGPJISIANG BRIDGE ENGINEERING CONSTRUCTION COMPANY

FIGURE 4: Comparison of Shanghai's Inner Loop Bridges

business with because you knew where you stood with him on all occasions. He called the VP in 1988 to inform him that DRC had been selected by the ADB as the Check Engineer for a Cable-stayed bridge design across the Huangpu River in Shanghai, PRC. The President and the VP traveled to Shanghai and met at Tungji University with the Design and Construction teams. The President was of Chinese descent and carried on all discussions while the entire group sat at a large, round table eating lunch.

This trip brings to mind the conditions in this huge country at that time. The night of arrival by China Air on a new Airbus, passenger, transport from Hong Kong they flew over China's largest city of 8.5 million inhabitants and there were no lights to be seen from the air. Driving to the hotel the streets were dimly lighted by incandescent light bulbs. The streets were flowing full with people and many were on bicycles. They were given the choice of a traditional Chinese or a Western Hotel and chose the traditional venue. Later that evening they went to a penthouse dinner high atop a modern, western hotel at another location.

While at the lunch table the VP (who spoke no Chinese) expressed exasperation and the Chinese official to his right, surprisingly, said in English "would you like to go for a ride?" They went to a relatively small cable-stayed bridge (~300'span) that bridged a passenger station rail yard not far from the University then they visited the Bund; the famous, riverfront, European Business District that had connected China to the west since the 1920's. While on the street the VP, identified by his Western shoes and attire, was stopped by two young men who wanted to practice their English. The official, during this sojourn,

FIGURE 5: North leg of Huangpu River flowing to the Yangtze delta at right

explained to the VP that he had been given the rights to distribute Coca Cola in China. After returning to the group a site visit was arranged.

The Huangpu River's source is the Lake of Dianshan, Shanghai's drinking water source, situated southwest of Shanghai. It flows for 30 miles to the east and abruptly changes directions to the north and travels another 40 miles until it empties into the Yangtze River (Figure 5). The city of Shanghai was almost entirely developed west of the river until it was decided to expand into the farmlands to the east. This action was to be realized by building two bridges close to the City's center and linking the planned, inner-loop highway that was to tie the undeveloped east with the highly developed areas west of the river (Figure 1).

The Huangpu River was crossed at many locations by ferries that would shuttle loads of pedestrians and bicyclists, before the first bridge was put into place, for the sum of 5 RMB (Peoples money = $0.73) per passage. Shanghai had originated on and evolved in the mainland area between Hangzhou Bay to the south and the Yangtze River to the north with its eastern tip (Pudong District) isolated

FIGURE 6: Ground view of Nanpu elevator towers

FIGURE 7: Ground view of Yangpu elevator towers

FIGURE 8: Nanpu ramps down for west bank, traffic connection

FIGURE 9: Yangpu prior to painting towers red for millennium change

from the mainland by the 71 mile long Huangpu River. The visit to the Nanpu Bridge site took them down a narrow street crowded, shoulder to shoulder, with people, many with their bicycles, waiting to surge forward onto the waiting ferry. At this stage of development the question would be, what will this giant bridge be connected to (Figure 2)?

The two returned to New York City and DRC continued with the Check Engineering for the Nanpu Bridge. The VP, with his continuing activities, came upon a notice from the ADB for another, second crossing of Shanghai's Huangpu River. He contacted Mr. Murray who advised him that another company from another country had been selected by the ADB to do the Check Engineering for the Design of the second bridge. With this information in hand the VP turned his attention to seeking other work for his company.

However, not too long later, Mr. Murray notified the VP that there had been a glitch in the contractual arrangements with the second Huangpu Bridge Check Consultant and if DRC could have a qualified engineer in Shanghai in two weeks the job was theirs. The President sent the imminently qualified Mr. Herbert Globig and the Twin contracts were in place for DRC's doing (Figure 3).

The Nanpu crossing, the first design, borrowed heavily from Buckland and Taylor's, 1987, Alex Frazer River Bridge in Vancouver, B.C., Canada. These Consultants worked with the Chinese designers to transfer cable-stayed, bridge experience and practice. The "H" tower configuration and cable arrangements were similar. The cast-in-place concrete tower construction along with a steel framed, composite concrete, cable stayed deck were alike. The pedestrian accommodations were the major difference from the Canadian bridge in that the Nanpu's two, 6'- 6" wide sidewalks embraced six vehicular, traffic lanes and included two pedestrian elevators on each shore to accommodate the heavy Shanghai pedestrian traffic (Figure 6).

The companion Yangpu Bridge was located 6.6 river miles north of the Nanpu and provided the second Haungpu River crossing that closed the Shanghai Inner Loop highway linking Shanghai to the eastern, Pudong, district with six lanes of motor vehicle traffic. Similarly, pedestrian traffic was a key consideration in the design and four pedestrian elevators were necessary to maintain the expected heavy pedestrian traffic across the two, 6'- 6" bridge walkways at the north location (Figure 7). A fee of nearly one Yaun ($0.15) was levied for the use of the elevators.

River ferries operated at capacity for a ride that takes only 5 minutes. The two tiered monetary system with the RMB (Peoples Money) was phased out in 1995. Although the ferries cross at a large number of locations the pedestrian capacity for both bridges has been increased to accommodate the enormous growth that was expected to ensue. As of this publication the estimated population of the City has mushroomed to 21 million.

The Yangpu design was primarily done by the now experienced Chinese with design assistance provided by the German Engineer, Mr. Holger S. Svensson. The distinctive concrete towers, shaped like an inverted slingshot, were cast-in-place concrete with two, narrowly spaced planes of stays radiating from the upturned stems (handles) down to more widely spaced anchorages at the steel plate, edge girders. The deck was designed as a steel framed, composite, concrete deck girder, also. The Yangpu towers were colored red to celebrate the millennium change (Figure 7).

The Asian Development Bank provided $155 million USD for the construction of these two bridges. Today, the Nanpu, opened to traffic in December, 1991, carries 120,000 motor vehicles per day and its counterpart to the north, the Yangpu, opened in 1993, accommodates 100,000 motor vehicles per day. This phenomenal expansion has produced the local phrase that characterizes the two bridges as dragons and built between them, on the east shore, is the Oriental Pearl Tower. The prideful saying is "two dragons playing the pearl" (Figures 1, 8 and 9).

Hillsborough County
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Guest Commentary

By: Don Sayenga

LET'S RETIRE "CABLE STAYED"

This is a little essay that asks a good question but doesn't provide any valid answer. The subject is our current English language name for the structure many people refer to as a Cable Stayed Bridge. I was reminded about this when I read the recent SPANS description of a new bridge in Chile. My question is: why do we call it that?

I don't know who first contrived the term but it has been around for a long time. I seem to think I first heard it used in the 1950s but I cannot verify how or where I heard it. I'm sure I heard it used before Walter Podolny and John Scalzi popularized it (with a hyphen in the middle) during the 1970s. What I do recall clearly from my first contact was that someone taught me to deprecate it, insisting it was either a misnomer or a malaprop. Beginning with my first exposure half a century ago, I've always tried to say "Stay-Cable Suspension Bridge" when the subject comes up. The truth is, I don't like the name "Stay-Cable Suspension Bridge" as a substitute.

My objections to the term ought to be obvious to most engineers and architects. Right up front we ought to recognize that "cable" is probably the most generic word in the entire glossary of terms applied in the cordage and wire industry. The **printer cable** I'm using to create this little essay bears no resemblance whatsoever to the **tow cable** in the trunk of my car, nor to the **guard cable** on our local highway, nor to the **elevator cable** in the shaft of our office building. In short: "cable" is simply not specific enough to be applied as an engineering term for the tension members of these beautiful bridges.

Shrouds on the ship Balclutha in San Francisco

Attaching tension members of the Zakim Bunker Hill Bridge in Boston

When we compound the felony by adding "stayed" we are combining a vague generic term with a misapplied modifier. We got these terms from British naval architecture of the 1700s. Yes, it is true this kind of bridge looks somewhat like a fully rigged sailing ship but the visual resemblance is no excuse for incorrect application of terminology. Anyone with the most rudimentary knowledge of sailing knows that a **stay** is a tensile member that resists the force of wind. When **stays** were first applied to suspension bridges (they were also called "braces" by Stevenson in 1821) the aerodynamics of suspension bridges, particularly the torsional forces, were poorly understood. The intent of adding the **stays** primarily was to resist the force of wind, not the force of gravity. If we want to nitpick to make the case, we might note the fore/aft alignment of single member stays. We should refer to multiple lateral stays which are called **shrouds**.

I've attempted to translate the German term ***schrägseilbrücke*** on several occasions but I always end up with "skew-cable suspension bridge"… something which doesn't sound much better to me than "stay-cable suspension bridge". I've not had much better luck with the French term ***hauban*** although "hauban suspension bridge" might be a slight improvement over what we've got. I've never seen the 1819 patent issued to Bernard Poyet (1742-1824) who first articulated the engineering principles but if someone had proposed "Poyet suspension bridge" back in the 1950s, today it would be my favored nomenclature for such magnificent structures.

I said at the beginning I don't have the answer. Some expert with more creativity than I've got ought to be tinkering with an innovative term. A "Cable Stayed Bridge" is difficult to explain to a neophyte. Let's retire the term. After all, they are suspension bridges - and we ought to call them suspension bridges

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