Double-deck delight

What is claimed to be the largest-ever orthotropic bridge deck paving project was completed recently in China, report *Wu Shengdong* and *Robert Gaul*

With the opening of the Runyang bridges this month, China will celebrate the completion of the latest of its many world-class bridge projects. The 758m-long cable-stayed bridge and the 1490m-main span suspension bridge, which together with the 1412m-long connecting viaduct form an impressive engineering achievement, were the subject of the largest ever orthotropic bridge deck paving project last year.

Chinese engineers and contractors completed the largest bridge deck paving project of its type last year when they installed 9,644t of epoxy asphalt concrete, covering a total 67,440m^2 of the Runyang cable-stayed bridge and the main span of the Runyang suspension bridge.

These impressive bridges span the Yangtze River between Yangzhou on the north and Zhenjiang on the south *(Bd&e issue no 30)*. A 1,412m long roadway on Shiyezhou Island, located in the Yangtze River, joins the northern twin tower cable-stayed bridge and the southern twin tower suspension bridge. The bridge complex will connect four expressways: the Beijing-Shanghai Expressway, the Nanjing-Nantong Expressway, the Shanghai-Nanjing Expressway and the Nanjing-Hangzhou Expressway.

Shiyezhou Island is about 29.4km^2 in area – roughly the size of Macao Island - and was an undeveloped agricultural area accessible only by car-ferry prior to the construction of the bridges.

The cable-stayed bridge main span of 406m combines with two 176m side-spans for a total length of 758m, while the suspension bridge main span is 1490m long. Both bridges carry three lanes of traffic in each direction on either side of a median barrier and have separate pedestrian walkways. Combined total roadway deck area for both bridges is 67,440m^2.

Very high summer temperatures and very low winter temperatures have been responsible for numerous durability problems with pavements on orthotropic steel decks in China. Other parts of the world with the similar weather conditions have experienced the same problems. Many of pavements on orthotropic steel decks have exhibited fatigue cracks, shoving, rutting or de-bonding. The Runyang Bridge Construction Command with the help of the Transportation College of Southeast University in Nanjing conducted a thorough investigation of available materials. Based on problem-free experience on the 2nd Yangtze River Bridge at Nanjing and laboratory fatigue tests at Southeast University they chose Chemco Systems' epoxy asphalt as the pavement. Fatigue tests at Southeast University demonstrated the ability of the epoxy asphalt pavement to resist fatigue cracking over the longitudinal stiffeners in the orthotropic steel deck.

Epoxy asphalt is a two-component thermoset polymer system that replaces asphalt as the binder in what is otherwise the same as paving with asphalt concrete. Epoxy asphalt is a thermoset polymer – it will not melt - rather than a thermoplastic material like mastic and bituminous pavements. It does not soften as much as bituminous pavements at high temperature and has shown no signs of rutting and shoving on previous projects in China that experience very high deck temperatures. The contractor mixes the product in an asphalt pug mill, transports it in trucks, installs with an asphalt paving machine and compacts with asphalt rollers.

Above: The bridge crossing consists of two structures - the cable-stayed bridge is shown here

Below: Paving both bridges took only 21 days in total

The design of the pavement first considered the deck design characteristics that would influence pavement performance. The design of both the cable-stayed and the suspension bridges incorporate 14mm deck plate with 300mm wide U-shaped stiffeners on 600mm centres. Floor beams on the cable-stayed bridge were spaced at 3,750mm and on the suspension bridge at 3,220mm. The cable-stayed Second Nanjing Bridge had used a 50mm pavement of epoxy asphalt. But the Runyang Bridge Command anticipated that the deck on the suspension bridge would have larger deck deflections than a similar deck on a cable-stayed bridge and thus decided to use a pavement thickness of 55mm. Designers selected a 9.5mm maximum aggregate from Jurong city in Jiangsu Province. It is a basalt that has also

been used successfully on the Second Nanjing Bridge. The specifications required the pavement be installed in two lifts to assure that the specified 3% minimum void content was achieved or bettered. Very low void content is important to maximise fatigue resistance and waterproofing.

The paving contractor, Shandong Highway and Bridge Construction Corporation, installed an asphalt batch plant on Shiyezhou Island in close proximity to both bridges. Laboratory facilities for quality control and offices were also built at the batch plant site.

The Bridge Command required Shandong to demonstrate the suitability of their construction equipment and construction methods by paving a 15m by 150m section of an approach to the bridges, after which the cable-stayed bridge was paved. The contractor first shot-blasted and sprayed the steel deck with a zinc-rich epoxy primer for back-up corrosion protection. The 1.5m wide median strip contained numerous protruding anchor points for the median barrier, so this strip was paved with flowable mastic asphalt because the protrusions would have made adequate compaction of the epoxy asphalt pavement very difficult and time-consuming.

The contractor used a spray machine supplied by Chemco Systems to apply an epoxy asphalt bond coat to the primed steel deck at a rate of 0.68l/m. The bond coat is a more viscous version of the epoxy asphalt binder. The spray machine maintains the temperature of the two components, meters the components at the proper mix ratio, mixes the components and sprays them onto the deck through a spray wand at about 150°C. The bond coat operation started either three to four hours before the paving or on the afternoon before the paving if the weather could be accurately forecast.

Shandong Highway & Bridge Construction Corporation modified a standard asphalt batch plant to more easily monitor the temperature of each batch of epoxy asphalt concrete. Temperature control of each batch is important because too high a batch temperature causes the epoxy asphalt binder to begin to cure too quickly. Curing too fast raises the viscosity of the binder and makes the mix too stiff to compact properly. Construction specifications require batch temperature to be between 110°C and 121°C. The plant was modified so that each batch was discharged from the pug mill into a hopper mounted on rails. The hopper moved on the rails to the haul truck and discharged into the truck after the temperature of the batch was measured with an infrared thermometer and recorded. In addition, a technician at the batch plant inserted three long stem bi-metallic thermometers into the mix through holes drilled in the sides of the haul trucks. These thermometers remained in the mix until the haul truck reached the bridge deck.

Top: Measuring the mix temperature on site

Above: Applying the bond coat

Below: Discharging the paving mix

For each truckload technicians at the batch plant prepared a time sheet that informed the contractor of the maximum and minimum time that the mix should be kept in the truck. Supervisors on the deck used these time sheets to decide when that truckload should be discharged into the paving machine.

Steel rollers of 10,000kg steel rollers and pneumatic rollers inflated to 620kPa at a minimum mass per tyre of 900kg provided the compaction of the paving mix on the deck. Specifications required that breakdown compaction of a minimum three passes be completed before the mat temperature dropped below 82°C. Three passes of intermediate compaction and three passes of finish rolling followed the breakdown rolling and were completed before the mat temperature dropped below 65°C. These temperature limits were strictly enforced to assure the best possible compaction. Unlike bituminous pavements, once the curing of epoxy asphalt concrete begins the viscosity of the binder increases to a point where further compaction is impossible.

A paving team from Southeast University College of Transportation provided quality control for the project. The college engineers monitored the aggregate delivered to the site and conducted Marshall tests on the paving mix taken on discharge from the pug-mill. The paving mix consistently tested at 45kN to 55kN Marshall strength, well above the specified 40.4kN specified minimum requirement. This paving team also checked the mix temperature, haul time, and time/temperature limits while the pavement was being compacted. The paving team engineers used infrared thermometers for all quality control temperature measurement on the bridge deck.

An unusually long rainy season caused frequent delays of the paving. However, the contractor was able to install the entire 9,644t of epoxy asphalt on both bridges in 21 working days ■

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