NUDECK INNOVATIVE PRECAST CONCRETE BRIDGE DECK PANEL SYSTEM

Nebraska Department of Roads (NDOR) is working on upgrading US 6 expressway between Omaha and Freemont, Nebraska. The project includes the construction of the interchange at Skyline Drive and West Dodge Road (Figure 1). The Skyline Drive Bridge (Figure 2) will carry Skyline Drive traffic over West Dodge Road (US 6 Expressway). Current average daily traffic of 1445 is estimated to increase to 3110 by the year 2022. “When we started the design phase of the project, we fond that a high speed construction system of the bridge deck is highly desired to minimize the road closure period and traveling inconvenience of the expressway users.” Hussam Falaha, Assistant to the State Bridge Engineer of NDOR, said. He added, “after investigating various systems used nationally during the past 20 years, we decided to use the NUDECK system. We have found that this system provides fast and efficient deck construction procedure, yields superior performance in service and reduces long-term maintenance and replacement costs, as well.”

The cutting edge technology that made this bridge project innovative was the result of research project NCHRP 12-41, titled “Rapid Replacement of Bridge Decks.” The project was conducted by University of Nebraska-Lincoln (UNL), 1995-1998, and was sponsored by the National Cooperative Highway Research Program, National Academies of Sciences. The Skyline Drive Bridge project provided a timely opportunity to apply the results of this research to a full-scale construction project.

BACKGROUND:

The primary source of bridge deficiency in the United States is deteriorated concrete decks. The NUDECK system evolved after careful studying and testing of the conventional precast concrete panel system that has been in use by many state highway authorities. The conventional precast concrete panel system utilizes 3 to 5 in. (76 to 127 mm) thick stay-in-place (SIP) pretensioned panels that span between beam edges and are totally separated over beam top flanges (Figure 3). The panels house the positive transverse moment reinforcement, which is generally pretensioned strand. Negative moment reinforcement is provided in a cast-in-place (CIP) composite concrete topping. The conventional system sometimes experiences reflective cracking over panel edges. In addition, experiments in the NCHRP 12-41 project have confirmed that lack of anchor of the transverse strand reinforcement, in individual panels into the beam supports, reduces arching action and the system’s load capacity. Additional drawbacks of the conventional system are the need for conventional forming and construction of overhangs and installation of big number of panels.

DESCRIPTION OF THE INNOVATIVE FEATURES OF THE NUDECK SYSTEM:

The NUDECK panel covers the full width of a bridge. The panel is plant precast and pretensioned in one direction with two layers of strands (the transverse blue lines in the plan view of Figure 4). In order to create an optimized space for the shear connectors extending from the beams into the deck, a full-length gap (blockout) is created at every beam line. To maintain the transverse pretension force of the strands across these gaps, each group of two strands is surrounded with short pieces of four #7 (M22) reinforcing bars (Figures 4 & 5). Therefore, in each gap, the strands are in tension, while the bars are in compression. In other words, the bars work as a bridge over the gap that transfers the prestress force from one piece of concrete to the next piece. Each bar is designed to carry a compression force equal to one half of the tension force in one strand, without being buckled. The bars are imbedded in the concrete an adequate distance to protect the panel from high stress concentration and to ensure a smooth transition of the compression force from the bar to the concrete.

After the panel is installed on the beams, its elevation is adjusted using four leveling bolts as shown in Figure 6. The leveling bolts are installed in the gap between the two layers of reinforcement; therefore, no special inserts are required to be installed in the panel. The panel is provided with a shear key detail at the transverse edges. The panel-to-panel joints and the longitudinal gaps are filled with high early-strength non-shrink cementitious grout.

The NUDECK system can be used either as a stay-in-place (SIP) panel with a composite cast-in-place (CIP) reinforced concrete topping, or as a full-depth precast deck panel. The panels are positively connected in the longitudinal direction with one of two options. The first option, which is used when the panel is utilized as a SIP panel with a composite CIP reinforced concrete topping, involves coupling the #4 (M13) longitudinal reinforcement bars of the panel through 5x5 in. (127x127 mm) pockets created at the transverse edges of the panel (Figure 5). A spiral is used to confine the splice and reduce the splicing length of the #4 (M13) bars. The second option, which is used when the panel is utilized as a full-depth deck panel, involves post-tensioning the panels in the longitudinal direction. The post-tensioning strands are fed in the gaps, between the two layers of reinforcement, therefore, no post-tensioning ducts are required to be installed in the panel and grouting of the post-tensioning strands can be visually inspected.

The NUDECK panels used in the Skyline Drive Bridge are full-depth precast panels, transversely pretensioned and longitudinal post-tensioned. Figures 7, 8 & 9 show the NUDECK panels of the project during fabrication and storage in the precast yard. A unique feature of the NUDECK panels that are used for this particular bridge is the crowning of the panels on a sharp skew angle, which had never been done before. With the two-way prestressing, the deck is expected to be crack free and to last as long as the supporting beams.

REFERENCES AND NATIONAL RECOGNITION:

The NUDECK system used in the Skyline Bridge Project is a hybrid of two systems published in the following papers. The second paper received the ACI-Structural Engineering Design Award in 2000. The third paper was cited in a survey of PCI JOURNAL readers as one of the top ten useful papers by designers and plant engineers. Also, the NUDECK System was recognized by the Civil Engineering Research Foundation (CERF) as one of the three finalists of the Charles Pankow Award for Innovation in 2001.

1. Yamane, Takashi, Tadros, Maher K., Badie, Sameh S., and Baishya, Mantu C., “Full Depth Precast, Prestressed Concrete Bridge Deck System” Precast/Prestressed Concrete Institute (PCI) JOURNAL, V43, N3, May-June 1998, p. 50-66.

2. Badie, Sameh S., Baishya, Mantu C and Tadros, Maher K., "Innovative Bridge Panel System A success," Concrete International, American Concrete Institute (ACI), Vol. 21, No. 6, June 1999, pp. 51-54.

3. Badie, S. S.; Baishya, M.C, and Tadros, M.K. “NUDECK-An Efficient and Economical Precast Bridge Deck System”, Precast/Prestressed Concrete Institute (PCI) Journal, September-October, Vol. 43, No. 5, 1998, pp. 56-74. See also discussion by Bassi, and authors, March-April, Vol. 44, No. 2, 1999, pp. 94-95.

Contact: Sameh S. Badie • George Washington University • 801 22nd St. NW • Academic Center • Suite 638
Washington DC 20052 • 202-994-8803 • Fax 202-994-0127 • badies@gwu.edu

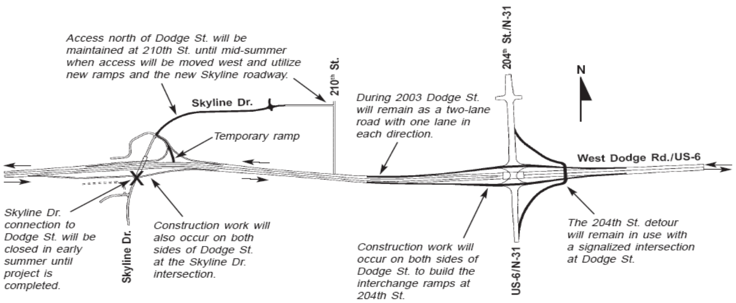

Fig.1. Overview of the US 6 Expressway Project

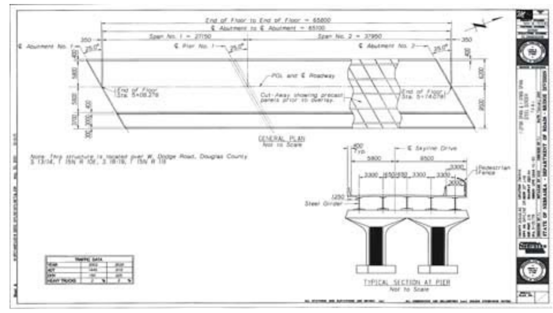

Fig. 2. Elevation & Plan Views of the Skyline Dr. Bridge

Fig.3. Conventional SIP Precast Panel System

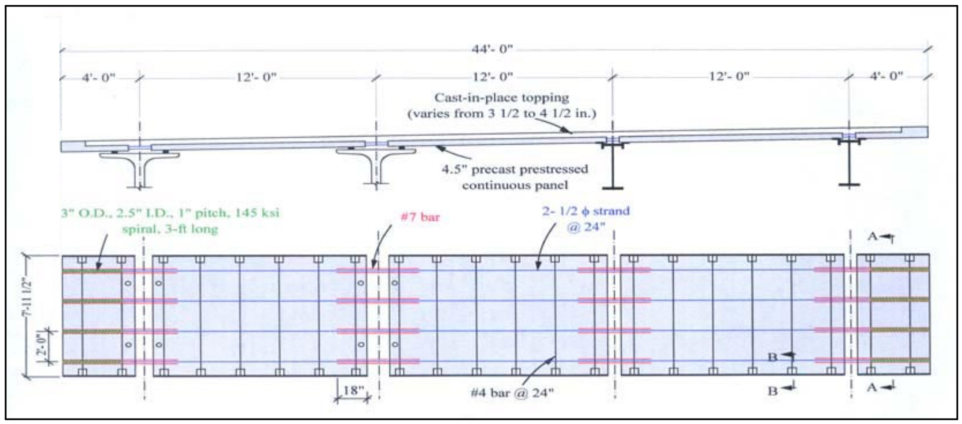

Fig. 4. Elevation & Plan Views of the NUDECK SIP Panel system

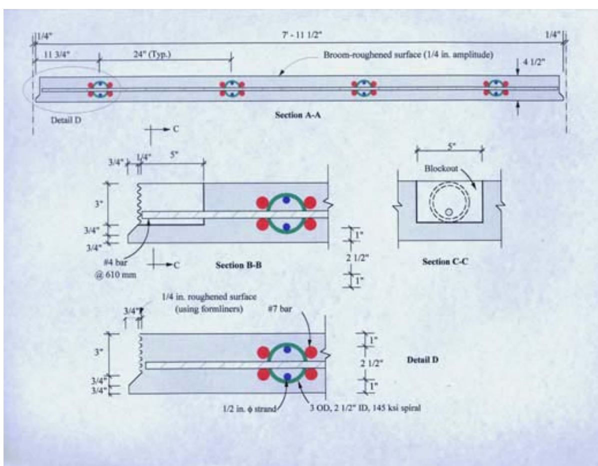

Fig.5. Details of the NUDECK SIP Panel System

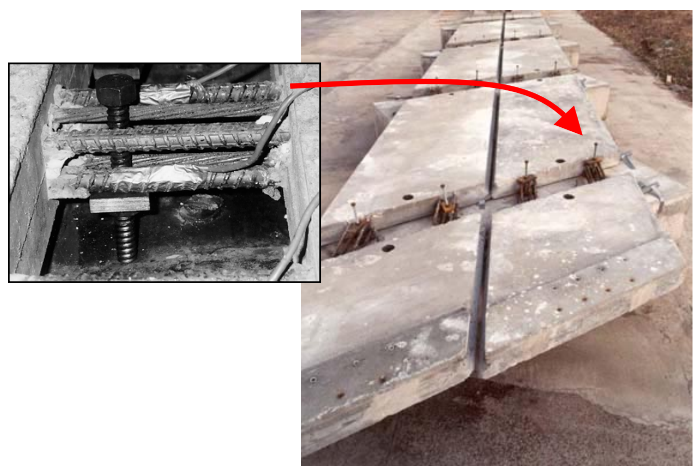

Fig. 6. A Mockup of the NUDECK Full-Depth Panels Showing Various Details

Fig. 7. The NUDECK being lifted from the Prestressing Bed

Fig.8. The NUDECK Panel during Shipping

Fig. 9. Storage of the NUDECK Panels in the Precast Yard