RE-DECKING the M. Harvey Taylor Bridge

Innovative Deck System Design Will Keep Traffic Flowing

Roger B. Stanley, P.E., M.S.C.E.

Fig. 1: Downstream elevation viewed looking eastward towards Harrisburg.

Faced with the prospect of potentially major impacts to motorists during the deck replacement of a 4,220' highway bridge crossing the Susquehanna River, PENNDOT and Frederic R. Harris selected a modular concrete filled steel grid deck system to minimize inconvenience to traffic during construction. Development of the rehabilitation design for this 50-year old bridge linking downtown Harrisburg, PA, with the outlying West Shore region was formulated to give the highest priority to maintenance and protection of traffic between the state capitol government complex in downtown Harrisburg and suburban communities across the Susquehanna River. Assuring the availability of all four existing travel lanes during daily peak traffic periods throughout the duration of construction, while still achieving a durable deck, was a driving force in conducting the initial study, preliminary engineering and final design phases of the project.

The bridge, shown in Figure 1, consists of 27 spans and was originally constructed in 1950. The two West Shore approach spans consist of a continuous steel rolled beam multistringer unit. The remaining 25 spans consists of a steel girder- floorbeam-stringer framing system with a typical span length of 166'-3". The existing typical section within the 25 main river spans is shown in Figure 2. The two variable-depth haunched main girders are spaced at 40'-6". Floorbeam cantilever brackets supporting 5'-0" wide sidewalks on each side of the bridge extend approximately 12', resulting in a total overall superstructure width of 64'-7". The existing superstructure carries two 25'-0" roadways for eastbound and westbound traffic separated by a 3'-0" median curb with tubular guiderail. The existing bridge deck consists of the original concrete flush-

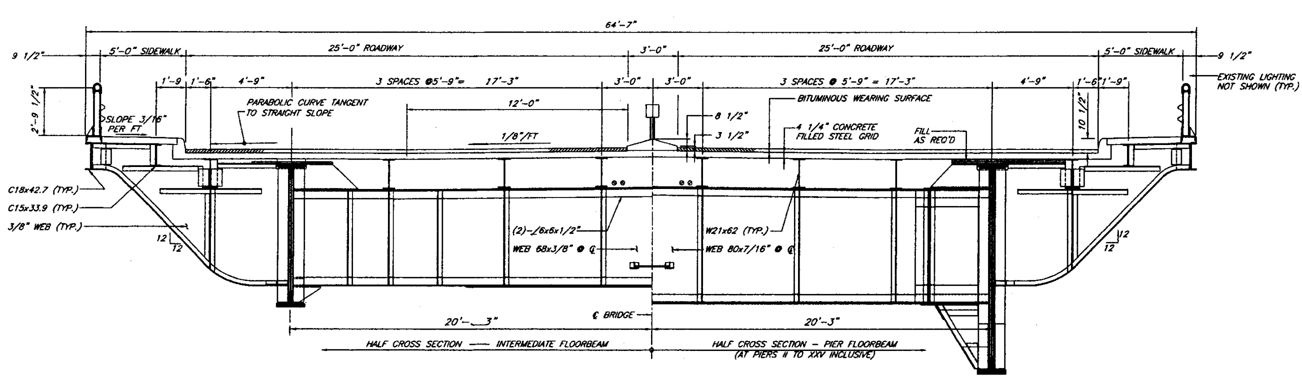

Fig. 2: Existing typical section within main river spans.

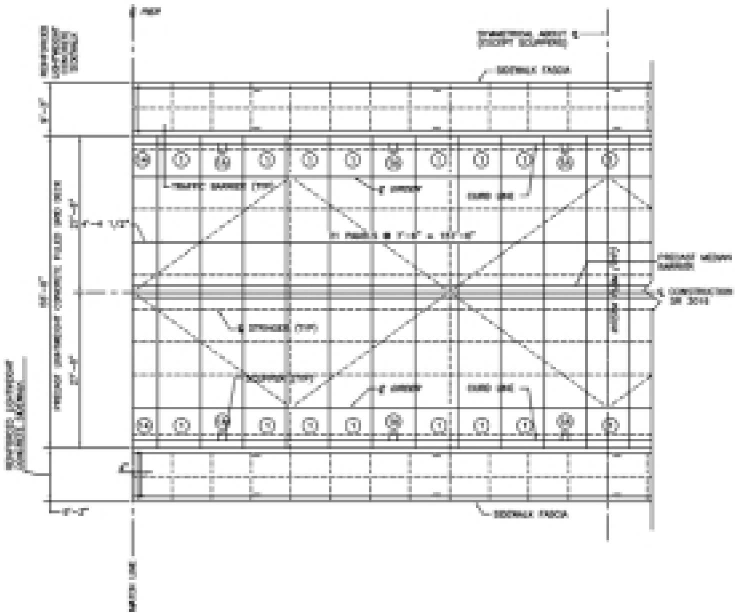

Fig. 3: Deck panel arrangement for half of a typical span.

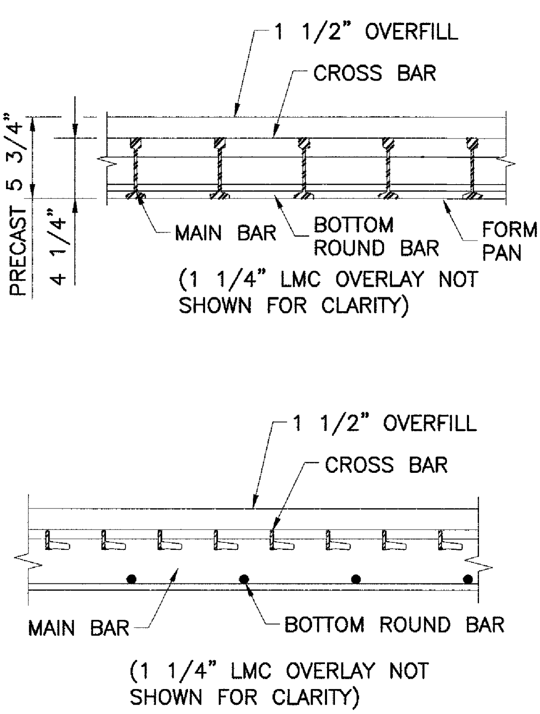

Fig. 4: Grid deck sections looking perpendicular to traffic in upper view and parallel to traffic in lower view.

filled steel grid deck overlaid with bituminous concrete pavement.

Preliminary design included a detailed inspection to identify necessary repairs and fatigue sensitive areas, as well as a feasibility study to determine the best solution for restoring the structure's integrity and reducing its maintenance needs. Options considered included re-decking the existing superstructure to its present width, widening the superstructure to facilitate maintenance of traffic during bridge construction staging and replacing the superstructure. The re-decking alternatives analysis included all available materials and construction methods for the new deck, such as lightweight concrete and modular grid deck construction. The selected re-decking scheme for final design and construction consists of overnight panelized replacement using a steel grid deck overfilled with lightweight concrete. Additional repairs include replacement of expansion joints, reconstruction of both sidewalks, new bicycle lanes, new traffic barriers at the median and sidewalk zones, replacement of all bearings using seismic isolation type bearings, total replacement of the bridge lighting system using historical-style fixtures and total bridge painting.

The bridge rehabilitation construction contract, valued at approximately $29.4 million, was awarded in June 2001 with Notice-to-Proceed provided on July 9, 2001. The project is in the shop drawing approval phase as of the submission date for this article. To date, construction of west approach retaining walls and west abutment widening have commenced with actual grid deck replacement anticipated to proceed in October of 2001. The estimated completion date is July of 2004.

Steel Grid Deck System

A concrete filled steel grid deck was selected as the preferred deck system to allow overnight panelized deck replacement of approximately 232,000 sq. ft. of deck surface area. This type of deck has been in use over 50 years including numerous major long span structures. Many grid deck applications are the result of situations where minimum weight floor systems are sought, such as in suspension bridges.

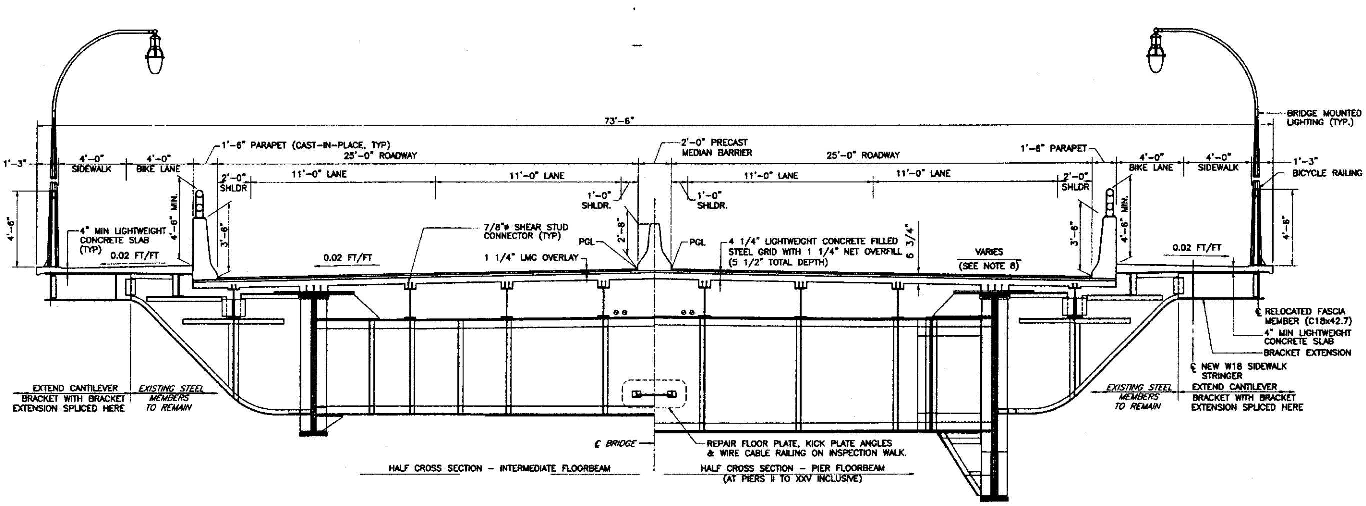

Fig. 5: Proposed typical section in main river spans.

In cast-in-place grid deck projects, finished deck weights as low as 50-60 psf are attainable, compared to deck slab dead loads of 100 psf for typical reinforced concrete decks. On the M. Harvey Taylor Bridge, deck weight was minimized through the use of lightweight concrete fill within the grid deck in order to attain the maximum feasible live load rating capacity. The concrete filled steel grid option was determined to be best suited since it offered a long service history in applications where minimum deck weight was a criterion and permitted keeping all four lanes of traffic in service during daily peak traffic periods.

The re-decking will be performed during limited duration nighttime or weekend total bridge closures while traffic is detoured to a parallel crossing located approximately one-half mile south. Individual steel grid deck panels measuring approximately 8' by 27'-6" will be placed across the longitudinal steel stringers in the two lane eastbound roadway, extending from the bridge centerline to the inside edge of the proposed raised sidewalk along the bridge fascia. The deck panel arrangement for a typical span is shown in Figure 3. A separate series of panels will be installed in similar fashion for the westbound roadway, with a field-bolted longitudinal joint provided between adjacent panels along the bridge centerline. Deck appurtenances will be shop installed to expedite construction, including tooth expansion dams, strip seal components and drainage scuppers. The fabricated grid deck panels will be hot-dip galvanized for corrosion protection purposes prior to receiving pre-cast fill concrete.

Main bearing bars running perpendicular to traffic serve as primary load-carrying members for the $4^1/_4$" deep grid deck. Section views showing the grid deck panel components and details are shown in Figure 4. Lightweight concrete fill will be pre-cast within the grid to an initial depth of $5^3/_4$", resulting in a $1^1/_2$" integral overfill above the top of the steel grid surface. Block-outs in the pre-cast fill will be provided at locations corresponding to longitudinal stringer haunch, traffic barrier and perimeter joint areas. The typical overnight panel erection sequence consists of removal of sections of the existing deck, removal of existing lead-based paint from the stringer top flanges, welding of shear studs, painting of the stringer top flanges, placement of the new deck panels and casting of rapid-setting concrete in the block-out regions to complete the modular panel. Panels are adjusted to proper grade using threaded studs after being positioned on the stringers. The deck cross-slope will be improved from 1% in the existing condition to 2% in the proposed condition by using variable haunch depths in the transverse bridge direction, resulting in maximum haunch concrete depths at the bridge centerline. In lieu of shop-installed forms proposed in the design drawings, the contractor elected to provide prefabricated support boxes consisting of angle members to contain the CIP rapid-setting concrete within the stringer haunch zones. The design drawings specified re-opening the bridge to traffic in time for the weekday morning peak traffic period after strength development of the rapid-setting concrete. The contractor has submitted modified deck panel installation procedures that will postpone placement of the CIP rapid-setting concrete until the weekend periods, thereby increasing the available window of time for strength gain. Traffic will ride on the concrete overfill surface during the remainder of construction. Upon completion of the panelized deck replacement, the top $^1/_4$" of the overfill will be scarified in advance of placing a $1^1/_4$" latex modified concrete wearing surface on the bridge.

Widening Considerations

Existing 5' wide sidewalks along both sides of the bridge will be widened to 8' to accommodate the addition of 4' wide bicycle lanes. The remaining 4' width of the proposed sidewalk will continue to serve pedestrian traffic. Overall, the superstructure will be widened by approximately 9', adding approximately 4'-6" of width to each bridge fascia sidewalk area. A proposed typical section for the widened main river spans is shown in Figure 5. Superstructure widening will be accomplished through framing modifications, including removal and relocation of the existing sidewalk fascia channel after extending the transverse floorbeam cantilever bracket members through splicing on a new W18 x 50 rolled section. The proposed widened sidewalk configuration is illustrated in Figure 6. A new W18 x 50 sidewalk stringer will be added along the middle

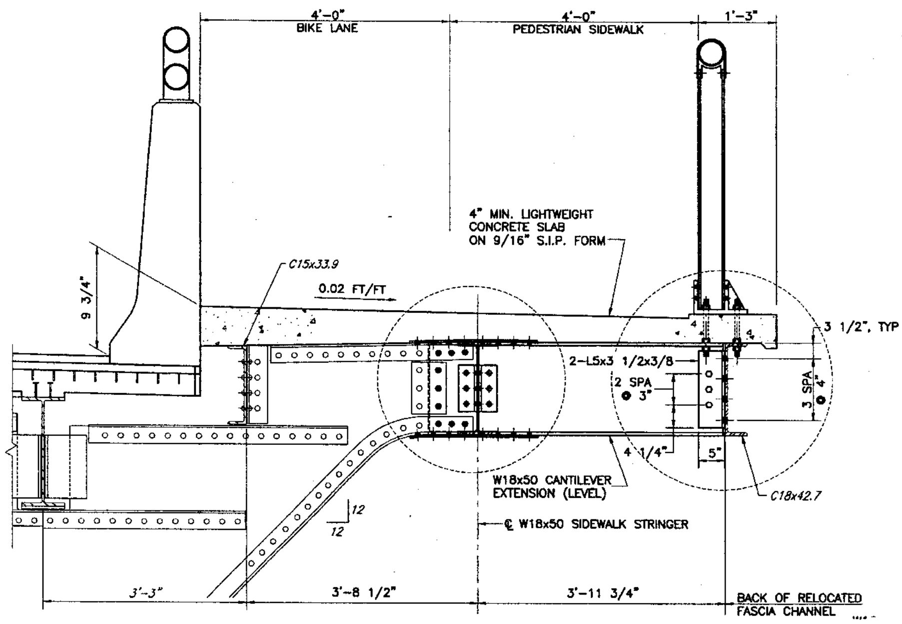

Fig. 6: Proposed widened sidewalk configuration.

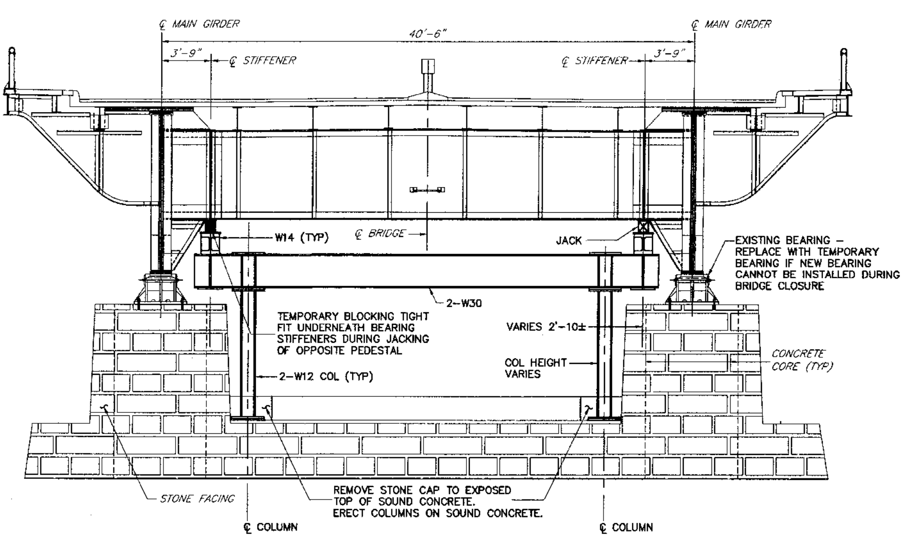

Fig. 7: Suggested jacking scheme for the main span girder bearings.

of the sidewalk for the full length of the bridge. The construction cost for widening was minimized through re-use of both existing longitudinal support framing lines in combination with the addition of one new center support member. The adequacy of the existing floorbeam cantilever bracket section for the additional dead and live loads was investigated including capacity of the connection to the main girder. All existing components, including the floorbeam cantilever bracket tie-plates, were determined to have sufficient capacity to carry the increased loadings. No substructure widening was required for the cantilevered widening scheme.

A 4” minimum variable-depth lightweight concrete sidewalk slab will be constructed on $^{9}/_{16}$” deep SIP metal forms. The addition of a curbside concrete barrier required a change in the sidewalk cross-slope direction. In contrast with the original sidewalk cross-slope directed toward the roadway slab, the proposed sidewalk cross-slope will be in the opposite direction in the river spans so that sidewalk runoff will drain “free-fall” over the outside edge of the slab.

Seismic Retrofit

An initial seismic-adequacy assessment performed during the feasibility study phase revealed critically deficient conditions associated with the main span river piers. The bridge was determined to be highly vulnerable to potentially major seismic damage due to the existing superstructure typical configuration, consisting of multiple four span continuous units. This arrangement provides only one fixed bearing line within each 665’ long continuous unit to resist all seismic horizontal forces applied in the longitudinal bridge direction. Predictably, detailed seismic analysis indicated significant overstress in foundation bearing pressure at the fixed pier locations due to the overturning effect from longitudinal loads under seismic group loading. Another major concern was the complete lack of reinforcing steel within the plain cement concrete pedestals at the main girder bearings on the solid wall type piers. These deficiencies made the structure an ideal candidate for seismic retrofit through the installation of isolation bearings to upgrade response to potential post-construction earthquake events.

The rehabilitation strategy selected for seismic retrofit was replacement of all existing steel rocker and fixed shoe bearings with seismic isolation bearings. Seismic analysis was performed using the multi-mode response spectrum method. The response spectrum for Seismic Performance Category B, Bedrock Acceleration of 0.15g and Soil Type 1was modified to account for increased damping beyond the AASHTO code-defined 5% damped elastic spectrum. In addition to improved seismic response through increased period of the structure and associated overall lateral force reduction in the isolated condition, the opportunity to achieve significant lateral force redistribution through seismic isolation was a major factor in recommending and ultimately implementing seismic retrofit as part of the overall rehabilitation. In the proposed isolated condition, all of the piers participate in resisting longitudinal loads, including the original expansion piers that previously offered no contribution to longitudinal load resistance.

Jacking methods and replacement bearing assembly details were developed and presented for the 52 main span girder bearings as well as 26 additional bearings within the two West Shore approach rolled beam spans. Jacking will be performed under dead load only during overnight and weekend total bridge closures while traffic is detoured. A contingency procedure will be implemented in the event an individual bearing cannot be completely replaced during one total bridge closure period. The contractor is permitted to install a temporary bearing or blocking assembly so that the girder can be lowered to allow resumption of traffic pending completion of the bearing change-out under the next available bridge closure. A suggested jacking scheme for the main span girder bearings is depicted in Figure 7. Eight different individual bearing types were required in all, with total design load values including dead, live and impact ranging from a minimum of 42 kips in the approach spans to a maximum of 1400 kips in the main river spans. A performance specification for the seismic isolation bearings was developed to permit different types of isolation bearing systems to be qualified for use on the project. The successful bidder based the overall winning bid on the use of laminated elastomeric isolation bearings of the lead core type.

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PROJECT OWNER:
Pennsylvania Department of Transportation, Engineering District 8-0, Harrisburg, PA

CIVIL/STRUCTURAL ENGINEER:
Frederic R. Harris, Inc.,
Philadelphia, PA

STEEL FABRICATOR:
L.B. Foster (AISC member),
Pittsburgh, PA

STEEL GRID DECK
GENERAL CONTRACTOR:
G.A. & F.C. Wagman, York, PA

SOFTWARE:
SEISAB program
(for seismic analysis)

PENNDOT BAR7 Bridge Analysis and Rating program (for
live load ratings analysis
and member forces/reactions)

STAAD program (for general analysis of selected members)

Additional PENNDOT in-house programs for substructure and retaining wall design/analysis