CONDITION ASSESSMENT and Repair

An Existing Composite Concrete Slab and Steel Beam Framed Parking Structure – Part 3

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This article, a continuation of those that appeared in the April and June 2012 issues of STRUCTURE®, presents a description of the repairs developed as a result of the condition assessment and analysis of the physical observations and material testing discussed in Parts 1 and 2.

Ramp Renovation in Progress.

Repairs

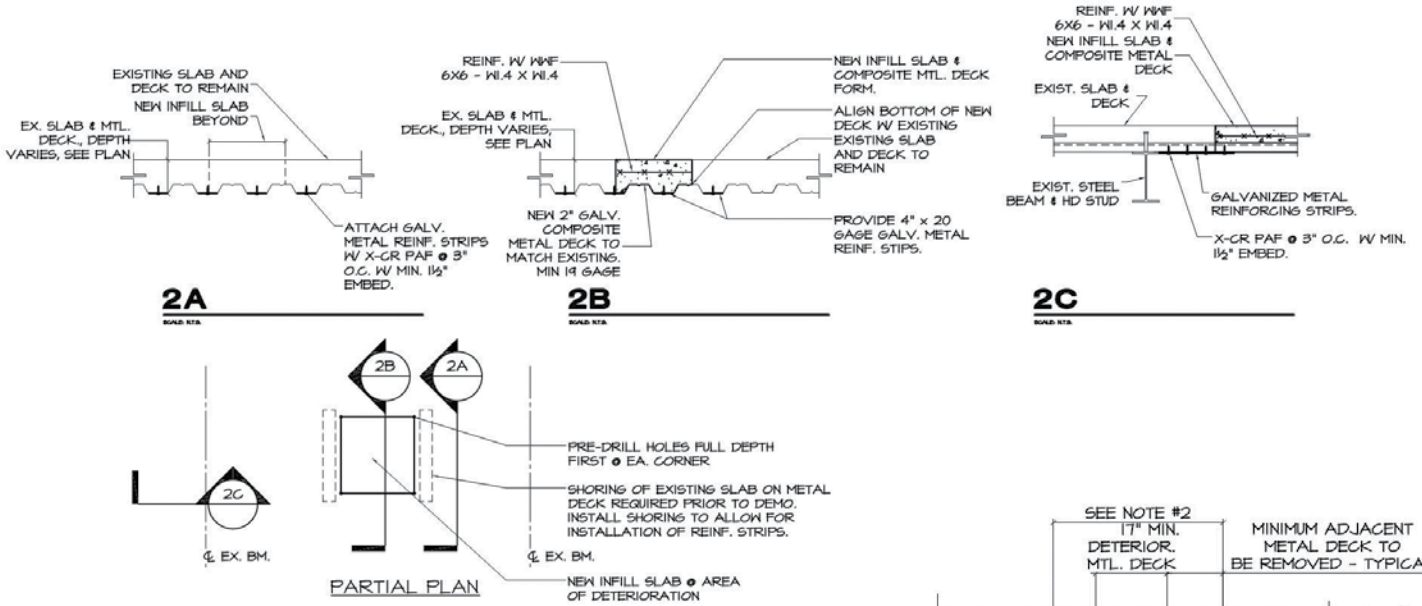
As a result of the condition assessment, the property management company retained Pennoni to develop a set of biddable repair and renovation documents. The intent was to develop effective procedures and specify appropriate materials for the repair of the deteriorated concrete surfaces, metal deck and structural steel associated with the expansion joints and trench drains.

Important criteria for development of the repair documents included the following:

1) Due to the relatively shallow thickness (3¼ to 4½ inches) of the concrete slab over the 2-inch-deep composite deck, repairs of surface spalls and subsurface delaminations would need to involve the complete demolition and replacement of the deteriorated slab and metal deck. However, at the loading dock slab (6-inch slab over 2-inch metal deck), there were situations where it was possible to accomplish shallow (2-inch maximum) repairs involving conventional saw cutting, mechanical demolition and placement of an infill topping.
2) The nature of the flexural capacity of the existing composite deck dictated that the majority of the full-depth repairs extend from supporting beam to supporting beam at most areas of concrete deterioration, in order to avoid a situation in which discontinuity of the metal deck would occur within a significant portion of the clear span of the existing slab. However, at a few isolated locations, a full-depth repair was possible that allowed for the replacement of the portion of lost composite deck with external, full-span soffit reinforcement as described in note 5 below.
3) Due to the high levels of chlorides, any new concrete repairs would result in the real potential for accelerated deterioration of the surrounding slab because of the incipient anode affect, which occurs through the following process. When an area of steel is corroding under the influence of chloride contamination, steel reinforcing is dissolving, which causes the formation of iron ions (tiny charged particles of iron). Simultaneously, electrons are released that flow along the reinforcing and react at some point remote from the point of corrosion with both air and oxygen. The corroding areas are therefore supplying electrons to surrounding areas of steel, effectively providing localized cathodic protection to the adjacent steel. If you remove the corroding area and apply a repair patch without dealing with chloride contamination in adjacent areas, the natural cathodic protection system will be removed. As a result, new corrosion cells will rapidly spring up on either side of the repair, and premature failure of the surrounding concrete will often occur.

In order to prevent this phenomenon, the slab repairs included the use of a sacrificial, passive galvanic protection system to protect both the internal slab reinforcement and

Installation of Internal Sacrificial Anode.

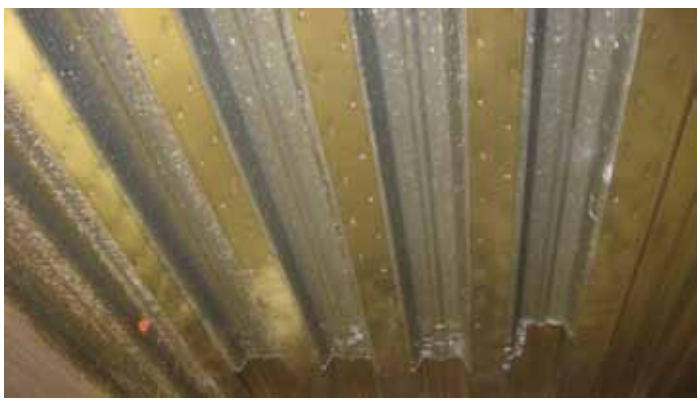


Isolated full depth repair detail.

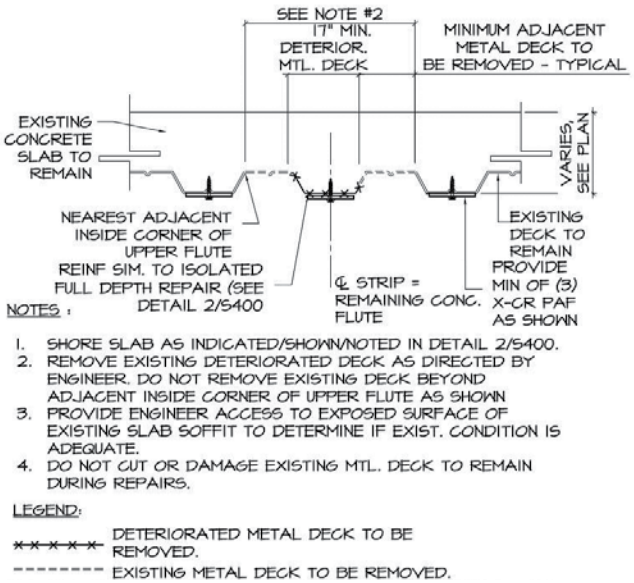
the metal deck from further corrosion. A passive galvanic protection system is different from an active or cathodic system, in which an impressed electrical current is provided from an external power source. A passive system protects the existing reinforcement and metal deck from further corrosion through the following process.

When two dissimilar metals are coupled together in an electrolyte, the metal with the higher potential for corrosion (i.e., more negative electrochemical potential) will corrode before the more noble metal. By placing a sacrificial zinc anode in the slab repair, corrosion of the anode will occur while an electrical current prevents corrosion activity at either the reinforcing or the deck due to the direct connection of electrical lead wires from these elements to the anode. The service life of this system ranges from 15 to 20 years, at which point it will be necessary to replace the anodes in order to prevent further reinforcing and metal deck corrosion, and resulting concrete deterioration.

4) Because the true extent of concrete deterioration at the slab soffit could not be determined until the areas of corroded metal deck were removed during the renovation phase, it was necessary to develop the base bid repair details under



Reinforcing Strips on Underside of Metal Deck (External Sacrificial Strip Anodes Not Installed).



Isolated metal deck repair detail.

the assumption that the full depth of concrete slab would have to be demolished and replaced. Similar to the full-depth surface repairs above, this also meant that the base bid repairs for the metal deck had to extend from supporting beam to supporting beam. However, in cases where the exposed concrete slab soffit had not actually deteriorated, an alternate detail allowed for just the remediation of the deck deterioration in lieu of a full-depth slab repair.

5) The alternate repair method for the metal deck presented the challenge of how best to replace the flexural capacity of the area of deck that had to be removed due to the resulting discontinuity of the deck, and how best to attach the new deck to the concrete above to ensure full composite action. Originally it appeared that carbon fiber reinforcement would be the best solution, but adhering the fabric strips to the bottom of a rust-stained concrete slab soffit was going to be problematic. In addition, there were issues with how best to lap and develop external fiber reinforcement with the remaining existing metal deck. The eventual solution was to employ galvanized sheet metal strips that could be attached to the concrete slab above using powder-actuated fasteners.

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6) Non-technical concerns included phasing the renovation work as required to maintain normal operation of the garage, and phasing the repair work such that the property manager could fund the project over a number of years. The construction phasing and sequencing assumed that work at the entrance and exit ramps could only be done during weekend hours. In addition, all work would be done during the summer months when the occupancy rate of the garage was at its lowest. Work in the loading dock area had to be phased such that no more than half of the facility would be closed at any one time. To facilitate the construction phasing, the plans segregated areas of repair and altered the normal traffic patterns accordingly. The available annual funding of the $3 million project required that it be spread out over a period of not less than five years. To facilitate this, the repair bid quantities were categorized by type and area of the garage, so that the submitted bids could be funded based on an established order of priority.

Conclusion

The renovation work for this project started during the summer of 2011 and is expected to extend until 2015. The initial work included the temporary shoring of a number of areas that exhibited such extensive metal deck deterioration that there was an immediate concern for the structural load-carrying capacity of the affected slab spans. The renovation that continues into 2012 includes the full-depth repair of the most significantly deteriorated and temporarily shored areas of the garage. Other areas that exhibit the most severe surface deterioration have been covered with steel plates that are capable of spanning from steel beam to steel beam under the imposed garage live load.▪

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Completed Surface Repair.