

The history and benefits of prefabricated grid reinforced concrete decks

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ABSTRACT: Accelerated Bridge Construction (ABC) techniques are employed predominately to reduce on-site construction time, minimize traffic impacts, and improve work zone safety. Grid reinforced concrete bridge decks have been an economic, lightweight, rapid deck replacement option long before ABC became the vogue acronym defining the desired construction practice for the 21st century. The prefabricated modular nature of grid reinforced concrete deck naturally lends to reduced construction periods and offers the advantage of shortened work windows – nighttime or weekend – when traffic volumes are lower and the travelling public is less encumbered. In addition, the reduced weight translates into direct savings in the superstructure and substructure for new construction and can minimize superstructure rehabilitation and increase live load capacity of existing structures. A few recent projects accentuate the role of grid reinforced concrete decks as the solution to lightweight, rapid deck replacements.

1 INTRODUCTION

As engineers searched for a lightweight, high strength deck alternative, the first grid reinforced concrete decks emerged in the 1920's as tees butted together at their flanges and encased in concrete. In the 1930's, the fully filled I-beam Interlock decks were introduced. The steel grid consisted of specially rolled narrow beams (main bars) evenly spaced and connected with cross bars oriented normal to the main bars, evenly spaced and welded flush to the top of the main bar. In addition, round bar was placed in the lower section of the grid, oriented in the same direction as the cross bar. Thin gage sheet metal rests between the bottom flanges to support the full-depth concrete (Gilmore, 1987) (see Figure 1).

In the 1950's, an intermediate flange was added at the center of the 5" I-beam. This offered support for the form pans, which constitute the bottom of the concrete. This created a half-filled system that reduced the total weight of the deck without loss of spanning capacity (See Figure 2).

Exodermic™ decks (Unfilled Grid Decks Composite with Reinforced Concrete Slabs as defined in AASHTO LRFD Design Specifications) were introduced in the 1980's. It is a system of inverted WT shapes evenly spaced with distribution bars normal to and welded to the web of the tee. The tee webs penetrate 1" into the bottom of a reinforced concrete slab and are made composite with the slab via closely spaced 3/4" diameter holes punched into the top of the grid (Bettigole, 1998) (see Figure 3).

Grid reinforced concrete bridge decks offer three major advantages over traditional reinforced concrete bridge decks. One is that they are lighter in weight. Grid reinforced concrete decks can weigh up to 50% less than traditional decks when span capacity is compared. For new bridge construction, this translates into a direct savings to the superstructure and substructure. For movable bridges, additional savings are realized in the counterweight, trunnion assemblies and drive machinery. For rehabilitated structures, specification of a lighter weight deck may re-

duce the amount of strengthening of the superstructure and result in an increase of live load capacity. For some structures, the weight savings could also mean that a much needed widening of the deck is now possible.

The second advantage is their durability. There are many grid reinforced concrete decks, built in the 1930 to 1960 time period that are still in service today. The Bronx-Whitestone Bridge (1939) and the Mackinac Bridge (1957) are just a couple of high profile structures that still have their original decks. Grid reinforced concrete decks are known to last twice as long as standard reinforced concrete decks. A perfect example of this is the Elizabeth Bridge over the Monongahela River in Allegheny County, Pennsylvania. The structure was built in 1950 with a grid reinforced concrete deck on the main span and a conventional reinforced concrete deck on the approach spans. Both deck types experienced the same traffic and were exposed to the same environmental conditions. In 1986, all of the approach ramp decks required replacement, whereas the main span only received a new overlay. There are several other mixed deck structures such as the Walt Whitman Bridge, the Thousand Islands Bridge, and the Homestead Bridge that have shown similar life cycles (BGFMA, 1994).

The third advantage is speed of installation. Grid reinforced concrete decks are modular by nature which when installed, can eliminate weeks or even months of field labor. For cast-in-place applications, the grid panel acts as its own formwork, leaving very little forming for the field. Precast panels also need very little forming and require only rapid-setting concrete closure pours over the supporting steel and between panels making them ideal for nighttime or weekend work when traffic is expected at the end of the work shift.

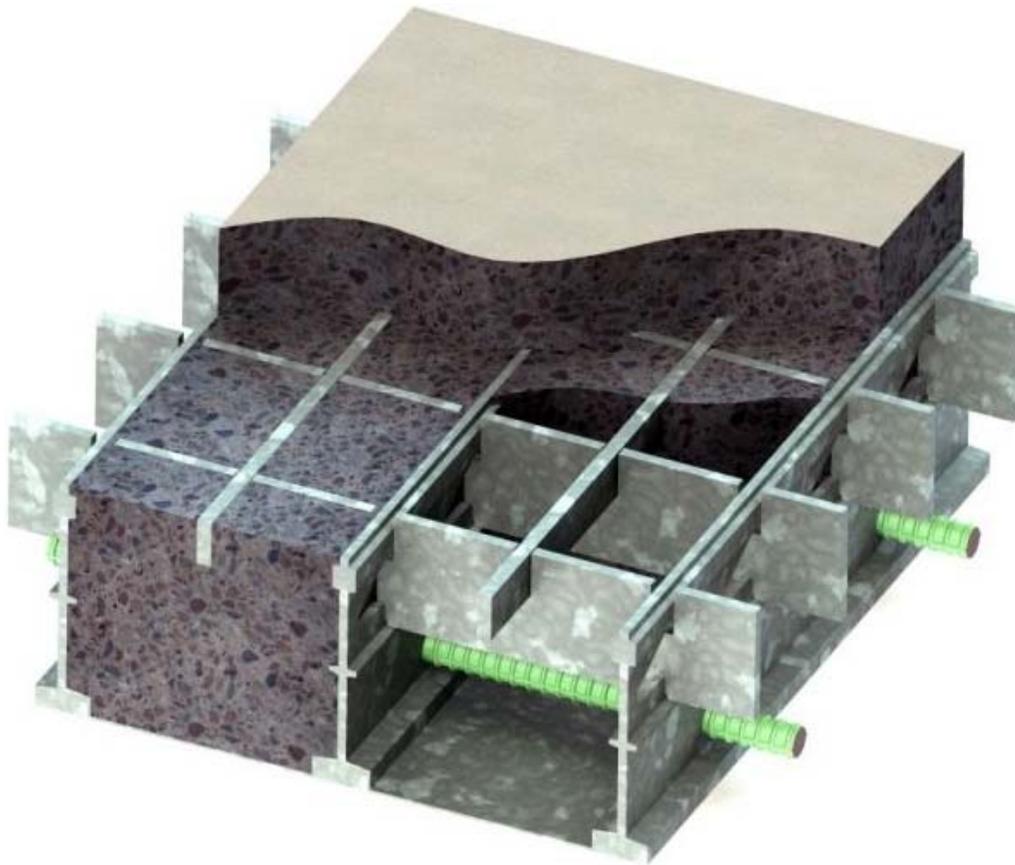


Figure 1. Fully filled grid reinforced concrete deck.

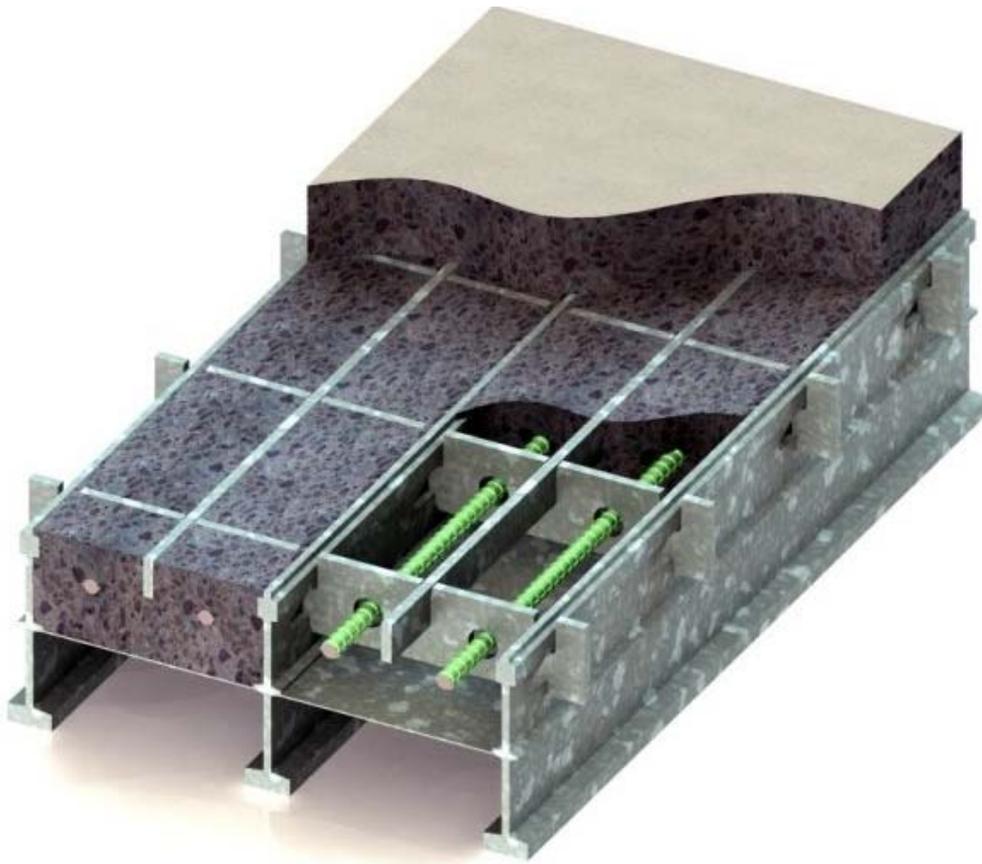


Figure 2. Partially filled grid reinforced concrete deck.

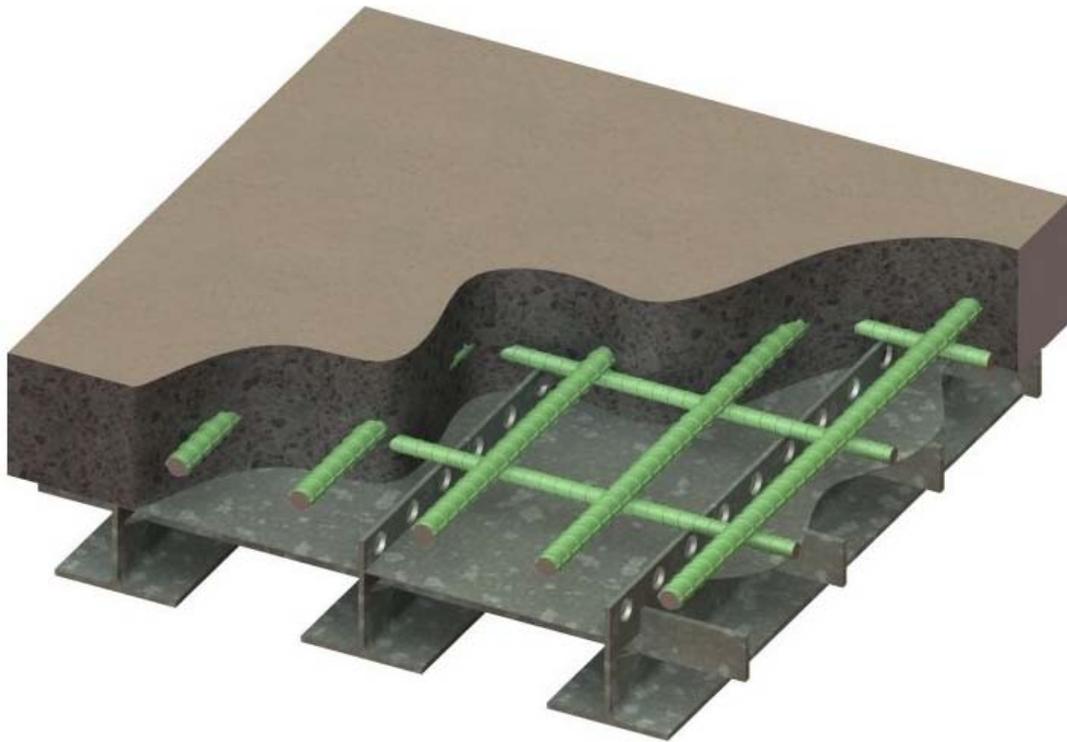


Figure 3. Unfilled grid deck composite with reinforced concrete (Exodermic™ deck).

2 I-285 NEAR ATLANTA, GA

When it came time to replace the decks of two major bridges on I-285, with traffic volumes nearly 300,000 vehicles per day, the Georgia DOT (GDOT) Office of Maintenance wanted a rapid method of replacement that would prevent grid lock in Metro-Atlanta (Edwards, 2006).

GDOT approaches rehabilitation of bridge decks using four major construction methods: (1) bonded concrete overlays, (2) hydro-demolition and concrete overlay, (3) conventional deck replacement with high early strength concrete, and (4) pre-fabricated deck systems. Each method is evaluated based on the condition of the existing deck, impacts to traffic, and construction costs.

Prefabricated deck systems are considered when the cost associated with the impacts to traffic outweigh the additional material costs. While it is hard to justify the cost of prefabricated deck systems, anyone who commutes on I-285 in rush hour traffic understands the impact of lanes being shut down. The potential for accidents in construction zones and loss of revenue to companies shipping goods on these roadways must also be considered. GDOT contracted with J.B. Trimble, Inc. (JBT) for this fast track rehabilitation project. JBT is an Atlanta based consultant with extensive interstate deck replacement experience and practiced at premiering different technologies for bridge rehabilitation. Because of the condition of the deck, JBT recommended a prefabricated deck system utilizing a steel grid deck composite with a full-depth, overfilled precast slab. Although GDOT was unfamiliar with this type of construction and the costs exceeded that of conventional replacement, the ability to reconstruct the deck on weekends, thereby minimizing any disruption to traffic flow, justified the specification.

The bridge carrying I-285 over Cobb Parkway (US 41) is located approximately 1 mile west of the I-75/I-285 Interchange. Cobb Parkway is critical from a traffic perspective because it links major commercial areas in Cobb County. The bridge is 243' long and 149' wide, carrying four lanes in each direction. The superstructure consists of steel girders spaced at 6.5 ft. on center supporting a 6.625" reinforced concrete deck slab.

The bridge carrying I-285 over Buford Highway (SR 13) is located approximately 1.1 miles west of the I-85/I-285 Interchange. Traffic on this bridge is heavily influenced by traffic conditions in the I-85 Interchange. Buford Highway is a vital link to commercial and industrial areas surrounding I-285 in DeKalb County. Two parallel structures span the intersection. The total length of each bridge is approximately 217 ft. The westbound bridge has girders spaced at 6.5' on center supporting a 6" concrete deck slab and carries six lanes. The eastbound side employs girders at 7.0' topped by a 6.25" deck and carries seven lanes. After widening in 1976, the bridge is now 197' wide.



Figure 4. Precast panel installation on I-285 near Atlanta, GA.
(Photograph courtesy of L.C. Whitford)

BGFMA member LB Foster supplied the 4 1/4 Inch Interlock steel grid panels to the prime contractor - The L. C. Whitford Co., Inc. (LCW) Georgia Division (see Figure 4). LCW specializes in accelerated bridge construction projects on the congested interstate system around Atlanta and is no stranger to the stringent demands of this type of work. Panels were then precast by LCW forces at their Alpharetta yard. Weekend work was confined to 56 hours – 9:00 pm on Friday to 5:00 am on Monday, and the contract limited the number of available weekends to sixteen, but LCW was able to complete the 25,720 sq. ft. of deck replacement in eleven weekends. From GDOT's perspective, this project was considered a success largely due to the significant reduction in traffic impact. Because of this success, GDOT, JBT and LCW have since completed two other similar projects on I-75, and GDOT will continue to examine other sites for potential use of prefabricated grid deck systems.

3 MATHEWS BRIDGE IN JACKSONVILLE, FL

Designers and owners routinely select Exodermic™ decks for their light weight, design efficiency and the speed at which they can be placed and completed. When the home town design firm Reynolds, Smith & Hills, Inc. (RS&H) was given the task to replace the open grid deck on the channel span of the Mathews Bridge in Jacksonville, Florida, they had yet another reason for selecting an Exodermic™ deck – Ride Quality.

The Mathews Bridge, carrying Alternate US 90/SR 115 over the St. Johns River, is one of the most heavily traveled bridges in Jacksonville with average daily traffic at 74,000 vehicles per day. The bridge is a direct link for the populated east side to downtown for work, and recreation including the Jacksonville Jaguars stadium and the shops and restaurants at The Jacksonville Landing (Florida Engineering Society, 2009).

The bridge was originally built in 1952 with an open grid for weight savings, and there have been subsequent open grid deck replacements and rehabilitations. FDOT desired a closed deck system, which would protect the superstructure elements from moisture and debris and thereby extend the service life of the structure.



Figure 5. Bare Exodermic™ panels placed on Mathews Bridge.
(Photograph courtesy of RS&H)

In 2006, FDOT awarded RS&H the contract to design a new closed deck system with the stipulation that the construction period be limited to 90 days. In addition to the required rapid replacement, the new deck would have to be weight conscious to replace the existing 18.5-lbs/sf open grid deck. A cast-in-place Exodermic™ deck with WT4x5 main bars spaced at 13.5" and 4" of lightweight reinforced concrete was specified to span new stringers spaced at 5'-10 1/2" designed to AASHTO LRFD Specifications vehicular design load (see Figure 5). The total weight of this Exodermic™ deck is 48.8-lbs/sf yet still providing 2" of cover over the rebar. This translated into savings toward minimal required strengthening of the truss system and the existing floor beams.

Tampa based PCL Civil Constructors, Inc. was awarded the contract, and BGFMA member, Interlocking Deck Systems International (IDSI), supplied the Exodermic™ grid panels. The project was constructed in phases maintaining westbound traffic and detouring the eastbound traffic. The project was scheduled to be complete by the end of July, 2007, but because of the prefabricated nature of an Exodermic™ deck in which the deck acts as its own form work, PCL completed the project two weeks early much to the relief of the Jacksonville residents.

4 SUMMARY

Grid reinforced concrete bridge decks have a long history of dependable service to the public and the industry. First appearing in the early twentieth century as an innovative lightweight design, they have been the preferred deck choice for many high profile structures such as the Verrazano Narrows Bridge, the Walt Whitman Bridge and the Brooklyn Bridge to name a few. Their durability has been demonstrated over time on numerous projects with many original decks still in service for more than 50 years. Grid reinforced concrete decks are also an effective alternative for projects that require accelerated replacement of existing bridge decks.

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