



A Magazine for Specifiers and Engineers

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WINTER 2013

BRIDGES AND TRANSPORTATION

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NPCA file photo

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PRECAST CONCRETE: RESILIENCY IN THE FACE OF FURY

By Claude Goguen, P.E., LEED AP

With Hurricane Sandy's recent invasion of the eastern seashore, Mother Nature continues to deal out disasters at a seemingly higher pace in recent years. Many communities in New Jersey, New York, Connecticut, Virginia and Delaware are faced with the same daunting task shared by cities like New Orleans, Tuscaloosa and Joplin: rebuilding. When rebuilding post-disaster, one question should be: "How can we be better prepared when this happens again? How can we enhance the resiliency of our community?"

BOUNCING BACK FROM DISASTERS

What is resiliency? In the study of physics, it is the physical property of a material to return to its original shape or position after a deformation. Resiliency can describe how a friend successfully battles a debilitating illness, or how rapidly a community recovers from a natural disaster. It's the ability to bounce back – or, more specific to precast concrete, a structure's ability to withstand a storm's stress forces without failure.

What does resiliency have to do with sustainability?

Everything. Sustainability, in the broadest sense, is the utilization of resources in a manner that meets the needs of present generations and protects the environment while preserving the needs of future generations. Buildings, roads and infrastructure that are designed and built to withstand natural and man-made disasters not only protect people and equipment, but also reduce the need for costly repair and rebuilding. Less rebuilding-related site disruption is a big part of being a responsible environmental steward.

PRECAST CONCRETE BUILDS RESILIENT COMMUNITIES

Each year in the United States, natural disasters cause more than \$35 billion in direct property loss, not to mention the loss of life. Disaster preparedness and community resiliency are on the forefront for U.S. Homeland Security and FEMA, and we will continue to hear more about this subject.

The goal is to build resilient communities. A resilient community anticipates problems, opportunities and the potential for unexpected events. It reduces vulnerabilities, and it responds effectively, fairly and legitimately. And a resilient community recovers rapidly and safely. In addition to critical disaster management services of local governments, a resilient community recognizes that private businesses, individual citizens, and volunteer organizations are critical recovery resources.

Based on experience from past natural disasters, officials agree that the key to community recovery is getting businesses up and running. This means restoring essential services that supply electricity, water and communications as fast as possible. Precast concrete infrastructure, foundations, buildings and enclosures are perfectly suited to enhance a community's ability to get back on its feet.

CONCRETE JOINT SUSTAINABILITY INITIATIVE: HELPING IN DISASTER RECOVERY

The National Precast Concrete Association (NPCA) is a member of the Concrete Joint Sustainability Initiative (CJSI, www.sustainableconcrete.org), an industry coalition. CJSI is involved in outreach efforts to obtain resources from local agencies, Homeland Security, and the United Nations in efforts to build resilient communities throughout the world. An example of a CJSI local program is the Smart Home Alabama (www.smarthomesalabama.org). Smart Home Alabama is a nonprofit organization whose desire was to alleviate

the suffering that resulted from the collapse of the residential insurance market on the U.S. Gulf Coast following Hurricanes Ivan and Katrina.

CJSI has invited officials from the Community and Regional Resilience Institute (CARRI) and Insurance Institute for Business & Home Safety (IBHS) to help them teach communities how to adopt a more resilient posture. CARRI (www.resilientus.org) was created through a request by the Department of Homeland Security to understand and evaluate how resiliency works within communities. It is currently funded through Oak Ridge National Labs and private sponsorship. CARRI seeks to understand how communities can best prepare for, respond to and, most importantly, recover from natural or man-made disasters and then translate that understanding into practical processes and tools to achieve ever-higher levels of resiliency.

IBHS (www.disastersafety.org) created a suite of FORTIFIED programs dedicated to improving the quality of residential and light commercial buildings. FORTIFIED programs feature practical, meaningful solutions for new and existing structures throughout the United States and uses applied building science solutions to reduce the risks facing these properties.

CJSI works with agencies such as the American Society of Civil Engineers (ASCE), Structural Engineering Institute (SEI), United Nations International Strategy for Disaster Reduction (UNISDR), and the National Institute of Building Sciences (NIBS). UNISDR's (www.unisdr.org) mandate is to serve as the focal point for the coordination of disaster reduction.

PRECAST CONCRETE: SAFER AND STRONGER

Sustainability is not just about being green – it's about being green and resilient. The precast concrete industry provides not only the means to build strong structures that meet the test of time, but offers resilient building designs to withstand natural disasters and help protect citizens and services. We encourage specifiers to consider resiliency when designing buildings and infrastructure and, in particular, to consider the outstanding resiliency of strong precast concrete when selecting materials. **PS**

For more information on the resiliency of precast concrete, contact Claude Goguen, NPCA's director of Technical Services, at cgoguen@precast.org or call (317) 571-9500.

WHY GCs AND DOTs CHOOSE JOINTED PRECAST PAVEMENT

WHEN TRANSPORTATION AGENCIES AND CONTRACTORS MUST REOPEN ROADS TO TRAFFIC AS SOON AS POSSIBLE, PRECAST CONCRETE PAVEMENT IS THE BEST SOLUTION.

By Evan Gurley

You might say precast concrete pavement is a late bloomer. One of the earliest reported uses of precast concrete pavement technology in the United States occurred in South Dakota during the 1960s. In the 1970s, Michigan, New York, Florida and Virginia all performed additional experiments with precast concrete pavement. And although initial trials were generally successful, real momentum for broader implementation didn't materialize until about a decade ago when the U.S. Federal Highway Administration (FHWA) introduced its Concrete Pavement Technology Program (CPTP) to improve the performance and cost-effectiveness of the systems.

TRANSPORTATION ENGINEERS NEED TO BE CONVINCED

Since that time, numerous jointed precast concrete pavement systems (PCPS) have been developed (both proprietary and nonproprietary) and are currently being installed on roadway projects all across North America.

The future is promising for jointed PCPS technology, but mainstream acceptance has been slow. Pavement engineers need to be convinced that precast slabs will provide a coherent pavement structure equal to, if not better than, a cast-in-place (CIP) installation. They recognize that load-transfer devices across transverse joints, ties across longitudinal joints, full and complete bedding of the slabs and 3-D surface geometry must be achieved for PCPS to be fully successful.

Engineers also need to be convinced that PCPS installs rapidly, in eight-hour or even five-hour work windows, and that the result will provide a service life at least as good as CIP pavements. In the past decade, extensive testing by state DOTs and other roadway specifiers has convinced them that PCPS can do all this and more, but it has been a case-by-case approach that has led to slow adoption.

"Precast pavement has a huge potential for speeding up and reducing the risk of overnight construction and getting the roadway returned to the public without them



even knowing anything happened – except for now, the roadway is easier to drive on and it stays that way for years,” said Kirsten Stahl, senior transportation engineer/district materials engineer with Caltrans.

FASTEST SYSTEM OUT THERE

With recent improvements, most pavement engineers consider PCPS to be the optimal material for rapid, durable repair on heavily traveled roadways. Engineers understand that paving slabs manufactured off site under controlled conditions have the superior quality needed for long-term performance on busy roads. More importantly, engineers appreciate that fully cured slabs support traffic immediately after placement, thus eliminating the long delays and traffic disruption experienced with CIP curing.

“The speed and efficiency of a jointed precast concrete pavement system are actually the primary drivers in the way that we have used precast pavement for repairs,” said Scott Nussbaum, Region One materials

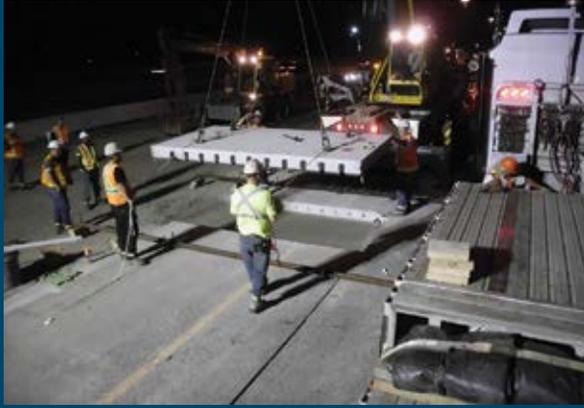
engineer, Utah Department of Transportation.

All CIP pavements, even specialized, fast-track concrete, require on-site curing and finishing time. PCPS is especially beneficial for work windows of eight hours or less, because slabs can be placed right up to the end of work shifts. “We like to close the road for the least amount of time as possible and get it open to traffic. We want to do all of the work off-peak. Precast concrete pavement systems are really the only way we’re able to stay within the kind of windows that we want to have and still expect durability for the repair,” added Nussbaum.

The speed, durability and service to local business and the driving public make PCPS the optimal transportation system for the specifying and design community. “I would recommend this product to owners, contractors and colleagues,” said Erich Brown, project manager, The Lane Construction Group. “It’s definitely a good option when dealing with high traffic-volume areas and areas where you have limited hours



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WHY CHOOSE PRECAST CONCRETE PAVEMENT SYSTEMS?

PCPS has several advantages:

1. Speed
 - Rapid installation
 - Expeditious opening to traffic serves public, business and agency reputation
 - More DOT control over project deadlines
 - No weather-dependent pour/finishing delays
 - Safer, quick repair methods
 - Eliminates lost time for CIP placing, curing and finishing

2. High quality, long service life
 - Proven durability
 - Consistent quality – certified plant inspection/testing procedures
 - Precise manufacturing meets specified project tolerances

3. Environment & site advantages
 - Keeps job site clean, meaning less construction-related pollution to groundwater and streams/ivers
 - No extra site space required for material laydown, washout or ready-mix trucks
 - LEED points
 - Fewer trades for less site congestion and safer work site
 - “Buy America” – local materials and labor support local economy

4. Cost considerations
 - No CIP concrete overrun expenses
 - Less labor time and payroll
 - Job completion incentives
 - Higher initial cost balanced by less construction time, labor and longer service life

5. DOT experience with PCPS
 - Proven DOT track record of successful projects
 - Just-in-time delivery and installation for scheduling/planning
 - Precast engineering assistance with on-site problems like connection questions
 - Precast producer coordination with DOT engineers on best project-specific solutions
 - Versatility – surface finishes, skew, superelevation and decking configurations
 - Simple, long-lasting load-transfer mechanism

of work. It's an expeditious way of repaving the roadway especially where you do not have access to full closures of the roadway or traffic redirection.”

MORE DURABLE, LONGER SERVICE LIFE

Durability of precast pavement is enhanced, because slabs are fabricated in a controlled plant environment free from adverse temperature and weather-related conditions. Precast concrete manufacturing plants stock a wider selection of admixtures and aggregates needed to extend pavement life. Plant casting eliminates problems associated with job-site curing and CIP shrinkage. In addition, PCPS service life far exceeds that of fast-track concrete or asphalt overlays.

“When comparing precast pavement with the other high-early strength and rapid repairs using cast-in-place concrete in Utah’s environment with as many freeze/thaw cycles as we have and as much salt as we put on our roadways, we know that the majority of our high-early cast-in-place concrete repairs do not last for more than five years,” said Nussbaum. “We have the potential with the precast system that’s properly cured, carefully constructed and carefully placed to see 10, 15, 40 years – we don’t know. But if properly placed with some good attention from the installers in the field, we have confidence that these repairs are going to last many years and significantly longer than some of the cast-in-place repairs that we’re seeing now.”

CONSISTENT, CERTIFIED, QUALITY PRODUCT

In states where NPCA certification is required, an independent engineering firm inspects precast plants, and approval is based on adherence to extensive manufacturing and inspection procedures.

Concrete is tested at frequent intervals in state-of-the-art facility labs, and every slab is thoroughly examined for defects and specification conformance. Quality control programs are specifically designed to prevent inferior concrete from reaching the job site, greatly enhancing the uniformity and quality of the finished pavement. The NPCA Plant Certification Program is accredited by ANSI (the American National Standards Institute).

“The biggest advantages of using precast pavement is that you get a quality product where you can control the manufacturing, design it to fit the needs of the project, improve the life-cycle cost of the product, and it’s safer and more durable. It’s not just one benefit – there are multiple benefits,” said Stahl.

SAFER, FASTER REPAIRS

Precast slabs last longer than alternative materials and enhance job-site safety, as fewer repair projects are required over time. Night work is dangerous at best, and every night shift avoided significantly improves overall safety for highway maintenance workers.

"I'd advocate the use of precast concrete pavement, not just for my peers but for anyone who will listen," said Stahl. "Whenever I see a tool that is very beneficial returning the roadway back to the public, making it safer for the workers and for the public, and giving us good service for an extended period of time, I would advocate that product or technology in future projects."

A REAL COST/BENEFIT ANALYSIS

Ultimately, designers and specifiers need to compare the cost of precast pavement to the cost of comparable pavement alternatives that can be installed in the same amount of time and with the prescribed service life expectancy. The usable life of fast-track CIP concretes varies as much as the types of mix designs used. CIP durability depends on mix design, worker skill, rate of placement, weather conditions during curing and finishing, and regional climate. When comparing other materials with PCPS – with a life expectancy of 40 years or more – it is important to compare life cycles and costs.

A detailed life-cycle cost analysis includes all maintenance and traffic protection over a 20- to 30-year period. Comparisons must also include costs associated with required replacement of the fast-track concrete for the same time period. In a recent 20-year life-cycle cost comparison of the two materials – on a project where both materials were installed side-by-side – results indicate that PCPS is 11% more cost effective.

"You can increase your production for roadway rehabilitation and repair, as you're not limited to an eight-hour work window in which you can only physically place concrete for four hours and then you have to let it cure for four hours," said Brown. "Using jointed precast pavement, you have the entire time almost entirely for setting these slabs. We were actually able to install more square yards of precast pavement than we were with cast-in-place pavement with the same amount of workers."

SERVING THE DRIVING PUBLIC

FHWA's Highways for LIFE program, which promotes and supports the implementation of ready-to-use and proven technologies, has identified PCPS as a vanguard technology. Clearly, PCPS has demonstrated success



Slab Above Hole



Injecting Grout



Completed Raise

in numerous projects and holds promise for use in the rapid repair and renewal of our aging infrastructure while minimizing maintenance and repair needs.

For a detailed description of other PCPS benefits, visit precast.org/pavement. **PS**

Evan Gurley is a technical services engineer with NPCA.



Photo courtesy of Roman Stone Construction Co. (www.romanstoneco.com)

NEW APPROACHES

PROJECT CHALLENGES AND LESSONS LEARNED IN BUILDING PRECAST CONCRETE BRIDGE SYSTEMS CREATE NEW APPROACHES FOR MICHIGAN'S DOT.

By Corey Rogers, P.E., Photos courtesy of MDOT (michigan.gov/mdot)

The Michigan Department of Transportation (MDOT) uses a Prefabricated Bridge Element Systems (PBES) approach under its Accelerated Bridge Construction (ABC) policy. Rapid bridge construction means less inconvenience and delay for the public, businesses and transportation users. Construction details and challenges encountered on two projects with multiple precast concrete bridge elements led to important improvements for the PBES approach going forward.

PBES BRIDGE PROJECT 1: PARKVIEW AVENUE OVER U.S. 131 SUBSTRUCTURE – SMOOTH SAILING IN SIX-WEEK SCHEDULE

In 2008, the Michigan Department of Transportation (MDOT) began PBES construction on Parkview Avenue Bridge over U.S. 131 in Kalamazoo County. The challenge was to build a 249-ft, four-span bridge on a 23-degree skew in 12 weeks. The solution was precast concrete elements. Time was of the essence, and an ambitious schedule was proposed to mitigate the impacts to traffic in this populated area of Kalamazoo.

The first six weeks of construction involved demolition of the existing structure and construction of the substructure. The substructure design was semi-integral, comprised of a single row of HP 12 x 53 H-piles supporting the precast abutment stems. The piers were supported by cast-in-place (CIP) spread footings. The

CIP footings, concrete diaphragms, back wall and bridge railing were the only elements of the bridge cast in the field.

After demolition of the existing structure, the pier footings were cast. In order to ensure proper fit-up of the columns and the footings, a block-out template was created detailing the location of the threaded rod inserts in the bottoms of the columns and used to lay out the voids in the footings for the footing-to-column connections. After the footing concrete reached a compressive strength of 2,500 psi, the threaded rods were inserted into the bottoms of the columns, and the columns were set over the respective voids in the footings. The voids were grouted and the connections completed. The tops of the columns did not utilize the threaded inserts but had the connecting resteel precast with the columns to match the corrugated ducts in the pier caps. The corrugated ducts were then grouted after fit-up to complete the column-to-pier cap connections.

The abutment stems were precast, incorporating pile sleeves. In this regard, the pile driving operation and location tolerances were critical, and the contractor ensured all the pile sleeves in the abutments lined up appropriately. The sleeves were then grouted and allowed to reach a compressive strength of 3,000 psi before beginning the erection of the superstructure.

The PBES allowed MDOT to complete the substructure within the six-week schedule by eliminating forming, large pours, sequencing and lengthy cure times – essentially reducing it to a grouting operation.



Parkview Avenue project

PBES BRIDGE PROJECT 2: M-25 OVER THE WHITE RIVER—TWO WEEKS AHEAD OF SCHEDULE

M-25 over the White River is located along Lake Huron on the east coast of Michigan's thumb in Huron County. Due to scour concerns and existing conditions, the bridge was programmed for replacement in 2011. This route is frequently traveled by tourists seeking recreational activities such as boating, fishing and camping. In order to reduce impacts to traffic and mitigate negative impacts to the local businesses, ABC techniques were a primary objective for MDOT.

A prefabricated bridge element system utilizing precast concrete abutments and precast decked box beams was chosen to expedite construction of a 48-ft-long, single-span bridge. MDOT's first experience with decked box beams presented some unique challenges but resulted in a very successful project. Conventional CIP construction would have resulted in a 20-week closure of M-25. The goal of the White River Bridge replacement was a construction schedule of 12 weeks, which was achieved through the use of precast elements.

Conventional construction requires forming, placing and curing concrete in the field. Structural concrete must reach an acceptable strength prior to loading and moving on to the next stage in construction. MDOT specifications for bridge deck pours require a seven-day wet cure prior to loading and subsequent concrete pours. The use of precast decked beams eliminates the need for a seven-day wet

cure, significantly reducing time on projects where every day counts.

The reinforced precast concrete segments consisted of two abutment stems, two wing wall segments, two slope walls and eight beam-deck segments. All were fabricated in an off-site precast plant and trucked to the job site.

The existing White River Bridge was removed and the footings were cast. After reaching a 2,500 psi compressive strength, the precast abutment segments were lifted into place with a 500-ton crane and positioned on the footing. The abutment stem segments and wing walls were connected to the footing with non-shrink, grout-filled mechanical splices. The vertical key between the two abutment segments was grouted, and the closure pour between the wing walls and the abutments was completed. Each abutment was assembled in one day.

The modular decked box beams were comprised of 21-in. prestressed box beams pre-topped with 10½ in. of deck. Typical bridge decks are approximately 9 in. thick; however, additional deck thickness was included to allow for deck surface corrections and ride quality of the structure. The beam-deck segments were spaced 6 ft on center and rested on the abutments via elastomeric bearings. Between each modular section, top and bottom longitudinal reinforcement was threaded through the overlapped D-hoops within the closure pour block-out.

The beams were preloaded to reduce variations in camber among



Parkview Avenue project



Parkview Avenue project



White River Project



White River Project

the beams to ensure a smooth transition at the closure pour joint. High Performance Superstructure Concrete (HPSC), capable of attaining 7,000 psi compressive strength, was used for the closure pours between beam-deck segments. Transverse post-tensioning tendons comprised of four ½-in.-diameter strands were installed in 5-in. ducts cast into the six diaphragms of the modular sections, stressed to 182 kips and grouted with HPSC.

Upon removal of the preloading, irregularities were still present in the deck due to slight camber variations and imperfections from lifting-loop locations. The deck was diamond-ground and coated with a thin epoxy overlay to improve aesthetics and ride quality, and provide a waterproof barrier. The project was completed in 10 weeks – two weeks ahead of schedule, and proved to be another successful endeavor utilizing precast concrete elements.

POST-CONSTRUCTION LESSONS LEARNED

The collaboration between MDOT and the contractor was remarkable. Innovations and efficiencies made in the field during construction and recommendations to improve similar types of construction in the future were discussed. The MDOT Cass City Transportation Service Center managed the project and detailed all facets of the project, including a post-construction meeting that focused on recommendations for future improvements.

RECOMMENDATIONS BROUGHT FORWARD AFTER CONSTRUCTION:

1. Verify the availability of HPSC near the project location, especially in rural and remote project locations.
2. Use recessed lifting loops on the precast segments. Recessed lifting loops eliminate the need for cutoffs and allow for easy mortar patching and increased longevity of the patch.
3. Eliminate the preloading guesswork. A table estimating the required preloading, based on a given camber deflection, would assist contractors in obtaining materials and expedite the preloading process.
4. Create a strength-testing procedure for expansive grouts.
5. Use a Qualified Products List or testing to verify required strength throughout the construction process. Contractors may not be familiar with the process to create and test the cubes



Completed White River Project

necessary for grout testing.

6. Use a thin epoxy overlay. Although the deck was precast 1 ½ in. thicker to accommodate the need for grinding imperfections, grinding often results in an unattractive deck appearance, micro-cracking and loss of the densified top layer of protective concrete. A thin epoxy overlay seals the deck and provides an aesthetically pleasing wearing surface.

PBES GOING FORWARD

On the Parkview Bridge Project, MDOT implemented the PBES philosophy using multiple precast bridge elements, thus laying the foundation for future precast projects throughout Michigan. Ultimately, a bridge replacement that typically would have taken about seven months to complete was finished in about five months, even though the deck panel error resulted in a two-month delay. But more importantly, MDOT gained invaluable experience in PBES construction and techniques related to proper prefabricated element fit-up.

The efforts put forth by MDOT project staff and the contractor to document the positives and negatives of these projects are a huge asset to the department. The successes and the lessons learned validated the effectiveness of precast concrete bridge elements and have allowed MDOT to develop a PBES implementation policy with guidance on future project selection. By sharing lessons learned statewide, future decision making is improved and the effectiveness of

precast elements can be utilized to the greatest benefit for both MDOT (in terms of quality construction) and the public (in terms of reduced impacts and delays).

Precast concrete elements have earned their place in bridge construction, and as engineers become more comfortable with their use, precast systems will surely become a standard building block for MDOT. **PS**



Corey Rogers, P.E., bridge construction engineer, bridge field services division, MDOT, is responsible for creating alignment in bridge construction practices, troubleshooting construction related issues and implementing new innovations in bridge construction on a statewide basis. Contact him at RogersC5@michigan.gov.

BE A KID IN A CANDY SHOP

By Kirk Stelsel

As an architect, engineer or contractor, have you ever faced a project where an accelerated schedule was of paramount concern to the client?

The better question, probably, is have you ever worked on a project where time was not of the essence? Most every client wants their project done yesterday for the best price possible – and oh, they want it to look nice and last a long time as well. That's the reality of the construction industry.

When it comes to bridge construction, timing pressures only increase, because mitigating traffic closures is always a top concern. You need a material that installs fast to save you and your client time and money – and time is money on a construction site. That material is precast concrete, and the following case studies show why it's the material of choice whether you need to replace an aging structure on a small, two-lane road or a mega structure over a major river or highway.

CASE 1: 14 BRIDGES REPLACED IN 10 WEEKENDS ON I-93 IN BOSTON, MASS.

When the Massachusetts Department of Transportation set out to replace 14 bridges in just 10 weekends, it was an aggressive timeline, to say the least. Amazingly, with a lot of planning and the right materials, the Fast 14 Project was completed on time. Among the critical components of the plan was the use of 252 composite bridge deck segments fabricated during a 14-week span at Jersey Precast in Hamilton Township, N.J.

CASE 2: SHORT-SPAN PRECAST CONCRETE BRIDGES

The need for short-span bridges is tremendous (See "Use Box Culverts for Rapid Bridge Replacement," page 28). Whether it's a small road with an aging structure over a creek, a running or biking path that needs a tunnel, or even an airport that needs a route for planes over a roadway, precast concrete short-span bridges are the solution. With a fast installation time, all the strength you could need, and a range of customizable options, there's no other product that affords a better option. And when it comes to looks, the addition of spandrel and wing wall panels, as well as custom finishes and color such as brick or natural stone – the diversity of architectural precast offers one-of-a-kind solutions.

CASE 3: NEW SOUTH MAPLE STREET BRIDGE

In Enfield, Conn., an aging bridge built in 1925 was in need of a replacement. The solution was a total precast design that was installed in just 17 days thanks to the use of 71 precast concrete pieces that made up the foundation, abutment and wing walls, beams, and approach slabs. With architectural form liners and rapid installation, the attractive result earned the owner's satisfaction.

To learn more about what precast concrete can do for your next transportation project, or to find a precaster in your area, visit our website at <http://precast.org/products>. **ps**

Kirk Stelsel is NPCA's director of Communication.

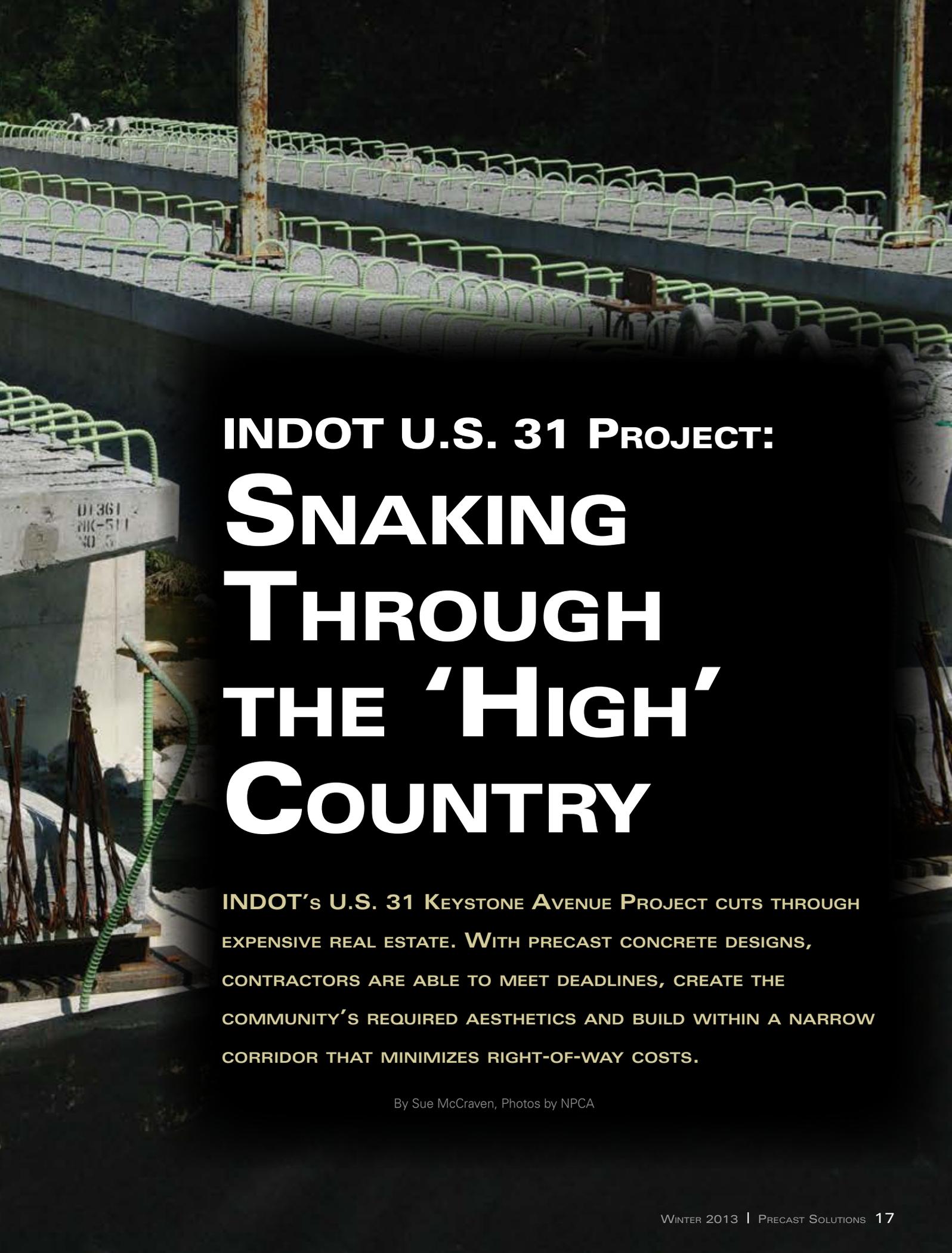


Top and left: Bridge installation during the Fast 14 project in Boston.
Photo courtesy of MassDOT

Above: Short-span bridge.
Photo courtesy of Speed Fab-Crete



The hybrid Bulb-T bridge beam has a shallower shape for a more efficient use of material.



INDOT U.S. 31 PROJECT: SNAKING THROUGH THE 'HIGH' COUNTRY

INDOT'S U.S. 31 KEYSTONE AVENUE PROJECT CUTS THROUGH EXPENSIVE REAL ESTATE. WITH PRECAST CONCRETE DESIGNS, CONTRACTORS ARE ABLE TO MEET DEADLINES, CREATE THE COMMUNITY'S REQUIRED AESTHETICS AND BUILD WITHIN A NARROW CORRIDOR THAT MINIMIZES RIGHT-OF-WAY COSTS.

By Sue McCraven, Photos by NPCA



Carmel, north of Indianapolis, is an appealing and rapidly growing city. In the Arts & Design District, quirky life-sized statues beguile visitors, and upscale restaurants and shops are inviting. Pricy homes abound and the meandering commercial streets are graced with professional landscaping. Land here runs about \$1 million/acre. Racing through the heart of Carmel and Westfield, the ever-busy Meridian Street (U.S. 31) is the major north-south artery for local businesses, shopping malls and residential areas. Commercial and municipal priorities demand continuous traffic access. Consequently, construction on this \$35-million, 1-mile segment of U.S. 31 is hands-down a “high-visibility” project. From the trenches, project contractors and precast producers tell the story.

TRAFFIC CONGESTION AND INCENTIVES

“Traffic congestion, stoplights and abutting residential driveways made the old U.S. 31 a real problem,” said Blake Morris, assistant project manager for Walsh Construction in Carmel. “INDOT needs a new road with overpasses, underpasses, off-ramps and on-ramps to alleviate these issues.” Tons and tons

of precast concrete MSE walls, drainage structures, pipes, box culverts and bridges make up the new road construction within this tight and costly corridor.

Morris oversees the “high visibility” stretch of roadwork through Carmel, including six bridges, 12,000 linear ft of drainage pipe, 1,500 sq ft of box culverts and 230,000 sq ft of MSE walls – all of it precast concrete (with the exception of a steel bridge for a tight-radius overpass). The entire 15-mile U.S. 31 Hamilton County Corridor Project¹ by INDOT offers the driving public 51 new bridges, \$9 million in roadway landscaping and the viewing pleasure of almost 2 million sq ft of spectacular “limestone” MSE walls, some towering over 50 ft.

Coordinating closely with INDOT, designers and contractors, Morris is responsible for the submittal process, shop drawings and making sure the project is completed on schedule. Under Morris’ watch, Walsh Construction was able to benefit financially from INDOT’s incentive program by beating critical ramp-closure deadlines by a week or more.

¹ Because Hamilton County, including Carmel and Westfield, is one of the fastest growing counties in the country, this INDOT project supports important economic growth and job creation.



EXPENSIVE PROPERTY: “A BUSY THREE YEARS”

“A busy three years” was how Jason Rowley, project design manager for RW Armstrong, understated his responsibilities. In charge of design and land acquisition, Rowley oversees nearly 90 designers on this large INDOT project. RW Armstrong administered all sub-consultants, surveyors, relocation agents, buyers, environmental documentation and utility relocation. “Our top priorities are to eliminate (private) driveway access, create a safe roadway for the driving public and relieve traffic congestion.” Beyond these goals, Rowley explained, “This new road will help build the local economy, serve the municipalities and bring in jobs for Carmel and Westfield.”

The biggest challenge for Rowley began in 2009 with the high cost of land in the path of this major transportation project. Between 96th Street and 216th Street to the north, more than 200 parcels were impacted by the required right-of-ways, and shrewd property owners – who were well represented – did not ease Rowley’s critical work. After the land purchases, said Rowley, “We started in on relocating the many

utilities, including Duke Electric, Panhandle Pipeline and Vectren, among others. All these utilities crisscross the route, creating an underground infrastructure design nightmare.”

CONSTRICTED CORRIDOR AND “BUY AMERICA”

“Precast concrete makes up such a huge part of this transportation project,” explained Rowley, “because it provides an economical solution for the narrow right-of-way and meets INDOT’s need for rapid completion and excellent aesthetics to match the upscale look of adjacent properties.”

Seth Schickel, P.E., structural design lead with RW Armstrong, said, “All but nine bridges on the entire U.S. 31 Hamilton Corridor are precast, and include I-beams and hybrid Bulb-T beams. This newer, (hybrid) shallower shape is a more efficient use of material. Bridge beams range from 50 ft to 150 ft long, and the precast meets INDOT’s design tolerances.”

The time, cost and space required for cast-in-place (CIP) concrete construction (rebar laydown and on-site pours) would not be possible on this tight job site, and form-work construction and curing time would not come



close to meeting INDOT's critical deadlines. "Besides the quick installation, precast is our preferred choice when it comes to material cost overruns," said Morris. "With CIP, the general contractor pays for any concrete overruns. With precast, the producer pays for overruns. This is especially critical for the box culverts and bridge beams."

INDOT's Hamilton County Corridor Project is a "Buy America" job. "With precast, we are using, for the most part, local materials, manufacturers and workers," said Morris. But more importantly, "precasters are able to deliver the product right when we need to install it," he said. Delivery efficiencies and ready-to-install components are the precast concrete industry's forte, and the only answer for this constricted construction site.



MSE WALLS: SITE CONFINEMENT AND COST-CUTTING BEAUTY

The Walsh Construction and RW Armstrong engineers agreed that precast MSE walls, in particular, were perfect for the confined work site (See "GRS-IBS: The 5-Day Wonder" on page 24). "Precast MSE walls require less land and help to save on acquisition costs," said Rowley. RW Armstrong engineers worked closely with the precaster on the design of the MSE walls. For example, Rowley said, "We had to put a new MSE wall next to an older, existing MSE wall. Coordination with the precaster served to work out the connection details for a situation that was a first."

The MSE wall producer, Sanders Pre-Cast Concrete Systems Inc. of Whitestown, Ind., provided wall mock-ups to make sure the architectural surface replicated



the prescribed look of the prominent local limestone. Precast MSE wall panels are stacked vertically in heights up to 50 ft. In addition, “The vertical joints accommodate differential settlement,” said Schickel, “making this precast solution inherently flexible and well-suited to our site requirements.”

A LABYRINTH OF UNDERGROUND UTILITIES

“We got on fast track the day Rinker Materials received this contract,” said Allen Squires, Rinker accounts manager. “The project’s extreme pace and tight footprint dictated that almost every run of box culvert and piping fell on the critical path schedule.” This resulted in an escalated production schedule that was met by supplying products from three of Rinker

Materials’ plants.²

“Precision scheduling of the underground work was made more challenging because of existing utility obstacles and site constraints – mountains of earth and a virtual maze of MSE walls and the bridges that towered over them,” said Squires. Rinker’s engineers designed reinforcing steel and stirrups for the underground precast installations to meet the specialized loading requirements of the MSE walls. This included increased box culvert wall, and top and bottom slab thickness beyond standard designs. “Effective and continuous



Rinker Materials manhole installation showing MSE wall in background.

² Rinker Materials’ plants supplying the INDOT U.S. 31 project in Indiana include: the Greenfield pipe plant (managed by Brian Bennett); the Holt Road large structures plant (managed by Jaime Hayes); and the Whitestown precast plant (managed by Wayne Terhune).



Rinker's RCP installation

coordination with Walsh Construction was the basis of timely product delivery and installation completion that met or beat INDOT's project deadlines," said Squires.

Significantly for underground installation efficiency, precast concrete is the only material approved by INDOT that does not require mandrel testing. "Installation of A200 and HDPE pipe requires strict attention to careful backfilling specs, and that is time consuming," said Morris.

UNDERGROUND PRODUCT DETAILS³

Box culverts:

1. 1,500 linear ft of box culverts
2. Sizes: 6 ft x 3 ft, 9 ft x 5 ft, 10 ft x 4 ft, 10 ft x 5 ft, 10 ft x 6 ft and 12 ft x 4 ft
3. Deep fills up to 46 ft in depth
4. MSE wall loading requirements
5. Heavy steel and stirrup reinforcement
6. Increased wall and top and bottom slab thicknesses
7. Escalated production requirements
8. Custom products for detention systems, wing and head walls, bends and special alignments

Reinforced concrete pipe:

10. 12,000 linear ft
11. Diameters: 12 in., 15 in., 18 in., 24 in., 30 in., 36 in., 48 in., 60 in. and 72 in.
12. Standard, specialized and modified structures

PRECAST CONCRETE SYSTEMS ACHIEVE 20 PROJECT OBJECTIVES

On-site commentary from the busy professionals at Walsh Construction, RW Armstrong and the local producers (Rinker Materials and Sanders Pre-Cast Concrete), explains why precast is the preferred solution for DOT transportation projects. This article proves precast concrete transportation solutions meet the following owner and contractor objectives:

1. Most economical solution for INDOT owner
2. Narrow MSE wall footprint significantly reduces high land-acquisition costs
3. Just-in-time product delivery meets INDOT's accelerated schedule
4. Close producer coordination with contractors helps to meet and exceed specified completion deadlines
5. On-time product delivery for immediate installation is perfect for constricted work site

³ Product information provided by Rinker Materials in Greenfield, Ind. www.rinkerpipe.com



- 6. Local materials and manufacturers meet “Buy America” requirements
- 7. RCP installation is easier because it does not require mandrel testing or the time-consuming backfilling requirements for HDPE pipe
- 8. Satisfies owner and community demands for tasteful, attractive roadway amenities
- 9. Concrete’s architectural range results in MSE walls that replicate the natural look and deep reveals of regional limestone deposits
- 10. No concrete material cost overruns for contractors as with CIP construction
- 11. Producers help contractors with connection details
- 12. Newer design of hybrid Bulb-T beam is more efficient use of material for bridge construction
- 13. Products made in controlled plant conditions meet INDOT’s tolerance specifications
- 14. Joint design of MSE wall joints (horizontal and vertical) provide flexibility to accommodate differential settlement and site conditions
- 15. Underground product manufacturer meets INDOT’s increased production demands
- 16. Precast engineers’ redesign accommodates site’s specialized loading conditions
- 17. Precision logistics by precaster avoids conflicts with a morass of existing utility runs

- 18. Serves the driving public and needs of adjacent communities and businesses by minimizing traffic disruptions
- 19. Supports local economy and job creation
- 20. Significantly reduces site disruption, construction debris and runoff, thus minimizing adverse environmental impacts **PS**

▲
U.S. 31

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Blake Morris



Jason Rowley



Seth Schickel

GRS-IBS: THE 5-DAY WONDER

IN JUST FIVE DAYS, SOME COUNTY TRANSPORTATION AGENCIES HAVE SPANNED STREAMS WITH SMALLER, SINGLE-SPAN BRIDGES AND REALIZED A 40% COST SAVINGS OVER CONVENTIONAL CONSTRUCTION.

By Chris Von Handorf, P.E.

If almost 30% of our nation's bridges are "either structurally deficient or functionally obsolete,"¹ transportation engineers need to make the most out of limited funding for bridge repair and new construction. Any bridge owner or contractor working under today's budget constraints will tell you that they need to have their project completed faster, easier, at lower cost, and last longer with minimum maintenance. A relatively new bridge system, GRS-IBS serves all of these project needs and more when used for appropriate site conditions.

GRS-IBS is one of many Federal Highway Administration's (FHWA) "Bridge of the Future" and "Every Day Counts" initiatives that aims to identify and encourage innovative solutions for shorter project delivery, enhanced safety and increased environmental

protection. GRS is also one of several "Accelerated Bridge Construction" (ABC) technologies that is informing and changing the way engineers design bridge replacement structures.

Let's begin with the ubiquitous engineering acronyms. GRS-IBS stands for Geosynthetic Reinforced Soil Integrated Bridge System. GRS is built by alternating layers of engineered backfill with sheets of geosynthetic reinforcement. The U.S. Forest Service first used gravity walls in the 1970s to stabilize logging road embankments. Although GRS has been used in only the last few decades, the concept of reinforcing soil with organic materials has been around for thousands of years, dating back to straw and mud dwellings.

PERFECT SOLUTION FOR SMALLER SINGLE-SPAN BRIDGES

GRS-IBS is adaptable to different site conditions and can be used for new or replacement structures

¹ According to the 2009 ASCE Report Card for America's Infrastructure





with steel or concrete superstructures. Even with this application flexibility, GRS-IBS is generally used to cross small to mid-sized streams with single-span bridges (lengths ≤ 140 ft and abutment heights ≤ 30 ft). Because GRS-IBS is a shallow design, it is used only at streams and rivers with low water velocities and no scouring issues.²

GRS bridge abutments do not require the elements of traditional designs, including overexcavation for a deep foundation, approach slabs, end walls and bridge bearings. Moreover, GRS-IBS eliminates the “bump” characteristic of older designs: the uneven settlement between the bridge and its approach. GRS crossings transition (integrate) directly from the reinforced-soil abutment to the bridge beams. The

bridge superstructure rests directly on the GRS-IBS substructure.

WHY GRS-IBS IS EASIER AND FASTER

GRS walls have shallow foundations that allow abutment construction to begin right after excavation and leveling of the underlying soil. Installation of the system’s concrete facing blocks calls for a level and plumb first row.

GRS abutment installation consists of three steps:

1. Laying the facing blocks
2. Placing and compacting the 6-in.-thick granular backfill layers
3. Laying down the reinforced geosynthetic fabric sheets

These three steps are repeated until the wall reaches its final height. A typical crew for construction of smaller,



Photo courtesy of Redi-Rock International (www.redi-rock.com)

² Some GRS-IBS applications have used riprap, embedments, aprons or other scour-mitigating constructs for sites with moderate scour potential.

The U.S. Forest Service first used gravity-reinforced soil walls in the 1970s to stabilize logging roads.

Photo credit: NCHRP Synthesis 430, 2012.



single-span bridge (≤ 140 ft) abutments consists of four to five workers and one backhoe excavator operator. No special worker skills or tools are required, and a walk-behind vibratory tamper and track hoe excavator are the only heavy equipment needed.

To begin, the geosynthetic reinforcement sheet is laid over the leveled soil base. Granular-fill lifts, or layers, are 6 in. high and properly compacted behind the facing blocks. It is crucial that there are no voids or wrinkles in the GRS fabric before backfilling each layer. Alternating layers of fabric, facing block and granular fill continue up to the reinforced bearing bed that supplies additional strength for the superstructure.

A minimum of five reinforced bearing-bed layers is required beneath the bridge beam seat. Bearing-bed fabric spacing is greater, at ≤ 12 in., and grouting and rebar are inserted in the concrete facing blocks. A 2-in.-thick layer of foam boards is placed on the top sheet for the bearing seat. A final layer of fine aggregate brings the height of the GRS abutment to bridge-beam grade and protects the fabric from hot asphalt. Superstructure construction typically commences with installation of precast concrete beams. Once the superstructure is installed, the approach is built. Using a process similar to the GRS design, backfill material and geosynthetic reinforcement are layered to create a strong, stable and flat approach (without the “bump” experienced by drivers crossing traditional bridge installations).

Upon completing the bridge approach, the bridge deck and approaches are paved and finished. GRS-IBS construction has been completed in five working days on some project sites.

GRS-IBS is a type of “gravity wall” that completely encapsulates the soil (geothermal sheets meet but do not overlap) and performs like a composite structure, exhibiting a predictable stress/strain curve. FHWA has published a GRS-IBS Interim Implementation guide that can be used by state and local agency engineers for the design and construction of GRS-IBS.

ENGINEERS LIST 10 ADVANTAGES FROM GRS-IBS INSTALLATIONS

County transportation engineers who have used GRS-IBS have reported what they view as the system’s most important advantages. Here are 10 GRS-IBS advantages:

1. Flexible and easily field-modified system adapts to different site conditions
2. Faster bridge completion and opening to traffic (about 5 days)
3. Reduced cost over conventional designs
4. Can be used in poor soil conditions or wet sites with standing water
5. No need for bridge piles
6. Easier to build (no special skills or tools, smaller crew, minimal equipment needs)
7. Increased durability and lower maintenance (fewer parts)
8. Jointless bridge system (integrated substructure and superstructure): no “bump” between sleeper slab and superstructure for improved driving conditions
9. Increased safety due to smaller crews and less heavy equipment
10. Sustainability and support of local economy (local materials and products)

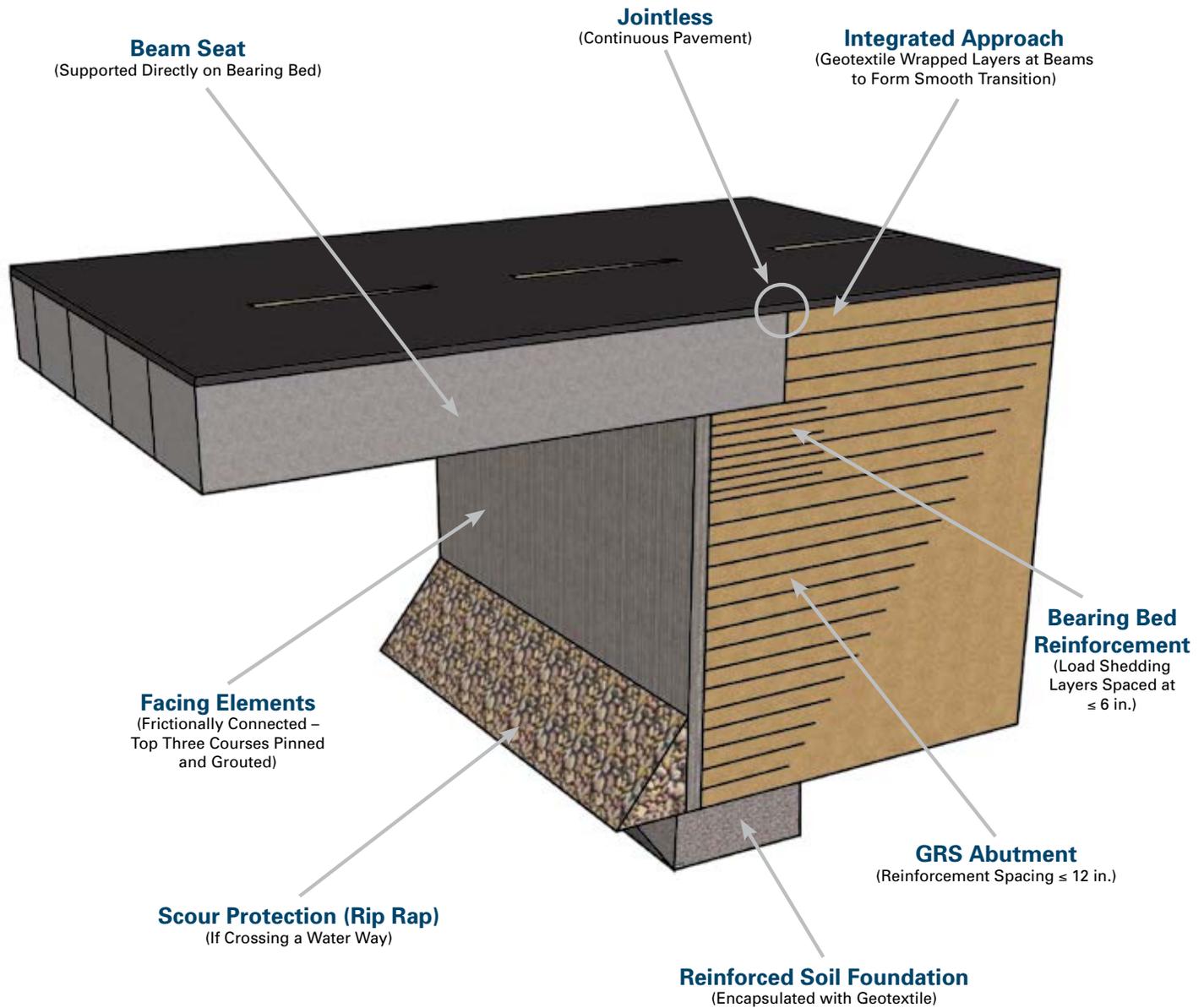
The FHWA and U.S. states report that the GRS-IBS reduces project costs from 25 to 60%, depending on the application. Another advantage to GRS-IBS construction is the use of local, readily available materials including specified backfill material, geosynthetic reinforcement, block facing units, superstructure materials (concrete or steel beams) and paving material (asphalt or concrete). With so many of the required materials produced close to most construction sites, it is easy to see how specification of GRS-IBS is both sustainable and contributes to the local economy.

ACCEPTANCE OF GRS-IBS IS GROWING

As of July 2012, there have been 74 GRS-IBSs constructed in 26 different states across the country. Additionally, seven of these bridges are part of the National Highway System. It is clear that GRS-IBS technology will soon be a widely accepted bridge construction and replacement method.

ABC, or accelerated technology, is changing our infrastructure rebuilding efforts. Instead of months and months of bridge construction and road closure, we are seeing bridge structures completed and opened to traffic in just weeks. New and replacement bridges are being

SECTION VIEW OF GRS IBS



constructed faster at lower costs and with improved worker safety and structural durability.

With infrastructure budgets shrinking, no assurance of massive injections of federal transportation dollars, and many of our current bridges in urgent need of replacement or repair, GRS-IBS technology could not have come at a better time. **ps**

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Single box culvert design
Photo courtesy of Lindsay Concrete Products (www.lindsayconcrete.com)

USE BOX CULVERTS FOR FAST BRIDGE REPLACEMENT

INSTALLED QUICKLY WITH LESS LABOR, MAINTENANCE-FREE PRECAST CONCRETE BOX CULVERT BRIDGES DELIVER A LONG SERVICE LIFE. THESE EIGHT BOX CULVERT DESIGNS DEMONSTRATE WHY PRECAST IS THE BEST CHOICE FOR A VARIETY OF SITE CONDITIONS.

By Gary K. Munkelt, P.E.



Maintenance and replacement of bridges over small streams are ongoing concerns for transportation agencies responsible for their upkeep. In recent years, however, infrastructure funding has not kept up with maintenance needs, and when bridge maintenance is not performed, the structures fall into disrepair.

A decision must be made as to when a bridge needs to be replaced. Should the bridge be replaced in kind, or are there better alternatives? The decision will be based on considerations such as cost, complexity of design, available materials and amount of time the highway is closed to traffic. Future maintenance should always be a part of the decision-making process.

MAINTENANCE-FREE SERVICE AND ASTM DESIGN ASSURANCE

Several systems are available for consideration before replacing a bridge. One of the alternative bridge systems to consider is precast concrete box culverts. They offer a range of sizes and configurations to fit specific site conditions. When properly installed, a precast concrete bridge replacement can provide maintenance-free service for many years. There are concrete structures in operation today that are 100 years old, and many of these structures don't require an



Top: Double box culvert, ADOT SR238 Maricopa Hwy. to Mobile (under state roadway), Maricopa, Ariz., VertiSet Box Culvert. Photo courtesy of Jensen Precast (www.jensenprecast.com)

Bottom: 3-box design

Photo courtesy of Lindsay Concrete Products (www.lindsayconcrete.com)



Clamshell box culvert

Photo courtesy of C. R. Barger & Sons Inc. (www.bargerandsons.com)

Center: U-shaped design, Jensen Black Water School Road (under roadway), Gila River Indian Reservation, Gila River, Ariz.

Photo courtesy of Jensen Precast (www.jensenprecast.com)

annual maintenance budget. The concrete sits in place year after year and does its job.

Design of box culverts is not difficult and is normally performed by the precast manufacturer. Standards such as ASTM C1577-11a¹ provide guidelines to ensure that the product design is adequate. By producing the same product repeatedly, the precast concrete industry can offer reliable, high-quality products. Precast manufacturers are located in most areas of the country, making the product readily available. Competition between producers helps to promote economy of cost.

ADVANTAGES OF PRECAST BRIDGES OVER CIP INSTALLATIONS

Replacing a bridge over a stream using a conventional cast-in-place (CIP) installation can close a road for 10 to 12 months due to the time required for curing concrete on site. For a typical CIP job, footings must be installed first. After they cure, the pedestals formwork can be made, followed by another concrete pour. After that, more curing time is required to form and place the concrete riding surface. Waiting three to four weeks between pours significantly extends the time required to finish a project.

Less time and labor: A precast concrete box culvert can be installed much faster than CIP construction, because the three- to four-week curing time is spent at the fabricator's plant. Precast box culverts are often manufactured before a project is started. In many

cases, preparation at the site takes less than one week. Installation of the finished precast box culverts is complete in a matter of days. There are box culvert installations on county roads where the road is closed for only two to three weeks. Fast installations provide an added advantage in cost savings, because labor hours are kept at a minimum.

Design agencies should consult with precasters in the project area to determine their capabilities. Using product sizes that are standard for a producer will normally enable them to provide more efficient pricing for quotes.

Design flexibility: The box culvert concept has been modified over the years to solve many job-site problems. Standard rectangular boxes are produced in many combinations of height and width. ASTM C1577 provides a table for sizes ranging from 3 ft wide by 2 ft high to 12 ft wide by 12 ft high. Other sizes are available and are limited only by the ability of local precasters to adapt their forms.

EIGHT DESIGNS MEET A VARIETY OF SITE CONDITIONS

Many precast concrete box culvert configurations may be used to span crossings that vary from narrow rivulets to fairly wide streams. Advantages of each these structures are usually unique to the job site, installation contractor or precast manufacturer. Here are eight precast box culvert designs:

- 1. Single box culvert:** One structure, 3 ft to 12 ft wide with wing walls, is installed (end-to-end as needed

¹ ASTM C1577-11a, "Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LFRD"



for road width) above narrow streams. The height of the box culvert is dependent on amount of flow and site conditions.

2. **Double box culvert:** Two 12-ft-wide box culverts are used together under highways that span medium-wide streams.
3. **Triple box culvert:** Three 12-ft-wide box culverts are set side by side for larger streams. The length of the culverts depends on the width of the highway.
4. **Bottom slab trough:** Some designers require a modified bottom slab to provide a small trough for low flows during periods of drought. This modification consists of a second pour of concrete that can be formed to any desired shape.
5. **Clamshell design:** An innovative method of reducing the weight of each component is to utilize a "clamshell" design, where the box is made in two pieces. The advantage to the contractor is that product weight is cut in half, requiring lighter, less-expensive equipment during installation.
6. **U-shaped design:** Some manufacturers make a box by using a "U" shaped piece and putting a flat slab on top. Or they use a flat slab for the bottom and set a U-shaped piece upside-down on the top.
7. **Three-sided arch design:** This is an adaptation of the box culvert concept that has no bottom slab.



It is popular where there are environmental issues or a desire to avoid disturbance to a stream bed. This structure can sit on a CIP footing situated on opposite sides of a stream. The three-sided arch spans the stream without adversely affecting the stream's natural state.

8. **Wildlife crossings:** Single, clamshell, U-shaped or three-sided arch box culvert designs may be used to provide a safe crossing for wildlife under roadways. **PS**

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Three-sided box culverts protect stream beds and aquatic life.

Photo courtesy of C. R. Barger & Sons Inc. (www.bargerandsons.com)



Under roadways, precast concrete box culverts are ideal for providing safe passage for wildlife.

Photo courtesy of Jensen Precast (www.jensenprecast.com)



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