Quality Matters
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from the Quality Assurance Branch (QAB) of Highway Design

Building from the bottom up

Drip. Drip. Drip. A leaky 15-year-old roof can make a homeowner's weekend less than relaxing, especially when he considers the cost of replacement. But is replacing the roof the best option? The leak involves only a small area. Would simply patching be an acceptable solution? It would certainly leave extra funds to replace the worn linoleum and rusting refrigerator, which would definitely have to wait if he does a full roof replacement. But could they wait? Ultimately, the homeowner has to balance needed home improvement projects with the overall function of the house and his limited money.

As stewards of transportation funds, we, too, have to make similar choices on individual projects that will impact the overall transportation system. We must look for the best value solutions on each individual project so we can create a better system.

To achieve this expectation, FHWA encourages the use of Performance-Based Practical Design to "eliminate nonessential project design elements resulting in lower cost and improved value." A concern is that agencies may overemphasize short-term cost savings without a clear understanding of how such decisions could impact other objectives. To address this concern, decision makers should exercise engineering judgment to build up the improvements from existing conditions to meet both project and system objectives.

KYTC leadership is closely examining the value (function divided by cost) of individual projects using a similar approach called Bottom-Up Design. When weighing potential options for a project, decision makers often encounter varying degrees of performance. Each increase in performance (function) usually leads to an increase in cost. Note on the *graph* the steepening sections of the curve. This is where the price increases at a faster rate than the function. The goal of Bottom-Up Design is to start at the bottom and follow the curve upward until the best value for a project solution is identified.

Spot improvements on US 119 in Letcher County
photo courtesy of Keith Damron

To demonstrate this concept, let's first consider projects that address needs on existing roads and second, touch on the design of new routes or replacement routes.

Let's say you have an existing 20-mile, two-lane road – comprising multiple sharp curves, narrow lanes and no shoulders – carrying 8,000 cars per day. Currently, it takes 40 minutes to drive the route, and you've been tasked with improving the travel time. What do you do?

One alternative is to build a new, parallel route that has a design (and travel) speed of 55 mph. That would reduce the travel time by 45 percent. Another option might be to use most of the existing alignment, widening slightly and straightening the curves to a speed of 40 mph, reducing travel time by 25 percent. The first alternative costs a third more than the second alternative.

Both alternatives offer an improvement over the current conditions and meet your assigned goal to improve travel

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time. Assuming both solutions are within budget, the project manager may think the obvious choice is the first alternative because of its higher performance. However, from a statewide program perspective, the second alternative not only addresses the project purpose, but also allows the project completion for far less money, freeing critical resources to address other projects.

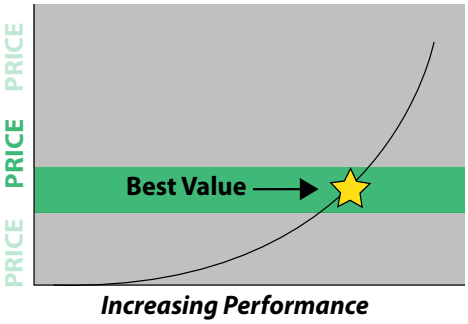
The AASHTO Green Book makes it clear: Resurfacing, restoration and rehab projects enable highway agencies to improve highway safety by selectively upgrading existing highway and roadside features without the cost of full reconstruction.

Bottom-Up Design also challenges the conventional practices of making a decision about design speed, geometric parameters and other project elements. For each individual roadway element (lane, ditch, shoulder widths, grades, pavement design, curvature), the question must be asked: What is the minimum acceptable level to meet the need of the project? The Green Book gives a range of acceptable values, and it must be noted that using values at or near the minimum does not suggest an unsafe design. In addition to a reduced cost, other impacts can often be minimized when using the lower design values.

The bottom line of Bottom-Up Design is that whether it involves an existing, new or replacement route, the location (district liaison) engineers will be working closely with project managers to scrutinize projects in Kentucky so we can stretch our transportation dollars further. Additionally, the Flex Team has been created to help examine larger projects that need to be scaled back due to excessive scope or budget.

In the words of a renowned KYTC engineer (aka Danny Jasper), "Engineering is no challenge if money is not an object." Turns out money is a reality, and we need to refocus our efforts on engineering projects that optimize our statewide transportation system.

by: Brent Sweger, PE



Highway Design Guidance Manual

The new Highway Design Guidance Manual was officially published in March 2017. It may be used as desired or deemed necessary by the project development manager; however, use of the guidance manual is required for projects that did not advance past preliminary line and grade by March 27, 2017.

Many thanks to everyone from the central and district offices who participated in the rewriting and review process, which took around four years to complete and required a lot of coordination, cooperation and many long meetings.

If you have any comments regarding the Highway Design Guidance Manual, please send them to Jill Asher.

Statewide Capacity and Safety Analysis

The Division of Highway Design recently created a new statewide contract for Capacity and Safety Analysis Services. The purpose of the contract is to collect, review or analyze traffic or safety data that will support project development decisions, such as alternative selection and operational improvements.

Possible uses of this contract include:

- Traffic forecasts, capacity analyses and micro-simulation modeling for in-house or consultant projects.
- Oversight for micro-simulation model development (in-house or consultant), including guidance to KYTC staff.
- Safety analyses on improvements or combinations of improvements based on the Highway Safety Manual (HSM) methodologies, as well as benefit-to-cost estimates.

As KYTC moves forward with its performance-based bottom-up design approach, a data-driven analysis will improve the development and evaluation of alternatives that address the purpose and need of the project.

Please contact Jill Asher for more information.

The Relict Darter

As KYTC`s District 1 began replacing three structurally deficient and functionally obsolete bridges in Hickman County, the team faced a unique challenge: protecting the Relict Darter (Etheostoma chienense), a federally listed endangered species of fish found only in the Bayou du Chien watershed.

Falling debris and sediment present the greatest threats to the Relict Darter during demolition and construction. Depending on the method, bridge demolition can yield a lot of debris. To combat this, the contractor used reinforced tarps to contain debris while the bridge deck, piers and abutments were cut and removed in sections. Another option – not used here but useful if the footprint of the existing pier or abutment does not conflict with the proposed bridge – is to leave a portion of the existing pier or abutment in place.

The Relict Darter typically finds shelter where the river has cut beneath tree roots, and the species spawns on undersides of sticks and rocks in these areas. Sediment left unchecked can quickly fill in the Relict Darter habitat, and certain types of organic sediment can actually deplete the oxygen levels in the water as it decomposes.

Protection of the Relict Darter in this project, therefore, focused on stopping or containing project-related sediment. Disturbances were limited to areas where immediate construction activities took place, with a requirement to stabilize those areas with an erosion control blanket or mulch either before or within 24 hours of a rain event. When sheet flow from steep slopes near the bridge proved too much for a temporary silt fence, the section office used a berm built of rock and fabric to manage erosion.

At times, it was necessary to completely separate the fish from the work site, such as during the installation and removal of cofferdams for pier construction. During these activities, installation of block nets upstream and downstream of the work area limited movement of fish. Once block nets were in place, a biologist hired by the contractor safely shocked and collected fish trapped within the project limits and then relocated them further upstream. Interestingly, monitored process revealed that the protections put in place to conserve the Relict Darter also benefited many other kinds of fish found in the stream.

As the project came to a close, an erosion control blanket made of biodegradable coconut fiber (coir blanket), a special seed mixture and live stakes (dormant cuttings from live plants installed directly into the ground) were used to stabilize areas near the creek that had been disturbed during construction. Riprap – originally placed around the bridge piers to eliminate scour – offered additional shelter for the Relict Darter.

KYTC further enhanced the species' natural habitat by installing several artificial spawning structures created by cutting concrete pipe in half. Over the three months biologists monitored use of these structures, they found the artificial structures to be ideal spawning areas filled with hundreds of eggs.

Kudos to the District 1 project team for their concerted efforts throughout design and construction that have directly benefited the Relict Darter, as well as the ecological health of the stream.

by: Anthony Norman, PE

Asphalt delamination

Sometimes things aren't as they appear – just ask District 3 where a recent post construction review seemed to indicate a recurring problem with potholing. In reality, the problem was asphalt delamination: an insufficient bonding of new asphalt pavement lift(s) to existing asphalt.

Without a good bond, the new asphalt lift(s) fail due to water penetration and the inability to support traffic. Over time, these areas peel away to reveal the underlying asphalt layer, leaving what looks like a pothole.

District 3 had observed water pumping out of asphalt pavements on several projects, possibly due to the high permeability of the new asphalt surface layer. While Superpave mix design offers advantages over traditional asphalt mixes (longer pavement life, less fatigue/thermal cracking, less rutting), it does have a greater propensity to allow surface water to penetrate the mix. When this water drains through and meets a less permeable base below (e.g., Marshall mix base), the water becomes trapped. This creates hydrostatic pressure, resulting in upward force and often leading to delamination.

The good news is that mix design improvements that should limit delamination from hydrostatic pressure are underway. For example, the Pavement Design Branch is exploring a reduction of the percentage of recycled pavement (RAP) being used. In the past, up to 30 percent recycled asphalt was routinely used as part of the mix design; future revisions to the Standard Specifications will allow less RAP to be used, requiring an increase in asphalt binder. Using a 0.38 mix (maximum aggregate size of 0.38 inches) in lieu of a 0.50 mix will also reduce the amount of water permeating the roadway surface.

Finally, milling the surface will eliminate existing pavement defects that could result in reflective cracking. A properly applied tack coat is vital as well, as it securely bonds the new pavement layer to the milled asphalt. As with new asphalt lift(s), the new pavement will act independently of the existing pavement in the absence of a good bond, resulting in early fatigue cracking and/or shoving. Furthermore, an independent top pavement layer will not be able to handle the traffic load by itself.

So, don't always assume the problem is typical potholing. You might just have an issue with asphalt delamination. Taking the proper precautions during the mix design and ensuring careful placement during construction will result in more enduring surfaces and fewer headaches for drivers and maintenance staff.

by: Bob Jones, PE, PLS

Properly applied tack coat

Poorly applied tack coat

Upcoming training:

- **Lexington One Day Seminar**
  12/15/2017
  Lexington 8:00 a.m. to 5:00 p.m.
- **7th Annual Bridge Seminar Day**
  2/6/2018
  Lexington 8:00 a.m. to 5:00 p.m.
- **Design of ADA Sidewalk Facilities for Roadways in the Public Right-of-Way**
  3/29/2018
  Frankfort 8:00 a.m. to 4:30 p.m.
- **2018 KSPE Annual Convention**
  4/18/2018 » 4/20/2018
  Owensboro, Kentucky

KYTC employees should register through **Keith Caudill** *for all classes.*

Consultants will only need to register through **Keith Caudill** *if the class is held at KYTC. Otherwise, consultants should contact the Kentucky Engineering Center.*

All times are local. All times are local.

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