BRENT SPENCE
BRIDGE CORRIDOR

Moving the Economy,
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BRENT SPENCE BRIDGE PROJECT

ANALYSIS OF DESIGN CONCEPTS

MAY 2020

STATE OF OHIO DEPARTMENT OF TRANSPORTATION

KENTUCKY TRANSPORTATION CABINET

HNTB

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1. EXECUTIVE SUMMARY

1.1 PROJECT HISTORY

In March 2012, an Environmental Assessment was prepared for the Brent Spence Bridge (BSB) project to analyze impacts to the natural and human environment for two feasible alternatives for improving the I-71/I-75 Corridor in Kentucky and Ohio. In August 2012, the Federal Highway Administration (FHWA) issued a Finding of No Significant Impact (FONSI) identifying the selected alternative for the BSB project. This selected alternative is referred to as Alternative I.

Two primary studies were conducted since 2013 to evaluate potential tolling solutions and to consider potential eastern bypass solutions. Each of these studies collected traffic counts and used travel demand models to forecast traffic volumes on the Brent Spence Bridge (BSB).

In 2019, the Kentucky Transportation Cabinet (KYTC) and the Ohio Department of Transportation (ODOT) determined that a review of the traffic data and forecasts from the previous studies should be conducted prior to moving forward with the Brent Spence Bridge (BSB) project. The goal of this new study was to provide concurrence between KYTC and ODOT on the traffic baseline and forecasts, and to develop and analyze additional concepts that meet the corridor goals and provide potential construction cost savings.

1.2 STUDY ACTIONS

Since the Fall of 2019, several traffic and design activities have progressed to establish an updated baseline for traffic counts and forecasts, perform traffic modeling, and evaluate practical design concepts for the BSB Corridor that could reduce construction costs. These efforts include:

Traffic Counts, Modeling and Forecast Review - December 2019

A review of the existing traffic counts, modeling and forecasts was conducted utilizing the data from the BSB studies conducted since 2013. For this *Traffic Counts, Modeling and Forecast Review* (Appendix 6.5), the 2040 regional travel demand model from the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) was utilized to project future traffic volumes. The BSB traffic projections include proposed improvements to the bridge and I-71/I-75 corridor in Kentucky and Ohio based on the current selected Alternative I and assumed no tolling.

Based on these efforts, KYTC and ODOT established the following criteria for the BSB project:

- The baseline traffic volume 160,000 vehicles per day (VPD) will be used for any additional near-term studies.
- The 2040 Toll Free estimated traffic volume of 227,900 VPD will be used in any near-term design and traffic studies.
- OKI is developing an updated regional travel demand model for year 2050 with current travel and census data. This model will be incorporated into the traffic forecasts for the BSB project when complete, and the forecasts will be extended to 2050.

Performance-Based Design Workshop - December 2019

In recent years, both KYTC and ODOT adopted a performance-based practical design philosophy that allows for engineering judgement to be used in the application of standards to develop a "right-sized," fundable project. The purpose of this effort was to apply this performance-based practical design philosophy to identify new concepts for the BSB corridor to reduce the overall cost of the project. This included a review of the design goals that led to the identification of Alternative I as the selected overall design for the corridor in 2012.

During the workshop, three concepts were developed for further analysis to determine the feasibility of the physical construction as well as the ability to handle traffic flows:

- Concept M - This design keeps many of the same traffic movements and local connections on the existing BSB as they are today, including both directions of I-71. The new bridge carries only I-75 and connections to and from the local street system along the west side of downtown.
- Concept W – This design has a similar mainline and ramp layout through the corridor as Alternative I. However, all interstate traffic for I-71 and I-75 is carried on the new bridge, and all local connectivity is accommodated via the existing BSB.
- Concept S – This design of the bridges and mainline approaches are similar to Concept W. However, the local roadway networks in Ohio and Kentucky are designed as a "super street."

TransModeler Calibration and Results - May 2020

TransModeler was utilized to evaluate travel time, speeds, and capacity along the mainline, ramps, and local streets for all three concepts developed at the Workshop. The analyses are presented in the *TransModeler Calibration and Results* report (Appendix 6.6).

During initial analysis of Concept S, the Ohio super street design was found to not be feasible as envisioned, due to physical design constraints. With additional analysis, it was also determined that the Kentucky super street design could not accommodate the high volume of circulating traffic without significant widening for additional lanes and traffic control. Therefore, Concept S was removed from further study.

The horizontal and vertical design of the remaining concepts were refined, and the alignments were integrated into the traffic models. The refined designs were compared to Alternative I to determine cost savings.

1.3 RECOMMENDATIONS

Based on the design and operational characteristics, Concept S is recommended to be removed from further study due to fatal flaws in the design and traffic operations. Concept M and Concept W are viable concepts that would provide significant cost savings on the project. It is recommended that both concepts be carried forward for more detailed analysis.

2. PURPOSE OF STUDY

The Brent Spence Bridge Corridor consists of 7.8 total miles of I-71 and I-75 located within portions of Ohio and Kentucky. This Corridor is located within the Greater Cincinnati/Northern Kentucky region and is a major route for local and regional mobility. Locally, it connects to I-74, I-275 and US 50. The Brent Spence Bridge provides an interstate connection over the Ohio River and carries both I-71 and I-75 traffic. The bridge also facilitates local travel by providing access to downtown Cincinnati, Hamilton County, Ohio and Covington, Kenton County, Kentucky. This corridor is also one of the busiest trucking routes in the US, connecting Michigan to Florida via I-75.

The Brent Spence Bridge (BSB) opened in 1963 and was originally designed to carry 80,000 vehicles per day (VPD). The March 2012 Brent Spence Bridge Project - Environmental Assessment listed traffic counts on the bridge at 160,000 VPD with projections of 233,000 VPD in 2035 with no tolling.

Two primary studies were conducted since 2013. The *Brent Spence Bridge Corridor Study (BSBC Study)* in 2013-2015 included the continued development of the Brent Spence project incorporating the potential for financing using tolling. The *Brent Spence Strategic Corridor Study (Strategic Corridor Study)* in 2017 included the development and evaluation of Brent Spence Bridge bypass concepts, including the proposed Cincinnati Eastern Bypass (CEB). Both the *BSBC Study* and the *Strategic Corridor Study* obtained traffic counts and used the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) travel demand model to forecast traffic in 2040. Since May 2019, OKI has set up continuous traffic counters on the BSB and other nearby bridges over the Ohio River.

The purpose of this study is to conduct a review of the traffic data and forecasts from the previous studies to establish an updated baseline for traffic forecasts and evaluate practical design concepts for the BSB corridor that could reduce costs. Microsimulation was selected as the traffic analysis tool for project scoping due to the complexity of the I-71/I-75 system interchange. The model developed for the *Strategic Corridor Study* was updated and calibrated appropriately for this project scoping. It was recognized that a more comprehensive calibrated model will be required for analysis to support the project NEPA document and Interstate Access Request (IAR).

3. STUDY PROCESS

3.1 TRAFFIC COUNTS, MODELING, AND FORECAST REVIEW

Traffic counts were taken on the Brent Spence Bridge at various times and by various methods by project stakeholders since 2013. These include counts used for the 2015 ODOT certified traffic; counts in 2017 used for the KYTC *Strategic Corridor Study*; and counts in 2019 from OKI continuous count stations on the Brent Spence Bridge and other nearby bridges over the Ohio River. The studies and counts have shown comparable results for existing traffic volumes.

A review of the traffic modeling and forecasts was also conducted utilizing the data from these earlier BSB studies. The 2040 regional travel model from OKI was utilized to project future traffic volumes. The BSB traffic projections include proposed improvements to the bridge and I-71/I-75 corridor in Kentucky and Ohio based on the current selected Alternative I and assumed no tolling.

Based on these efforts, KYTC and ODOT established the following criteria for the BSB project:

- The baseline traffic volume 160,000 VPD will be used for any additional near-term studies.
- The 2040 Toll Free estimated traffic volume of 227,900 VPD will be used in any near-term design and traffic studies.
- OKI is developing an updated regional travel demand model for year 2050 with current travel and census data. This model will be incorporated into the traffic forecasts for the BSB project when complete, and the forecasts will be extended to 2050.

3.2 PERFORMANCE-BASED DESIGN WORKSHOP

In December 2019, a performance-based design workshop was held with members of ODOT, KYTC, FHWA and HNTB in attendance. The goal of the workshop was to identify concepts that could reduce the construction cost of selected Alternative I for the BSB corridor. The workshop was spurred by KYTC's and ODOT's adoption of a performance-based design methodology that would allow for the consideration of new ideas and initiatives that were not available in previous iterations.

A key point of discussion at the workshop was the design goals for the current selected Alternative I. It was decided that the potential to produce significant cost savings, rather than strict adherence to the previous design goals, should be the driving factor for developing new concepts. At the meeting, it was decided that:

- A 55 MPH (posted speed limit) design speed would be acceptable for interstate 71 and 75 (Alternative I had a 60 MPH design speed).
- Ramps with approved design exceptions from the Fort Washington Way Project would not be required to be modified to meet current standards as part of the BSB project.
- System-to-system connections of I-71, I-75 and US 50 could be from the left lane.
- System-to-system connections should not be made on the collector-distributer roadways, if possible.
- Collector-Distributor roadways could have lower speeds than 55 mph if the system-to-system connections were removed, but they must provide sufficient capacity so as not to queue onto the interstate.
- Vertical clearance was to meet state standards (15.5' for ODOT and 16.5' for KYTC).
- Cost/benefit analysis would be used to determine if it was feasible to design outside the project footprint evaluated in the 2012 Environmental Assessment.

The performance-based design workshop identified three new concepts for the BSB project for further traffic operational and design study. These concepts and the results of the additional study are discussed in the following sections.

4. CONCEPTS CONSIDERED

The three concepts identified in the performance-based design workshop were labeled as Concept M, Concept W, and Concept S and were evaluated using TransModeler to determine any fatal flaws with traffic operations or geometric layout. Construction cost estimates were also prepared to compare the new concepts with selected Alternative I.

Traffic volumes were redistributed for each of the concepts and assigned to the appropriate mainline, ramp and local street section. This allowed for a high-level review of capacity and anticipated number of lanes for each concept. TransModeler software was used to evaluate travel time, speeds, and capacity along the mainline, ramps, and local streets. The analysis followed an iterative process of geometric modifications and redistribution of traffic movements to further refine each concept.

Horizontal and vertical geometry were designed to meet the requirements as determined in the workshop. Vertical clearances were checked using ConceptStation, which estimates structure depth based on pier spacing. ConceptStation utilizes FHWA design criteria to add superelevation in the design to be more accurate on vertical clearance checks. ConceptStation also allowed for quick calculations of retaining wall quantities. The analysis of the additional concepts is summarized in the following sections.

4.1 CONCEPT M

In Concept M, all I-71 traffic will be on the existing Brent Spence Bridge (as it is today), and all I-75 traffic will be on the new bridge. Local traffic connectivity will be distributed to both bridges, with many connections to the existing bridge remaining. I-71 traffic on the Ohio side will utilize the existing structures in both directions. Both I-71 approach bridges north of the BSB will be widened to 3 lanes to support the projected volume of traffic. Bridges that connect I-71 and US 50 in both directions over 3rd Street will remain in place.

Traffic movements and bridge cross sections for Concept M are shown in Appendix 6.1 and described below:

- I-71 SB local traffic will only be able to exit in Kentucky at 5th Street and will navigate the local network to reach locations farther south.
- I-75 SB local traffic will only be able to exit at 9th Street in Kentucky and will navigate the local network to reach locations farther north.
- Local I-75 SB traffic entering in Cincinnati will connect to I-75 SB without navigating the local street network.
- The I-75 NB exits to 5th Street and Winchell/Ezzard Charles in Ohio will use the new bridge with mainline I-75 NB traffic.
- Local Kentucky residents traveling to 5th Street and Winchell/Ezzard Charles in Ohio will need to enter I-75 NB just north of 9th Street.
- The 4th Street entrance ramp in Kentucky will take vehicles to I–71 NB, 2nd Street and US 50 EB and WB.
- The I-75 SB collector-distributor (C-D) system will still have exits in Ohio to 7th Street, 5th Street and 2nd Street.
- A new connection will be added from the I-75 SB C-D system to exit at 3rd Street across from the Clay Wade Bailey Bridge, similar to Alternative I.
- An entrance ramp in Ohio across from the Clay Wade Bailey bridge will provide access to the I-75 NB C-D system that can continue along Winchell or enter onto I-75 NB south of Ezzard Charles.

Concept M utilized 55 MPH design speeds for all interstate movements. The C-D systems were designed at a minimum of 45 MPH, with ramp design speeds variable based on ramp design standards. Concept M does not impact areas outside of the current footprint evaluated in the 2012 Environmental Assessment.

Concept M performed acceptably and has shown to be feasible for advancement and refinement in further studies. The main issue of concern occurs in the AM peak at the diverge of I-71/I-75 northbound. In the current design as modeled, there are 5 lanes approaching the major diverge, with the two right lanes traveling to the existing BSB and the three left-most lanes traveling to the new bridge. The traffic performs at the LOS E/LOS F threshold, and becomes so dense that a "rolling queue" is formed.

To improve this rolling queue, consideration was given to the addition of a third lane on the approach to the existing BSB, with the approaching middle lane at the diverge operating as an option lane. However, with the original concept as designed and modeled, the plan was for the existing bridge to have only 3 lanes, to allow for adequate shoulders (instead of the 4 lanes that exist today.) An additional third lane from the diverge could be achieved, but one of the 3 lanes would have to be dropped prior to meeting the 4th Street entrance ramp on the bridge.

Upon review of the design plans, it was determined that this additional lane could physically be built and a merge designed after the 5th Street off-ramp and before meeting the existing bridge. A quick check of the model with this option lane revealed no congestion downstream. There was still a slowdown at the diverge, but a notable improvement from the design without the option lane. For this reason, the design of Concept M shown in Appendix 6.1, and the costs included in Appendix 6.4, include this additional lane. However, the overall model runs and associated graphics do not reflect this change. Consideration of number of lanes and lane assignments on the existing bridge should be analyzed in further studies, as part of the process to determine the preferred alternative for the BSB Corridor.

The construction cost for Concept M was developed as a cost reduction from Alternative I. Retaining walls, new structures and structure removal quantities were compared between Concept M and Alternative I. All other quantities were viewed to be the same or have a minimal impact to the overall cost. In Kentucky, Concept M is ~$24M less through the elimination of a long bridge structure. In Ohio, Concept M is ~$175M less by eliminating retaining walls and utilizing existing bridges, which reduces the amount of new bridge to be constructed and the removal of the old bridges. For the new river crossing, Concept M is ~$185M less by reducing the lane width of the structure from 172' to 133'. The total savings for Concept M relative to Alternative I was found to be ~$384M. (See Appendix 6.4 and Page 9)

4.2 CONCEPT W

The Concept W design will change the location of the mainline and C-D system on the existing Brent Spence Bridge and the new river crossing. **In Concept W, all the local traffic (C-D system) will be on the existing bridge and all interstate traffic will be on the new bridge.**

Traffic movements and bridge cross sections for Concept W are shown in Appendix 6.2 and described below:

- SB local traffic will be on the upper deck of the existing bridge and NB local traffic will be on the lower deck of the existing bridge. This is due to the short distance available for the NB 4th Street entrance ramp in Kentucky.
- The SB local exit to 5th Street in Kentucky will be a left hand exit due to horizontal and vertical constraints that will push the exit profile above an 8 percent downgrade.
- All SB local traffic will have access to the 5th Street exit, the 9th Street exit and the 12th Street entrance onto the interstate in Kentucky.

- The NB local route will provide connections to NB I-71/EB US 50, NB I-75, WB US 50, 2nd Street, 5th Street and Winchell/Ezzard Charles in Ohio.
- A new connection will be added from the I-75 SB C-D system to 3rd Street across from the Clay Wade Bailey Bridge, similar to Alternative I.
- An entrance ramp in Ohio across from the Clay Wade Bailey bridge will provide access to the I-75 NB C-D system that can continue along Winchell or enter onto I-75 NB south of Ezzard Charles.
- An additional 12 feet of width will be added across the new river bridge to accommodate future maintenance.

Concept W design speeds for all movements are within 5 MPH of the selected Alternative I design speeds. Concept W does not impact areas outside of footprint evaluated in the 2012 Environmental Assessment.

Concept W performs the best out of the three alternatives analyzed. The southbound I-75 exit to the Kentucky local network is on the LOS D/LOS E threshold. This diverge could be reconfigured as the concept is further refined to improve traffic operations. Otherwise, Concept W performs at LOS D or better within the project area.

The construction cost for Concept W was developed as a cost reduction from Alternative I. New retaining walls, new structure costs and the new river crossing were compared. In bridges other than the new river crossing, Concept W was ~$26M less than Alternative I due to the width reduction at each end of the new bridge. Concept W required new walls for an additional cost of ~$11M. The new river crossing width was reduced from 172' to 119' which had a cost reduction of ~$246M. The total savings for Concept W relative to Alternative I was found to be ~$261M. (See Appendix 6.4 and Page 9)

4.3 CONCEPT S AND CONCEPT WS

Concept S includes the construction of an at-grade superstreet in both Kentucky and Ohio. The superstreet will eliminate structures crossing the mainline at 6th Street and 7th Street in Ohio and will eliminate two braided ramps in Kentucky. System-to-system connections between I-71, I-75 and US 50 will be direct and not part of the superstreet movements. However, due to the proximately of each exit/entrance on the Ohio side and the associated high volume of weaving traffic, the resulting unsafe operation was deemed a fatal flaw for this concept. (See Appendix 6.3)

While the Ohio side of the superstreet failed the basic traffic operational analysis, the super street in Kentucky appeared to function effectively and was incorporated into a new Concept WS - a hybrid design of Concept W in Ohio and Concept S in Kentucky. In Kentucky, all local SB traffic not traveling to the interstate will exit at 5th Street at a new signalized intersection. The local SB traffic will then merge with traffic from Bullock, similar to other concepts. (See Appendix 6.3)

Initial analysis concluded that Concept WS was not a viable option. The superstreets in this concept move trips through a series of signalized intersections, that would otherwise be on an access-controlled freeway ramp system. The traffic signals could not accommodate the traffic moving through the superstreets and the traffic on intersecting east-west local roads. This inability to accommodate the traffic movements, and the associated unsafe conditions due to queuing, proved to be a fatal flaw for Concept WS.

5. RECOMMENDATIONS

Concept S and Concept WS are recommended to be removed from further study due to fatal flaws in traffic operations.

Concept M and Concept W are both considered viable options for the BSB corridor:

- Concept W separates local and interstate traffic. The total savings for Concept W relative to Alternative I was found to be approximately $261M.
- Concept M uses the new bridge for all I-75 traffic and keeps I-71 traffic on the existing BSB by maintaining existing connections in Ohio. The total savings for Concept M relative to Alternative I was found to be approximately $384M, or $123M less expensive than Concept W.

It is recommended that Concept M and Concept W be carried for further study. Consideration of other items should be a part of additional efforts to refine or eliminate concepts; such as safety, constructability, future maintenance, event traffic control, incident management, tolling logistics, and local connectivity.

Cost Comparison: Alternative I with Concept M and Concept W

		Construction Costs (2017 Dollars)							
Contract #	**Segment Description**	**Alternative I**		**Concept M**		**Alternative I**		**Concept W**	
KY-7	I-75 Reconstruction from South Termini of 12th Street Interchange to New Bridge over Ohio River	Retaining Walls	$30,214,143	Retaining Walls	$55,096,387	Retaining Walls	$0	Retaining Walls	$11,448,699
		New Structures	$162,557,947	New Structures	$114,210,940	New Structures	$100,407,239	New Structures	$89,510,807
	Kentucky Totals		$192,772,090		$169,307,327		$100,407,239		$100,959,506
OH-7 (PID 89068)	I-75 Reconstruction from New Bridge over Ohio River to North of Linn Street	Retaining Walls	$23,209,947	Retaining Walls	$13,978,846	Retaining Walls	$0	Retaining Walls	$0
		New Structures	$271,680,043	New Structures	$117,390,822	New Structures	$189,161,276	New Structures	$173,691,021
		Remove Structures	$17,672,641	Remove Structures	$6,061,563	Remove Structures	$0	Remove Structures	$0
	Ohio Totals		$312,562,632		$137,431,231		$189,161,276		$173,691,021
	New River Crossing	New Bridge	$555,225,840	New Bridge	$369,649,988	New Bridge	$555,225,840	New Bridge	$308,998,818
	New River Crossing Totals		$555,225,840		$369,649,988		$555,225,840		$308,998,818
	Combined Totals		$1,060,560,561		$676,388,546		$844,794,355		$583,649,344
	Total Amount Saved with Concept M	**$384,172,015**							
	Total Amount Saved with Concept W					**$261,145,011**			