



ECONOMIC IMPACT OF CLOSING LOW-VOLUME RURAL BRIDGES

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BACKGROUND

The State of Kansas has approximately 25,464 bridges that are located on the state, county and city roadway network. As the infrastructure in Kansas ages, bridges can become structurally deficient or functionally obsolete. The Kansas Department of Transportation (KDOT) defines a bridge as structurally deficient if an inspector determines the bridge deck, superstructure, substructure, culverts and retaining walls are not able to support today's federal legal loads (KDOT, 2008). A bridge that is defined as functionally obsolete consists of design characteristics, which could include narrow width, inadequate clearance beneath, condition of the structure, or deficient approaching roadway alignment (KDOT, 2008). Limited research has been performed that specifically investigates advantages and/or disadvantages of closing a bridge on a rural low volume road. The objective of this research project was to determine a cost comparison of replacing and/or repairing a rural low volume structurally deficient bridge, versus closing the same bridge and finding the change in vehicle operating cost based on the proposed driver detour.

DATA

The structurally deficient bridges located on Kansas rural low-volume roads were identified by the Kansas Department of Transportation in May, 2012 using the National Bridge Inventory Database (NBI). These bridges were located on two-wheel path roads where the average daily traffic (ADT) was estimated to be 25 or under. A total of 1,229 bridges met these criteria. The earliest bridge inspections occurred in 1996 with the newest inspections occurring in 2012. The identified bridge data also included the latitude and longitude as well as the type of bridge (Concrete, Steel, Masonry, or Timber).

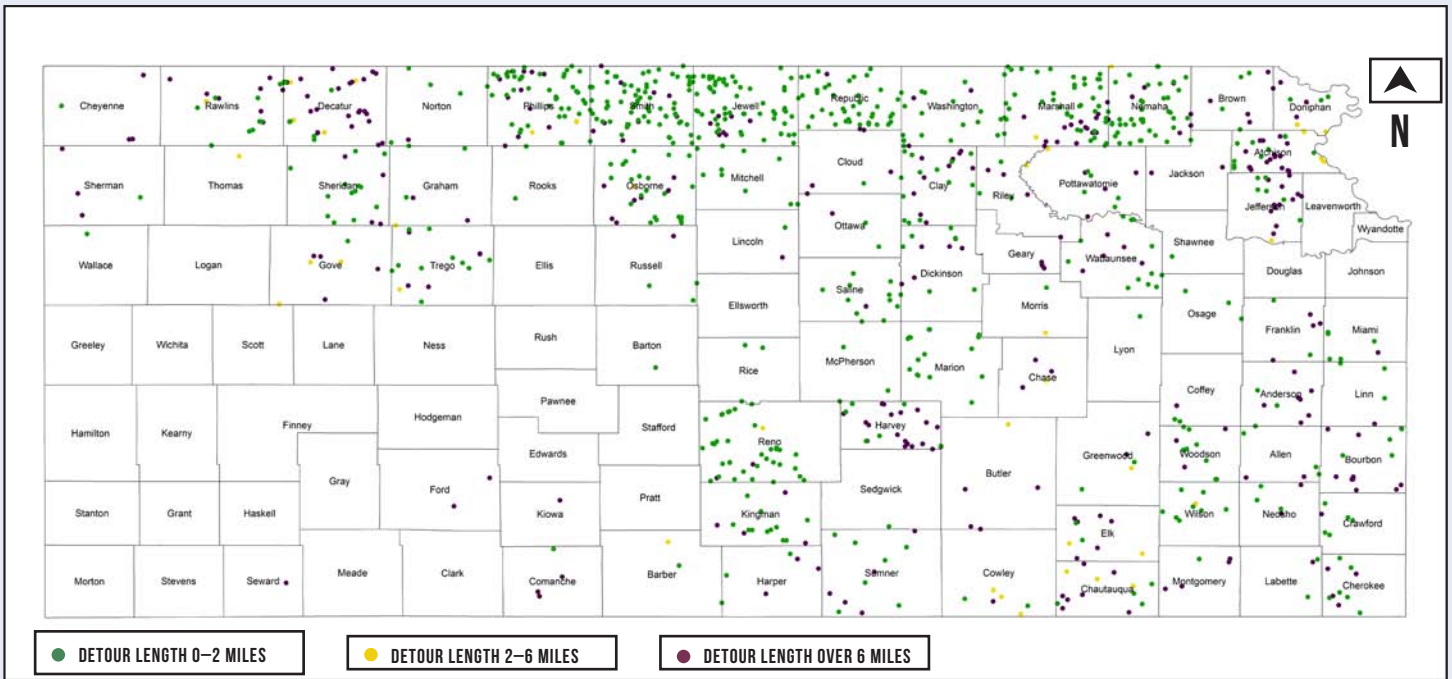


FIGURE 2. LOCATION OF STRUCTURALLY DEFICIENT BRIDGE AND RESPECTED DETOUR LENGTH

ANALYSIS AND DRIVER DETOUR LENGTH DETERMINATION

Using the latitude and longitudinal coordinates provided for each bridge, each bridge structure was identified in Google Earth. The research team ensured, based on the coordinates, that: (1) the bridge existed on the 2012 aerial imagery knowing the inspector data may have been off, and (2) that the existing bridge had not been closed, replaced, or converted to a culvert or an engineered low-water stream crossing. After the initial screening, a total of 992 structurally deficient bridges were identified.

With an assumption that a vehicle could safely detour around one of the identified structurally deficient bridges, the research team investigated the length of the shortest driver detour around each of the 992 identified bridges. To determine the short driver detour length, the structurally deficient bridge was identified on Google Earth, adjacent private properties were investigated to ensure farmsteads would not be landlocked if the bridge were to be closed, and there was a safe detour route that included a paved or two/three wheel path gravel road. The driver detour length was assumed to be the length a vehicle had to travel out of its way to get to the nearest intersection after the closed bridge. For example, if a closed bridge was located on one side of a one-mile grid, a driver detour length of two miles was recorded since the vehicle would have to travel one mile whether the bridge was closed or not. Shown in Figure 1 are the number and types of bridge with the respected driver detour length.

As shown in Figure 1, 648 out of 992 bridges (approximately 65%) had a potential driver detour of 2 or fewer miles which indicates if these bridges were to be closed, a relatively short driver detour would be required of the driver. Also shown in Figure 1, a total number of six structurally deficient bridges with a driver detour length of over 11 miles were found. Based on the driver detour length alone, these bridges would be excellent structures to be considered for repair or replacement. Overall, the number of structurally deficient bridges was much higher for steel

bridges than any other type of bridge material. With the driver detour length assigned for each structurally deficient bridge, the locations of the bridges were plotted using latitude and longitude as shown in Figure 2.

As shown in Figure 2, a significant number of structurally deficient bridges on rural low-volume roads are found generally in the northern and eastern counties of Kansas. The dots in yellow indicate bridges with the longest driver detour length of over 6 miles, and the green dots indicate bridges with the shortest driver detour lengths of 2 miles and under. Very few bridges, let alone structurally deficient bridges, were found in the southwestern part of Kansas due to geography and non-existing rivers and streambeds.

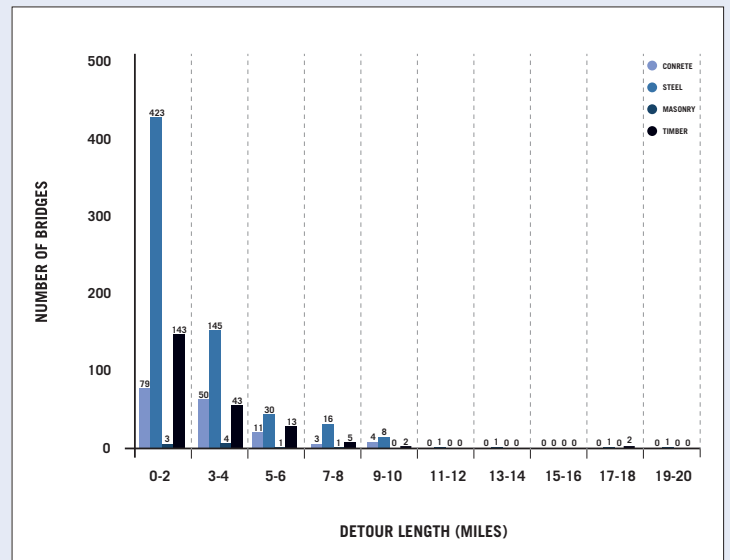


FIGURE 1. NUMBER AND TYPE OF BRIDGES VERSUS DETOUR LENGTH

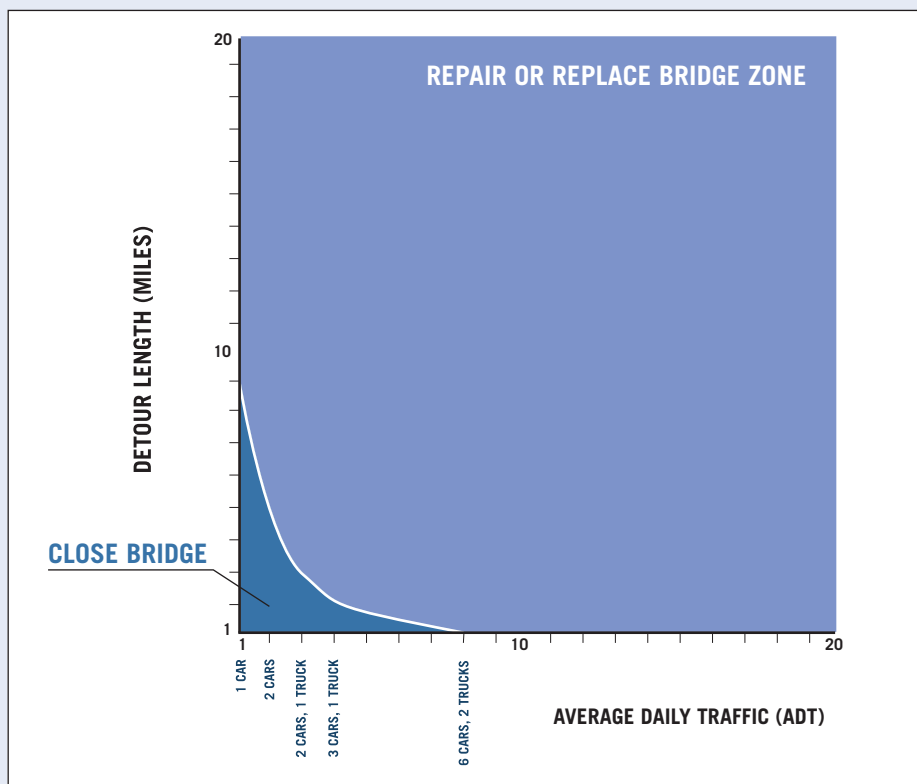


FIGURE 3. DETERMINING BRIDGE CLOSURE / REPAIR / REPLACE BASED ON ADT AND DETOUR LENGTH

Analysis and driver detour length determination continued knowing the driver detour length for each structurally deficient bridge, vehicle operating costs can be established. For this project, it was assumed the structurally deficient bridge is located on a two-wheel path secondary roadways where the ADT was 25 vehicles or less. It was assumed that the operating cost for a passenger car was \$0.60 per mile and for a large-truck/farm implement was \$1.00 per mile. It was also assumed that an 80/20 split between passenger cars and large truck existed for each bridge ADT. For example, if the ADT was estimated to be 10, 8 vehicles would be passenger cars and 2 vehicles would be large trucks. The research team assumed the 80/20 split would account for season changes when planting and harvest occurred.

Once vehicle operating costs were established, a conservative bridge replacement cost was determined by the research team and representatives from KDOT. A bridge on a rural low-volume roadway replace cost was estimated to be \$150,000 with a lifespan of 75 years. This equals approximately \$2,000 per year assuming the yearly maintenance cost and periodic inspection costs was included. Knowing the price of replacing the bridge at an annual rate, the driver detour length, and vehicle operational costs, Figure 3 was developed.

As shown in Figure 3, a relationship was developed between driver detour length and ADT on the road the structurally deficient bridge was located on. Based on the previous section which developed a yearly cost to replace a bridge, the vehicle operating cost and detour length were then computed and compared to the bridge replacement cost. As shown, the cost of operating a vehicle and adding a detour due to a bridge closure is much higher than the cost of replacing a bridge. However, if there is very low ADT

and a detour less than 9 miles, justification could be made to close the bridge based on vehicle operating costs.

DISCUSSION AND CONCLUSIONS

As Kansas bridge infrastructure ages on low-volume roadways, the cost of repairing or replacing a structurally deficient bridge can be a serious hardship for any county. This research project investigated the economics of closing a structurally deficient bridge by quantifying driver detour length, vehicle operating costs, and bridge replacement costs. Locations of structurally deficient bridges were provided by KDOT and their respected detour lengths determined. It was found that there are 648 structurally deficient bridges, if closed, would result in a driver detour length of 2 miles for less. Many assumptions were made by the research team and KDOT including vehicle operation costs and bridge replacement cost with known data limitations. Conservative values for vehicle operating cost for a passenger car and a large-truck were determined to be \$0.60 and \$1.00, respectively, and bridge replacement cost was set at \$150,000 with a 75 year life-span. It was anticipated that this study would have resulted in a large number of bridges in the “closed bridge” category (see Figure 3). However, in reality the number of vehicles daily traveling on these bridges need to be very low with a short driver detour.

Local highway agencies in Kansas need to work with county commissioners in determining an economical plan to close or repair a rural bridge while considering the safety of drivers. This study along with a companion study, *The Economics of Potential Reduction of Rural Road System in Kansas**, provides a basic framework for discussion between commissioners and engineers in determining if a rural county network of roads and bridges could obtain a cost benefit from being reduced.

* Babcock, M.J. *The Economics of Potential Reduction of the Rural Road System in Kansas*. Kansas Department of Transportation (Report No. K-TRAN: KSU-10-5), Topeka, Kansas 2011

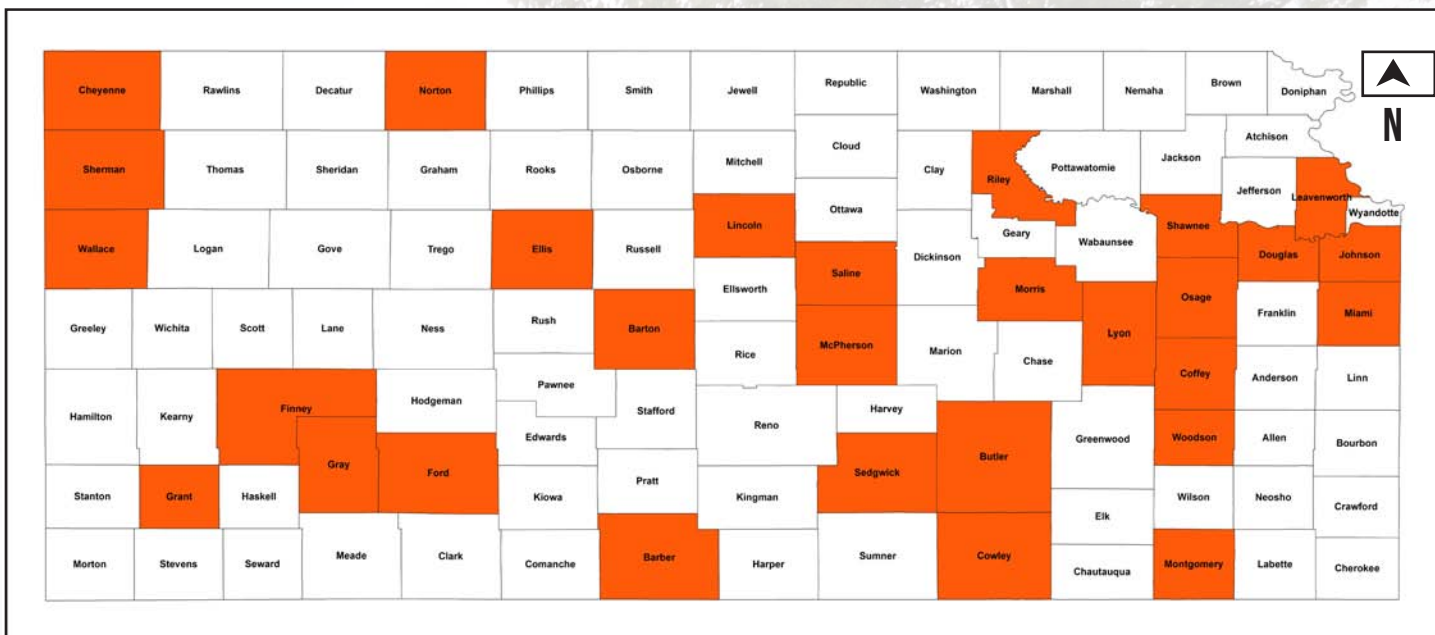


FIGURE 4. COUNTIES THAT RESPONDED TO RESEARCH PROJECT SURVEY

In March, 2012 the research team conducted a survey of practice by contacting county engineers and road supervisors in all of the 105 counties in Kansas. The survey was designed to evaluate whether counties in Kansas have considered or have closed bridges on rural low-volume secondary roads. A total of 29 counties responded as shown in Figure 4, which represents all geographical areas of the state. The list of questions and summary of answers are as follows.

Q1. Has your jurisdiction ever closed a bridge on a rural low-volume roadway?

A rural low-volume roadway for this study is considered gravel or dirt with two wheel paths. Counties reporting bridge closures: Saline County has closed approximately 28 bridges since 2005, Leavenworth County is currently attempting to close bridges, Butler County has closed six bridges in the last 23 years, Montgomery County has closed four bridges in the past ten years, Sherman County converts closed bridges to non-engineered low-water stream crossings with no concrete bottom or tube. Generally, all responding county engineers / road supervisors stated that bridges have not been closed during their careers.

Q2. What criteria were used to determine that the bridge(s) needed to be closed?

Many reasons were given by counties that included the following: Saline County proposed a bridge closure program which has been accepted by commissioners after careful explanation. Many counties reported that maintenance costs and traffic operations were two very important variables. Counties also reported that land-locked farmstead property also heavily influence the need to repair a bridge. Almost all of the counties reported that a non-engineered low-water stream crossing is always considered for an alternative. Two counties reported that the decision to close a bridge was based on the

bridge substructure condition. One county reported a bridge may be considered for closure if it is located in a flood-prone area, and finally all counties reported that local politics heavily influenced the decision to close or repair a bridge.

Q3. Has your jurisdiction ever tried to close a bridge, but was unable to due to other reasons?

Responses from the counties indicated that only a few cases of proposed bridge closure met resistance from the public. One county reported included local politics, three counties reported that the land owner requested the bridge remain open, and one county reported that the county commissioners did not want to make the tough call to close a bridge. Additionally, one country reported resistance but found a fair and friendly way to work with the Kansas Historical Society to keep a bridge opened.

Q4. Does your jurisdiction have a standard cost to repair a structurally deficient or functionally obsolete, or unsafe bridge on a low-volume roadway?

The responses for this question indicated that many counties do not have standard cost to repair or replace a bridge. However, it was found that seven counties did and that many did the repair work in-house. Prices indicated by the respondents included a price per square foot of \$50 to \$110. For counties that responded based on bridge replacement cost, the prices ranged from \$50,000 to \$250,000.

Q5. Would your jurisdiction be interested in an electronic copy of the final report?

All of the counties that responded to the survey stated they would be interested in the findings of the report. This indicates that bridge closure on rural low-volume roadways is an important topic as counties are faced with aging bridge infrastructure.