

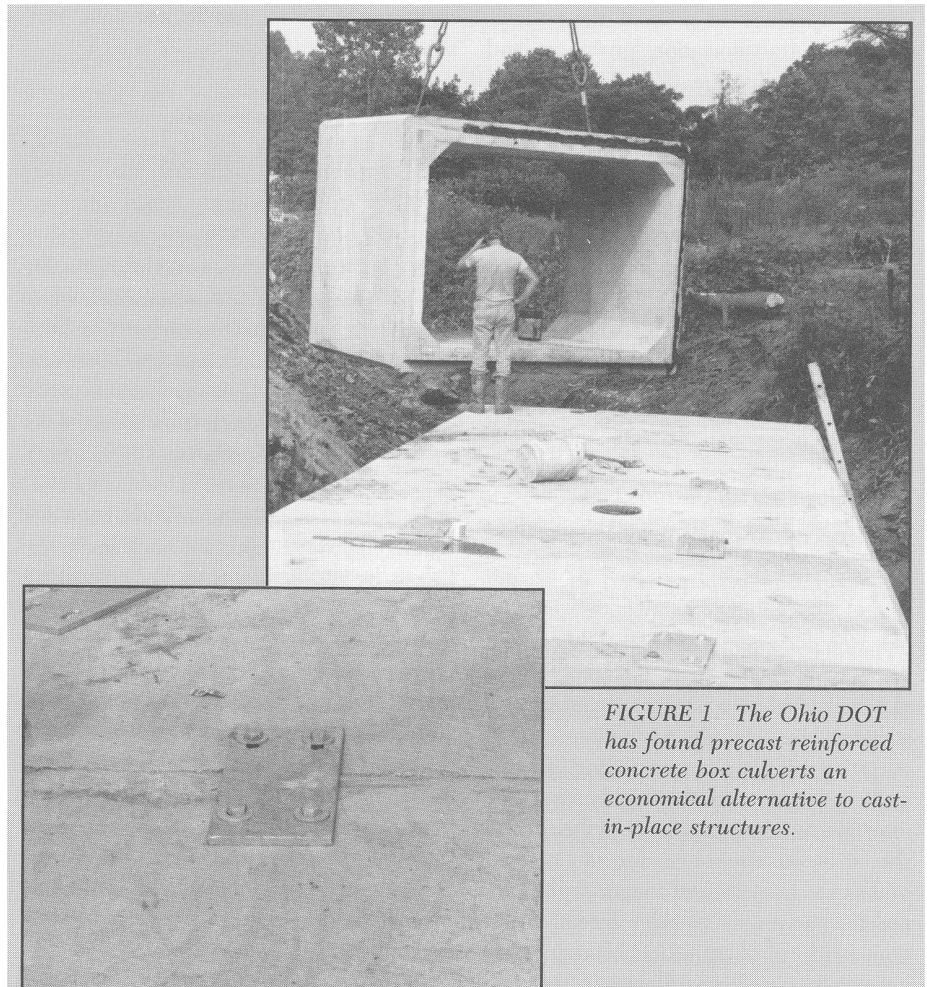
# RESEARCH PAYS OFF

## Eliminating Shear Connectors Slashes Culvert Cost



Since 1979, the Ohio Department of Transportation (ODOT) has found precast reinforced concrete box culverts (Figure 1) to be an economical alternative to cast-in-place structures. ODOT currently uses 8-, 10-, and 12-ft-span precast concrete box culverts, typically in sections 6 to 8 ft long with tongue-and-groove joints. These sections conform to ASTM specifications C850 for culverts with less than 2 ft of cover and C789 for culverts with 2 ft of cover and greater.

ODOT Supplemental Specification 955, which applies to these structures, initially required the installation of shear connectors on all C850 box culvert joints. The shear connectors, steel plates bolted to adjoining sections (see Figure 2), were placed at a maximum of 2½ ft apart. Their use was prompted by Federal Highway Administration (FHWA) and ODOT officials' concern that load transfer would not occur across a conventional tongue-and-groove pipe joint and that the differential deflections between adjacent box sections induced by live loads might damage the structure joint and overlying pavement.



*FIGURE 1 The Ohio DOT has found precast reinforced concrete box culverts an economical alternative to cast-in-place structures.*

*FIGURE 2 Shear connectors were initially added to ensure load transfer across the tongue and groove joints of adjacent box sections.*

## Problem

After construction of several C850 box culverts it became obvious that the shear connectors posed a threefold problem. First, the shear connectors proved difficult to install. The bolted plate configuration was difficult to align with preset holes and inserts, and field drilling and setting inserts was time consuming. As a result of size variations in the tops of the box sections, contact between the shear plates and the box sections required grout to ensure uniform bearing. Furthermore, to weld plate connectors required having a certified welder onsite. Difficulties with installing shear connectors thus counteracted a principal advantage of precast box culverts over cast-in-place structures—quick installation.

Second, using shear connectors made installation of waterproofing membranes more difficult. In some cases, the shear connectors had poked holes through the waterproofing membrane when bolted, thereby allowing water containing road salt to penetrate the top slab. Thus the use of shear connectors could adversely affect the long-term durability of the concrete structure.

Third, the shear connectors were costly. With an average installed cost of about \$50 each, the total cost per joint was about \$200 for each 12-ft-span joint and \$150 for each 8- or 10-ft-span joint. This represented an increase of 5 to 10 percent in the total cost of the box culvert.

## Solution

Because ODOT has successfully used circular and elliptical reinforced-concrete culverts with conventional joints and cover depths of 1 ft without joint problems, the question was whether shear connectors were actually needed on the C850 precast concrete box culverts. To determine this, ODOT awarded a \$46,000 contract to the University of Toledo in 1982 to undertake a research project. The project, entitled "Evaluation of Shear Connectors on Precast Reinforced Concrete Box Sections," was financed with Highway Planning and Research funds.

Testing was conducted on both an

TABLE 1 Ohio DOT Savings Resulting from Deletion of Shear Connectors on C850 Precast Concrete Box Culverts

Year	Number of Culverts	Number of Shear Connectors Deleted	Yearly Savings <sup>a</sup>	Accumulated Savings <sup>a</sup>
1983	10	614	30,700	30,700
1984	15	515	25,750	56,450
1985	21	850	42,500	98,950
1986	18	651	32,550	131,500
1987	4	165	8,250	139,750
1988 <sup>b</sup>	22	795	39,750	179,500

<sup>a</sup>In 1983 dollars.

<sup>b</sup>Through July.

actual full-scale installation and a 1/6-scale model manufactured as closely as possible to ASTM and ODOT minimum requirements. The culvert and models were loaded up to 2½ times the AASHTO HS-20 design load plus impact. Measured strains and deflections were evaluated to determine the load transfer and differential deflection that occurred across joints with and without shear connectors. The results showed that (a) significant load transfer occurred across the joint without shear connectors; (b) the differential deflection between box sections without shear connectors was insignificant for design loads; and (c) total deflections were much lower than the AASHTO allowable limits for design loads. The conclusion of the research was that shear connectors as specified by ODOT were not required on C850 box culverts.

## Application

ODOT's hydraulic personnel closely monitored the research as it progressed, and the department began to implement the research findings as soon as they became available in 1983—the use of shear connectors on C850 precast reinforced concrete box culverts was thus discontinued.

## Benefits

Benefits of the research can be easily measured in dollar savings. Table 1 shows actual amounts saved for each year, through July 1988. Projected savings for the coming 5 years are estimated at another \$250,000. Examination clearly shows that the research project paid for itself before its final report was distributed and that projected 10-year savings could fund 17 additional culverts of average size and length. These savings consider only ODOT projects and do not include savings accrued by other agencies that use ODOT specifications.

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*Suggestions for "Research Pays Off" articles are welcome. Contact David K. Witheford, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone 202-334-2972).*