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BY THE U.S. GENERAL ACCOUNTING OFFICE

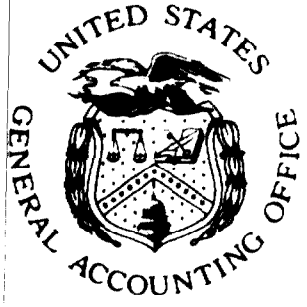
Report To The Secretary Of Transportation

Limited Funds And Numerous Deficient Off-System Bridges Create Federal Bridge Program Dilemma

The majority of the Nation's 252,000 deficient bridges is off the Federal-aid highway system. These bridges, generally located in rural areas with low volumes of traffic, are usually the responsibility of local governments, and billions of dollars will be required to replace or rehabilitate them. Federal assistance is increasing, but the number of deficient bridges is also increasing. As a result, a dilemma is how to best use limited funds to address this sizable bridge problem.

GAO found that off-system bridge replacement costs vary by thousands of dollars depending on which state a given bridge is in, who pays for its replacement, and who makes the design and construction decisions. The cost differences largely relate to the standards that the bridges are built to and willingness to use less costly designs and construction techniques.

GAO believes that economy is essential if progress is to be made in dealing with the off-system bridge problem, but the emphasis on economy must be tempered with the need to ensure that safety and long-range cost are not unduly compromised. GAO is recommending that the Federal Highway Administration, in administering the Federal bridge program, provide policy guidance on off-system bridge standards, balancing economy, safety, and long-range costs.



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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY,
AND ECONOMIC DEVELOPMENT
DIVISION

B-212424

The Honorable Elizabeth Hanford Dole
The Secretary of Transportation

Dear Madam Secretary:

This report discusses how Federal assistance for bridges off the Federal-aid highway system can more effectively address the sizable off-system bridge problem. It contains recommendations to you on pages 20 and 56. As you know, 31 U.S.C. §720 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the Senate Committee on Governmental Affairs and the House Committee on Government Operations not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

We are sending copies of this report to the Director, Office of Management and Budget; appropriate Senate and House Committees; and other interested parties. In addition, we are sending copies to the Administrator, Federal Highway Administration.

Sincerely yours,

J. Dexter Peach
Director

GENERAL ACCOUNTING OFFICE
REPORT TO THE SECRETARY
OF TRANSPORTATION

LIMITED FUNDS AND NUMEROUS DEFICIENT OFF-SYSTEM BRIDGES CREATE FEDERAL BRIDGE PROGRAM DILEMMA

D I G E S T

The Federal bridge program provides funds to the States to help replace or rehabilitate deficient bridges. The bridge problem is especially acute for those bridges off the Federal-aid system (off-system bridges). According to the Federal Highway Administration, 73 percent, or 183,000, of all deficient bridges are located off system. Recognition of the seriousness of the problem with off-system bridges is evidenced by 1978 legislation which made off-system bridges eligible for Federal funding under the bridge program and requires that from 15 to 35 percent of the funds apportioned to the States be used for off-system bridges.

As of September 1983, the States had obligated about $3.7 billion of the $4.5 billion of fiscal year 1979-83 bridge program funds apportioned to them. Over $700 million, or about 19 percent, of total obligated funds was for off-system bridges. This amount for off-system bridges will continue to grow as overall program funding was increased from the $4.2 billion for fiscal years 1979-82 to slightly over $7 billion for fiscal years 1983-86.

GAO's review was designed to provide information on the effectiveness with which available program funds were utilized to deal with the off-system bridge problem. GAO performed its detailed review in four states having a high percentage of deficient off-system bridges. For a broader perspective, it also obtained data from several other states on particular aspects of the bridge program. (See pp. 1-4, 7, 8, and 11.)

LIMITED PROGRESS CREATES A PROGRAM DILEMMA

In spite of the substantial increases in funding, the program is still severely strained by the magnitude of the bridge

Tear Sheet

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problem. According to Federal Highway Administration data, it would cost $22.2 billion to replace or rehabilitate off-system bridges that are currently deficient, to say nothing of costs resulting from further deterioration.

During the first 5 years of program assistance for off-system bridges, an average of about 1,000 bridges per year had been or were in the process of being replaced or rehabilitated under the program. Although noteworthy, this number is small in comparison to the 183,000 bridges that are currently deficient and the other bridges that continue to age and will need replacing in the future. (See pp. 8 and 11.)

As a result, a basic dilemma that confronts the program is how to replace or rehabilitate as many deficient off-system bridges as possible with the limited funds available. GAO found that the costs to replace a given off-system bridge can vary by thousands of dollars, depending on which state the bridge is in, who is paying for its replacement, and who makes the decisions on its design and construction. Some of these cost differences are due to varying climate, terrain, etc. However, differing policies at the local, State, and Federal levels are also major factors.

In this regard, Federal, State, and local officials often disagree on the level of funds that should be committed to replace or rehabilitate an off-system bridge. Local governments using their own funds tend to build bridges that cost much less than bridges built by State highway departments. The States also differ in the cost of the bridges that they build. (See pp. pp. 16-17, and 37-38.)

VARYING STANDARDS AFFECT COSTLINESS

A major reason for these cost differences is the varying standards that the bridges are built to. The Federal Highway Administration has delegated much of the responsibility for the choice of design and construction of off-system bridges to the States through agreements usually called Secondary Road Plans. Federal Highway's responsibility is largely restricted to an oversight role and, as a result, the States have been given a great deal of latitude to shape their own programs.

The standards which the States use for off-system bridges are those approved by the individual Federal Highway division offices. These standards are generally minimum ones based on national standards or guides developed by the American Association of State Highway and Transportation Officials. The States can build to higher standards but must obtain exceptions from the division offices to build below the minimum standards. (See pp. 12-13, and 43-46.)

The States are taking different approaches to addressing the off-system bridge problem by applying the standards differently when replacing or rehabilitating these bridges. New Hampshire, for example, rarely requests exceptions to the minimum standards and generally builds bridges that State officials believe can last longer than the 50-year life that bridges are normally designed for. By contrast, Vermont builds more of a variety of bridges and, with the Federal Highway division office's approval, builds below the minimum standards where it believes lower standards are warranted. As a result, the States substantially differ in their off-system bridge project costs and the number of deficient bridges replaced. Both believe that their approaches are the best strategy for dealing with the off-system bridge problem. (See pp. 17, 44-46, and 58.)

Federal Highway divisions also differ in their approaches. For example, the division in Vermont was approving the State's requests to build one-lane bridges on roads with low volumes of traffic. The division in Maine, however, would not approve the State building one-lane bridges on some of its lightly traveled roads. (See p. 47.)

LOCAL GOVERNMENT PREFERENCE FOR LESS COSTLY BRIDGES

GAO found that local governments build less costly bridges with their own funds largely because they are more likely to build to local rather than national standards. In these cases, local governments believe their bridges are safe and satisfactory for local conditions.

GAO also found that this local emphasis on less costly bridges has clashed with State preferences for higher standards. Local officials have expressed frustration regarding both the higher cost and longer delays involved in building bridges that they believe exceed their needs. For example, one State had proposed to replace a bridge at an estimated project cost of $644,000. The county, however, objected to the cost and is proposing a $240,000 bridge project. The major differences are the bridge width and the amount of roadway approach that is to be improved. For example, the locally-proposed bridge would not be as wide as called for by the State's current standards for new bridges. However, it would be wider than the existing bridge, which is on a narrow road with a low volume of traffic and slow vehicle operating speeds. At the end of GAO's review, a final decision on the project had not been made.

Local frustrations at times have been sufficiently intense that local officials have foregone Federal or State funding, relying instead entirely on their own sources of funding. (See pp. 37-42.)

LESS COSTLY ALTERNATIVES ARE AVAILABLE

The States GAO reviewed do not have procedures to ensure that less costly alternatives available for off-system bridges are identified and appropriately considered nor does Federal Highway generally review State decisions for off-system bridges. Instead, GAO found that State bridge engineers determine the type of bridge to build largely based on engineering/professional judgment and personal preferences. GAO did not find evidence that they sufficiently take such alternatives into account when making their decisions. (See pp. 12 and 16.)

GAO identified various innovative materials and techniques that could reduce project costs, but their use is not widespread. In addition, several conventional designs, types of materials, and construction techniques which can affect costs are usually available. (See pp. 16 and 21.)

An example of a potential cost-saving innovation is the long-span metal culvert, a large pipe-like structure that can be used at some locations instead of a conventional bridge. Despite Federal Highway Administration approval and successful use in some locations, some State bridge engineers do not fully consider such culverts. For example, one State bridge engineer had never used a long-span metal culvert. GAO identified three small projects in the State where use of these culverts could have saved over $500,000 in construction costs. (See pp. 21-27.)

SAFETY AND LONG-RANGE COST CONSIDERATIONS

One of the major considerations of State and local officials in replacing and rehabilitating off-system bridges is the safety of those who will use the bridges. A side issue facing these officials is the potential for lawsuits against them if an accident occurs on the bridges they build. In addition, these officials are reluctant to build bridges that will require excessive maintenance and have a short life. Limited funding and the on-going need to replace deficient off-system bridges, however, will intensify the debate concerning the standards for off-system bridge work and related costs. For example, some States have recently reduced their standards for off-system bridge widths. (See pp. 34-35, and 46.)

GAO believes that a greater emphasis on economy is needed to spread more widely the program's benefits to the thousands of deficient off-system bridges. However, it also believes this emphasis must be tempered with the need to ensure that safety and the bridge's life are not unduly compromised and long-range costs remain reasonable. Some Federal Highway and State officials, for example, are concerned that local governments build bridges to standards that are too low, and the bridges may not be as safe or last as long as they should. (See pp. 38 and 57.)

CONCLUSIONS

Given the magnitude of the off-system bridge problem and the limited funds available for addressing it, GAO concludes that less costly replacement and rehabilitation of deficient

off-system bridges deserve greater attention at all levels of government if the bridge program is to make an inroad into solving the problem. Potentially less costly alternative designs and construction techniques such as GAO identified need to be considered for more general use, and the issue of lower versus higher standards for off-system bridges needs to be addressed at the policy level. The effort to achieve economy and spread program benefits must, of course, be tempered by the recognition of competing factors, especially the concern for safety and the control of long-term costs. The program needs to provide for as many bridges as possible that are safe and adequate, have a reasonable life, and do not require excessive maintenance. In view of the competing factors and different approaches Federal Highway, State, and local officials are taking, GAO believes that the Federal Highway Administration needs to provide further program direction in this regard without unduly restricting the role of the States in the program. (See pp. 17-18, 35, and 55.)

RECOMMENDATIONS

GAO recommends that the Federal Highway Administration provide policy guidance to its offices and the States on off-system bridge standards and the appropriate level of effort that should be directed to individual off-system bridges. The purpose of this guidance should be to provide for program funding of the largest number of off-system bridges, consistent with concerns for safety and longer-term costs. This guidance should also recognize the size of the bridge problem, the nature of off-system roads and traffic, and local needs. GAO also recommends that Federal Highway include a requirement in the Secondary Road Plans that the States build off-system bridges according to the guidance recommended above. (See pp. 20 and 56.)

AGENCY COMMENTS AND GAO EVALUATION

The Department of Transportation (see app. I) stated that the Federal Highway Administration sees no need for additional detailed requirements but will continue to cooperate with State and local governments and with other organizations to develop and disseminate information on new technologies. In addition,

Federal Highway is conducting a 2-year review of its monitoring effectiveness which it believes will result in significant changes in its policy, procedures, and operations. Federal Highway believes that the results of this review and its recent regional office reorganization will address GAO's recommendation concerning the need for further guidance on off-system bridges.

GAO continues to believe that the Federal Highway Administration needs to provide additional guidance to help solve the dilemma of limited funds and numerous deficient off-system bridges. GAO suggests that, at a minimun, the Federal Highway Administration, as a part of its review of monitoring effectiveness, consider carefully the findings in this report. (See pp. 18-19, 35-36, and 56-58.)

STATE COMMENTS AND GAO EVALUATION

The State transportation departments (see apps. II through V) told GAO that they do consider in the design of off-system bridges the initial costs, safety, service, and long-term maintenance costs, even though they may not have formal procedures or documentation in their files. They also referred to the many factors and difficulties in bridge design and the need to depend on qualified staff and good engineering judgment rather than procedures. New Hampshire State officials said that they share GAO's concern about the bridge problem and plan to review their approach to the off-system bridge problem with the Federal Highway Administration.

GAO's report recognizes that state officials are constantly reviewing bridge plans for ways to stretch the use of available funds and maximize both safety and service. GAO, however, did not find evidence that the States fully identify and consider the various alternatives available for off-system bridges. GAO recognizes the continuing value of qualified staff and good engineering judgment. However, it believes that more clearly defined procedures for identifying and considering alternatives would help ensure that the staffs consider the use of designs that are innovative as well as less costly. GAO further believes that New Hampshire's decision to review its

position on off-system bridges with Federal Highway will help clarify the issue of standards for local bridges. This issue also affects the other states, and thus GAO anticipates that the policy guidance which it recommends Federal Highway provide to the States would have widespread benefits. (See pp. 19-20, and 58-59.)

Contents

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
CARE	Cost-Avoidance, Reduction, and Efficiency Program
DOT	Department of Transportation
FHWA	Federal Highway Administration
GAO	General Accounting Office

CHAPTER 1

INTRODUCTION

According to Federal Highway Administration (FHWA) data, about 45 percent, or over 250,000, of the Nation's 565,000 bridges are deficient. FHWA's latest--December 1982--estimate is that it would cost almost $49 billion to replace or rehabilitate them, and the cost is increasing as additional bridges become deficient. Many bridges are old and have reached or are approaching the end of their design life. The threat to safety, the inconvenience, and the financial burden of deficient bridges have become concerns to the public and all levels of government.

This report discusses the bridge problem and the Federal assistance provided for "off-system bridges," those bridges that are not part of the Federal-aid highway system. Over half of all bridges and nearly three out of every four deficient bridges are off-system. The total estimated replacement/rehabilitation cost is over $22 billion. Off-system roads are mostly the responsibility of county, city, and other local governments with limited resources. Historically, these roads have generally not been eligible for Federal highway funds. In recent years, however, a portion of the Federal funds provided to the States specifically for bridge replacement and rehabilitation have been designated by law for off-system bridge work.

THE FEDERAL BRIDGE PROGRAM

At the beginning of the Federal-aid highway program, funds were made available to the States for Federal-aid system highways and bridges, with no general requirement that a certain amount of the funds had to be used solely for bridges. Then the Silver Bridge over the Ohio River between West Virginia and Ohio collapsed in 1967, killing 46 people and focusing the Nation's and the Congress' attention on bridge conditions. The Congress established a legal requirement for periodic inspections to identify bridge conditions, maintenance needs, and safety problems and later provided funds to the States specifically to help replace unsafe bridges. The program was initially limited to bridges on the Federal-aid system where Federal highway assistance has generally been directed. November 1978 legislation, however, substantially increased Federal funding for bridges and extended the assistance and inspection program to include off-system bridges.

The Federal-Aid Highway Act of 1968 (Public Law 90-495, sec. 26, 82 Stat. 815) established the bridge inspection requirement. The act required the Secretary of Transportation, in consultation with State highway departments and other interested and knowledgeable parties, to establish standards for inventorying and inspecting Federal-aid bridges. The States (including the District of Columbia and Puerto Rico) were authorized to use Federal-aid highway administration and planning funds for training, inventory, and inspection.

The Highway Safety Act of 1970 (Public Law 91-605, sec. 204, 84 Stat. 1713) established the Special Bridge Replacement Program by authorizing $100 million for fiscal year 1972 and $150 million for fiscal year 1973 to supplement the States' efforts to replace unsafe bridges. The funds were to be appropriated out of the Highway Trust Fund, and the Federal share of each bridge replacement was limited to no more than 75 percent. Federal-Aid highway legislation of 1973 and 1976 continued the bridge program by authorizing an additional $585 million from the trust fund for fiscal years 1974-78.

The Surface Transportation Assistance Act of 1978 (Public Law 95-599, secs. 124 and 202, 92 Stat. 2689) extended and expanded the Special Bridge Replacement Program to what is currently known as the Highway Bridge Replacement and Rehabilitation Program. Rehabilitation[1] rather than complete replacement of unsafe bridges was now permitted and funding was greatly increased over previous authorizations. The $4.2 billion authorized for the 4 fiscal years 1979-82 was about five times more than the $835 million authorized for the previous 7-year period. Also, the program was no longer limited to Federal-aid bridges over waterways and topographic barriers. It now also included bridges off the Federal-aid system and bridges over highways and railroads, and the Federal share of replacement/rehabilitation costs was increased to 80 percent.

The Surface Transportation Assistance Act provided two categories of funds. The first category was apportioned to the States based on their relative share of the estimated cost to replace or rehabilitate deficient bridges. The second category of funds--$200 million of each year's authorization--was to be used for replacing or rehabilitating bridges whose project costs are more than $10 million[2] selected at the Secretary of Transportation's discretion. These funds have generally been used for Federal-aid system bridges. On the other hand, from 15 to 35 percent of the apportioned funds was to be used for off-system bridges. However, the Secretary of Transportation could reduce the 15-percent requirement if the Secretary determined that a State had insufficient off-system needs to justify the requirement.

The Surface Transportation Assistance Act of 1982 (Public Law 97-424, 96 Stat. 2097) extended the bridge program through fiscal year 1986 and again substantially increased funding with authorizations totaling $7.05 billion for the 4-year period.

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[1]The act defined rehabilitation to mean major work necessary to restore the structural integrity of a bridge as well as work to correct a major safety defect.

[2]Public Law 96-106, dated November 9, 1979, amended the 1978 act to allow the discretionary funds to also be used for bridges whose project costs are less than $10 million but twice a State's annual apportionment.

Program administration and responsibilities

The Secretary of Transportation has delegated administration of the bridge program to FHWA, which administers the program principally through a headquarters office (the Bridge Division in the Office of Engineering), 9 regional offices and 52 division offices with 1 in each State, the District of Columbia, and Puerto Rico. The division offices, each headed by an administrator and under the jurisdiction of the regional offices, are responsible for the day-to-day operations and monitoring of the program.

Generally, the bridge program works as follows. The States and/or local governments are responsible for inspecting their bridges in accordance with the national bridge inspection standards. Each State is further responsible for maintaining an accurate and current inventory and submitting specified inventory data (including inspection results) to FHWA for its computerized national bridge inventory. (For the purposes of inspection and the replacement/rehabilitation program, FHWA defines a "bridge" as those that are more than 20 feet long.) Based on the inventory data, FHWA submits to the States a listing of deficient bridges that are eligible for replacement and/or rehabilitation under the bridge program, and for their apportioned funds the States may select any bridge on the listing and apply for funding to the FHWA division offices. FHWA and the Secretary of Transportation select the bridges to be replaced or rehabilitated with discretionary funds from among those recommended by the States. The States agree to build or rehabilitate the selected bridges in accordance with certain national design and construction standards. FHWA's involvement in the design and construction of the bridges varies by factors such as the highway system the bridge is on, project cost, and agreements with the States whereby a State assumes certain responsibilities of FHWA for design and construction. These matters are discussed in greater detail in chapter 3.

OBJECTIVES, SCOPE, AND METHODOLOGY

Our major review objectives were to assess the cost effectiveness of off-system bridge replacement and rehabilitation under the Federal bridge program and to identify ways to reduce costs and improve program effectiveness. Our purpose was not to make detailed cost evaluations of individual bridge projects but rather to examine cost effectiveness in the broader context of

- --the appropriateness of FHWA, State, and local philosophies, policies, and strategies for dealing with the bridge problem, considering factors such as the nature and extent of the problem, the resources available to address it, and the type and volume of traffic on the bridges.

- --the adequacy of FHWA and State efforts, requirements, and procedures to ensure that the most cost-effective bridges are built.

- --the effective use of various opportunities to reduce costs and improve cost effectiveness.

Our review was made primarily at (1) FHWA headquarters in Washington, D.C., (2) its Regions 1 and 7 in Albany, New York, and Kansas City, Missouri, respectively, and (3) in the States of Iowa, Kansas, New Hampshire, and Vermont. We also briefly visited and obtained limited data from Arkansas, Massachusetts, New York, and Oklahoma. We also contacted numerous other FHWA, State, and local officials by telephone and/or mail. In the four States we reviewed in detail, we performed our work at the FHWA division offices, the States' departments of transportation, selected local governments, and other locations, primarily during the period of March to October 1982.

The States of Iowa and Kansas were selected because they are among the States with the largest total number and largest number of deficient off-system bridges and receive substantial Federal bridge program funds. New Hampshire and Vermont were chosen because they provided geographical and climatic contrasts to the other two States and also have a large percentage of off-system bridges that are deficient. The choice of New Hampshire and Vermont also enabled us to compare bridge design and construction in two States with the same geography and climate in close proximity to each other. Other considerations were our own staff availability and a desire to select States other than those that were the subject of our recently completed review of certain aspects of the bridge program.[3] The other States we visited or contacted during this review were chosen to obtain certain specific data. For example, we visited Arkansas to learn more about the efforts of a certain county to address its bridge problem. The FHWA regional offices were selected because they are responsible for the States we visited.

At FHWA headquarters, we reviewed policies and procedures and examined pertinent legislation, documents, reports, studies, records, budget and financial data, and national bridge inventory data relating to off-system bridge design and construction under the Highway Bridge Replacement and Rehabilitation Program and the Federal-Aid Secondary Road Program. We also reviewed American Association of State Highway and Transportation Officials (AASHTO) highway and bridge standards and numerous relevant documents on standards and bridge problems prepared by State transportation agencies, universities, and other organizations such as the Transportation Research Board, the Congressional Budget Office, and the Congressional Research Service.

At FHWA regional and division offices and State transportation offices, we reviewed appropriate policies, procedures, FHWA-State agreements and correspondence, budget and financial data, and bridge project files. Discussions were held with FHWA regional, FHWA division, State highway, and local officials, primarily those with responsibilities pertaining to the bridge program and off-system bridge design and construction. We also visited bridge project sites and other off-system bridges for physical observation.

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[3]Better Targeting Of Federal Funds Needed To Eliminate Unsafe Bridges, CED-81-126, August 11, 1981.

We made our review in accordance with generally accepted Government audit standards. Our work was coordinated with the Department of Transportation's Office of the Inspector General.

HANDLING STATE COMMENTS

We asked the heads of the transportation departments of the four States included in our detailed review to comment on the sections of our draft report that pertained to them. In keeping with our Office policy, we did not include the overall report conclusions and recommendations, as these are addressed to the Secretary of Transportation.

We received responses from all four States. In some cases, their specific comments added to, updated, or warranted further clarification of the data presented in our report. In other cases, they commented on our findings. Changes have been made in the data as presented in this report or their comments have been summarized at the end of the chapters, as appropriate. The State comments are included as appendices II through V.

HANDLING AGENCY COMMENTS

We requested Department of Transportation comments on the complete draft report from the Assistant Secretary for Administration, who obtained and summarized comments from appropriate departmental officials, including those of FHWA. These comments have been incorporated in this report in the same manner as the States' comments. The Department's comments are contained in appendix I.

CHAPTER 2

OFF-SYSTEM BRIDGES: A LOCAL PROBLEM OF NATIONAL PROPORTION

All highway systems are affected by deficient bridges but none to the extent that the off-system is affected. Nearly 73 percent of all deficient bridges are off-system, and off-system bridges generally are in worse condition than Federal-aid system bridges. A deficient bridge is not necessarily unsafe but it does have a deficiency that can affect its use, serviceability, or safety.

Off-system bridges, for the most part, are on local, rural roads with low volumes of traffic. They are usually smaller, simpler in design and construction, and cost less than bridges on major highways. However, they are important to local traffic and most of them are the responsibility of counties, cities, and other local governments which have limited resources to repair or replace them. As a result, the Federal bridge program and many of the States are providing financial assistance for these bridges. Despite substantial efforts, limited progress is being made.

THE OVERALL BRIDGE PROBLEM

The average bridge is designed for a life of 50 years and many bridges are approaching the end of their design life. FHWA data shows that as of December 1981, about 37 percent of the bridges in the United States were built before 1940. Many of these bridges have become obsolete as traffic has increased and roadways have been widened and improved but the bridges have not. In addition, physical deterioration has forced authorities to post weight restrictions or close some bridges altogether and thus restrict free movement and commerce.

The following chart shows the total number of bridges and the number of deficient bridges by highway system.

The Number of Total and Deficient Bridges by Highway System[a]

Highway system	Number of bridges	Number deficient	Percent deficient	Percent of total deficient
			-----(percent)------	
On-system:				
Interstate	48,638	5,151	10.6	2.0
Primary	89,941	22,348	24.8	8.8
Urban	31,993	9,457	29.6	3.8
Secondary-State	50,123	16,911	33.7	6.7
Secondary-local	41,437	15,297	36.9	6.1
Total	262,132	69,164	26.4	27.4
Off-system:				
Rural-State	36,750	17,055	46.4	6.8
Urban-State	2,353	914	38.9	0.3
Local-rural	244,528	157,280	64.3	62.4
Local-city	19,536	7,823	40.0	3.1
Total	303,167	183,072	60.4	72.6
Total	565,299	252,236	44.6	100.0

[a]FHWA's national bridge inventory data as of July 15, 1982.

Both the on-system and off-system have a bridge problem, but the off-system problem is larger in that 60 percent of its bridges are deficient compared to 26 percent for the on-system. About 73 percent of all deficient bridges are off-system and in fact slightly over 62 percent of all deficient bridges are on local-rural roads.

The cost to replace or rehabilitate deficient bridges is large

As shown in the following chart, FHWA estimates that it would cost almost $49 billion to replace or rehabilitate deficient bridges: $26.7 billion for on-system bridges and $22.2 billion for off-system bridges. Many more off-system bridges are deficient but the total replacement/rehabilitation cost for on-system bridges is slightly greater. Off-system bridges are generally smaller and cost less to replace or rehabilitate. The estimate--the latest available--is for deficient bridges as of December 31, 1982.

System	Bridges eligible for replacement or rehabilitation	Estimated replacement cost	Bridges eligible for rehabilitation only	Estimated rehabilitation cost	Total cost
		(billions)		-----(billions)-----	
Federal-aid:					
Interstate	481	$ 0.5	3,098	$ 1.3	$ 1.8
Primary	8,182	6.3	12,440	4.9	11.2
Urban	3,920	4.3	4,623	2.1	6.4
Secondary	14,721	4.1	15,331	3.2	7.3
Total	27,304	15.2	35,492	11.5	26.7
Off-system	123,698	17.2	51,352	5.0	22.2
Total	151,002	$32.4	86,844	$16.5	$48.9

THE ROLE OF OFF-SYSTEM BRIDGES

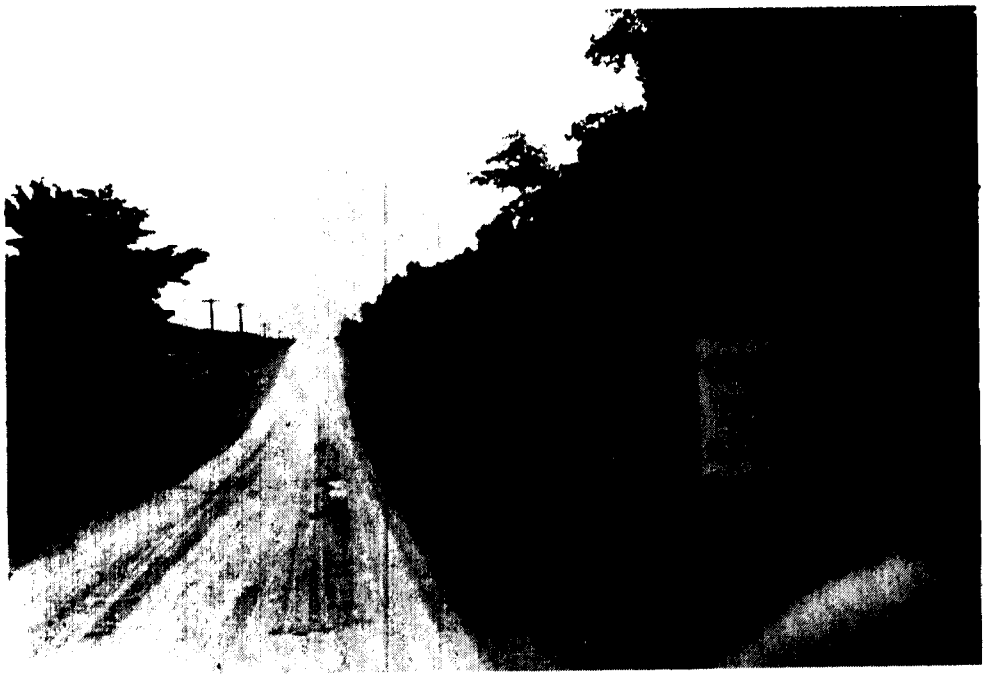
The Nation's highway network is made up of almost 4 million miles of roads. Roads off the Federal-aid highway system account for almost 80 percent of the total mileage, but carry only 20 percent of the traffic, slightly more than the Interstate carries with only 1 percent of the mileage. They are important, however, in that they provide access to rural resources, farms and residences, as well as urban businesses and residences. Also, the Secretary of Transportation's January 1981 report, "The Status of the Nation's Highways: Conditions and Performance," states that the condition of local roads and bridges is of special concern in rural areas where the density of highway facilities, and therefore the choice of alternate system access routes, is much lower than in urban areas. According to the report, the existence of an inferior road or bridge in these areas could effectively isolate rural residents and economic activities from the rest of the country.

The typical deficient off-system bridge is less than 50 feet in length and located on a local, rural road with a low volume of traffic. It is in poor condition, posted or should be posted for a reduced weight limit, and the responsibility of a county government. It primarily services local residents, farmers, and townspeople in the area. Most of the traffic consists of repeat travel over a short distance and characterized by lower speeds.

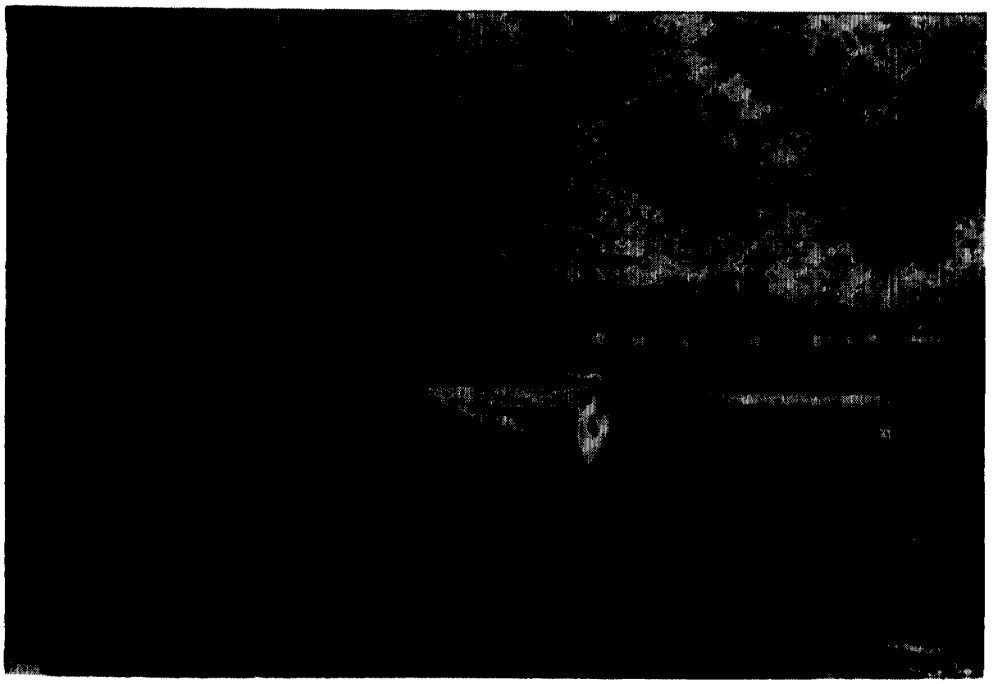
THE FEDERAL BRIDGE PROGRAM--PROGRESS BUT LIMITED IMPACT ON THE PROBLEM

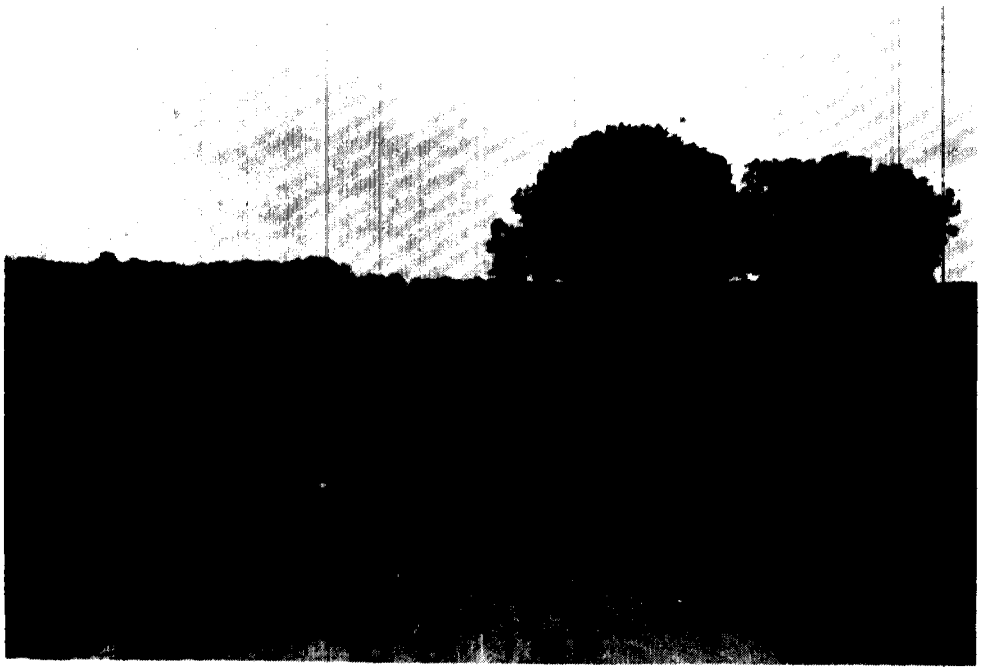
A large amount of Federal assistance for bridges has been provided to State and local governments, and a large number of bridges have been or are being replaced or rehabilitated. However, the total number of off-system projects funded under the program represents only about 2 percent of the off-system bridges that are currently deficient. The funding is increasing, but

Examples Of Deficient, Off-System Bridges.



Examples Of Deficient, Off-System Bridges.





the number of deficient bridges is also increasing. In addition, according to FHWA, the "rapidly accruing needs of bridges on the Primary and Interstate systems will steadily demand a larger and larger portion of available funds to prevent further decline of their load carrying capacity and safety."

Of the $5.8 billion authorized for the bridge program for fiscal years 1979-83, about $4.5 billion has been apportioned to the States. (The other funds were for discretionary projects, certain demonstration projects, FHWA administrative costs, and planning and research.) As of September 30, 1983, about $3.7 billion of the apportioned funds had been obligated for bridge replacement/rehabilitation. About $712.2 million, or about 19 percent, of the obligated funds was for off-system bridges. During this period, an average of about 1,000 off-system bridges per year was being funded under the program. The number of funded bridges, however, is small compared to the over 180,000 deficient off-system bridges.

State and local funding

FHWA does not collect data on either the amount of funds or the number of bridges replaced or rehabilitated solely with State and/or local funding. Our review, however, indicated that State highway departments largely depend on the Federal bridge program to fund bridge replacement/rehabilitation projects and the local contribution varies substantially.

Although State highway departments replace few of their bridges on their own, they generally provide the required match for the Federal bridge program, and they are also responsible for maintaining and repairing their bridges and replacing or rehabilitating their many structures that are less than 20 feet in length and that do not qualify as a bridge for the Federal program. Furthermore, some States are providing financial assistance to local governments to help replace bridges or to pay at least part of their required matching funds for Federal bridge projects.

Because of limited resources, many local governments are doing little on their own to solve their bridge problems. However, some towns and counties are making an effort on their own (without Federal funding). For example, a Tennessee county superintendent told us that his county had recently added a property tax for the specific purpose of replacing deficient bridges.

Department of Transportation (DOT) officials told us that State and local governments will have to do more on their own to better address the off-system bridge problem. According to DOT, FHWA is preparing a training course on rehabilitating existing bridges that will be offered to local government officials throughout the Nation in fiscal year 1984 and beyond. The course is to stress evaluation and cost-effective rehabilitation of existing bridges.

CHAPTER 3

FHWA AND THE STATES COULD GIVE GREATER ATTENTION TO OFF-SYSTEM BRIDGE COSTS

FHWA and the States have made considerable efforts to reduce overall bridge costs and improve cost effectiveness. However, in examining off-system bridge design and construction, we believe further improvements could be made through increased emphasis by FHWA and the States on cost effectiveness, involving a more formal consideration of available alternatives and options at the individual project level. At present, FHWA does not require that the most cost-effective bridge be built and the States do not have procedures to ensure that the alternatives available for a particular bridge site are identified and appropriately considered. FHWA generally requires or encourages that this be done for larger, high-cost Federal-aid system bridges for which FHWA has more direct involvement, but this cost effectiveness has not been emphasized as much at the local level.

Although FHWA, State, and local officials are concerned about cost effectiveness, they often disagree on what cost effective is with regard to off-system bridges. As discussed in this chapter and in chapter 5, FHWA has not clearly defined and provided policy guidance on cost-effective, off-system bridges.

OFF-SYSTEM BRIDGE DESIGN AND CONSTRUCTION ARE PRIMARILY A STATE RESPONSIBILITY

The design and construction of off-system bridges with Federal bridge program funds is primarily a responsibility of the State highway departments. Other than approving the project for funding and receiving data on its costs, FHWA does not routinely become involved in the project until it makes a final inspection at completion. The States, however, are to obtain FHWA approval for exceptions to certain design standards and FHWA provides technical assistance if requested by the State. On the national level, FHWA has worked with the States to develop and establish national bridge standards and at the State level to agree on State implementation of the standards.

FHWA has substantial project review and approval responsibilities but many of these responsibilities have been delegated to the States. A State highway department can certify that the plans, design, and construction for Federal-aid projects on the Secondary System are in accord with standards and procedures adopted by the State highway department and approved by the Secretary. These certified statements are referred to as Secondary Road Plans and usually also include or are used as a basis for administering off-system bridge projects. The 1973 Federal-Aid Highway Act expanded the Secondary Road Plan concept to what is called certification acceptance. Except for the Interstate System, certification acceptance can be granted for all work related to all federally assisted projects or specific

highway systems, programs, phases of work, classes of projects, or combinations of these. All but three States operate under certification acceptance or a Secondary Road Plan for the Secondary System. The States which we reviewed operate under road plans for Secondary and off-system bridge projects.

FHWA COULD DO MORE TO ENSURE COST EFFECTIVENESS

Over the years FHWA has taken various actions, such as funding research and introducing new technology that have helped reduce bridge costs and improve cost effectiveness. FHWA can also point to examples where its program and project reviews and monitoring have helped reduce costs. Although these efforts may have benefited the Secondary and off-system, the emphasis has been upon the Interstate and Primary Systems, for which most of the Federal-aid highway funds are provided and FHWA believes it has more direct responsibility. According to FHWA Bridge Division officials, in the last 2 years FHWA has placed special emphasis on cost effectiveness in its programs.

FHWA responsibilities for cost effectiveness

FHWA headquarters officials, including the Associate Administrator for Engineering and Traffic Operations, told us that when Federal-aid highway funds are used, FHWA is responsible for assuring that the lowest cost facility which will safely serve present and future traffic over the design life of a given bridge is built. The FHWA officials defined cost effectiveness as providing an adequate facility that will produce the desirable results at the lowest cost. However, this FHWA definition and statement on responsibilities do not appear in FHWA guidance to its field offices or the States, and there is no requirement for such an approach in the Secondary Road Plans we examined. Furthermore, FHWA has not clearly defined what is an adequate facility and what are the desirable results with regard to off-system bridges replaced or rehabilitated under the bridge program.

FHWA officials believe that the States have the overall responsibility to assure that cost-effective bridges are built and FHWA provides technical assistance, project oversight, and program reviews. According to the officials, the States' responsibility is carried out through cost-effective bridge designs, efficient project development, consideration of alternatives, and other procedures to promote competition in bidding and construction techniques. FHWA officials also told us that its major management approach is to be sure that State design and construction procedures are adequate to achieve FHWA's primary goal of providing a bridge that will safely serve its intended purpose through its design life yet cost no more than necessary.

FHWA efforts to encourage cost effectiveness

FHWA and the States spend millions of dollars each year for highway-related research, development, and technology transfer. These expenditures have resulted in the discovery and/or

production of new materials, methods, and equipment. FHWA has also issued orders and technical advice encouraging the use of various cost reduction techniques such as alternate designs, materials, and construction techniques. These consist of broad general guidance, and the extent to which they are applied to bridges on Secondary System and off-system roads is left to the discretion of the various FHWA regional and division offices.

The approaches taken by the FHWA offices are varied and some may meet with only limited success. For example, in FHWA Region 1, the orders and technical advisories on cost-reduction techniques have been provided to the States through the FHWA division offices without effort to encourage the use of the techniques suggested on the Secondary and off-system. The FHWA division bridge engineers in New Hampshire and Vermont have very little involvement with the States' activities under the Secondary Road Plan. They generally consider the bridge program to be structured to allow a State to build whatever type of bridge it prefers.

FHWA Region 7 also presented these orders and technical advisories to the States through the FHWA division offices. In addition, the region has promoted their use in meetings with FHWA division officials as well as State and local highway officials. As a result, some actions have been taken. For example, the FHWA Kansas division office required Kansas to begin using a composite (steel and concrete) design on all steel bridges, including those on the Secondary and off-system roads. About 50 steel bridges were to be redesigned, saving an estimated 10 percent of the structural steel costs. Kansas Department of Transportation officials told us that the use of composite design on all steel bridges may reduce the initial cost, but they were concerned that more expensive repair costs may occur during the structure's useful life.

The FHWA Kansas division also invited Kansas State highway officials responsible for bridges on the Secondary and off-system roads to a workshop on value engineering, a widely recognized management tool designed to optimize the value of each dollar spent on an item.[1] As a result, Kansas may establish a value engineering group within the unit responsible for low-volume Secondary and off-system roads with the hopes of further reducing bridge costs. Kansas officials told us, however, that formal value engineering studies should be used only on high cost projects because of the cost of increased staff time to perform the studies.

The FHWA Iowa division in some instances has recommended alternate designs for bridges on Secondary and off-system roads when they did not consider a proposed design to be cost-

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[1]Value engineering employs a systematic, multidiscipline, creative approach to identify, analyze, and establish a value for an item's function. The objective is to satisfy the required function at the lowest cost consistent with the requirements of performability, reliability, and maintainability. Value engineering is discussed in greater detail in chapter 4.

effective. For example, an Iowa FHWA engineer noted that a steel bridge was planned when concrete would be cheaper. The division's recommendation that the bridge be redesigned as a prestressed concrete beam bridge was accepted by the State and the applicable county, saving an estimated $165,000.

FHWA Secondary Road Plan and regional management reviews

Cost effectiveness, as already noted, is not an explicit requirement of the Secondary Road Plan and is generally not addressed in FHWA's reviews. In the four States we studied, we found only one instance where cost effectiveness was emphasized in FHWA's review of the State's operation under its Secondary Road Plan. The Iowa FHWA division office reviewed the State Department of Transportation's practice of routinely approving bridge designs wider than specified by the Secondary Road Plan on low-volume, unpaved roads. As a result, Iowa implemented procedures to limit such bridges to those projects where specific circumstances required a wider bridge than called for in the Secondary Road Plan.

FHWA regional office efforts are generally limited to those projects where the division offices are directly involved in the design approval and construction process, that is, the Interstate, Primary, and Urban Systems, unless the State has certification acceptance for the latter two. Regional management reviews are intended to ensure compliance with regulations and procedures and do not directly address cost effectiveness.

Management initiatives to emphasize cost-effectiveness efforts

FHWA management has taken action to stress to its staff the importance of their efforts to improve the cost effectiveness of highway (and bridge) design and construction. The result has been a greater emphasis on cost effectiveness but primarily with regard to Interstate and large, high-cost bridge projects on the Primary System in which FHWA has more involvement.

For example, the FHWA Administrator annually designates program areas to which FHWA will give special emphasis, and specific objectives are established for each area. For fiscal year 1982, one area receiving emphasis was a cost-effective design and construction program whose objective was to reduce costs in the highway program through more widespread use of improved practices in design, construction, and traffic operations. The specific tasks were to (1) use alternate designs on Federal-aid bridge projects to increase competition, (2) use alternate designs for pavement-type selection, (3) make effective use of alternative materials and construction expertise, (4) promote cost effectiveness in all elements of the highway program and assist in identifying specific cost-cutting procedures, (5) promote traffic signal system improvements and other fuel-efficient traffic operations measures, and (6) promote planning efforts to prioritize projects and programs on a cost-effective basis. This effort is

continuing in 1983. FHWA also has a Cost-Avoidance, Reduction, and Efficiency (CARE) Program, which is designed to further encourage its staff to work to reduce costs in FHWA programs and report on their accomplishments.

We reviewed the FHWA CARE reports and the program emphasis area progress reports for fiscal year 1982 that related to bridges and discussed their efforts in this regard with several FHWA headquarters, region and division officials. The specific areas of emphasis varied by region and division but the major efforts were mostly directed at larger Interstate and Primary System bridges.

THE STATES AND COST EFFECTIVENESS

Available bridge materials and prices can fluctuate quickly and new materials and construction techniques are continuously being developed. Also, bridge sites and conditions differ, and the amount and type of traffic on the bridges and the needs and desires of those who use the bridges vary. These factors, along with the need to consider long-range costs and safety, make the decisions on bridge design and construction difficult. However, State bridge engineers make design and construction decisions for off-system bridges based largely on engineering judgment, experience, and preferences. None of the four States in our detailed review had established formal procedures to ensure that the most cost-effective bridges are built. For example, we found little evidence in State and FHWA files that State officials fully considered alternatives or made cost comparisons between different type structures or materials in designing or approving the design of bridges for off-system roads.

In some cases, the State suggests more cost-effective designs to the counties, but the counties do not use them. In Iowa, county engineers usually are responsible for designing off-system bridges, but a State Department of Transportation bridge engineer reviews these designs to ensure the hydraulic requirements are met and the type, size, and location of the structure is satisfactory. If the State bridge engineer notices that an alternate design would be more cost-effective, he will suggest the alternate. It is then up to the county to use it. In most instances they do not, according to Iowa officials. For example, a bridge engineer suggestion that the use of concrete beams instead of steel beams would save about $49,000 on a 175-foot long x 28-foot wide bridge was not used by one county.

As a further example, we discussed with the bridge engineer a total of 11 bridge projects, some at his suggestion. These may not be representative of the total but the results were consistent with the bridge engineer's statement that, in most instances, the alternates are not accepted by the counties. For the 11 bridges, the alternate was accepted in two cases, rejected in six cases, and in the other three, a cost-saving alternate could have been suggested by the bridge engineer but was not. Iowa Department of Transportation officials told us that, as a result of our review, they were considering action to require counties to accept less costly alternates or justify the type of bridge they request.

We also found that the States varied in their approaches to cost effectiveness and dealing with the off-system bridge problem. The extent of variance is best illustrated by the different approaches followed in New Hampshire and Kansas for shorter bridges. New Hampshire attempts to build what it considers the best bridge, which it defines as the one that will last the longest with the least maintenance. This approach, which New Hampshire considers the most cost-effective, often results in a steel bridge, which is one of the more costly type of structures for these situations. In contrast, Kansas tries to build the least costly structure and usually constructs reinforced concrete box culverts for short-span bridges. In the rare instances when a concrete culvert cannot be used, concrete slab bridges are used. Kansas considers its box culverts to be long-lasting with little maintenance. The different approaches followed in these States are reflected in part by the cost to construct bridges on the off-system in these States. A project for a small Secondary or off-system bridge in New Hampshire may cost $250,000 or more while a similar size project in Kansas may cost less than $100,000.

Other factors such as terrain, labor costs, and available materials also enter into a comparison of cost between States as different as New Hampshire and Kansas. However, New Hampshire's off-system bridge project costs are also substantially higher than Vermont's, a State with basically the same terrain and climate. This is in part due to the different approach to bridge design between the States. Vermont builds more of a variety of bridges depending on the topography and hydraulic requirements. For short span structures this is usually a concrete slab bridge.

CONCLUSIONS

A substantial number of off-system bridges are deficient and the cost to replace or rehabilitate them is large. FHWA and the States are concerned about bridge costs and both contribute toward the design and construction of more cost-effective bridges. We believe, however, that their efforts could be improved, at least for off-system bridges.

The State highway departments need a better, more formal process to ensure that cost effectiveness is emphasized and cost-saving opportunities and alternatives are identified and properly considered in the design and construction of off-system bridges. Off-system bridges are generally smaller, less complex, and less expensive. State bridge engineers tend to make decisions on the design and construction of these bridges based on engineering judgment, experience, and preferences without indications that alternatives are fully considered.

An explicit requirement for cost-effective bridge design and construction under the Federal bridge program is also needed to handle situations such as in Iowa where the State suggested more cost-effective bridge designs to the counties but the counties often did not accept the alternatives, and the State did not require their acceptance.

FHWA, with some oversight and review responsibilities, also needs to place more emphasis on cost effectiveness. We do not propose that FHWA assume any of the State responsibilities for off-system bridge design and construction or become involved in individual project design review and approval. FHWA could better provide for cost effectiveness by establishing a requirement that cost-effective bridges are to be built, including the requirement in the Secondary Road Plans and monitoring compliance with the requirement.

AGENCY COMMENTS AND OUR EVALUATION

With regard to our proposal to establish a requirement for cost-effective, off-system bridges, DOT stated that FHWA believes that sufficient requirements already exist for this purpose. According to FHWA, the current provisions in Section 109 of Title 23 of the U.S. Code and FHWA policies and procedures require that cost-effective bridges be designed for all Federal-aid projects, and the agency is firmly committed to the principles of cost effectiveness.

DOT also said that FHWA has a comprehensive 2-year-long ongoing review of its design and construction monitoring effectiveness. According to DOT, the review should result in significant changes in FHWA policy, procedures, and operations that will improve the quality of design and construction of federally funded highway projects. DOT stated that cost effectiveness is a major force driving this review. DOT also said that current management reviews by FHWA headquarters, regional, and division offices concentrate on both safety and cost effectiveness in bridge designs. DOT further said that value engineering principles, available resources, and program demands require that FHWA bridge engineers concentrate their detailed review efforts on the more costly bridge projects.

Many FHWA policies, guides, and related efforts--especially those of a technical or engineering nature--do impact on cost effectiveness, and we do not question that their purpose is to help provide for cost-effective highways and bridges. We also do not question that FHWA already has this authority and responsibility. Section 109 of Title 23 does give the Secretary of Transportation substantial authority over geometric and construction standards for federally assisted highway and bridge projects.

Much of these responsibilities under Section 109 for off-system bridges, however, have been delegated to the States. The States are primarily responsible for off-system bridge design and construction and FHWA has limited involvement in off-system bridge projects. We believe an explicit overall requirement would further emphasize cost effectiveness and clarify FHWA and State responsibilities in this regard. FHWA headquarters officials define cost effectiveness as providing an adequate facility that will produce the desirable results at the lowest cost. We did not find such a requirement or this definition in major FHWA policies relating to administering the bridge program or in the Secondary Road Plans. FHWA division bridge engineers we talked to

generally considered the States to be responsible for cost-effective, off-system bridges because the States have the design and construction responsibility. FHWA periodically conducts management and Secondary Road Plan reviews but these have been limited in scope in that they have been generally directed toward State compliance with certain regulations and processes rather than cost effectiveness.

We are not proposing that FHWA become involved in the design and construction of individual off-system bridge projects. However, FHWA regional and division officials need to be better aware of their responsibilities with regard to ensuring that cost-effective off-system bridges are built and provide some oversight. We believe that this can be accomplished by establishing a program requirement that cost-effective bridges are to be built and include such a requirement in the Secondary Road Plans. As a result, we would envision that FHWA's periodic management and Secondary Road Plan reviews, for example, would include the States' compliance with the requirement.

During our audit, FHWA officials preferred not to discuss the preliminary results of their ongoing monitoring review. Thus, we are not aware of their findings and the potential changes that may be made. However, we appreciate FHWA's concern about its monitoring. We anticipate that this report will help FHWA in its review and that our proposal will be fully considered.

STATE COMMENTS AND OUR EVALUATION

In commenting on our draft report, the heads of the State departments of transportation told us that they believe that they are cost-effective in the design of off-system bridges. The Director of the Iowa Department of Transportation, for example, said that FHWA and State officials are constantly reviewing bridge plans for ways to stretch the use of available funds and maximize both safety and service. He further said that bridge owners must consider initial cost, safety, service, and maintenance costs in the design of the bridge, and these decisions are part of every design thought process but may not be documented.

The Secretary of the Agency of Transportation for Vermont told us that they consider cost-effective design to be an integral part of the design process. He said that they use a variety of structures and this proves they do make cost comparisons between different types of structures even though their files may not have been well documented.

The Commissioner of the New Hampshire Department of Public Works and Highways commented that the State's bridge engineer is guided by a general policy that seeks the most cost-effective bridge for the life span of the facility.

The Kansas Secretary of Transportation stated that there are many difficulties in determining optimal bridge designs. He said bridge designs are evaluated on the basis of their experience gained from the many types of structures built both with and

without Federal funds. The Secretary believes the use of a stable group of extremely qualified engineers specializing in this area produces results not inconsistent with those that would result from a more formal procedure. The officials commented that the existence of formal procedures will become more desirable to them as they begin to experience staff turnover.

We do not question the States' design of off-system bridges nor their intent to build cost-effective bridges. We recognize the difficulties and many factors that must be considered when selecting the design for a particular bridge site and the importance of qualified staff and good engineering judgment. We are not recommending that the States regiment their design process. However, we continue to believe that the process would be improved if the States establish procedures to ensure that various alternatives are identified and appropriately considered. We found little evidence that the States are doing this. In this regard, we would not envision elaborate procedures, extensive documentation, or the elimination of engineering judgment. But the growing bridge problem, the many factors that must be considered in bridge design, the increasing number of alternatives available, and changing prices and economic conditions warrant more formal procedures than currently exist.

RECOMMENDATION TO THE SECRETARY OF TRANSPORTATION

We recommend that the Secretary of Transportation direct the FHWA Administrator to establish an explicit requirement in the Secondary Road Plans that cost-effective, off-system bridges are to be built under the Federal bridge program. This requirement should provide for the States to build cost-effective bridges according to the policy guidance recommended in chapter 5.

CHAPTER 4

OPPORTUNITIES TO REDUCE OFF-SYSTEM BRIDGE COSTS

Various innovative materials, designs, construction, and management techniques offer potentially substantial cost savings for off-system bridges. These innovations have been available for some time but State highway departments are often reluctant to use them for a variety of reasons.

Innovative technology and management techniques are not always appropriate and the experience with some technology may not be sufficient to warrant wide application. But when properly used they can substantially reduce costs and more deficient bridges can be replaced with the limited amount of funds available for this purpose. The following is a discussion of several examples of innovative technology and management techniques that we found in use by some State and local governments and the major constraints to their wider acceptance.

INNOVATIVE TECHNOLOGY CAN LOWER COSTS

Long-span culverts--a less costly alternative to a new bridge

One alternative available to State and local governments to use in replacing some bridges is the long-span culvert.[1] For many years, culverts or pipes have been placed in streams and covered with soil rather than building a short bridge. These were of limited diameter and could only be used when a very small waterway opening was satisfactory. However, long-span culverts were developed several years ago to provide a larger opening that would be suitable for more bridge sites. A long-span culvert, for which there are several manufacturers, is usually made out of steel or aluminum and usually has an arch, pear, elliptical, or similar shape. It is usually brought to the bridge site in sections to be assembled at the site. It is then placed on a concrete footing or set in the stream bed and covered over with backfill, a certain thickness of soil, preferably a granular material such as sand or gravel, that should be carefully placed and compacted around and over the culvert. After installation, the stream flows through the open ends of the culvert and the roadway and guardrail are built across the top of the backfill and the culvert. Long-span metal culverts are usually galvanized to protect against rusting. The larger culverts are also being used as grade separations, with one road running through them and the other road running across the top.

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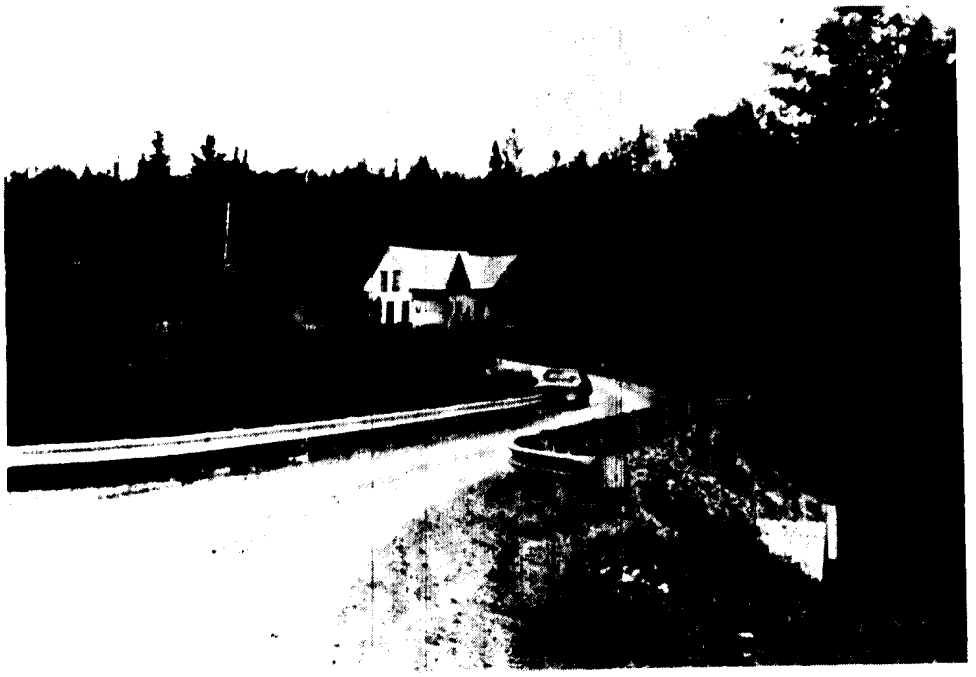
[1]Structural plate pipes and arches, which are similar in concept to long-span culverts, may be used for slightly shorter spans. In this report, we refer to both as long-span culverts.

(Photographs Courtesy Of Armco, Inc.)

A Long-Span Culvert During Installation And After Completion.



Top And Side View Of A Long-Span Culvert Near Concord, Vermont.

The use of long-span culverts has generally resulted in substantially reduced construction cost and time. In addition to reduced costs and quick installation, a characteristic that appeals to local governments is that the culverts can be installed with their own employees. The manufacturers, however, generally require that one of their professional engineers supervise, because proper installation is critical to the structures' success.

FHWA has supported the use of long-span culverts for bridge replacement. In 1978 the director of FHWA's Region 10, Office of Bridges, in reporting the results of a survey of counties and other local jurisdictions in the States of Idaho, Oregon, and Washington concluded that the first question for local governments in planning a bridge replacement program should be: How many of the old bridges can be replaced with culverts, including long-span culverts? According to the FHWA Region 10 official, over 600 of the long-span culverts had been installed in North America--including several in Region 10--and culverts can be constructed faster than most bridges and often at substantially less cost. He also cited such advantages as low maintenance, no bridge icing, and no deck deterioration. The official believed that when site conditions are right for the large culvert, careful study should be made to determine the relative merits of a culvert versus a bridge.

In 1979 the Chief of FHWA's Bridge Division sent a memorandum concerning certain long-span culverts to the heads of FHWA's regional offices. He noted that there were three manufacturers of galvanized steel long-span culverts in the United States who were actively promoting and selling this product: (1) Armco, Inc. (Super Span); (2) Republic Steel Corporation (Maxi-Span); and (3) Syro Steel Company (Syro Long-Span). He added that in the past 15 years several hundred Armco Super-Span culverts had been erected in the United States and Canada and generally the performance of these structures had been excellent. Also, a number of Maxi-Span and Syro Long-Span culverts had been installed in the last few years and their performance also had been excellent. The Chief of the Bridge Division concluded that these structures can be bid in competition with each other and specified as an alternate to competitive conventional designs such as concrete box or arch culverts or a small bridge. In June 1981 FHWA also approved the use of long-span corrugated aluminum culverts on Federal-aid projects. However, FHWA officials pointed out that there have been several failures of long-span culverts, and it is important to have qualified personnel install them. FHWA officials also pointed out that long-span culverts are not always cheaper. In some cases, where culverts have been bid as alternates to conventional bridges, the conventional bridge has been bid at a lower cost.

Despite FHWA's endorsement of these long-span culverts, we found that State highway departments have been reluctant to use them. For example, the New Hampshire State bridge engineer has never approved the installation of a long-span culvert. According to the State bridge engineer, his philosophy and practice is to build the best possible bridges, those that will last the

longest and generally be most maintenance-free. He does not believe that long-span culverts meet this criteria. However, according to FHWA and long-span culvert manufacturers, low maintenance is one advantage of the culverts. Industry claims they will last 50 years, the length of time bridges are generally designed for, and that their products meet AASHTO specifications for this type of bridge. As stated above, FHWA has found the performance of the three long-span culvert products to be excellent, based on those that have been installed for several years.

Long-span culvert manufacturer representatives told us that these structures could replace 20 to 35 percent of the short-span (less than 50 feet) bridges in New Hampshire. About 75 percent of the State's over 1,000 deficient off-system bridges are less than 50 feet in length. The State bridge engineer agreed that the use of culverts could save from 30 to 50 percent of bridge replacement costs when used instead of the conventional bridge that New Hampshire usually builds.

To test the possible use of the structures in New Hampshire and the potential savings in replacement costs, we examined data on off-system bridge projects of less than 50 feet in length that have recently been proposed for funding under the Federal bridge program. Based on waterway opening requirements, we selected four sites where it appeared a long-span culvert could have been used. In August 1982 we met with an Armco professional engineer to discuss using long-span culverts at the four bridge sites in New Hampshire--Amherst, Antrim, Brentwood, and Deerfield. After reviewing the State hydraulic reports and bridge plans, he stated that the Amherst site was not suitable for a long-span culvert but he did believe the other three sites were suitable. The Armco engineer and the State Municipal Highways Engineer, who was familiar with the location, accompanied us to the sites. After inspecting the sites they both agreed a long-span culvert was appropriate at each of the three locations.

Following is a comparison of the State's cost estimates for a conventional bridge and Armco's cost estimates for a long-span culvert at the three locations. In preparing his estimates, the Armco engineer maintained the same width proposed by the State. All estimates are as of August 24, 1982, except the State's actual cost for the Brentwood bridge, which had already been completed.

Town	State estimate	Armco estimate	Possible savings	Percent
Antrim	$360,000	$ 96,200	$263,800	73.3
Brentwood[a]	160,000	88,610	71,390	44.6
Deerfield	300,000	104,853	195,147	65.0
Total	$820,000	$289,663	$530,337	65.0

[a]This bridge has already been built by the State. These costs reflect only the bridge cost, i.e., no approach roadway work is included in this estimate. The figure shown under the column "State estimate" is an actual-cost figure which is 3 years old. Armco's estimate was a current market estimate.

Thus, the use of long-span culverts in these three locations could possibly have saved over $500,000. If these could be used for 20 to 35 percent of bridges less than 50 feet, the savings could be substantial and the Federal bridge program could replace many more bridges.

The Bridge Maintenance Engineer, whose unit primarily repairs bridges but also replaces a few, believes long-span culverts are a good inexpensive alternative for replacing small bridges. He pointed out that these structures are not suitable for all locations but estimated that they could replace 20 to 30 percent of New Hampshire's small bridges. The Bridge Maintenance Section uses culverts extensively to replace bridges under 20 feet and to date has not had any problems with those it has installed. The Bridge Maintenance Engineer stated that for many towns, culverts could be the answer to their bridge problems. Some towns are now putting them in with their own funds as an inexpensive alternative to the more expensive conventional bridges.

FHWA and New Hampshire officials told us that they believe having Armco estimate what one of its culverts would cost at a given location would tend to result in a low estimate. According to FHWA officials, only actual bids received would give true costs. According to Armco officials, however, their estimates were based on the more recent figures that they have been using for bidding in the New England and New York area. Our purpose was to provide a relative comparison of costs.

Vermont uses some long-span culverts but limits their use to certain situations. Where used, the State requires a minimum 5-feet cover of backfill, which limits the number of sites where a culvert would be economical because of the cost of the backfill and the approach roadway work. Several large culverts, however, have been installed in Vermont. One serves as a highway bridge over railroad tracks in Essex Junction, Vermont. The culvert opening had to be high enough to provide safe clearance for trains passing through the tunnel, yet too high a rise would

mean a steep grade for vehicles crossing the bridge. To solve this problem, a small concrete pad was put on top of the pipe, allowing a reduction in the amount of cover. The project was privately funded and neither the State nor the Federal Government was involved in its design or construction.

Another large culvert was used in St. Johnsbury, Vermont, for a railroad tunnel. One estimate indicated the pipe saved about $150,000 and construction time was less than that required by a conventional bridge. This project received Federal and State aid and was designed and constructed by the State. A third large culvert bridge serves the Bromley Mountain ski resort. It spans slightly over 35 feet and carries a two-lane road with a pedestrian sidewalk on both sides. The project was designed and built by the State, and it received Federal and State funding.

The Kansas Department of Transportation routinely uses cast-in-place, reinforced concrete box culverts for bridges less than 50 feet in length. Department officials told us, however, that they do not encourage the use of the long-span metal culverts even in locations where their use is appropriate. They do not believe that they are cheaper than the box culverts the State builds. They did not have cost comparisons to support this but their views were shared by several county engineers to whom we talked. FHWA officials told us that many times concrete box culverts are just as cheap or cheaper than long-span culverts. Also, State officials do not believe culverts will last 50 years because of rust. Furthermore, they believe that there are problems getting sufficient soil to cover the culverts at most project sites. In Iowa 3 of the 229 county Secondary and off-system bridges let for bid involving Federal funds have been long-span culverts.

Armco representatives in Topeka, Kansas, stated that their products were not appropriate in most of Kansas and part of Iowa because of the flat terrain. In flat terrain with shallow stream beds, insufficient "headroom" exists to install their structures without significantly raising the grade of the roadway. In locations where their structures can be installed, they stated they were more cost-effective than concrete boxes or cast-in-place, reinforced concrete slab bridges for bridges under certain circumstances. However, they were unable to provide detailed cost estimates or an estimate of the number of deficient bridges where the potential exists for use of their products.

Precast, prestressed concrete

Prestressed concrete is an alternative material whose use is increasing. FHWA is encouraging the States to consider it as an alternate to steel on major long-span bridges, and many times it is being used for this purpose. Prestressed concrete can also be used for shorter-span bridges. In the previously mentioned FHWA Region 10 survey of local governments in Idaho, Oregon, and Washington, the Region 10 Director of the Office of Bridges concluded that with the large number of deficient bridges nationwide, most of which are on low-volume roads, it is imperative that new

bridge construction on such roads be as economical as possible and yet be long-lasting and nearly maintenance-free. He also concluded that precast, prestressed concrete appears to be an attractive and economical solution for replacement of existing deficient structures. According to the official, prestressed concrete is by far the most commonly used material for bridges on low-volume roads in the Northwest in the short- to medium-span range (20 to 130 feet long). In the States we examined, the use of precast, prestressed concrete, however, has been mixed.

The Vermont Department of Transportation's Chief of Bridge Inspection and Design stated that prestressed concrete slabs are most appropriate when the waterway opening is small because prestressed concrete is less likely than steel beams to snag floating debris and is very quick to erect. In spite of such advantages, he added that they do not use them often because they are not readily available in Vermont. Only recently a firm began producing prestressed concrete in Middlebury, Vermont. The New Hampshire assistant bridge engineer told us that the State has not built any prestressed concrete off-system bridges because there are no prestressed concrete plants in New Hampshire.

Of the 229 county Secondary and off-system bridges that Iowa had let for bid involving Federal funds, 78 were precast, prestressed slabs. At the county level we contacted eight county engineers and found two who precast their own bridge sections. In one case, the use of prestressed concrete saved an estimated $165,000.

In Kansas, 191 county Secondary and off-system bridges have been let for bid since October 1978 and 21 were precast, prestressed concrete. Of six county engineers we contacted, we found one that was considering precasting his own bridge sections.

Standard plans

Use of standard plans can also reduce costs by reducing the time needed to design bridges. Many States use standard plans to some extent but Pennsylvania is in the process of developing more detailed, standardized bridge plans, primarily for smaller-span local bridges. The plans are intended to lessen costs, with attention given to ease and speed of construction, safety, and type of traffic, and availability of materials. The FHWA bridge engineer for Region 3, which includes Pennsylvania, told us that these standards will greatly decrease the design cost of a bridge, and the designs, which will include both steel and concrete alternates, will be particularly useful to small, local governments without an engineer. The bridge engineer said that he is so impressed with the designs that he will try to promote them region-wide and perhaps nationwide.

The FHWA division bridge engineer in Pennsylvania commented that the standard designs will be cost-effective and save small, local governments money. He added that the designs are more cost-effective than the standard designs FHWA has previously developed. FHWA's Region 3 has approved Pennsylvania's standard

designs for use on Federal-aid projects. FHWA headquarters officials, however, cautioned that a qualified bridge engineer should always evaluate the hydrology and hydraulic needs and the foundation requirements when using standard plans.

Use of State and local employees to replace or rehabilitate bridges

According to many State and local officials, they can replace or rehabilitate a bridge at substantially less cost by using their own employees (force accounts) rather than contracting out. They attribute the lower in-house cost to factors such as being able to use their crews on new construction when they are not otherwise occupied with maintenance work and the higher wages of contractor employees. Officials cite the requirements of the Davis-Bacon Act, under which construction workers on projects receiving Federal funds have to be paid the prevailing wage rates in an area, as increasing the cost of construction contracts.

Use of force accounts on Federal-aid highway and bridge projects has generally been discouraged. FHWA headquarters officials told us that its policy on the use of force accounts permits States to use them on their own initiative if within previously established Federal-State agreements or to come to FHWA for a determination that it is in the public interest. Until recently, Title 23 of the U.S. Code, Section 112, required that construction of each project be performed by contract awarded by competitive bidding unless the Secretary of Transportation finds that some other method is in the public interest. The 1982 Surface Transportation Act, however, revised Section 112 by allowing some method of construction other than contract awarded by competitive bidding if a State highway department demonstrates to the Secretary of Transportation's satisfaction that some other method is more cost-effective. The act was enacted at the end of our field work and we have not assessed the impact of the revision on the use of force accounts for off-system bridges. The following discusses the use of force accounts at the time of our review.

The State of Vermont generally limited the use of force account labor to projects costing less than $40,000. The State Transportation Board's approval had to be obtained to use force account labor on larger projects. According to State officials, this limit was established to protect the construction industry in the State. As a result, force account projects were usually bridge rehabilitation projects or reconstruction of bridges shorter than 20 feet. The FHWA Vermont Division bridge engineer told us that the division does not encourage the use of force account labor and would only fund rehabilitation projects and not new construction projects using force account labor.

The New Hampshire State bridge maintenance engineer stated that the State tries to limit its force account work because it otherwise gets complaints from contractors that the State is taking away its business. Although no formal limit exists, the Bridge Maintenance Section tried to keep its work to around $25,000 for each bridge. Actual replacement or even rehabilitation of bridges over 20 feet with State forces was rare.

Iowa's and Kansas' Secondary Road Plans allow for the use of force account labor. However, force account labor had rarely been used to construct bridges involving Federal funds. Kansas considered allowing a county to build bridges if the county's workers were qualified and it was found to be in the public interest, i.e., the county's offer was less than 80 percent of the estimated cost if let for bid and the project was not considered attractive for competitive bids. These were the criteria used in negotiating contracts with the counties for grading, surfacing, and other work on road projects. In Iowa, county force account labor can be and had been used on projects up to $20,000 with no approval and on projects up to $40,000 with State approval. Projects over $40,000 must be let for bid in Iowa. According to Iowa officials, bids are required on work in excess of $40,000 to ensure cost effectiveness. Local governments can compare their costs to those of the contractor and make the most effective use of public funds.

Some local governments have made substantial use of force account labor to address their bridge problems. In 1980 Washington County, Arkansas, began a 10-year program to replace 84 deficient bridges using its own forces. The county has limited funds with which to match Federal or State aid and these funds have generally been used for the match on road projects.

The county used a standard design provided by the State highway department to precast bridge sections for use by county forces to build bridges 25-feet wide and up to 60-feet long. According to the county administrator, longer bridges are not attempted because county forces are not qualified to build them and they do not employ a professional engineer. From June 1980 to July 1982, the county had built 23 such bridges. County officials estimated that their largest precast bridge costs less than $20,000.

Another example of the large use of force account labor is Oklahoma. In 1980 Oklahoma enacted a county bridge improvement program, which provides technical assistance and funds to the counties to help them solve their bridge problem. About 75 percent of the over 14,800 county bridges in Oklahoma are deficient and the counties did not have the resources to solve this problem on their own. As of July 26, 1982, the program had replaced or rehabilitated 192 bridges at a cost of $15.6 million and $17 million had been committed for the replacement or rehabilitation of an additional 343 bridges. The State developed standard plans for the counties' use and State engineers do the necessary site work, make the required hydraulic analysis, and adapt one of the standard plans to the site.

Top And Side View Of A Bridge Built By Washington County, Arkansas' Employees With Their Own Pre-cast Concrete Sections. The Cost Was Less Than $20,000.

Two of the standard plans were designed for use by unskilled county forces. The counties have used these, as well as other State standard plans, to construct bridges with their own forces. County forces were used on 46 of the 192 bridges replaced or rehabilitated through July 26, 1982, and the counties had agreed to replace or rehabilitate 274 more with their own forces.

The FHWA Oklahoma division office cooperated with the State in the development of the county bridge standards. As a result, bridges built in Oklahoma with these standards are eligible for Federal funding. However, Oklahoma limited the use of Federal funds to bridges costing over $200,000. Very few of the county bridge projects cost this much, so Federal funds were seldom used for these bridges according to State officials.

The State relaxed some standards to reduce the cost of the county bridges and to build as many bridges as possible with the available funds. Examples of the relaxed standards include:

--26-foot widths versus the 28 feet and 30 feet required for some State bridges.

--Less guardrail and lighter guardrail than required for State bridges.

--Risk analysis to determine the waterway opening for each bridge rather than building to a fixed standard. (According to FHWA Bridge Division officials, FHWA and many States are currently examining the use of risk analysis to determine waterway openings.)

No estimates were available of the amount saved by relaxing these standards.

VARIOUS MANAGEMENT TECHNIQUES CAN REDUCE COSTS

Several management techniques, such as alternate design, value engineering, and design and construct contracts (or the turnkey system), are also available to reduce bridge construction costs in appropriate situations. Overall, these are being used to varying extents by the States but to a very limited extent for off-system bridges.

Alternate design

Greater use of alternate design by the States is one of FHWA's major objectives. This involves offering bidders alternate designs that they can choose from and bid on for the work. Generally, at least a structural steel and a concrete design would be offered. The purpose of alternate design is to take advantage of competition among the different types of materials and construction methodologies and to take into account the fluctuations in economic conditions from the time of design until the request for bids. According to FHWA, a cost savings in construction of 10 percent or more may be realized.

FHWA believes that alternate designs generally are desirable for bridges with multiple repetitive spans or long spans, major bridges, or where there is an extended period of design from project conception to a release for bids. FHWA headquarters officials told us that sometimes alternate designs can be appropriate for smaller bridge projects. If engineering costs for alternates exceed anticipated savings, alternates are not cost-effective.

FHWA's policy to encourage the use of alternate design is implemented by its field offices. For the four States in our detailed review, alternate design generally was required or encouraged for bridges costing over $5 million. None of these bridges were off-system bridges.

Although the States we visited for detailed review believe that alternate designs are not cost-effective for small bridges, some other States are using alternate designs for these bridges. For example, Arkansas, Louisiana, and Texas are now "testing the water" on alternate design for small, off-system type bridges. Pennsylvania requires that alternate design be considered for all bridges costing $50,000 or more unless waived by the State Secretary of Transportation. Georgia routinely lets very small bridge projects, primarily on local roads, with four alternate designs. According to FHWA, the State saved an estimated $12,000 in fiscal year 1982 as a result. FHWA also reported apparent savings in construction costs of $17,472 when Kentucky provided two complete designs for contractors to bid as alternates on two small bridge replacement projects.

Value engineering

Greater use of value engineering to reduce bridge costs is also a major FHWA objective. Value engineering is the use of a multidisciplinary approach to identify the function of an item, establish a value for the function, develop alternatives through the use of creative thinking, and provide the necessary function at the lowest overall cost, considering its performability, reliability, and maintainability.

FHWA officials told us that they do not have specific information on how much value engineering is used in bridge replacement and rehabilitation but bridges are generally considered to be high-cost items and therefore good candidates for review by value engineering teams. They noted that their text "Value Engineering for Highways," used in FHWA-sponsored training courses, cited 16 examples of value engineering recommendations, and eight of the recommendations relate directly to bridges. Therefore, the officials concluded that a majority of value engineering savings are derived from bridge projects. These 16 examples are summaries of some typical results from team studies during 40-hour value engineering training workshops of highway and bridge designs that had undergone their last reviews and were ready to be advertised for bid.

Our review of these examples indicates that value engineering principles may be beneficial for the smaller bridges also. In

one example, a proposed 127-foot bridge with an estimated cost of $156,000 was recommended to provide for a 23-foot shorter span at an estimated savings of $49,000 or 32 percent of the original proposal. In another example, the width of a proposed bridge on a low-volume road was reduced from 42 feet to 36 feet to conform with standards for the projected traffic and the width of the adjacent highway. Fourteen percent, or $405,000, of the estimated $2.8 million, would be saved. In another example, a proposed $778,000 bridge was recommended to be replaced with a multiplate arch culvert with the desirable hydraulic characteristics of the stream being preserved. The estimated savings was $537,000, or 69 percent.

Some States have also applied value engineering to items such as their standards for bridge width for potentially significant savings. For example, Maryland estimates that it will save $16 million on bridges currently in the design stage as a result of its value engineering of State bridge width standards. Maryland's bridge width standards had been AASHTO's desirable minimums rather than the absolute minimums, but value engineering showed that the standards could be reduced to the absolute minimums. The bridges in the design stage were redesigned to the lesser widths, resulting in the cost savings. FHWA division and State officials do not believe that the change will have an adverse impact on safety.

Turnkey projects

A few States have also started to use the turnkey system for small bridge projects. Under this system the contractor is given responsibility for design as well as construction of the bridge. Kentucky and West Virginia have tested the concept on small bridges and were pleased with the results. The low bid on the Kentucky project was $186,407, or about $25,000 less than the State estimate of $212,000. Also, from the start of design to completion of the bridge was only about 6 months as compared to the 2 to 3 years for a normal Federal-aid bridge project in the State.

In West Virginia, the State offered contractors a choice of following a design provided by the State or bidding for original design and construction as one package. The low bid, using the turnkey alternate, was $660,230, or $99,770 less than the State's estimate. The highway department is "pleased" with the results and is considering using the concept again.

CONSTRAINTS TO GREATER USE OF INNOVATIVE TECHNOLOGY AND MANAGEMENT TECHNIQUES

Innovative technology and management techniques are not being used to a greater extent for a variety of reasons. Some bridge engineers told us that when it comes to using innovative materials and construction techniques they are concerned about the possible poor performance of the innovations. Poor performance can threaten the safety of those who will use the bridges or shorten the life of bridges, which are expensive, and increase maintenance costs. Bridge engineers are also concerned about tort liability.

In many States, State and local government officials are personally liable for the decisions they make as public officials. Thus, they are fearful that if an accident occurs at a bridge, for example, the bridge engineer will be sued in court as an individual and may face financial disaster if the accident is tied to one of his/her decisions regarding the bridge's design and construction. One county engineer told us that at conferences and seminars county engineers used to discuss how to do things better, but now they discuss tort liability and how to avoid lawsuits. A State bridge engineer told us that the concern over tort liability is not just a factor in the bridge engineer's decisionmaking, it is in the forefront.

FHWA has several programs to provide research and development and disseminate information on innovative materials and techniques to State and local officials. For example, the purpose of its Demonstration Projects Program is to show, by actual demonstration, State and local highway personnel how research results can be applied to an actual situation.

CONCLUSIONS

Various innovative technology and management techniques have the potential to reduce off-system bridge costs. Some innovations, such as using certain long-span culverts rather than building conventional bridges, have substantially lowered bridge costs. For example, the use of culverts on three projects in New Hampshire could have saved over $500,000. Culverts are not appropriate for all locations and may not always be the most cost-effective but their use should be considered where hydraulic conditions permit. Such consideration is especially important because of the large number of deficient off-system bridges and the limited resources to address the problem. Another consideration is force accounts. Their use can reduce bridge costs but had generally been discouraged even on relatively small projects. Of course, a major consideration is the technical capabilities and experience of force account personnel. Safety and long-range cost considerations are also important concerns when considering the use of any innovation. In this regard, we believe that it is important that FHWA continue to help make State and local officials aware of innovations. The proper use will depend on the actions of the State and local officials.

AGENCY COMMENTS AND OUR EVALUATION

DOT said that FHWA agrees that it should continue to have an ongoing program to make States and local governments aware of new technological advances and innovations which will result in more cost-effective structures. DOT also said it will continue to cooperate and work with State and local governments and with other organizations to develop and disseminate information on new technology and innovations to build cost-effective bridges.

DOT commented that long-span culverts are indeed viable alternatives to conventional bridges at a good percentage of locations. According to DOT, these structures require detailed

design and construction control supervision and they should not be constructed without a knowledgeable engineer on the project. DOT's other comments on long-span culverts and standards plans have been incorporated into the appropriate sections of this chapter.

STATE COMMENTS AND OUR EVALUATION

The Secretary of Transportation for the State of Kansas told us that his department will be observing steel and/or aluminum long-span culverts built with local funds to compare their life with that of concrete. He said that if favorable results are observed, the department will reevaluate its current position of using mostly concrete box structures for shorter bridges. He also told us that, as a result of the 1982 Surface Transportation Assistance Act, the department is revising its force account procedures to allow counties to build small bridges by the force account method when it would be cost-effective. The Kansas Secretary of Transportation also commented that the department considers alternate design on all expensive projects. He suggested that it might be appropriate to provide alternate designs whenever the structure is estimated to cost more than $1 million. He also suggested that alternate designs to steel always be considered in the design process due to current steel prices.

The Secretary of the Vermont Agency of Transportation told us that based on their experience with consultant designs on off-system projects, the turnkey system would not be a good way to reduce costs on Vermont projects.

The Director of the Iowa Department of Transportation said long-span culverts are not cost-effective where material costs are prohibitive or soil and water conditions provide for rapid deterioration of metal surfaces or cannot maintain stable flow lines. He also said it is questionable whether complete alternate designs are cost-effective on single-span local bridges, but the savings can accrue through predesign discussions and a single design. The Director further commented that Iowa has provided standard plans to counties for over 60 years and they are continually looking at ways to update and improve those standards as the technology changes.

We appreciate the additional comments and information on the examples of innovations presented in this chapter. We recognize, as pointed out earlier, that innovations are not always appropriate for a site, and the experience with some may not be sufficient to warrant wide application. Innovative materials, designs, construction, and management techniques, however, offer potentially substantial cost savings and should be appropriately considered in the design and construction of off-system bridges. Turnkey projects, for instance, may not be cost-effective in Vermont if it is a question of contracting out for design services versus doing the design with State personnel. If a design is to be performed under contract as is often done in some States because of a shortage of staff, the turnkey system may be cost-effective. Efforts such as that of Kansas to at least observe long-span culverts in use are beneficial.

CHAPTER 5

OFF-SYSTEM BRIDGE STANDARDS SHOULD BE CLARIFIED

The standards that bridges are built to can greatly affect their cost. Building to lower standards can reduce costs but may not be cost-effective in the long run because lower standards may result in safety problems, higher maintenance costs, a shorter bridge life, or a less aesthetically pleasing bridge. Building to higher standards may avoid these problems but higher than needed standards unnecessarily increase costs. National (AASHTO) standards represent the collective judgment of the members of many organizations responsible for highway and bridge design and construction as to the best guidance for meeting safety and traffic service requirements over the life of the highway or bridge. It is generally agreed, however, that national standards cannot be developed that would reasonably apply to all situations, and some exceptions to the standards are needed. Some highway officials also question whether the national standards, which they believe were developed primarily for the Interstate and Primary Systems, are applicable to local bridges, which are often rural with low volumes of traffic and on roads built to lower standards.

FHWA allows for exceptions to build below the standards on Federal-aid projects but provides only general guidance to its division offices and the States on when to make exceptions. Also, FHWA and the States generally consider the standards to be minimum ones, and the States have considerable flexibility to exceed the standards. As a result, the States vary in how they apply the standards and when they request exceptions. FHWA division offices vary in the type of exceptions they approve and under what conditions. Local officials often substantially differ with both FHWA and the States on applying the standards to local bridge projects. The standards that apply to a particular bridge depend first on who is providing the funds for the project. If it is federally assisted, the standards that apply depend not only on the volume of traffic, the terrain, and so forth, but they also depend on which State the bridge is in, the division office, and who makes the final decision on how the standards are to apply. Further guidance on off-system bridge standards is needed to ensure that the bridge program provides for the replacement/rehabilitation of as many off-system bridges as possible that are safe and adequate, have a reasonable life, and do not require excessive maintenance.

LOCAL OFFICIALS BELIEVE FEDERAL-AID BRIDGES ARE TOO COSTLY AND TAKE TOO LONG TO BUILD

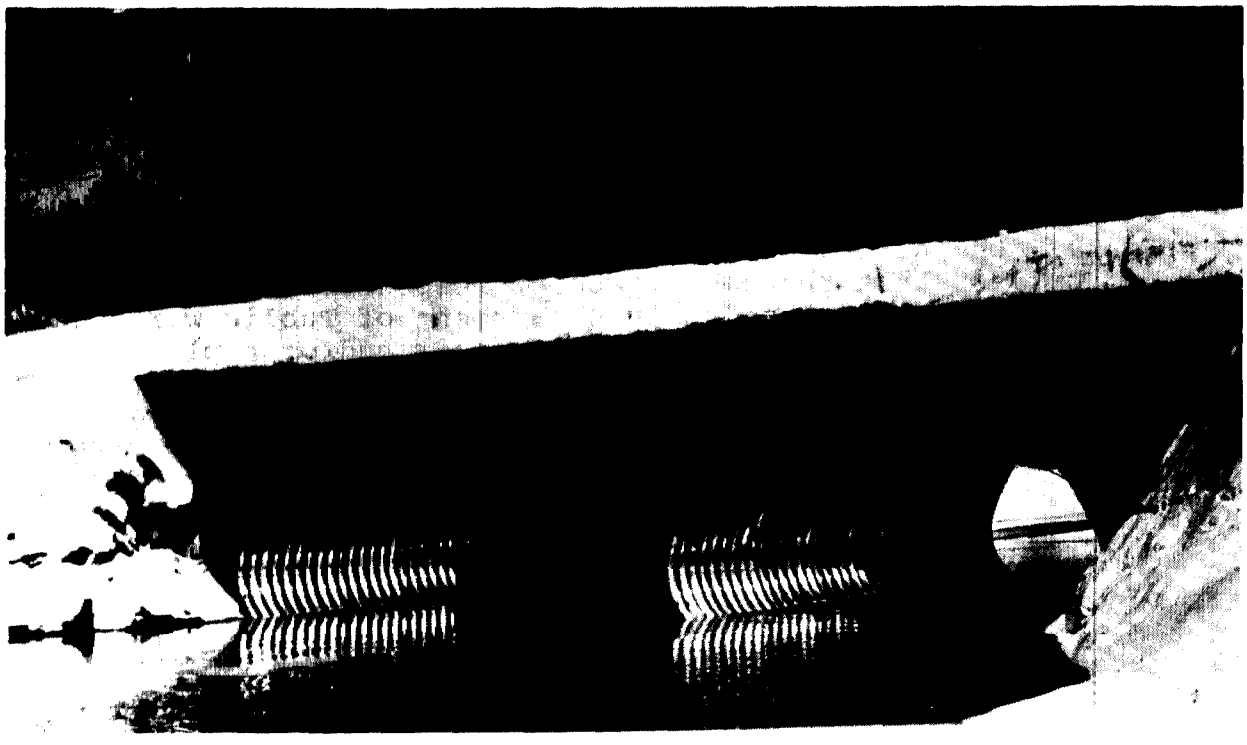
Many local governments have expressed concern that bridges replaced under the Federal bridge program are too expensive. According to some of these officials, they can replace up to two or three bridges with their own funds to every one bridge with Federal funds. Some have even stated that they build bridges for as little as 20 percent of the cost of Federal-aid projects.

On occasion, some local officials have refused Federal assistance for a bridge because they considered the proposed project cost to be too high even if they have to pay only a small percentage of the cost. Much of the cost difference is attributed to what local officials consider "overdesign" of the federally assisted bridges or "too much bridge" for their needs. Local officials are also unhappy with the time it takes to complete Federal-aid projects. On the other hand, some FHWA and State officials have expressed concern that local governments build to standards that are too low, and the bridges may not be as safe or last as long as they should.

Our review showed that local governments often do build bridges with their own funds that cost less than the bridges the State highway departments design and build under the Federal bridge program. The major portion of the cost differences is the type of bridge selected for construction and the standards to which the bridges are built.

The town of Enfield, New Hampshire, for example, recently replaced a bridge without any Federal or State aid. The State Department of Public Works and Highways had inspected the old bridge and suggested it be posted for a 3-ton, passenger cars only, weight limitation. Because the bridge was on a school bus route and a school bus would exceed the limitation, the town requested State assistance, and in January 1981 received a State estimate of $260,000 to replace the bridge. The estimate included a statement that the State could not begin to rebuild the bridge for 3 years because of its present workload.

Enfield town officials found both the cost and time frame unacceptable. They believed the proposed State bridge was overdesigned for their needs and considered other options. The selectmen (town officials) decided to use twin aluminum structural plate pipe arches. The town closed the bridge and completed construction with its employees and the assistance of a structural plate pipe company engineer in 5 to 6 weeks, thus eliminating the need for a $40,000 temporary bridge. According to a town official, the bridge meets the State's minimum load requirements. Town officials consider the new structure to be functionally comparable to the structure proposed by the State and was built at substantial cost savings. At the time of our review, the town has spent $46,000 for the bridge and town officials believed a final cost estimate would be about $55,000, or $205,000 less than the State estimate. On the next page is a photograph of the new Enfield bridge. The guardrail was scheduled to be added in the spring.



The State bridge engineer could not cite anything wrong with the Enfield bridge but added he would have reservations about the bridge unless he knew how Enfield installed the pipe arches. He stated he would not have built that particular bridge type at that location because he believes the middle pier between the two pipes could cause an ice or tree jam and result in a flood or loss of the bridge. Enfield's administrative assistant told us, however, that the lake which the bridge is across has slow flowing water, lessening the chance for ice and tree jams. The New Hampshire Water Resources Board approved the structure's waterway opening.

The State of New Hampshire has been replacing an average of about six Secondary and off-system bridges annually at an average cost of $250,000 to $500,000 each. In comparison, New Hampshire has over 1,100 deficient Secondary and off-system bridges, most of which are the towns' responsibility. Not all these need immediate replacement but the figures do indicate why Enfield and other towns are concerned about the cost of State-designed bridges.

The following three examples further illustrate the different philosophies Federal, State, and local officials have toward off-system bridge replacement and the Federal bridge program.

Lomala Bridge

The Lomala Bridge in Dutchess County, New York, was built in 1930 across a creek between the towns of Fishkill and East Fishkill. It is 81 feet long and about 11 feet wide (one lane) with no sidewalks. The bridge has an average daily traffic of about 200 vehicles and primarily services a residential area of single-

family homes, with only minor growth expected in the surrounding area. The bridge is on a one-lane, two-way traffic road between the towns and is in a flood-prone area. The original owner/builder of the bridge is not known and for many years jurisdictional responsibilities were questionable and little maintenance was done on the bridge.

In 1975 the bridge's deteriorating condition prompted the towns to request that the county accept responsibility for the bridge. Subsequently, the County Department of Public Works made an engineering study for the bridge's repair and/or replacement but neither the towns nor county committed to implement the recommendations. The study presented two alternatives: a bridge costing $130,000 and another costing $100,000. Both proposed structures were to be 24-feet wide but the more expensive structure provided a larger waterway opening beneath the bridge.

In June 1979 the county applied to the New York State Department of Transportation for the bridge to be included in the State's Federal-Aid Bridge Reconstruction Program. In December 1979 the county received a State Department of Transportation proposal for a replacement bridge 81-feet long and 24-feet wide with considerable alterations to road approaches and widening and raising of grades to contain high water flow through the bridge and eliminate flooding of road approaches. The State would pay 15 percent of the estimated $900,000 cost and the towns would equally split the other 5 percent ($22,500 each) of the required 20-percent match for the Federal bridge program.

In July 1980 county and town officials met with State officials to discuss the bridge, and town officials requested that the project's scope be scaled down to reduce the cost. A State official at the meeting indicated that the Federal program had specific standards that must be met, and using the minimum standards the price would be about $900,000 but he agreed to request the FHWA division office to review the bridge site to clarify the minimum design standards for the project. In May 1981 the State suggested that the county and towns outline what they consider the appropriate engineering solution and write directly to the State Commission of Transportation and FHWA to determine whether Federal and State participation was possible.

In August 1981 the county forwarded its engineering study with three project alternatives. The first alternative was a replacement bridge 76-feet long and 22-feet wide of prestressed concrete box units supported by concrete abutments. This new structure would provide more waterway area than the old bridge but substantially less approach work than the State proposed. The cost would be $250,000. The second alternative was a replacement structure comprised of a series of corrugated steel pipe arches with minimal approach work at a cost of about $150,000. The waterway area would approximate the area of the existing bridge. The third alternative was to remove the existing bridge and terminate both road approaches with permanent turning circles. The cost would have been about $50,000 and the longest detour would have been about 1.5 miles. The county recommended the first alternative.

Dutchess County has received informal approval from the State to replace the bridge with a 100-feet long, one-lane bridge. The total project cost would be about $400,000 with the State paying 10 percent and the towns paying 5 percent each for the required 20-percent match. According to the State Department of Transportation Regional Planning Engineer, county, State, and Federal officials had discussed the issue and reviewed plans and standards at great length since August 1981. He is confident that all parties will agree on the $400,000 project. Project completion is at least 2 years away, or over 5 years after the county first applied to the State for assistance. The Regional Planning Engineer told us that the Highway Bridge Replacement and Rehabilitation Program is beginning to "jell" as FHWA begins to understand the needs of the local governments and off-system bridges and grant exceptions to the standards.

Bryant Pond Bridge

The Bryant Pond Bridge in Putnam County, New York, is over the Peekskill Hollow Creek and was built in 1930. It is 31-feet long and 17.4-feet wide from one curb to the other with no sidewalks. The bridge is on a 14-foot-wide, two-way traffic, asphalt roadway without shoulders and serves a rural residential area. The narrow roadway, steep grades, and sharp curves make the average operating speed on the road about 30 miles per hour or less. The annual average daily traffic was estimated to be 450 vehicles, with no significant development expected in the area. The town of Putnam Valley is responsible for the bridge's maintenance.

Based on an August 1978 State inspection, the bridge is considered to be seriously deteriorated and potentially hazardous. In April 1981 the State Department of Transportation, at the county's request, completed the "Problem Definition and Project Proposal" report for Federal bridge program funding to replace it. The project proposal report added the bridge to the department's work program and recommended a bridge with two 10-foot lanes and two 2-foot shoulders on the existing alignment, with no sidewalks. The maximum length of the project would be 400 feet, including approach roadway work, at an estimated cost of $400,000.

In February 1982 the State decided that the project should be designed for a 35-mile-per-hour speed and that the shoulders should be 3-feet wide instead of 2 feet. The estimated cost of the bridge project was about $644,000 broken down as follows: preliminary engineering (performed by a consulting firm), $194,000; right-of-way, $10,000; bridge construction, $200,000; approach work, $200,000; and construction engineering, $40,000. The project was at a standstill because the county objected to the cost, and the County Commissioner of Highways had asked to meet with the State to come up with an alternative. The county had proposed a 21-foot-wide bridge project costing $240,000.

Hospital Bridge

The Hospital Bridge in Sierra County, California, is over the Downie River on Main Street in Downieville, California. It was built in 1902 and is on a one-lane, two-way traffic, paved road through a residential section of the town that becomes a dirt road a short distance after crossing the bridge in one direction. The one-lane bridge is 12-feet wide from one bridge rail to the other and 102-feet long. It crosses a steep canyon and gorge formed by the river and has high mountains on one side and a drop on the other side. The average daily traffic is 164 vehicles and is projected to increase to about 400 in 20 years. According to county officials, the road the bridge is on will always be one lane because of geographic constraints and the prohibitive cost of additional right-of-way. Downieville has a population of 320 people and the county's population is 3,081.

The bridge is in poor condition and requires major repairs or replacement. The county asked for State assistance and the State selected the bridge for funding under the Federal bridge program. The State proposed a two-lane, 24-foot-wide bridge costing about $425,000. The county would have to pay the required 20-percent match--about $85,000--for the Federal funds.

For about a year, the county argued with the State and FHWA that a one-lane bridge would be sufficient. The county's arguments were that the road the bridge is on will always be one lane and a two-lane bridge would mean destroying the river frontage of three residential properties. In September 1982 the State Department of Transportation verbally agreed on a one-lane bridge. In December 1982 the county sent the State Transportation Department a formal request for an exception to the two-lane standard. The next step will be for the State to request an exception from FHWA. However, a State official told us that the county would have to submit additional information and documentation and hold a public hearing on the issue before formal approval is granted. One State official told us he personally believes the county is being shortsighted because timber that may be harvested some day is on one side of the bridge and a wider bridge would be needed to bring the timber across the bridge. But he believes the one-lane bridge will be approved. An FHWA headquarters official familiar with this bridge told us that the projected traffic volume and the likelihood of logging trucks using the bridge would make a one-lane bridge unsafe.

After the county turned down the plans for the two-lane bridge, the State Department of Transportation's policy committee revised the criteria used to prioritize bridges so that bridges with high average daily traffic are replaced first. Because the Hospital Bridge has a low traffic count and the county population is so small, the bridge has dropped to a lower priority. According to State officials in January 1983, it could be 5 years or more before the bridge is constructed.

THE APPLICATION OF NATIONAL STANDARDS TO OFF-SYSTEM BRIDGES NEEDS TO BE CLARIFIED

FHWA has worked with the States, primarily through AASHTO, to develop national standards for bridge design and construction that have been adopted by FHWA for use on federally assisted projects. FHWA division offices have worked with the individual States to agree on implementation of the standards within the respective States. FHWA provides general guidance to its divisions and the States on applying the standards. However, in examining off-system bridge projects, we found that inconsistencies were occurring in how the standards are applied and when exceptions are granted. We believe the appropriateness of the standards and the granting of exceptions need to be clarified because standards can substantially affect project costs, maintenance requirements, and possibly safety. The large number of deficient bridges and limited funds require that project costs be kept as low as possible without unduly affecting safety and long-range costs.

Federal bridge standards are mostly developed by the States

The major standards applicable to bridge design and construction under the Federal bridge program generally fall into one of two categories: (1) geometric design standards and (2) structural design standards and standard specifications. These, for the most part, were developed and issued by AASHTO.

AASHTO represents the 52 State highway and transportation agencies (including the District of Columbia and Puerto Rico). Its members consist of the heads and other chief directing officials of these agencies, with the U.S. Secretary of Transportation as an ex officio member. FHWA and other Department of Transportation officials participate in various AASHTO committees and activities as nonvoting representatives. Among other functions, AASHTO develops and issues standards, specifications, policies, guides, and related materials for use by the State on all highway projects. FHWA must independently review and adopt these, including any revisions, before they can be applied on Federal-aid projects. Some of the standards established very specific minimum criteria while others are very general.

Geometric highway (and bridge) design pertains to the design of the visible features of the highway and may be thought of as the tailoring of the highway to the terrain, to the controls of land space usage, and to the requirements of the highway user, individually and collectively. Geometric design includes elements such as roadway and bridge width, sight distance, curvature, alignment, vertical clearance, and so forth. AASHTO has published geometric design standards, policies, and/or guides for various types of roads and highways (including bridges), including freeways, rural highways, local roads and streets, and so forth. FHWA requires that federally assisted projects comply with the appropriate AASHTO standards it (FHWA) has approved.

The geometric design criteria for off-system bridges are those approved by the FHWA division administrator in each State. Most off-system roads and streets are local. Therefore, the national standard that is applicable to off-system bridges is AASHTO's 1970 publication, "Geometric Design Guide for Local Roads and Streets." According to FHWA, this publication is for use as a guide. The criteria established by the guide are generally incorporated into the States' Secondary Road Plans and similar agreements.

Structural design standards and standard specifications contain policies, specific criteria, and controls for the actual design and construction of highways and bridges and related items such as guardrail and bridge railing. These standards include hydraulic design criteria, specifications for construction materials and procedures, testing of materials, and so forth.

Provisions for exceptions to the standards

FHWA permits the States to make exceptions to build below the standards on a project basis by obtaining the approval of the FHWA division offices. Exceptions may be requested and given for projects involving experimental features or unusual conditions. According to Federal regulations and FHWA instructions, an exception is to be made only after due consideration is given to all project conditions such as maximum service and safety benefits for the dollar invested, compatibility with adjacent sections of unimproved roadway, and the probable time before reconstruction of the section due to increased traffic demands or changed conditions.

The States and FHWA division offices generally decide on how the standards are to be applied to federally assisted projects and when exceptions to the standards are to be made. FHWA guidance to the division offices and the States on the standards and exceptions is very limited. FHWA believes that the decisions on the standards and exceptions can be made best at the division level because the divisions have a closer and better understanding of local conditions, and conditions can vary from State to State. As discussed later in this chapter, we recognize the need for the divisions to have flexibility in this regard, but we believe additional guidance on off-system bridge projects would be beneficial.

FHWA and State application of the standards varies

With regard to off-system bridge projects, FHWA divisions vary in the types of exceptions that they grant and the State highway departments vary in their application of the standards and the exceptions requested.

Building below minimum standards

New Hampshire seldom requests FHWA exceptions. On the rare occasions the State requests exceptions, it is usually to lower the design speed or to modify the required alignment. It has

never requested a bridge width exception and does not build one-lane bridges. The State bridge engineer believes that the State has many bridges too narrow but none too wide. Moreover, he believes the State's population is growing and a one-lane bridge may become obsolete before its useful life is over. FHWA's New Hampshire Division bridge engineer agrees with the State's policy of not building one-lane, two-way traffic bridges.

According to State of Vermont officials, the State builds to minimum standards in most situations but will go below standards if such actions can be justified. State officials could think of only one example where a bridge was built below standards and could not be justified to the FHWA division's satisfaction. The one-lane bridge was funded with only State and local funds. The State and town are satisfied with the results.

The State has deviated from the standards in other situations but only with the approval of the FHWA division office. The most frequent bridge exception requested is for width. AASHTO standards and Vermont's Secondary Road Plan call for a minimum two-lane, 24-feet-wide bridge, but five of the 23 off-system bridges replaced by the State in fiscal year 1981 under the Federal bridge program were one-lane. These five bridges all had an average daily traffic of less than 50 vehicles.

Both Iowa and Kansas Secondary Road Plans provide for exceptions. Kansas has requested exceptions for flood plain and alignment on new construction projects and width on rehabilitation projects. All were granted by FHWA. Kansas would like exceptions to the bridge rail requirements but has not requested an exception because they believe it would not be approved. Kansas has omitted approach guardrail on certain bridges at the request of counties. According to State officials, Iowa also has received approval of exceptions dealing with flood plains on new construction and bridge width on rehabilitation projects. For certain bridges, Iowa had been eliminating approach guardrail and would have liked exceptions on bridge rails for these but had made no requests as they "knew" the requests would not be approved. The State, however, is now requiring approach guardrail on all bridges, in accordance with Federal guidelines.

FHWA Iowa and Kansas division officials stated that they consider AASHTO as the minimum standards and discourage exceptions even on low-volume, off-system bridges. Iowa division officials stated that if they receive requests for exceptions, they consider them on a case-by-case basis. Kansas officials stated they would approve exceptions only if safety was not a factor.

State officials in both Iowa and Kansas would like clear guidelines setting out what exceptions will be granted and how they should be justified. As a result of our review, the Iowa FHWA division office may develop a policy statement on exceptions, and the Iowa Department of Transportation was developing more definitive guidelines for the counties.

Building above minimum standards

Building above AASHTO minimum standards does not require FHWA approval. FHWA division offices, however, have taken different approaches to the States exceeding the standards. The FHWA New Hampshire division bridge engineer told us that the State Department of Public Works and Highways, as well as FHWA, is geared toward building Interstate-type bridges which require high standards and carry heavy traffic volumes and loads. He believes FHWA and the State no longer can afford this type of bridge for the off-system, but FHWA's philosophy has been to let the States decide their needs. According to the FHWA bridge engineer, the bridge program is a State program and if a State chooses to exceed a minimum standard, it is the State's decision.

In contrast, the Iowa FHWA division approved Iowa's Secondary Road Plan which exceeded AASHTO minimum standards in some respects, but it did not approve Iowa's practice of building bridges which exceed the plan. The Iowa Department of Transportation was routinely approving 28- to 30-feet-wide bridges on low-volume gravel roads. Both the plan and AASHTO require only 24-feet-wide bridges in these circumstances. Since August 1982, Iowa is approving bridges wider than the Secondary Road Plan standards only when individually justified.

In Nebraska, several county boards have passed resolutions that all bridges built in their counties be at least 30-feet wide. As a result, FHWA established a policy that on roads with an average daily traffic of 250 vehicles or less, Federal funding is limited to the cost of 28-feet-wide bridges.

Other States, however, recently have questioned their own bridge standards. The State of Maryland applied value engineering to examine State bridge width standards. Maryland standards for bridge width was the AASHTO desired minimum rather than the absolute minimum. After reconsidering the standards, Maryland reduced them to the AASHTO minimum. These standards apply to the Federal-aid and State highway systems. FHWA's Georgia division and the State of Georgia recently evaluated the standards in use for bridge widths. As a result of the review, the State's standards are to be modified on low-volume roads to more nearly conform to AASHTO minimums. According to division officials, the revision will result in more efficient use of funds and replacement of more bridges. They cited the example of three bridges designed 30-feet wide when reevaluation showed that 24-foot width would be appropriate considering the class of road, traffic volumes, and operating speeds. The plans were changed with an estimated $100,300 in construction savings on the three bridges.

Below is a discussion of three areas of bridge standards--bridge width, approach guardrail and bridge railing, and hydraulic design--that illustrate the impact of the standards on off-system bridge design.

Bridge width

Some FHWA, State, and local officials have expressed concern as to whether bridges should be replaced to the standards for new construction. The off-system, consisting of over 3-million miles of highways and roads, generally was not constructed to today's standards. In fact, much of it is unpaved and narrow. Since it appears doubtful that local governments can afford to upgrade all this mileage to new construction standards, it becomes less essential to make off-system bridges conform to new construction standards. In this regard, an FHWA Associate Regional Administrator for Engineering and Operations, responding to an informal FHWA request to its field staff for comments on highway design standards, stated:

> "* * * Standards that have been developed over time with considerable professional input make an ideal guide, but only a guide. When the emphasis on safety was impacting us at every turn, there were many who were paranoid with standards. We have bridges that did not get the deck rehabilitation that was warranted because of a ridiculous stand taken by local FHWA on minimum acceptable width. We have excessively wide bridges (considerably wider than approach roadways) at locations where the roadway is not scheduled or planned for improvement and width was based entirely on application of a standard and not judgement."

FHWA headquarters officials told us that considering the long 50-year life of a bridge, it should be built to current geometric criteria if there is a reasonable chance of upgrading the roadway in the foreseeable future. They added that if there is no chance of upgrading the roadway, lower criteria may be appropriate, but each case must be evaluated to be sure that safety and operations are not jeopardized. FHWA, however, has only general guidance to assist FHWA and State officials in making these decisions.

Controversy concerning the acceptability of one-lane bridges illustrates the need for such guidance. When off-system bridges became eligible for the program in fiscal year 1979, FHWA headquarters officials' position was that the minimum width of a bridge built under the program should be 24-feet wide and no one-lane, two-way traffic bridges should be built. This position, however, was not consistently applied. As previously mentioned, the FHWA Vermont division office had been routinely approving one-lane bridges with low traffic volumes and serving only a few houses. At the same time, the State of Maine was proposing to build one-lane bridges with Federal funds on low-volume roads, but FHWA did not grant an exception.

Until recently the FHWA division office in California made it known that it would not approve building a bridge less than 24-feet wide under the program. As a result, the State never requested an exception for a one-lane bridge even though some local governments wanted to build them. The alternatives given local

officials were to build a two-lane bridge with Federal funding or build the one-lane bridge without it. The FHWA California division office now believes that one-lane bridges may be appropriate in some cases and has formal criteria for when it will approve a one-lane bridge.

Bridge railing and approach guardrail

Bridge railing and approach guardrail standards are a major issue in some States and not an issue in others. Vermont and New Hampshire State officials generally have no problems with the standards and build to AASHTO specifications. Kansas, Iowa, and other States, such as Wisconsin and Tennessee, believe that the standards should be applied in a more flexible manner for smaller, low-volume, off-system bridges. These States, however, were proceeding differently.

Iowa

Since the late 1960's, Iowa has not required approach guardrails for bridges wider than 26 feet when the entire roadway was carried across the bridge. Bridge rails, however, were required. The number of bridges with unprotected bridge rails increased as off-system bridges became eligible for Federal funding. The unprotected bridge rails, in the opinion of some FHWA engineers, presented a greater hazard than a bridge without a rail. In September 1980, the FHWA Iowa Division cited a conflict between AASHTO's Standard Specifications for Highway Bridges and AASHTO's Guide for Selecting, Locating, and Designing Traffic Barriers and requested from the FHWA regional office a blanket exception to the bridge rail requirements for certain short, low-volume bridges on gravel roads where the distance to the stream bed is 10 feet or less. AASHTO's bridge specifications require bridge rails with appropriate end treatment on all bridges. Appropriate end treatment of the railing usually involves approach guardrail to protect motorists from running into the railing and from running down the bridge embankment before they reach the bridge. The barrier guide recognizes that many bridges on low-volume, rural roads do not have guardrail to shield the bridge rail and suggests that this condition is more hazardous than the elimination of the bridge rail. It provides a methodology for determining when bridge and approach guardrail can be eliminated.

The FHWA regional office denied the request for a blanket exception but referred the question of the conflict between the AASHTO bridge specifications and barrier guide to FHWA's Bridge Division Chief. The Chief Bridge Engineer decided that the bridge specifications should prevail and wrote that he believed all bridges should have crash-worthy bridge rails and approach guardrail. All FHWA divisions in the region were advised of this decision.

FHWA's Iowa Division, however, conducted a cost analysis in accordance with the AASHTO barrier guide and found that for the low-volume county bridges:

--Neither bridge rail nor approach rail is cost-effective when the average daily traffic is below 300 (unless some other site specific hazard is present).

--When average daily traffic is above 300, bridge rail with full approach treatment is most cost-effective.

--It is never cost-effective to build a bridge rail without appropriate treatment to protect motorists against hitting the end of the bridge rail.

On the basis of this study, they again requested permission in November 1981 to eliminate bridge rails. This request applied only to Secondary and off-system bridges less than 100-feet long with average daily traffic less than 300. They noted that this would only apply to about 12 Federal-aid bridges each year but that it would avoid about $168,000 in cost for the required bridge railing and approach guardrail. However, only an additional $60,000 for the bridge rails would actually be saved as the approach rails were still not being used. This request was forwarded to FHWA headquarters by FHWA Region 7. No formal action has been taken to date nor is any expected until AASHTO decides the issue. AASHTO is currently considering the proposal by a county engineer in Kansas to amend the specifications to allow the use of the barrier guide to determine if bridge rails are needed on short-span bridges over shallow streams. Iowa officials told us that the State is currently not approving exceptions in approach guardrail, as per Federal guidelines. According to the officials, the department and the FHWA division office are continuing to explore the area, and future decisions must weigh the trade-off of construction and maintenance costs versus tort claim costs.

Kansas

Historically, Kansas has required bridge rails with appropriate end treatment on all Federal-aid bridges. Even before the off-system bridges were eligible for Federal funding, the Kansas Department of Transportation began receiving requests to eliminate both bridge and guardrail from reinforced concrete box bridges over shallow streams. As the off-system bridges became eligible for Federal funding, the number of these requests increased according to department officials. The department issued instructions in October 1980 that

--allowed approach guardrail to be omitted from bridges with average daily traffic of 400 or less if justified by the AASHTO barrier guide and

--allowed both the bridge rail and guardrail to be omitted from reinforced concrete box bridges where the bridge opening was low (4 to 6 feet).

Approach Guardrail And Bridge Railing On A Federally Funded Project In Kansas.

Approach Guardrail Left Off Of A County-Funded Bridge In Kansas.

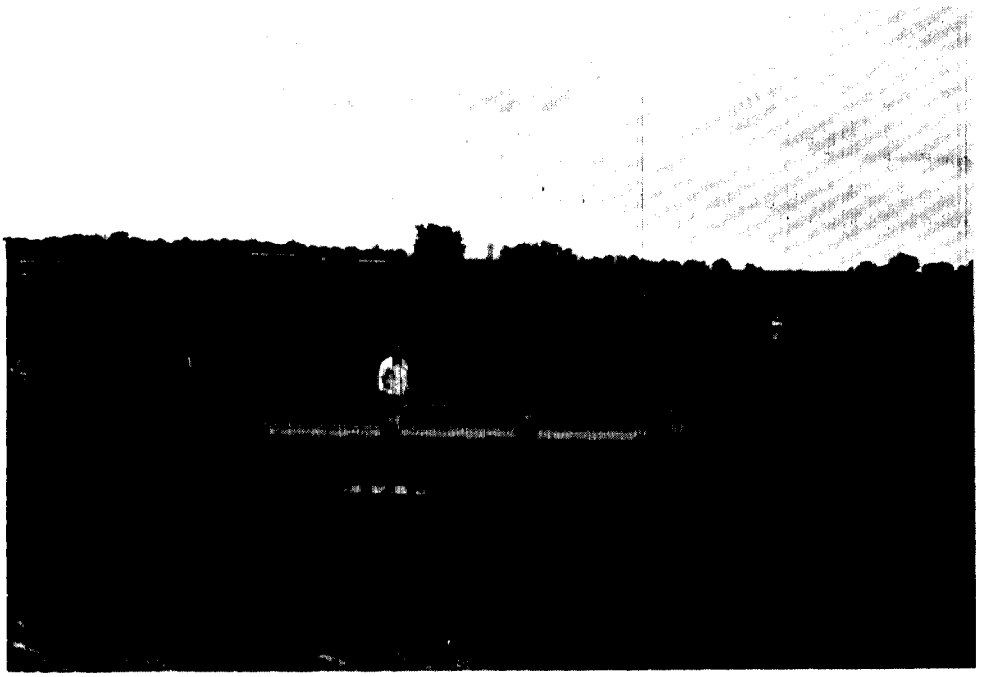
Four months later the department rescinded this policy on the basis of the FHWA Bridge Division Chief's response to the Iowa FHWA Division's request. In January 1982 after discussions with FHWA Kansas Division officials, the department again allowed the use of the AASHTO barrier guide to decide whether to eliminate approach guardrail, but they continued to require bridge rail.

Data on the number of bridges where only the approach guardrail would be left off were not available, but both bridge and guardrail would likely have been omitted from only 4 of the 97 federally funded bridges let for bid in Kansas from October 1980 through June 1982. These were reinforced concrete box bridges 6 feet or less in depth. Detailed cost data available for three of these bridges illustrate the potential for savings on small bridges if the bridge rail and approach guardrail are eliminated.

Example number	Length and width of bridge (feet)	Total cost	Bridge railing and guardrail Costs	Bridge railing and guardrail Percent of total cost
1	32x30	$45,067	$3,975	9
2	32x26	27,625	7,554	27
3	43x30	35,011	4,932	14

In commenting on our draft report, the Secretary of Transportation for Kansas told us that they have not requested exceptions to bridge rail but they have omitted approach guardrail at a county's request and after a cost-effectiveness analysis has been performed and justified an exception.

Many local officials would like to see the bridge railing and approach guardrails eliminated because it is more convenient for farmers to move their farm machinery across the bridges. In some areas, farmers have reportedly removed the railing and guardrail from the bridges they use. The following photograph shows a bridge where farmers have reportedly knocked off the top portion of the rail so they can move their equipment across. The bridge is scheduled for replacement.



Wisconsin

In December 1980 the FHWA Wisconsin Division approved the State of Wisconsin's new procedure for design of traffic barriers, including bridge railing and approach guardrail. The AASHTO guide is part of the procedure. The most current procedure, which is dated November 6, 1981, states that the Wisconsin Department of Transportation's standard practice is to not install guardrail on highways that have a current average daily traffic less than 300, including bridge approach guardrail. However, if it can be shown to be cost-effective, guardrail may be provided as an exception to this policy for the purpose of shielding serious hazards such as steep drop-offs, bodies of deep water, bridge ends on the outside of curves, or any road-side obstacle which has a significant accident history. According to the procedure, it can generally be concluded from some recent research findings[1] that guardrail will not be cost-effective for highways having a current average daily traffic less than 400. According to the FHWA bridge engineer in Wisconsin, the policy is based on the State's experience and accident data, with the recent research findings as collaborative evidence.

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[1]"Design and Traffic Control Guidelines for Low-Volume Rural Roads," NCHRP Report 214, John C. Glennon, Transportation Research Board, October 1979.

Tennessee

The State of Tennessee has taken a different approach to Wisconsin's. According to the FHWA division bridge engineer, since the start of the expanded Federal bridge program, the State has begun to replace or rehabilitate many of their low-volume rural bridges. Oftentimes the State engineer finds that there are no plans in the near or distant future to upgrade the rural roads that approach these bridges. As a result, the State Department of Transportation and the FHWA division reevaluated the design criteria for these bridges. Part of the review was the AASHTO bridge rail specifications. The review showed that the specifications did not differentiate by nature of the highway over the bridge. That is, the specifications call for the same bridge rail regardless of the average daily traffic or design speed of the road. The State designed a bridge rail that is below AASHTO specifications but which the FHWA division and the State believe is equally as safe. The new rail is lighter material and the posts are spaced farther apart. Tennessee has limited the use of this new rail to bridges with less than 750 average daily traffic and design speed of 30 miles per hour or less. The new standard was approved on September 1, 1982, and at the end of our review the new standard had not been applied to a project. The FHWA division bridge engineer told us he is comfortable with the new Tennessee bridge rail standard but would be extremely uncomfortable with the idea of eliminating approach guardrail if the bridge had railing.

Hydraulic design

Hydraulic design standards largely relate to the amount of water flow and the size of the opening under the bridge for the waterway. The requirement is commonly expressed in terms of flood year. For example, the bridge can be designed for the 10-year, 25-year, 50-year, 100-year flood, and so forth. The 50-year flood, for instance, would be based on historical data and would indicate, on an average, the largest flood every 50 years at the bridge site.

The choice of a design flood year can substantially influence the cost of the bridge. For example, a New Hampshire State engineer calculated that it costs 25 to 33 percent more to build a bridge for a 100-year flood rather than a 50-year flood. Construction to withstand a higher flood year generally increases the height and length of a bridge and, thus, the cost.

According to State officials, New Hampshire generally designs bridges to withstand a 50-year flood with a minimum of 2 feet of clearance below the bridge deck, but we also found that many times the State actually builds to the 100-year flood. As shown below, the State bridge engineer significantly increased the waterway area needed beyond the 50-year flood requirement for three off-system and secondary bridges. According to a State official, the three bridges all met the 100-year flood requirement.

Town	Old waterway opening	50-year flood waterway	New waterway opening
	(square feet)		
Amherst	137	150	265
Brentwood	312	300	624
Deerfield	150	155	262

In contrast, Vermont builds off-system bridges to handle a 25-year flood, on-system bridges for a 50-year flood, and Interstate bridges to handle a 100-year flood. Exceptions have been made to these standards. For example, one federally funded off-system bridge was built for a 10-year flood because the amount of approach work required to raise the roadway to provide a larger waterway opening would have been extremely costly. According to State officials, it is less costly to let the roadway wash out and repair it after each flood.

FHWA Iowa Division officials noted that there are not specific AASHTO standards for flood year. Iowa uses the 50-year flood as standard for paved roads and the 25-year flood for unpaved roads. This was established jointly by the Iowa Department of Transportation and the Iowa Natural Resources Council. This council has authority over flood standards under Iowa law.

Until April 1981, the Kansas Department of Transportation used the 25-year flood standard if adequate overflow existed and the 50-year if not. In April 1981, FHWA published Hydraulic Engineering Cirular No. 17. They now use the risk analysis procedures described in this circular to establish flood-year requirements for each bridge rather than building to a standard. This effectively eliminates the need for exceptions to the flood-year standards. Kansas will request approval from the FHWA division office for any bridge built to less than a 10-year flood level on the basis of these procedures.

One very flexible approach to hydraulic standards is the low water crossing. A low water crossing is a bridge that is built slightly over the stream that it crosses with the understanding that during periods of high water, water will flow over and around the bridge and travelers may have to find an alternate route. Low water crossings generally cost about 10 percent of the cost of a standard bridge. An Iowa Department of Transportation official told us that some counties have been replacing deficient bridges with low water crossings rather than new bridges built to AASHTO standards. Other counties in the State have been reluctant to use them because of potential tort liability from accidents when water is over the bridge. The Iowa Highway Research Board commissioned a study which found that proper signing can reduce the risk of accidents and subsequent tort liability to an acceptable level. The Research Board is now in the first phase of a three-phase project to develop, test, and establish standard plans for use by the counties. FHWA's Iowa Division has encouraged the State's

use of low water crossings on low-volume unpaved roads. Kansas officials told us they do not expect to construct low water crossings with Federal funds. They said they recognize low water bridges that are defined in Kansas statutes, and then the bridges become eligible for bridge replacement funding.

CONCLUSIONS

Deficient off-system bridges are numerous and the magnitude of the problem is increasing. Federal bridge program funds are very limited in comparison. Thus, it is essential that the funds be used to replace or rehabilitate as many deficient bridges as possible. Building bridges to reduced standards can lower construction costs and allow more bridges to be built, but building to standards that are too low can cause safety problems, unreasonably high maintenance, too short a bridge life, or an unattractive bridge. High standards may prevent these problems but they can add substantially to construction costs. Selecting appropriate standards to balance concerns for the overall bridge problem, safety, and initial and long-range costs of individual bridges is a difficult but important task if the bridge program is to effectively address the off-system bridge problem.

We found, however, that Federal, State, and local officials disagree on what standards are appropriate for off-system bridges. State highway departments vary on how they apply national standards to these bridges, and FHWA divisions vary in the exceptions to the standards that they approve. Local governments when using their own funds tend to build to local rather than national standards, and these bridges cost much less than those the State highway departments build. The result is that the cost to replace a given off-system bridge can vary by thousands of dollars, depending on which State the bridge is in, who is paying for its replacement, and who makes the decisions on its design and construction.

Less costly replacement and rehabilitation of deficient off-system bridges need greater attention at all levels of government if the bridge program is to make an inroad into solving the off-system bridge problem. This emphasis on economy, however, must be tempered by the need to ensure that safety and the bridge's life are not unduly compromised and long-range costs remain reasonable. The standards for off-system bridges replaced or rehabilitated under the program, and their application by FHWA, State, and local officials, ought to provide for the replacement/rehabilitation of as many off-system bridges as possible that are safe and adequate, have a reasonable life, and do not require excessive maintenance. We believe that FHWA needs to establish a program policy on off-system bridges that provides further guidance to its offices and the States on off-system bridge standards. This guidance should take into account the size of the off-system bridge problem, the limited resources to address it, the nature of off-system traffic, local needs, and the likelihood of the roads the bridges are on being upgraded in the near future. This policy guidance should also address the conditions that warrant exceeding minimum AASHTO bridge standards and specific criteria for considering exceptions to build below the minimum standards.

RECOMMEMMENDATION TO THE SECRETARY OF TRANSPORTATION

We recommend that the Secretary of Transportation direct the FHWA Administrator to provide further policy guidance to FHWA offices and the States on off-system bridge standards. The policy guidance should

--provide for the replacement/rehabilitation of as many bridges as possible that are safe and adequate, have a reasonable life, and do not require excessive maintenance;

--take into account factors such as the size of the off-system bridge problem, available resources, the nature of off-system traffic, local needs, and the likelihood of the roads being upgraded in the near future; and

--include guidance on the conditions that warrant exceeding the minimum AASHTO bridge standards and specific criteria for considering exceptions to build below the minimum standards.

AGENCY COMMENTS AND OUR EVALUATION

DOT said that FHWA agrees with the concept of its headquarters office providing policy guidance on off-system bridges but disagrees with the detailed guidance we recommend. However, according to DOT, FHWA's recent regional office reorganization and its ongoing review of its design and construction monitoring effectiveness will address our recommendation. FHWA anticipates that its review will result in significant changes that should improve the quality of the design and construction of federally funded highway projects.

As shown in this report, FHWA needs to provide additional guidance to solve the dilemma of limited funds and numerous off-system bridges. We believe that FHWA's review of its monitoring effectiveness is a major step in that direction. We recognize that conditions at bridge sites can vary and some flexibility is needed in applying standards. These varying factors and the fact that decisions are made on a State-by-State basis point to the need for flexibility, but they also justify the establishment of a clear policy that establishes parameters for the standards off-system bridges are to be built to and provide guidance to the division offices and the States to help implement the policy. We believe that current guidance is too general to direct a program as large and as important as the bridge program, especially considering the wide range of views on what off-system bridge standards should be. These decisions have an impact on cost and possibly safety. The guidance we recommend would help ensure that the various factors that should be considered are appropriately considered when these decisions are made.

With regard to geometric standards, DOT commented that the AASHTO guide for local roads and streets was definitely not

prepared with Interstate and Primary System highways in mind and that AASHTO is about to publish a new geometric design guide for all categories of roads. We agree that the current AASHTO guide was not prepared with Interstate and Primary System highways in mind. Some highway officials have expressed concern that the standards, in general, were developed based on the principles used for Interstate and Primary highways and should not routinely apply to low-volume, local roads. The new AASHTO guide may alleviate these concerns.

DOT said that the bridge rail/guardrail question for low-volume roads is not satisfactorily defined yet, but a number of researchers and AASHTO are working on it. According to DOT, an FHWA-funded research effort should answer many of the safety questions soon. We recognize the difficulty of this issue. In our opinion, this difficulty is more support for better guidance to FHWA division offices and the States on applying the standards.

DOT said that different climate, topography, and road use characteristics throughout the United States support different low-volume road standards in different States. In this regard, DOT said that FHWA expects its division staff to make decisions on design exceptions based on personal knowledge and evaluation of site conditions, something which cannot be put into standards.

We agree that engineering judgment and personal knowledge and evaluation are important and the many situations can never be completely defined by standards or guidance. Policy guidance does not have to deal with every situation or dictate a particular decision for each site. It can provide direction for the program and establish the factors that should be weighed when making decisions.

DOT stated that FHWA has offered extensive training to State highway agencies in economic (risk) analysis of hydraulic structures and its program manual provides specific guidance on cost effectiveness in hydraulic structure design. DOT also stated that FHWA has an ongoing program to promote the use of such concepts and to offer technical assistance to the States when needed.

DOT said that one result of local governments building bridges cheaper and to lower standards than those for Federal-aid projects is that they have a much shorter life span and a much greater percentage of safety deficiencies and most bridges must safely serve the public for 50 years or more. DOT also said that local governments do not ordinarily have to abide by the Uniform Relocation Act, the 1970 National Environmental Policy Act, and various other Federal requirements when they build a bridge with their own funds. DOT believes that this does result in cheaper project development costs and sometimes faster project completion, but the protection to the public provided by these provisions of Federal law is not provided when projects are undertaken by local governments.

We did not examine these Federal requirements in detail; however, we would anticipate that not following them would reduce

some project costs. However, a major reason for the difference in the cost of locally funded and federally funded bridges is in the type of bridge and the standards--such as those for bridge width and approaches--that the bridge is built to. It should also be pointed out that off-system bridges are generally older and reportedly have not been as well maintained. Also, deficiency is judged according to FHWA criteria and local governments may not agree with this assessment. For example, a narrow bridge would generally be considered deficient by FHWA, but local officials may consider it adequate for their needs. Possibly a more important consideration is that local governments are faced with many bridges needing replacement. We agree that local bridges should be safe and have an adequate life. The FHWA guidance on off-system bridges should take into account the impact of costs and lower standards on cost effectiveness.

STATE COMMENTS AND OUR EVALUATION

The Commissioner of the New Hampshire Department of Public Works and Highways commented that the current state of repair of bridges when weighed against projected revenue highlights a problem of when should we "quick fix" and when should we make the "prudent investment." How do we accomplish the most with available resources? He said differentiating between the quick fix, prudent investment, and the in-between option is more easily critiqued than addressed on a project-by-project basis. The Commissioner also commented that our report could be construed to say that the State is blindly building the biggest bridges it can with no regard for cost effectiveness.

The Commissioner points to a basic issue with regard to off-system bridges, that is, what is the best strategy for the Federal bridge program to address the off-system bridge problem? Of the States we examined, New Hampshire's off-system bridge project costs were the highest. Often its project costs were substantially higher than Vermont's, for example. The result is that New Hampshire is replacing very few deficient off-system bridges with available Federal bridge program funds, and it has many deficient off-system bridges. Nonetheless, we do not believe that New Hampshire is blindly building bridges without regard for costs. The cost differences are largely attributed to the type of bridge selected and the standards they are built to. The New Hampshire State bridge engineer believes that he is making cost-effective decisions by building the more expensive bridges. He believes these will last longer than the normal 50 years that bridges are designed for with less maintenance, and they will safely serve future traffic over an extended period. The other State bridge engineers also believe they are cost-effective in the designs they select and the standards they build to. The Vermont bridge engineer, for example, believes the bridges he builds will have a satisfactory life and the standards the bridges are built to are appropriate for off-system bridges. And he can replace more deficient bridges. We believe that it is important for this issue to be addressed. An important part of addressing the issue is the FHWA guidance that we are recommending. We are pleased that, in this regard, New Hampshire intends to review its overall position

with FHWA. But, as illustrated in this report, New Hampshire is not alone in being affected by this issue.

The New Hampshire Commissioner also commented that our discussion of hydraulic design does little to examine whether or not there were overall project parameters relating to geometric and environmental considerations that also influenced or dictated bridge design. Our purpose was to illustrate the differences in how hydraulic design standards are applied in the various States rather than describe the detailed rationale for their varying applications. We did find another project in New Hampshire that was built for a 100-year flood but we did not include it in this report because the size of the waterway opening was determined by geometric considerations.

The Director of the Iowa Department of Transportation commented that off-system bridge standards should vary from State to State. The Secretary of Transportation for the State of Kansas pointed out that AASHTO standards are in the process of being revised and are soon (estimated 1984) to become available. He said that with the new standards low-volume roads will be designed to local road standards instead of to collector or Federal-aid Secondary System standards. We agree that conditions can vary and the States need some flexibility whether under the current or new AASHTO standards. The FHWA guidance on off-system bridges that we recommend can guide the program and allow the States sufficient flexibility.

APPENDIX I

U.S. Department of Transportation

Assistant Secretary for Administration

400 Seventh St., S.W. Washington, D.C. 20590

JUN 8 1983

Mr. Oliver W. Krueger
Associate Director, Resources, Community and Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Krueger:

This is in response to your letter requesting Department of Transportation (DOT) comments on the General Accounting Office (GAO) draft report, "Federal Assistance for Off-System Bridges: Further Direction and Guidance Could Make It More Effective," dated May 5, 1983.

The GAO recommends that the Federal Highway Administration (FHWA):

1. Establish a requirement that cost-effective, off-system bridges are to be built under the Federal bridge program.

2. Establish a policy on cost-effective, off-system bridges that takes into account factors such as the size of the problem, available resources, the nature of off-system roads, and the basic requirement for adequate and safe bridges. This policy should include guidance to FHWA offices and the States on how bridge standards should be applied to meet this policy, with emphasis on the conditions that warrant exceeding the minimum standards and specific criteria for considering exceptions to build below the standards.

3. Encourage the States to establish procedures to ensure that the various alternatives available for off-system bridges, including cost-saving innovations, are identified and appropriately considered.

Although the FHWA sees no need for additional requirements for building more cost-effective off-system bridges, as recommended by the GAO, the agency is firmly committed to the principles of cost effectiveness. The FHWA will continue to cooperate with State and local governments and with other organizations to develop and disseminate information on new technology and innovations to build cost-effective structures. Furthermore, the FHWA is

APPENDIX I

currently conducting a comprehensive review of design and construction monitoring effectiveness which, when completed, should lead to significant changes in agency policy, procedures, and operations to improve the quality of design and construction of federally funded highway projects.

If we can further assist you, please let us know.

Sincerely,

Karen S. Lee

for Robert L. Fairman

Enclosure

Department of Transportation Reply
To
GAO Draft Report
On
Federal Assistance for Off-System Bridges: Further Direction and Guidance Could Make It More Effective

Summary of General Accounting Office (GAO) Findings and Recommendations

The Federal Highway Administration (FHWA) and the States have made considerable efforts to reduce overall bridge costs and make bridge program funds more cost-effective. However, GAO examined the portion of the program for bridges off the Federal-aid highway system and found that opportunities still exist to further reduce costs and improve effectiveness.

To improve the cost-effectiveness of Federal assistance for off-system bridges, GAO recommends that the FHWA:

1. Establish a requirement that cost-effective, off-system bridges are to be built under the Federal bridge program.

2. Establish a policy on cost-effective, off-system bridges that takes into account factors such as the size of the problem, available resources, the nature of off-system roads, and the basic requirement for adequate and safe bridges. This policy should include guidance to FHWA offices and the States on how bridge standards should be applied to meet this policy, with emphasis on the conditions that warrant exceeding the minimum standards and specific criteria for considering exceptions to build below the standards.

3. Encourage the States to establish procedures to ensure that the various alternatives available for off-system bridges, including cost-saving innovations, are identified and appropriately considered.

Summary of Department of Transportation's (DOT) Position

1. The FHWA believes that sufficient requirements are already in existence for the construction of cost-effective off-system bridges and additional requirements are not needed. The current provisions of 23 U.S.C. 109, Highways, and FHWA policies and procedures require that cost-effective bridges be designed for all Federal-aid projects. Efforts by the FHWA to emphasize this requirement are discussed below.

2. The FHWA agrees with the concept of the Headquarters office providing policy guidance on cost-effective, off-system bridges. However, we do not agree with the detailed guidance recommended, especially for off-system bridges. The current procedure to review individual project sites for waivers to established system standards at the State's request is most appropriate in order to evaluate the unique situation which exists at each bridge site. Current regional office reorganization and an ongoing FHWA review of design and construction monitoring practices will, we believe, address the GAO recommendation.

The concept of cost-effectiveness is basic to the fabric of FHWA. It is firmly embedded in the agency's purpose, programs, and people. The recent reorganization of regional offices resulted in the term cost-effective being included in the mission and functional statements of the Offices of Structures, Engineering and Operations, and Planning and Program Development.

There are only two reasons to have bridge engineers:

A. To be sure that bridges are safe.

B. To be sure that bridges are cost-effectively designed, constructed, and maintained.

Current management reviews by the Headquarters, regional, and division offices concentrate on both safety and cost-effectiveness in bridge designs.

The FHWA has a substantial 2 year long ongoing review of design and construction monitoring effectiveness. The results of this review, which involves all levels of FHWA, will result in significant changes in FHWA policy, procedures, and operations to improve the quality of design and construction of federally funded highway projects. Cost-effectiveness is a major force driving this review.

Value engineering principles, available resources, and program demands require that FHWA bridge engineers concentrate their detailed review efforts on the more costly bridge projects.

3. The FHWA agrees that it should have an ongoing program to make States and local governments aware of new technological advances and innovations which will result in more cost-effective structures. In fact, the FHWA does have such programs; the Demonstration Projects Program, Experimental Projects Program, Implementation Program, and National Highway Institute are vital parts of this effort. The FHWA division and regional structural engineers keep current in such matters and actively promote them. One important function of the FHWA Headquarters Bridge Division, is to provide guidance, assistance, and promotion of these efforts FHWA wide.

   We will continue to cooperate and work with State and local governments and with other organizations to develop and disseminate information on new technology and innovations to build cost-effective structures.

Specific DOT Comments Related to GAO Conclusions and Observations

State and Local Governments Involvement (Page 11)

The DOT agrees that "State and local governments will have to do more on their own to better address the off-system bridge problem." In an effort to assist local governments to most effectively use available resources, the FHWA is preparing a training course titled, "Workshop on Rehabilitation of Existing Bridges," under the provisions of the Rural Transportation Assistance Program. This training will be offered to local governmental officials throughout the Nation in Fiscal Year 1984 and beyond. It will stress evaluation and cost-effective rehabilitation of existing bridges.

Long Span Culverts (Page 21)

Long Span Culverts are indeed a viable alternative to conventional bridges at a good percentage of locations. However, there have been a number of failures of these structures during the past decade or so. The recent Antwerp, Ohio, failure and resultant five fatalities are one example. These structures require detailed design and construction control supervision. They should not be constructed without a knowledgeable engineer on the project.

Having an Armco engineer estimate what a Superspan Culvert would cost at a given location tends to result in a low estimate. Only actual bids received will tell true costs.

In some cases where they have been bid as alternates to conventional bridges, the conventional bridge has been bid at a lower cost. Concrete box culverts are many times just as cheap or cheaper.

Long Span Culverts have specific site limitations.

1. They need adequate headroom to provide minimum cover.
2. They do not always provide adequate freeboard to allow debris to pass through during floods.
3. In some soil conditions, their life span can be very short. (Acid soils in coal mining areas for example.)

Standard Plans (Page 28)

Any bridge project should be engineered. For maximum cost-effectiveness, a qualified engineer should:

1. Design the superstructure.
2. Evaluate the hydrology and hydraulic needs of the site.
3. Evaluate the foundation requirements at the site.

Standard plans can often be used without compromising the first requirement, but the last two require engineering evaluation at virtually every bridge to meet both cost-effectiveness and safety requirements.

Geometric Standards (Page 37)

The current applicable American Association of State Highway and Transportation Officials (AASHTO) Guide for most off-system projects is the "Geometric Design Guide for Local Roads and Streets." The publication was definitely not prepared with Interstate and Primary System highways in mind. After more than 7 years of effort, AASHTO is about to publish a new Geometric Design Guide for all categories of roads. It can be approved as soon as October 1983.

The bridge rail/guardrail warrant question for low volume roads is not satisfactorily defined yet. But a number of researchers and AASHTO are working on this. A comprehensive FHWA funded research effort should define and answer many of the roadside safety questions soon. While some engineers may consider

a 300 average daily traffic breakpoint for bridge rail cost-effectiveness, current research does not necessarily support it. The National Cooperative Highway Research Program Report 239 authors indicate the breakpoint is about 80, provided that the consequences of running off the bridge are not severe.

Different climate, topography, and road use characteristics throughout the U.S. support different low volume road standards in different States.

The FHWA expects Division Administrators and their staff to make decisions on design exceptions based upon personal knowledge and evaluation of site conditions; something which cannot be put into standards. Engineering judgment must be applied to the wide plethora of situations which will never be completely defined by standards.

Hydraulic Design (Page 53)

The FHWA has offered extensive training to State highway agencies in economic (risk) analysis of hydraulic structures. Federal-aid Highway Program Manual 6-7-3-2 dated November 30, 1979, provides specific guidance on the need for and application of cost-effectiveness in hydraulic structure design.

The AASHTO Highway Drainage Guides, Volume 7, 1982, contain specific guidance to the effect that a balance of structure costs, inconvenience or risk costs to the public and the resultant flood frequency accommodated should be struck when designing hydraulic structures.

The FHWA has an ongoing program to promote the use of such concepts and to offer technical assistance to States when needed.

Locally Funded Bridges (Page 29)

The current Report to Congress on the Highway Bridge Replacement and Rehabilitation Program shows one result of local governments building bridges cheaper and to lower standards that for Federal-aid highway projects. They have a much shorter life span and a much greater percentage of safety deficiencies. Most bridges must safely serve the public for 50 years or more.

Local governments do not ordinarily have to abide by the Uniform Relocation Act, the 1970 NEPA requirements, Equal Opportunity, or various other Federal requirements when they build a bridge with their own funds; this does result in cheaper project development costs and sometimes faster project completion. However, the protection to the public provided by the environmental, equal opportunity, and real estate acquisition provisions of Federal law are not provided when projects are undertaken by local governments.

GAO NOTE: Page references have been changed to agree with the final report.

APPENDIX II

KANSAS DEPARTMENT OF TRANSPORTATION

JOHN B. KEMP, Secretary of Transportation JOHN CARLIN, Governor

May 25, 1983

Mr. Oliver W. Krueger, Associate Director
Resources, Community, and Economic
Development Division
U. S. General Accounting Office
441 G. Street, N. W. - Room 4903
Washington, D. C. 20548

Dear Mr. Krueger:

A copy of your draft report entitled "Federal Assistance For Off-System Bridges: Further Direction And Guidance Could Make It More Effective", has been reviewed by the Kansas Department of Transportation (KDOT). We feel that the report is thorough and covers the off-system bridge problem. However, we have several concerns with the report and offer the following comments:

1. Bridge Definitions (p.2). In Kansas, Statutes classify bridges to be structures over 20 feet in length. Twenty-foot long structures are not considered bridges.

2. Cost Effectiveness (p.5-6). We feel that the designs we have selected fulfill the requirement of an adequate facility that will produce the lowest costs over the entire life of the structure when maintenance costs are included. Composite design in steel bridges is an example of our concerns. As you note on p. 6, the use of composite design on all steel bridges may reduce the initial cost. However, we are concerned that more expensive repair costs may occur during the structure's useful life.

   Formal value engineering studies may help to optimize the value of each dollar spent. Increased staff demand is an associated cost trade-off that would occur. Therefore, these studies should be utilized only on high cost projects.

3. Bridge Design Evaluations (p.7-8). There are many difficulties in determining optimal bridge designs (p.7). Bridge designs, whether for large or small structures are evaluated on the basis of our experience gained from the many types of structures built both with and without Federal funds.

   The use of a stable group of extremely qualified engineers specializing in this area produces results not inconsistent with those that would result from a more formal procedure. Your observation of our excellent results (p.8) providing less expensive structures is appreciated. The existence of formal procedures will become more desirable to us as we begin to experience staff turnover.

4. Short Span Bridge Design (p.9). The second paragraph should be corrected to read "Cast in place concrete slab or precast prestressed bridges are usually used on the longer multi-span structures". The last sentence should read "..... but they do not do this when the cost is considered to be nearly equal for a structure type which the county may prefer".

   We are also concerned that the last sentence of the last paragraph implies that the main consideration for design selection is working relationships with counties; this is one consideration.

5. Innovative Technology (p.10). KDOT will be observing long span culverts (built with local funds) constructed of steel and/or aluminum to compare their life with that of concrete. Currently, we utilize mostly concrete box structures. If favorable results are observed in the use of long span culverts, we will re-evaluate our position.

6. Force Account Labor (p.15). KDOT is revising its procedures as a result of the 1982 Surface Transportation Assistance Act. Counties will not be able to construct small structures by negotiated contract, but where cost effective, may do construction by the force account method.

7. Alternate Design (p.15). Kansas considers alternate designs on all expensive projects. We suggest that it might be appropriate to provide alternate designs whenever the structure is estimated to cost more than $1,000,000.

   We also suggest that alternate designs to steel always be considered in the design process due to the current steel price. However, complete plans for alternate designs (for both steel & concrete) in this case are rarely necessary.

8. Value Engineering (p.16). We consider value engineering to be a "tool" that could be recommended for use on high cost structures or bid items. Its use should not be required for all bridges, as this would only require additional paperwork and lead time. Certain aspects of the value engineering procedure are used in normal project development.

9. Standards (p.18). National (AASHTO) Standards are in the process of being revised and are soon (estimated 1984) to become available in the new "Purple Book". The Purple Book provides standards by functional classification. Low volume roads will soon be designed to Local Road Standards instead of to collector or FAS standards.

10. Expense With Federal-aid (p.19). We too have heard that federal aid projects cost units more than doing the projects themselves. However, we have been unable to document this. KDOT gives consideration to each site's hydraulics, ADT, safety, county needs, etc., such that the structure selected will provide appropriate service for its design life.

11. Geometric Standards (p.19). In Kansas, geometric design guidelines for FAS and off-system bridges were jointly adopted by counties and KDOT, and approved by the FHWA.

12. Bridge Rail/Guardrail (p.21). KDOT has not requested exceptions to bridge rail. KDOT has omitted approach guardrail at the request of a county and after a cost effective analysis has been performed and justified an omission.

13. Low Water Crossings (p.25). Kansas does not expect to construct low water crossings with Federal funds. We recognize existing low water bridges that are defined in Kansas Statutes, and thus they become eligible for Bridge Replacement funding. We have used an RCB as a vented ford in conjunction with a grading and paving project.

We have appreciated the opportunity to comment on your report. We feel your comments were in general, favorable to the procedures we are using in Kansas to develop our FAS and off-system bridge projects.

If we can be of additional service or if you have other questions, please contact me or Raymond E. Olson in the Bureau of Rural and Urban Development.

Sincerely,

John B Kemp

JOHN B. KEMP, P. E.
Secretary of Transportation

JBK:REO:dh

GAO Note: The page references refer to the draft report summary provided Kansas for comment. All of the above comments except for numbers 8, 10, and 11 have been incorporated into the report. We did not believe changes in response to these comments were necessary. The Kansas Department of Transportation's general views on value engineering for off-system bridges are already contained in the report. Also, none of the examples that we developed on locally funded versus Federal-aid bridges were in Kansas, and the report recognizes that the State believes that it designs cost-effective bridges based on comment number 2. In addition, the report does not take issue with the Kansas counties' involvement in developing the geometric design standards.

APPENDIX III

STATE OF NEW HAMPSHIRE
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
JOHN O. MORTON BUILDING
CONCORD, N.H. 03301

JOHN A. CLEMENTS, P.E.
COMMISSIONER

May 31, 1983

Oliver W. Krueger, Associate Director
Resources, Community and Economic
Development Division
U.S. General Accounting Office
441 G Street, N.W. - Room 4903
Washington, D.C. 20548

Subject: Federal Assistance for Off-System Bridges: Further Direction and Guidance Could Make It More Effective

Dear Mr. Krueger:

The Department has no issue with the basic thesis (or what we believe to be the basic thesis) of the subject report. Certainly, the current and warranted concern with the state of repair of the so-called "intra-structure" when weighed against projected revenue highlights a problem: When should we "quick fix" and where should we make the "prudent investment"? How do we accomplish the most with available resources?

Current growth studies for the Northeast project a 70% growth in New Hampshire in the next 17 years. (The year 2000). Consequently, differentiating between the "quick fix", the "prudent investment" and the in-between option is more readily critiqued than addressed on a site-by-site basis. In New Hampshire, narrow dirt roads can turn into housing developments overnight.

Old examples of several of the design alternatives you suggest can be found throughout the State: Approach grades designed to accommodate overflow at flood stage and minimize structure cost, inadequate (narrow) geometry and lack of provision for pedestrians have generated safety issues with the public on both State and Off-State Systems.

A bridge has a projected 50 year life but with present design technology and material controls, there is a strong potential for a 75 to 100 year life given reasonable maintenance and loading control. In light of the investment and the possible life, it certainly is logical to require serious address to the potential service demands on the structure.

The preceding is not intended as "justification" of where we are. It is intended to indicate that the problem may not be as readily resolved as your report would indicate.

APPENDIX III

We have additional comments:

1. There is no question concerning your obvious conclusion that a long span culvert is less costly than a bridge. However, it should also be noted that the disparity in the estimates you cite may be aggravated by the marketing zeal of the representatives of the private sector with whom you talked. We question that the "alternative" estimates recognize environmental considerations, Davis-Bacon, standard specifications, construction methods, full-time construction inspections and the miscellaneous "boiler plate" that are all cost factors in any Federal-aid project.

2. We believe that the diverse professional backgrounds of your people verses ours has not provided the best basis for good communication. Many of the engineering considerations that are factors in deciding what type of bridge should be constructed at a given site are not addressed. We believe that this is because they were not recognized or understood.

3. Your bleak citation of waterway openings does little to examine whether or not there were overall project parameters relating to geometric (roadway grades) and environmental considerations that also influenced, or dictated, the bridge design.

4. We do not believe that your first paragraph on page 8, accurately reflects the design process, nor do we believe that the Bridge Engineer has "--no incentive other than to build the best bridge". The Bridge Engineer is guided by a general policy that seeks the most cost effective bridge for the life span of the facility.

In summary your report could be construed to say that New Hampshire is blindly building the biggest bridges it can with no regard for cost effectiveness. We do not believe that is a fair appraisal.

We do share your interest in making every effort to carry out the bridge replacement mission in the most cost effective manner possible. To that end, we intend to review our overall position with the Federal Highway Administration.

Very truly yours,

John A. Clements, P.E.

JAC/ab

GAO Note: All of the above comments have been incorporated into the report except for number 2. We recognize the many engineering considerations that are factors in deciding what type of bridge should be built at a given site. All the States must consider these factors. We also appreciate the difficulty of these decisions, considering that bridges must be designed to meet future needs over a relatively long life. However, we did not believe it necessary to describe these engineering considerations in detail in this report.

APPENDIX IV

Iowa Department of Transportation
800 Lincoln Way, Ames, Iowa 50010 515-239-1111

May 24, 1983

Mr. Oliver W. Krueger
Associate Director
Resources, Community & Economic Development Div.
U.S. General Accounting Office
441 G Street, N.W. - Room 4903
Washington, D.C. 20548

Dear Mr. Krueger:

SUBJECT: Draft Report Entitled "Federal Assistance for Off-System Bridges: Further Direction and Guidance Could Make It More Effective."

I appreciate the opportunity to review the draft due to its impact on those states involved in your survey and the off-system bridge funding program. There are several problems with the material presented in the draft report. It would be totally inappropriate to allow public officials to base funding decisions on the data as it is presented. The conclusions drawn would point toward more national standards, federal control and higher costs, rather than local control and cost effective savings consistent with your concerns. The use of selected sections of this document by the news media would distort the facts and point the way to improper conclusions.

The following proposed changes would correct many of the errors and omissions in the draft report materials.

1. Page 2, Paragraph 1 - The FHWA and the Secretary's discretionary bridge fund authority does not apply to the general bridge replacement fund and procedures. This reference should be removed.

2. Page 3, Paragraph 2 - States also fund the construction or replacement of bridges over 20 feet in length with state funds. This may occur when the state's federal fund allocation has been depleted or the bridge fails to meet funding criteria. The paragraph seems inappropriate in a discussion of off-system bridges.

3. Page 3, Paragraph 3 - The use of two Iowa counties for assessing the use of federal-aid bridge funds is misleading. The statement may be true but it leads the reader to make a similar conclusion about 97 other Iowa counties. It also fails to give the specific reasons why the counties had not used local funds and fails to state what bridges, if

APPENDIX IV

any, had been built during the time period. The specific details often provide clear reasons for monetary decisions.

The statement regarding Iowa and Kansas county bridge replacement requires clarification. What were the local conditions - such as bridge length, ease of construction and service - to be provided by these bridges? What funding sources were utilized?

4. Page 5, Paragraph 1 - Cost effective guidance may not be written in each FHWA manual but division staff and state officials are constantly reviewing bridge plans for ways to stretch the use of available funds and maximize both safety and service. It is often referred to as "good engineering judgment." This is well stated at the end of paragraph 2 on page 5.

5. Page 6, Paragraphs 2 and 3 - The material centers on initial construction savings only. Life cycle costs provide a more realistic analysis for state and local officials. The federal government does not fund routine maintenance. The bridge owners must consider initial cost, safety, service and maintenance costs in the design of the bridge. These decisions are part of every design thought process but are not documented just to fill files.

   Both the state and county accepted the redesigned prestressed concrete beam bridge identified in paragraph 3.

6. Page 7, Paragraph 2 - Formal procedures do not insure that cost effective bridges are built. Life cycle cost analysis and cooperation between local, state and FHWA personnel will provide the best answer to the bridge problem. State-level decisions can address local conditions. FHWA review provides the continuity across state and county lines and allows for technology transfer across the country.

7. Page 9, Paragraphs 1, 2 and 3 - The data is correct but it is presented in a very poor manner portraying a negative approach to the reader. A cost effectiveness determination is routinely made by the bridge engineer as part of the planning process and design review. The reviews are

discussed verbally between the bridge engineer and bridge owner and result in many changes being made in initial designs. The bridge engineer's statewide experience removes the expensive process of preparing several designs for each bridge. Local response to suggested changes has been very good when conducted in such a manner. Written comments are only used when the differences cannot be resolved verbally in the planning process.

The final disposition of changes recommended for the 12 bridges in paragraph 2 is unclear. One must understand why certain recommendations were not made or rejected before leaving a reader with the idea Iowa is not insuring cost effectiveness.

Iowa law and Department of Transportation policies do give the local governments considerable authority in local bridge construction decisions. Final funding with federal funds is vested in the Iowa DOT Commission. It can act as an aid in resolving design cost effectiveness problems.

8. Page 10, Paragraph 3 - Long-span culverts are not cost effective where material costs are prohibitive or soil and water conditions provide for rapid deterioration of metal surfaces or cannot maintain stable flow lines. Life cycle costs must be considered in any design.

9. Page 13, Paragraph 3 - Iowa has provided standard plans to counties for over 60 years. The Department is continually looking at ways to update and improve those standards as the technology changes. The Iowa Highway Research Board is currently involved in such an effort.

10. Page 14, Paragraph 3 - The first sentence is incorrect and should be deleted from the report. Many counties do have qualified bridge construction personnel. Bids are required on work in excess of $40,000 to insure cost effectiveness. Local governments can compare their costs to those of the contractor and make the most effective use of public funds.

11. Page 15, Paragraph 2 - It is questionable whether complete alternate designs are cost effective on single-span local bridges. The savings can accrue through predesign discussions and a single

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design. Multi-span structures may provide some savings in alternate designs but proper planning can achieve similar results. This is why "type, size and location" (TSL) studies are made by the Department. These ideas are properly conveyed in paragraph 2 on page 16.

12. Page 16, Paragraph 4 - Where have turnkey projects been developed and what are the benefits?

13. Page 18, Paragraph 2 - Standards should vary from state to state on off-system bridges. Their purpose is to provide local service needs.

14. Page 22, Paragraphs 1 and 2 - The entire paragraph should be changed for clarity. Iowa has requested and received approval for exceptions dealing with floodplains on new construction and bridge width or rehabilitation projects. The state is currently not approving exceptions in approach guardrail construction, as per federal guidelines. This is an area that the Department and the FHWA division office are continuing to explore. Future decisions on the subject must weigh the trade-off of construction and maintenance costs versus tort claim costs.

15. Page 27, Paragraph 3 - The three phase low water crossing project is being developed by the Iowa Highway Research Board rather than the Department.

I would appreciate your consideration in making the noted changes to develop a useful report.

Sincerely,

Warren B. Dunham
Director

WBD/bas

APPENDIX IV

GAO NOTE: The page references refer to the draft report summary provided the Iowa Department of Transportation for comment. All of the above comments have been incorporated into the report except for the overall comment and numbers 1, 7, and 12. With regard to the overall comment, the report recognizes the nature of off-system bridges and Federal-State relationships with regard to administering the program. We have not concluded or recommended a change in that relationship or more national standards and Federal control except to the limited extent that we believe some additional FHWA direction and guidance would benefit the program. This oversight would not involve project-by-project involvement or review.

The reference to the discretionary program is included in the introductory chapter as background. Part of the program funds are designated for discretionary projects, and this was our reason for mentioning this part of the program. With regard to comment number 7, the report is making the point that the State bridge engineer could have or did recommend more cost-effective designs that were not used. We did not believe it necessary to discuss all the reasons why the more cost-effective designs were not used. We agree that the Iowa DOT Commission could act as an aid in resolving design cost-effectiveness problems if they are brought to its attention. Data on turnkey projects were not provided to Iowa for comment because none of the examples we present in the report were in Iowa.

APPENDIX V

STATE OF VERMONT
AGENCY OF TRANSPORTATION
133 State Street, Administration Building
Montpelier, Vermont 05602

May 16, 1983

Mr. Oliver W. Krueger, Associate Director
Resources, Community, and Economic
Development Division
U.S.General Accounting Office
441 G Street, N.W. - Room 4903
Washington, D.C. 20548

Dear Mr. Krueger:

We have reviewed the draft report entitled "Federal Assistance for Off-System Bridges: Further Direction and Guidance Could Make It More Effective". In general we concur with that portion of the report which was forwarded to us, but we do have the following specific comments:

1. Page 6, The States and Cost Effectiveness, 4th sentence. We believe the fact that we use a variety of structures for spans of any given length proves that Vermont does make cost comparisons between different types of structures. Therefore, even though our files may not have been well documented, we consider this statement to be untrue relative to Vermont.

2. Page 7, State Procedures, Vermont. The first sentence of this paragraph intimates that because Vermont "does not have formalized, systematic procedures or a written policy..." cost effective bridges are not built. This is not a true statement because we consider cost effective design to be an integral part of the design process, thereby not needing a separate written policy. Our review process insures that cost effective designs are obtained. The second paragraph again makes the same negative statement. We do have the process to insure that less expensive designs are considered, despite the fact that the auditors did not see a written policy.

3. Page 11, Paragraph 3, 2nd sentence. This is not a true statement. In fact, one of the projects reviewed by the auditors, Concord BRZ 1447(2), used a corrugated galvanized metal plate pipe arch with a span of 20'-7" and a rise of 13'-2". We also request that the reference to the Essex Junction, Vermont, railroad project be eliminated. This was a private project using no State or Federal funds and therefore should not be a part of a report on Federally funded Off-System Bridges.

4. Page 14, Various Management Techniques Can Reduce Costs. The first sentence is a judgement, not a statement of fact, and therefore should not be a part of this report. It is our opinion, based on experience with consultant designs on Off-System projects, that the so-called turnkey system would not be a good way to reduce construction costs on Vermont projects.

If you have any questions concerning these comments, please contact our Structures Engineer, Warren Tripp, at (802)828-2621.

Sincerely,

Patrick J. Garahan
Secretary

PJG:WBT:kg

GAO Note: The page references refer to the draft report summary provided the Vermont Agency of Transportation for comment. All of the above comments have been incorporated into the report except for the request not to refer to the Essex Junction project. The report points out that the project was not federally funded. It is an example of how long-span culverts have been used in Vermont.

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