KANSAS HIGHWAY SAFETY DESIGN

STATE-OF-THE-ART

by

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DISCLAIMER

The contents of this report reflect the views of the review team and the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views or policy of the Department of Transportation, Federal Highway Administration.

INTRODUCTION

In 1967, the American Association of State Highway Officials (AASHO), now the American Association of State Highway and Transportation Officials (AASHTO), published a report entitled "Highway Design and Operational Practices Related to Highway Safety" (2). The report, commonly known in the highway engineering field as the "Yellow Book," contained highway safety principles and recommendations which, when implemented, would create a safer roadway environment for the traveling public. A Second Edition of the "Yellow Book" updating and expanding the earlier publication was published in 1974 (10).

It is now just over ten years since the original issuance of the "Yellow Book." The highway sector responsible for designing, constructing and maintaining highways has been seriously criticized by private sector safety groups for failure to include the highest possible safety features in the construction of new highways and in the safety upgrading of existing roads.

In view of the criticism and controversy regarding the implementation of the "Yellow Book" principles and recommendations, the Federal Highway Administration (FHWA) initiated a program in late 1977 to determine the State-of-the-Art in Highway Safety Design in each of the fifty States. The State-of-the-Art determination in each State was based upon an office review and a number of site reviews of recently completed highway construction projects by a FHWA Review Team. The author was a member of the review team in Kansas and was responsible for the coordination of the review and preparing the subsequent report of findings and recommendations.

In Kansas, the office review consisted of a review of current State Standard Plans, State Design Manuals, project plans and specifications,

and other appropriate documents as related to practices described in the "Yellow Book." Site reviews were conducted on four roadway sections selected at random meeting the following criteria:

A. Design speed equal to or greater than 50 miles per hour (80.47 kilometers per hour).

B. Sufficient length and complexity to illustrate typical practices related to traffic operations, interchange or intersection design, and roadside design including both cuts and fills.

C. Plans, Specifications and Estimate (PS&E) were approved by FHWA after 1970.

D. Roadways represent rural and urban Interstate highways and rural and urban arterial highway facilities.

The roadway sections selected for review are shown in Table I. Project histories for each roadway section are included in the Appendix.

TABLE I

Site Review Roadway Locations

Route	Location
I-35	Franklin Co., W. County Line to US-50 Spur
I-635	Wyandotte Co., U.S. 24 (State Ave.) to Ks.-Mo. State Line
K-132	Wyandotte Co., From 0.35 mile east I-635, thence east 0.48 mile to the Kansas River Bridge
US-56	Morris Co., E. City Limits Council Grove to E. County Line

The office and site reviews were divided into five basic phases: Roadway Surface, Geometrics, Traffic Barrier, Roadside, and Miscellaneous. Night site reviews were included for the urban Interstate and urban arterial facilities. The following paragraphs summarize the findings and recommendations of the FHWA Review Team.

Roadway Surface

The 1973 Edition of the Kansas Standard Specifications for State Road and Bridge Construction requires that concrete pavements be constructed to provide a surface trueness not to exceed 1/8 inch (.32 centimeters) deviation in ten feet (3.05 meters) (17). Asphalt pavements are to be constructed to provide a surface trueness not to exceed 1/4 inch (.64 centimeters) deviation in ten feet (3.05 meters). Surface texturing of asphalt pavements is primarily dependent upon the design of the bituminous mixture. Surface texturing of concrete pavements is typically provided utilizing a burlap or cotton fabric drag. The specifications require the drag be maintained in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over 1/16 inch (.16 centimeters) in depth. Kansas does not currently require any other type of performance standards for the pavement surface texture.

Kansas has constructed a concrete pavement test section on I-35 in Lyon County. The test section features five different methods of surface texturing: (1) typical burlap or cotton fabric drag, (2) coarse carpet drag of polyethylene fibers, (3) transverse grooving by metal comb with a 1/2 inch (1.27 centimeters) tine spacing, (4) transverse grooving by metal comb with 3/4 inch (1.91 centimeters) tine spacing, and (5) transverse brooming with a plastic bristle broom. The test section is being monitored

to evaluate rideability, abrasive wear, and skid resistance of the surface over time. Laboratory and field evaluation of the frictional characteristics of various asphalt pavement designs are also currently under study by the Kansas Department of Transportation (KDOT).

The KDOT is developing a skid resistance inventory for roadways in Kansas. Inventory work is being accomplished with priority being given to the highways with the higher traffic volumes and on the State System of Highways. Locations where the inventory testing indicates low skid resistance exists are reviewed and corrective action is undertaken if appropriate. The KDOT is utilizing data from their skid testing program in their efforts to identify various pavement designs and materials that result in high skid resistance pavement surfaces.

Of the roadway sections selected for review, one (US-56) was constructed with asphalt pavement and three (I-35, I-635, K-132) were constructed with concrete pavement. Data from the KDOT's skid inventory indicates the roadway section on I-35 has an average SN_{40} (skid number determined at 40 miles per hour) of 47, the roadway section on US-56 an average SN_{40} of 44, and the roadway section on I-635 an average SN_{40} of 45. The roadway section on K-132 had not been included in the KDOT's skid inventory at the time of this review. The aforementioned skid numbers are above the recommended minimum skid numbers included in Highway Safety Program Manual, Volume 12 (25).

A review of the accident data from January 1, 1975 through October 31, 1977 for the review section of I-35, I-635, and K-132 indicated the following percentage of wet-weather accidents respectively: 11%, 14%, and 11%. The roadway section on US-56 was opened to traffic in June 1976. From that time through October 1977, two accidents occurred and roadway conditions

were classified as dry for both. The wet weather accident history for the roadway sections reviewed indicates that the pavement surface texture performance has been adequate to this point in time.

There were no areas of significant variation in texture, ponded water, roughness at bridge approaches or ramp terminals noted during the review. The turf shoulders on the section of US-56 were wet and soft at the time of the review; however, the KDOT Maintenance Department had placed appropriate signs warning of the temporary condition.

Kansas State Statutes provide for the Secretary of Transportation of the KDOT to adopt a manual and specifications for a uniform system of traffic control devices which shall correlate with and conform to the extent possible with the Manual on Uniform Traffic Control Devices (MUTCD) and other standards issued or endorsed by the Federal Highway Administrator (6). The Secretary of Transportation has adopted the MUTCD for the State Manual.

Pavement markings on the rural roadway sections reviewed appeared satisfactory. Pavement markings on the urban roadways were practically worn off and the review team noted drivers tending to follow the longitudinal construction joints. This did not appear to present any problem except at the east end of the section on K-132 where the roadway transitioned from four-lane divided to two-lane with two-way traffic. Traffic was following the longitudinal construction joint rather than the pavement markings which indicated the outside lane merge in advance of the two-way roadway. This condition resulted in some abrupt movements from the outside lane to the inside lane. This condition could be improved by renewing the pavement markings when weather permits.

Geometrics

This portion of the review primarily focused on the critical design elements of intersections and interchanges. Roadway cross-sections are included in the "Roadside" portion of this report.

The KDOT Design Manual (15) contains design standards consistent with the AASHTO publications "A Policy on Geometric Design of Rural Highways" (1965) (1) and "A Policy on Design of Urban Highways and Arterial Streets" (1973) (9). The AASHTO publications as well as the "Highway Capacity Manual" (1965) (14) are referenced within the Design Manual as guides to be followed by design personnel. The Design Manual also contains a checklist of 16 items that should be considered by a designer in completing interchange details. The checklist is not intended to be a complete list but does include important items related to the design of ramps, acceleration and deceleration lanes, weaving sections and lane drops.

On the roadways reviewed in the field, I-35 had a design speed of 75 miles per hour (120.70 kilometers per hour). The maximum degree of horizontal curve used was 1° - 45' and the maximum grade was 3.34 percent. Sag vertical curves varied from 600' to 1800' (182.88 to 548.64 meters) in length and crest vertical curves ranged from 800' to 2400' (243.84 to 731.52 meters) in length. Stopping sight distance of 725' (220.98 meters) or greater was provided throughout the section. The roadway section generally consisted of a four-lane divided rural freeway with a 60' (18.29 meters) edge-of-pavement to edge-of-pavement depressed median. Sections of independent roadway alignment and variable width median were also observed.

I-635 had a design speed of 60 miles per hour (96.56 kilometers per hour), a maximum grade of 4.521 percent, and a maximum degree of horizontal curve of 4°. Sag vertical curves ranged from 300' to 1350' (91.44 to 411.48 meters) in length. Stopping sight distance of 475' (144.78 meters) or greater was provided. The roadway section is basically a six-lane divided urban freeway with a 16' (4.88 meters) edge-of-pavement to edge-of-pavement mountable, raised median containing a double-faced W-beam median barrier. Interchange ramps were constructed 18' (5.49 meters) in width. Current design calls for the construction of ramps 14' (4.27 meters) in width. Right-of-way constraints resulted in the design and construction of ramps very close to the overpass structure at Parallel Avenue. The exit ramp terminals at this location operate under a signalized condition. The exit ramps diverge from the mainline as single lanes and then widen to two lanes to provide for left and right turning movements onto Parallel Avenue. Sight distance from the ramp terminals along Parallel Avenue is quite restricted by the closeness of the ramps to the overpass structure; vertical curvature, bridge railing, and sidewalk of the structure; and traffic barrier. Skid marks, broken glass, etc., indicated an accident problem associated with the I-635 northbound exit ramp and Parallel Avenue. This may be a location where the right-turn-on-red in conjunction with the restricted sight distance is causing operational problems. Signing of this section of I-635 appeared consistent with the MUTCD; however, the night review revealed that approximately one-half of the sign lighting units were out.

Of the roadways reviewed, the section in the I-635 - US-24 interchange area was the oldest construction (1970-71). In this area, it was noted that curbs had been constructed in the gore areas. KDOT representatives

indicated this design practice is no longer used and safety upgrading projects have been initiated to modify such locations. It was also noted that the bridge piers for the I-635 structures over US-24 did not have any traffic barrier or crash cushion protection installed. US-24 functions as a major arterial at this location and has a signed speed limit of 40 miles per hour (64.37 kilometers per hour).

US-56 had a design speed of 70 miles per hour (112.65 kilometers per hour), a maximum grade of 3.94 percent, and maximum degree of horizontal curve of 2°. Sag vertical curves varied from a 1000' to 1600' (304.80 to 487.68 meters) in length and crest vertical curves ranged from 800' to 3000' (243.84 to 914.40 meters) in length. Stopping sight distance in excess of 725' (220.98 meters) was provided throughout the section reviewed. This section of roadway is a two-lane rural highway with partial control of access. The KDOT typically designs and constructs a paved mailbox turnout on this type of highway; however, it was noted that the adjoining property owners were not locating their mailboxes consistent with the turnout design.

K-132 had a design speed of 60 miles per hour (96.56 kilometers per hour) and partial control of access. The grade was relatively flat and the maximum degree of horizontal curve was 2°. The roadway was a four-lane section with a 20' (6.10 meters) edge-of-pavement to edge-of-pavement mountable, raised median containing a double-faced W-beam barrier. Two at-grade intersections were within the section reviewed.

Other than noted in the preceeding discussion, there were no other particular driving or operational problems noted which were associated with the geometrics of the roadways reviewed.

Traffic Barriers

The KDOT used the warrants indicated in National Cooperative Highway Research Program (NCHRP) Report 118 (22) in determining the need for traffic barrier and crash cushions. NCHRP Report 118 and 129 are referenced in the KDOT's Design Manual for additional guidance in the selection and design of traffic barriers and crash cushions. The W-beam rail with either wood or steel posts and block outs (See Figure 1) has been the traffic barrier primarily utilized by the KDOT in recent years.

KDOT design requirements indicate the traffic barrier is generally to be installed with the face of the W-beam rail 2' (0.61 meters) outside the shoulder line. The "leading" end of the barrier is flared 8' (2.44 meters) from the shoulder line and the "trailing" end 5' (1.52 meters) typically. The barrier may be placed further from the roadway depending on the location. The barrier terminates at each end with a W-beam Terminal Section (Standard). KDOT representatives indicated that there has been a very low number of reported accidents associated with the flared terminal section; however, this is not documented in any formal report at this time. KDOT representatives did indicate the recently developed breakaway cable terminal was being studied for possible installation at select locations but a retro-fit project to change all locations would not be considered cost-effective.

Transition sections are used to connect the W-beam rail to barrier or railing systems of greater lateral stiffness and/or fixed objects.

The KDOT utilizes a 25' (7.62 meters) barrier transition design for the W-beam rail consisting of 3' - 1½" (0.95 meters) post spacing and a 25' (7.62 meters) nested section of 12 guage rail (See Figure 2).

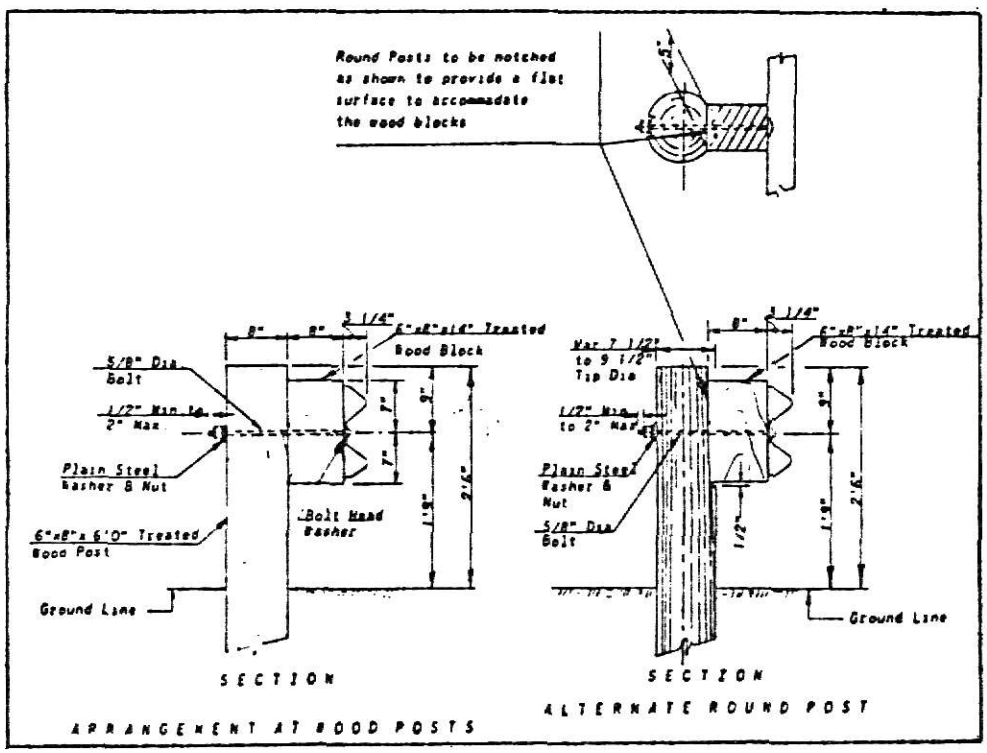

Round Posts to be notched as shown to provide a flat surface to accommodate the wood blocks
8"
8"
3 1/4"
6"x8"x1/4" Treated Wood Block
5/8" Dia Bolt
1/2" Min to 2" Max
Plain Steel Washer & Nut
6"x8"x 6'0" Treated Wood Post
Bolt Head Washer
Ground Line
SECTION
ARRANGEMENT AT WOOD POSTS
Max 7 1/2" to 9 1/2" Tip Dia
SECTION
ALTERNATE ROUND POST

FIGURE 1

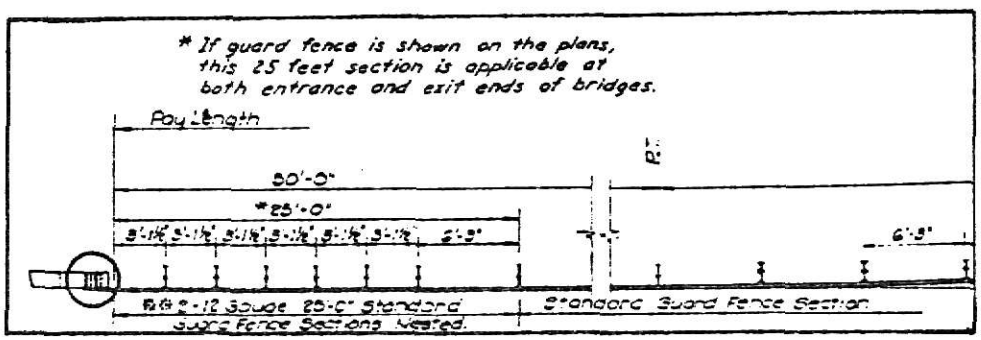
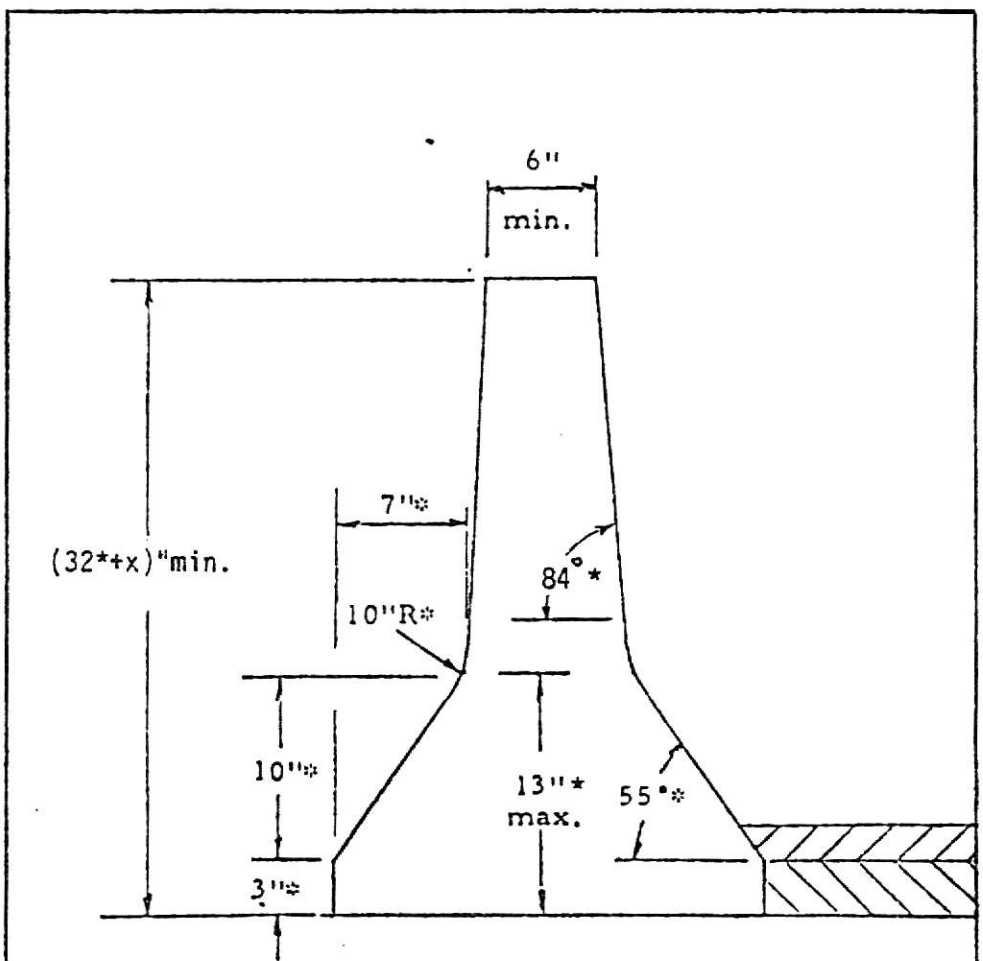

* If guard fence is shown on the plans, this 25 feet section is applicable at both entrance and exit ends of bridges.
Pay Length
50'-0"
*25'-0"
6'-3"
Standard Guard Fence Section

FIGURE 2

On safety upgrading projects to connect the traffic barrier to bridge ends, the barrier transition is modified as needed to connect with the various bridge rail designs used in Kansas.

In maintaining their traffic barriers, the KDOT Maintenance Department generally replaces barriers receiving extensive damage with barriers of current design, as appropriate. Non-current design barrier receiving minor damage, 1 or 2 sections of barrier in a long installation (over 400' typically), is normally repaired with in-kind hardware. Through the Maintenance Program each KDOT District identifies its priority needs for materials (including traffic barrier and associated hardware) on an annual basis. These materials are in part used for the replacement of barrier which is not of current design. The KDOT's program for replacing barrier was supplemented in 1976 and 1977 through the use of Federal-aid Highway Safety Funds to install current design barriers and connect barriers to bridge ends at priority locations. Locations for the installation of barriers, including locations with existing barriers, are determined in accordance with the warrants in the KDOT's Design Manual. Locations where existing barrier is unwarranted are noted for elimination of the barrier. The KDOT has utilized Federal-aid Interstate Funds for safety upgrading projects on the Interstate System of Highways. Such projects include traffic barrier installation/modification as required to reflect current design.

The KDOT also uses concrete traffic barrier. The design configuration shown in the KDOT's Standard Plans is consistent with the acceptable shape known in the highway engineering field as the "New Jersey" configuration (See Figure 3).



*New Jersey (MB5) standard geometry.

FIGURE 3

The KDOT Design Manual reflects that crash cushions are designed according to the procedures in N.C.H.R.P. Report 118. The type of crash cushion specified is based on economic considerations and the geometrics of the proposed location. Crash cushion systems currently in use in Kansas include steel drums, Hi-Dro Cells, and the Fitch Barrier. The KDOT previously used the Tor-Shok system but found it expensive to maintain and its use has been discontinued. Existing installations are being studied for possible replacement. In 1977, Highway Safety Incentive Funds were utilized by the KDOT to purchase replacement parts for the Fitch Barrier systems.

All four roadway sections reviewed in the field had installations of the W-beam barrier using either wood or steel posts. The I-635 section also contained approximately a 1000' (304.80 meters) long section of concrete median barrier. The concrete barrier was built in substantial compliance with the plans; however, the design configuration provided only one slope from bottom to top creating a triangular section more or less. The recent pooled funds research project, "Concrete Median Barrier Research," shows that subtle variations in shape has a significant influence on barrier performance. The shape of this particular barrier may increase the probability that an impacting vehicle would roll over.

It was noted in the I-635 - US-24 interchange that the barrier installation on the ramps did not contain a transition section as it approached and connected to the bridge end. The roadway section on I-635 was constructed with a W-beam median barrier. The same median barrier design was constructed across the separation structures; however, the barrier was not continuous across the structures. The barrier had been terminated at each end of the structure creating a gap of approximately 1' (0.30 meters) in

the barrier. It was the opinion of the Review Team that the full lateral stiffness of the barrier was lost at these locations by this design feature and increased the possibility of snagging impacting vehicles.

It was also noted on I-635 that the median barrier was constructed approximately 2' (0.61 meters) from the center piers of overpassing structures. This was acceptable design at the time of construction. The 1977 AASHTO "Guide for Selecting, Locating, and Designing Traffic Barriers" (GSLDTB) indicates that deflections over 4' (1.22 meters) have been measured in test crashes involving barrier design similar to that utilized in Kansas. Such Deflections can be reduced by decreasing the post spacing from 6'3" (1.91 meters) to 3' 1½" (0.95 meters) and/or using two thicknesses of W-beam rail.

The 1977 AASHTO "GSLDTB also recommends the use of a "W" section back-up plate, 1' (0.30 meters) in length, placed behind the W-beam rail at intermediate posts does not currently include the use of such a back-up plate.

On the roadway section reviewed on K-132, W-beam median barrier had been constructed utilizing turned-down-end sections. The use of such turned-down-end sections may cause impacting vehicles to vault the barrier or roll over. The 1977 AASHTO "GSLDTB" contains alternate crashworthy end treatment designs for median barrier terminals.

Roadside

The KDOT Design Manual indicates that it is the design intent to provide a roadway cross-section containing a 30' (9.14 meters), unobstructed recovery area from the edge of the outside driving lane wherever practical. A 20' (6.10 meters) recovery area from the edge of the shoulder is used on the Federal-aid Secondary System of highways. The use of extensive amounts

of traffic barrier is avoided by using these recovery areas. The KDOT typically uses a roadway section providing 12' (3.66 meters) lanes, 10' (3.05 meters) outside shoulders, 6:1 slide slopes in the recovery area, and 4:1 or 3:1 side slopes (dependent on height of embankment fill) beyond the recovery area. Such a section is usually referred to as the "barnroof" section (See Figure 4). Shoulder type, turf or stabilized, is dependent upon the predicted design year traffic. Lesser shoulder widths and side slopes are used for low volume roads (less than 750 ADT). On divided highways, median U-turn openings are designed with 10:1 side slopes. Side slopes of 6:1 are used for side roads and entrances entering state highways at grade.

Flat bottom ditches 10' (3.05 meters) in width are used to provide a traversable roadside. The ditch width is generally part of the recovery area provided. Drainage structures 24' (7.32 meters) in diameter or less can be constructed and terminated within the recovery area. Drainage structures with a height or length between 2' and 10' (0.61 and 3.05 meters) are generally designed and constructed with headwalls outside the recovery area. Larger drainage structures may be designed and constructed within the recovery area but are to be accompanied by protective traffic barrier.

The KDOT utilizes a design feature which extends the pavement cross-section 2' (0.61 meters) into the shoulder on the outside of superelevated sections. This feature provides for better drainage and decreases the possibility of drop-off and ponded water at the pavement edge on the outside of curves.

The KDOT, when possible, installs all signs outside the recovery area, typically 40'-42' (12.19-12.80 meters), using breakaway support features. Exceptions to this are delineators, milepost markers and exit signs in

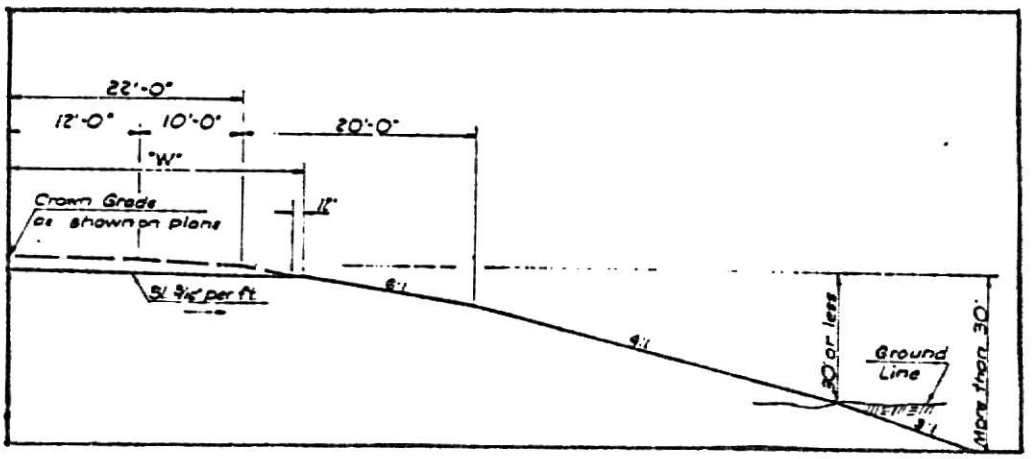

22'-0"
12'-0"
10'-0"
20'-0"
"W"
12"
Crown Grade
as shown on plans
1/2 3/4" per ft
6:1
4:1
30' or less
Ground
Line
3:1
More than 30'

FIGURE 4

gore areas. Where roadway design and right-of-way will not permit such lateral placement, breakaway support features and/or traffic barrier are utilized.

On I-35, small drainage structures in the median and 18 within the recovery area were designed and constructed with grates adding to the traversibility of the roadside. It was noted, however, that several vertical headwalls, approximately 3' (0.91 meters) in height, had been built on drainage structures outside the recovery area. While outside the 30' (9.14 meters) recovery area, a different inlet or grate system could have been used to provide a safer roadway section at those locations.

Where fill materials was available, a special ditch or berm section was constructed on I-35 on high fills (See Figure 5). Such a berm may be effective in intercepting run-off-the-road vehicles which do not recover within the recovery area.

It was also noted on I-35, that several overcrossing structures were designed and constructed with the piers approximately 31' (9.45 meters) from the edge of pavement and located within the 10' (3.05 meters) flat bottom ditch. Protective traffic barrier is not utilized at these locations. One location was observed where one of the piers appeared to have been hit by a truck.

During the review of project files for the I-35 construction, it was noted that discussions had been held and decisions made regarding the removal of particular trees within the right-of-way as potential hazardous roadside obstacles.

On US-56, the 30' (9.14 meters) recovery area was maintained (no traffic barrier) throughout the section reviewed except at the bridge

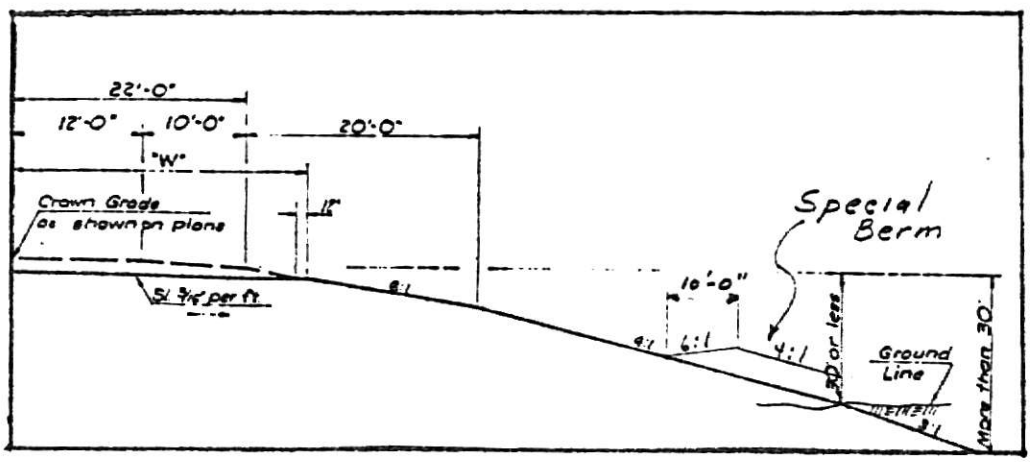

22'-0"
12'-0"
10'-0"
20'-0"
"W"
Crown Grade
as shown on plans
12"
Special
Berm
10'-0"
4:1
4:1
4:1
4:1
30' or less
Ground
Line
More than 30'
5/8" per ft.

FIGURE 5

locations. The bridges were constructed to full shoulder width and the bridge ends were protected with traffic barrier.

Miscellaneous

On the urban roadways reviewed, a number of sign supports consisting of 4" x 6" (10.16 x 15.24 centimeters) wood posts (drilled in the 4" dimension to make them breakaway) had been hit and replaced with undrilled posts. This practice was called to the attention of KDOT representatives.

The overhead sign bridges used by the KDOT generally have a ladder attached to one end to provide access to the sign face and sign lighting units by maintenance personnel. It would appear this design feature creates a potential hazard and temptation to unauthorized personnel, particularly in urban areas.

In 1976, the Kansas legislature passed laws pertaining to the responsibility of local officials for providing curb ramps for handicapped persons. The law also provided minimum design requirements for such ramps. The KDOT had previously incorporated provisions for curb ramps in its design practice.

Wood post and yielding metal post sign supports are generally set in a concrete foundation with a post seat. The concrete foundation gives the sign needed support in wet conditions and high winds. The post seat allows replacement of the post without driving new posts or digging new post holes.

The KDOT uses a highway sufficiency rating system on their rural highways as one indication of relative need for improvement. It was noted during the review that the sufficiency rating procedure was modified to include safety criteria from the 1967 and 1974 editions of the "Yellow Book." The rural roadway sections, I-35 and US-56, included in this review had sufficiency ratings in the upper nineties in 1976 reflective of their current design and safety features.

Recommendations

It is recommended that the KDOT continue their evaluation efforts in the area of pavement surface texturing and improved skid resistance consistent with the guidelines contained in the Federal-aid Highway Program Manual (FHPM) Volume 6, Chapter 2, Section 4, Subsection 7, "Skid Measurement Guidelines for the Skid Accident Reduction Program" (28).

Increased emphasis should be given to the review of on-the-shelf plans in the area of roadside appurtenances (culvert headwalls, inlets, traffic barrier, etc.) to assure the incorporation of acceptable safety features prior to construction.

It is recommended that the KDOT review and modify, as needed, the warrants and design requirements stated in their Design Manual for traffic barrier to be consistent with 1977 AASHTO "Guide for Selecting, Locating, and Designing Traffic Barriers." The subject guide replaces National Cooperative Highway Research Program (NCHRP) Report No. 118.

The AASHTO "Guide for Selecting, Locating, and Designing Traffic Barriers" indicates additional safety can be obtained by placing fixed objects (bridge piers) in the back slope rather than the side slope or ditch bottom. It is recommended that the KDOT consider placing bridge piers in the back slope rather than the ditch bottom as observed on I-35. The ditch could have the effect of steering errant vehicles toward the pier.

It is recommended that the KDOT Maintenance Department give increased attention to the maintenance and replacement of highway hardware to insure that safety features are retained and operational.

It is recommended that the KDOT review the need for a permanently attached ladder on sign bridges and eliminate this feature if possible.

APPENDIX A

Project History - I-35

Project Description:

Federal-aid Number: 35-30 I-35-3(96)167
35-30 I-35-3(97)167
35-30 I-35-3(159)168

Location: I-35, From West Franklin County Line N.E. to One-half Mile West of US-59 at Ottawa

Work: Grading, Bridges, Concrete Pavement, Roadside Improvement, General Building, Lighting, Signing and Delineation

Length: 14.2 Miles

Type of Facility: Rural Interstate Freeway

Shoulder Width: 10 ft. outside and 6 ft. inside

Median Type & Width: Depressed, 60 ft. (edge-of-pavement to edge-of-pavement)

Number of Lanes: 4

Number of Interchanges: 3

Number of Grade Separations: 7

Number of Bridges: 17

Terrain: Rolling

Date PS&E Approved:

Grading and Bridges: March 1971

Concrete Pavement: January 1972

Roadside Imp., Gen. Bldg., Lighting: January 1972

Signing and Delineation: February 1973

Date Initial Construction Started: June 1971

Date Opened to Traffic: July 1973

Traffic Data: 5580 (1977)

Accident Data: 69 total accidents, accident rate = 0.707 accidents/ 1,000,000 vehicle miles, fatality rate = 2.048 fatalities/ 100,000,000 vehicle miles

APPENDIX B

Project History - I-635

Project Description:

Federal-aid Number: 635-105 I-635-3(37)235
635-105 I-635-3(41)235
635-105 I-635-3(42)235
635-105 I-635-3(44)237
635-105 I-635-3(91)238
635-105 I-635-3(92)238
635-105 I-635-3(106)234
635-105 I-635-3(126)236
635-105 I-635-3(185)237
635-105 I-635-3(191)237
635-105 I-635-3(199)230

Location: I-635, From US-24 (State Avenue) North to the Missouri River Bridge

Work: Grading, Bridges, Concrete Pavement, Lighting, Traffic Signals, Signing and Delineation

Length: 3.4 Miles

Type of Facility: Urban Interstate Freeway

Shoulder Width: 10 ft. outside

Median Type and Width: Mountable, Raised Median with Barrier, 16 ft. from edge-of-pavement to edge-of-pavement

Number of Lanes: 6

Number of Interchanges: 4

Number of Grade Separations: 6

Number of Bridges: 15

Terrain: Rolling

Date PS&E Approved:

Grading and Bridges: July 28, 1967; February 27, 1973; April 21, 1974

Concrete Pavement: June 20, 1969; November 20, 1972; December 30, 1974

Traffic Signals: January 23, 1970; December 10, 1973

Lighting: February 22, 1973; February 21, 1975

Signing and Delineation: October 30, 1975

Date Initial Construction Started: September 1967

Date Opened to Traffic: From US-24 to K-5 - May 1971
From K-5 to Missouri River - December 1975

Traffic Data: From US-24 to Parallel Avenue: 31,165 (1977)
From Parallel Avenue to K-5: 22,840 (1977)
From K-5 to Missouri River: 18,800 (1977)

APPENDIX B

(Continued)

Accident Data: From US-24 to K-5: 93 total accidents, accident rate = 2.165 accidents/1,000,000 vehicle miles, fatality rate = 2.328 fatalities/100,000,000 vehicle miles

From K-5 to Missouri River: 13 total accidents, accident rate = 0.950 accidents/1,000,000 vehicle miles, fatality rate = 7.306 fatalities/100,000,000 vehicle miles

APPENDIX C

Project History - K-132

Project Description:

Federal-aid Number: 132-105 U-084-1(6)

Location: K-132, From 0.4 Mile East of I-635 East

Work: Grading, Concrete Pavement, and Seeding

Length: 0.4 Mile

Type of Facility: Urban Arterial (Expressway)

Shoulder Width: 10 ft. outside

Median Type and Width: Mountable, Raised Median with Barrier, 20 ft. from edge-of-pavement to edge-of-pavement

Number of Lanes: 4

Number of Intersections: 2 (1 signalized)

Terrain: Flat

Date PS&E Approved: May 1973

Date Construction Started: August 1973

Date Opened to Traffic: December 1974

Traffic Data: 11,515 (1977)

Accident Data: 22 total accidents, accident rate = 2.374 accidents/ 1,000,000 vehicle miles, fatality rate = 0.0

APPENDIX D

Project History - US-56

Project Description:

Federal-aid Number: 56-64 RF-062-3(5)

Location: US-56, From 10th Street in Council Grove to the East Morris County Line

Work: Grading, Bituminous Surfacing, Bridges, and Seeding

Length: 6.6 Miles

Type of Facility: Rural Arterial (Partial Control of Access)

Shoulder Width: 10 ft.

Number of Lanes: 2

Number of Bridges: 2

Terrain: Rolling

Date PS&E Approved: September 1974

Date Construction Started: December 1974

Date Opened to Traffic: June 1976

Traffic Data: 1345 (1977)

Accident Data: 4 total accidents, accident rate = 0.761 accidents/ 1,000,000 vehicle miles, fatality rate = 0.0

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KANSAS HIGHWAY SAFETY DESIGN

STATE-OF-THE-ART

by

Edward Lee Wilson

B.S., Kansas State University, 1968

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of

the requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY

Manhattan, Kansas

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ABSTRACT

In 1967, the American Association of State Highway Officials (AASHO), now the American Association of State Highway and Transportation Officials (AASHTO), published a report entitled "Highway Design and Operational Practices Related to Highway Safety." The report contained highway safety principles and recommendations which, when implemented, would create a safer roadway environment for the traveling public. Since 1967, AASHO has published additional design guides and standards which incorporate many of the principles and recommendations from the aforementioned publication (commonly known in the highway engineering field as the "Yellow Book"). A Second Edition of the "Yellow Book" was published in 1974.

The highway sector responsible for designing, constructing and maintaining highways has been seriously criticized by private sector safety groups for failure to include the highest possible safety features in the construction of new highways and in the safety upgrading of existing roads.

In view of the criticism and controversy regarding the implementation of the "Yellow Book" principles and recommendations, the Federal Highway Administration (FHWA) initiated a program in late 1977 to determine the State-of-the-Art in Highway Safety Design. The State-of-the-Art determination was conducted in each state by conducting an office review of standard plans, design manuals, specifications, and other appropriate documents and a field review of recently completed highway construction projects by a FHWA Review Team. The author was a member of the review team in Kansas and was responsible for the coordination of the review and preparing the subsequent report of findings and recommendations.