TRANSPORTATION CABINET
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DESIGN MEMORANDUM NO. 04-13

TO: **Chief District Engineers**
Design Engineers
Design Consultants

FROM: **Jeff D. Jasper, P.E., Director**
Division of Highway Design

DATE: **August 27, 2013**

SUBJECT: **Design Guidance for Shared Four-Lane (2+1) Roadways**

The Kentucky Transportation Cabinet continues to support the use of innovative facility designs capable of providing improved mobility and safety for Kentucky motorists. As such, the attached guidance for shared four-lane facilities (also known as a 2+1 Roadway) is issued for consideration by Project Teams as they develop feasible alternatives. A shared four-lane facility typically maintains a continuous three-lane cross section, utilizing the center lane to provide a passing lane in alternating directions along the highway. This concept may be used to address operational deficiencies on rural, two-lane highways that do not have the volume to warrant a four-lane facility. Shared four-lane highways have been shown to improve operational efficiency and reduce crashes over two-lane highways, and present a lower cost option of between 50 to 90 percent over four-lane divided highways.

Shared four-lane facilities may be considered as a cross-section alternative for all high speed rural highways with moderate volumes. This design can be used on new alignment or retrofitted on existing alignment, specifically on existing "Super 2" designs. Shared four-lane facilities are recommended for roadways having an ADT range of 5,000 to 20,000 vehicles per day. For design volumes approaching 20,000 a project team may consider a shared four-lane design with right-of-way purchased for a future full four-lane facility. These facility types have the potential to increase travel speeds on long roadways connecting major activity centers or towns; however, the concept may also be used on shorter roadways.

No special review or approval is required for the use of shared four-lane facilities. However, as the design is new to Kentucky, the project team should coordinate early with the Division of Traffic Operations to obtain guidance for signing and striping plans.

Any questions regarding the use of shared four-lane highways should be directed to this office.

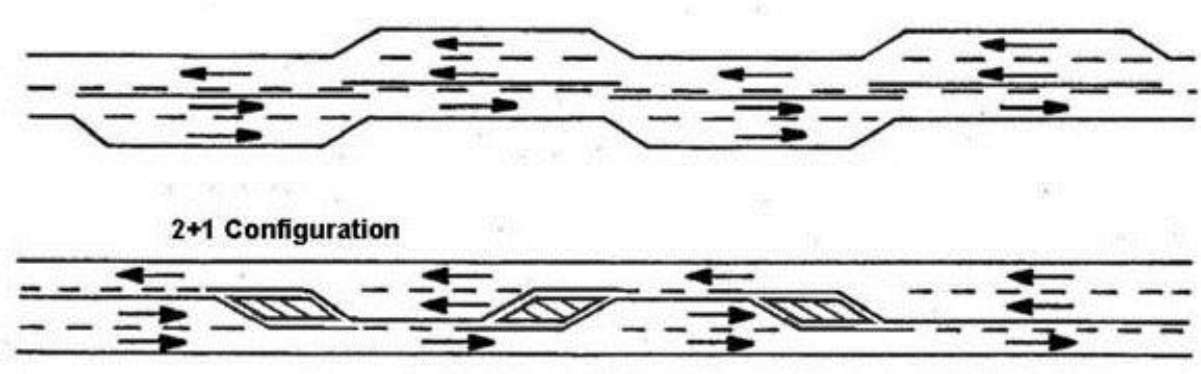
JDJ:BS:jjf

Attachment

SHARED FOUR-LANE FACILITIES

A shared four-lane facility typically maintains a continuous three-lane cross section, utilizing the center lane to provide a passing lane in alternating directions along the highway. This concept can be used to address operational deficiencies of two-lane highways that are present prior to capacity being reached that would require a full four-lane facility. Shared four-lane highways have been shown to improve operational efficiency and reduce crashes over two-lane highways, and present a cost effective alternative to four-lane divided highways. A conceptual drawing of shared-four-lane facilities are shown in Figure 1 below.

Figure 1: Shared Four-lane Concept



It should be noted that the typical section may be varied throughout the project based on project constraints. As an example, the 3-lane section may be readily reduced to a standard 2-lane section when passing through structures or deep cuts where the full-width cross section would significantly increase project costs.

The presence of passing lanes have been found to increase average travel speed by as much as 8 to 11 percent. The speed benefits of passing lanes also continue for approximately 2 miles downstream of the passing lane. Passing lanes typically reduce the percent time spent following (PTSF) by 58 to 62 percent, depending on traffic volume, within the passing lane itself and can continue up to 13 mi downstream of the passing lane. Improvements to travel speed and PTSF can greatly improve the level of service for two-lane designs.

Comprehensive safety evaluations of shared four-lane highways have not been completed within the United States. However, NCHRP Project 20-7 evaluating the performance of shared four-lane roads (Also called 2+1 roadways) in Europe found the following results.

- In Germany, shared four lanes roads have been found to operate with accident rates 36 percent lower than conventional two-lane highways.
- Finland has estimated that shared four lane roads operate with accident rates 22–46 percent lower than conventional two-lane highways.
- Sweden observed a 55 percent reduction in fatal and injury accidents with the implementation of shared four-lane roads.

Before/after studies of shared-four lane highways in Missouri showed a total crash reduction of over two thirds with head on collisions reduced by 100 percent in one case study.

Experience by other states has shown that the use of a shared four-lane highway can reduce costs from 50 to 90 percent over a four-lane divided highway on new alignment.

Application

Shared four lane facilities may be considered as a cross-section alternative for all high speed rural highways with moderate volumes. This design can be used on new alignment or retrofitted on existing alignment, specifically on existing "Super 2" Designs.

Application of the shared four lane facilities on roadways with low speed curves should be approached cautiously. As the shared four-lane cross section will increase travel speed and encourage passing, geometric deficiencies should be reviewed to ensure they are adequate for the anticipated operation or improved to match the design speed of the facility.

It is recommended that a shared four lane facility be considered as the ultimate design for roadways having a design year volume of 15,000 ADT or less. For roadways with design year volumes of 15,000 to 20,000 ADT it is recommended that shared four lanes be considered as the initial design and that right of way be purchased to ensure the potential expansion to a full four lane facility. Passing lanes lend themselves to staged construction, which is less dependent on the accuracy of traffic forecasts. If a large increase in traffic volume that has been forecast never materializes, the ultimate 4-lane section need not be built. Typically highways with a design year volume less than 5000 ADT would not see a benefit from a shared four lane facility over a two-lane roadway.

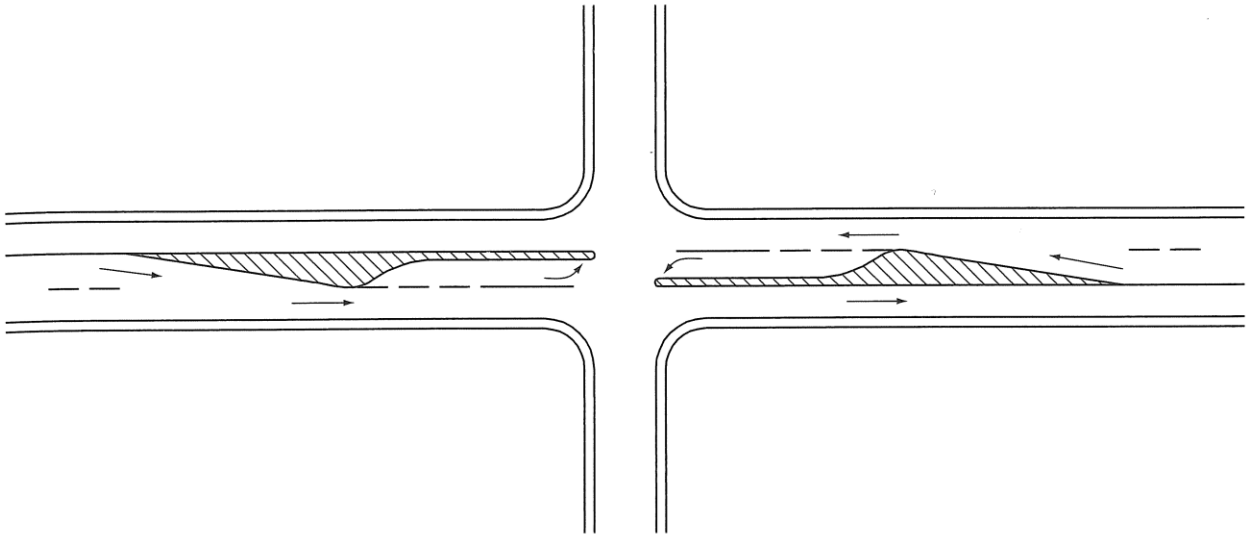
Shared four lane facilities have the potential to increase travel speeds on long roadways connecting major activity centers or towns. However, the concept may also be used on shorter roadways with the minimum length determined by the required passing zone length for a single section. A minimum passing lane length of 0.5 miles is recommended.

Shared four lane highways may be used on all access control categories at the discretion of the project team.

Access Control

It is recommended shared four lane roadways be designed to eliminate left turns within the first 1000 feet of the start of the passing lane, as this area is the most prone to higher speeds and overtaking maneuvers. On highways with access controlled by permit it is recommended that major intersections or access points be placed at the passing zone transition zones to minimize the volume of turning traffic where passing is encouraged and so that auxiliary turn lanes may be readily accommodated (see Figure 2). Where the presence of higher-volume intersections and driveways cannot be avoided, special provisions for turning vehicles, such as exclusive left-turn lanes, are to be considered.

Figure 2: Passing Lane Transition at Major Intersections (source: AASHTO Green Book)



For some projects, the purchase of access rights from adjacent properties should be considered. This approach can be used to create full control of access between major intersections and improve long term safety of the corridor. If access rights are purchased, alternate access to the public street system should be provided to the affected properties.

Traffic Analysis

No special traffic engineering analysis, beyond those detailed in Design Memo 03-11, Traffic Engineering Analysis for Design, are required for the use of a shared four-lane facility.

Design

The location, length and transition of each passing lane should be determined by the project team through careful examination of geometric, operational and site specific factors. These factors include:

- Grades are to be considered when choosing which side to install the passing lane.
- Preference for passing is normally given to the departing traffic from an incorporated area. Providing access in this manner provides passing opportunities as traffic leaves congested areas and can serve as a traffic calming measure for traffic entering the lower speed area.
- Passing maneuvers should be located away from major intersections to decrease the probability of speed differentials between turning and passing traffic.
- Passing lanes work most effectively if the majority of drivers enter the right lane at the lane transition and use the left lane only when passing a slower vehicle. Thus the

geometric design of the lane addition transition should encourage drivers to enter the right lane.

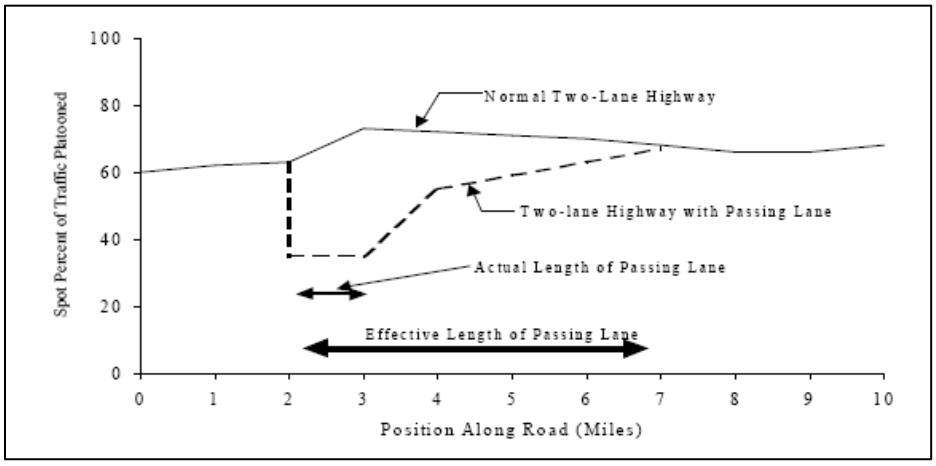
A key to the effective operation of the shared four lane facility is to utilize longer passing lane lengths than are typically applied for truck climbing lanes or other auxiliary lane configurations. The utilization of longer passing lane lengths and the repeated use of passing lanes in each direction, can diminish the high speed differential and aggressive driving patterns typically seen with truck lane usage. A minimum passing lane length of 0.5 miles is recommended as lengths less than 0.5 miles are not effective in reducing vehicle platooning. Table 1 below summarizes the optimum passing lane lengths based on the directional flow rate of the roadway.

Table 1: Optimum Passing Lane Length

Directional flow rate (pc/h)	Passing lane length (mi)
<400	≥0.5-0.75
<700	≥0.75-1.00
≥700	>1.00-2.00

It should be noted that passing lanes can have an effective length greater than their physical length, where platoons are reduced up to 6 miles beyond the passing lanes (see Figure 3 below). This allows sections of shared four lane roadways to reduce the overall number of lanes to two for extended lengths to fit site constraints, without significantly impacting the level of service of the roadway.

Figure 3: Effective Length of Passing Lanes (source HCM2010)



The transitions which initiate or terminate the passing lane should be located where the change is in full view of the driver. Two types of transitions are present in the design. A “critical” transition is one located immediately downstream of a lane drop. It is called “critical” because vehicles in the middle lane are heading toward each other before merging into the right lane; therefore, a substantial buffer between the vehicles traveling in opposite directions is needed. A 100 m (320 foot) buffer between the end of each lane drop is recommended by the Green Book. A “noncritical” transition is one located immediately upstream of a lane addition. Transitions upstream of a lane addition are not as critical as those downstream of a lane drop because vehicles in the middle lane are heading away from each rather than toward each other.

Lane drops and additions should be designed in accordance with the latest edition of the Greenbook. Examples of critical and non-critical lane transitions are shown in Figures 4 and 5, respectively.

Figure 4: Critical Lane Transition (source: AASHTO Green Book)

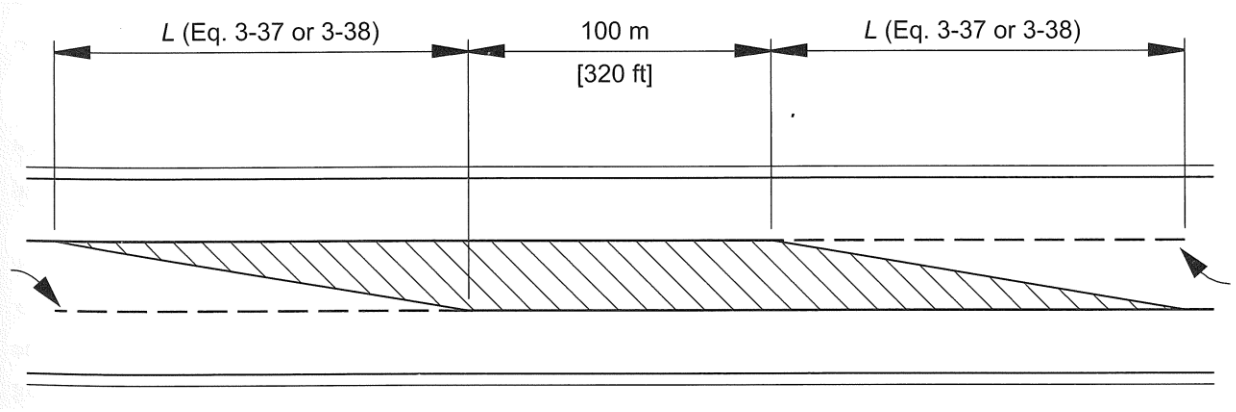
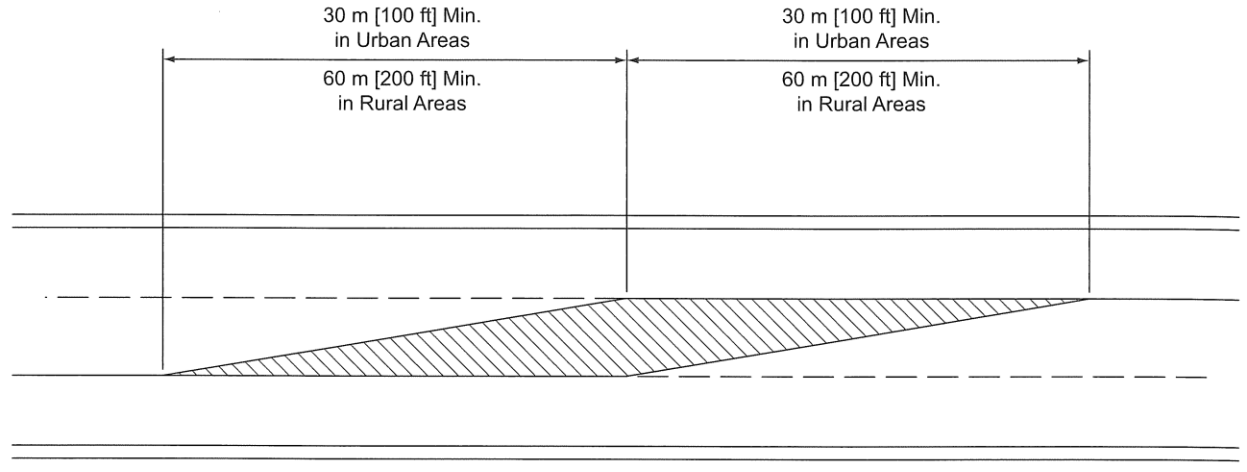


Figure 5: Non-Critical Lane Transition (source: AASHTO Green Book)



Typical Section

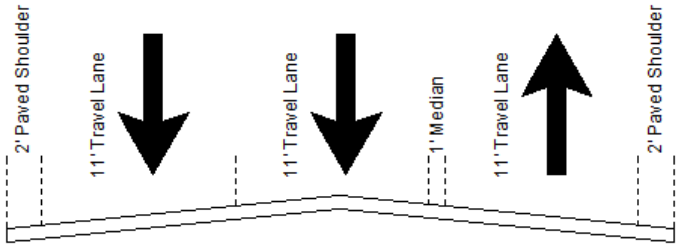
Passing lanes can operate effectively with no separation between opposing lanes of travel. However, some separation is desirable. A flush median separation of 4 ft. between the opposing directions of travel is preferred, where feasible. Centerline rumble strips are recommended on all shared four lane facilities whether a median is present or not.

The location of the crown is perhaps one of the more complicated design issues on shared four-lane roadways. Where an existing two-lane highway is restriped or widened to become a shared four-lane road, the crown may be placed within the traveled way. An existing highway may also be widened on one side only, with the result that the crown is located at a lane line. For new construction, it is recommended that the crown be placed at a lane boundary. If it is necessary to transition the crown point along the roadway, it is recommended that this transition be done along the lane drop or lane addition tapers. There is no indication of any difference in crashes between placing the roadway crown at a lane boundary or placing it within a lane. See Figures 6 and 7 for recommended crown locations.

Superelevation should be handled no differently on a shared four lane road than on a comparable two-lane or four-lane undivided road.

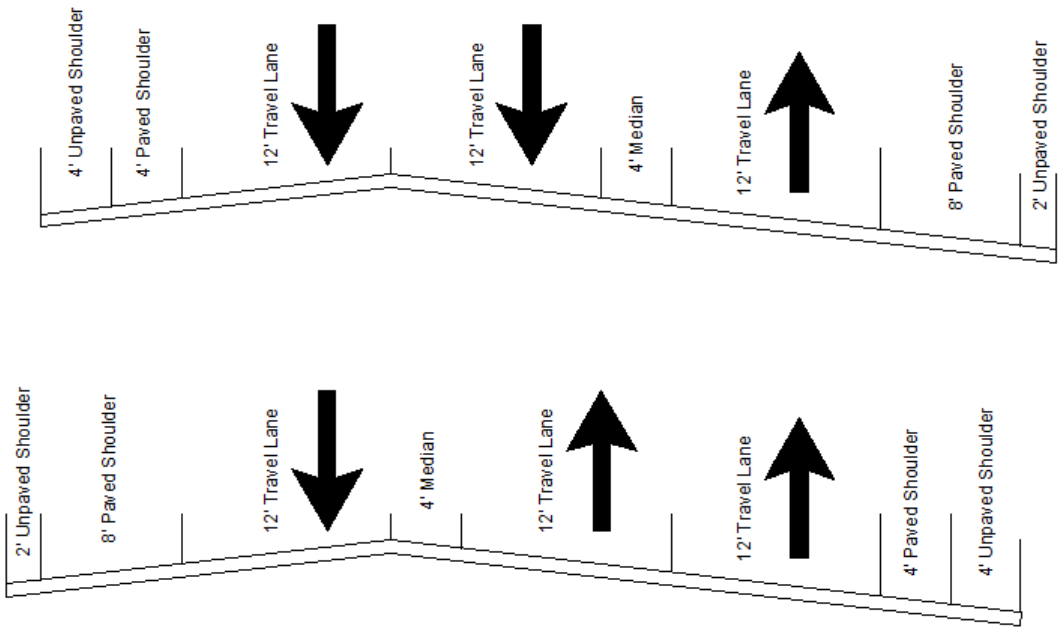
The minimum recommended typical section for a shared four-lane facility is 38 feet of pavement width (See Figure 6). The minimum section would utilize 11 foot lanes and 2 foot paved shoulders. This section width can be used to retrofit existing Super two-lane roadways.

Figure 6: Minimum Recommended Typical Section (38 feet)



For new construction and high-speed/high volume designs, a wider cross section is recommended. The ideal typical section is shown in Figure 7. This section utilizes full 12 foot lanes, a 4-foot flush median and wide shoulders. Note, the use of narrower shoulders is recommended adjacent to the passing the lane.

Figure 7: Ideal Typical Section (58 feet)



When site or budget constraints dictate a narrower cross section than detailed in Figure 7, the project team should determine the where cross section element reductions should be made based on traffic volumes, roadside conditions, geometric alignments and existing crash problems if applicable.

It is desirable to hold a consistent typical section throughout the project, however, individual elements may be reduced or the passing lane eliminated for short sections such as structures or extensive cut sections, where doing so would provide significant cost savings.

Traffic Control

Traffic control plans for shared four-lane facilities should be coordinated with the Division of Traffic Operations and be developed in compliance with the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD).

Public Involvement

Due to the unique design features of the shared four-lane facility, additional public involvement activities are encourage to demonstrate the benefit of the proposed design and to educate the public on its intended use.