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CHAPTER FIFTY-FOUR

GEOMETRIC DESIGN OF EXISTING FREEWAY (3R) OR (4R) PARTIAL RECONSTRUCTION

54-1.0 GENERAL

54-1.01 Background

The Department began construction of its freeway system in the 1950s and, today, the Indiana system has been completed. The freeway system has introduced a level of mobility and safety for the traveling public which was unattainable without its special features, such as full control of access, wide roadway widths, and higher design speeds.

The freeway system requires periodic repair and upgrading which exceeds the limits of normal maintenance. Such a capital improvement is defined as a 3R project (resurfacing, restoration, and rehabilitation), partial-reconstruction (4R) project, or full-reconstruction (4R) project. This Chapter discusses the Department's design criteria for a 3R or partial 4R reconstruction project on a freeway. These criteria meet or exceed the criteria described in AASHTO's *A Policy on Design Standards - Interstate System* and AASHTO's *A Policy on Geometric Design of Highways and Streets*. A full-reconstruction project should be designed in accordance with the criteria described elsewhere in this *Manual*.

54-1.02 Applicability

54-1.02(01) Freeway Definition

Within the functional-classification system, a freeway is the highest level of arterial. Such a facility is characterized by full control of access, divided roadways, high design speed, and a high level of driver comfort and safety. Each Interstate highway as well as any other route with full control of access is classified as a freeway (e.g., US 31 around South Bend, SR 912 in Lake County, Airport Expressway in Indianapolis). See Section 40-1.0 for more information on the functional-classification system and the role of the freeway within the system.

54-1.02(02) Project Scope of Work

Section 40-6.01 defines the typical types of improvements that are made on a 3R or reconstruction project on the National Highway System (NHS). The following provides an overview of what may represent a 3R freeway project or a freeway reconstruction project. For a more in-depth description, the designer should review Section 40-6.01. For a freeway, the distinction between 3R, partial reconstruction, and complete reconstruction can be summarized as follows:

1. 3R Project. A 3R freeway project may include the improvements as follows:

    a. pavement resurfacing;

    b. full-depth pavement reconstruction, if the reconstructed pavement area is 30% or less of the traveled way;

    c. widening existing travel lanes or shoulders;

    d. upgrading the structural strength of shoulders;

    e. improving the superelevation of existing horizontal curves;

    f. adding auxiliary lanes;

    g. improving roadway delineation;

    h. upgrading roadside safety;

    i. increasing the length of acceleration and deceleration lanes at an interchange;

    j. widening an existing bridge as part of a bridge reconstruction project;

    k. upgrading or replacing bridge railings;

    l. overlaying bridge decks;

    m. preservation of bridge substructures;

    n. improving roadside drainage;

    o. widening existing ramps;

    p. flattening horizontal or vertical curves; or

    q. increasing the vertical clearance at underpasses.

2. Partial-Reconstruction (4R) Project. A partial-reconstruction (4R) freeway project may include the improvements as follows:

   a. more than 30% of the travelway pavement area must be removed and replaced,

   b. a concrete overlay of a least 6 in. is required, or an asphalt overlay of at least 8 in. is to be placed;

   c. the facility cannot adequately accommodate the current or projected (10-year) traffic demand and additional lanes are necessary;

   d. major revisions are necessary to the existing horizontal and vertical alignment requiring that more than 30% of the travelway pavement must be replaced;

   e. total bridge or bridge-deck replacement is required;

   f. bridge-deck widening is necessary due to added travel lanes on the approaches; or

   g. interchange upgrading is required to meet current and projected (20-year) traffic demands.

3. Complete-Reconstruction (4R) Project. A freeway improvement is considered to be a complete reconstruction if the project intent is to replace the existing facility. Complete reconstruction will typically provide significant improvements in level of service, operational efficiency, and safety. For a complete-reconstruction project, the criteria described in Chapter Fifty-three should be used.

54-1.03 Objectives

The basic objective of a 3R/partial 4R freeway project is to improve the freeway's serviceability to meet future demands by extending the service life of the existing facility and enhancing highway safety. This objective applies to all aspects of the freeway's serviceability. If a project is classified as a partial 4R project, an additional objective, where practical, is to upgrade existing elements to new-construction criteria. For example, where the pavement is to be replaced, it may be practical to improve the horizontal or vertical alignment.

54-1.04 Approach

A 3R/Partial 4R freeway project is most-often initiated to make a specific improvement to the freeway (e.g., resurfacing or roadside-safety improvements). The Department's policy is to review and upgrade other design elements, wherever practical. The Department's 3R/partial 4R approach is summarized as follows.

1. <u>Nature of Improvements</u>. Identify the specific improvements intended for the project. The designer should review Section 54-1.02(02) for typical freeway-project improvements.

2. <u>Numerical Criteria</u>. The criteria are based on AASHTO *A Policy on Design Standards - Interstate System* and the AASHTO *Policy on Geometric Design of Highways and Streets*, new construction/reconstruction criteria for a freeway. Sections 54-2.0 through 54-6.0 provide the 3R/partial 4R freeway criteria. Unless stated in this Chapter, the freeway-design criteria described elsewhere in this *Manual* should be incorporated where practical.

3. <u>Secondary Impact</u>. Identify and evaluate any secondary impact which may be precipitated due to the freeway improvement. Examples are as follows:

   a. the installation of a median barrier may restrict horizontal sight distance;
   b. a pavement overlay may reduce the vertical clearance requirements under a bridge;
   c. a pavement overlay may require the adjustment of roadside-barrier height.

4. <u>Other Improvements</u>. Identify geometric design deficiencies within the project limits which can be practically corrected without exceeding the intended project scope of work. A review of the accident history is important in conducting this evaluation.

5. <u>Design Exception</u>. The discussion in Section 40-8.0 on design exceptions applies to the geometric design of a 3R/partial 4R freeway project. However, the designer should evaluate the proposed design against the criteria described in this Chapter. The need for a design exception should be based on the minimum AASHTO Interstate System criteria that were in effect at the time of original construction or when the facility was incorporated into the Interstate system. These design elements include the following:

   a. horizontal alignment, except superelevation;
   b. vertical alignment;
   c. shoulder widths; and
   d. median width.

<u>54-1.05 3R or Partial 4R Project Evaluation</u>

Sections 54-2.0 through 54-6.0 provide the specific geometric design and roadside-safety criteria which will be used to determine the design of a 3R/partial 4R freeway project. The following should also be evaluated as described below.

1. Accident Experience. The historical accident data within the project limits should be evaluated. Accident data is available from the Office of Environmental Services. Section 55-8.0 further describes the Department's accident-analysis procedure.

2. Existing Geometrics. The designer will review the as-built plans and combine this review with the field review and field survey (if conducted) to determine the existing geometrics within the project limits. This includes lane and shoulder widths, horizontal and vertical alignment, interchange geometrics, and roadside-safety design.

3. Physical Constraints. The physical constraints within the project limits will often determine what geometric improvements are practical and cost-effective. These include topography, adjacent development, available right of way, utilities, or environmental constraints (e.g., wetlands).

4. Field Review. The designer will conduct a thorough field review of the proposed project. Other personnel should attend the field review as appropriate, including personnel from the district traffic, maintenance, and construction offices. The objective of the field review should be to identify potential safety hazards and potential safety improvements to the facility.

5. Pavement Condition. A 3R/Partial 4R project is programmed because of a significant deterioration of the existing pavement structure. The extent of deterioration will determine the necessary level of pavement improvements, which may include milling of the existing pavement surface or replacement of the pavement. This decision will also influence the extent of practical geometric improvements. For a freeway to be eligible for pavement resurfacing or replacement, the pavement should exhibit one or more of the conditions as follows:

    a. alligator cracking;
    b. bleeding;
    c. block (cracking);
    d. bump (upheaval);
    e. corrugation;
    f. depression and rutting;
    g. edge cracking;
    h. longitudinal or transverse cracking;
    i. patching or utility cut;
    j. polished aggregate;

k. potholing;
l. slippage-cracking; or
m. weathering and raveling.

Pavement resurfacing or replacement will be based upon the design-year traffic data, at 10 years for resurfacing or 20 years for reconstruction. The pavement surface should be designed to incorporate skid resistance.

6. Geometric Design of Adjacent Highway Sections. The designer should examine the geometric features and operating speeds of the freeway sections adjacent to the project. This will include investigating whether or not highway improvements are in the planning stages. The project should provide design continuity with the adjacent sections. This involves a consideration of factors such as driver expectancy, geometric design consistency, and proper transitions between sections with different geometric designs.

7. Early Coordination for Right-of-Way Acquisition or Utilities Coordination. Significant right-of-way acquisitions are typically outside the scope of a 3R/partial 4R freeway project. However, the field review and accident or speed studies may indicate the need for selective safety improvements or other minor operational improvements which will require right of way purchases (e.g., interchange improvements). Therefore, the designer should, as early as feasible, determine the improvements which will be incorporated into the project design and initiate the right-of-way acquisition process.

8. Maintenance and Protection of Traffic. For work on an existing alignment, maintenance and protection of traffic during construction should be considered in project development. The protection of construction workers should also be considered. The designer should see Part VIII for criteria on the design of a work zone for traffic accommodation.

9. Traffic-Control Devices. Signing and pavement markings should be in accordance with Part VII and the *Manual on Uniform Traffic Control Devices* (MUTCD). The Highway Operations Division's Office of Traffic Engineering is responsible for selecting, locating, and analyzing the adequacy of breakaway or yielding sign or light supports. However, the designer should work with the Office of Traffic Engineering to identify possible geometric and safety deficiencies which will remain in place (i.e., no improvement will be made). The Office of Traffic Engineering will then determine if additional signing, traffic-control devices, or delineation treatments are warranted.

10. Documenting the Design Process. The Office of Environmental Services will prepare the Engineer's Report which will address the following:

a. existing geometric and roadside features, traffic volumes and speeds, and accident history;

b. applicable minimum design criteria;

c. specific safety problems or concerns raised as a result of a review of accident data, by a field inspection, or by the public;

d. design options for correcting safety problems and the cost, safety, and other relevant impacts of these options;

e. proposed exceptions to applicable design criteria and the rationale to support the exceptions; and

f. the recommended design proposal.

The Office of Environmental Services will identify design exceptions that will be required. The designer will be responsible for the preparation of a design-exception request (See Section 40-8.0).

54-2.0 TABLE OF 3R OR PARTIAL 4R FREEWAY GEOMETRIC-DESIGN VALUES

Figure 54-2A provides the Department's criteria for the design of a 3R or partial 4R freeway project for either a rural or an urban area. The designer should consider the following in the use of the table.

1. *Design Manual* Section References. The designer should review the appropriate section references for greater insight into the design elements.

2. Footnotes. The table includes footnotes which are identified by a number in parentheses, e.g., (6). The information in the footnotes is critical to the proper use of the table.

3. Controlling Design Criteria. Controlling design criteria are identified with an asterisk. The designer should evaluate the proposed design against the criteria shown in the table and elsewhere in this Chapter.

4. Design Exception. These standards are for use on an existing freeway including that on the National Highway System. They are to be used for each project that is classified as 3R or partial reconstruction regardless of funding source. Deviation from controlling design criteria should be addressed in an approved design exception. Operational or maintenance changes, permanent or temporary, exclusive of work-zone traffic control that create substandard conditions such as by re-striping to obtain added lane(s) by reducing existing lane widths or shoulders, must be addressed in a design exception whether or not actual construction or reconstruction is involved.

54-3.0 GEOMETRIC DESIGN

Though Figure 54-2A provides the required geometric-design criteria, the designer must still make certain decisions, such that some flexibility can be applied. These are discussed below.

The design criteria used for horizontal alignment excluding superelevation, vertical alignment, and width of median or shoulders may be the AASHTO Interstate System criteria that were in effect at the time of the route's original construction or inclusion into the Interstate System.

54-3.01 Design Controls

54-3.01(01) Traffic-Volume Analysis

1. Design Life. The pavement-resurfacing portion of a 3R project should be designed using a 10-year design life. All other elements should have a design life of 20 years beyond the expected construction date.

2. Level of Service (LOS). Figure 54-2A provides the desirable and minimum LOS criteria. The geometric-design elements should be designed to be in accordance with the level-of-service criteria for a design hourly volume at 20 years beyond the expected completion date.

3. Traffic Data. The designer should obtain the necessary traffic data from the Office of Environmental Services. This should include current and future (10 and 20 years) AADT, DHV, percent of trucks and buses (including that for each interchange), accident data for the most recent 3-year period, and any known future traffic impact.

4. Capacity Analysis. The analytical techniques in the *Highway Capacity Manual* and Chapter Forty-one will be used to conduct the capacity analysis.

54-3.01(02) Design Speed

Chapter Fifty-three provides the Department's criteria for selecting the design speed for a new construction or complete 4R freeway project. These will also apply to a 3R/partial 4R freeway project. As a minimum, the design speed for the original work may be used. Under restricted urban conditions, the existing posted speed limit may be used as the design speed.

The design speed selected must equal or exceed the existing posted speed limit or a design exception will be required. See Section 40-4.0 for additional information on design speed.

54-3.02 Horizontal and Vertical Alignment

Unless the specific objective of the freeway project is to improve one or more horizontal- or vertical-alignment features, the existing alignment will be acceptable under the conditions as follows:

1. the design is in accordance with the AASHTO Interstate System criteria that were in effect at the time of the route's original construction or inclusion into the Interstate system; and

2. a review of the accident history for the past three years does not indicate a problem.

Once the decision has been made to reconstruct a horizontal- or vertical-alignment feature, the designer should apply the criteria described in Chapter Forty-three or Forty-four.

54-3.02(01) Superelevation

On a horizontal curve where the existing radius will be retained, it may be necessary to make improvements to the superelevation. This may require revising the pavement-resurfacing thickness to meet the superelevation criteria described in Sections 43-2.0 and 43-3.0. Where the pavement structure will be reconstructed, the superelevation design should be in accordance with the new construction criteria described in Sections 43-2.0 and 43-3.0.

54-3.02(02) Grades

The maximum grades are shown in Figure 54-2A.

54-3.02(03) Vertical Clearance

The minimum vertical clearance is 16 ft over the entire roadway including the usable shoulder widths for both the left and right shoulders. If practical, the 16-ft clearance should be provided at each overpass within the project limits. If the 16-ft clearance cannot be obtained, a design exception will be required. However, for the routes in Marion County listed below, an existing overpass with a vertical clearance of at least 14 ft may be retained without a design exception.

1. I-65 from I-465 South to I-465 North;
2. I-70 from I-465 East to I-465 West; and
3. I-465 from I-69 Westward to I-65 North.

A low-clearance warning sign should be provided for each structure with a vertical clearance of less than 14.5 ft.

54-3.03 Cross Section

54-3.03(01) Lane and Shoulder Width

Each travel-lane or shoulder width not in accordance with Figure 54-2A should be evaluated for widening.

1. Travel Lane. The width of each travel lane or auxiliary lane should be 12 ft.

2. Shoulder. Existing shoulder widths may be retained if they are in accordance with the AASHTO Interstate System criteria in effect at the time of the route's original construction or inclusion into the Interstate system.

54-3.03(02) Curbs

1. Safety Considerations. All existing curbs should be removed for safety reasons, unless they are required for drainage.

2. Type. If curbing is required for drainage, only sloping curbs will be permitted.

3. Guardrail. A curb in front of a guardrail may cause an errant vehicle to vault over or break through the barrier. Where guardrail is used and curbing is necessary for drainage, the maximum curb height should be 4 in. and should be placed behind the front face of the guardrail.

54-3.03(03) Median

1. Width. The existing width should be retained.

2. Parallel Slopes. Existing slopes of 4:1 or flatter should be retained. If existing slopes are flattened, the designer should consider the effect on drainage within the median.

3. Transverse Slopes. Transverse slopes for ditch checks or median crossovers should be 10:1 or flatter.

4. Median Opening. See Section 54-6.0 for information.

54-3.03(04) Fill or Cut Slope

1. No Roadway Widening. An existing slope of 2:1 or flatter should be retained. However, a slope steeper than 4:1 should be evaluated for flattening.

2. Roadway Widening. If the lanes or shoulders are widened as part of the project, this will produce a steeper fill slope or ditch foreslope (assuming the toe of fill slope or toe of backslope remains in the same location). The roadside design should be modified to provide a configuration which is the same as or flatter than the roadside cross section before the project limits. As a minimum, the following will apply.

    a. Embankment slope. A fill slope or ditch foreslope beginning at the shoulder break should not be steeper than 4:1 unless steeper slopes can be justified in an engineering and economic analysis. If the slope can be made flatter than 4:1, the designer should desirably provide a 6:1 slope at least within the clear zone.

    b. Ditch. If right of way is available, the existing ditch line should be moved outward and the slopes flattened as much as practical. A drainage ditch within the clear zone should be regraded as much as practical to make it traversable for an errant vehicle. See Section 49-3.02 for information on a traversable ditch.

    c. Embankment Stability. Stable embankment material is required. Sod or other appropriate materials or methods should be provided where erosion may be considered a problem.

3. Roadside Safety. Upgrading the roadside safety is often an objective of the project. The designer should consider the safety benefits of flattening fill or cut slopes to eliminate guardrail and, as a minimum, to be in accordance with Item 2 above. An evaluation of run-off-the-road accidents will assist in the assessment (see Chapter Fifty). See Section 54-4.0 for more information on roadside-safety criteria.

54-3.03(05) Right of Way

Where practical, additional right of way should be secured to permit cost-effective geometric and roadside-safety improvements.

54-3.03(06) Interchange

The project may include proposed work on an interchange. This work will only include selective improvements to the interchange geometrics. This may include lengthening acceleration or deceleration lanes, clearing the gore area, correcting the ramp superelevation, etc. The designer should consider the following.

1. Desirable. The criteria provided in Chapter Forty-eight should be used to design each interchange element which will be improved as part of the freeway project.

2. Minimum. The criteria provided in the AASHTO *A Policy on Geometric Design of Highways and Streets* may be used as the minimum design where INDOT's criteria exceed AASHTO's. For example, Figures 54-3A and 54-3B may be used to determine deceleration distance for a freeway exit instead of INDOT's standard 1000-ft length.

3. Acceleration or Deceleration Lane. Only a parallel ramp exit or entrance should be used; see Section 48-4.0. If converting a taper design to the preferred parallel design, the existing taper portion that is less than 12 ft wide should be removed and reconstructed to provide the full 12-ft width for the entire acceleration or deceleration length.

4. Ramp Shoulder. Under restrictive conditions, an existing right-hand-side shoulder width of 7.5 ft may be retained.

54-4.0 ROADSIDE SAFETY

The project should be evaluated for potential roadside-safety improvements within the project limits. The criteria described in Chapter Forty-nine will apply to the evaluation. This includes roadside clear zone, barrier warrants as shown in Figure 49-4G(1), barrier design, and drainage features.

Not all 2:1 fill slopes or foreslopes will require the use of guardrail. The designer first should conduct a cost-effective analysis based on traffic volume, design speed, accident frequency, accident cost, accident severity, installation costs, and repair costs to determine if guardrail is necessary. Section 49-11.0 provides information on the AASHTO computer software program entitled ROADSIDE, which should be used for the cost-effectiveness analysis.

54-5.0 BRIDGES

54-5.01 General

Figure 54-2A provides the Department's criteria for structural capacity and width for a new or reconstructed bridge, or for an existing bridge to remain in place. An existing bridge may remain in place if it meets, or is upgraded to meet, the structural and geometric requirements described in

Figure 54-2A and Section 54-5.02. Upgrading a bridge to be in accordance with these criteria may be considered if an engineering analysis determines that the upgrading is appropriate. Some of the items that should be considered in the analysis include the following:

1. remaining service life;
2. sufficiency rating;
3. traffic volume;
4. clear-roadway width;
5. design speed; and
6. accident records.

If it is determined that a bridge should be replaced or undergo major reconstruction (e.g., replacing superstructure, widening superstructure or substructure), the design will be in accordance with the AASHTO LRFD criteria and load-carrying capacity (see Part VI).

54-5.02 Bridge To Remain In Place

An existing bridge should be evaluated for possible upgrading or replacement (see Section 54-5.01), if it is not in accordance with the following.

1. Width. The width should be evaluated against the criteria shown in Figure 54-2A.

2. Structural Capacity. The structural capacity should be evaluated against the criteria shown in Figure 54-2A.

3. Vertical Clearance. An existing structure should provide at least a 16-ft vertical clearance over the entire roadway including the usable shoulder widths for both left and right shoulders. If it is necessary to retain a vertical clearance of less than 16 ft, a design-exception request is required as described in Section 40-8.0. However, Section 54-3.02 provides a list of routes foe which existing an overpass with a minimum 14-ft vertical clearance may be retained without a design exception.

4. Bridge Railing. Only an existing bridge railing that have been proven to be acceptable through crash testing may be retained. Each new bridge-railing installation should in accordance with Section 61-6.01. Consideration should be given to widening the bridge at the same time the railing is replaced to achieve the full approach-roadway width.

5. Approach-Barrier Transition. An approaching barrier transition should be in accordance with Chapter Forty-nine and the INDOT *Standard Drawings*.

54-6.0 MEDIAN OPENING

On a fully access-controlled freeway, median crossing is denied to the public. However, an occasional median opening or emergency crossover is required to accommodate maintenance, snowplowing, or emergency service vehicles.

54-6.01 Guidelines

A median crossover should be placed away from a mainline conflict, such as an interchange. The number and location of median crossovers should be kept to a minimum.

1. Spacing. A median opening may be provided if it is in accordance with the spacing requirements as follows:

   a. A median crossover may be provided approximately half way between teo interchanges if the spacing between them is greater than 3 mi but less than 4 mi.

   b. Multiple crossovers may be provided such that the distance between each crossover or interchange is not greater than 3 mi if the spacing between interchanges is greater than 4 mi.

2. Jurisdiction. A median crossover may be appropriate at a State line or a division line between districts or subdistricts.

3. Urban. A crossover should not be located in an urban area or an area with a narrow median.

4. Interstate-Route Usage. Section 54-6.04 provides a listing of the FHWA-approved crossover sites on the Interstate System.

5. Rest Area or Weigh Station. A crossover should be located at least 1500 ft from the end of the exit or entrance ramp taper for a rest area or weigh station.

54-6.02 Implementation

If warranted as discussed in Section 54-6.01, each new crossover on an existing facility should be in accordance with 54-6.03. The addition of a median crossover, either during construction or after the highway is in use, requires the approval of the Chief Engineer and concurrence from the FHWA.

54-6.03 Design

The INDOT *Standard Drawings* provide the criteria for the design of a freeway crossover. The designer should also consider the following.

1. Interchange or Lane Drop. A crossover should be at least 1500 ft from the terminus of an exit ramp, entrance ramp, or lane drop.

2. Overhead Structure. A crossover should be located at least 1500 ft from a structure crossing over the freeway.

3. Sight Distance. Because of unexpected nature of a U-turn maneuver, adequate sight distance should be available at a crossover. Decision sight distance should be provided in both directions. This would favor, for example, placing the crossover in a sag vertical curve. The minimum stopping sight distance should be provided.

4. Median Barrier. A crossover should be avoided where a median barrier is present. If a crossover must be provided, the barrier should be flared as shown in Figure 54-6A, or terminated with an appropriate end treatment as discussed in Chapter Forty-nine. The width of the opening should not be greater than 35 ft.

6. Horizontal Curve. A crossover should not be located within a curve requiring superelevation.

7. Pavement. The crossover pavement will be constructed with an asphalt surface of sufficient strength to accommodate the largest expected vehicle (e.g., fully loaded dump truck, fire truck). See Chapter Fifty-two.

8. Drainage. A crossover should be located such that an additional drainage structure would not be required. The designer should review the median drainage patterns to ensure that the median crossover will not negatively disrupt the median drainage (e.g., cause ponding in the median). If a culvert is required under the crossover, consideration should be given to providing inlets or culvert end sections which are in accordance with Section 49-3.03 and the INDOT *Standard Drawings*.

54-6.04 Location of Interstate-Route Crossover

The FHWA-approved sites for median crossovers on the Interstate system are listed in Figure 54-6B(64) for I-64, Figure 54-6B(65) for I-65, Figure 54-6B(69) for I-69, Figure 54-6B(70) for I-70, Figure 54-6B(74) for I-74, Figure 54-6B(94) for I-94, or Figure 54-6B(100) for the three-digitnumbered routes. The sites are listed according to district, reference marker, and location description.