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Section 4
SEISMIC DESIGN AND RETROFIT

4.1 GENERAL REQUIREMENTS

4.1.1 Purpose

Designers in applying seismic design criteria should be aware that the purpose of the AASHTO seismic design requirements is to minimize damage and prevent collapse. They are not intended to eliminate all damage.

This Section is intended to supplement the AASHTO Specifications for seismic design.

4.1.2 Acceleration Coefficient

The acceleration coefficient (A) used for determining the seismic loading is based on the Peak Ground Acceleration Maps in the AASHTO Specifications. The acceleration coefficients for Connecticut generally vary on these maps from 0.14 to 0.16. To provide uniformity of design, a value of 0.16 shall be used for all designs.

4.2 ANALYSIS REQUIREMENTS

4.2.1 Single Span Bridges

Seat width and restraint forces for single span bridges shall be calculated according to the AASHTO Specifications.

4.2.2 Bridges with Two or More Spans

4.2.2.1 “Regular” Bridges

Bridges classified as “Regular” as defined by the AASHTO Specifications and not classified as “critical” bridges by the Department are to be analyzed by either the Uniform Load Method or the Single Mode Spectral Method. The Uniform Load Method is the preferred method of analysis. Bridges classified as “critical” by the Department shall be analyzed by the Multi-Mode Spectral Method.

4.2.2.2 “Irregular” Bridges

Bridges classified as “not regular” as defined by the AASHTO Specifications are to be analyzed by the Multi-Mode Spectral Method.
4.2.2.3  **Special Cases**

For bridges that are not conclusively “Irregular” as defined by the AASHTO Specifications, it is the option of the designer whether to use the Single Mode or Multi-Mode Spectral Method for analysis.

The Multi-Mode Spectral Method may also be used where it is anticipated that the increased accuracy of this method would be advantageous in reducing seismic demands or retrofit needs.

4.3  **NEW BRIDGES**

4.3.1  **General**

All new bridges are to be analyzed and designed for seismic forces in accordance with the AASHTO Specifications using the load factor method or the load and resistance factor method except as amended in this Manual. Special attention should be given to the pier type selection since the piers are the primary load carrying members for seismic loads.

4.3.2  **Abutments and Wingwalls**

New abutments and wingwalls (excluding single span bridges) shall be designed for seismic forces. Abutments shall be designed for seismic forces transmitted from the superstructure and all seismic design criteria for retaining walls.

4.3.3  **Seismic Isolation Bearings**

Seismic isolation bearings may be used at bridge piers and abutments, where it can be demonstrated that the performance characteristics of the bearings will provide a necessary benefit for the design of the bridge substructures. The design of seismic isolation bearings shall be in accordance with the AASHTO Guide Specifications for Seismic Isolation Design.

4.4  **NEW RETAINING WALLS**

Except for certain conditions stated below, the Department waives the AASHTO requirements that retaining walls be designed for seismic induced lateral earth pressures and inertia effects.

Only walls meeting at least one of the following conditions shall be designed for seismic forces:

- A wall that is greater than 25 feet high and is supporting a major highway.
- A wall that is greater than 25 feet high and is in front of a sidewalk.
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- A wall located such that its collapse would endanger buildings or the lives of people.
- A wall supporting a multi-span structure (such as an abutment).

4.5 REHABILITATION OF EXISTING BRIDGES

4.5.1 General Requirements

In general, retrofit work on piers and abutments will not be required. Most retrofit work shall consist of providing lateral restraint at bridge bearings and providing adequate seat width.

The Department may require more extensive analysis and retrofit for major bridges, or if a unique situation exists such as a multi-level structure. The decision to include seismic retrofit of piers and abutments for these structures will be made on a case-by-case basis by the Department. For these cases, the designer shall use the load factor method for the analysis and design.

Actual implementation of corrective measures on bridge rehabilitations will be dependent on the cost, practicality of the modification, seriousness of the shortcoming, and the importance of the bridge.

4.5.2 Bridge Deck Patching Projects

All bridge rehabilitation projects that only include patching of the bridge deck need not be analyzed for seismic forces.

4.5.3 Bridge Widening Projects

4.5.3.1 Widenings \( \leq 25\% \)

All bridge rehabilitation projects where the widened portion of the cross section is less than 25% of the total width of the completed bridge will generally not require analysis for seismic forces.

4.5.3.2 Widenings \( > 25\% \)

All bridge rehabilitation projects where the widened portion of the cross section is greater than or equal to 25% of the total width of the completed bridge shall be designed for seismic forces.

The preliminary design of the new portions of the substructure shall be based on all AASHTO loading conditions with the exception of seismic forces. Once the preliminary design is complete, the entire structure shall be analyzed for seismic forces. If deficiencies are found in the existing structure, the designer shall investigate the following alternatives:
• Retrofit of existing substructures and design of new foundations for seismic forces.

• Strengthen and stiffen the new foundations to carry a larger portion of the seismic forces.

• Reduce the seismic forces in the foundations through the use of seismic isolation bearings.

• If the costs of any of the preceding alternates are excessive, or if the deficiencies are not significant, the new substructures should be designed for non-seismic forces only.

The decision to implement needed retrofit work for the existing as well as new portion of the structure must be determined on an individual basis for each bridge based on factors such as retrofit cost and seriousness of the deficiencies.

If new columns are designed for non-seismic forces only, the detailing of the confinement reinforcement shall be according to seismic provisions in the AASHTO Specifications for Performance Category B.

4.5.4 Superstructure, Deck or Bearing Replacement Projects

All bridge rehabilitation projects that include replacement of the superstructure, bridge deck, or bridge bearings are to be analyzed for AASHTO seismic forces. The method of analysis should involve modeling the entire structure. For most cases, the piers can be assumed to be fixed at the top of the footings.

In general, seismic retrofit work shall be limited to correcting deficiencies in support length and providing adequate restraint for seismic forces at bearings. No retrofit will be required for the bridge substructures.

4.5.5 Superstructure Replacement Projects with Widening > 25%

On projects where the bridge superstructure is to be replaced along with being widened, the completed bridge shall be designed for seismic forces. On existing multi-span structures, the designer shall investigate eliminating deck joints by making spans continuous.

The preliminary design of the new portions of the substructure shall be based on all AASHTO loading conditions with the exception of seismic forces. Once the preliminary design is complete, the entire structure shall be analyzed for seismic forces. If deficiencies are found in the existing structure, the designer shall investigate and compare construction costs for the following alternatives:
• Retrofit of existing substructures and design of new foundations for seismic forces and any additional loads induced by the elimination of simple spans.

• Strengthen and stiffen the new foundations to carry a larger portion of the additional seismic and non-seismic forces.

• Reduce the additional forces in the foundations through the use of seismic isolation bearings.

• Replace the entire structure, including foundations taking advantage of longer, continuous spans.

The decision to implement needed retrofit work for the existing as well as new portion of the structure must be determined on an individual basis for each bridge based on factors such as retrofit cost and seriousness of the deficiencies. It may be more prudent and cost effective to replace the structure in its entirety.

If new columns are designed for non-seismic forces only, the detailing of the confinement reinforcement shall be in accordance with the seismic provisions in the AASHTO Specifications for Performance Category B.

4.5.6 Retrofit Guidelines

The following two FHWA reports should be used as a guide for seismic retrofit of bridges:

• Report No. FHWA-IP-87-6, “Seismic Design and Retrofit of Highway Bridges”

4.5.7 Seismic Isolation Bearings

Seismic isolation bearings may be used for bridge rehabilitation projects at piers and abutments, where it can be demonstrated that the performance characteristics of the bearings will provide a necessary benefit for the design of the bridge substructures. The design of seismic isolation bearings shall be in accordance with the AASHTO Guide Specifications for Seismic Isolation Design.