20-12 SEISMIC DESIGN CRITERIA FOR BRIDGE WIDENINGS [1]

Definition

A bridge widening is defined as an increase of bridge deck width or modifications to the sidewalk or barrier rails of an existing bridge resulting in significant mass increase or structural component changes. Bridge widening projects are common due to the increase in traffic and safety demands on existing routes.

Bridges in close proximity may influence each other during earthquakes. Should a widening be constructed immediately adjacent to or in close proximity with an existing structure, both the new and existing structures shall comply with the seismic design guidelines stated herein. Existing structures in close proximity to a new or widened bridge shall be considered in the seismic analysis as part of a complete bridge system.

In accordance with the Caltrans Seismic Design Criteria (SDC) and Memo to Designer (MTD) 20-1, a bridge widening is considered as an Ordinary Non-standard Bridge. However, the guidelines in the SDC and supplemental guidelines set forth hereto shall apply. A bridge widening project shall also comply with guidelines and requirements for stage construction, and for structures carrying public traffic, or over public traffic, if applicable[2].

Classifications of Bridge Widening Projects

Bridge widening projects are classified according to the scope of work as either Minor Modification or Major Modification projects.

Minor Modification Projects

A bridge widening project is classified as a Minor Modification project if all of the following conditions are met:

- Substructure bents are not modified and no new columns or piers are added, while abutments may be widened to accommodate the increase of bridge deck width.
- The net superstructure mass increase is less than 20% of the original superstructure mass.
- Fixity conditions of the foundations are unchanged.

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1 See MTD 9-3, "Widening Existing Bridges" on other requirements for bridge widenings.

2 See MTD 20-2, "Site Seismicity for Temporary Bridges and Stage Construction" and MTD 15-14 "Loads for Temporary Highway Structures" for seismic criteria related to temporary bridges, emergency bridges, and stage construction.

- There are no major changes of the seismicity of the bridge site that can increase seismic hazard levels or reduce seismic performance of the structure since the initial screening or most recent seismic retrofit. Major changes in seismicity include, but are not limited to, the following: near fault effect, newly found faults, significant liquefaction potential, or lateral spreading.

If there are concerns about changes to the Design Spectrum at the bridge site, about a previous retrofit to the existing bridge, or an unusual imbalance of mass distribution resulting from the structure modification, the design project engineer should consult the Office of Earthquake Engineering Analysis and Research (OEEAR) or, for externally designed projects, the Structure Liaison Engineer for determining whether or not the widening can be considered as a Minor Modification.

Major Modification Projects

A bridge widening project is classified as a Major Modification project when the widening does not meet the criteria for Minor Modification projects.

Seismic Design for Bridge Widening Projects

Minor Modification Projects

Bridge widening projects classified as Minor Modification projects do not require either a seismic evaluation or a retrofit of the structure. If the conditions for Minor Modifications are met, it is anticipated that the augmented structure will not draw enough additional seismic demand to exceed the capacity of the existing sub-structure elements.

Any modification of the superstructure components, such as girder or deck, shall be designed with sufficient nominal strength and proper details to ensure that the load path of the seismic force due to additional mass to the existing substructure is adequate. For example, when a sliver widening includes a soundwall, the overhang and connecting reinforcement must be strong enough to resist the seismic overturning of the attached wall.

Major Modification Projects

For Major Modification projects, a seismic evaluation, analysis or retrofit design is required and the guidelines stated herein shall apply.

If the designer deems that an existing structure is seismically vulnerable, a seismic retrofit Strategy Meeting should be held following the Seismic Retrofit Guidelines specified in MTD 20-4.

The seismic retrofit of the existing structure shall conform to MTD 20-4, while the newly widened portions of the bridge shall comply with the SDC, except portions of SDC Section 1.1 and the balanced stiffness criteria as stated in SDC Section 7.1, which may be difficult to meet due to the existing bridge configuration. However, the design project engineer should strive for the best balanced frame stiffness for the entire widened structure that is attainable in a cost effective manner.

Seismic demands are based on the analysis of the entire widened structure as it is assumed that forces will be transmitted through the closure pour between the new and existing structures.

The seismic design strategy for Major Modification projects may be categorized into one of the following three categories:

Category I. The widened portion resists the horizontal seismic demands of the entire structure, while the original structure maintains its vertical load carrying capacity without collapse.

- This retrofit strategy may be considered when the columns and footings of the existing bridge do not conform to the current earthquake design criteria and cannot be practically rebuilt or upgraded.
- This strategy may be well suited when a bridge is widened on both sides and the total added width is relatively large compared to the deck width of the original structure. It may be feasible to design the earthquake restraining devices in the widened portion to carry the seismic demands of the entire structure. The nominal capacity of the restraining devices shall be used to resist the seismic demands in the design.
- This approach requires that the widening be adequately attached to the existing structure. Hinge restrainers and shear keys should be designed to resist the demands for the entire structure and limit the seismic demands on the existing bents to the acceptable level.
- The existing structure shall maintain its vertical load carrying capacity under the seismic displacement demands of the entire structure.

Category II. The widened portion and retrofitted original structure, in combination, resist the horizontal seismic demands of the entire structure.

- This retrofit strategy is considered when it is more practical to retrofit the components of the existing bridge to contribute seismic resistance than to rely solely on the widening to resist the seismic demands of the entire structure.
- This seismic design strategy may be suitable for bridges that are widened on only one side or when the widening is relatively small compared to the width of the original structure.
- The retrofitted structures shall conform to MTD 20-4. The displacement ductility demand (μ_D) of the retrofitted substructure may be allowed up to 8 if approved in the Retrofit Strategy meeting or Type Selection meeting.

- The design project engineer must ensure that the seismic behavior of the widened portion is complementary with the existing structure. The difference in structure types between the existing and the widening, past retrofit work completed on the existing structure, and the age of the existing structure being pre- or post-1971 (San Fernando earthquake) should be taken into consideration for seismic design strategy. The design project engineer may consult with the OEEAR or, for externally design projects, the Structure Liaison Engineer for support.

Category III. The original structure resists the horizontal seismic demands of the entire structure.

- This seismic design strategy is typically considered when the widening does not involve the construction of new substructures, such as a sliver widening. If the existing structure is deemed insufficient for its seismic demands, the structure shall be retrofitted and conform to the requirements set forth in MTD 20-4.

Seismic Design Details for Bridge Widening Projects

Compatibility of Seismic Design Details

Bridge widenings pose a set of challenges that are absent in retrofit or new bridge projects. Compatibility of the boundary conditions introduced in the widening portions with those in the existing bridge shall be considered. The following is a partial list of potentially incompatible seismic details that should be avoided if feasible:

- Rocker bearings supporting the existing bridge and elastomeric bearing pads supporting the widening.
- A large gap between the superstructure and seat-type abutment backwall on an existing bridge while no gap is provided on the widening, or vice versa.
- Expansion joints at abutments or hinges not lining up.

There are a number of solutions that can resolve or mitigate the incompatibilities listed above:

- Remove and replace the existing rocker bearings with elastomeric bearings.
- Provide blocking in the abutment gap of the existing structure so the new and the existing bridges close the gap together.
- Modify the existing abutment such as increasing end diaphragm thickness by adding drill-and-dowel concrete blocks to line up the new and existing expansion joints.

Thermal expansion joints at abutments, bents, and in-span hinge locations for existing bridges and widenings should be made compatible. It is recommended that the expansion joint in the widening behave in a way that is compatible with the existing bridge. For instance:

- Diaphragm type abutments should be widened with diaphragm abutments.
- Seat type abutments should be widened with seat abutments and the seat width should exceed the demand displacement. The existing bridge abutment should be retrofit (if necessary) with seat extensions.
- In-span hinges for bridge widenings should have an adequate seat width and should be compatible with the hinges on the existing bridge. The existing hinges should be retrofit (if needed) such that the existing hinge and the hinge for the bridge widening exceed the displacement demand. Table 1 provides the hinge details for some common types of bridges.

Bridge Type	Hinge Seat for the Widening	Existing Hinge Seat Retrofit
Box Girder Bridge	Pipe/Cable Restrainer System XS7-070-(1&2)	Pipe/Cable Restrainer System XS7-080-(1 to 3)
Slab Bridge	Slab Hinge Details MTD20-7	Slab Bridge Seat Extender XS7-100-(1&2)
Other Bridge Types (Steel, Precast)	Project Specific Details by Designer	Project Specific Details by Designer

Table 1: Hinge Details for Bridge Widenings

Project Delivery Impact

Seismic retrofit can have a tremendous impact on project scope, cost, and schedule. Therefore, it is important that required seismic retrofit for bridge widening projects be identified as early in the project development process as possible, ideally at the Advanced Planning Study phase. If a bridge widening project, particularly safety related projects, is jeopardized due to cost increase and schedule delay because the required seismic retrofit work is not identified early in the project development process, the design project engineer is responsible for consulting OEEAR or the Structure Liaison Engineer prior to requesting a design exception per MTD 20-11.

Creating a Record of Seismic Assessments for Bridge Widenings

When the seismic demand and capacity are determined for a proposed bridge widening or when the existing portion of a bridge being widened is retrofitted or the retrofit needs are assessed, then a Seismic Retrofit Assessment Form should be completed by the design project engineer and

Branch Chief. A copy of this form should be submitted to the Chief of the OEEAR before P&Q as required in MTD 1-3 and MTD 1-29, for incorporation into the permanent bridge records.

Also, MTD 20-4 has requirements when there is an adjacent structure with potential seismic vulnerabilities similar to the bridge being widened (for example left and right bridges). It is important to ensure the adjacent structure is either retrofitted or identified for future retrofit assessment. This may be accomplished by submitting a Seismic Retrofit Assessment Form, Attachment A of MTD 20-4, to the OEEAR. If the design project engineer has concerns about seismic vulnerability on a Minor Modification Project, a Seismic Retrofit Assessment Form should be submitted to the OEEAR.

The Seismic Retrofit Assessment Form may be found in either MTD 1-3 (Attachment 3) or MTD 20-4 (Attachment A). It may also be found at:

http://onramp.dot.ca.gov/hq/des/spi/earthquake_engineering/documents/Seismic_Retrofit_Assessment_Form.pdf

The purpose of the Seismic Retrofit Assessment Form is to keep a record of previous seismic evaluations for future reference. See MTD 20-4 for more information on requirements for seismic evaluation and retrofit for widenings.

Original Signed by Susan E. Hida for:

Barton J. Newton
State Bridge Engineer
Deputy Division Chief, Structure Policy & Innovation
Division of Engineering Services