20-13 TSUNAMI HAZARD GUIDELINES

Introduction

While not as common as the hazards associated with earthquake induced ground shaking, tsunamis are capable of producing high levels of damage and pose a potential risk to life safety. Tsunamis are most typically associated with offshore subduction zone earthquakes, but can also be caused by submarine landslides, volcanic activity, and other sources. In California, sources of tsunami hazards may be due to local tsunami-generating activity occurring along the California coast, or from sources hundreds or thousands of miles away across the Pacific Ocean.

Bridge Vulnerabilities to Tsunami Hazards

Bridges and other structures may be susceptible to several types of vulnerabilities associated with tsunamis. The large flow of water over and around foundations as the water rushes in and then recedes can lead to significant scour. Scour effects may be intensified if the bridge is located over a creek, river or other site where the return flow from a watershed area is concentrated due to local topography. Depending on the speed of the water as the tsunami rushes in, it may create a substantial surge and/or drag force as it contacts and then flows past the bridge. The forces associated with the backflow of water returning to the coast may be significantly higher than the initial surge and drag forces, particularly if it includes large amounts of debris. If the height of the tsunami reaches the superstructure, in addition to lateral forces, it may be subject to buoyant forces, particularly affecting box girder bridges. After the water recedes, the saturated soil may cause large hydrostatic forces on bridge wingwalls and abutments, as well as on retaining walls.

Currently there are no approved tsunami runup maps to be used for assessing the tsunami hazard to transportation structures. Assessment of the tsunami hazard shall be made on a project specific basis. Tsunami runup may be affected by many factors including topography of the land, bathometry of the sea floor, incidence of the tsunami waves relative to the coast, natural and manmade barriers, and other factors. Historically the tsunami hazard is significantly reduced at locations beyond one-half mile of the coast or at elevations greater than 40 feet above mean sea level.

Mitigating Tsunami Hazards

Many of the most effective steps that can be taken to protect life safety in the event of a large tsunami, such as early warning systems, emergency evacuation plans, education, and training, are outside the primary responsibility of the bridge engineer. While bridge design details typically required to address seismic ground motions will provide a relatively high level of protection, there are other common-sense measures that may be considered to mitigate the effects of tsunamis on bridges. These include providing:

- Continuity of the superstructure
- Deep foundations less vulnerable to the potential effects of scour
- Monolithic connections
- Tie downs or open vents to alleviate buoyancy effects

In some situations, it may be prudent to take additional measures to protect a bridge from tsunami hazards. This may include bridges identified as part of an official Tsunami Evacuation Route or local emergency response plan, or due to the importance and purpose of the bridge. While not required for most bridges, these more extensive measures requiring project-specific approval may include:

- Raising the elevation of the bridge
- Using open barrier rails
- Placing fenders as protection
- Explicit tsunami design (contact the Office of Earthquake Engineering)

Superstructure mitigation measures will not generally be required if the minimum soffit elevation exceeds an elevation of 40 feet above mean sea level. Consideration of tsunami hazards will generally not be required if it is assessed that all vulnerable bridge components are above an elevation of 40 feet.

Responsibilities

The tsunami hazard shall be considered for bridge components below 40 feet above mean sea level for all new bridges and widenings within ½ mile of the Pacific Ocean coastline or other locations considered vulnerable to tsunami hazards. The Project Engineer is responsible for presenting information considered necessary to determine the need to mitigate for the tsunami hazard during the Type Selection Meeting. Type Selection attendees for projects designed by Caltrans should include the Project Engineer, Project Geologist/Geotechnical

Engineer, representatives from Structure Hydraulics and Earthquake Engineering, and the District Project Manager. For projects designed by external entities for Caltrans, additional attendees should include the Oversight Engineer and the Oversight Geologist/Geotechnical Engineer. Information to be presented during the Type Selection Meeting may include both local and regional topography, manmade and natural barriers between the coast and site, foundation types being considered, site geology, and any identified locally determined emergency plans affecting the bridge. Several communities have completed emergency plans to address tsunami hazards, and more are under development. The Project Engineer shall contact the District Project Manager to determine whether the bridge is included in a locally determined evacuation or emergency response plan.

The extent to which tsunami mitigation measures are to be taken shall be documented and approved through the process identified in *Memo to Designers 20-11*.

Project Impact

Once the need to consider tsunami hazards has been established for a project, the impact on project scope, schedule, and cost shall be determined and appropriate action taken as established elsewhere in Caltrans guidance material.

There remain a number of issues that still need to be addressed by the engineering community with regard to the design of bridges for tsunami hazards. This memo provides general guidance on prudent measures that can be considered during the planning and design phase of new projects to mitigate the effects of tsunami hazards.

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