American Railway Engineering and Maintenance of Way Association

Proposed Letter Ballot 09-22-01

Proposed changes as follows:

Deleted text noted by ~~strikethrough~~.
Added text shown in red.

Replace Article 1.6.3.2 Fills and Earth Cuts:

1.6.3.2 Fills and Earth Cuts

~~Variations in soil materials and soil moisture contents found within existing fills and earth cuts, in general economically preclude adequate data collection for analysis of the site conditions. The Engineer may, based on the geometry, applicable standards of construction and a conservative estimate of existing soil properties, make an analysis of slope stability for the general case.~~

~~The magnitude of the seismic force should be calculated as a function of the vertical acceleration component of the design event. The combination will affect both magnitude and direction of the resultant force exerted by the mass above the failure (sliding) surface. This load would be applied as a uniform dead load surcharge at the level of the centroid of the mass. The Factor of Safety against sliding would be determined based on risk factors, and a value close to unity may be acceptable.~~

~~Fills founded on sloping strata or on strata of high moisture content should be given special attention.~~

~~Retrofit designs for fills would include stabilization by piling, toe berms and revised side slope run-to-rise ratios. Earth cut retrofit designs include stabilization by piling and revised side slope run-to-rise ratios.~~

Slope instability may induce significant deformation in fills and earth cuts during a seismic event. Previously unstable or marginally stable slopes may experience large-scale deformation. The Engineer should evaluate seismic stability of slopes that could adversely impact major structures or critical facilities in the event of failure. Stabilization measures should be installed to mitigate seismically induced slope instability where the stability evaluation indicates unstable conditions, and the consequences of slope failure are significant. Seismic instability associated with routine cuts and fills, where the consequences of failure are minor or can be rapidly repaired, are not always mitigated because of the typically large number of these slopes along the railroad right-of-way and the high cost, relative to the potential benefits, of installing stabilization measures uniformly throughout the right-of-way.

The railroad should first survey its right-of-way, using available-records, reports, history and possibly a field visual survey, to identify and prioritize areas of fill and earth cuts requiring further analysis.

Seismic stability evaluation of slopes should be based on data collected from a geologic site investigation and subsurface exploration program. The evaluation should include a pseudo-static stability analysis, consisting of limit-equilibrium modeling where the earthquake load is simulated by an equivalent static horizontal acceleration (k_{eq}) acting on the sliding mass. The Engineer should select k_{eq} based on local practice, published methodologies, and engineering judgement. The minimum Factor of Safety for the pseudo-static stability evaluation should be 1.1; slopes with lower Factors of Safety should be considered unstable and at-risk of failure. Newmark sliding block or other cumulative displacement analyses may be performed, as warranted, if the pseudo-static stability analysis indicates a low Factor of Safety to estimate the magnitude of slope deformation. The amount of tolerable seismically induced slope deformation yielded from these analyses should be at the discretion of the Engineer; however, a slope deformation exceeding 6 inches is generally judged to be at high risk of failure.

Fills constructed on slopes, particularly those with sloping strata, or cuts that expose sloping strata should be given special attention. Groundwater conditions should be accurately and comprehensively characterized to evaluate the stability of fills or cuts.

Possible retrofits to reduce the potential for seismically induced instability in fills or cuts include structural reinforcement (e.g. piles, walls, geosynthetics, etc.), buttressing, dewatering, and/or reshaping the slope geometry.

Replace Article 1.6.3.3 Rock Cuts:

1.6.3.3 Rock Cuts

~~Analytical investigation of rock cuts, as groups or as individual structures, is generally not practical. The Engineer should review the history of rock scaling programs for evidence of an extraordinary frequency of work at a specific site.~~

~~Retrofit designs include increased scaling efforts, rock stabilization by bolting or other means, increasing existing bench catchment capacity and selective rebenching.~~

Seismic events may induce large-scale failures in the side slopes of rock cuts or generate heavy rockfall from unstable material in the cut. Seismic analysis or design for rock cuts may incorporate a limit equilibrium model, as described in Article 1.6.3.2, or kinematic analyses that incorporate seismic design considerations. Due to the complexity of rock cut design, seismic design considerations should be incorporated and applied to rock cuts at the discretion of the Engineer.

The railroad should first survey its right-of-way, using available records, reports, history and possibly a field visual survey to identify and prioritize areas of rock cuts requiring further analysis.

Possible retrofits to reduce the potential for seismically induced instability in rock cuts include scaling, bolting, adding wire mesh, increasing catchment capacity, and/or benching.

Revise Article 1.6.6.1 Tunnels:

1.6.6.1 Tunnels[2]

Tunnels are presumed to be of a design generally resistant to seismic forces, but not to displacements due to fault rupture at the site or other large ground movements such as those caused by soil liquefaction. Existing tunnel conditions should be reviewed to determine susceptibility to damage in a seismic event. Specific attention should be paid to the design of and conditions at the portal structure. The Engineer should review the history of tunnel maintenance programs for evidence of an extraordinary frequency of work at specific locations.

New tunnel design is beyond the scope of this chapter.

Possible retrofits to reduce the potential for seismically induced instability in tunnels ~~Retrofit designs~~ include ~~increased~~ scaling ~~efforts~~, ~~rock stabilization by~~ bolting ~~or other means~~, and/or the installation or strengthening of linings.