Submission Guidelines for Crash Walls

Crash walls may be required for the protection of overhead structures, and in some cases the Railway may consider a crash wall as an alternative to an earthen berm for the protection of structures or facilities adjacent to the track. When proposing or designing such a structure, the following components should be in the submission. Where there is a discrepancy between the requirements here and those provided by the client Railway or AREMA, the more stringent shall govern.

1. Covering Letter

- Summary of items enclosed,
- Location and date of previous, approved, similar designs by this designer, if any,
- Where the crash wall is proposed as an alternative to an earthen berm: alternative materials / configurations considered and benefits of this design,
- A Location or Key Plan. This will be used to identify the mileage and subdivision, the classification of the rail line, and the maximum speed for freight and passenger rail traffic, all obtained from AECOM Canada for CP and CN-owned corridors or from GO Transit for GO-owned corridors.
- Name, phone, fax and e-mail address of your contact.

2. Geotechnical Report - (2 copies)

- Soil properties used in design, and how determined,
- Borehole logs including location plan, if required to support these properties,
- Narrative report describing soil and ground water conditions, if required as above.

3. Design of Crash Walls

- One of the following methods may be chosen, or an alternative design load may be selected and if it can be justified by the engineer responsible for the design. The simplified approach of Method 1 may be used in most cases. Method 2 may be used to optimize the design, or where factors such as distance from the track to the wall, track speeds, side slopes along the track, consequences of collision or others may justify a different load.
- **Method 1**: The wall may be designed for a minimum point load of 600 kip (2700 kN) applied horizontally and normal to the face at any point along the wall
    - The point load shall be applied at a height of 6 feet (1.8 m) *above the top of rail* for walls up to 25 feet (7.6 m) from the centerline of track, or a height of 6 feet (1.8 m) *above the groundline* for walls farther than 25 feet (7.6 m) from the centerline of track.

  - This method may be applied where track speeds do not exceed 50 mph (80 km/hr) for freight or 70 mph (112 km/hr) for passenger trains; where speeds exceed these limits, Method 2 shall be used.

- **Method 2**: an energy balance approach considering collision by glancing blow and single car rotation may be used to determine the design load. The following four cases must be considered:

  - Freight Train Load Case 1 - Glancing Blow: nine cars weighing 143 tons (129 700 kg) each, impacting the wall at an angle, θ_G. The angle of impact will be a function of track curvature, and for tangent track may be taken as 3.5 degrees.

  - Freight Train Load Case 2 - Single Car Impact: single car weighing 143 tons (129 700 kg) impacting the wall as it undergoes rotation about its center. The angle of rotation at impact is:

    $$\theta_f = \text{asin}\left(\frac{d_{CL}}{8.5}\right) \quad [1]$$

    where d_{CL} is the distance from the crash wall to the centerline of track in m. The closest existing or future track is to be used. Where d_{CL} is greater than 8.5 m, this load case need not be considered.

  - Passenger Train Load Case 3 - Glancing Blow: eight cars weighing 74 tons (67120 kg) each impacting the wall at an angle, θ_G. The angle of impact will be a function of track curvature, and for tangent track may be taken as 3.5 degrees.

  - Passenger Train Load Case 4 - Single Car Impact: single car weighing 74 tons (67120 kg) impacting the wall as it undergoes rotation about its center. The angle of rotation at impact is:

    $$\theta_f = asin\left(\frac{d_{CL}}{13}\right) \quad [2]$$

    Where d_{CL} is greater than 13 m, this load case need not be considered.

  - The analysis should reflect the specified track speeds for passenger and/or freight trains applicable within the subject corridor.

  - To assist in designing the structure for the above load cases, use:

    - For the glancing blow load cases, the speed of derailed equipment impacting the wall is reduced from the track speed, v_o, to

      $$v_G = \sqrt{v_o^2 + 2a\left(\frac{d_{CL}-1.625}{\sin\theta_G}\right)} \text{ [m/s]} \quad [3]$$

      Where d_{CL} is the distance from the crash wall to the centerline of track in m.

      v_o is the track speed in m/s

      θ_G is the angle of impact

a is the acceleration in m/s, calculated as $-9.8(.25 + \mathrm{G})$

G is the grade in decimal unit of the groundline in the direction of travel defined by the angle of impact relative to the centerline of track; calculated as $\frac{Groundline\ at\ wall - Base\ of\ Rail}{d_{CL}/_{sin\theta_G}}$.

- For the single car load cases, the speed of derailed equipment impacting the wall is

$$v_A = \frac{2.3\theta_f}{\sqrt{1-cos\,\theta_f}}\left[\frac{m}{s}\right] for\ freight\ cars \quad [4]$$

$$v_A = \frac{2.9\theta_f}{\sqrt{1-cos\,\theta_f}}\left[\frac{m}{s}\right] for\ passenger\ cars \quad [5]$$

Where θ_f is the angle of impact, in radians, defined in [1] and [2].

- For energy dissipation, assume:
  - Contact with the wall stops all movement in the direction perpendicular to the wall, but not along its length
  - Plastic deformation of individual car due to direct impact is 1 foot (.3048 m) maximum,
  - Total compression of linkages and equipment of the 8 or 9 car consist is 10 feet (3.048 m) maximum,
  - Deflection of wall is considered negligible in equations [6] to [9]. Where the designer wishes to include it, those equations may be modified.
  - In lieu of more rigorous analysis, these energy balance equations may be used to determine the design load perpendicular to the wall. The design load acts along the given length of wall.
    - For the glancing blow load cases

$$F_G = \frac{\frac{1}{2}m(v_G \sin\theta_G)^2}{d_G} \quad [6]$$

And the load is considered to act along the length l_G in m:

$$l_G = \frac{3.048}{\cos\theta_G} \quad [7]$$

Where m is the mass of the derailed cars in kg.

v_G is the impact speed in m/s, defined in [3]

$\theta_G$is the angle of impact

d_G is the deformation of the consist in the direction of the applied force, and $d_G = 3.048 \sin \theta_G$, in m

- For the single car impact

$$F_A = \frac{\frac{1}{2} m (v_A \cos \theta_f)^2}{d_A} \quad [8]$$

And the load is considered to act along the length l_A in m:

$$l_A = \frac{.3048}{\sin \theta_f} \quad [9]$$

Where m is the mass of the derailed cars in kg.

v_A is the impact speed in m/s, defined in [4] or [5]

θ_f is the angle of rotation at impact defined in [1] or [2]

d_A is the deformation of the consist in the direction of the applied force, and $d_A = .3048 \cos \theta_f$, in m

Where the influence areas of two sequential cars in an accordion style of derailment overlap, the wall must be designed for the simultaneous impact of both cars.

- Regardless of the method selected, the following guidelines must be followed:
    - The minimum thickness for walls up to 25 feet (7.6 m) from the centerline of track shall be 2'-6" (.760 m); minimum thickness for walls farther than 25 feet (7.6 m) from the centerline of track shall be 18 inches (.45 m).
    - Crash walls less than 12 feet (3.6 m) from the centerline of track shall be a minimum of 12 feet (3.6 m) above the top of rail. Crash walls between 12 feet (3.6 m) and 25 feet (7.6 m) from the centerline of track shall be a minimum of 7 feet (2.135 m) *above the top of rail*. Crash walls greater than 25 feet (7.6 m) from the centerline of track shall be a minimum of 7 feet (2.135 m) *above the adjacent groundline*.
    - The face of the crash wall shall be smooth and continuous, and shall extend a minimum of 6 inches (0.15 m) beyond the face of the structure (such as a building column or bridge pier) parallel to the track.
    - The design must incorporate horizontal and vertical continuity to distribute the loads from the derailed train.
    - The wall must be of solid, heavy construction, and separate precast blocks or stones will not be permitted.

4. Drawings - (2 hard copies as well as .pdf format)

- Site plan clearly showing property line, location of wall structure, centerline and elevation of nearest rail track,
- Layout and structural details of proposed structure, including all material notes and specs and construction procedures/phasing. All drawings signed and sealed by a professional engineer registered in the province having jurisdiction at the project location.
- Extent and treatment of any temporary excavations on railway property.

5. Cheque

- A cheque payable to AECOM will be required for the cost of this review. Please contact AECOM for current pricing. Cost will take into consideration number of submissions, site visits, meetings, and alternative or unusually complex designs.

6. Post-Construction Certificate - (1 copy)

- Engineer's certificate of completion describing actual construction, and certifying that the structure was built as per approved drawings,
- Copy of as-built drawings, as part of the engineer's certification of completion.

Access to Railway Operating Rights-of-Way

Permits **MUST** be obtained before entering into any Railway Operating right-of-way.

Some or all of the following may also be required: - proper railway flagging protection, cable locates, liability insurance, release of liability, safety training.

AECOM Canada Ltd. will provide guidance as to the proper process to be followed in this regard. Fees will be established based on the nature and extent of the work being proposed.

Communication for Submissions

All correspondence during the review process should be directed to AECOM Canada Ltd.

Upon completion of our review, a confidential report on our findings will be made to the railway company, who will subsequently contact the applicant.

The applicant will be notified when the report has been submitted to the railway.

Liability and Responsibility

The review will be undertaken with the understanding that neither the railway nor AECOM Canada Ltd. shall have any responsibility nor liability whatsoever for the design or adequacy of the crash wall, notwithstanding that any plans or specifications may have been reviewed by the railway nor AECOM Canada Ltd. No such review shall be deemed to limit the applicant's full responsibility for the design and construction adequacy of the works.

AECOM Canada Ltd.

Mississauga, Ont.

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