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PROFESSIONAL RECOMMENDATION MEMORANDUM

Project Name: **Engineering Support Services and Recommendations for Roadside Safety Issues/Problems for Member States**

Sponsor: **Roadside Safety Pooled Fund**

Task 21-11: **Clear Space Behind Oregon 32-inch F-shape Barrier**

DATE: **November 19, 2021**

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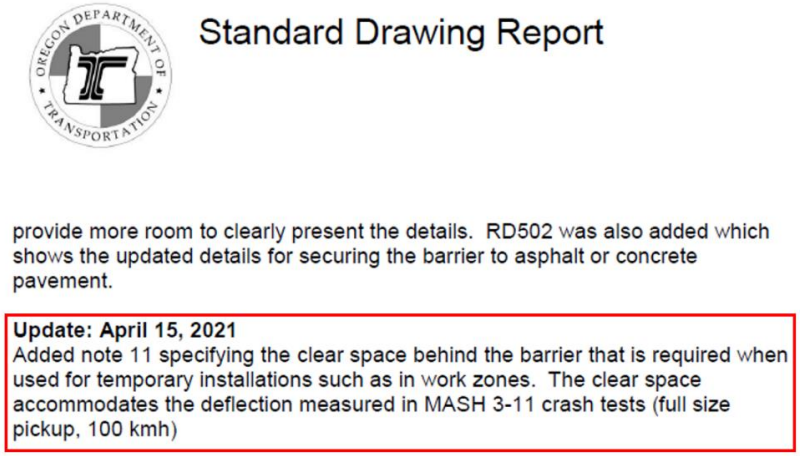
Overview/Problem Statement

Following a professional opinion on comparison of Oregon DOT's F-shape precast concrete barrier and the portable concrete barrier tested by TxDOT (Task 21-9), PennDOT requested another professional opinion to TTI if an 18-inch clear space is adequate for the considered barrier type. On April 15, 2021, the Oregon Department of Transportation added note 11 on RD500's standard drawing report, specifying the clear space behind the barrier that is requested when used for temporary installations (Figure 1). It is specified that the clear space needs to accommodate the deflection measured in MASH 3-11 crash tests (full-size pickup, 100 km/h). The 18-inch clear space is based on the WSDOT Pooled Fund research (No. 405160-25-1, 'Development and Testing of Anchored Temporary Concrete Barrier for Use on Asphalt'). In this letter, TTI researchers

evaluated the adequateness of the 18-inch clear spacing behind the F-shape barrier in RD500 standard drawing by investigating previous experimental studies.

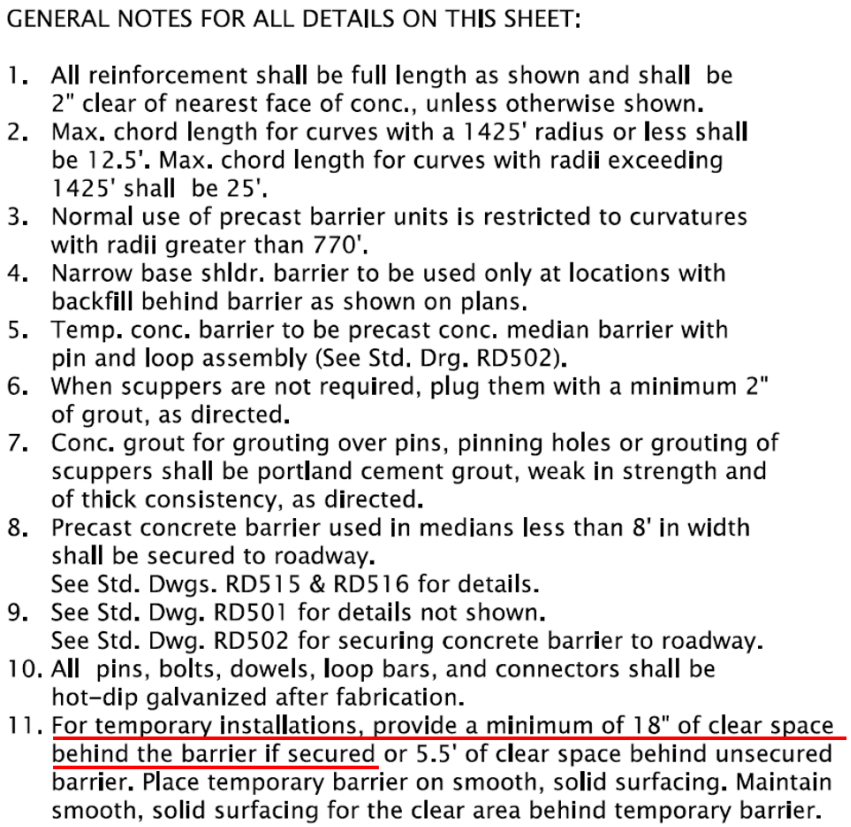


Standard Drawing Report

provide more room to clearly present the details. RD502 was also added which shows the updated details for securing the barrier to asphalt or concrete pavement.

Update: April 15, 2021
Added note 11 specifying the clear space behind the barrier that is required when used for temporary installations such as in work zones. The clear space accommodates the deflection measured in MASH 3-11 crash tests (full size pickup, 100 kmh)

(a) Standard Drawing Report



GENERAL NOTES FOR ALL DETAILS ON THIS SHEET:

1. All reinforcement shall be full length as shown and shall be 2" clear of nearest face of conc., unless otherwise shown.
2. Max. chord length for curves with a 1425' radius or less shall be 12.5'. Max. chord length for curves with radii exceeding 1425' shall be 25'.
3. Normal use of precast barrier units is restricted to curvatures with radii greater than 770'.
4. Narrow base shldr. barrier to be used only at locations with backfill behind barrier as shown on plans.
5. Temp. conc. barrier to be precast conc. median barrier with pin and loop assembly (See Std. Drg. RD502).
6. When scuppers are not required, plug them with a minimum 2" of grout, as directed.
7. Conc. grout for grouting over pins, pinning holes or grouting of scuppers shall be portland cement grout, weak in strength and of thick consistency, as directed.
8. Precast concrete barrier used in medians less than 8' in width shall be secured to roadway.
   See Std. Dwgs. RD515 & RD516 for details.
9. See Std. Dwg. RD501 for details not shown.
   See Std. Dwg. RD502 for securing concrete barrier to roadway.
10. All pins, bolts, dowels, loop bars, and connectors shall be hot-dip galvanized after fabrication.
11. For temporary installations, provide a minimum of 18" of clear space behind the barrier if secured or 5.5' of clear space behind unsecured barrier. Place temporary barrier on smooth, solid surfacing. Maintain smooth, solid surfacing for the clear area behind temporary barrier.

(b) Note in RD500 Standard Drawing

Figure 1. Clear space on Oregon 32-inch F-shape concrete barrier

Summary of Past Work

In 2008, TTI developed a pinned-down F-shaped temporary concrete barrier design that was easy to install and minimized damage to the bridge deck and concrete pavement. This pinned-down barrier successfully passed NCHRP Report 350 Test Level 3 requirements at that time by showing maximum permanent and dynamic barrier deflections of 5.76 and 11.52-inch, respectively (Sheikh et al. 2008).

A further TTI study was conducted to modify the anchoring design of the previously developed F-shaped pinned-down concrete barrier and extend its use for asphalt pavement and/or soil base (Sheikh and Menges, 2012). The new design was verified using subcomponent level testing, finite element (FE) analysis, and full-scale crash testing to meet MASH test level 3 criteria.

The response of a single anchoring pin was evaluated to determine the appropriate pinning scheme from a series of dynamic pull tests with soil and different thicknesses of asphalt pad laid over soil base. It was shown that pinning directly on soil is not likely to sufficiently anchor the barrier with 2-3 pins per barrier segment. However, the anchoring pin in a 4-inch thick asphalt pad yielded the required lateral restraint.

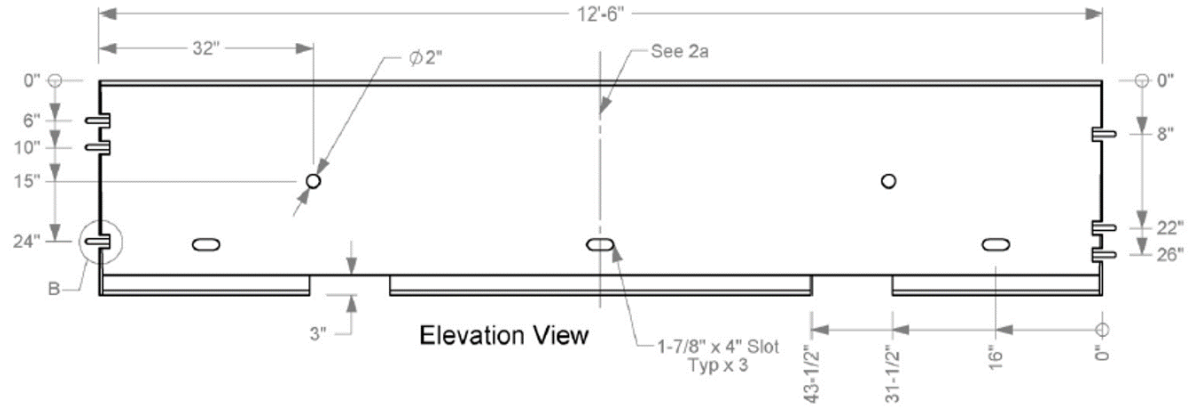
FE analysis was performed with a 5,000-lb pickup truck model impacting the barrier system restrained by two and three anchoring pins per barrier segment. FE analysis results showed slightly better performance for three anchoring pins per segment over two anchoring pins. Also, three anchoring pins provided a greater safety factor against failure and asphalt cracking. The barrier segment anchored with three pins was thus considered appropriate for further evaluation in full-scale crash testing.

In full-scale crash testing, a 151-ft test installation comprising of 12 barrier segments, connected using the pin-and-loop connection, was built for MASH test level 3 testing. The barrier was anchored using three 1.5-inch diameter steel pins per barrier segment. MASH Test 3-11 was performed with a pickup truck at an impact speed and angle of 62.2 mi/h and 24.8 degrees, respectively. The full-scale crash testing showed that the F-shape temporary concrete barrier pinned on asphalt successfully contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation. Maximum static and dynamic deflections of the barrier system during the test were 17.0-inch and 17.8-inch, respectively.

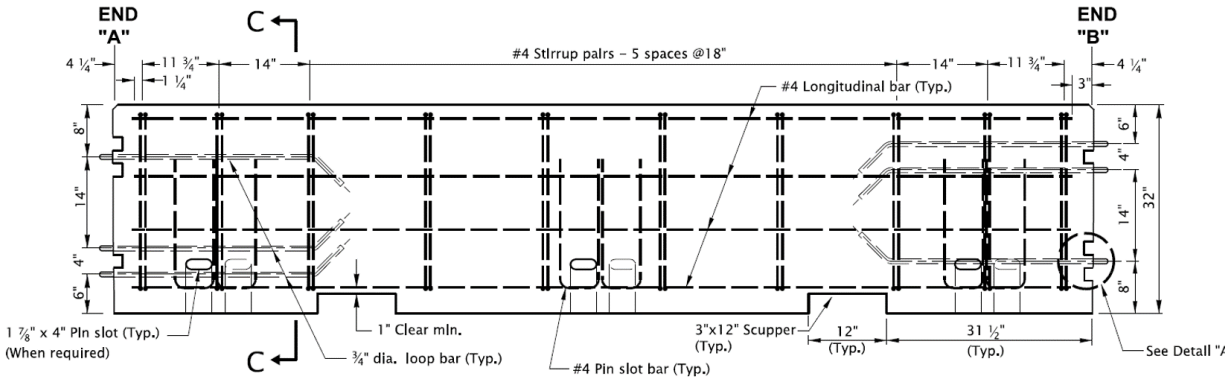
Summary of Professional Opinion

F-shape barrier design that met MASH Test 3-11 in Sheikh and Menges (2012) is the same as the portable concrete barrier in Report No. 607911-1&2 tested by TxDOT (Sheikh et al. 2017). From the earlier professional opinion regarding the difference between the Oregon 32-inch F-shape barrier and the F-shape portable concrete barrier tested under the WSDOT Pooled Fund research (Roadside Safety Pooled Fund Task 21-09), the structural performance of those two concrete barriers is expected to be the same. Those two barriers have very similar sectional properties, and some minor differences in details are considered to be non-significant (See Figures 2 and 3). Thus, TTI researchers conclude that the 18-inch clear spacing is adequate for Oregon's 32-inch F-shape barrier under MASH 3-11 condition as long as the barrier is anchored in the same manner as it was anchored in the MASH testing.

Note: 1) The Oregon standard barrier has 3 slots for pinning on each side, and the impact side needs to be specified, and 2) The crash-tested barrier from the pooled fund used a connecting pin consisting of a 1-1/2-inch dia. x 48-inch long A36 cold rolled anchor pin with a welded 4-inch x 4-inch x 0.5-inch plate washer. The connection performance shall be at least equivalent to or better than that of the tested details to secure structural integrity between barriers. Thus, the anchor pin details used in the tested barrier are recommended unless otherwise better and approved details are available.

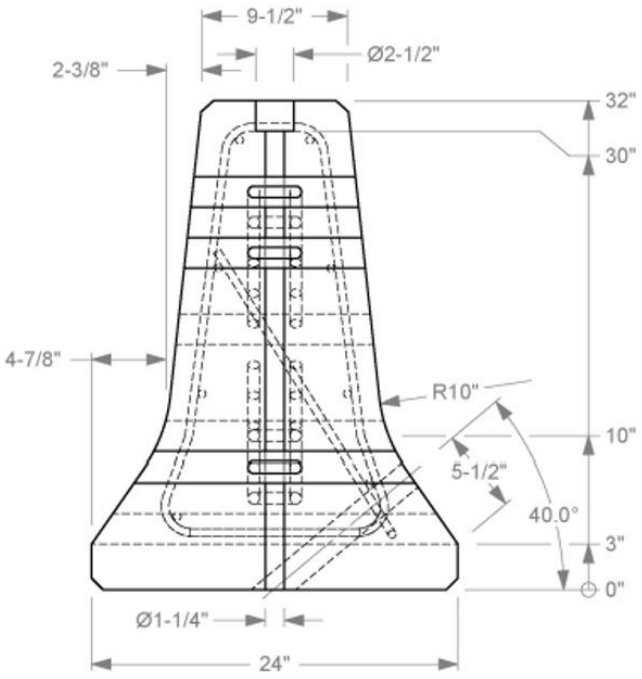


(a) Pooled fund (from Report No. 607911)

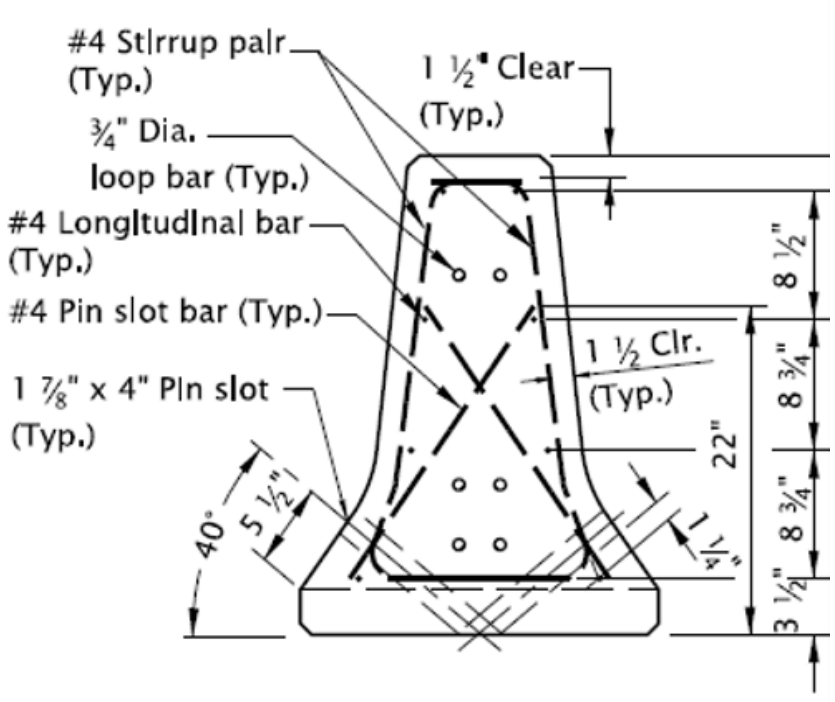


(b) Oregon standard barrier design (RD500)

Figure 2. Elevation View



(a) Pooled fund (from Report No. 607911)



(b) Oregon standard barrier design (RD500)

Figure 3. Cross Section

References

Sheikh, N., Bligh, R.P., and Menges, W.L. (2008) “Crash Testing and Evaluation of the 12 ft Pinned F-shape Temporary Barrier,” Texas Transportation Institute, College Station, TX.

Sheikh, N., and Menges, W.L. (2012) “Development and Testing of Anchored Temporary Concrete Barrier for Use on Asphalt,” Report No. 405160-25-1,Texas Transportation Institute, College Station, TX.

Sheikh, N., Menges, W., and Kuhn, D., (2017). “MASH TL-3 Testing and Evaluation of Free-Standing Portable Concrete Barrier.” Report No. 607911-1&2. Texas A&M Transportation Institute, College Station, TX.