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Crossing Surface Recommendations for At-Grade Rail Crossings of U.S. Routes 29 and 15 in Prince William County, Virginia

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Supplementary Notes

Abstract

The intersection of a rail line and a roadway at an at-grade crossing represents the meeting of two vastly different transportation modes. Although they may share a common crossing where they intersect, the typical structural design of the supporting foundation for each is quite different. The design of a roadway consists of multiple layers of low-permeability materials, whereas the design of a rail line includes rails and crossties supported by open-draining aggregate ballast. Because of the use of highly permeable materials, the open draining nature of a rail line substructure can cause the early deterioration of a nearby roadway unless steps are taken to provide adequate drainage. In addition to structural differences, the rail line is designed to accommodate a substantial vertical deflection from passing loaded rail cars; it is common for a rail line to undergo up to 0.3 inch of vertical displacement. This large deflection can result in a greatly reduced service life for nearby pavements because of fatigue failure. Although it is inevitable that a rail crossing structure will have to undergo periodic reconstruction, selection of an optimum crossing surface constructed over an adequately prepared foundation will greatly increase the service life of the crossing. An optimum crossing structure can be viewed as one that combines safety, cost-effectiveness, long service life (reducing user costs by increasing the time between successive replacements), good performance, and ease of maintenance.

This report discusses the advantages and disadvantages of several crossing types that are the most appropriate for the conditions expected at the U.S. Route 29 and U.S. Route 15 crossings in Prince William County, Virginia. Specific recommendations for each crossing type are provided. It is the author's opinion that the following crossing types represent the optimum alternatives for these locations and conditions in the following order: precast concrete platform panels, high rut-resistant hot-mix asphalt; and steel-reinforced rubber panels. It is expected that these crossing alternatives will exceed the typical service life if the recommended materials and design elements are used.

FINAL REPORT

CROSSING STRUCTURE RECOMMENDATIONS FOR AT-GRADE RAIL CROSSINGS OF U.S. ROUTES 29 AND 15 IN PRINCE WILLIAM COUNTY, VIRGINIA

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Virginia Department of Transportation and
the University of Virginia)

Charlottesville, Virginia

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DISCLAIMER

ABSTRACT

The intersection of a rail line and a roadway at an at-grade crossing represents the meeting of two vastly different transportation modes. Although they may share a common crossing where they intersect, the typical structural design of the supporting foundation for each is quite different. The design of a roadway consists of multiple layers of low-permeability materials, whereas the design of a rail line includes rails and crossties supported by open-draining aggregate ballast. Because of the use of highly permeable materials, the open draining nature of a rail line substructure can cause the early deterioration of a nearby roadway unless steps are taken to provide adequate drainage. In addition to structural differences, the rail line is designed to accommodate a substantial vertical deflection from passing loaded rail cars; it is common for a rail line to undergo up to 0.3 inch of vertical displacement. This large deflection can result in a greatly reduced service life for nearby pavements because of fatigue failure. Although it is inevitable that a rail crossing structure will have to undergo periodic reconstruction, selection of an optimum crossing surface constructed over an adequately prepared foundation will greatly increase the service life of the crossing. An optimum crossing structure can be viewed as one that combines safety, cost-effectiveness, long service life (reducing user costs by increasing the time between successive replacements), good performance, and ease of maintenance.

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FINAL REPORT

CROSSING SURFACE RECOMMENDATIONS FOR AT-GRADE RAIL CROSSINGS OF U.S. ROUTES 29 AND 15 IN PRINCE WILLIAM COUNTY, VIRGINIA

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INTRODUCTION

In 2004, The Virginia Department of Transportation's (VDOT) Manassas Residency asked the Virginia Transportation Research Council for assistance in selecting an optimum or revised crossing structure for two at-grade rail crossings with high-volume roadways. The request was in response to the deterioration of two rail crossings in Prince William County, one at U.S. Route 29 in Gainesville and the other at U.S. Route 15 in Haymarket (Figure 1). New crossing surfaces were installed at these locations in the mid-to-late 1990s and showed signs of deterioration and unacceptable performance within approximately 6 years. These crossings were expected to function with an acceptable level of service for 10 to 12 years.

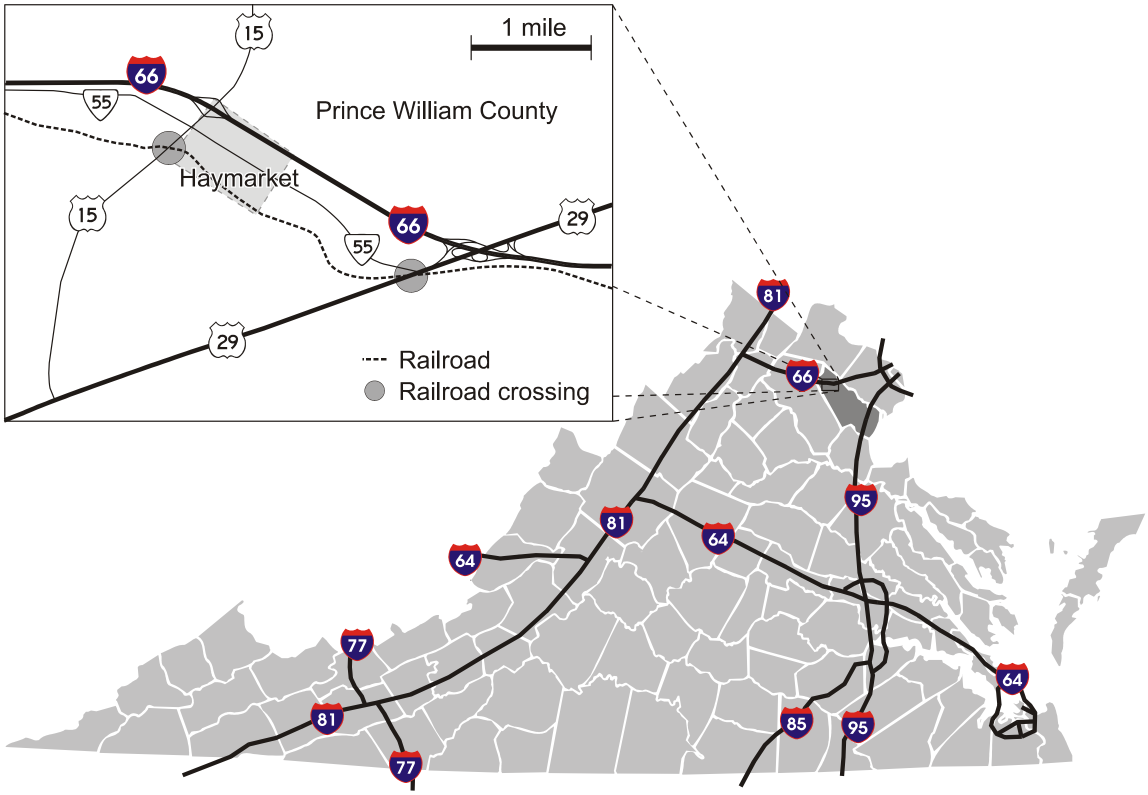

Figure 1. Location of Rail Crossings.

The intersection of a rail line and a roadway at an at-grade crossing represents the meeting of two vastly different transportation modes. Although they may share a common crossing where they intersect, the typical structural design of the supporting foundation for each is significantly different. The design of a roadway typically consists of multiple layers of low-permeability materials, whereas the design of a typical rail line includes rails resting on crossties supported by an open-draining aggregate ballast. Because of the use of highly permeable materials, the open-draining nature of a rail line substructure can cause the early deterioration of a nearby roadway unless steps are taken to provide adequate subsurface drainage. In addition to structural differences, the rail line is designed to accommodate a substantial vertical deflection from passing loaded rail cars; it is common for a rail line to undergo up to 0.3 inch of vertical displacement. This large deflection can result in a greatly reduced service life for nearby pavements because of fatigue failure. Although it is inevitable that the surface of a rail crossing will have to undergo periodic reconstruction, the selection of a proper surface and an adequately prepared foundation will greatly increase the service life of the crossing.

Unless innovative construction techniques and crossing designs are used, the service life of typical rail crossings is likely to decrease as the volume of rail cars and the weight each carries increase. According to the Association of American Railroads (2004), the number of rail car loads in the United States increased from 27.2 million in 2002 to 27.9 million in 2003. In Virginia, the average rail car load of coal, the product most commonly shipped by rail in the state, increased from approximately 101 tons in 1993 to 111 tons in 2002. Coal represented 61% (30.7 million tons) of all tonnage originating and 64% (36.7 million tons) of all tonnage terminating in Virginia in 2002.

PURPOSE AND SCOPE

The purpose of this study was to determine the most appropriate crossing structures for the U.S. Route 29 and U.S. Route 15 at-grade rail crossings in Prince William County, Virginia. In addition, specific recommendations for the pavement design and construction details for each crossing type were to be developed.

METHODOLOGY

To achieve the study objective, the following tasks were performed:

1. The current level of surface distress was assessed at the two crossings by visual survey.

2. The available and appropriate types of surfaces for at-grade rail crossings with high-volume roadways were determined through a literature review and communications with other professionals and researchers in this field.

3. Recommendations for the pavement design and construction details of the crossing structure for each type of surface were developed based on current practice in

pavement design and with the assistance of manufacturer representatives and with staff of VDOT's Materials Division. These resources were also used to conduct a basic analysis of material costs for typical construction.

RESULTS AND DISCUSSION

Current Level of Surface Distress at Crossings

In terms of vehicular traffic, the rail crossings at Routes 29 and 15 in Prince William County represent two of the most heavily traveled at-grade rail crossings in Virginia. In 2002, Route 29 carried approximately 53,000 vehicles per day with 7% trucks and Route 15 carried approximately 11,000 vehicles per day with 13% trucks. The crossing at Route 29 is one of the most heavily traveled in the United States.

These crossings are in close proximity and intersect the same rail line, a main east/west corridor through the Washington, D.C./Northern Virginia area operated by Norfolk Southern Corporation. Figures 2 and 3 show an overview of the crossings at Route 29 and Route 15, respectively. The current crossing structures consist of a precast concrete panelized system. The panels are placed on top of the compacted track ballast and act as the riding surface. Each panel is bolted in two locations (at two opposing corners of the panel) to the track ties below.

Figure 4 shows the recent condition of the rail crossing at Route 29 and shows examples of typical concrete panel deterioration, including panel settlement, cracking, spalling, and loss of metal edge band. The settlement and cracking deterioration represent primarily a reduction in

Figure 2. Overview of crossing at U.S. Route 29 (facing south).

Figure 3. Overview of crossing at U.S. Route 15 (facing south).

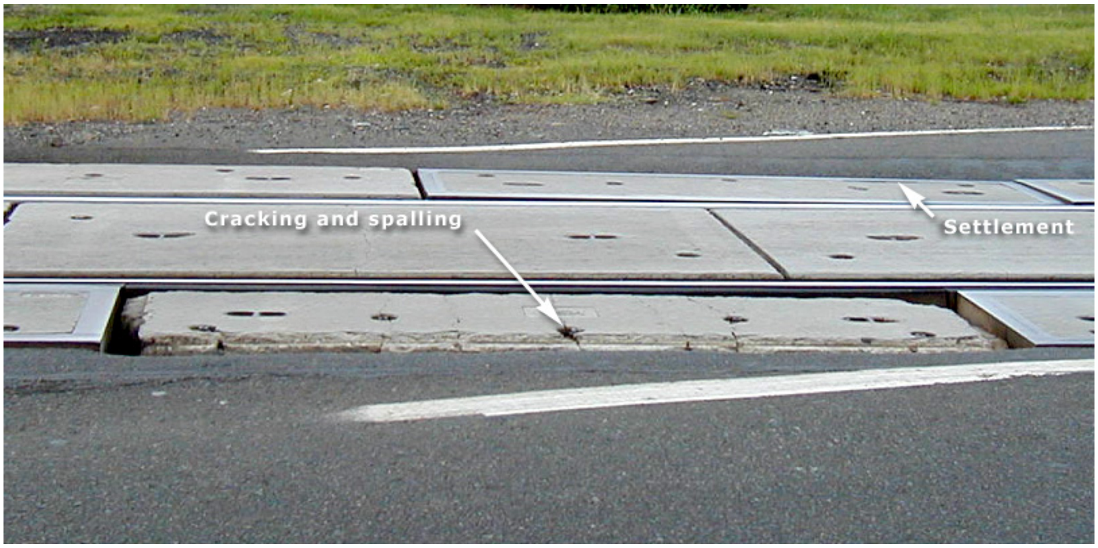

Figure 4. Deterioration of Concrete Panel Crossing.

the ride quality and minor safety issues. The spalling and loss of the metal edge band, however, represent possible serious safety concerns. To the right and left of the panel in the center foreground (labeled as cracking and spalling) are panels that still have their metal edge bands. These edge bands are pieces of angle iron designed to protect the concrete slab from damage by traffic and snowplows. Figure 4 also shows that these edge bands may be lost in typical service. The primary concern is that the loss of the edge band may occur under traffic and become a serious safety hazard.

Figure 5 shows the recent condition of the rail crossing at Route 15. As may be seen, a deteriorated panel has been removed and patched with asphalt. In addition, cracking of the approach roadway (possibly fatigue from movement of the adjacent panel) is evident to the right of the concrete panels.

Although the most often used repair method for rail crossings is to restore the riding surface by placing an asphalt patch, this type of repair is often a temporary solution and does not address any underlying structural issues. Hastily performed repair work often results from a combination of traffic volumes and questions of right-of-way/ownership. The likely cause of most deterioration is the high volume of vehicular and rail traffic. However, it is this same condition that keeps substantial repair work from being performed, as it is desirable not to close the roadway or track. In addition, motorists are more likely to call the local highway agency rather than the railroad to fix any perceived problems with a rough crossing. Often, it is more efficient for the local highway agency to patch a rough crossing repeatedly in an effort to stem complaints from motorists than wait for the railroad/owners to address the issue.

Figure 5. Concrete Panel Crossing Repaired with Hot-Mix Asphalt and Deterioration of Approach Pavement.

Types of Surfaces for At-Grade Rail Crossings

Many different materials and combinations of materials are typically used for rail crossing surfaces. Each crossing surface alternative may have advantages at a particular location depending on traffic and other conditions; unfortunately, no single solution is optimum for every location.

The following surfaces are the most common, and an approximate traffic volume range is given for each (Richards, 1998):

- *Unbound materials, low traffic volume.* These are typically used on unpaved roads; sand or gravel is placed between the rails.

- *Timber planks, low traffic volume.* Timber planks are placed surrounding the rail tracks; the approaches may be paved with asphalt. This surface may include a rubber seal placed between the rails and the timber.

- *Timber panels, low traffic volume.* Timber planks are joined together to form panels covering the area between the two rails (gauge area); the approaches are typically paved with asphalt.

- *Conventional asphalt or concrete pavement, low/moderate traffic volume.* The areas between (gauge area) and adjacent (field area) to the rails is paved with asphalt or concrete.

- *Concrete slab, low/moderate traffic volume.* The entire crossing area is placed as precast reinforced concrete slabs.

- *Rubber rail seal, low/moderate traffic volume.* A thin rubber seal is placed next to the rails, and adjacent areas are paved with asphalt or concrete.

- *Rubber panels, moderate/high traffic volume.* Rubber panels (which may be reinforced) are placed either as gauge panels only or as both gauge and field panels.

- *Concrete panels, moderate/high traffic volume.* Concrete (not reinforced, conventionally reinforced, or prestressed) panels are placed as only gauge panels or as both gauge and field panels.

- *Concrete tub-type crossing, moderate/high traffic volume.* This is a concrete crossing that replaces ballast and cross ties.

Crossing Surface Materials Suitable for Crossings Under Investigation

Although numerous commercially available options for crossing surfaces exist, there are few proven alternatives for a crossing with a high-volume roadway carrying a high percentage of truck traffic. Three alternatives that could potentially offer the longest service life for such crossings are precast concrete platform panels, high rut-resistant hot-mix asphalt, and steel-reinforced rubber panels (suitable only for the Route 15 crossing). Schematics for each alternative are presented in Appendix A.

Precast Concrete Platform Panels

Precast concrete platform panels are manufactured in various sizes; they are typically 8 to 11 feet wide by 5 to 17 feet long and range from 12 to 18 inches thick. The rail is attached to the panel using spring clips and is typically sandwiched between rubber seals. Each panel has two wide slots in which the rail and rubber seal combination is placed. The panel can be placed on a support bed of flowable backfill. No ties are used beneath the platform panels. The platform panels are different from the currently used panelized surface at the Route 29 and Route 15 crossings in that they use one panel to span the distance across the rail crossing. The currently used panelized crossing uses a combination of three panels to span the crossing; one panel carries traffic from the pavement edge to each rail, and a separate panel is located between the rails.

Platform panels have historically been used on lines with a low train volume; however, they have the potential to offer the longest service life on highway crossings where high traffic volumes and heavy truck traffic are present. This alternative is presented with the understanding that usage of the platform crossing makes it nearly impossible for the track owner to raise the track section and add ballast as it naturally compacts over time. However, this drawback may never be realized, as preliminary engineering is underway to replace the current at-grade crossing at Route 29 with a grade separated crossing within the next 15 to 20 years.

Platform panels also have a history of use on Virginia's roadways. Three roadway/rail line crossings currently use the platform panel crossing (shown with 2002 traffic data):

1. Route 13 near Cape Charles (13,000 AADT with 8% trucks)
2. Route 7 Business in Berryville (4,100 AADT with 6% trucks)
3. Route 250 Business–Preston Avenue in Charlottesville (21,000 ADT with 3% trucks).

It should be noted that these sites are not subjected to the same high vehicular traffic levels or the same high rail tonnage that would be expected at the Route 29 crossing.

High Rut-Resistant Hot-Mix Asphalt

A typical hot-mix asphalt (HMA) crossing is usually placed at a rail crossing with a low-volume roadway. Experience has shown this type of crossing to fail prematurely because of structural rutting within a few years when placed in areas with a high traffic volume. However, with careful consideration of the material properties, the HMA layers can be designed such that the typical rutting failure of a conventional asphalt crossing will be mitigated. This can be accomplished by employing an HMA surface, an intermediate HMA course, and an HMA underlayment. The intermediate layer will be designed using a larger nominal maximum aggregate size for a stronger intra-particle interlock, and the surface and intermediate mixes will use an asphalt binder having a higher stiffness. Placement of a thick rubber rail guard between the asphalt and the rails is recommended.

The use of an HMA crossing surface may prove to be beneficial in terms of periodic maintenance. As HMA or cold-applied asphalt is typically used for repair work, initial construction using HMA will result in a more homogeneous crossing that could result in a higher quality repair in the long term. In addition, an HMA crossing will provide a more water-resistant surface than will a panelized crossing having joints. This will result in a reduced infiltration of water into the crossing foundation that can severely weaken the crossing area and reduce the life of the crossing.

Typically, when an asphalt surface is installed at a replaced crossing, train traffic is allowed to pass over the crossing for a day or two to help compact the ballast aggregate layer.

During this time, a paved material or timber planks temporarily cover the vehicular crossing surface. However, this technique is not considered practical for the locations under consideration. It is the author's opinion that the pavement design and construction details discussed later, used in conjunction with proper compaction of the subsurface layers, will reduce this settlement to negligible levels.

Steel-Reinforced Rubber Panels

Steel-reinforced rubber panels are approximately 3 inches thick and 3 feet long. They are manufactured with a corrugated steel plate at approximately mid-depth. The rails are typically sealed with a flexible rubber rail guard; a solid rubber flange is also available. The rubber panels are placed on top of hardwood shims that are placed either longitudinally or transversely. The rubber panel/shim assembly is placed on top of the cross ties and then bolted in place.

This type of crossing is somewhat flexible and allows for movement within the crossing structure without transferring that movement to the surrounding pavement. Incorporation of the steel reinforcement is designed to resist panel deformation when heavy vehicle loads are expected. However, these types of panels should not be used where turning movements are likely to occur, as shearing failure may be an issue. In addition, the use of rubber panels is not recommended where the rail line and roadway cross at angles significantly different than 90 degrees (i.e., this alternative should be considered for the Route 15 crossing only).

A similar version (no reinforcement) of this crossing type is currently in place along the same rail line near the intersection of Route 28 and Wellington Road (2002 AADT was 21,000 with 5% trucks) in the city of Manassas. The crossing is performing well except at the center of the crossing. In this location, there are multiple tears of the rubber crossing and other areas where the material has ripped away. The damage is occurring in a U-turn area at a separation in the raised concrete median. In areas of the crossing where no turning movements occur, a small amount of panel settlement is the only deterioration that can be observed.

Crossing Structure Pavement Design and Construction Details

The premature deterioration of a rail crossing structure is often linked to an inadequately prepared foundation and/or improper use of a crossing surface that cannot withstand the traffic at a particular location for the anticipated service life. Commonly seen modes of deterioration include settlement, rutting, gouging, and cracking. The pavement approaching the crossing may also undergo similar forms of deterioration. The deterioration of the approach pavement is often a result of a loss of support from the underlying foundation (often attributable to excessive moisture allowed into the pavement substructure by the porous ballast material) or a failure in the surface material from the large rail track deflection and/or heavy truck traffic.

The key to achieving the longest service life for any crossing is to construct it over a properly prepared base and to provide a smooth surface with the surrounding pavement. Without a proper foundation, even the best solution for a particular crossing is likely to fail prematurely by loss of support from the underlying material. A smooth surface ensures a uniform transition in loading from the approach pavement to the crossing surface, thereby reducing the magnification of the applied load by dynamic impact.

For each crossing alternative, several steps may be taken during the reconstruction process to help ensure a strong foundation and a smooth crossing surface. One or more of the following should be included for each recommended crossing surface:

- improved foundation strength and subsurface drainage
- proper roadway/track surface alignment
- hot-mix asphalt underlayment.

The consideration of these improvements in a crossing reconstruction project is as important as the choice of surfacing material if a crossing is to function as designed for its expected service life.

Improved Foundation Strength and Subsurface Drainage

Any crossing structure will fail prematurely if the underlying foundation cannot adequately support the applied loading from traffic and effectively remove water that infiltrates through the porous ballast. The pavement structure is designed to spread the effects of traffic loading over a wider area through the use of a layered system. Thus, the native subgrade material must also be capable of providing a good foundation and be able to provide some structural capacity to the system. If the native materials cannot do this, they must be modified so that sufficient strength can be developed.

The presence of water in the foundation at the rail line/roadway crossing can result in reduced subgrade strength, contamination of the overlying layers with fines, and possibly frost heave during freezing temperatures. Without a proper and well-drained foundation, an approaching roadway constructed of flexible pavement can be expected to fail prematurely because of permanent deformation (rutting) and fatigue, and a rigid pavement can be expected to fail because of displacement and faulting. Therefore, incorporation of underdrain pipes or similar means for removing water from the crossing area should be considered an essential part of any crossing reconstruction project.

Proper Roadway/Track Surface Alignment

Where practicable, the approaching roadway surface should be aligned with the track to account for elevation/grade changes within the rail line where it is practicable. Examples of elevation/grade differences are a roadway grade approaching a level rail line (e.g., Route 15 in Haymarket) and a level or nearly level roadway approaching a rail line in a curve (e.g., Route 29 in Gainesville). For the case of a roadway grade approaching the rail line, the level rail line represents a discontinuity in the grade of the road. This discontinuity will be perceptible to the users of the roadway if the grade is significantly different than the level rail line. For a roadway intersecting a curved portion of a rail line, the rail on the outside of the curve will be slightly higher than the rail on the inside of the curve. Again, this will create a perceptible discontinuity to the users of the roadway because of the difference in the elevations of the two rails. This discontinuity may seem to be only an inconvenience to the users of the roadway; however, it represents an area of dynamic impact loading that can dramatically magnify the load applied to the crossing foundation by a passing vehicle. Because of multiple repetitions of this magnified loading, the service life of a misaligned crossing can decrease substantially because of settlement and fatigue failure. This is especially true for an area of heavy truck traffic. In addition, a study by the Michigan Department of Transportation (2002) suggests that an increase in crossing roughness may lead to a increase in accidents as drivers search for a smoother path rather than pay attention to crossing warning devices and train traffic.

Hot-Mix Asphalt Underlayment

Results of research by Rose and Tucker (2002) and Rose et al. (2002) indicate that the use of an HMA underlayment system between the subgrade and the track ballast significantly reduces the load applied to the subgrade by train and vehicular traffic and provides an impermeable base. The reduction in load applied to the subgrade reduces the likelihood of subgrade rutting and settlement within the crossing area. By the provision of an impermeable base, any moisture that infiltrates through the ballast can be removed before reaching the subgrade within the crossing area. In addition, the underlayment offers a supporting base for compaction of the track ballast minimizing possible future settlement. The use of HMA as an underlayment provides additional support at the crossing area without causing an increase in track stiffness. An abrupt change in track stiffness causes an impact to rail traffic at the crossing, resulting in dynamic loading to the track itself. Increased support without an increase in stiffness is offered by the underlayment as the asphalt allows some flexibility as the rail traffic passes that does not occur when a rigid (portland cement concrete) pavement is used as an underlayment.

An HMA underlayment is typically constructed using a dense-graded highway base mix that is compacted in the same manner as if it were a roadway base. The binder content of this mix is often increased by 0.5% over that typically specified for the paving mix to give an underlayment with some resilient properties. After communications with researchers and engineers specializing in rail crossing surfaces (personal communication, J. G. Rose and S. Erekson), the use of HMA as an underlayment of the ballast layer is recommended. A set of illustrations showing a typical cross section of a reconstructed crossing surface including an HMA underlayment is provided in Appendix A.

RECOMMENDATIONS

The following crossing surface alternatives, listed in order of anticipated service life from longest to shortest, are recommended for reconstruction of the rail crossings at Routes 29 and 15 in Prince William County:

1. precast concrete platform panels
2. high rut-resistant hot-mix asphalt
3. steel-reinforced rubber panels (suitable only for the Route 15 crossing).

Approximate crossing surface material costs per foot of track for the precast concrete platform panels, high rut-resistant hot-mix asphalt, and steel-reinforced rubber panels are $270, $120, and $290, respectively. As there is no difference in the recommended pavement base materials between the various options, these costs are not included.

These alternatives are considered to have the best opportunity for the longest service life based on the assumption that the as-built reconstructed crossings include provisions for adequate foundation support (including proper drainage), proper alignment of the roadway surface and rail track, and an asphalt underlayment. Recommended structural design and construction details are presented in Appendix B.

ACKNOWLEDGMENTS

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APPENDIX A: EXAMPLE CROSSING DRAWINGS

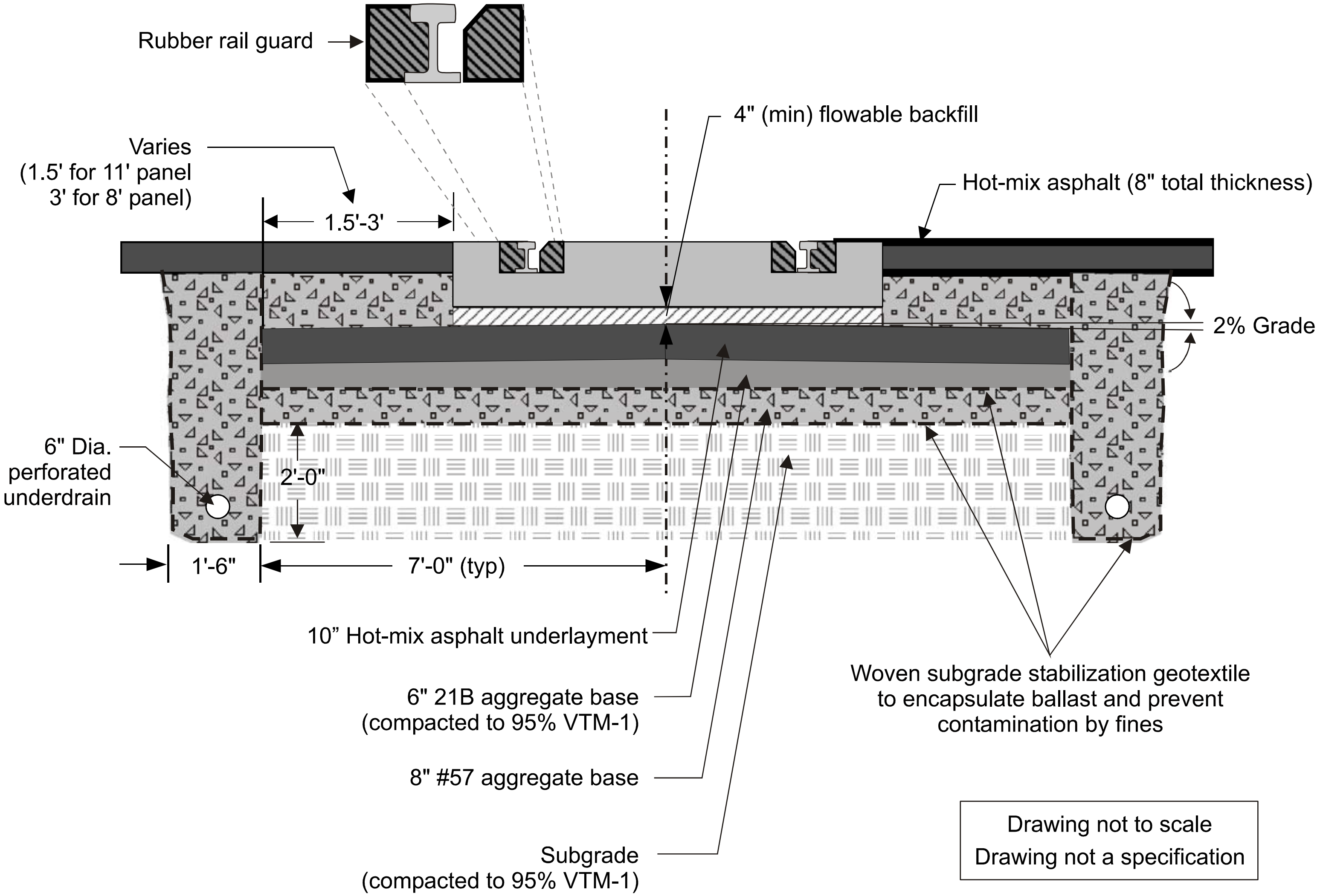

Figure A1. Profile View of Reconstructed Rail Crossing Using Precast Concrete Platform Panels.

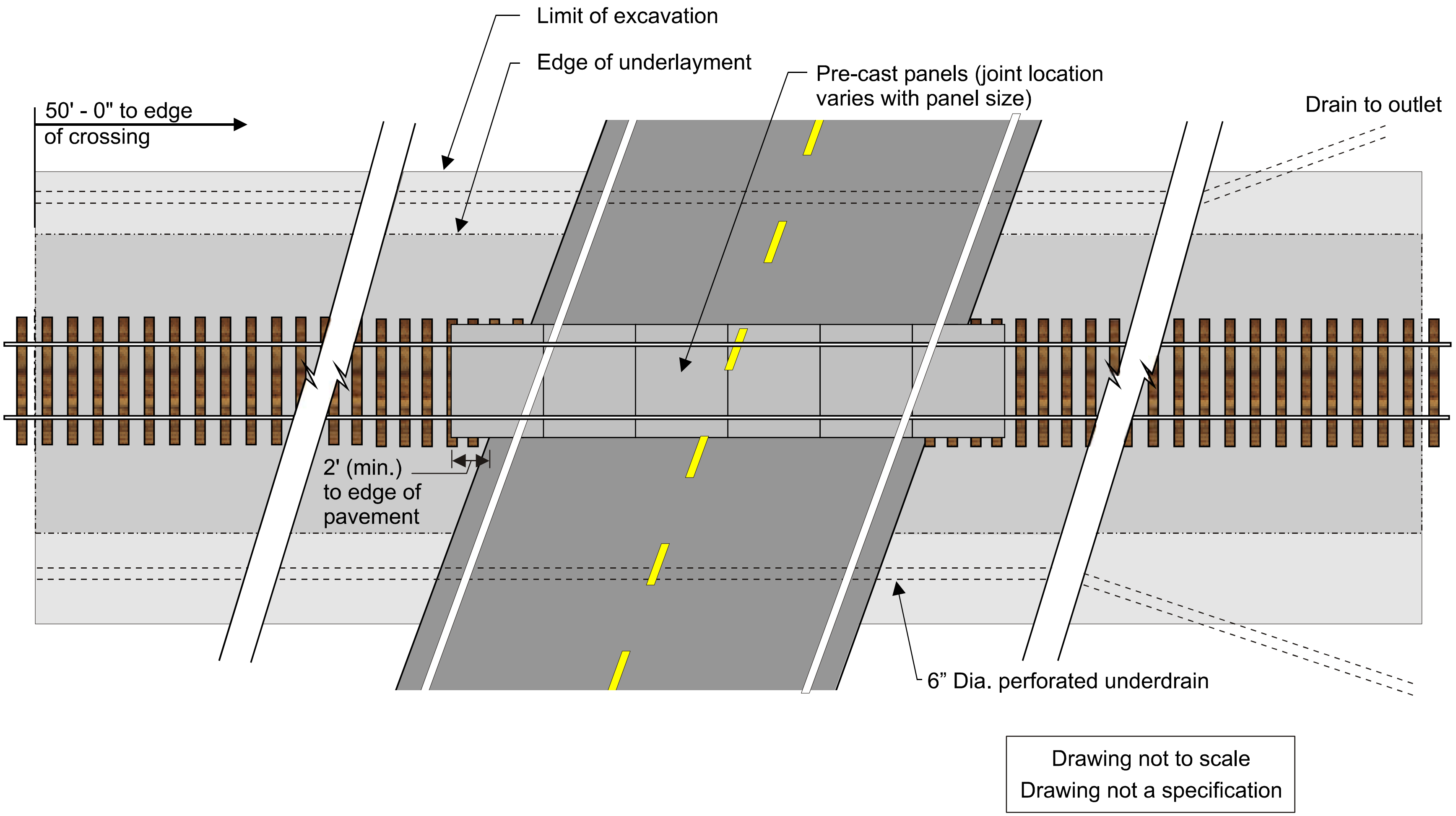

Figure A2. Plan View of Reconstructed Rail Crossing Using Precast Concrete Platform Panels.

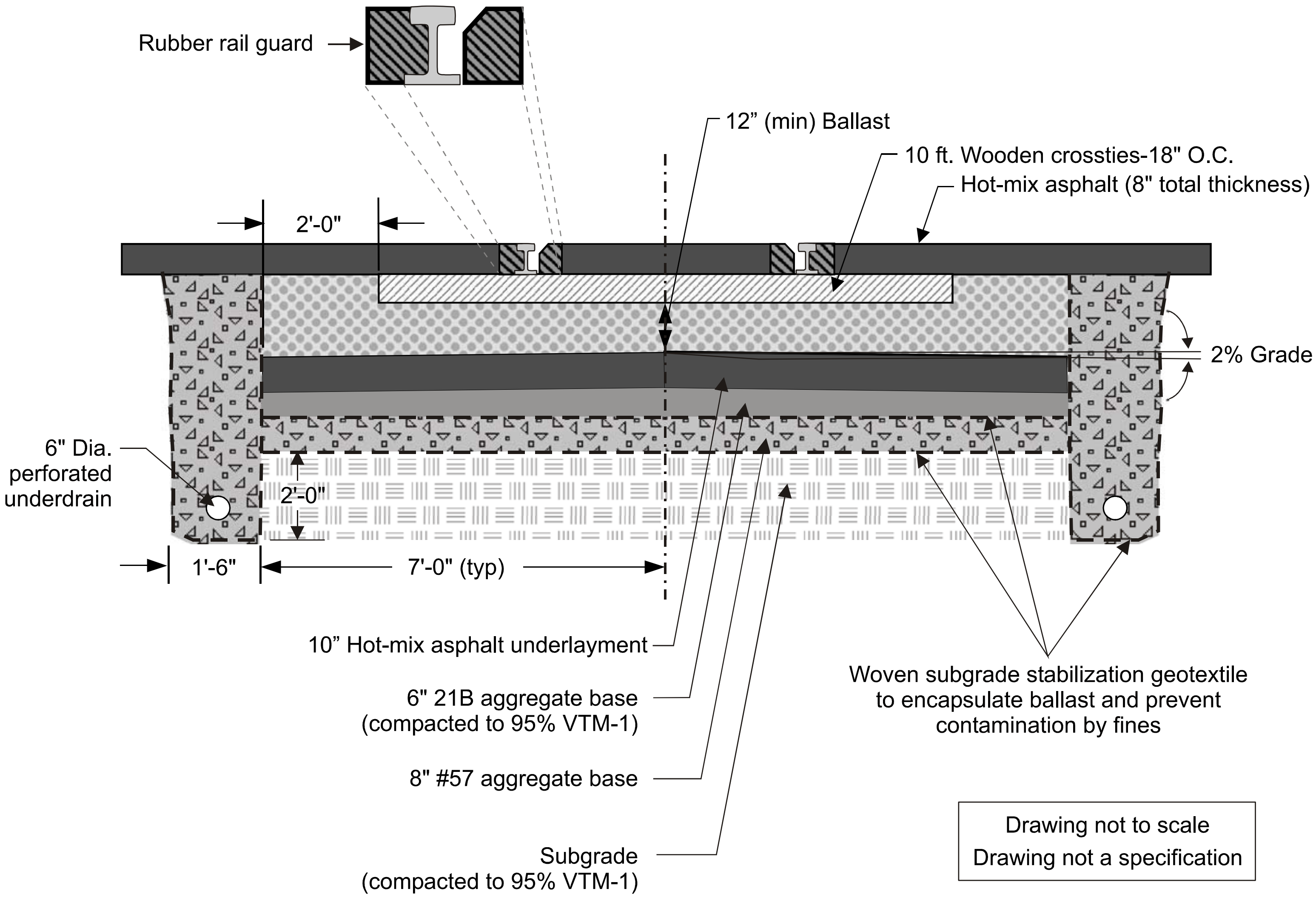

Figure A3. Profile View of Reconstructed Rail Crossing Using High Rut-Resistant Hot-Mix Asphalt.

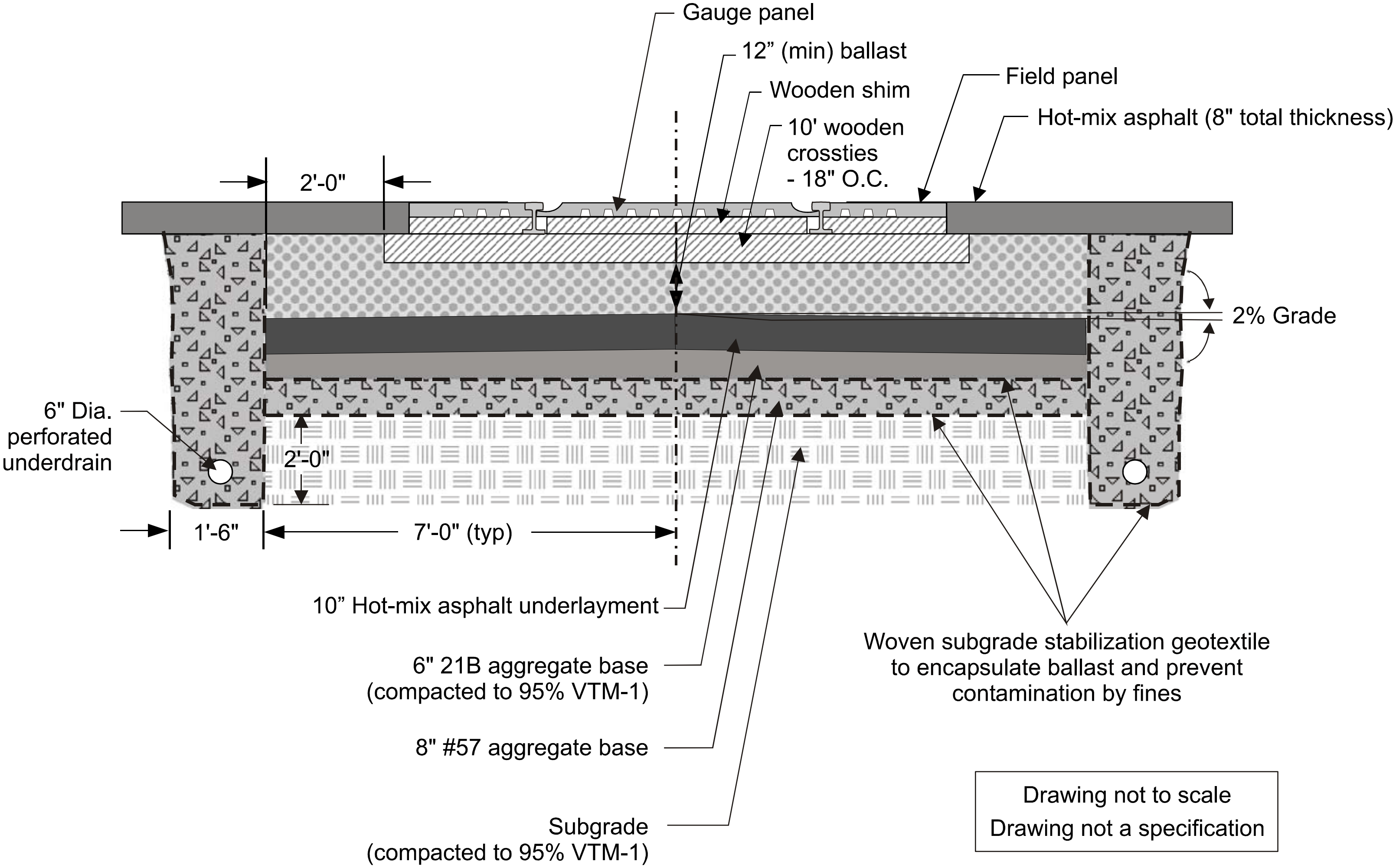

Figure A4. Profile View of Reconstructed Rail Crossing Using Steel-Reinforced Rubber Panels.

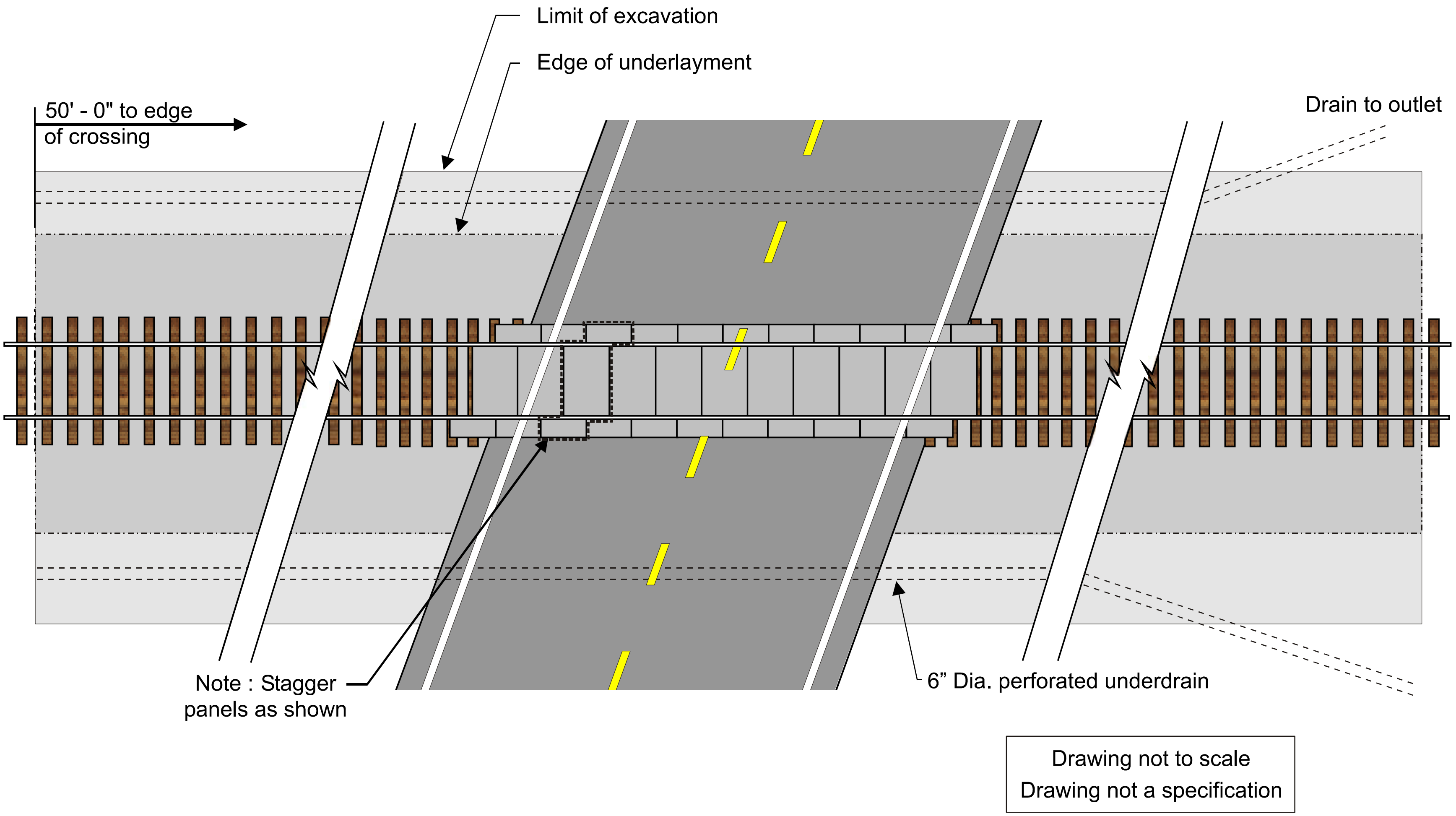

Figure A5. Plan View of Reconstructed Rail Crossing Using Steel-Reinforced Rubber Panels.

APPENDIX B: RECOMMENDED DESIGN AND CONSTRUCTION ELEMENTS

The following recommendations do not constitute a specification. However, they may be used as a guide to develop actual specifications.

Precast Concrete Platform Panels

- The existing track and ballast at the crossing shall be removed out to a distance of 50 feet beyond each roadway edge.

- The existing pavement surrounding the crossing shall be saw cut to a minimum width of 14 feet on each side of the track centerline. This area (50 feet by 14 feet) shall be excavated to accommodate the selected crossing design.

- Following excavation, the existing subgrade shall be mixed with 10% lime to a depth of 18 inches and compacted to 98% maximum density in accordance with VTM-1 (VDOT, 2004). If the existing subgrade material cannot be compacted, due to excessive moisture (or high plasticity), this material shall be removed, replaced by VDOT designation 21B aggregate subbase material (VDOT, 2002), and then compacted to the desired level.

- The modified subgrade shall be covered by a layer of VDOT designation 21B aggregate base material compacted to a depth of 18 inches at 98% maximum density per VTM-1 (VDOT, 2004).

- A hot-mix asphalt underlayment shall be placed on top of the compacted subbase and shall consist of BM-25.0 having a binder content 0.5% greater than the design binder content.

  — The underlayment shall have a slope of 2% from the centerline of the tracks.

  — The underlayment shall be 4 inches thick.

  — The underlayment shall extend the full width and length of the excavated area.

  — Any asphalt pavement placed as an underlayment shall be constructed in accordance with the same specifications that apply to a typical highway pavement base mix, especially with regard to antistripping additive and binder type criteria when using recycled asphalt pavement (VDOT, 2002).

- A layer of flowable backfill (approximately 4 inches thick) shall be used to create a support for the platform panels. A layer of sand (1.5 inches maximum thickness) shall be used to bring the crossing panels to the final level.

- Trenches for the placement of transverse underdrains shall be excavated just beyond the previously constructed layers to a width of 18 inches.

    - The existing pavement surface shall again be saw cut prior to excavation.
    - The trenches shall be dug to a depth of 2 feet below the surface of the subgrade.
    - Perforated Schedule 40 PVC underdrain pipes (6-inch diameter) shall be placed in the trenches.
    - No. 57 aggregate shall be used as backfill and compacted within the trenched area. The backfill shall be brought up to the elevation of the top of the underlayment.
    - The bottom and sides of the trench shall be lined with geotextile drainage fabric.

- Following placement of the crossing panels, No. 57 aggregate material shall be built up between the new crossing panels and the existing pavement and compacted to within 8 inches of the final pavement surface.

- The area between the new crossing panels and the existing pavement shall be paved with hot-mix asphalt: 3.5 inches of BM-25.0, followed by 2.5 inches of IM-19.0D, followed by 2.0 inches of SM-9.5E (modified using SBS polymer), placed using typical highway pavement application procedures (VDOT, 2002). A tack coat shall be applied to the face of the existing pavement just prior to paving.

- StarTrack reinforced concrete panels, manufactured by Oldcastle Precast, Inc., are an example of this type of rail crossing.

High Rut-Resistant Hot-Mix Asphalt

- The existing track and ballast at the crossing shall be removed out to a distance of 50 feet beyond each roadway edge.

- The existing pavement surrounding the crossing shall be saw cut at a minimum width of 14 feet on each side of the track centerline. This area (50 feet by 14 feet) shall be excavated to accommodate the selected crossing design.

- Following excavation, the existing subgrade shall be mixed with 10% lime to a depth of 18 inches and compacted to 98% maximum density in accordance with VTM-1 (VDOT, 2004). If the existing subgrade material cannot be compacted, due to excessive moisture (or high plasticity), this material shall be removed, replaced by VDOT designation 21B aggregate subbase material (VDOT, 2002), and then compacted to the desired level.

- The modified subgrade shall be covered by a layer of VDOT designation 21B aggregate base material compacted to a depth of 18 inches at 98% maximum density in accordance with VTM-1 (VDOT, 2004).

- A hot-mix asphalt underlayment shall be placed on top of the compacted subbase and shall consist of BM-25.0 having a binder content that is 0.5% greater than the design binder content.

  - The underlayment shall have a slope of 2% from the centerline of the tracks.
  - The underlayment shall be 4 inches thick.
  - The underlayment shall extend the full width and length of the excavated area.
  - Any asphalt pavement placed as an underlayment shall comply with the same specifications that apply to a typical highway pavement base mix, especially with regard to antistripping additive and binder type criteria when recycled asphalt pavement is used (VDOT, 2002).
- A layer of aggregate ballast shall be placed and compacted to a depth of 12 inches and compacted following typical installation procedures (VDOT, 2002).
- Trenches for the placement of transverse underdrains shall be excavated just beyond the previously constructed layers to a width of 18 inches.
  - The existing pavement surface shall again be saw cut prior to excavation.
  - The trenches shall be dug to a depth of 2 feet below the surface of the subgrade.
  - Perforated Schedule 40 PVC underdrain pipes (6-inch diameter) shall be placed in the trenches.
  - No. 57 aggregate shall be used as backfill and compacted within the trenched area. The backfill shall be brought up to the elevation of the ballast surface.
  - The bottom and sides of the trench shall be lined with geotextile drainage fabric.
- Wooden crossties (10 feet in length) shall be placed along the path of the rail at 18 inches on center for the length of the paved underlayment. The elevation of the new ties shall match the grade of the existing crossties.
- Additional aggregate ballast shall be placed and compacted to a level that is even with the top of the crossties.
- Following installation of the rails, a heavy rubber rail guard (e.g., OmniRail RailGuard VRA) shall be installed.
- The crossing surface (area between the existing pavement and each rail and the area between the two rails) shall be paved with hot-mix asphalt: 3.5 inches of BM-25.0, followed by 2.5 inches of IM-19.0D, followed by 2.0 inches of SM-9.5E (modified using SBS polymer) placed following typical highway pavement application procedures (VDOT, 2002). A tack coat shall be applied to the face of the existing pavement just prior to paving.
- Pavement design calculations are provided in Appendix C.
- Soil boring data are presented in Appendix D.

Steel-Reinforced Rubber Panels

- The existing track and ballast at the crossing shall be removed out to a distance of 50 feet beyond each roadway edge.

- The existing pavement surrounding the crossing shall be saw cut at a minimum width of 14 feet on each side of the track centerline. This area (50 feet by 14 feet) shall be excavated to accommodate the selected crossing design.

- Following excavation, the existing subgrade shall be mixed with 10% lime to a depth of 18 inches and compacted to 98% maximum density in accordance with VTM-1 (VDOT, 2004). If the existing subgrade material cannot be compacted, due to excessive moisture (or high plasticity), the material shall be removed, replaced by VDOT designation 21B aggregate subbase material, and then compacted to the desired level.

- The modified subgrade shall be covered by a layer of VDOT designation 21B aggregate base material compacted to a depth of 18 inches at 98% maximum density per VTM-1 (VDOT, 2004).

- A hot-mix asphalt underlayment shall be placed on top of the compacted subbase and shall consist of BM-25.0 having a binder content 0.5% greater than the design binder content.

    - The underlayment shall have a slope of 2% from the centerline of the tracks.

    - The underlayment shall be 4 inches thick.

    - The underlayment shall extend the full width and length of the excavated area.

    - Any asphalt pavement placed as an underlayment shall comply with the same specifications required for a typical highway pavement base mix, especially with regard to antistripping additive and binder type criteria when using recycled asphalt pavement (VDOT, 2002).

- A layer of aggregate ballast shall be placed and compacted to a depth of 12 inches and compacted following typical installation procedures (VDOT, 2002).

- Trenches for the placement of transverse underdrains shall be excavated just beyond the previously constructed layers to a width of 18 inches.

    - The existing pavement surface shall again be saw cut prior to excavation.

    - The trenches shall be dug to a depth of 2 feet below the surface of the subgrade.

    - Perforated underdrain pipes (6 inch diameter) shall be placed in the trenches.

    - No. 57 aggregate shall be used as backfill and compacted within the trenched area. The backfill shall be brought up to the elevation of the ballast surface.

— The bottom and sides of the trench shall be lined with geotextile drainage fabric.

- Wooden crossties (10 feet in length) shall be placed along the path of the rail at 18 inches on center for the length of the paved underlayment. The elevation of the ties shall be such that the existing rail grade is matched.

- Additional aggregate ballast shall be placed and compacted to a level that is even with the top of the crossties.

- The rubber panels shall be installed in accordance with to the manufacturer's directions.

- Following placement of the rubber panels, the No. 57 aggregate material shall be built up between the new crossing panels and the existing pavement and compacted to within 8 inches of the final pavement surface.

- The area between the new crossing panels and the existing pavement shall be paved with hot-mix asphalt: 3.5 inches of BM-25.0, followed by 2.5 inches of IM-19.0D, followed by 2.0 inches of SM-9.5E (modified using SBS polymer) placed using typical highway pavement application procedures (VDOT, 2002). A tack coat shall be applied to the face of the existing pavement just prior to paving.

- OmniRail Steel Reinforced (SR) rubber panels, manufactured by Omni Products, Inc., are an example of this type of rail crossing.

REFERENCES

Virginia Department of Transportation. (2002). *Road and Bridge Specifications*, Richmond.

Virginia Department of Transportation, Materials Division. (2004). *Virginia Test Methods*, Richmond.

APPENDIX C: HOT-MIX ASPHALT PAVEMENT DESIGN

1993 AASHTO Pavement Design

DARWin(tm) Pavement Design System
A Proprietary AASHTOWARE(tm) Computer Software Product

Flexible Structural Design Module
U.S. Route 29 Rail Crossing – Gainesville

Flexible Structural Design Module Data

18-kip ESALs Over Initial Performance Period:	50,000,000
Initial Serviceability:	4.2
Terminal Serviceability:	2.9
Reliability Level (%):	98
Overall Standard Deviation:	.49
Roadbed Soil Resilient Modulus (PSI):	20,000
Stage Construction:	1

Calculated Design Structural Number:	5.63

Specified Layer Design

Layer	Material Description	Structural Coefficient (Ai)	Drainage Coefficient (Mi)	Thickness (Di), inches	Calculated SN
1	SM9.5	.4	1	2.0	0.8
2	IM19.0	.4	1	2.5	1.0
3	BM25.0	.4	1	3.5	1.4
4	Aggregate Ballast	.1	1	12.0	1.2
5	BM25.0	.4	1	4.0	1.6
6	21B Aggregate Base	.1	1	18.0	1.8
7	Lime Stabilized Subgrade	.1	1	18.0	1.8
Total				**60.0**	**9.6**

Rigorous ESAL Calculation

Performance Period (years):	30
Two-Way Daily Traffic (ADT):	53,000
Number of Lanes In Design Direction:	2
Percent of All Trucks In Design Lane (%):	90
Percent Trucks In Design Direction (%):	50
Growth:	Compound

Class	% ADT	Annual % Growth	Average Initial Truck Factor (ESALs/truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs Over Performance Period
1	93	3	.0002	0	77,086
5	4	3	.37	0	6,133,705
9	3	3	1.28	0	15,914,479
Total	**100**				**22,125,270**

1993 AASHTO Pavement Design

DARWin(tm) Pavement Design System
A Proprietary AASHTOWARE(tm) Computer Software Product

Flexible Structural Design Module
U.S. Route 15 Rail Crossing–Haymarket

Flexible Structural Design Module Data

18-kip ESALs Over Initial Performance Period:	25,000,000
Initial Serviceability:	4.2
Terminal Serviceability:	2.9
Reliability Level (%):	98
Overall Standard Deviation:	.49
Roadbed Soil Resilient Modulus (PSI):	20,000
Stage Construction:	1

Calculated Design Structural Number: 5.08

Specified Layer Design

Layer	Material Description	Structural Coefficient (Ai)	Drainage Coefficient (Mi)	Thickness (Di), inches	Calculated SN
1	SM9.5	.4	1	2.0	0.8
2	IM19.0	.4	1	2.5	1.0
3	BM25.0	.4	1	3.5	1.4
4	Aggregate Ballast	.1	1	12.0	1.2
5	BM25.0	.4	1	4.0	1.6
6	21B Aggregate Base	.1	1	18.0	1.8
7	Lime Stabilized Subgrade	.1	1	18.0	1.8
Total				**60.0**	**9.6**

Rigorous ESAL Calculation

Performance Period (years):	30
Two-Way Daily Traffic (ADT):	11,000
Number of Lanes In Design Direction:	1
Percent of All Trucks In Design Lane (%):	100
Percent Trucks In Design Direction (%):	50
Growth:	Compound

Class	% ADT	Annual % Growth	Average Initial Truck Factor (ESALs/truck)	Annual % Growth in Truck Factor	Accumulated 18-kip ESALs over Performance Period
1	87	3	.0002	0	16,630
5	6	3	.37	0	2,121,722
9	7	3	1.28	0	8,563,346
Total	**100**				**10,701,698**

APPENDIX D: SOIL BORING DATA FOR ROUTE 29 CROSSING

Table D1. Soil Boring Data Collected for Preliminary Design of Grade-Separated Crossing at Route 29

Date Drilled
Samples 1 through 12: May/June 2001
Samples 13 and 14: March 2004

Offset from	Abut-ment	Sample	Offset	Station	Depth	blow counts				water, depth	
						1st 6in	2nd 6in	3rd 6in	N (2nd + 3rd)	when first encountered	after 24hrs
29 Southbound CenterLine	A	1	88ft L	36+00	0-1.5	5	4	5	9	5	3.6
					2.5-4	3	4	5	9		
					5-6.5	14	3	1	4		
		2	40ft L	37+94	0-1.5	4	2	3	5	none	5.3
					2.5-4	4	4	4	8		
					5-6.5	2	0	1	1		
		3	24ft L	40+65	0-1.5	1	2	3	5	10	3.5
					2.5-4	2	2	2	4		
					5-6.5	0	0	2	2		
		4	78ft R	43+06	0-1.5	3	5	9	14	none	3.8
					2.5-4	8	14	7	21		
					5-6.5	2	3	6	9		
		5	121ft R	44+96	0-1.5	1	4	5	9	none	dry
					2.5-4	3	6	8	14		
					5-6.5	3	18	26	44		
		6	180ft R	47+74	0-1.5					none	dry
					2.5-4	4	8	11	19		
					5-6.5	11	18	33	51		
	B	7	170ft R	36+22	0-1.5	3	2	3	5	none	dry
					2.5-4	2	1	1	2		
					5-6.5	2	1	2	3		
		8	108ft L	39+00	0-1.5	2	4	9	13	5	2.5
					2.5-4	2	1	2	3		
					5-6.5	0	1	2	3		
		9	60ft L	41+04	0-1.5					none	dry
					2.5-4	5	2	6	8		
					5-6.5	2	2	2	4		
		10	17ft L	43+00	0-1.5					none	dry
					2.5-4	1	2	1	3		
					5-6.5	0	0	0	0		
		11	15ft R	44+36	0-1.5	3	5	7	12	none	dry
					2.5-4	2	3	7	10		
					5-6.5	3	8	13	21		
		12	80ft R	47+35	0-1.5	6	6	5	11	none	3
					2.5-4	17	50		50		
					5-6.5		50		50		
		13	114ft L	40+25	1-2.5	10	11	10	21	none	dry
					2.5-4	2	14	4	18		
					5-6.5	3	4	4	8		
		14	25ft R	39+10	0-1.5					none	dry
					2.5-4	7	8	8	16		
					5-6.5	5	5	5	10		