PGSuper Tutorials

from BridgeSight Software

Modeling Wearing Surfaces

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Title PGSuper Tutorial – Modeling Wearing Surfaces	**Publication No.** BS01292014-5

Abstract

PGSuper can model several types of wearing surfaces. Each type of wearing surface has different implications for the analysis performed by the software. This document describes the wearing surface types that are supported and the methods to model them, and will explain how each affect section properties, stress analysis, dead load analysis, and load rating analysis.

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Introduction

Several types of wearing surfaces can be modeled in PGSuper. Each type has different implications for the analysis performed by the software. This document examines the types of wearing surfaces that are supported, describes how they are modeled, and how each affects the analysis.

Wearing Surfaces

The wearing surface is the surface upon which the vehicular live load travels. PGSuper supports three types of wearing surfaces; Sacrificial, Overlay, and Future Overlay. The wearing surface can be part of, or on top of, the bridge deck. In addition, when adjacent elements such as box girders, slabs, and deck-bulb tee members are used without a concrete overlay, the wearing surface is the top surface of the precast element.

The parameters for modeling the wearing surface in PGSuper are found in the Wearing Surface group on the Deck Geometry and Materials tab of the Bridge Description window as illustrated in the following sections.

*TIP: Access the Bridge Description window by selecting **Bridge** from the **Edit** menu.*

Sacrificial Wearing Surface

Friction and abrasion from many years of traffic traveling on the wearing surface can cause wheel ruts and loss of section. The section loss that results from this wear is modeled in PGSuper with the Sacrificial Depth parameter as shown in Figure 1.

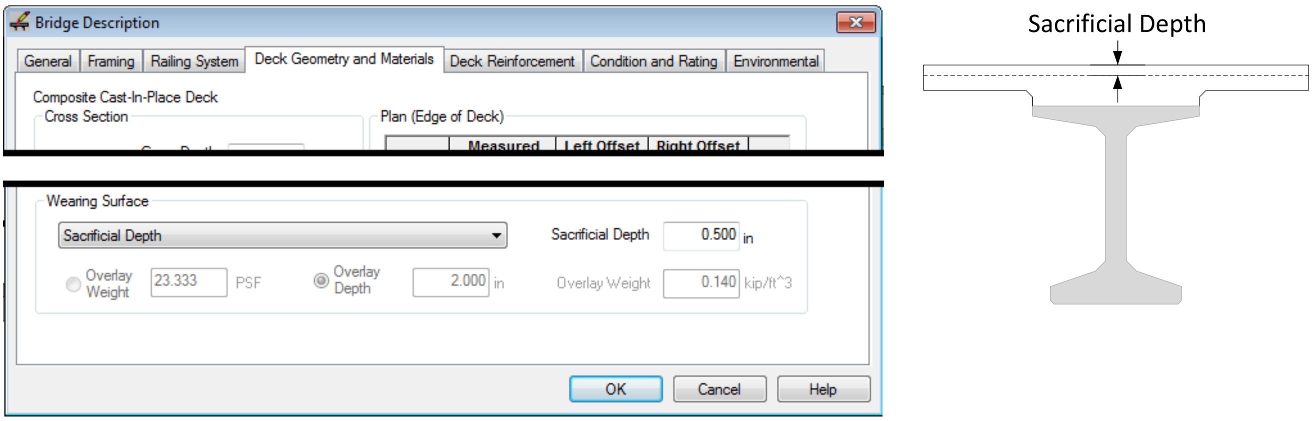


Figure 1 Sacrificial Wearing Surface

TIP: Modeling of the section loss in box girders, slabs, and deck bulb tee sections due to wearing and rutting is a new feature in PGSuper 2.8.

Overlay

One option for preventing wear of a concrete bridge deck is to protect it with an overlay of asphalt concrete pavement (ACP) or hot mix asphalt (HMA). The overlay can also be used to provide a smooth final riding surface for a bridge constructed of adjacent box, slab, or pre-decked elements with longitudinal joints between the elements. In addition, an overlay can hide imperfections caused by variation in camber between adjacent elements and; can also be built up to compensate for the difference between actual camber in a precast element and the desired final profile grade.

PGSuper has two options for modeling overlays: using Overlay Depth and Unit Weight, or Overlay Weight directly as an equivalent pressure as shown in Figure 2. The Overlay is considered to be installed as part of the original bridge construction, and is assumed to be installed shortly after the railing system is constructed, before the bridge is put into service.

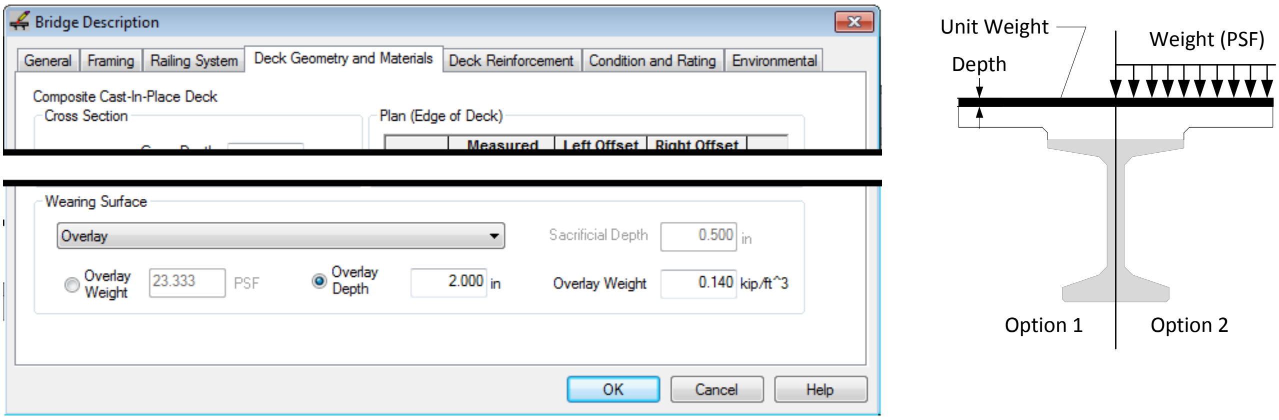


Figure 2 Overlay

Future Overlay

Think of a future overlay as a hybrid of a sacrificial wearing surface and an overlay. The bridge is first put into service with traffic traveling directly on the sacrificial wearing surface. Later, the future overlay is installed when the wear of the riding surface warrants mitigation.

In PGSuper, a future overlay is modeled with both the sacrificial depth parameter and one of the overlay options described above. As you can see in Figure 3 both the Sacrificial Depth and Overlay Depth/Weight parameters can be input.

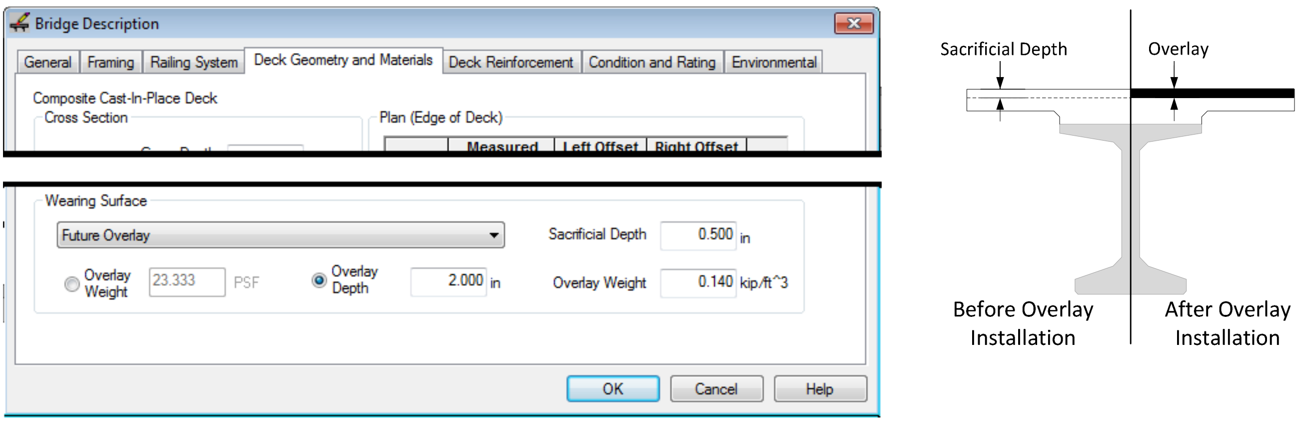
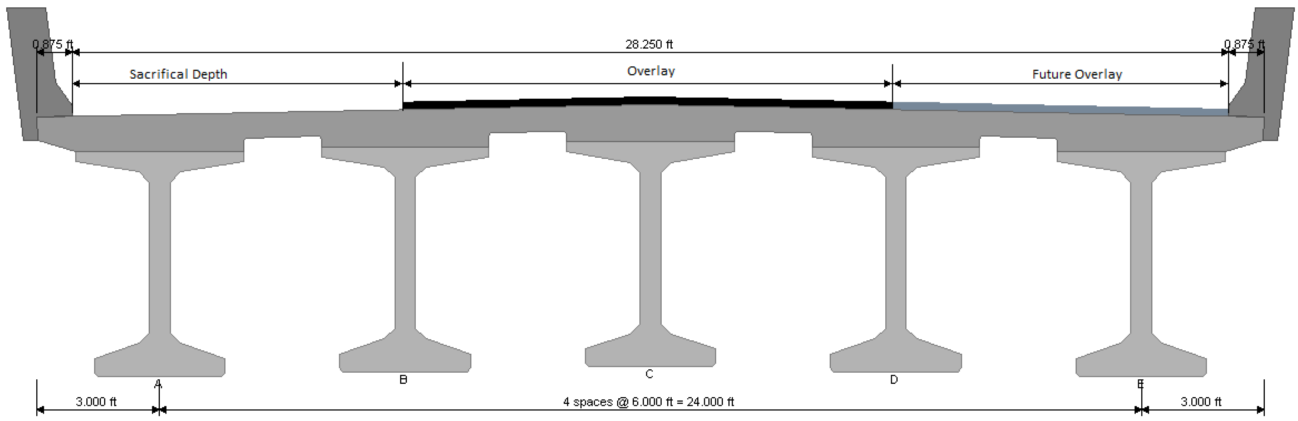


Figure 3 Future Overlay

TIP: *PGSuper's bridge section view provides a visual cue to indicate the type of wearing surface modeled:*



Implications on Analysis

The choice of wearing surface has subtle implications on how the analysis is performed by PGSuper. In this section, we'll describe how the wearing surface affects section properties, dead load analysis, stress analysis, flexural and shear capacity analysis, load rating analysis, and roadway surface elevations.

Section Properties

The determination of section properties is dependent on wearing surface. When a sacrificial wearing surface or future overlay is used, it is assumed that the entire wearing surface will been removed due to the abrasive action of traffic at some future time. Hence, the depth of the deck slab or precast element supporting traffic is reduced by the sacrificial depth.

The depth of the deck slab or precast element used for computing section properties, and the depth of the compression flange for moment capacity calculations, is taken to be the gross depth minus the sacrificial depth. There is no reduction in depth when an overlay is installed as part of the original bridge construction.

Dead Load Analysis

When the sacrificial wearing surface is first constructed, the bridge must carry the full dead load of the wearing surface. For this reason, the dead load for the deck slab and pre-decked elements is based on the total gross depth of the element.

The dead load of an overlay-type wearing surface (overlay or future overlay) is always considered in the final service load condition. That is, the dead load of an overlay is modeled in Bridge Site Stage 2.

Stress Analysis

Calculation of compression stresses in Bridge Site Stages 2 and 3 for the Service I and Fatigue I limit states becomes a bit complicated when a future overlay is modeled. The dead load of the future overlay causes tension in the bottom of the girder and compression in the top. Depending on the location in the girder (bottom or top), the critical case may be either just before or just after the future overlay is installed.

TIP: *PGSuper's stress sign convention models compression stresses as negative and tension stresses as positive.*

Figure 4 plots the convention in the form of a number line: The compression stress limit (red circle) is plotted to the left of zero. The stress furthest to the left on the number line is the controlling condition. Stresses to the left of the compression stress limit exceed the allowable limit. The top and bottom girder stresses (blue and green circles, respectively) with and without the future overlay dead load stress effects (solid and open circles, respectively) are also plotted on the number line. Here it is obvious that the controlling cases are top of girder with overlay dead load and bottom of girder without overlay dead load.

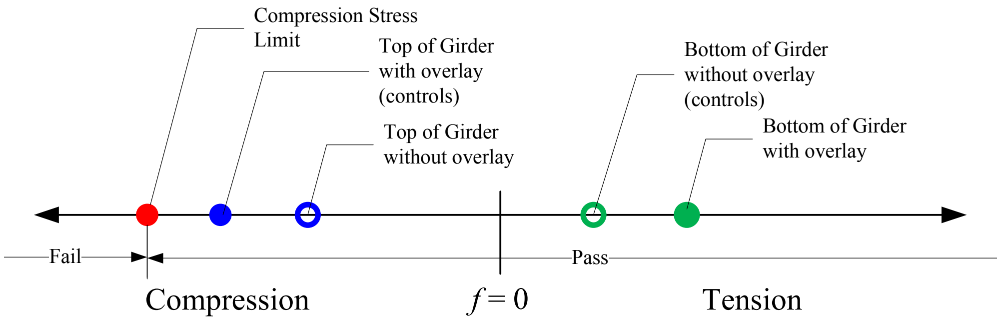


Figure 4 Stress Analysis Number Line

Flexural Capacity Analysis

Future overlays also further complicate the evaluation of flexural capacity. When the future overlay causes moment with the opposite sense of the moment capacity being evaluated, the controlling case occurs before the future overlay is installed. Similarly, at sections where the future overlay causes moment that has the same sense as the moment capacity being evaluated, the controlling case occurs after it is installed. That is to say, at sections where the future overlay causes positive moment, the controlling case for positive moment capacity occurs after the overlay is installed and the controlling case for evaluating negative moment capacity is before it is installed. Evaluation of moment capacity at sections where the future overlay causes negative moment is similar.

Similarly, when evaluating shear capacity, the shear force due to the future overlay dead load is included only when it contributes to the governing condition.

Load Rating Analysis

Load ratings are performed for the current condition of a structure as input. When a bridge is modeled with a future overlay, it is assumed that the overlay has not yet been installed and is therefore excluded from the load rating analysis.

TIP: *If you are using the load rating feature of PGSuper as part of your bridge management and vehicle permitting solution, make sure to update your PGSuper project files after a future overlay has been installed. Simply change the wearing surface type from Future Overlay to Overlay and adjust the depth of the bridge deck to account for any loss of section that may have occurred.*

Finished Grade Elevations

The profile information modeled in PGSuper describes the finished profile grade. The finished grade elevation is assumed to be at the top of the wearing surface when the bridge is originally constructed. When the overlay is to be installed in the future, the finished grade elevation is taken to be the top of the bridge deck.

TIP: *Learn more about how finished grade elevations are computed in the "Computing Bearing Seat Elevations" tutorial.*

Summary

The type of wearing surface modeled in a PGSuper project has subtle effects on the analysis. The various effects have been described throughout this document and are summarized in Table 1 below.

Table 1 Summary of Wearing Surface related effects

	Wearing Surface		
	Sacrificial	Overlay	Future Overlay
	Sacrificial Depth	Overlay	Future Overlay
Reduction in section depth for section properties	Yes	No	Yes
Overlay Dead Load	N/A	Bridge Site Stage 2	Bridge Site Stage 2
Included in Bridge Site Stage 2 and 3, compression stress checks	Yes	Yes	Only if load causes compression
Included in Bridge Site Stage 3, strength limit state check	Yes	Yes	Only if load contributes to governing condition
Included in load rating	Yes	Yes	No
Finished Grade Elevation	Top of Deck	Top of Overlay	Top of Deck

From its inception, the developers of PGSuper have paid very careful attention to the small details. Recognizing and accounting for the subtle difference between the wearing surface types is an excellent example of our attention to detail, and is one of the many reasons PGSuper is widely considered the leading precast-prestressed girder bridge design, analysis, and load rating software.

Customizing PGSuper

PGSuper has an advanced software architecture that allows third parties to extend and enhance its capabilities. At BridgeSight Inc., we can add new capabilities to meet your needs. For details, contact us at

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PGSuper Professional

BridgeSight Inc. is offering an enhanced version of PGSuper called PGSuper Professional. In addition to all the great features in the free version of PGSuper you get:

- BridgeSight's one-of-a-kind Girder Design Dashboard™
- PGSuper to AASHTOWare Bridge Exporter
- 3D Visualization
- Export Analysis Results to Excel
- Enhanced Library Management
- LandXML Data Exchange
- Enhanced Reporting
- Toll-free telephone support
- Direct Email support
- High priority treatment in the PGSuper.com Support Forums
- Exceptional customer service from a reputable and proven company

If you like PGSuper, you'll love PGSuper Professional!

Visit our web site at www.bridgesight.com for more information and a free trial offer.

References

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3. Computing Bearing Seat Elevations, BridgeSight Inc., 2014