

# Temperature-gradient loading for bridge objects

Test Problem	
Name:	Temperature-gradient loading for bridge objects
Description:	This test problem demonstrates CSI Software calculation and application of temperature-gradient loading to bridge objects.
Program:	SAP2000
Version:	14.0.0
Model ID:	97

## On this page:

This test problem explains and demonstrates the application of temperature gradient to bridge objects. To summarize the process, temperature gradient is specified and applied to the transformed section, axial force ( $P$ ) and moment ( $M3$ ) are calculated, then an equivalent temperature distribution (constant + linear) is applied over the depth.

This process enables the correct calculation of overall cross-sectional force and moment. Nodal application of actual temperatures induced by the temperature distribution specified would yield incorrect net force and moment without the cross section being finely discretized.

## Procedure

The stress distribution of a temperature gradient is calculated as  $E T$ . Users may analytically solve for axial force ( $P$ ) by integrating this expression over the section, accounting for the web and flange areas. To solve for  $M3$ , integrate the moment of stresses about the neutral axis. CSI Software derives temperature-gradient response by following these formulations. First, the software assumes a linear gradient with two unknowns, including neutral-axis value and gradient slope. Integration procedures yield a set of polynomial expression for  $P$  and  $M3$ . Simultaneous solution then yields exact expressions for axial force and moment.

## Examples

The following two examples demonstrate temperature-gradient application. Screenshots and attached hand calculations illustrate the procedure.

### Example 1: Bridge-modeler model

Please note that the [hand calculations](#) attached provide additional details.

A single-span concrete-box bridge, fixed at both abutments, is created using the [bridge modeler](#). The [linked](#) bridge object is updated as a [solid](#) model. Loading from temperature gradient is defined as shown in Figure 1:

Bridge Temperature Gradient Data

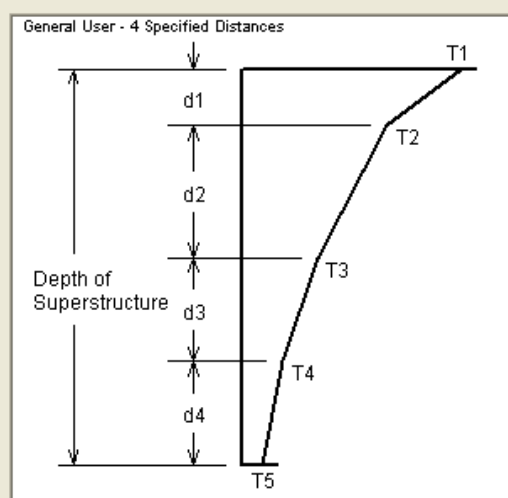
Temperature Gradient Name:  Units:

Temperature Gradient Type

AASHTO Default  
 Zone:   
 Negative Temperature Multiplier:

Chinese JTG D60 Default  
 Overlay Type:   
 Asphalt Thickness:   
 Negative Temperature Multiplier:   
 Use 0.7 Concrete-Masonry Arch Factor:

User  
 Type:



Temperature Difference Data

Number of Specified Distances:

This Distance May Vary:

Include These Temperature Difference Values:

d1	<input type="text" value="3.937"/>	T1 Positive	<input type="text" value="32.4"/>	T1 Negative	<input type="text" value="0"/>
d2	<input type="text" value="11.811"/>	T2 Positive	<input type="text" value="10.8"/>	T2 Negative	<input type="text" value="0"/>
d3	<input type="text" value="May Vary"/>	T3 Positive	<input type="text" value="0."/>	T3 Negative	<input type="text" value="0"/>
d4	<input type="text" value="5.9055"/>	T4 Positive	<input type="text" value="0."/>	T4 Negative	<input type="text" value="0"/>
		T5 Positive	<input type="text" value="5.4"/>	T5 Negative	<input type="text" value="0"/>

Figure 1 - Temperature-gradient loading

As mentioned earlier, an equivalent *constant + linear* temperature gradient generates the temperature load for a solid model. This procedure correlates precisely with the attached [hand calculations](#) , as shown in Figure 2:

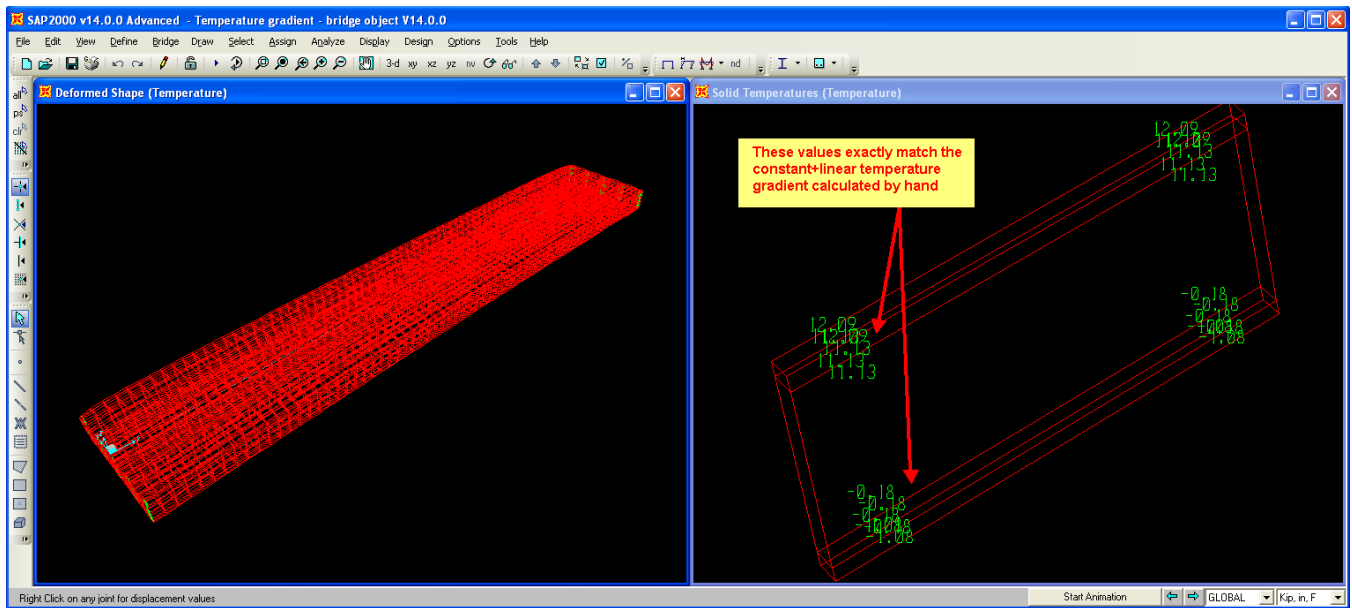


Figure 2 - Temperature-gradient loading on solid elements

For bridge response, loading from the temperature gradient induces a moment of 2568 kip-ft, which closely correlates with the [hand calculated](#) moment of 2669 kip-ft. Software output is shown in Figure 3:

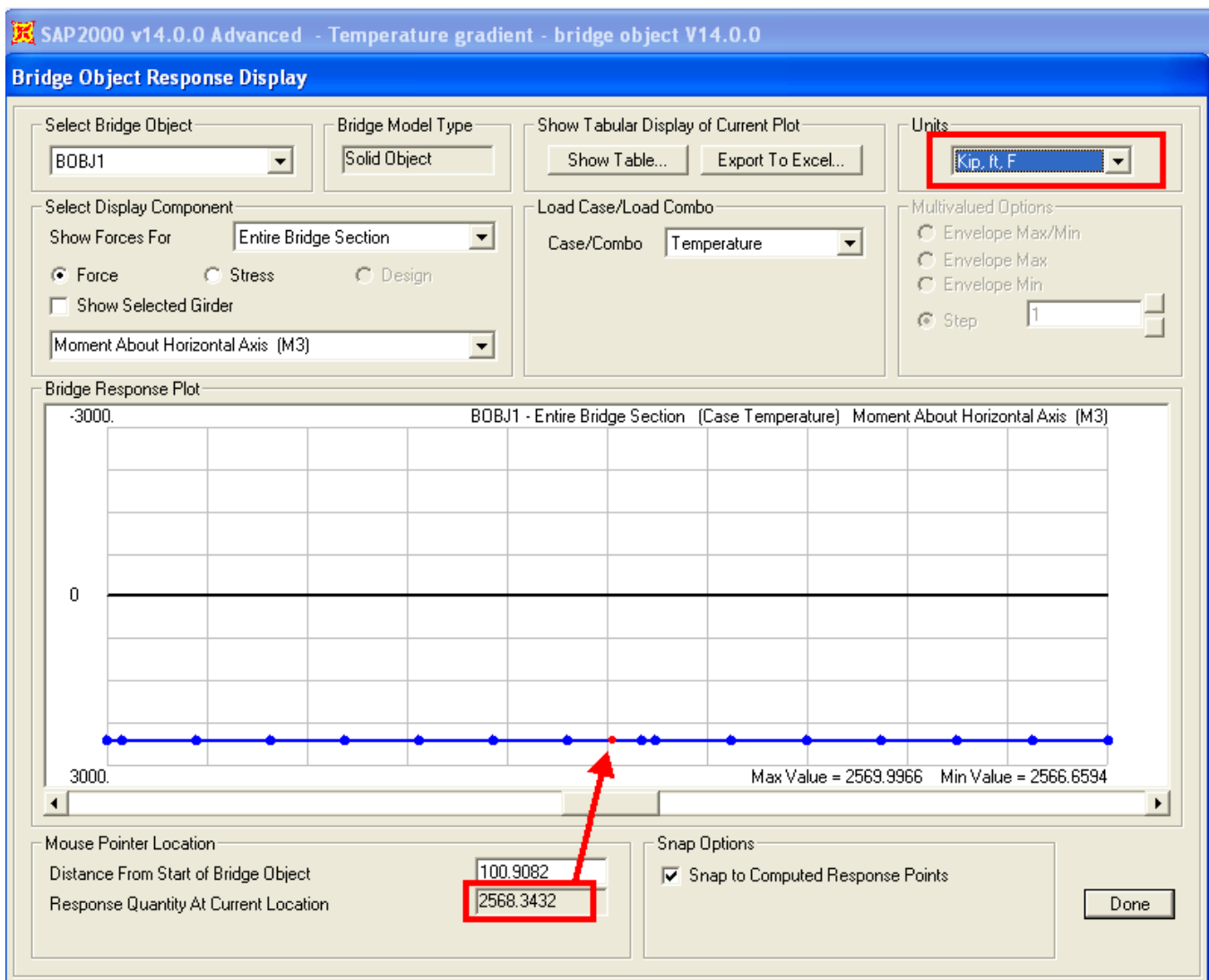


Figure 3 - Moment induced by temperature gradient

## Example 2: Single frame-element model

Please note that the [hand calculations](#) attached provide additional details.

For example 2, a single, beam frame element is fixed at both ends and manually loaded with the *constant + linear* temperature gradient. Element cross section is defined to match those properties of the entire bridge deck section from example 1. The temperature-gradient loading creates a moment of 2668 kip-ft, nearly identical to the hand-calculated moment of 2669 kip-ft. Software output is shown in Figure 4:

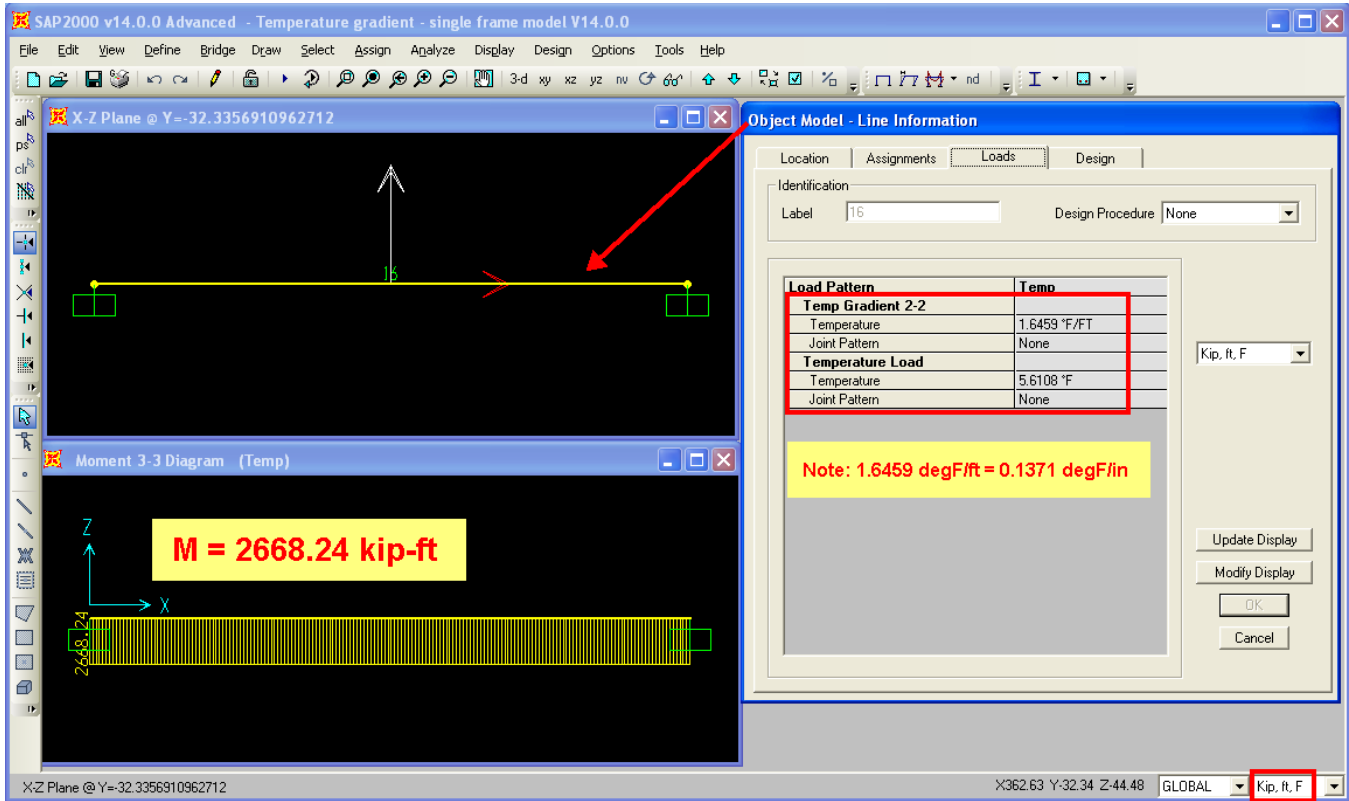


Figure 4 - Temperature-gradient on the frame-element model

## Attachments

- [SAP2000 V14.0.0 models](#) (zipped .SDB files) – Example 1: Bridge-modeler model, Example 2: Single frame-element model
- [Hand calculations](#) (PDF)