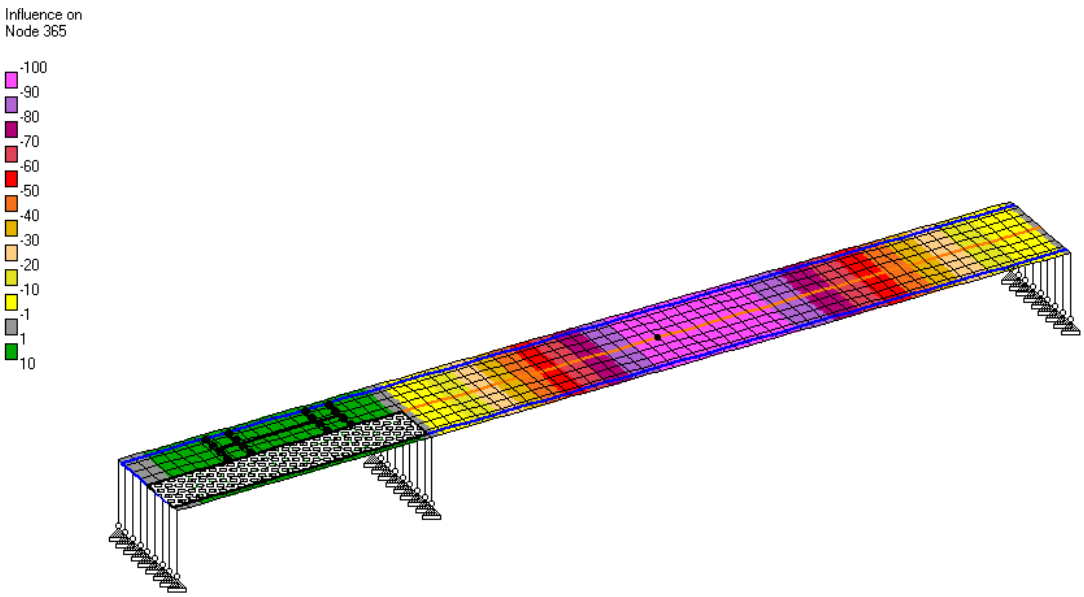
Bridge Engineering Automated Vehicle Application
B.E.A.V.A



Developed by

Research Engineers International

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VERSION 1.1

Contents

1. Introduction

The general philosophy governing the design of bridges is that, subject to a set of loading rules and constraints, the worst effects due to load application should be established and designed against.
The process of load application can be complex as governing rules can impose inter-dependant parameters such as loaded length on a lane, lane factors and load intensity. To obtain the maximum design effects, Engineers have to try many loading situations on a trial and error basis. This leads to the generation of many live load application instances and a large volume of output data that has to be combined with dead load effects as well.
In view of the above, a computer program has been developed to minimise the load application process while complying with national code requirements.
Users can avoid the trial and error approach and eliminate any possible errors arising from inaccuracies associated with it.
The program is based on the use of influence surfaces, which are generated by Staad.Pro as part of the loading process. An influence surface for a given effect on a bridge deck relates its value to movement of a unit load over the area of interest. The influence surface is a three-dimensional form of an influence line for a single member.
Staad.Pro will automatically generate influence surfaces for effects such as bending moments for elements, deflection in all the degrees of freedom of nodes and support reactions. The engineer will then instruct the program to utilise the relevant influence surfaces and, with due regards to code requirements, optimise load positions to obtain the maximum desired effects.
Once the influence surfaces have been generated, they are saved and can be used for any further investigation that may be required. This will remain valid as long as the user has not altered the structural model. Changes to the structural model can alter the pattern of the influence surfaces and the user must ensure that a further run takes place before any further processing.
The Engineer's knowledge and judgement is critical in deciding which effects are required and at what position to obtain them. This is where users can save a lot of processing time and also, can ensure critical positions are not missed.

2. General Description

The Current version of Bridge Engineering Automated Vehicle Application (B.E.A.V.A), version 1.1, supports the UK BS5400 part2 code and the American AASHTO standards.
All the relevant code instructions for loading definitions and traffic lane calculations are incorporated in BEAVA and in cases where vehicle axle arrangements are not standard, it is possible to define a vehicle and save it in the library for use it in the analysis.
BEAVA is fully integrated in Staad.Pro and utilises the same GUI for all input and output data.
The user defines the width of the Carriageway as straight or curved parallel lines, BEAVA then automatically calculates the following in accordance with the selected code:

- Number of Notional Lanes (Traffic Lanes)
- Influence lines along the centre line of notional lanes
- Loaded length along the Lanes
- Critical location of uniformly distributed load
- Critical location of knife edge load
- Critical location of vehicle load
- Maximum effect value
- Associates effects values

Once the program has completed calculating the above, a text file containing the results is displayed on the screen; as the user can then start examining the results graphically.
Loading arrangements for the effects requested can be displayed on the model and, for every loading arrangement produced, the user can instruct the program to generate a Staad.Pro load case.
The added live load cases can be combined with dead loads in the normal way of Staad.Pro load combination generation.
The final model can then be analysed in Staad.Pro and then post-processed.

3. Program Installation

Program installation is automatically carried out as part of the Staad.Pro installation; there are no additional installation procedures to follow.
For Staad.Pro installation instructions please refer to theStaad.Pro Getting Started manual.
Also, please note that BEAVA is only available with release 2001 of Staad.Pro and not with any previous releases. If your current version is not release 2001 you will need to reinstall Staad.Pro version 2001.

4. Copy protection

Staad.Pro comes with a copy protection devices in the form of a hard lock.
The device must be inserted in the parallel port of your computer and must remain there during the entire duration that you are in one of the Staad.Pro component programs.
For more information on copy protection device please refer to the Staad.Pro Getting started manual.
Please note that if your hard lock device does not support the bridge loader module you will not be able to use it. In this case the option is greyed out from the menu and will not function.

5. User Requirements

BEAVA is an additional module to Staad.Pro and is intended to work with structural models that are generated using Staad.Pro. It is therefore imperative users are familiar with the model generation and analysis procedures of Staad.Pro before they can proceed with efficient use of the bridge-loading module.
If this is not the case, please follow the Getting started and Examples manual in order to obtain the basic knowledge in the use of Staad.Pro.
Further, it is essential that engineers who fully understand the analysis data and have knowledge of the loading code use this program.
Although every effort has been made to ensure the correctness of these programs, Research Engineers will not accept responsibility for any mistake, error or misrepresentation in or as a result of usage of these programs.

6. Program Operation Overview

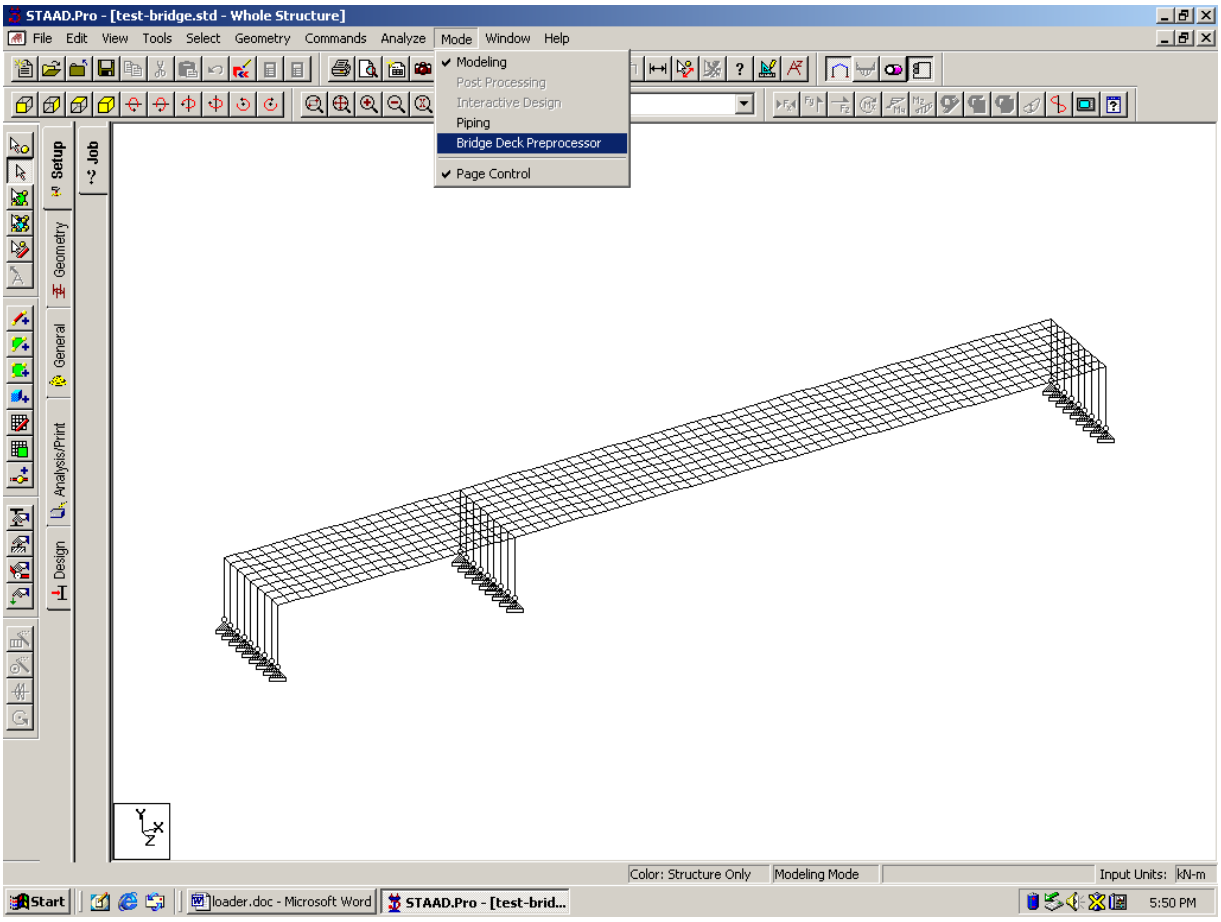
There are a number of distinct stages in the use of the program.
To avoid inefficient use of the program, it is recommended that the following steps be taken in the order suggested.

- Create the structural model including member properties and support conditions.
- From the Mode menu select Bridge Deck Preprocessor; note that if your security device is not programmed for this module you will not be able to proceed.
  The menu bar has been modified to show Deck and Vehicle.
- Select the elements/members that define the deck area of the model
- From Deck menu select Create Deck to define the deck
- From Deck menu select Influence Surface Generator. This will start analysis procedures to create the influence surfaces.
- From Deck menu select Define Carriageway and define either a straight or curved carriageway.
- From Deck menu select Load Generator. Proceed to select the required input, on completion select OK. The loading program in now engaged and will calculate all the required loading arrangements that leads to the max/min effects you have requested. On completion a text file will be displayed on the screen containing the loading arrangements, which you can now display graphically.
- For each effect requested display the loading arrangements and examine the correctness.
- For each effect requested select Create Loading in Staad Model from Deck menu.
- After all load cases have been created, from Mode menu select Modeling and return to carry on with other load generations and combinations.
- Proceed with analysis and post-processing in the normal way.

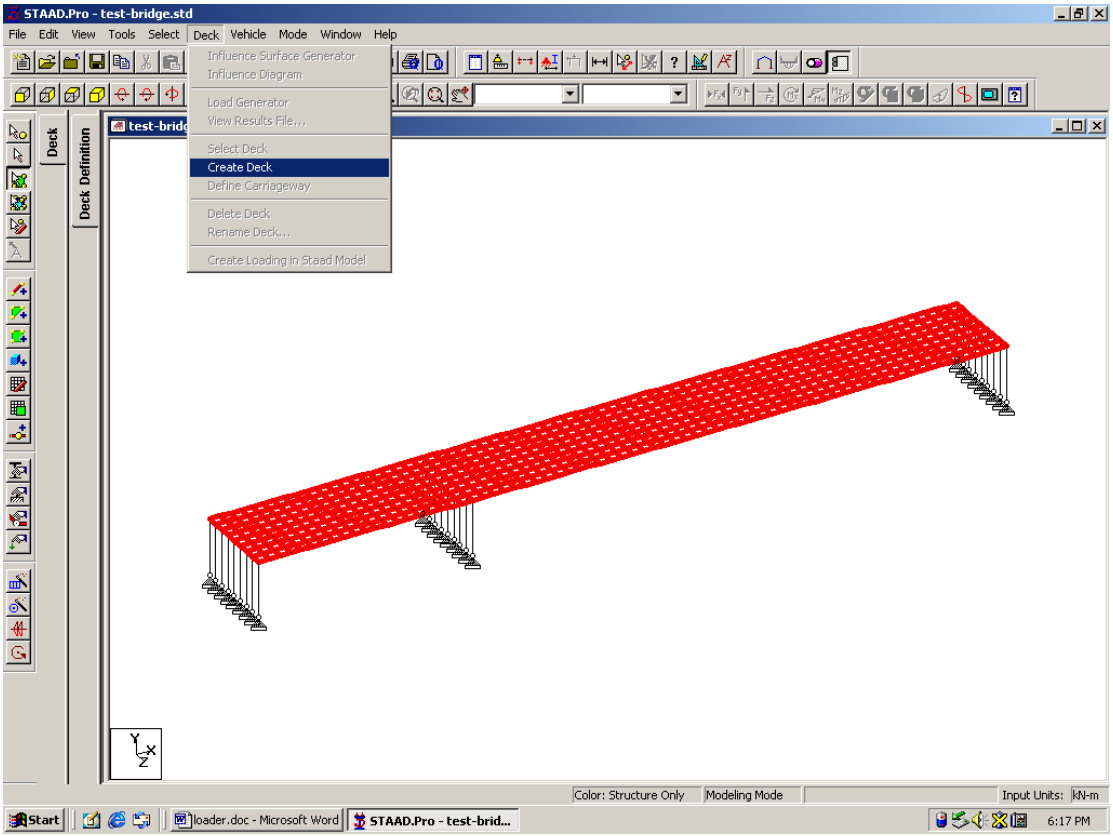
The following worked example will illustrate the above steps in detail.

8. Worked Example

For the purpose of this example a Staad.Pro model has been created that is a simple finite element model with column support as illustrated in the following diagram.



From the Mode menu select Bridge Deck Preprocessor to change to bridge loading environment.
You now need to select the elements that define the deck for load application. Make sure you are in element select mode as indicated by the mouse cursor.
Select the elements as shown, and from the Deck menu select Create Deck and either accept the default name or change it if you like to do so.
Please note that you can define as many decks as you like, however, only one deck at a time can be analysed.


STAAD.Pro - test-bridge.std
File Edit View Tools Select Deck Vehicle Mode Window Help
Influence Surface Generator
Influence Diagram
Load Generator
View Results File...
Select Deck
Create Deck
Define Carriageway
Delete Deck
Rename Deck...
Create Loading in Staad Model
Deck
Deck Definition
Color: Structure Only
Modeling Mode
Input Units: kN-m
Start
loader.doc - Microsoft Word
STAAD.Pro - test-brid...
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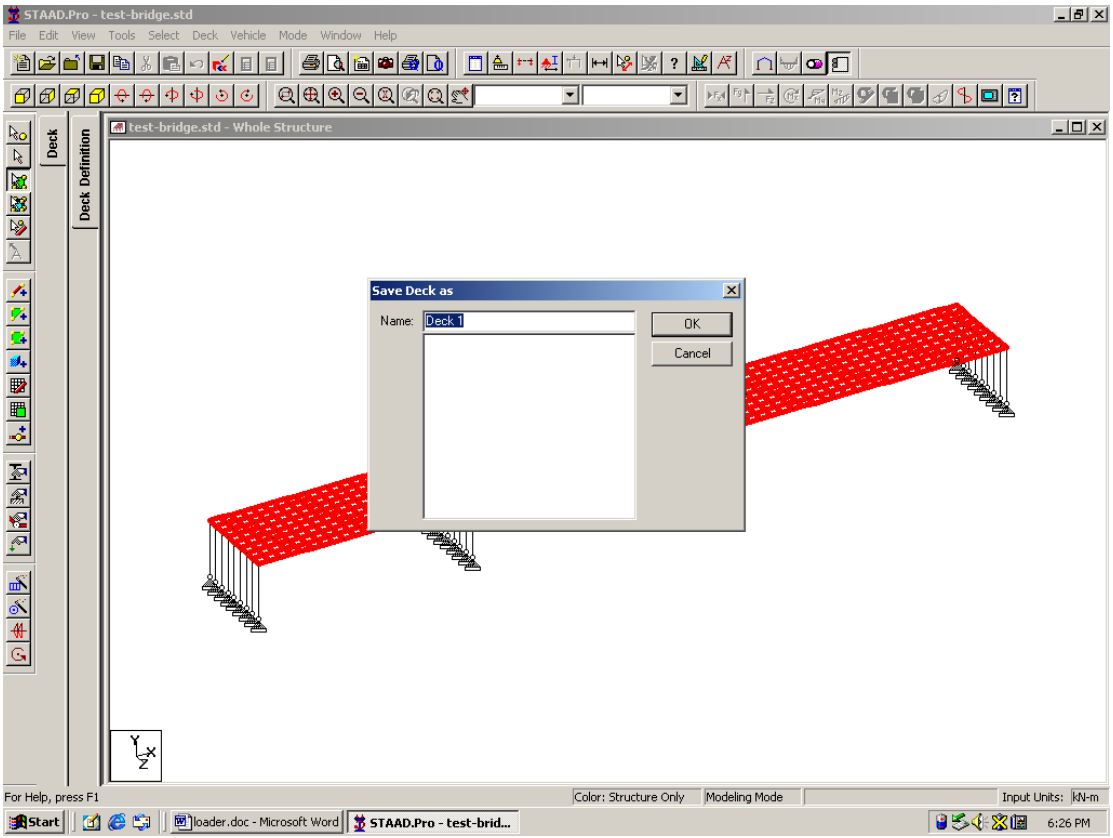
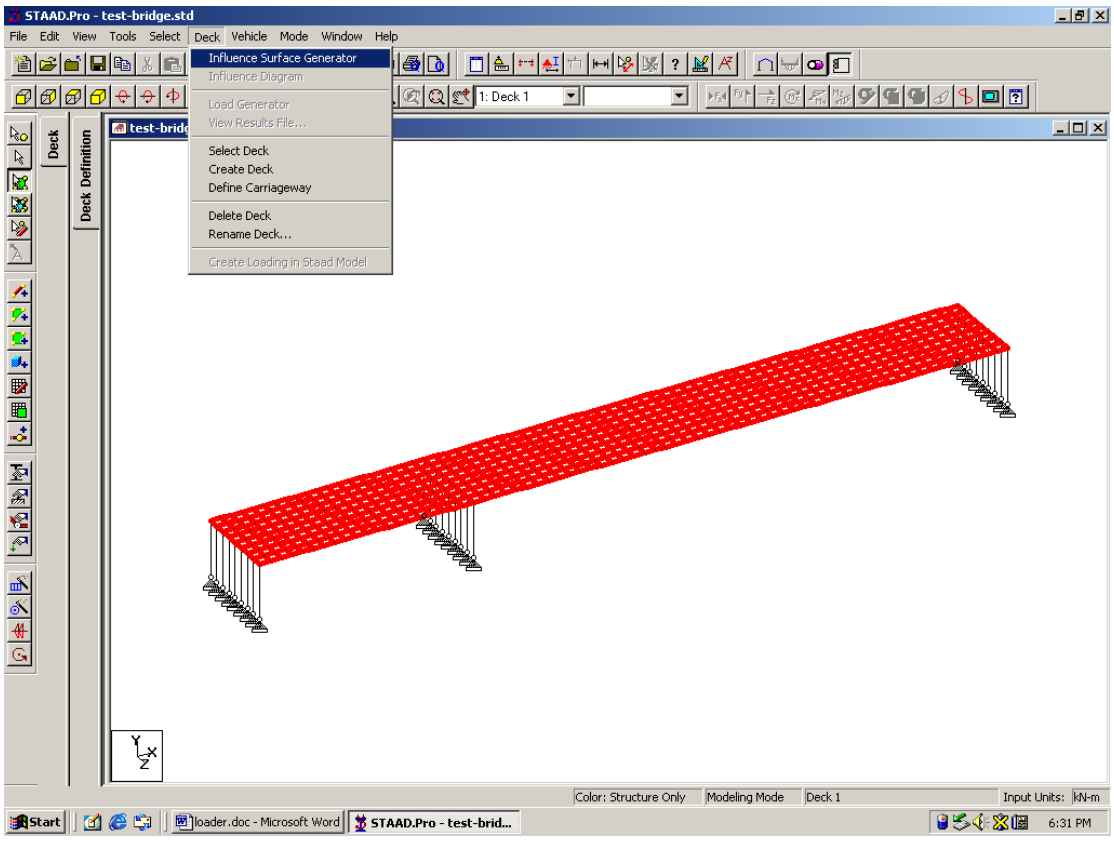
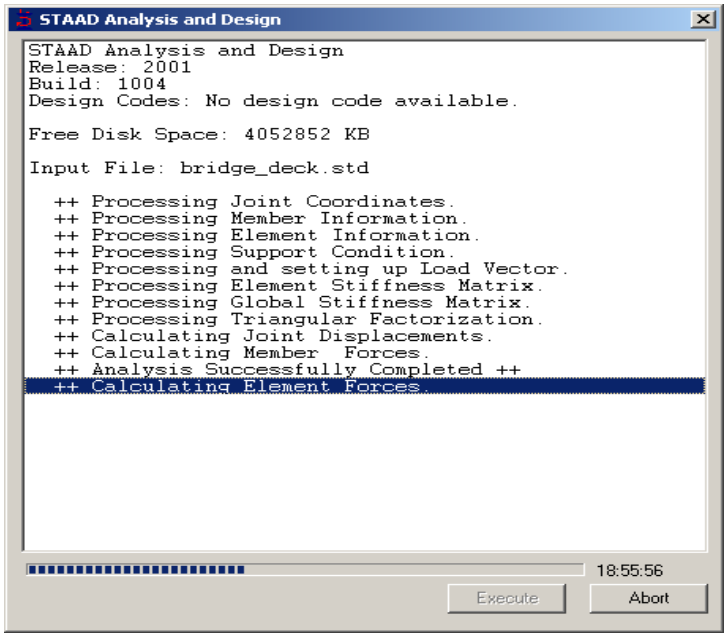

STAAD.Pro - test-bridge.std
File Edit View Tools Select Deck Vehicle Mode Window Help
test-bridge.std - Whole Structure
Deck
Deck Definition
Save Deck as
Name: Deck 1
OK
Cancel
For Help, press F1
Color: Structure Only
Modeling Mode
Input Units: kN-m
Start
loader.doc - Microsoft Word
STAAD.Pro - test-brid...
6:26 PM

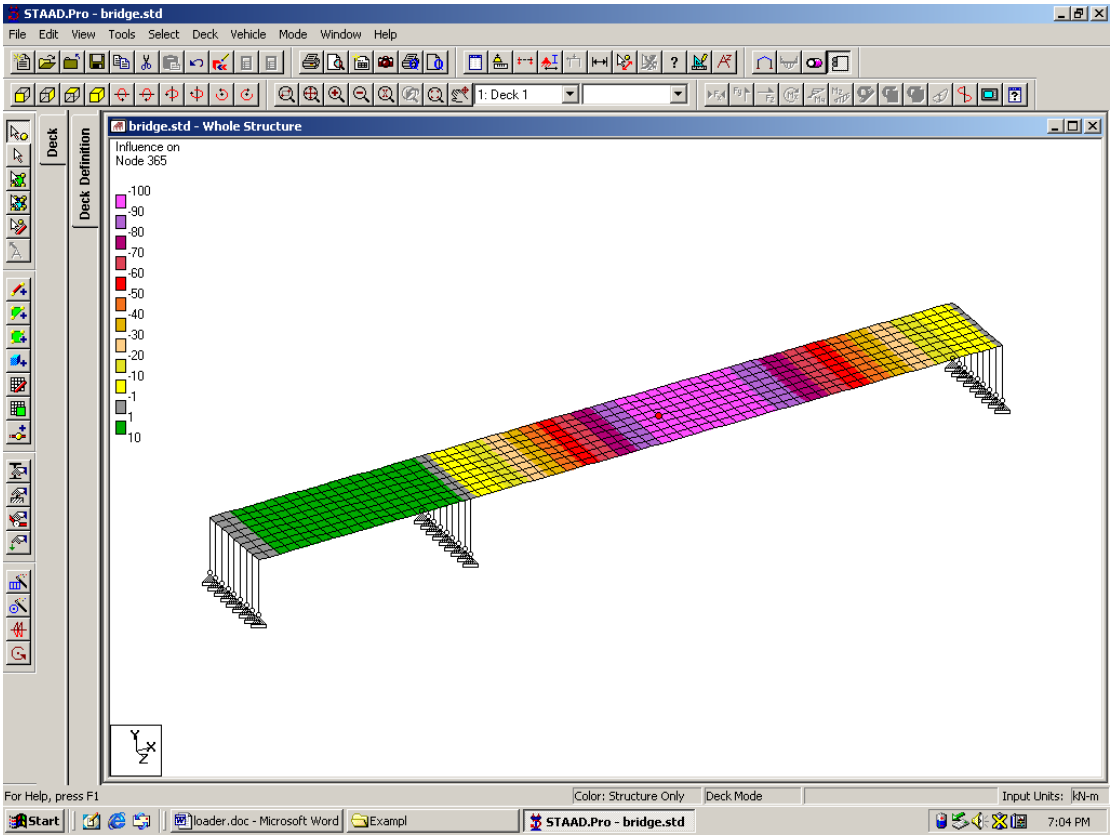
Now that the deck has been defined we can proceed with the influence surface generation. From the Deck menu select Influence Surface Generator as shown.



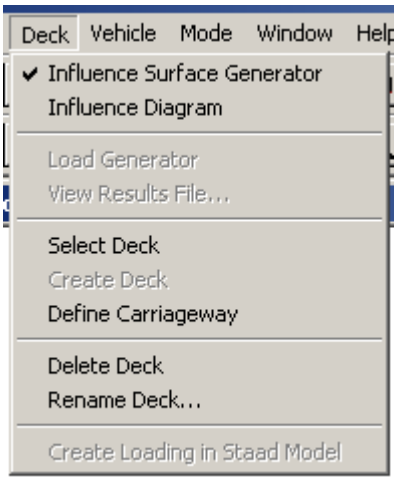
Once selected the program starts the analysis to generate the surfaces. The following window appears and calculations proceeds. On completion the window will close automatically.



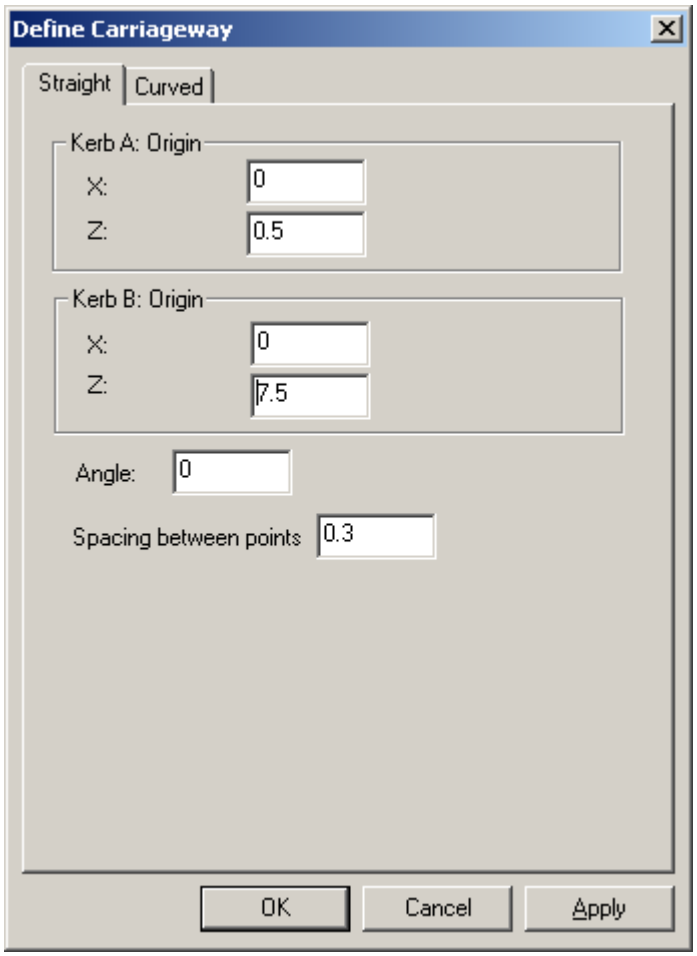
We are now able to examine the influence surfaces for all the effects associated with the model.
A typical influence surface is displayed for deflection in the global Y direction at node 365.



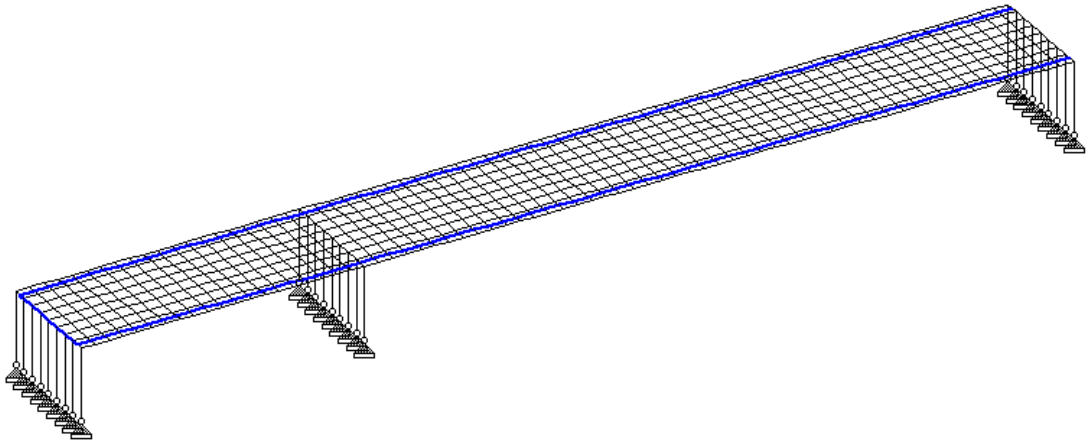
Note that you can display influence surfaces the same way you display stress contours, alternatively, from Deck menu select Influence Diagram and proceed to select the desired influence surface diagram.



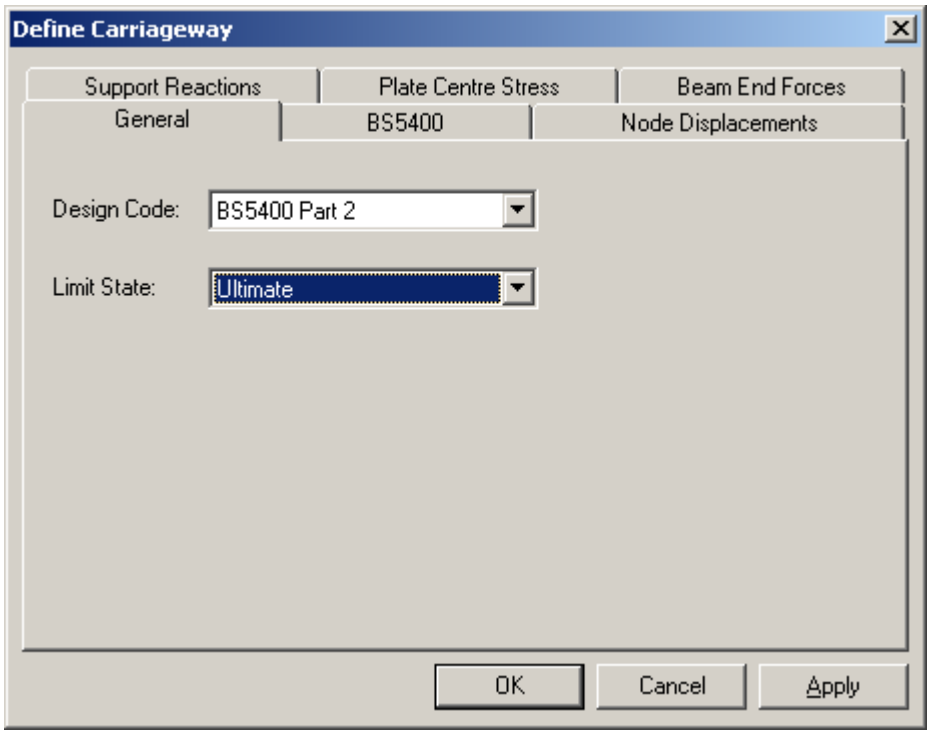
We will now define the carriageway that will be the loaded area in the deck of the model.
From Deck menu select Define Carriageway to display the following dialog box.



We can define straight or curved carriageways: in this example a straight carriageway is defined with the two starting point coordinates as shown in the above figure.
On completion select apply and you will see the carriageway displayed on the deck area as shown on the next page.

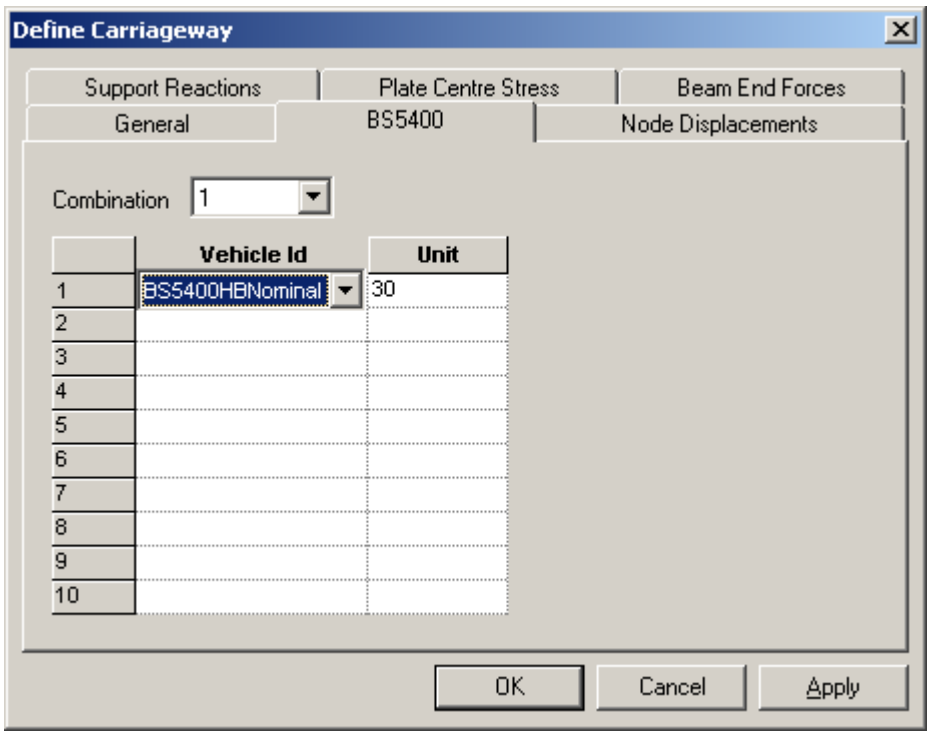


We can proceed with loading the carriageway area by selecting Load Generator from the Deck menu. The following dialog box appears.

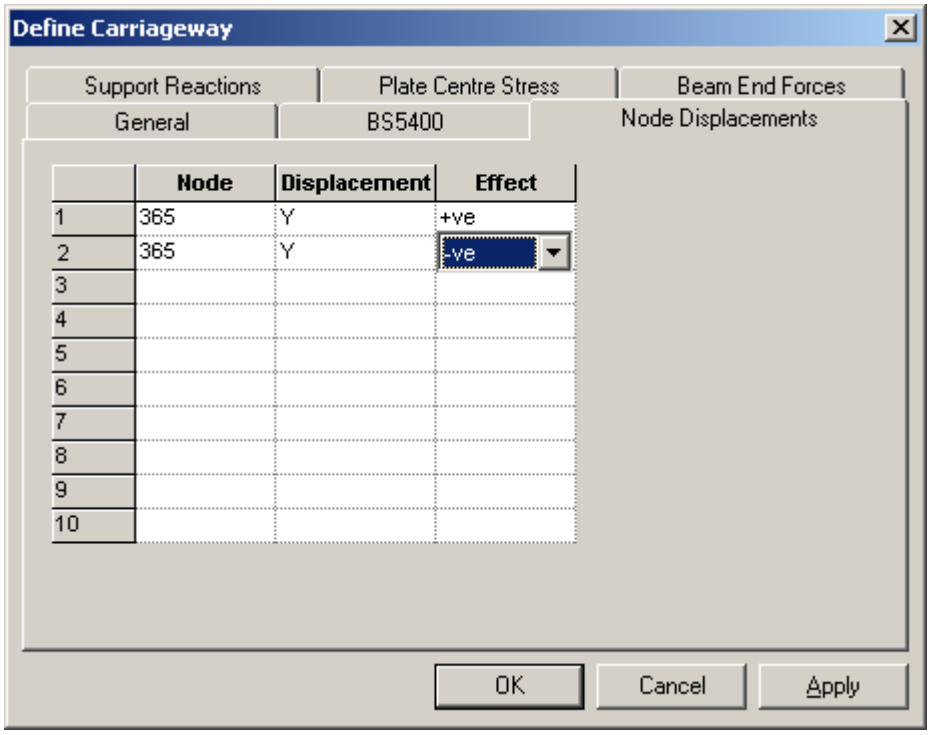


For this example the Limit State has been changed to Ultimate by clicking the list box and selecting Ultimate.

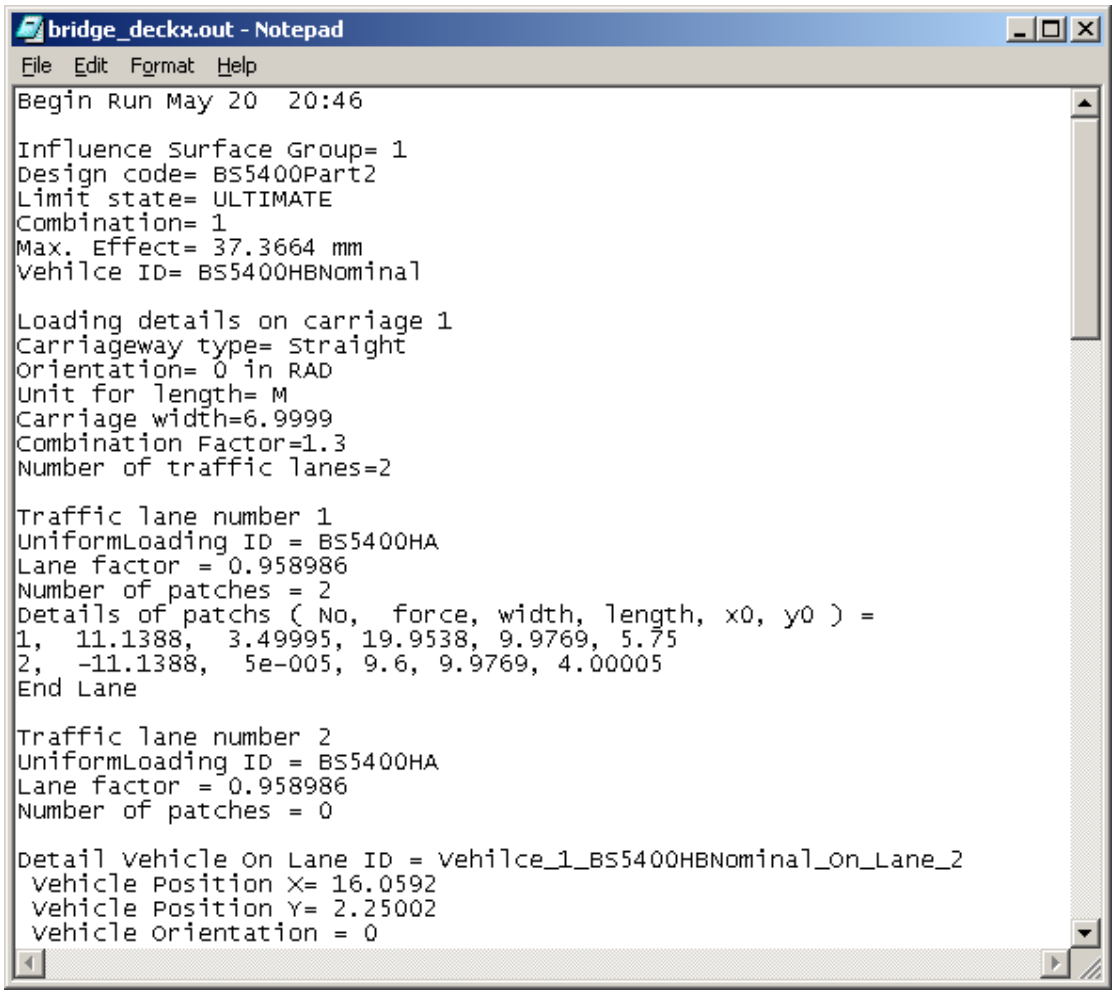
Select BS5400 tab to see the current settings for load combination types and HB unit values. Please note that you can select three types of load live combinations form the drop down list box.



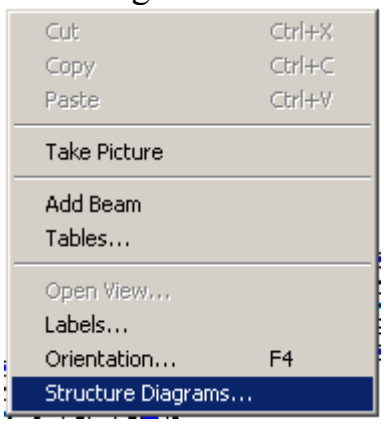
We will now select Node Displacements tab and provide the following data. Note that we have requested +ve and –ve displacements for node 365.
Any other effects can be requested by selecting the relevant tab in a similar way.



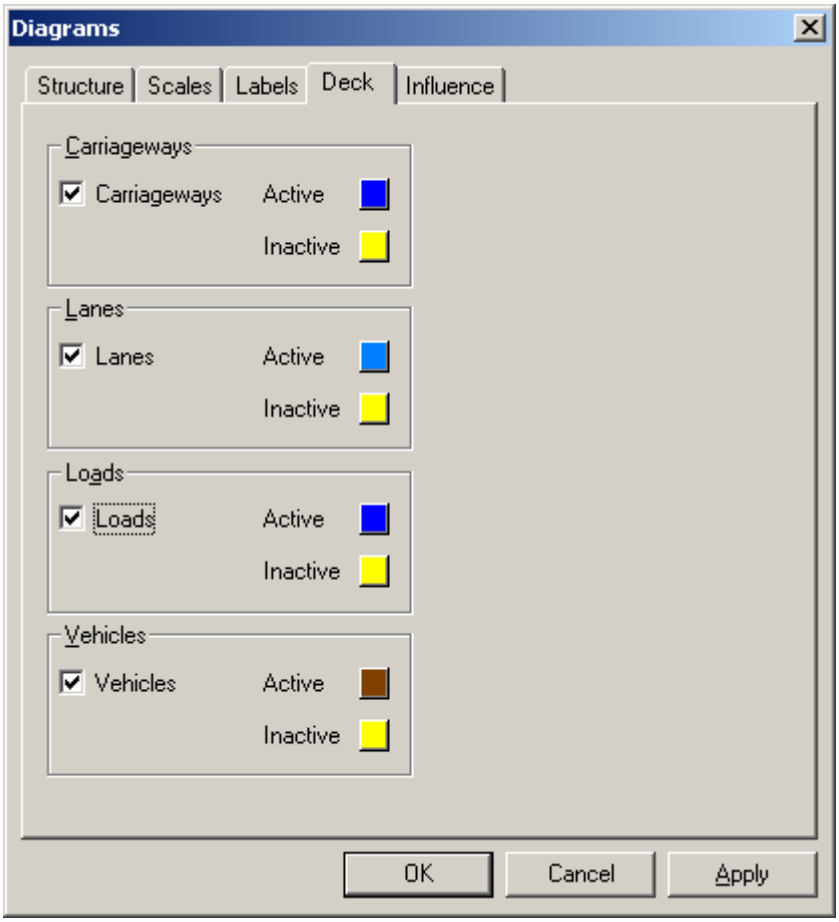
Select OK and the program will start the analysis to obtain the critical load positions for the effects requested.
On completion the following text output will appear with the numerical results provided as shown.



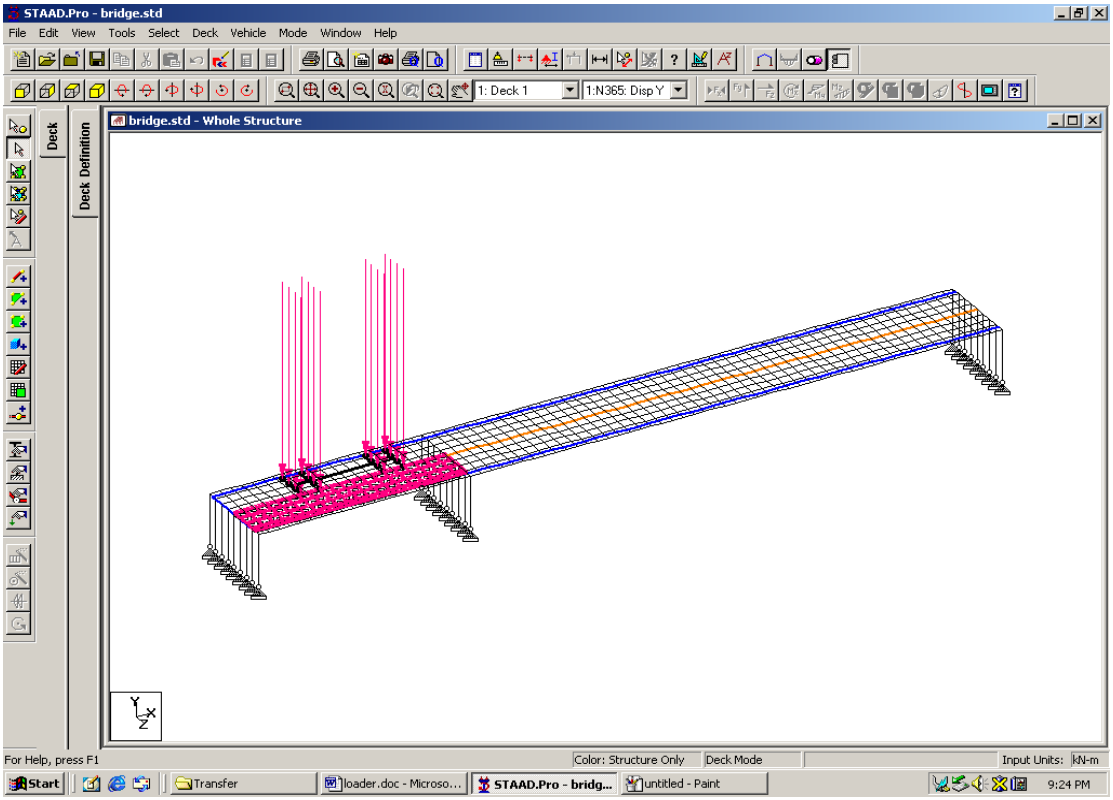
All the provided text data can now be displayed graphically as well. Close the text file and right click the mouse button to see the following selection box.



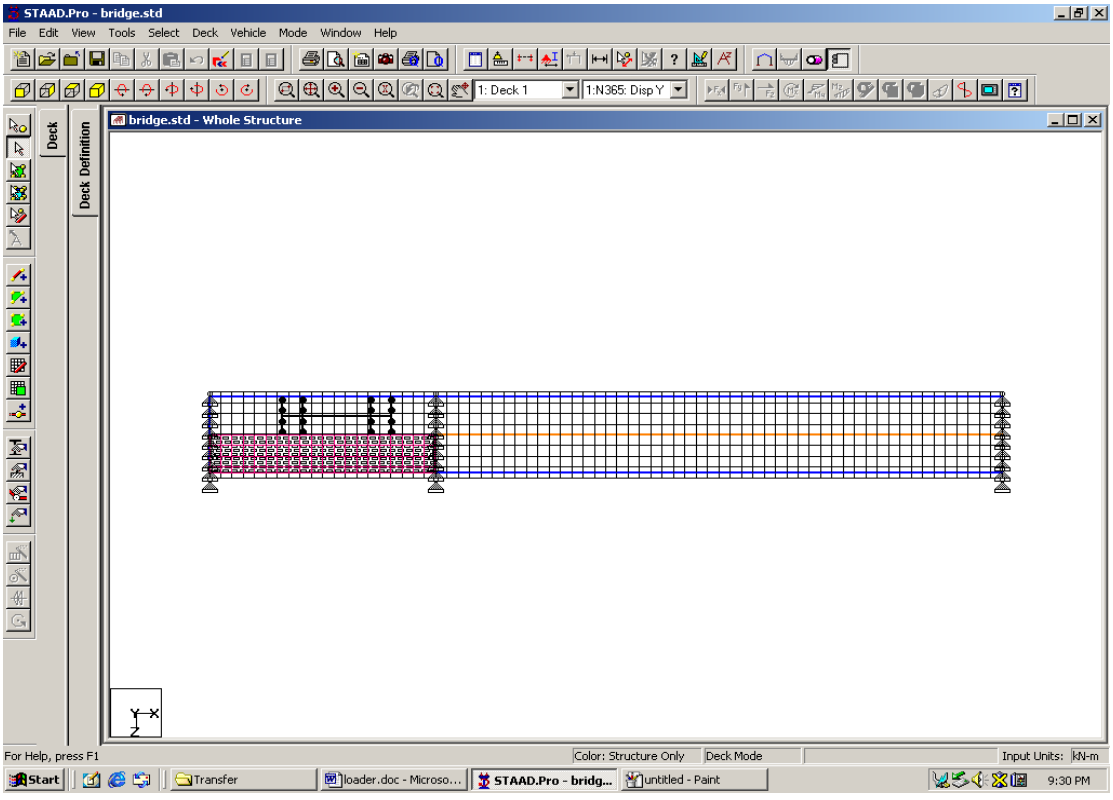
Select Structure Diagrams… to display the following dialog box.



Tick the options as shown above to display the notional traffic lanes and the loads as calculated by the program.
Note that you can change the display colours of all the items on the dialog box.
Select OK to see the graphical display of the loading arrangements for the desired effects.
In this example load position and arrangements for maximum global Y displacement is displayed as shown in the following diagram.
Please note that selecting View Result File from the Deck menu can display the text file output again.

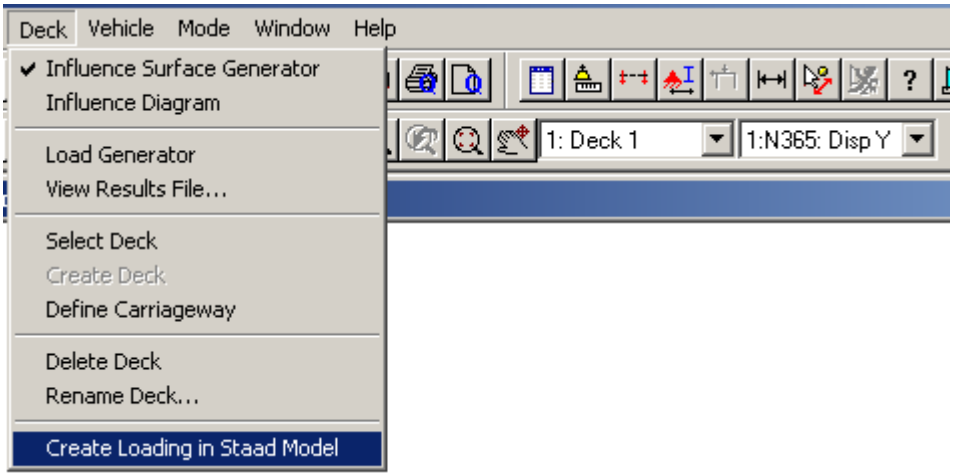


Isometric View

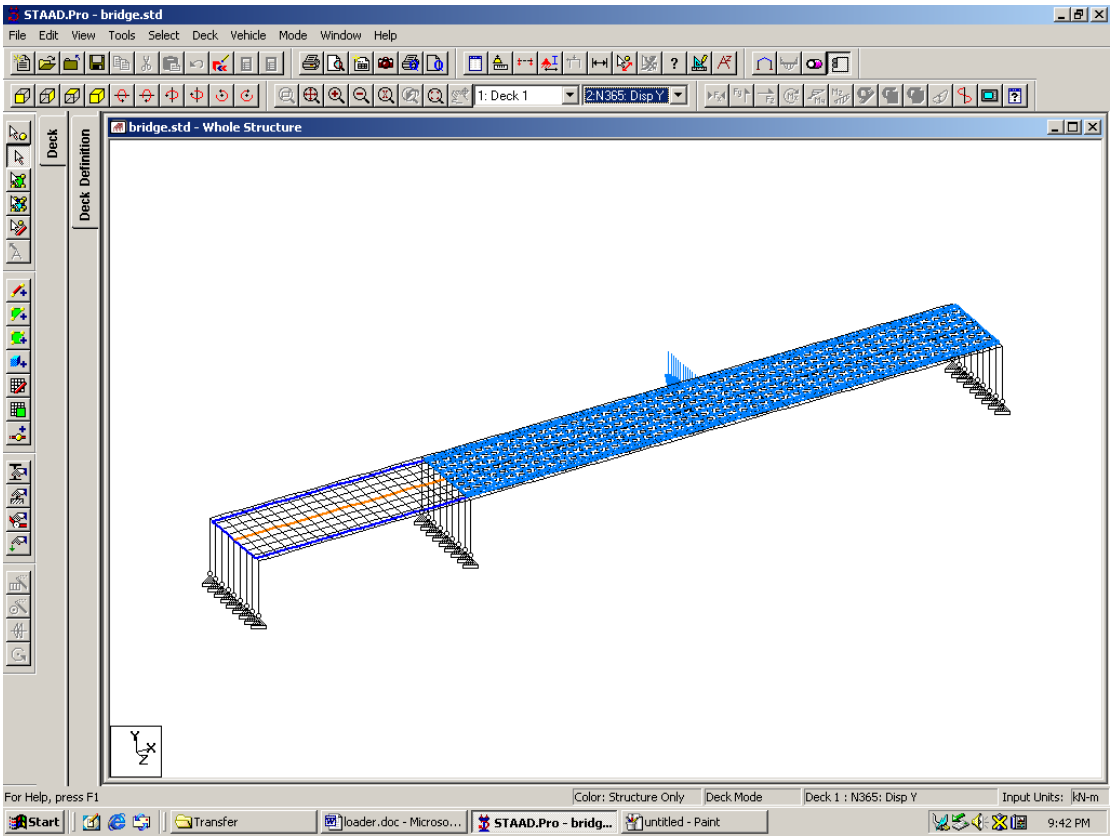


Plan View

For the above effect we can create a Staad loading case by selecting Create Loading in Staad Model from the Deck menu as shown.



Loading arrangements and position for maximum negative Y displacement at node 365 is shown below.



Staad load case for this effect can also be generated in a similar way.

Having examined all the required effects and generated relevant load cases, we can return to the main Modeling mode and carry on with other load case generations and combinations.
Analysis and post-processing can follow in the normal way.