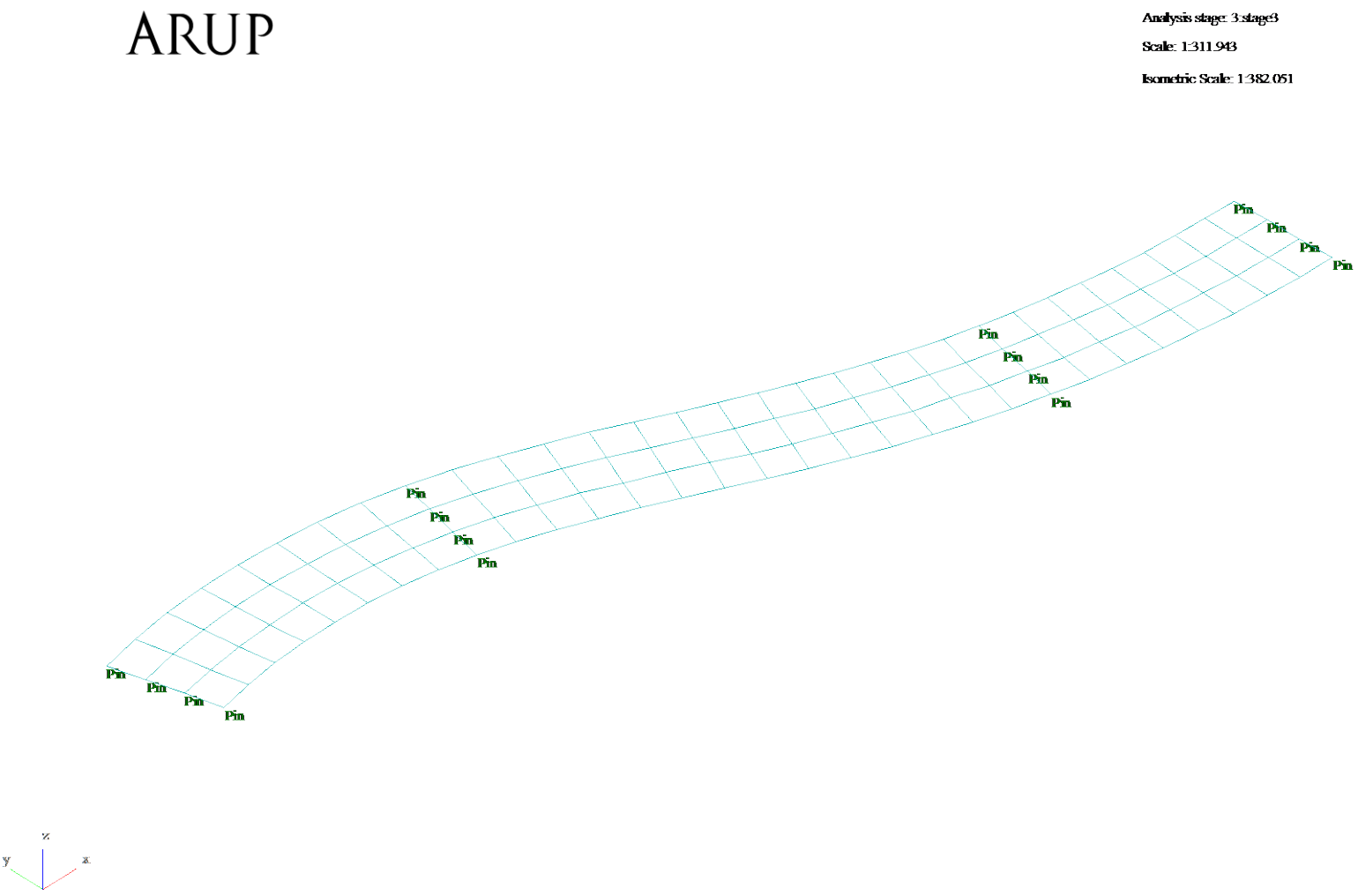
The Bridge Workshop Model

ARUP



Bridge Workshop Model

This curved three span bridge deck has a varying alignment. The workshop model has been saved at various stages of development. These data files have been installed with GSA in the 'Samples' folder that hangs off the GSA program folder. e.g. C:\Program Files\Oasys\GSA 8.6\Samples\bridge\Bridge5.gwb.)

The model is built in the following steps.

Step	Hint	Sample
Model generation	This section describes how to use the sculpt tools to generate a model to follow a complex alignment without doing any complex geometrical calculations. The example has been kept simple but a similar process has been used "on the job" for some complex tapered viaducts (set out from more than one alignment) where the alignment was only available in hardcopy.	
• Open a blank space frame model	New Model Wizard	
• Set up a new Cartesian axis named as "inside", the origin is at (0, 0, 0), the x vector is (4, 1, 0) and the y vector is (0, 1, 0) • Set up a grid plane named as "deck" using this axis and all elements at height 0	(in a real example the origin and orientation would come from a point on the alignment, and either be set up using nodes like this, or directly in the axes table) Note: In a real example, even for a straight bridge, it is important that the alignment (the original of the axis) starts at least a vehicle length before the start of the structure and extends a similar length beyond the end of the structure. Grid Planes table (choosing two way spanning will speed up analysis if the grillage mesh is regular, i.e. all the panels on the grid plane are either triangles or quads) Check on graphic by defining current grid using this grid plane Note that there are strict rules about what constitutes a valid grillage of elements for bridge loading, see Help – Step By Step Guide | Bridge Analysis | Modelling implications.	
• Set up alignment named as 'edge' (0,Right, 50), (25,Right, 50), (50,Left,100), (150,Left, 100)	Alignments table Check using Diagram | Bridge This gives 50m and 100m radius curves with a standard highways transition curve between them	Bridge1.gwb

• Create 1 new node at (0, 0, 0)	Can be done on node table or using 'Add New Node Sculpt Tool' Use 'Sculpt | Define Current Grid…' to enable this sculpt operation. Turn on 'Draw grid' and 'Snap to grid points' if using sculpt tool to create the node	
• Create initial three beam elements by using 'Extrude Selection…' sculpt tool	Select the node and from menu 'Sculpt | Extrude Selection…' to open extrude dialog box, select axis 'inside' and direction y. Number of increments is 3, increment length is 3 m and check 'Include Beam elements along extrusion' checkbox. Note: before doing element generation, make sure the element default property number is 1	Bridge2.gwb
• Create the whole bridge deck model by using 'Extrude Selection…' sculpt tool	Select the 3 elements and run menu command 'Sculpt | Extrude selection…', Use 'Alignment 1' as direction of the extrusion. Number of increments is 30, increment length is 3 m and check 'Include Beam elements along extrusion' checkbox All elements are created for the bridge deck, we need to change the property number of elements in longitudinal direction to property 2. To do this, select the first 4 longitudinal elements (4, 5, 6 & 7) and run menu command 'Edit | Select String' to select all longitudinal elements, then run menu command 'Sculpt | Modify Selection…' to open Modify element dialog box and change property number to 2	Bridge3.gwb
• Add pinned supports at ends and two internal lines to give 8:14:8 bay spans • Add section properties: P1 Rectangular section 250 deep 3000 wide, P2 T section 1000 deep, 3000 wide, 500 web 300 slab • Add gravity load -0.5 in z	Select the relevant nodes and run menu command 'Sculpt | Modify Selection…' to open modify nodes dialog box to modify node constraints to pin Sections Wizard, modify J to 25% & 40% for P1 & P2 respectively Gravity Loads (this is a crude approximation for demonstration purposes only)	
Analyse this model to check behaving OK, then delete results **End of Model Generation**	Analyse / Delete Results	Bridge4.gwb

Bridge Loading Workshop **Method A**	Having built the model, this section of the course takes you through the steps to carry out a bridge analysis, see Help | Step-by-Step | Bridge Analysis	
• Set up Bridge Specification for UK loading, with 45 HB units for ULS and 0 HB units SLS. • Set up a Carriageway from –7 to –1 and a Footway from –8.5 to –7.2	'Specification | Bridge Loading Specification' in Gateway Paths table Note that sign convention for offsets follows highway practise, which is opposite to the direction of the y axis in GSA. Check using Diagram | Bridge	
• Set up node influence effects for combined vertical reaction at internal support (33, 34, 35, 36) • Set up element influence effects for moment at midspan (111) and internal support (61)	Node Influence Effects table Using the same effect number on successive lines will optimise the combined effect Element Influence Effects table, different effect numbers Check using Diagram | Bridge Option	Bridge5.gwb
Carry out Bridge analysis	Analysis Wizard This 'analysis' has a number of parts to it. First the carriageway is split into lanes and vehicle paths are defined to allow for HB vehicles straddling lanes. An influence analysis is carried out for the key paths and remaining influence lines are interpolated. (in this case only paths 1 to 3 and 8 are analysed). Then bridge loading is optimised to give maximum (most +ve) and minimum (most –ve) effects at each influence point, in accordance with BD37 (choosing critical position for HB both longitudinally and transversely and applying lane factors). This Static Bridge Loading is then expanded into Grid loads and a static analysis is performed.	Bridge6.gwb

Review output	Graphic View | Loading Load cases are named to identify influence effect (BIE or NIE) number and load combination. Plot loads to see how the bridge loads have been optimised. The influence lines, both analysed and interpolated can be viewed graphically and can be set from 'Diagram Settings' and the influence lines are under 'Global Results'. Combination cases are set up by the bridge analysis, FBIE and FNIE are combination cases including load factors, and some envelope cases are also set up. Note that there is an option to save results at influence points only, which can help to greatly reduce file sizes for large models with many influence points (needed for prestressed bridge design)	
Set up analysis envelope tasks to replace the 'All IE ULS1' generated envelope case (envelope for Fz reaction and Myy moment).	Analysis Tasks | Analysis Envelopes Not worth doing for a simple example like this, but if you have many influence effects and a large model then it can be very slow to view results from the automatic envelopes, and can become completely unmanageable if they are combined with wind or thermal effect envelopes (record was 500 million permutations)	

Bridge Loading Workshop Method B	**Lane by lane method**	
• Delete all results and analysis cases • Change Bridge code to 'Undefined', in the next page select 'Eurocode loading – UK'	This also deletes all generated Grid Loads, Load cases and Combination cases Bridge Loading Specification	
• Delete existing Paths and set up Lane paths from –4 to –1 (name: right_lane) and –7 to -4 (name: left_lane) and a Track path at –8 (name: track)	Paths Table	
• Keep node influence effects for combined vertical reaction at internal support (33, 34, 35, 36) • Keep element influence effects for moment at midspan (111) and internal support (61)		
• Set up path loadings of EU1:Lane1 on left_lane, EU1:lane2 on right_lane and UIC71-RU loading on track	Path Loading table Optimisation will be done for each Path Loading for each influence effect.	Bridge7.gwb
Carry out Influence Analysis	Analysis wizard & influence analysis only Note that influence analysis will only succeed if grillage defined by grid plane satisfies all restrictions	
View results of analysis, graphical and tabular	Diagram settings | Global results | Influence Lines Output settings | Global results | Node/Beam influence results/lobe details These will give guidance on which paths are critical and a useful check on the output of the optimiser.	
Optimise Bridge Loading, use start group number 1	'Tools | Bridge analysis | Optimise Path loading…'	Bridge8.gwb
Examine Static bridge loading, use Effect columns to choose unnecessary entries to delete	Static Bridge Loading table One group is produced for each maximum (most +ve) and minimum (most –ve) effect for each path loading. Effect columns at right of table are proportional to the effect produced by that line of loading.	

Expand static bridge loads into Grid loads. Load cases start case no. as first group no.	'Tools | Bridge analysis | Expand bridge loading…' Set Initial load case to 3 to make sure that Ax = Lx later Remember that only grid loads are used in the static analysis and they will not be updated automatically unless this process is repeated.	
Static analysis under these loads	Analysis Wizard, default cases start 3 to 20, this will Ax = Lx (analysis case number is matching load case number	
Set up combination cases to get worst lanes + worst track	Combination cases table – use C1max etc	Bridge9.gwb
Bridge Loading Workshop Method B	**Batch method**	
Delete all results and analysis tasks, Delete grid loads, static bridge loads, load case titles and combination cases	Right click in gateway on 'Analysis Tasks and run 'Delete All Analysis tasks' Right click in gateway on 'Grid Loading' and run 'Delete All Grid Loading' Open 'Load Case Titles' and 'Combination Cases' tables to delete all titles and cases	
Redo bridge analysis, in addition to check 'Influence analysis', all the other three options, Optimise bridge loading, Expand bridge loading & Static analysis, are to be checked. This will run a batch analysis and no chance to refine loads before expansion with this option. Combination cases need to be set up later manually.	Analysis | New Analysis Task… | Bridge optimization analysis | tick all boxes	Bridge10.gwb

Bridge Loading Workshop Method C	In some cases it is useful to be able to place vehicles directly on the model (e.g. Accidental wheel loads, crane outriggers, detailed slab analysis). This section will also demonstrate the effects of different spanning options for Grid Planes.	
Delete all results and analysis tasks Delete all grid loading and load case titles	As Method B is a batch run, deleting bridge analysis task will also delete the bridge load generated static bridge loads, grid loads and load case titles in addition to the analysis task and results	
Set up two more grid planes, one with one-way spanning, and one with an element list which contains all the longitudinal elements (P2) and the end transverse elements only.	Previous analyses have spread load on to all elements, slab elements and longitudinal beams. This is generally undesirable because if confuses global and local effects on the transverse slabs. One way spanning is not appropriate for a curved bridge but is included to demonstrate the differences.	
Generate 3 static vehicle cases each with SV80EC-1.2 vehicle on grid plane at (10,1) but on different grid planes. Redefine load case titles to make which is which, clear after the three load cases are generated	Tools | Bridge Analysis | Generate Static Vehicle loads. Note that if doing a detailed analysis of local effects it is possible to split individual wheel loads into patch loads, but this mesh is too coarse to gain any benefit from this feature. Also note that this tool can be used to generate loads relative to alignments or on paths.	
Analyse this model and look at shear forces in beams in the elements surrounding the loads	The original grid plane gives load on all beams (note slope on shear force diagrams on transverse elements). The one way spanning grid plane puts point loads (step change in shear force) where planks would hit beams, mostly on long beams but some on transverse beams. The preferred two way spanning with selected elements puts all load on the longitudinal elements, distributed as the slab would distribute load. (no load on transverse beams)	
Expand grid loads to see the loading used by the analysis directly **End of Bridge loading workshop**	Tools | Expand Grid loading… This tool is provided for the curious (and the developers).	Bridge11.gwb

Analysis Stages	Analysis stages allow the combination of results for different stages of construction in a single model.	
Start from Bridge11.gwb model and delete results, grid loads etc as above. Create the following three analysis stages: Stage 1: Span 1 + 1 bay Stage 2: Spans 1 and 2 + 1 bay Stage 3: Whole model	Right click on Gateway and delete relevant entities Highlight and copy relevant elements from graphic and paste into Stage Definition table, and in to Lists table.	
Define a new section (section 3), it is the same as section 2, the purpose here is to demonstrate section properties can be changed from stage to stage. Set analysis stage properties for stages 1 2 and 3, i.e. if elements use section property 2 in element table, then they will use section property 3 in the relevant stages Set up beam loads for cases 2, 3 and 4 to load stages (spans) 1, 2 and 3 individually and case 5 to load the whole model. Enter load case titles	Sections Wizard Analysis Stage Properties table Check elements in stages on graphics Beam loads table, make use of element list (e.g. #1) in defining beam list in Beam Loading table, pay attention to make sure loads are not duplicated. Load case titles table	Bridge12.gwb
Use analysis wizard to set up analysis tasks for each of the stages (stages 1, 2 & 3) and the whole model. One task has only one analysis case with the relevant loads.	Analysis wizard – select stage on the first page of the analysis wizard, give task name to tell the stage of the task, give analysis case name to tell the stage and load of the analysis case. On last page choose Analyse Later.	
Carry out static analysis	Click 'Analyse all' button – notice 4 analysis tasks	
Set up combination of the three stages loaded and compare with all load on the full model	Combination cases	Bridge13.gwb