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PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

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1 Introduction

1.1 Scope

The purpose of this report is to present and describe the semi local model prepared at the towers during for Progetto Definitivo.

1.2 Report Outline

This report is organized into the following sections:

- Section 1 includes this introduction and provides a list of references, including design specifications and design codes
- Section 2 describes the Global IBDAS model
- Section 3 describes the Element stiffness's and added weights to the analysis model
- Section 4 show selected results

1.3 References

The semi local model it self is prepared as a part of the global analysis model.

This report will only describe the additional information necessary for the semi local model, reference is made to the report prepared for the Global IBDAS analysis report, "CG1000-P-RG-D-P-SV-00-00-00-00-00-01" for detailed information on the global analysis model.

1.3.1 Design Specifications

[1] CG1000-P-RG-D-P-GE-00-00-00-00-00-02 "Design Basis, Structural, Annex".

2 Description of the Tower Semi Local model

This section describes the global FE-model established for the Semi Local analysis of the towers.

The semi local model is included into the global analysis model in the sense that for most parts of the bridge the global (beam) model is used but for selected parts a more detailed modelling with

shell elements and diaphragms is used. This ensures correct boundary conditions for the detailed model.

The term “semi local” instead of “local” is used to emphasize that some details may not be accurately modelled. The level of detailing in the semi local shell model will be made clear in the following.

2.1 Geometry.

The semi local model is placed around the 2nd cross beam and the adjoining tower leg sections.

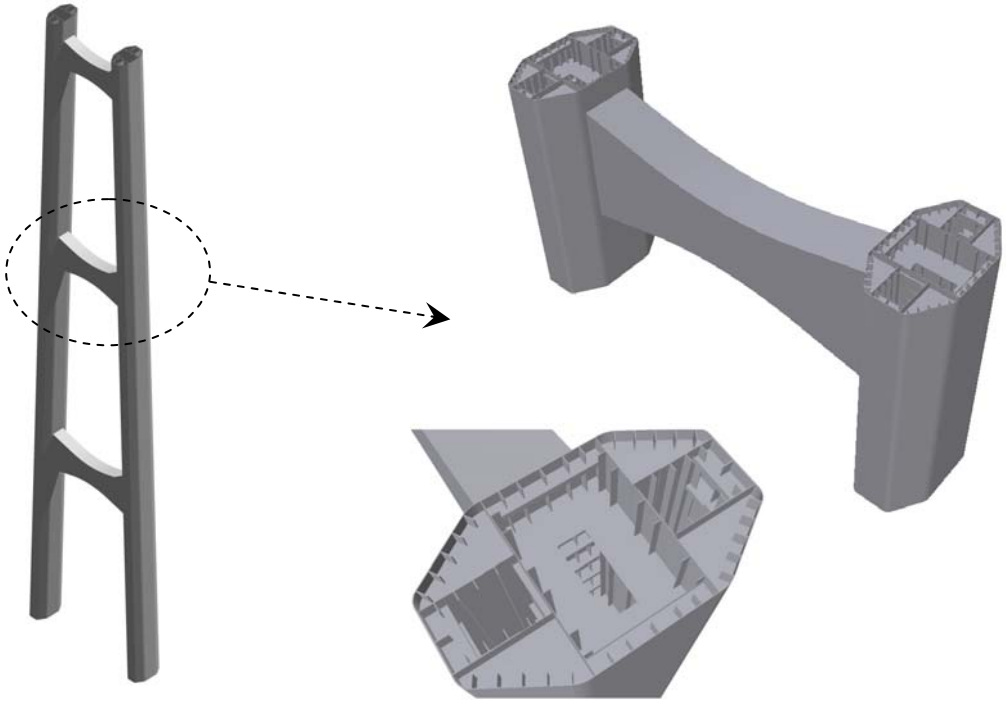


Figure 2.1: Messina Strait Bridge, geometry model of the semi local model for the towers.

The tower legs are modelled geometrically correct with all the longitudinal steel. The transverse diaphragms and frames in the tower legs are modelled with almost correct geometry as shown on the design drawings, the exception being the circular cut-outs in the four corner plates.

The cross beams are modelled correct for the longitudinal steel, but with the stiffeners placed slightly different as what is shown in the design drawings. The diaphragms in the cross beam are

modelled with a full steel plate with constant thickness, with consideration to the overall distributed weight.

2.2 Coordinate systems

2.2.1 Global coordinate system

In the model several coordinate systems have been defined. The global coordinate system used for reporting of e.g. displacements and reactions is a left-hand coordinate system, defined as follows:

- the **S**-axis (1st axis) extends along the centre line of the bridge, positive towards Calabria, s=0 is at the centre of the main span.
- the **Y**-axis (2nd axis) is orthogonal to the **S**-axis and the **Z**-axis forming a left hand coordinate system. The Y-axis thus extends horizontally transverse to the centre line of the bridge.
- the **Z**-axis (3rd axis) is vertical and extends positive upward, zero at elevation 0.00 according to the project drawings.

The global coordinate system can be seen in Figure 2.2.

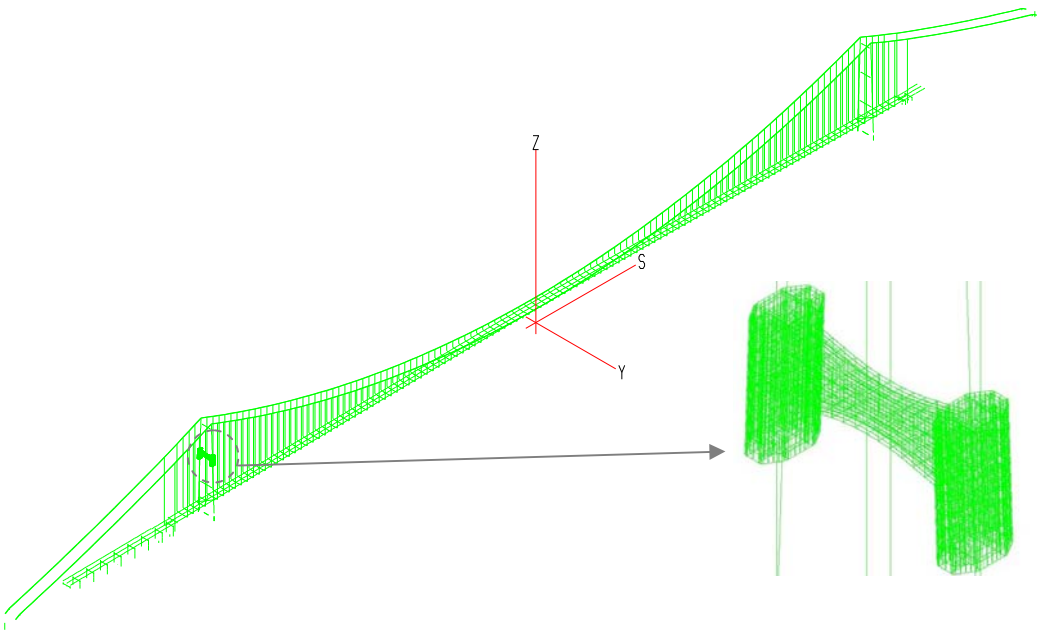


Figure 2.2: Global left hand coordinate system used in the IBDAS model. The plot also shows the entire FE-model as well as the selected semi local model at the Sicily Tower.

2.2.2 Element coordinate systems

The following plots show the element coordinate systems for the semi local model shell elements only. The coordinate systems are all left-hand systems. These coordinate systems are used for reporting of element actions such as generalised stresses (section forces).

All elements always have the s-axis along the element positive upwards for the tower legs and positive towards the global y-axis. The y-axis of the shell elements is transverse to the s-axis in-plane of the element and z-axis as an orthogonal to the element.

The coordinate systems are illustrated in the figure below.

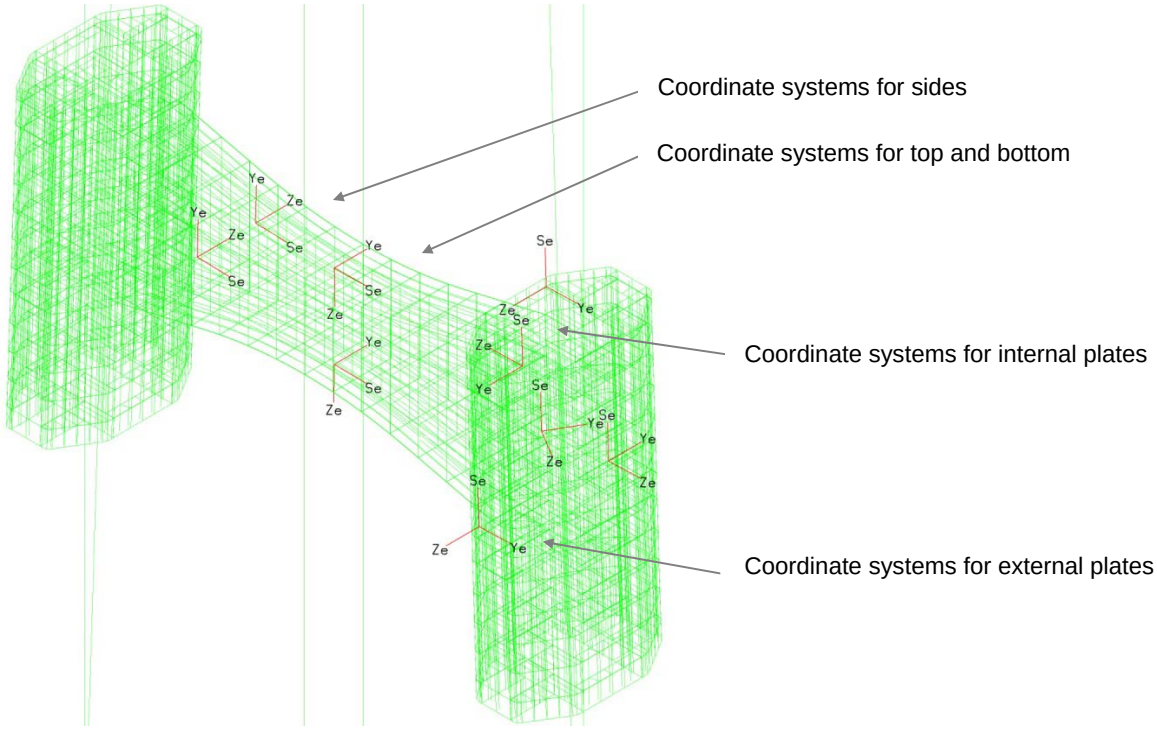


Figure 2.3: Element coordinate systems (left hand) at tower legs and tower cross beams.

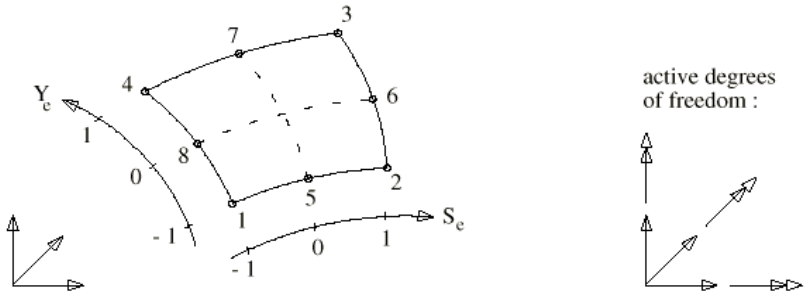
2.3 Elements

The IBDAS elements used in the global model are all 3D iso-parametric beam or truss elements. Shell elements are used in the semi local model.

Generally all structural steel members are modelled using 3-noded parabolic beam elements (IBDAS BEAM18) with 6 degrees of freedom in each node. Shear deformations are taken into account.

The hanger cables and main cables are modelled with 2-noded truss elements (IBDAS TRUSS6) with 3 degrees of freedom in each node.

The shell elements incorporated into the semi local model are using 8-noded shell elements (IBDAS SHELL48) with 8 degrees of freedom in each node, out of plane shear deformations are taken into account.



2.4 Support Conditions

The support conditions for the bridge are as described for the global analysis model.

3 Stiffness, Masses and Weights

3.1 Masses and Weights

The difference in the weight handling between the global and semi local model is that the diaphragms are modelled in the semi local model and thus no weight is added for diaphragms at the shell modelled part.

3.2 Sign convention

The force signs used in IBDAS are as shown below

The signs for the stress resultants in an infinitesimal element around a gauss point in a shell element are shown in the figure below. The analysis model and, thus, the results are based on the left-hand coordinate system. It should, however, be noted that it generally applies that a positive moment about a cross-section axis yields compression in the top side of the shell.

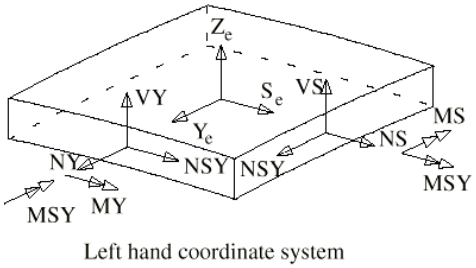


Figure 3 *Stress results at stress point for spatial shell element. Infinitesimal element around stress point shown.*

4 Results from the Semi Local

Detailed results from the semi local model will be presented in the various design reports where applicable. The present report will give selected results only and explain what has been analysed.

In order to avoid end effects close to the transition between beam sections and shell sections, results are only valid at a distance from the transition i.e. at least one diaphragm away.

Contour plots and stress value plots are taken out.

Only a very limited number of load cases are plotted in order to limit the number of plots given to the design groups

These load cases have been selected:

- Case 1 (Total permanent load) - reference condition of bridge
- Case 6902 (ULS envelope)
- Case 6931 (SILS envelope)

4.1 Contour plots

The results of this type taken out from the semi local model and reported to the design group are plots showing:

- Contour plots of sss, syy and ssy stresses (both max and min)
- Contour plots of von mises stresses (both max and min)

Generally, the above types of plots are taken out for 7 different locations:

1) Upper Diaphragm at the Cross beam 2
2) Lower Diaphragm at the Cross beam 2
3) Wall H/G/H (side span side)
4) Wall A (side span side)
5) Wall B (side span side)
6) Wall C (side span side)
7) Wall D (side span side)

Appendix A includes results for Case 1 (Reference Condition) and Case 6931 (SILS envelope).

A contour plot of the maximal normal stresses for Case 1 (Total permanent load) is shown in the figure below. The plot is shown as an example of the information possible to obtain by use of the semi local model.

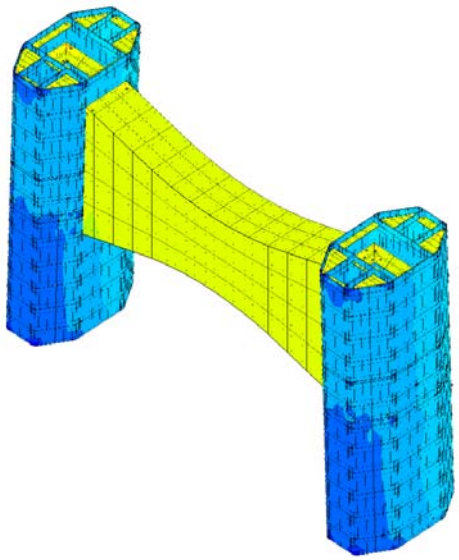


Figure 4.1: Contour plot - max normal stresses (sss) for Case 1 (Total permanent load)