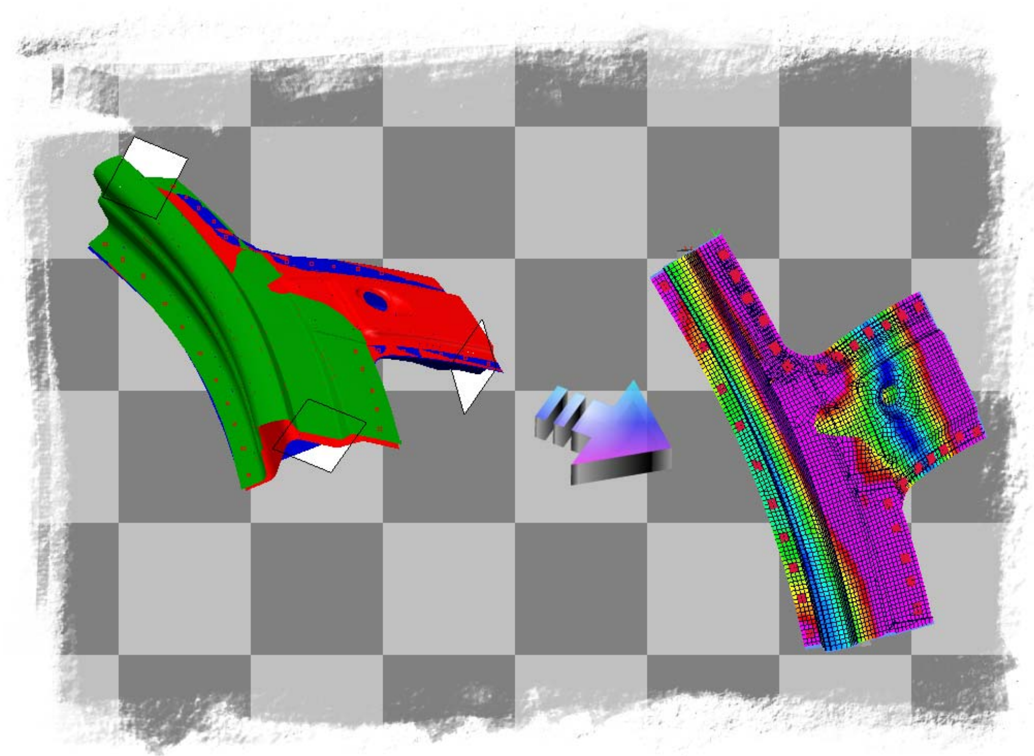
CHALMERS

VOLVO
Volvo Car Corporation



Development of ADRIAN Joint Analysis Software

Methods and implementation

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M. Sc. Thesis

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Preface

This thesis concludes the authors' M.Sc. degree in Civil Engineering at Chalmers University of Technology, Gothenburg. The thesis work has been carried out at Volvo Car Corporation. Nicklas Bylund at the department of Painted body Engineering has supervised the work. Examiner has been Klas Samuelsson from Finite Element Centre at Chalmers University of Technology.

We would like to thank our supervisor and our examiner for all help and support during this thesis work. We would also like to thank all people involved at Volvo Car Corporation, especially Jan Samuelsson for all help regarding the general analysis program MSC/Nastran.

Gothenburg, March 2002

Henrik Sandström　　　　Mattias Shamlo

Abstract

The background to this thesis work is the lack of software analysing car body joints. In order to shorten car development lead-time, it is important to control properties of car body elements. Studying the present development process, design engineers have little insight in the mechanical properties of their produced body parts. As engineering analysts enter the scene, the development process has come to a state where radical changes are hard and costly to achieve. Thus, there is an information gap between the concept model made by senior engineers experienced with analysis tools and the detail design made by design engineers.

As a short development lead-time is of great interest in the automotive industry of today, a main goal is to involve the design engineers in the area of engineering analysis. As creating models for finite element analysis is quite complex, the design engineers do not have the time to learn and use available analysis software. The solution applied here is development of a single purpose program, which should be time saving and easy-to-use.

This problem formulation resulted in new software for joint analysis called ADRIAN. ADRIAN imports a geometry file in the IGES-format, transforms it into a finite element model, submits a job to the solver MSC/Nastran and visualises the results by means of a frequency animation and an HTML-page giving information on stiffness values for the joint.

The design of the software is focused on the intended users. Therefore most of the interactive job is located to the home environment of the design engineers, i.e. the CAD-software Catia. After having exported the joint model from Catia, the remaining calculation process should only be a few interactions away. The presented process and tool is not intended to replace the complete body simulations of today, but merely permitting the design engineer to make a preliminary check of his design, leaving the detailed analysis to the analysis department.

The conclusion is that ADRIAN can be very useful for controlling car body joint design and in giving design engineers a deeper understanding for joint stiffness aspects. In turn, this may free resources in engineering analysis departments or make expensive consultant cases regarding joint stability unnecessary. By creating all joint models with the same algorithm, comparing results becomes more interesting.

A comparison of models created by ADRIAN and a job performed by the technical consultant company Semcon was made. Due to differences in modelling methods, comparing absolute frequency values would be misleading. Comparing the shape of the first three modes, the results generated by ADRIAN were identical to Semcon results.

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1 Introduction

This report is divided into two parts. The first part (chapter 3-6) contains a description of methods used today for evaluating joint capacity. This part will also describe the method developed in this thesis work, and implemented in the new software called ADRIAN. The second part (chapter 7) describes how the software works. The software is constructed using C++.

1.1 Background

In the present development process, design engineers have little insight in the mechanical properties of their produced joints. The present situation with analysts following up the work of the design engineers is somewhat ineffective. It may also be difficult to achieve radical changes for the analysts, as the work done by the design engineers is followed up late in the development process, making changes costly.

Today different crash situations are simulated using finite element models of complete cars. In 2001, attempts to strengthen the bond between performance of the complete car and performance of single components were made. This resulted in the software DAMIDA, used for section capacity simulation. This program in addition with software focused on joint analysis would form an effective tool in controlling car body architecture.

1.2 Purpose

The purpose of this thesis work is to bridge the gap between the concept model made by senior engineers experienced with analysis tools and the detail design made by design engineers. By revealing joint design problems early in the development process, the risk for late radical design changes is reduced.

1.3 Goal

The goal of the project is to introduce software capable of analysing a joint with few user interactions. The design engineers are the intended users of the software. By using the software, the design engineers shall have the possibility of making a preliminary check of the joint design.

2 Problem formulation

In order to reach the goal described in the previous section, the software must be designed for the specific platform and users at Volvo. The main features of the software are capability to import a joint Catia-model via the graphical format IGES, transformation to a finite-element-model, linear analysis and visualisation of stiffness and frequency aspects of the joint.

2.1 Program specification

The resulting program is intended to have characteristics as follows:

- Simple joint model construction in Catia
- Compatibility with the graphical exchange format IGES
- Easy-to-use graphical interface
- Automatic geometry meshing
- Automatic and mesh-independent adding of weld spots
- Automatic modelling of joint leg ends
- Automatic submission to the MSC/Nastran solver
- Automatic and pedagogical presentation of results

3 The role of the Finite Element Method

3.1 Engineering analysis methods

Engineering analysis can be divided into two different categories, classical methods and numerical methods.

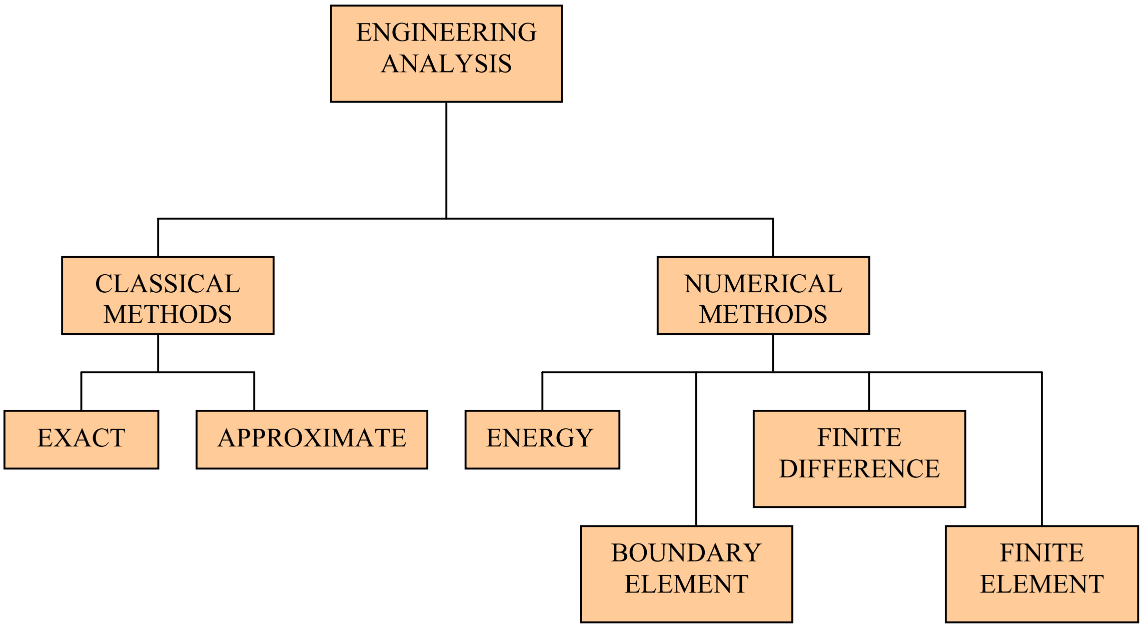

Figure 3.1: Engineering analysis methods according to [9].

3.2 Classical methods

Exact classical methods can only be applied on simple geometries, though they attempt to solve differential equations based on fundamental physical properties. To increase the application range, problems can be solved using approximate solutions to the differential equations. This approach has its advantage in a high degree of problem insight, but is still way to narrow to be applied on the geometric shapes typical for car body construction [9].

3.3 Numerical methods

There are different numerical methods, divided by the properties the method focuses on. Common for all the methods is that they address a broad range of problems. The energy method minimises the potential energy for a structure over its entire domain. This is very well suited for some problems, but it is not broadly applicable. The boundary element method approximates functions satisfying the governing differential equations, except for the boundary conditions. By letting elements represent only the boundary of the domain, problem size is reduced. This method has its limitation in the fact that the solution to the governing equations can be hard to obtain. The finite difference method replaces governing differential equations and boundary conditions with corresponding algebraic equations. This makes solution of somewhat irregular problems possible, but complex geometry, boundary conditions and load become difficult to handle [9].

3.4 Finite Element Method (FEM)

The Finite Element Method is the most general numerical method, and often the only possible method of analysis. The problem generality of the method is virtually unlimited. This is achieved by using basic elements of regular shapes to represent the geometry. These elements can be combined to approximate any irregular boundary. The method seeks to approximate the behaviour of an arbitrarily shaped structure under general loading and constraint conditions with an assembly of discrete finite elements. By taking the collective behaviour of the elements into account, the behaviour of the entire structure is obtained [9].

3.5 Linear analysis

When modelling the entire structure as an assembly of elements, a stiffness matrix represents each element. The total stiffness matrix derived from all contributions from the element stiffness matrices is the so-called global stiffness matrix K. Letting k represent the stiffness matrix for each element, F is the vector of forces and u is the vector of displacements resulting from F. The equation of movement is,

$$F_{elem} = k_{elem} u_{elem} + m_{elem} \ddot{u}_{elem} \quad (1)$$

As all contributing elements describe the behaviour of the entire structure, the equation for the structure is,

$$F = Ku + M\ddot{u} \qquad (2)$$

This is the equation solved by MSC/Nastran in linear analysis. With zero applied force,

$$Ku + M\ddot{u} = 0 \qquad (3)$$

Looking for solutions of the form,

$$u = u_0 \cos(\omega t) \qquad (4)$$

We obtain the vibration equation,

$$Ku = \lambda Mu \qquad (5)$$

where $\lambda = \omega^2$

Thus, solving equation (5) becomes a matter of inverting the matrix K with an effective algorithm. The solution flowchart for the method is shown in figure 3.2.

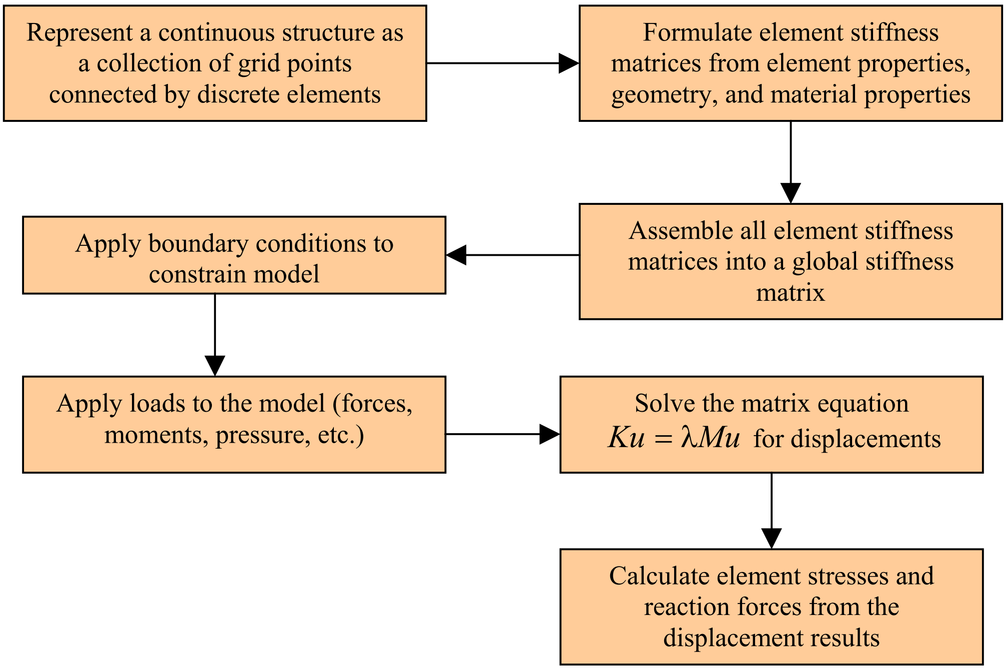

Fig 3.2: Solution flowchart for Finite Element Method [9]

Assumptions and limitations of linear analysis

There are a few assumptions and limitations in linear analysis which must be taken into account when using this solution method. Failure to ensure that these restrictions are accounted for will lead to solutions not representing the factual physical properties of the structure [9].

- **Linear elastic material:** Material must be isotropic and homogeneous. The method assumes material in which stress is directly proportional to strain. Loads may not take the material beyond the point where the material is no longer elastic. The unloaded structure must also be free of initial and residual stress.
- **Small displacements:** The method is restricted to small displacements. This restriction is due to the formulation of governing equations for the elements. A lateral plate deflection can be considered small if it is substantially smaller than the thickness of the plate and a beam deflection substantially less that the smallest dimension of the cross section of the beam.
- **Slowly applied loads:** The structure must be in static equilibrium. Loads may not induce a dynamic effect. Therefore loads disturbing this equilibrium, for example impact loads, are not allowed. Slowly applied loads shall be taken to mean loads that do not result in a significant dynamic behaviour.

4 Methods for analysing joint capacity

4.1 Experimental methods

Background

In the seventies, Lubkin showed that the overall stiffness of frame structures are very sensible to the stiffness of joints, governing up to 60 % of the global stiffness. Later, Moon evaluated 3-legged joints in the plane by representing the joints analytically with rigid elements and torsion springs. The joint is then measured statically in order to identify the stiffness of the springs [3].

Problems

When evaluating joints experimentally there are two major difficulties. Problems occur when trying to define the centre of the joint and in the area of experimental set up. Due to complexity in car body design, joints may have more than one centre, as in figure 4.1.

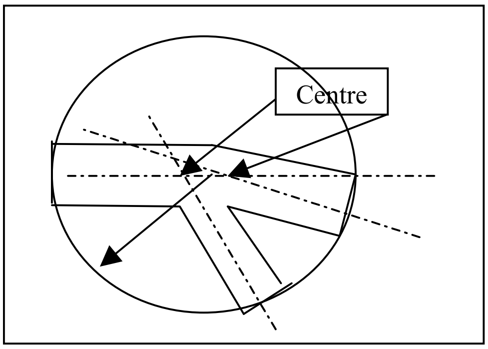

Figure 4.1: Joint without an absolute centre [3]

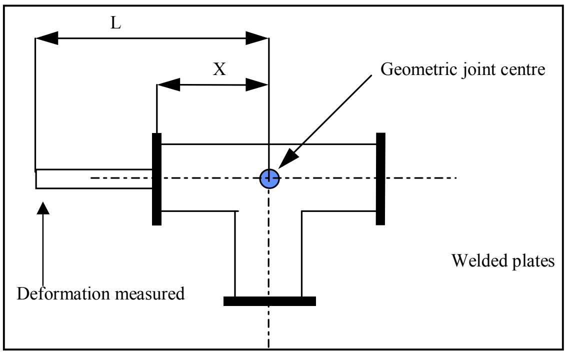

Figure 4.2: Measurement set up [3]

Parametrising a joint with a lack of a well-defined centre using rigid elements and torsion springs is unfeasible. The legs can not be represented unambiguously leading to great errors. Even when a joint centre can be defined, there are problems with the experimental set up. The joint has to be permuted, i.e. each leg has to be grounded while one of the others are attached to a force lever [3], see figure 4.2.

An alternative approach

In order to avoid these problems, an alternative set up method can be applied. The joint is set up freely using soft springs and rubber ropes and heavy masses are cast to the joint legs. The joint is defined as inscribed in a sphere with radius r, for an automotive joint 250 mm. The centre of the sphere is put at the mean distance from the different joint centres. The joint is cut out where the sphere cuts the legs (figure 4.3).

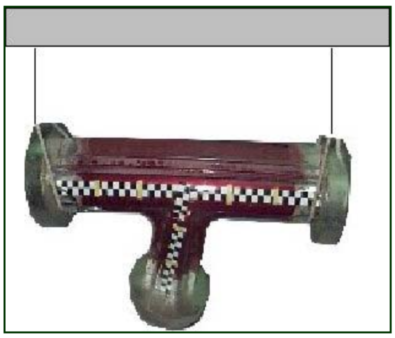

Figure 4.3: Alt. measurement method

Dynamic measurements are carried out with hammer impact and accelerometers on various locations on the joint. The frequencies and the corresponding eigenvectors are used to visualise the vibrational behaviour of the joint [3].

This method has been introduced at Volvo. Thus, it is important to make virtual modelling similar to the models used experimentally in order to make results comparable.

4.2 Present simulation method

At this moment, there is no software available for simulation analysis of car body joints. The analysis is carried out manually either by engineers employed at Volvo or by engaging consultants. The manual method used by engineering analysts at Volvo is similar to the method used by ADRIAN.

4.3 Method used by ADRIAN

The software ADRIAN can be regarded as a "container of knowledge", where program components are contributions from different Volvo Car Company departments.

The Process

The design engineer exports a CAD-model and converts it into the IGES-format. The CAD-model contains information on joint geometry, weld spots, sheet thickness and weld diameter. There are also planes defining the end of the joint in the CAD-model. Information is separated in the Catia model by placing it in different sets. The material is not explicitely involved in the calculations. As ADRIAN uses linear analysis the material only enters in form of the ratio of the E-module and the density. This ratio is close to constant for the materials of interest.

The program consists of a pre-processor converting the IGES-model to the Nastran-format. Both the IGES-format and the Nastran-format are ASCII (plain text) formats. ADRIAN extracts the sets in the IGES-file and takes appropriate actions due to the set contents (see section 7.4).

The program ADRIAN has a rather simple user interface. ADRIAN is intended to bridge the gap between existing software used at Volvo. By using existent software in an efficient way, there is no need for an advanced interface with a great deal of user interactions.

As pre-processing is finished, ADRIAN submits a job to the solver MSC/Nastran. The solving process is carried out on an external server. Calculations are not treated on the local computer due to the fact that the local system configuration may differ between computers at Volvo. While processing, ADRIAN waits for significant files to be returned and then launches the post-processing sequence automatically. As post-processing is finished, the user obtains a HTML-page containing rotational and translational stiffnesses for the joint legs. ADRIAN also gives the possibility of analysing the frequency modes in the post-processing software Animator. These results can be used for a comparison with a full simulation of concept models.

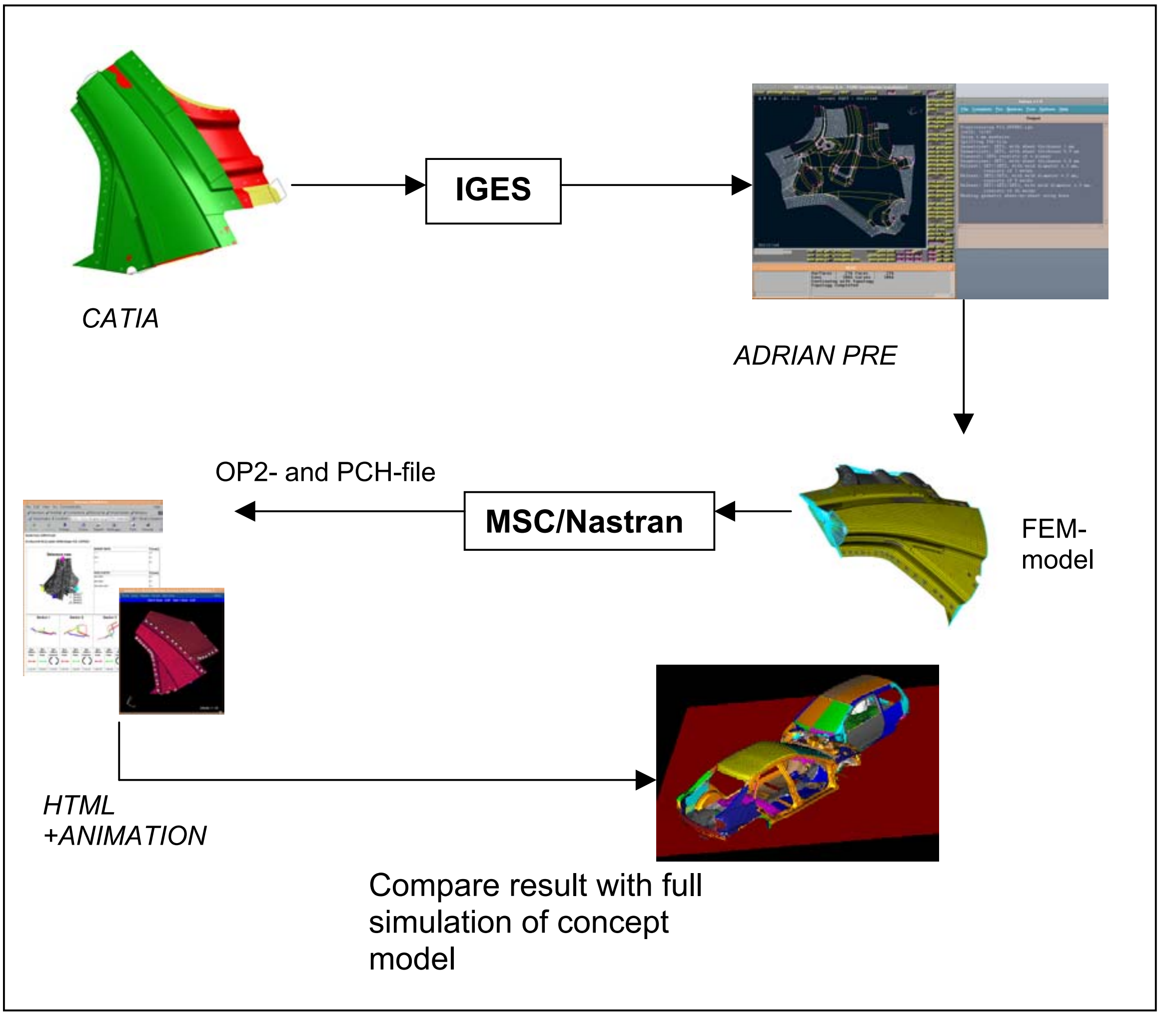

Figure 4.4: The ADRIAN Method

5 Data formats

5.1 The IGES format

IGES (The Initial Graphics Exchange Specification) is a widely adopted standard for geometric data produced by CAD/CAE systems. IGES consist of five sections, the start section, the global section, the directory section, the parameter section and the termination section [17].

- **The Start Section:** This section contains information assisting the receiving user such as features and the revision number of the originating system.
- **The Global Section:** Here the parameters necessary for translating the file are given.
- **The Directory Section:** Contains an entry for each entity in the file comprising a code representing the entity type and sub-type and pointers to the entity data in the next section. Each entry consists of two lines comprising 18 fields with 8 characters used in every field.
- **The Parameter Section:** Contains the entity specific data such as co-ordinate values, annotation text, number of spline data points and so on. The first parameter in each entry identifies the entity type. From this parameter the meaning of the remaining parameters can be derived.
- **The Termination Section:** Marks the end of the data file, and contains sub-totals of records for data transmission check purposes.

By using IGES, ADRIAN is not restricted to be used in a Catia environment. The IGES entities identified by the program are given in table 5.1.

Type	Entity	Type	Entity
102	Composite curve	128	NURBS surface
108	Plane	142	Curve on parametric surface
116	Point	144	Trimmed surface
126	NURBS Curve	402	Set

Table 5.1: IGES entities used

More information on the algorithm used when reading IGES can be found in section 7.4. An example of an IGES-file can be found in Appendix B.

5.2 The Nastran format

The Nastran format is the text format representing FEM models that are to be submitted to the MSC/Nastran solver. Data is given in blocks consisting of eight characters or by separating blocks by a comma. ADRIAN represents data in blocks of eight characters. The first data block specifies the element type, for example ‘GRID’ is a grid point in the mesh and ‘CQUAD4’ represents a mesh element with four edges. The element type specifies the syntax of the parameters belonging to the element. An example of a Nastran-file can be found in Appendix C.

6 Description of Software used by ADRIAN

6.1 Catia

Catia is the CAD software used by Volvo. CAD (Computer Aided Design) is used for creating a digital product definition. The car body components are drawn digitally in Catia. Volvo uses shell modelling, i.e. sheets are represented by a surface which is given a theoretical thickness. Weld spots are in separate models, consisting of weld spots for the entire car.

6.2 ANSA

ANSA (Automatic Net-generation for Structural Analysis) is the pre-processing and meshing software used by Volvo. The program contains geometry cleanup-, meshing- and mesh improvement-functions used by ADRIAN. ANSA has the possibility of submitting script jobs to the program. ADRIAN creates scripts that are read by ANSA on each run. ANSA consists of an IGES translator and a Nastran-export routine. ANSA also supports STEP (Standard for the Exchange of Product model data). ADRIAN is implemented in a way making a future add of STEP-compatibility possible.

Mesh and mesh improvement

ADRIAN uses the ANSA Free-meshing-algorithm. This algorithm creates the least number possible of elements, taking into account the shell element distortion and minimum length.

Element quality checks in ANSA are made by means of aspect ratio, warping, skewness, taper and jacobian (figure 6.1).

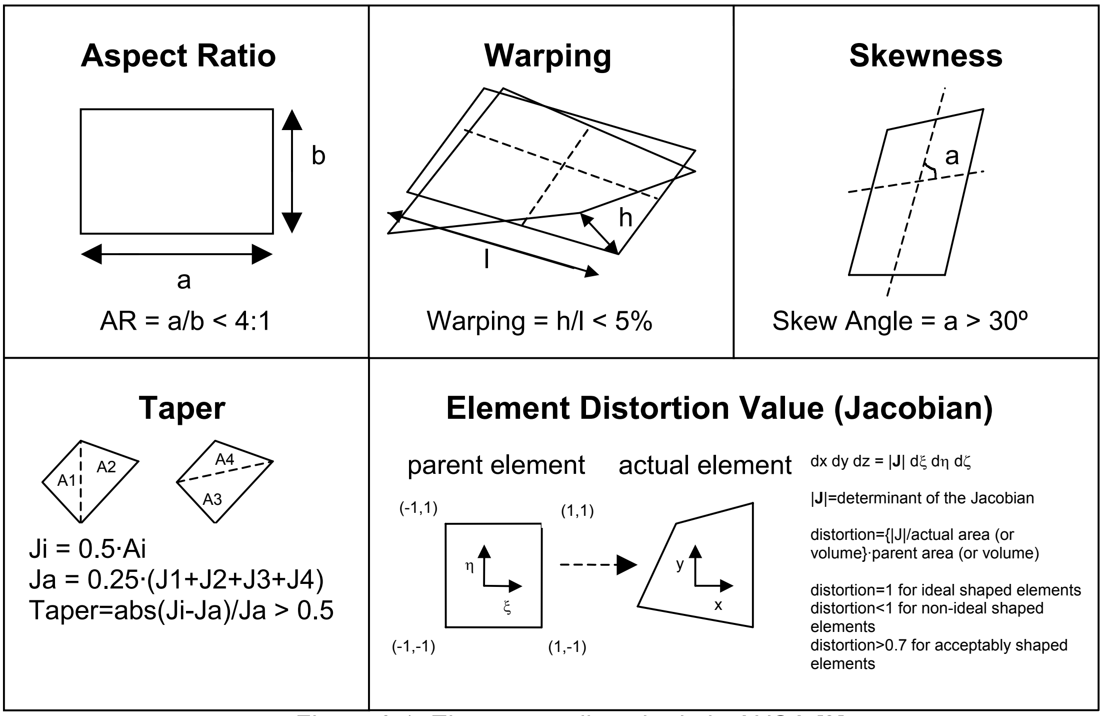

Figure 6.1: Element quality criteria in ANSA [2]

In the ANSA version 11.1, the mesh improvement algorithms supported by the ANSA scripting language used by ADRIAN are algorithms for reducing element warping and jacobian [1].

6.3 MSC/Nastran

MSC/Nastran is the Finite Element problem solver. This section describes the method used by Nastran for solving the linear FEM-problem [11].

The Lanczos Method

Nastran uses a solution method called the Lanczos method. The Basic Lanczos recurrence (1950) is a transformation process to tridiagonal matrix form.

Basic Lanczos Recurrence

The basic Lanczos recurrence solves the eigenvalue problem,
$Ax = \lambda x$ (2.1)
and can be formulated as:

1. **Initiation**
   a. A starting vector q_1 is chosen with $\|q_1\| = 1$.
   b. $\beta_1 = 0$ and $q_0 = 0$ are set.
2. **Iteration**
   For j=1,2,3….., iterate until convergence as follows:
   $r_{j+1} = Aq_j - \alpha_j q_j - \beta_j q_{j-1}$
   where,
   $\alpha_j = q_j^T A q_j$
   $\beta_{j+1} = \|r_{j+1}\|$
   $q_{j+1} = \dfrac{r_{j+1}}{\beta_{j+1}}$

If the algorithm is carried out without round-off errors, the vectors q_1, q_2,… are orthonormal. These vectors can be considered to be column vectors of an orthogonal matrix $Q_j = (q_1 \quad q_2 \quad .... \quad q_j)$. The scalars α_j and β_j can be combined in a tridiagonal matrix T_j:

$$T_j = \begin{pmatrix} \alpha_1 & \beta_2 & & & & & \\ \beta_2 & \alpha_2 & \beta_3 & & & & \\ & \beta_3 & ... & & & & \\ & & \beta_i & \alpha_i & \beta_i & & \\ & & & & ..... & \beta_j & \\ & & & & \beta_j & \alpha_j & \end{pmatrix}$$

The eigenvalues and corresponding eigenvectors of A are computed from those of T. Let θ and s be an eigenpair of T_j, thus

$$T_j s = s\theta$$

then θ and y with $y = Q_j s$ is an approximate eigenpair for the original problem. This is where the computational gain can be found. In a typical application the order of the matrix A may be in the tens of thousands, whereas the order of T_j is about 20 to 30.

Modification of the Basic Lanczos Recurrence

In order to apply the Basic Lanczos Recurrence on the vibration problem, some modifications have to be made. The vibration problem is a symmetric generalised eigenvalue problem using the following form:

$$Kx = \lambda Mx$$

where K is a symmetric matrix, M is a symmetric positive semidefinite matrix and λ is the eigenvalue.

If applying the Basic Lanczos Recurrence on the vibration problem, the algorithm yields precise approximations to the large, well-separated, but uninteresting, eigenvalues and poor approximations to the small, clustered, and interesting eigenvalues. By shifting and inverting the eigenvalue problem, the Lanczos algorithm can be applied with a better outcome:

$$M(K - \sigma M)^{-1} Mx = \frac{1}{\lambda - \sigma} Mx$$

The shift σ is chosen close to the eigenvalues of interest. A properly chosen shift guarantees rapid convergence to all eigenpairs in the vicinity of the shift. The cost is the factorisation of $(K - \sigma M)$.

The shifted Lanczos algorithm has difficulties with eigenvalues of high multiplicity. Each step of the shifted Lanczos recurrence requires the solution of a sparse linear system of equations of the form $(K - \sigma M)x$ and one multiplication by the matrix M. These operations require accessing matrices stored on disk file and thus entail significant I/O costs. Due to this fact, MSC/Nastran uses a Block Lanczos Algorithm. This approach makes multiple eigenvalues easier to compute and the amount of I/O is reduced. The result is the general Lanczos procedure.

The procedure used by MSC/Nastran

The general Lanczos procedure used by Nastran is summarised in figure 6.2 on the next page. The procedure consists of two levels, the outer level in shift strategy and administration, and the inner level is the actual Lanczos iteration.

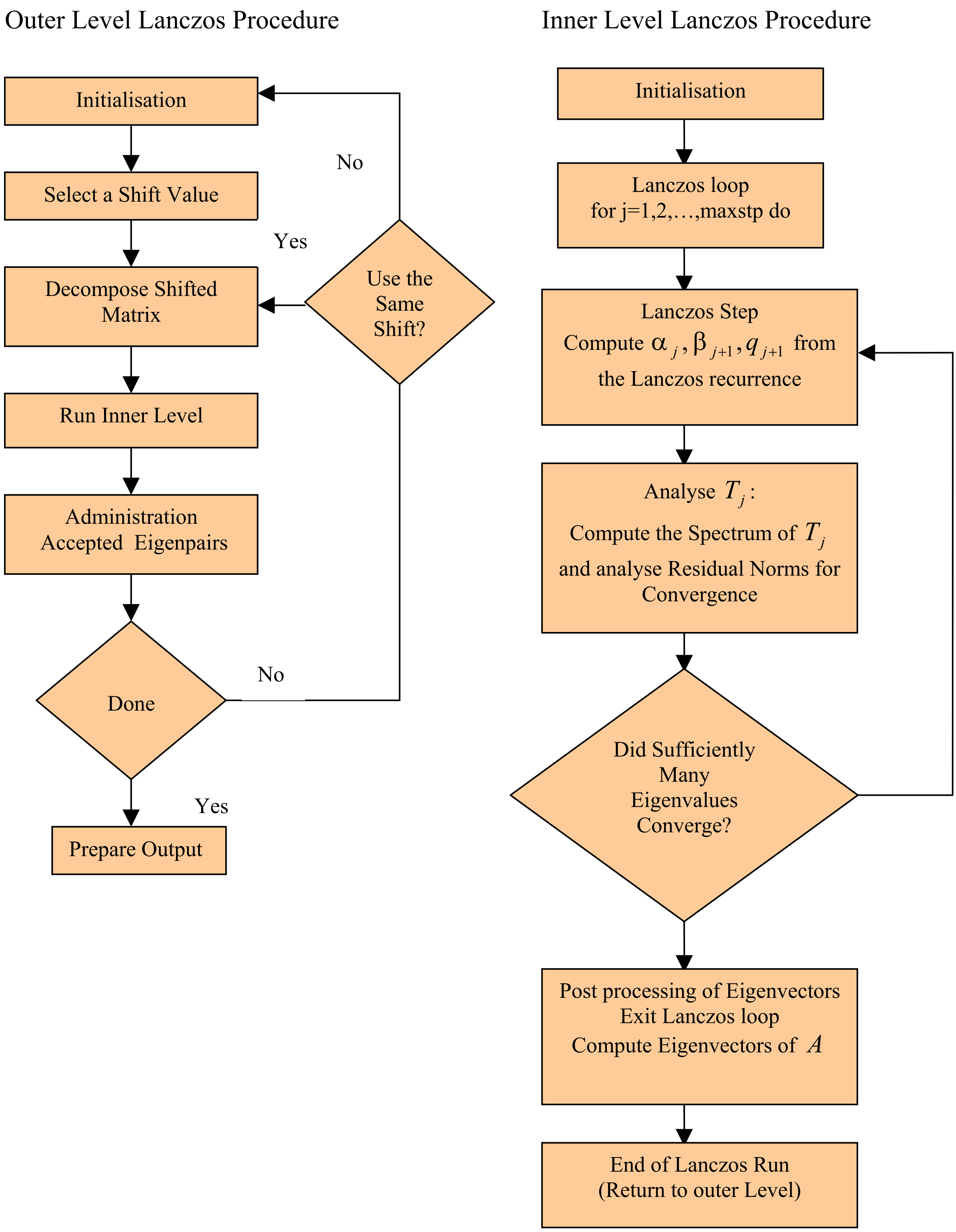

Figure 6.2 The Lanczos Procedure [11]

Superelement reduction

In order to reduce the stiffness output matrix, the joint is modelled with a master node at each leg. Dividing the stiffness matrix K in a masternode part and in a part describing internal interaction, only substantial information on the stiffness characteristics of each leg is obtained. If K_{mm} is the stiffness from interaction between masternodes and K_{ss} is the stiffness from interaction between internal nodes we have that

$$\begin{pmatrix} K_{mm} & K_{ms} \\ K_{ms}^T & K_{ss} \end{pmatrix} \cdot \begin{pmatrix} D_m \\ D_s \end{pmatrix} = \begin{pmatrix} F_m \\ F_s \end{pmatrix}$$

where D_m are the degrees of freedom for the masternodes, D_s are the internal degrees of freedom, F_m are the forces on the masternodes and F_s are the forces on the internal nodes.
By taking

$$K_m = K_{mm} - K_{ms} K_{ss}^{-1} K_{ms}^T$$

the reduced stiffness matrix is obtained. In this way, only stiffness information describing the masternodes is given. Note that this reduction does not include any approximation of the original problem. [10].

The stiffness output

The result of the reduction described above is a 18x18 stiffness matrix for a joint with three legs, and a 24x24 matrix for a joint with four legs, represented in the structure shown below:

$$K = \begin{pmatrix}
\sigma_{xx}^{T1} & \sigma_{xy}^{T1} & \sigma_{xz}^{T1} & .... & & & & & \\
\sigma_{yx}^{T1} & \sigma_{yy}^{T1} & \sigma_{yz}^{T1} & .... & & & & & \\
\sigma_{zx}^{T1} & \sigma_{zy}^{T1} & \sigma_{zz}^{T1} & .... & .... & .... & .... & & \\
... & ... & .... & \sigma_{xx}^{R1} & \sigma_{xy}^{R1} & \sigma_{xz}^{R1} & .... & & \\
 & & .... & \sigma_{yx}^{R1} & \sigma_{yy}^{R1} & \sigma_{xz}^{R1} & .... & & \\
 & & .... & \sigma_{zx}^{R1} & \sigma_{zy}^{R1} & \sigma_{zz}^{R1} & .... & & \\
 & & & .... & .... & ..... & \sigma_{xx}^{T2} & \sigma_{xy}^{T2} & ..... \\
 & & & & & & \sigma_{yx}^{T2} & .... & \sigma_{xz}^{Rn} \\
 & & & & & & .... & \sigma_{zy}^{Rn} & \sigma_{zz}^{Rn}
\end{pmatrix}$$

where for example σ_{yy}^{T2} represent the translational (T) stiffness for masternode 2 in the y-axis direction.

The elements outside the tridiagonal are stiffness values representing the connection between the translational and rotational stiffness and the connection between different masternodes. These elements are not of interest for ADRIAN post-process purposes. Each 3x3 submatrix represent a translational and rotational tensor for the specific masternode. This tensor describes the stiffness values in all directions for the node.

The frequency output

Animations of the 12 first modes are stored in a file, named .op2, by the Nastran solver. The modes are described by the eigenvector calculated by Nastran. The frequency of each mode can be found in a so called f06-file. Each frequency is the square root value of the corresponding eigenvalue,

$$f = \frac{\sqrt{\lambda}}{2\pi}$$

Thus, small eigenvalues correspond to low frequency. The low frequency modes are the most interesting ones, describing the weakest directions of the joint.

6.4 Animator

Animator is an graphic post-processor for finite element computations. It can be used for different finite element applications, such as crash and static. ADRIAN uses Animator in order to animate frequency modes.

7 Program description

This chapter contains a description of the developed program.

7.1 Program requirements

ADRIAN is developed using the HP-UX 11.0 platform. The program uses existent software available at Volvo. ADRIAN is tested with the configuration described below:

- HP-UX 11.0
- Catia v. 4
- ANSA v. 11.1
- MSC/Nastran v. 2001
- Matlab v. 5.3
- Animator v. 5.3

7.2 File structure

Directory creation

The first time ADRIAN is started, the program creates a directory named ADRIAN_ROOT in the user home directory. Under this directory a directory named .TEMP is also created.

Each time the program is executed, a temporary working directory for this specific session is created. This temporary working directory is named according to the time ADRIAN was executed. By using separate temporary working directories, it is possible for the same user to start many independent ADRIAN sessions.

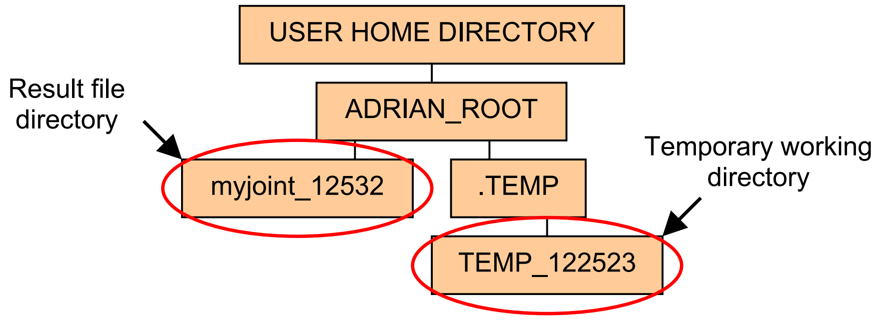

Figure 7.1: File structure used by ADRIAN

When the pre-processing sequence is running, ADRIAN stores temporary files in the temporary working directory. As pre-processing is finished, a result file directory is created, named accordingly to the model imported and a job identification number given by the program. The temporary working directory is also used for storing temporary files used by the post-processing routines. By storing all ADRIAN files under the same directory, result-files could easily be removed if desired.

Directory deletion

If the user chooses to quit the ADRIAN session, the temporary working directory is deleted. This is done regardless the user quits by entering the file/quit menu or presses CTRL-C. In order to make sure no unwanted old temporary directories are left behind, the program checks for temporary working directories older than one day when a new session is executed and deletes them.

7.3 Graphical User Interface

The ADRIAN Graphical User Interface (GUI) is programmed using OSF/Motif. As most software for GUI design requires installation of libraries, the GUI was programmed directly in Motif. Motif libraries are in the default installation at Volvo. The GUI and the program functions are well-separated, leaving the possibility of attaching the program functions to another GUI in the future.

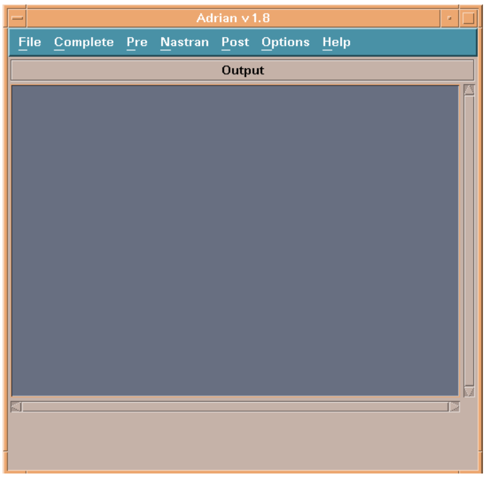

Figure 7.2: The ADRIAN Graphic User Interface

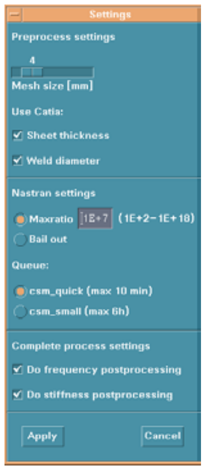

Figure 7.3: Settings menu

The program may be run completely or by launching separate routines. The complete process consists of pre-processing, Nastran-solving and post-processing. Each of these sub-processes is stand-alone and may be executed from specific menus. Under the options menu, settings for the process are set. There is also a help section available from the interface, consisting of relevant user information. The ADRIAN Help can be found in Appendix E. In the Output-window, processing information is printed. Examples of given information are IGES-file contents, Nastran calculation results and processing errors. During processing, the ADRIAN GUI is locked from interaction.

7.4 Pre-processing

Joint modelling in Catia

This section describes what to export from Catia. To use ADRIAN successfully it is important to use the syntax described below. It is also very important that the model exported is clean and therefore only consists of the components described below:

- Each **sheet** shall be placed in a separate Catia set
- A separate set consisting of **planes** describing the beam ends must be existent
- Sets for the **welds**

Sheets

Each sheet must be placed in a separate set named according to the syntax: **NAME**:T**SHEETTHICKNESS**. A setname may consist of maximum 30 characters. **NAME** is a unique name for each set, for example SET1, SET2 and SET3. The second part, **SHEETTHICKNESS**, is the sheet thickness given in millimetres in the range 0.5-2.5 mm. The sheet thickness is optional, if no value is given, ADRIAN uses a default sheet thickness of 1.0 mm. The following setnames are examples of valid ADRIAN setnames: SET1:T2.1, SET2:T0.9 and SET3.

Restrictions on geometry

To obtain the best performance of ADRIAN, the model should have faces on every surface. This is discussed more thoroughly later in this section.

Planes

A separate set consisting of planes describing the joint ends must be existent. ADRIAN looks for a set consisting of three or four planes, depending on joint type. The setname must be unique and consist of a maximum of 30 characters. There must be nothing else than these planes in the plane set.

Welds

In order to weld two sets together, a new set named **NAME**:**NAME**:D**DIAMETER** is created, where **NAME** is the name part of the sheet set and **DIAMETER** is the weld diameter given in millimetres and in the range 4.0-9.9 mm, for example: SET1:SET2:D4.5. It is also possible to weld three or four sets together, for example: SET1:SET2:SET3:D6.3 or SET1:SET2:SET3:SET4:D5.5. The

Figure 7.4: A Catia joint model

weld diameter is optional; it is possible to create a weld set with the syntax **NAME**:**NAME**, for example SET1:SET2. If this is done, ADRIAN uses a default weld diameter of 4.5 mm. As the set is created, points marking the position of the welds are placed in the set.

If, for some reason, ADRIAN fails to create a weld, the user gets a warning message identifying the point causing the problem. It is important to make sure weld spots are in logic positions and that they belong to the correct sets, named after the sheets being welded together. There must be nothing else than points in a weld set and there is no limit in how many weld sets that can be existent in a model.

Reading IGES

ADRIAN consists of an algorithm for reading the IGES format. IGES indata is restricted to have the characteristics as described above. The program checks that these restrictions are fulfilled and takes actions with respect to the content identified.

Reading sets

As mentioned above, the information the program needs shall be stored in separate sets. The program identifies these sets in the IGES-file and appends them to a linked list. When this is done, the program checks the contents of each set. In order to continue processing, ADRIAN must identify a set containing planes describing the joint leg ends, at least one set containing geometry (i.e. at least one sheet) and at least one set containing weld spots.

- **Planes:** ADRIAN looks for a set containing three or four planes and nothing else. Thus, the software is capable of analysing joints with three or four legs. As the set of planes is identified, ADRIAN stores these planes to a temporary file.
- **Geometry:** The must be at least one set consisting of IGES NURBS surfaces or IGES Trimmed Parametric surfaces in the IGES-file. One set containing geometry is equal to a single sheet. As a set containing geometry is found, ADRIAN creates a separate IGES-file with the set contents.
- **Welds:** Weld spots are represented in sets containing points only. The set name shall consist of information on the sheets that are to be welded together and the weld diameter. The welding information is stored to a file used by the welding program SPOT.

Reading geometry sets

For each entity in the geometry set, ADRIAN checks if the entity is a Trimmed Parametric Surface or a NURBS Surface. An example of a line representing a Trimmed Parametric Surface in the Parameter Section can be found on the next page.

```
102,4,201,203,205,207,0,0;                                       209P    375
142,0,165,199,209,0,0,0;                                         211P    376
144,165,1,1,189,211,0,1,215;                                     213P    377
```

Figure 7.5: Trimmed Parametric Surface representation

The first parameter, the integer 144, indicates a Trimmed Parametric Surface. Then there is a pointer to the definition line of the surface entity D that is to be trimmed (165). The third parameter indicates whether the outer boundary of the D surface is the boundary of the trimmed surface. In this case the parameter is equal to one indicating that the outer boundary of D is not the outer boundary of the trimmed surface. The next parameter is an integer telling the number of inner boundaries. Then there is a parameter pointing to the Curve on a Parametric Surface Entity that constitutes the outer boundary (189). The succeeding parameters (in this case only the integer 211) are pointers to the inner boundary curves.

If there are faces on all surfaces in the Catia model the only geometric representation in the IGES-file will be Trimmed Parametric Surfaces. Catia surfaces which have not a corresponding face are represented by IGES NURBS surfaces (Entity ID 128). If ADRIAN finds single surfaces in the model, the user is confronted with a warning message.

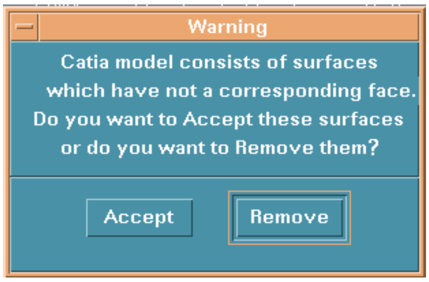

Figure 7.6: Warning message for models consisting of surfaces which do not have a corresponding face.

It is strongly recommended that models containing faces on all surfaces are constructed. If this warning message occurs when importing such a model, the user knows that the surfaces detected are not intended to be included in the model. The user simply clicks the Remove-button to clean the model from these unwanted surfaces. Moreover, performance of translating IGES surfaces in ANSA is better for a model consisting of faces on all surfaces (Trimmed Parametric Surfaces) than for a model containing single surfaces (NURBS Surfaces).

Using ANSA

As the information needed is identified, ADRIAN starts processing the data. ANSA has the capability of launching script jobs. As all sets containing geometry have been found, ADRIAN creates a script which is sent to ANSA. The script contains information on what IGES-files to be read and what to do with each file. ADRIAN splits the total geometry in files consisting of only one sheet due to the fact that problems might occur in ANSA if two different sheets are close to each other. In this case, surfaces belonging to different sheets may be connected to each other.

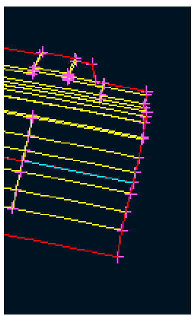

Figure 7.7: Surface boundary representation in ANSA

In figure 7.7 yellow lines represent a connected surface boundary and red line represent an unconnected outer boundary. If a red line can be detected inside the outer boundary of the sheet, ANSA has failed in translating CAD-data correctly and two neighbouring surfaces are unconnected. If a blue line is existent, more than two surface boundaries are inside the tolerance for connection. For the program purposes there shall not be any blue lines existent when reading data into ANSA.

The meshing process

Each sheet is translated and a mesh is constructed. As ADRIAN is intended to be used with a low amount of user interactivity, the default mesh size is set to 4 mm. This is regarded as a very small mesh size and increases the time for solution of the FEM-problem. However, the advantage concerning a reduced risk of badly shaped elements is a strong argument for a fine mesh. Increasing the mesh size increases the risk of getting elements not tolerated by the Nastran solver, for example triangulary shaped quad-elements.

As meshing is finished, ANSA makes some slight improvements of the mesh. The software consists of algorithms for detecting bad elements and improving the representation, checking quality factors as described in sec 6.2. The improvement algorithms used are the Reduce/Split and the Reduce/Jacobian algorithms. By using the Split algorithm, quadrangular elements with high amount of warping are splitted, creating two triangular elements. Triangular elements can not be warped though a triangular element is always planar. The Jacobian algorithm reduces the number of second order elements exceeding the Jacobian quality criteria.

No licence

The number of ANSA licences is limited. If ADRIAN is unable to start ANSA due to a lack of licences, pre-processing is interrupted and the user is recommended to make a new attempt later on.

Welding

A requirement for modelling welds automatically and in an efficient manner is that the welds are constructed independent of the mesh. To accomplish this, a program designed for modelling weld spots is used. By transforming the information from the IGES-file, i.e. weld spot coordinates, weld diameter and what sheets that are to be connected, suitable indata for the welding program SPOT is printed to file by ADRIAN. The sheets are identified by their Nastran PID (Part ID).

SPOT creates a solid hexa element (CHEXA) representing the spot weld itself, and connects the corners of the solid element to neighbouring mesh elements. SPOT uses the displacement interpolation functions of the CQUAD4 and CTRIA3 elements (Mesh elements with three or four corners). For each element, each displacement component (including rotation degrees of freedom) is represented by a bi-linear shape function. The problem is to determine the contribution of each corner point of the CQUAD4 or CTRIA3 to the displacement of a point on the interior of the element. SPOT solves the problem by manipulating the shape functions. At the end of this process the following equations are obtained for one of the solid element corners with id 10002.

$$u_x^{10002} = a_1 u_x^8 + a_2 u_x^9 + a_3 u_x^{11} + a_4 u_x^{12}$$
$$u_y^{10002} = a_1 u_y^8 + a_2 u_y^9 + a_3 u_y^{11} + a_4 u_y^{12}$$
$$u_z^{10002} = a_1 u_z^8 + a_2 u_z^9 + a_3 u_z^{11} + a_4 u_z^{12}$$

where 8,9,11 and 12 are the corners of the neighbouring CQUAD4 element. Note that the coefficients are the same for the x,y and z displacements. This information is then expressed using a rigid element connecting the solid element corner with the mesh. These calculations are made for all eight corners of the solid element. The resulting geometry is shown in figure 7.9.

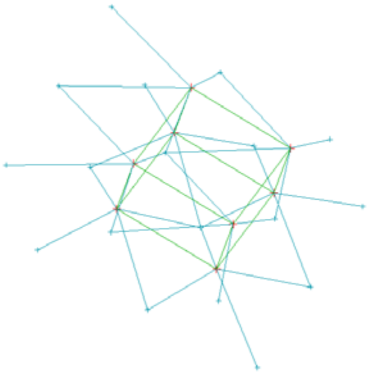

Figure 7.8: Weld spot structure

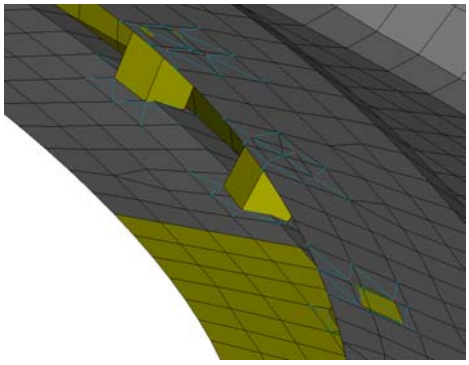

Figure 7.9: Weld spot between two flanges

The program supports welding 2-4 sheets together with one weld. In the case of a three joined flange, two hexa elements are generated, one between each of the flanges [5].

Leg end modelling

As ADRIAN uses superelement-reduction, the end-sections of the joint leg ends must be modelled. The program uses the indata planes to identify the elements nodes lying in the end plane. Taking the mean value of the coordinates of these nodes, defines the position of a masternode for the end section.

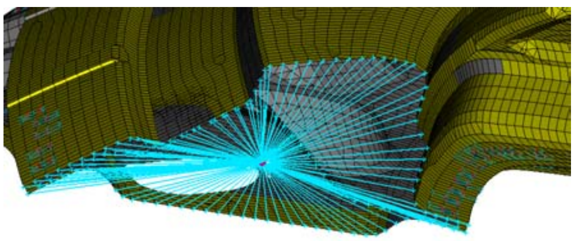

Figure 7.10. Joint leg end section with a rigid body

As this is done, the calculated masternode is connected with the nodes lying in the section with a rigid body.

In order to construct a model similar to the joints used in the experimental methods described in section 3.1, masses must be attached to the leg ends. By using a point mass with a given moment of inertia, a disc-shaped mass can be modelled. In ADRIAN this is done primarily by defining a local coordinate system for the joint leg. A Cartesian coordinate system is placed with its origo in the masternode and with the z-axis pointing in the direction of the normal vector of the plane. A mass is defined with its centre of gravity in the masternode and with moments of inertia in the x-,y- and z-axis directions. The mass is set to 5 kilos and the moment of inertia is calculated according to fundamental mechanical formulas for a solid cylinder:

$$I_z = \frac{1}{2} m r^2$$

$$I_x = \frac{1}{12} m (h^2 + 3r^2)$$

$$\rho = \frac{m}{\pi r^2 h}$$

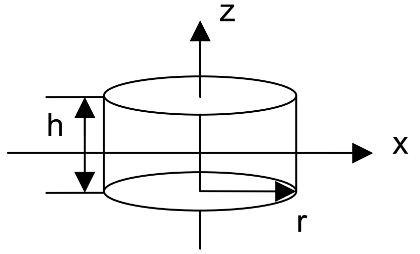

Figure 7.11: Moment of inertia of a solid cylinder [13]

The mass is assumed to have r=125 mm. The density ρ is set to the density of steel i.e $\rho = 7.85 \cdot 10^{-9} \frac{tons}{mm^3}$. This result in $I_x = 19.7 tons \cdot mm^2$ and $I_z = 39.0 tons \cdot mm^2$.

Pre-processing options

The available options for pre-processing in ADRIAN is

- **Mesh size:** The mesh size used by ANSA can be set to a value of minimum 1 mm and maximum 20 mm. Default is 4 mm.
- **Use Catia sheet thickness:** Sheet thickness is normally intended to be set in Catia. If the box is checked, ADRIAN searches for definitions of sheet thicknesses in the IGES-file. If no thickness is defined in the Catia model, ADRIAN sets the sheet thickness to the default value of 1.0 mm. If the box is unchecked, ADRIAN identifies the sheets in the IGES-file and creates a pop-up. In this pop-up the user may state the thicknesses.

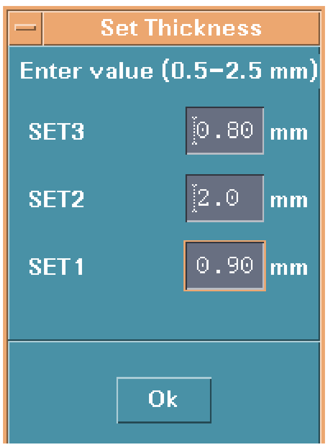

Figure 7.12 Sheet thickness pop-up

- **Use Catia weld diameter:** Same as for the sheet thickness options but instead gives the possibility of changing actual weld spot diameters in the model.
- **Advanced option/user interactivity in ANSA:** This option is made in order to expand ADRIAN from only being a "black box" where indata goes in and results pop out. By unchecking the box, the program stops in ANSA for each sheet. The user can manipulate the geometry and then export the sheet in the Nastran format. This option is intended for people experienced with analysis and familiar with the software ANSA.

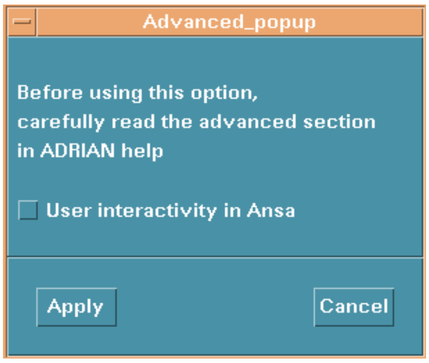

Figure 7.13: Advanced option

Storing information for post-processor

The pre-processor stores information for the ADRIAN stiffness post-processor in a post-file. This file contains joint geometry used for creating appropriate graphs.

Result from pre-processing

The FEM-model resulting from pre-processing of the Catia-model found in figure 7.4 is illustrated in figure 7.14.

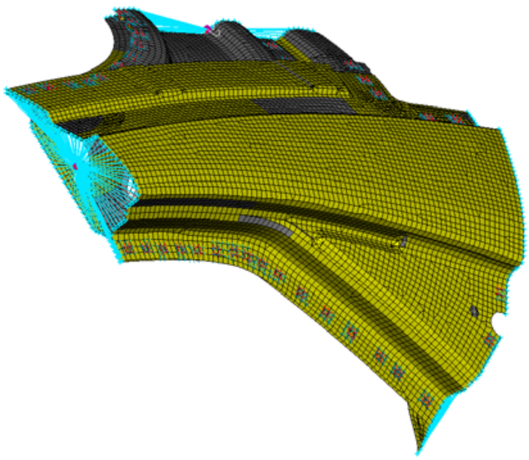

Figure 7.14: Resulting ADRIAN FEM-model

7.5 MSC/Nastran

MSC/Nastran jobs are submitted either automatically when running the complete process or by selecting the Nastran import-nas-menu. In order to perform a Nastran calculation from the ADRIAN menu, the model should have been pre-processed by the ADRIAN pre-processing routine.

As a job is submitted to the Nastran server, date and time is added to the post-file. This information is later given in the post-process sequence.

Nastran options

There are a few possibilities of controlling the tolerances of the solver:

- **Max Ratio:** The value of the Max Ratio indicates when Nastran shall consider the stiffness matrix to be singular. Default in ADRIAN is the same as the default for the solver (10^7). As the diagonal ratio of the matrix increases this value calculation is interrupted.
- **Bail out:** If this box is checked, Nastran continues processing even if the stiffness matrix is found singular. This option can be useful when trying to identify the underlying problem to a high Max Ratio. For example, an unconnected part can be identified in the post-process animations.
- **Queue:** The default queue for the job in ADRIAN is csm_quick. This queue has a maximum of 10 minutes CPU time processing on the server. This should be enough for most joint configurations. The other queue available is the csm_small with a limit of 6 hours CPU time.

7.6 Post-processing

Visualisation of joint stiffness values

As Nastran has finished the job, an HTML-page will be constructed. This page contains information about the job and the most important graphs, such as a reference view of the joint and graphs representing the joint leg end-sections. The graphs of the end-sections contain information on the direction of the principal axes of stiffness and the absolute stiffness values in these directions. Information on the rotational stiffness of the joint leg can also be found here. The principles of the ADRIAN stiffness postprocessor are given in figure 7.15.

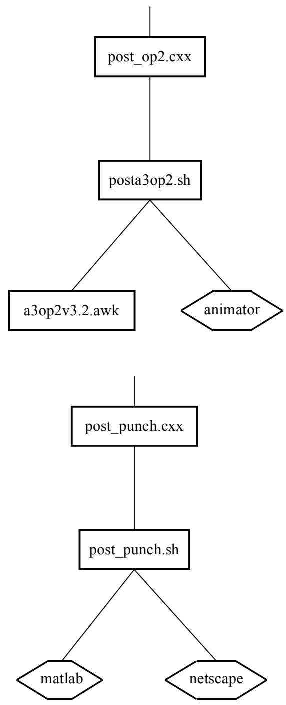

Figure 7.15: ADRIAN post-processing routines

The C++ post_punch-routine

The postpch-routine reads the ADRIAN post-file containing information on the model geometry and splits it into so called view.vw files. There are different view files for the masternode coordinates, the node coordinates for each sheet, the planes describing the joint ends, the nodes lying in each plane. This information is indata to the Matlab procedure. All data is ready for plotting. This is due to the fact that extracting data using loop algorithms is rather slow in Matlab.

The Unix script post_punch.sh

The C++ routine invokes an UNIX-script, creating an HTML-document and a MATLAB m-file. By running MATLAB in background-mode the result-files are evaluated and transformed into graphs. The MATLAB program extracts the stiffness matrix delivered by Nastran in the pch-format. In order to set a reference view for the graphs, three masternodes (there may be three or four) are chosen. These master nodes define a plane. The upward direction is set to the normal vector n_{up} to this plane. An orthogonal coordinate system is defined with the n_{up} vector along the z-axis. All nodes are transformed into this coordinate system creating a reference view of the joint. As the reference view is created the following algorithm is repeated for each leg of the joint:

- Make sure that the normal of the plane (n_{end}) describing the end is pointing out from the geometry.
- Define the z-axis in a local orthogonal coordinate system by $z = n_{end}$.
- Define the x-axis in the local orthogonal coordinate system by evaluating $x = n_{up} \times n_{end}$.
- Define the y-axis in the coordinate system by $y = z \times x$.
- Transform all nodes lying in the plane describing the end to the local coordinate system and plot.
- Extract the translational and rotational stiffness tensor for the corresponding masternode from the total stiffness matrix. The tensor is of the form $T_{end} = \begin{pmatrix} \sigma^T_{xx} & \sigma^T_{xy} & \sigma^T_{xz} \\ \sigma^T_{yx} & \sigma^T_{yy} & \sigma^T_{yz} \\ \sigma^T_{zx} & \sigma^T_{zy} & \sigma^T_{zz} \end{pmatrix}$.
- Define a normalised vector v in the plane and evaluate $\sigma^T = |v_s \cdot T_{end}|$ for all $v_s = v \cdot (\cos\theta + \sin\theta), 0 \le \theta \le 2 \cdot \pi$. Locate $\sigma^T_{\max}$, $\sigma^T_{\min}$ and the corresponding direction v_s of the stiffness value. These two directions are the so-called principal axes.
- Plot the principal axes.
- Evaluate the rotational stiffness around the z-axis by taking $\sigma^R = |z \cdot R_{end}|$.

The graphs and the resulting stiffness values are embedded in an HTML-document. This document can then be viewed in Netscape. By representing the stiffness values in the directions of the principal axes, the results can more easily be compared with, for example, optimisation results. Examples of HTML result-pages can be found in Appendix D.

Frequency mode animations

The second possibility of post-processing in ADRIAN is modal analysis. The post-processor is automatically launched when running a complete ADRIAN job but can also be invoked manually. The structure of the post-processor can be found in figure 7.15.

Animator

Animator is the most frequently used software for post-processing available at Volvo. ADRIAN uses Animator through the scripting language used by Animator. Many functions are predefined in Animator. In order to simplify the viewing of modes, ADRIAN defines the F1-F12 buttons for this purpose. The principle of definition of buttons is shown below:

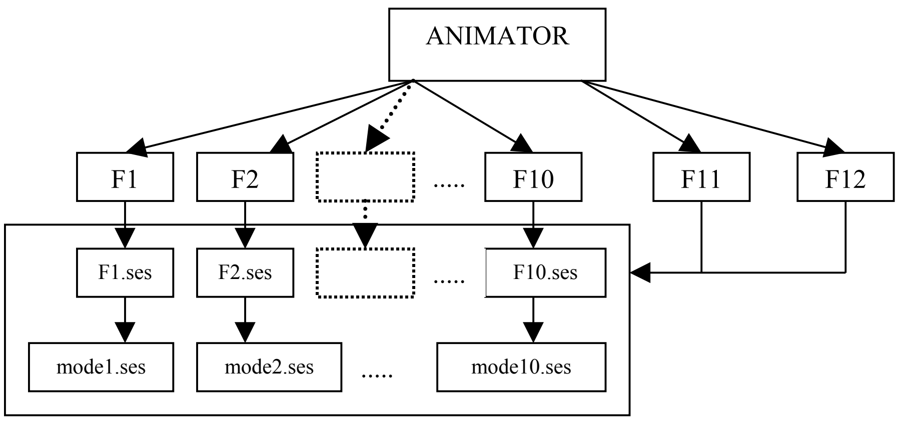

Figure 7.16: Principle of definition of buttons in Animator

Before Animator is started, ADRIAN starts a UNIX-script named posta3.sh. This script creates an animation directory in the temporary working-directory. By invoking each animation from a unique directory, there is no limit in the number of animations that can be run at a time. This script creates files f1.ses,f2.ses….f12.ses and mode1.ses, mode2.ses….mode10.ses in the created directory. The f.ses files refer to the corresponding mode.ses file. The mode.ses file contain information on which mode to be animated and the frequency of that mode. The frequency is taken from the f06-file generated by Nastran.

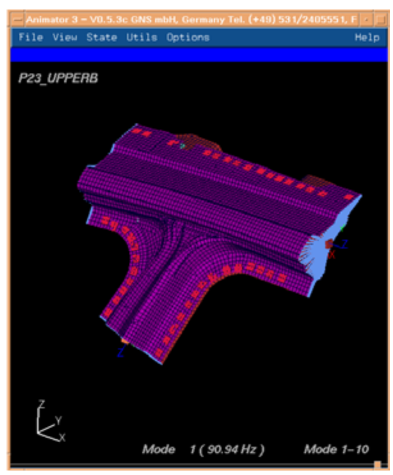

Figure 7.17: Post-processing in Animator

As Animator is started, the op2-file containing the animations is read in. Animator is started from the animation directory described above. Pressing F1 in Animator invokes the script f1.ses (Animator looks for this file in the directory the program was executed from), which in turn invokes the script mode1.ses. The script mode1.ses starts the animation of mode 1 and prints the frequency of the mode to screen. The F12 button deletes the session files created and creates new sessions for the next ten modes. It also prints out what ten modes which are the currently available by pressing F1-F10. The F11 button is opposite to the F12 button, it toggles to the previous ten modes.

In Animator, the user can rotate and zoom the joint for a view in a different perspective. There is also a possibility of viewing nodal displacements in different colors.

No licence

If there is no Animator license when invoking the frequency animation post-processor, ADRIAN gives a warning message and stops the post-processing sequence.

Post-processing options

There are two options for the ADRIAN post-process routines, both treating running ADRIAN in Complete process mode.

- **Do stiffness post-processing:** If this box is checked, ADRIAN launches the stiffness post-processor automatically when running in Complete mode.
- **Do frequency post-processing:** If this box is checked, ADRIAN launches the frequency animation post-processor automatically when running in Complete mode.

8 Program verification

8.1 Analysis of a symmetric joint

Joint design

In order to check the consistency of the calculation results, analysis of a symmetric joint was carried out. A flanged sheet with a rectangular cross-section was drawn in CAD-software CATIA. The sheet was made bent, making an angle of 120°. This sheet was copied and rotated in space. By joining three parts of the design described above, a symmetric joint was constructed. On each flange eight weld spots was drawn, making a total of three weld sets and three sheet sets. The sheets were given a thickness of 1.0 mm and the weld diameter was set to 4.5 mm. The total geometry is illustrated in figure 8.1.

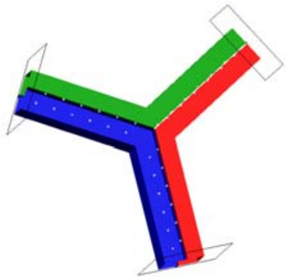

Figure 8.1: Symmetric joint

Results

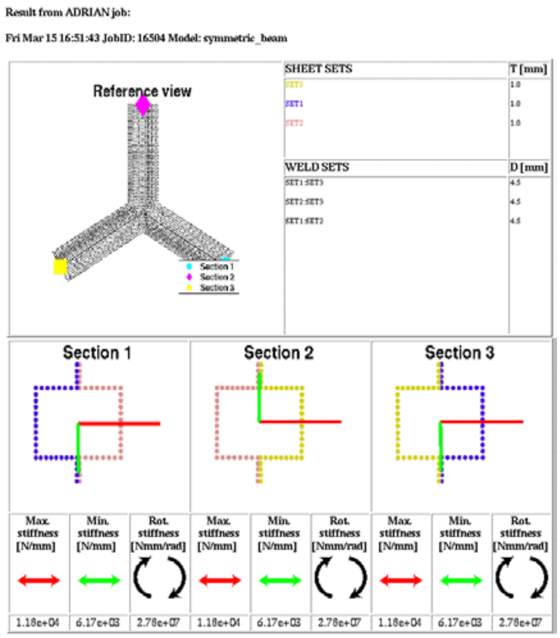

Figure 8.2: Results from ADRIAN analysis of a symmetric joint

Conclusions

The geometrical symmetry is reflected in symmetrical stiffness values. The principal axes for the three ends are identical, both by means of direction and absolute value. The rotational stiffness is same for all joint legs. This reduces the risk of a fatal error in the stiffness post-process algorithm.

8.2 Results from joint stiffness calculations of Volvo S80-model

Five joints from the Volvo S80-model were modelled in Catia with regards to ADRIAN standards. This in order to detect program problems and to compare the results with a consultant case carried out by Semcon in 2001-06-26. The global positions of the analysed joints are shown in figure 8.3.

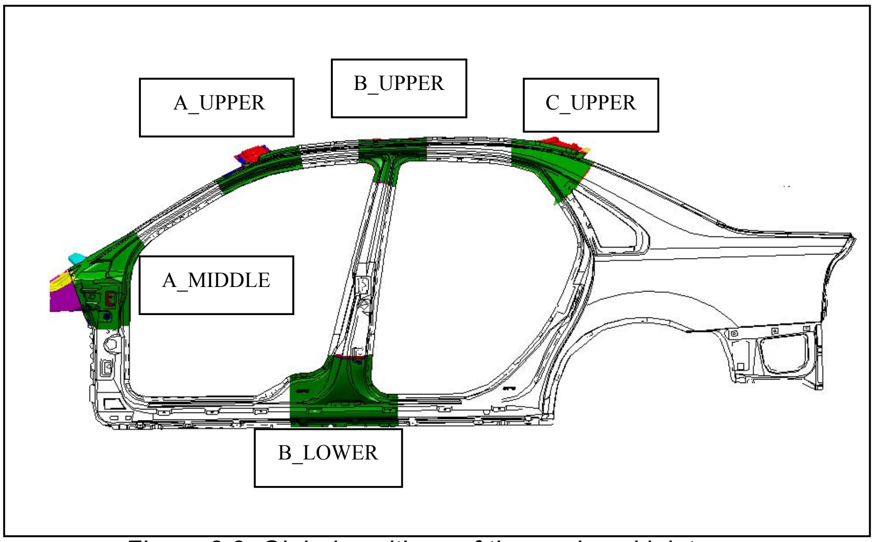

Figure 8.3: Global positions of the analysed joints

Modelling method

The models were not made exact, i.e. they were constructed in order to verify the performance of ADRIAN. Sheet thicknesses were chosen according to drawing data. Weld spots were attached freely, no weld model was used. Sections were not cut according to the sphere-method described in section 3.1.

Results

The entire results, i.e. HTML-pages and animation pictures, can be found in Appendix D. These results are presented without absolute values. Results with absolute values included can be found in Appendix A.

Conclusions

The program showed good capability of transforming CAD-models to FEM-models. Some faces were not connected in the models. The possible resulting problems are discussed below. The overall performance was very satisfying. For the most complex model, the time from submitting a job to a complete result was less than ten minutes. All of the FEM-models produced by ADRIAN passed through the standard limits for singularities set by MSC/Nastran.

The calculations of principal stiffness axes for the joint legs resulted in logical directions with the stiffest direction along the flange. Noteworthy is also that the joints positioned in the lower sections of the car body were stiffer than the upper joints.

Possible instabilities

When running ADRIAN, it is important that all the faces forming the entire sheet are sucessfully read when imported into ANSA. Sometimes ANSA fail to represent a face, remaining a hole in the mesh where the face should have been. Comparing results from a joint with a small hole and the joint in its correct representation, small holes do not seem to affect the global properties of the joint.
Instabilities can also be identified in the connections between the faces read in. ANSA has a tolerance level in order to define what faces are joined together. In one of the analysed joints, P23_B_LOWER, ANSA failed to connect two rather large faces. This resulted in a rip in the plate, visible when studying the modal animations. To fix the problem, cutting the face of interest in Catia may be one way. This may reduce the area containing the problem. Another approach is to use the advanced option in ADRIAN, correcting errors manually in ANSA. It may be valuable to seek the underlying problem causing the errors in ANSA, and, if possible, constructing a geometric CAD-representation even more suitable for FEM-analysis.
However, it is important to emphasise that only one face of the thousands of faces in the models had a problem affecting the total result, and that this problem was easily corrected by cutting the face in Catia.

8.3 Comparisons with Semcon results

Due to differences in modelling method, comparing absolute values of frequency modes is not of great interest. For example, models differ in section cut position, mesh size, weld spot position and joint leg end mass modelation. A rough comparison can be carried out by comparing mode shapes [18].

Conclusion

The shape of the first three modes for each of the five models were equal to the mode shapes calculated by Semcon [18].

9 Future Work

Target values

In order to make analysing joints worthwhile, target values describing acceptable frequency and stiffness values for each joint in the car body is necessary. If ADRIAN is connected to the optimisation studies carried out on Volvo, appropriate target values can be achieved. As these values are set, it would be a good thing presenting the values in the HTML-result page, making comparison easy.

Modelling rules

Rules for construction of joint models in Catia must be set. If this is not done, comparison between models constructed by different design engineers will make no sense.

Data formats

It would be desirable if ADRIAN could import the Catia-model without an explicit transformation to IGES. This could be achieved in two ways. Either a more integrated IGES converter in future releases of Catia, or by adding the IGES-conversion script used by Volvo in the ADRIAN pre-processing sequence.

If the STEP-format become more frequently used in the development process at Volvo, it would be a good idea to implement ADRIAN STEP-compability.

Software performance

It is of great importance that some sort of quality check of the calculations made by ADRIAN is carried out in the future. This would increase the credibility in the method used by ADRIAN. This could be done by letting an experienced analysis engineer perform calculations on the joints presented in this report manually and by performing experimental tests using the method described in section 4.1. The results from this analysis can be compared with the results in Appendix A.

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10 Appendix

A – Flowcharts and source code

B – Example of IGES-file

C – Example of MSC/Nastran ecd-file and nas-file

D – HTML result documents and pictures of freqency animations
for five joints in Volvo S80-series

E – ADRIAN Help section

F – Structural diagrams

Appendix A – Flowcharts and source code

ADRIAN flowcharts and source-code.

[Due to confidential restrictions from Volvo Car Corporation, the ADRIAN source-code and post-processing scripts are presented in a separate publication, Development of ADRIAN, Joint Analysis Software, APPENDIX A – Flowcharts and source code. This publication is only available at Volvo Car Corporation]

Appendix B - Example of IGES-file

An IGES-file consisting of a single surface with a corresponding face:

```
MODEL NAME:                                                             S      1
ONEFACE                                                                 S      2
========================================================================S      3
1H,,1H;,20HCATIA - IGES PRODUCT,11HONEFACE.IGS,57HIBM CATIA IGES - CATIAG      1
 SOLUTIONS V4RELEASE 2.2 REFRESH 01,40HCATIA SOLUTIONS V4RELEASE 2.2 REFG      2
RESH 01,32,75,6,75,15,7HONEFACE,1.0,2,2HMM,1000,1.3999999999999999,13H02G      3
0326.142321,0.001,1.0E+04,7HPCP1088,10HVOLVO CARS,8,1,13H020326.142314; G      4
     406       1       0       0       0       0       0        000020301D      1
     406       0       0       1       1                PROP0001       0D      2
     406       2       0       0       0       0       0        000020301D      3
     406       0       0       1      15                PROP0015       0D      4
     406       3       0       0       0       0       0        000020301D      5
     406       0       0       5       1                PROP0001       0D      6
     406       8       0       0       0       0       0        000020301D      7
     406       0       0       1      15                PROP0015       0D      8
     406       9       0       0       0       0       0        000020301D      9
     406       0       0       4       1                PROP0001       0D     10
     406      13       0       0       0       0       0        000020301D     11
     406       0       0       1      15                PROP0015       0D     12
     406      14       0       0       0       0       0        000020301D     13
     406       0       0       4       1                PROP0001       0D     14
     406      18       0       0       0       0       0        000020301D     15
     406       0       0       1      15                PROP0015       0D     16
     406      19       0       0       0       0       0        000020301D     17
     406       0       0       2       1                PROP0001       0D     18
     406      21       0       0       0       0       0        000020301D     19
     406       0       0       1      15                PROP0015       0D     20
     406      22       0       0       0       0       0        000020301D     21
     406       0       0       2       1                PROP0001       0D     22
     406      24       0       0       0       0       0        000020301D     23
     406       0       0       1      15                PROP0015       0D     24
     406      25       0       0       0       0       0        000020301D     25
     406       0       0       3       1                PROP0001       0D     26
     406      28       0       0       0       0       0        000020301D     27
     406       0       0       1      15                PROP0015       0D     28
     406      29       0       0       0       0       0        000020301D     29
     406       0       0       3       1                PROP0001       0D     30
     406      32       0       0       0       0       0        000020301D     31
     406       0       0       1      15                PROP0015       0D     32
     406      33       0       0       0       0       0        000020301D     33
     406       0       0       2       1                PROP0001       0D     34
     406      35       0       0       0       0       0        000020301D     35
     406       0       0       1      15                PROP0015       0D     36
     406      36       0       0       0       0       0        000020301D     37
     406       0       0       3       1                PROP0001       0D     38
     406      39       0       0       0       0       0        000020301D     39
     406       0       0       1      15                PROP0015       0D     40
     406      40       0       0       0       0       0        000020301D     41
     406       0       0       2       1                PROP0001       0D     42
     406      42       0       0       0       0       0        000020301D     43
     406       0       0       1      15                PROP0015       0D     44
     406      43       0       0       0       0       0        000020301D     45
     406       0       0       2       1                PROP0001       0D     46
     406      45       0       0       0       0       0        000020301D     47
     406       0       0       1      15                PROP0015       0D     48
     406      46       0       0       0       0       0        000020301D     49
     406       0       0       5       1                PROP0001       0D     50
     406      51       0       0       0       0       0        000020301D     51
     406       0       0       1      15                PROP0015       0D     52
     406      52       0       0       0       0       0        000020301D     53
     406       0       0       6       1                PROP0001       0D     54
     406      58       0       0       0       0       0        000020301D     55
     406       0       0       1      15                PROP0015       0D     56
     406      59       0       0       0       0       0        000020301D     57
     406       0       0       4       1                PROP0001       0D     58
     406      63       0       0       0       0       0        000020301D     59
     406       0       0       1      15                PROP0015       0D     60
     406      64       0       0       0       0       0        000020301D     61
     406       0       0       4       1                PROP0001       0D     62
     406      68       0       0       0       0       0        000020301D     63
```

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     406       0       0       1      15               PROP0015       0D     64
     406      69       0       0       0       0       0        000020301D     65
     406       0       0       4       1               PROP0001       0D     66
     406      73       0       0       0       0       0        000020301D     67
     406       0       0       1      15               PROP0015       0D     68
     406      74       0       0       0       0       0        000020301D     69
     406       0       0       2       1               PROP0001       0D     70
     406      76       0       0       0       0       0        000020301D     71
     406       0       0       1      15               PROP0015       0D     72
     406      77       0       0       0       0       0        000020301D     73
     406       0       0      12       1               PROP0001       0D     74
     406      89       0       0       0       0       0        000020301D     75
     406       0       0       1      15               PROP0015       0D     76
     124      90       0       1       0       0       0        000000001D     77
     124     250       8       1       0                   AXS1      38D     78
     124      91       0       0       0       0       0        000010201D     79
     124       0       0       1       0               TRANSFOR       0D     80
     402      92       0       0       0       0       0        000000301D     81
     402       0       0       1      16               PLANAR A       0D     82
     406      93       0       0       0       0       0        000020301D     83
     406       0       0       1    6004               PROP6004       0D     84
     124      94       0       0       0       0       0        000010201D     85
     124       0       0       1       0               TRANSFOR       0D     86
     406      95       0       0       0       0       0        000020301D     87
     406       0       0       1    6004               PROP6004       0D     88
     410      96       0       0       0       0      85        000020101D     89
     410       0       0       1       0                    VU1       3D     90
     404      97       0       0       0       0       0        000000101D     91
     404       0       0       1       0                  DRAFT       4D     92
     406      98       0       0       0       0       0        000020301D     93
     406       0       0       1      16               PROP0016       5D     94
     314      99       0       0       0       0       0        000000201D     95
     314       0       0       1       0                COLOR12       0D     96
     314     100       0       0       0       0       0        000000201D     97
     314       0       0       1       0                COLOR14       0D     98
     314     101       0       0       0       0       0        000000201D     99
     314       0       0       1       0                COLOR15       0D    100
     128     102       0       2      61       0       0        000030001D    101
     128     250     -95      15       8                  SUR29       9D    102
     406     117       0       0       0       0       0        000020301D    103
     406       0       0       1    6007               PROP6007       0D    104
     126     118       0       1     124       0       0        000010501D    105
     126     250     -99      11       0                  FAC50      11D    106
     126     129       0       1     124       0       0        000010501D    107
     126     250     -99       7       0                  FAC50      12D    108
     126     136       0       1     124       0       0        000010501D    109
     126     250     -99       7       0                  FAC50      13D    110
     126     143       0       1     124       0       0        000010501D    111
     126     250     -99       7       0                  FAC50      14D    112
     102     150       0       1     124       0       0        000010501D    113
     102     250     -99       1       0                  FAC50      15D    114
     126     151       0       1     124       0       0        000010001D    115
     126     250     -99      14       0                 CRV133      16D    116
     126     165       0       1     124       0       0        000010001D    117
     126     250     -99      10       0                 CRV132      17D    118
     126     175       0       1     124       0       0        000010001D    119
     126     250     -99      10       0                 CRV134      18D    120
     126     185       0       1     124       0       0        000010001D    121
     126     250     -99       9       0                 CRV136      19D    122
     102     194       0       1     124       0       0        000010000D    123
     102     250     -99       1       0                  FAC50      16D    124
     142     195       0       1     124       0       0        000010001D    125
     142     250     -99       1       0                  FAC50      16D    126
     144     196       0       4     124       0       0        000020001D    127
     144     250     -99       1       0                  FAC50       9D    128
     406     197       0       0       0       0       0        000020301D    129
     406       0       0       1    6007               PROP6007       0D    130
     124     198       0       1       0      89      79        000020101D    131
     124     250       8       1       0                   DRAW      11D    132
     402     199       0       0       0       0       0        000000301D    133
     402       0       0       1       7                   SET1       0D    134
406,1,80,0,1,3;                                                       1P      1
406,1,6HPROPOS,0,0;                                                   3P      2
406,70,101,102,103,104,105,106,107,108,109,110,111,112,113,114,       5P      3
115,116,117,118,119,120,121,122,123,124,125,126,127,128,129,130,      5P      4
131,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,      5P      5
147,148,149,150,151,152,153,154,155,156,157,158,159,170,171,172,      5P      6
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173,174,175,176,177,178,179,200,0,1,7;                                  5P      7
406,1,6HCHANGE,0,0;                                                      7P      8
406,65,0,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,40,41,42,        9P      9
43,44,50,51,52,53,54,102,103,104,105,106,107,108,109,110,111,           9P     10
112,113,114,115,116,117,118,119,140,141,142,143,144,150,151,152,        9P     11
153,154,240,241,244,245,246,250,252,253,0,1,11;                         9P     12
406,1,6HWIRALL,0,0;                                                     11P     13
406,67,0,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,        13P     14
38,39,45,46,47,48,49,55,56,57,58,59,120,121,122,123,124,125,126,       13P     15
127,128,129,130,131,132,133,134,135,136,137,138,139,145,146,147,       13P     16
148,149,155,156,157,158,159,240,244,246,250,252,253,0,1,15;            13P     17
406,1,6HSURALL,0,0;                                                     15P     18
406,28,0,40,41,42,43,44,45,46,47,48,49,140,141,142,143,144,145,        17P     19
146,147,148,149,240,241,244,246,250,252,253,0,1,19;                    17P     20
406,1,6HUNIQLH,0,0;                                                     19P     21
406,28,0,50,51,52,53,54,55,56,57,58,59,150,151,152,153,154,155,        21P     22
156,157,158,159,240,241,244,246,250,252,253,0,1,23;                    21P     23
406,1,6HUNIQRH,0,0;                                                     23P     24
406,36,0,20,21,22,23,24,25,26,27,28,29,46,47,56,57,120,121,122,        25P     25
123,124,125,126,127,128,129,146,147,156,157,240,241,244,246,250,       25P     26
252,253,0,1,27;                                                         25P     27
406,1,5HSUR A,0,0;                                                      27P     28
406,36,0,30,31,32,33,34,35,36,37,38,39,48,49,58,59,130,131,132,        29P     29
133,134,135,136,137,138,139,148,149,158,159,240,241,244,246,250,       29P     30
252,253,0,1,31;                                                         29P     31
406,1,5HSUR B,0,0;                                                      31P     32
406,32,0,2,3,4,5,6,7,8,9,41,42,51,52,102,103,104,105,106,107,          33P     33
108,109,141,142,151,152,240,241,244,246,250,252,253,0,1,35;            33P     34
406,1,5HWIR A,0,0;                                                      35P     35
406,36,0,10,11,12,13,14,15,16,17,18,19,43,44,53,54,110,111,112,        37P     36
113,114,115,116,117,118,119,143,144,153,154,240,241,244,246,250,       37P     37
252,253,0,1,39;                                                         37P     38
406,1,5HWIR B,0,0;                                                      39P     39
406,25,0,5,15,25,35,42,44,47,49,52,54,57,59,105,115,125,135,142,       41P     40
144,147,149,152,154,157,159,0,1,43;                                     41P     41
406,1,6HREQALL,0,0;                                                     43P     42
406,20,60,61,62,63,64,65,66,67,68,69,160,161,162,163,164,165,          45P     43
166,167,168,169,0,1,47;                                                 45P     44
406,1,6HAUXGEO,0,0;                                                     47P     45
406,86,0,1,2,3,4,5,6,7,8,9,18,19,20,21,22,23,24,25,26,27,28,29,        49P     46
41,42,46,47,51,52,56,57,70,71,72,73,74,75,76,77,78,79,100,101,         49P     47
102,103,104,105,106,107,108,109,120,121,122,123,124,125,126,127,       49P     48
128,129,141,142,146,147,151,152,156,157,170,171,172,173,174,175,       49P     49
176,177,178,179,200,240,241,244,246,250,252,253,0,1,51;                49P     50
406,1,5HMOD A,0,0;                                                      51P     51
406,88,0,1,10,11,12,13,14,15,16,17,18,19,30,31,32,33,34,35,36,         53P     52
37,38,39,43,44,48,49,53,54,58,59,70,71,72,73,74,75,76,77,78,79,        53P     53
100,101,110,111,112,113,114,115,116,117,118,119,130,131,132,133,       53P     54
134,135,136,137,138,139,143,144,148,149,153,154,158,159,170,171,       53P     55
172,173,174,175,176,177,178,179,200,240,241,244,246,250,252,253,       53P     56
0,1,55;                                                                 53P     57
406,1,5HMOD B,0,0;                                                      55P     58
406,64,0,2,4,5,6,7,8,9,10,11,12,14,15,16,17,18,19,41,42,43,44,         57P     59
51,52,53,54,60,63,66,102,104,105,106,107,108,109,110,111,112,          57P     60
113,114,115,116,117,118,119,141,142,143,144,151,152,153,154,160,       57P     61
163,166,240,241,244,245,246,250,252,253,0,1,59;                        57P     62
406,1,7HWIRDRAW,0,0;                                                    59P     63
406,66,0,2,4,5,6,7,8,9,10,11,12,14,15,16,17,18,19,41,42,43,44,         61P     64
51,52,53,54,60,63,66,100,102,104,105,106,107,108,109,110,111,          61P     65
112,113,114,115,116,117,118,119,141,142,143,144,151,152,153,154,       61P     66
160,163,166,200,240,241,244,245,246,250,252,253,0,1,63;                61P     67
406,1,15HWIRDRAW+REF.PT.,0,0;                                           63P     68
406,67,0,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,40,41,42,       65P     69
43,44,50,51,52,53,54,100,102,103,104,105,106,107,108,109,110,          65P     70
111,112,113,114,115,116,117,118,119,140,141,142,143,144,150,151,       65P     71
152,153,154,200,240,241,244,245,246,250,252,253,0,1,67;                65P     72
406,1,14HWIRALL+REF.PT.,0,0;                                            67P     73
406,17,0,201,240,241,242,243,244,245,246,247,248,249,250,251,          69P     74
252,253,254,0,1,71;                                                     69P     75
406,1,9HSEC.START,0,0;                                                  71P     76
406,199,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,       73P     77
22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,        73P     78
43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,63,66,70,        73P     79
71,72,73,74,75,76,77,78,79,81,82,90,91,92,93,100,101,102,103,          73P     80
104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,       73P     81
120,121,122,123,124,125,126,127,128,129,130,131,132,133,134,135,       73P     82
136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,       73P     83
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152,153,154,155,156,157,158,159,160,163,166,170,171,172,173,174,      73P     84
175,176,177,178,179,200,201,202,203,204,205,206,207,208,209,210,      73P     85
211,212,213,214,215,216,217,218,219,220,221,222,223,224,225,226,      73P     86
227,228,229,230,231,232,233,234,235,236,237,238,239,240,241,244,      73P     87
246,250,252,253,0,1,75;                                               73P     88
406,1,6HPARAMS,0,0;                                                   75P     89
124,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0,0;              77P     90
124,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0,0;              79P     91
402,1,1,79,131,0,0;                                                   81P     92
406,1,1,0,0;                                                          83P     93
124,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0,0;              85P     94
406,1,0,0,0;                                                          87P     95
410,1,1.0,0,0,0,0,0,0,1,81,2,83,87;                                   89P     96
404,1,89,1.0E+05,1.0E+05,0,0,1,93;                                    91P     97
406,2,2.0E+05,2.0E+05,0,0;                                            93P     98
314,100.0,53.333336114883423,53.333336114883423,7HCOLOR12,0,0;        95P     99
314,86.666667461395264,0.0,66.666668653488159,7HCOLOR14,0,0;          97P    100
314,93.333333730697632,0.0,0.0,7HCOLOR15,0,0;                         99P    101
128,1,5,1,5,0,0,1,0,0,0.0,0.0,1.0,1.0,0.0,0.0,0.0,0.0,0.0,0.0,       101P    102
1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,     101P    103
1.0,1.0,2620.660337813827,-741.77987839884747,                       101P    104
1753.7369910376553,2639.4709781390311,-746.64767231685596,           101P    105
1741.5281575369104,2612.7571927632835,-743.5594820318297,            101P    106
1745.1203595594527,2632.0672165209398,-748.12478890822501,           101P    107
1733.6549005850775,2605.2768208125667,-745.28121211978828,           101P    108
1736.1037283247665,2625.0332407982714,-749.541451032819 4,           101P    109
1725.4225371883663,2598.2840782645162,-746.92877537617017,           101P    110
1726.6767404740067,2618.4289414884206,-750.88429546278371,           101P    111
1716.8177357803215,2591.8527293460966,-748.4827516953136,            101P    112
1716.8427603936484,2612.3250225112788,-752.13754810878834,           101P    113
1707.837702667734,2586.0622796869411,-749.92070228417379,            101P    114
1706.6316269498975,2606.8028308588177,-753.28310858515192,           101P    115
1698.5011333688924,0.0,1.0,0.0,1.0,0,1,103;                          101P    116
406,2,1,1,0,0;                                                       103P    117
126,10,5,1,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,        105P    118
2.0,2.0,2.0,2.0,2.0,2.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,     105P    119
1.0,0.23245663692928367,0.65549340598675776,0.0,                     105P    120
0.24494091570472551,0.5794784437124092,0.0,0.25628879766477253,      105P    121
0.50343448244869449,0.0,0.26644767965591071,0.42736374550523398,     105P    122
0.0,0.27539924956721623,0.35127002095234117,0.0,                     105P    123
0.28316405422363189,0.27515750689539054,0.0,0.28415039867277292,     105P    124
0.26548841998961314,0.0,0.28511767309704522,0.25581904492108354,     105P    125
0.0,0.28606587749644885,0.24614938168980172,0.0,                     105P    126
0.28699501187098375,0.23647943029576768,0.0,0.28790507622064992,     105P    127
0.22680919073898143,0.0,0.0,2.0,0.0,0.0,1.0,0,0;                     105P    128
126,5,5,1,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,1.0,     107P    129
1.0,1.0,1.0,1.0,1.0,1.0,-1.1102230246251565E-16,                     107P    130
0.17906783724057648,0.0,0.20208529840797829,0.21184062860381359,     107P    131
0.0,0.40324203327511476,0.2457303169210439 1,0.0,                    107P    132
0.60334072730673416,0.28078840664032911,0.0,0.80230968779290301,     107P    133
0.31708079404494116,0.0,1.0000000000000007,0.35466240391881665,      107P    134
0.0,0.28571233372997135,0.98240689650936364,0.0,0.0,1.0,0,0;         107P    135
126,5,5,1,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,1.0,     109P    136
1.0,1.0,1.0,1.0,1.0,1.0,0.98192028465554726,0.22237481410268387,     109P    137
0.0,0.98269327479807422,0.37789942943733612,0.0,                     109P    138
0.98366419421193763,0.53342386576180689,0.0,0.98454857636867932,     109P    139
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0.0,0.98636055026224656,0.99999734287303721,0.0,                     109P    141
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0.0,0.83707180288432625,0.78549124371198509,0.0,                     111P    145
0.68755906050604521,0.75183487849241715,0.0,0.5369075393959869,      111P    146
0.7189650513986523,0.0,0.38518183026886199,0.68686180561249666,      111P    147
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1.0,0,0;                                                             111P    149
102,4,105,107,109,111,0,0;                                           113P    150
126,10,5,0,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,        115P    151
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1.0,2601.4625231380633,-748.21563064534712,1721.5291120921393,       115P    153
2604.1894023485283,-747.69105077977986,1724.9995472943076,           115P    154
2606.9735948648508,-747.15116284945691,1728.4222333073292,           115P    155
2609.8109586822575,-746.59604688395154,1731.7989722811562,           115P    156
2612.6976801659707,-746.02588703240133,1735.1309352249853,           115P    157
2615.6305472708168,-745.44110273641093,1738.4188074122919,           115P    158
2616.0017084220904,-745.36709588718361,1738.8348889628171,           115P    159
2616.3736017456131,-745.29285793464953,1739.2502757312011,           115P    160
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2616.7462391191771,-745.21838417275285,1739.6649542837099,          115P    161
2617.1196101996197,-745.14367544209688,1740.078928710612,           115P    162
2617.4936955653984,-745.06873699751236,1740.4922152774345,0.0,      115P    163
2.0,0.0,0.0,0.0,0,0;                                                115P    164
126,5,5,1,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,1.0,    117P    165
1.0,1.0,1.0,1.0,1.0,1.0,2613.7236749491458,-743.35371835426668,     117P    166
1745.8934003500985,2616.3408065564863,-744.55413329069256,          117P    167
1742.143863388405,2618.960298601432,-745.73895663563883,            117P    168
1738.3909515536966,2621.5822868514351,-746.90681048015676,          117P    169
1734.6344594063166,2624.2069428993518,-748.05609461794268,          117P    170
1730.874140020285,2626.8345078809853,-749.18486625125206,           117P    171
1727.1096605078169,0.2879484711334489,0.98261164072408724,          117P    172
-0.82000696081867042,-5.8451089264416334E-06,                       117P    173
-0.57235354823287532,0,0;                                           117P    174
126,5,5,0,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,1.0,    119P    175
1.0,1.0,1.0,1.0,1.0,1.0,2631.0788601203235,-748.17673542490513,     119P    176
1732.8006056022314,2625.6015116315516,-749.28788849145542,          119P    177
1726.4089751149004,2620.3758703547282,-750.35771471811756,          119P    178
1719.7922558463156,2615.429929355194,-751.37749019737487,           119P    179
1712.9526133416707,2610.801757236386,-752.3405417025167,            119P    180
1705.8894656800142,2606.5200145680296,-753.23723194092361,          119P    181
1698.6121530281373,0.16589786618932054,0.76849627089981454,         119P    182
-0.82000696081867042,-5.8451089264416334E-06,                       119P    183
-0.57235354823287532,0,0;                                           119P    184
126,5,5,1,0,1,0,0.0,0.0,0.0,0.0,0.0,0.0,1.0,1.0,1.0,1.0,1.0,1.0,    121P    185
1.0,1.0,1.0,1.0,1.0,1.0,2611.6583758345132,-752.16484110141641,     121P    186
1706.9202960744065,2609.6152747931365,-751.40561626746,             121P    187
1709.847421042806,2607.5741834720625,-750.63000354408484,           121P    188
1712.7716743387873,2605.5349911961612,-749.83916048256788,          121P    189
1715.6931958309951,2603.4976303146464,-749.03409956152166,          121P    190
1718.61210377916,2601.4620295148675,-748.2157254693733,             121P    191
1721.5284844870639,0.0,1.0,-0.82000539781986614,                    121P    192
5.6468497980355359E-06,-0.57235578752590266,0,0;                    121P    193
102,4,115,117,119,121,0,0;                                          123P    194
142,0,101,113,123,0,0,0;                                            125P    195
144,101,1,0,125,0,1,129;                                            127P    196
406,2,2,2,0,0;                                                      129P    197
124,1.0,0.0,0.0,0.0,0.0,1.0,0.0,0.0,0.0,0.0,1.0,0.0,1,81,0;         131P    198
402,1,127,0,0;                                                      133P    199
S      3G      4D    134P    199                                       T      1
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Nas-file

Structure of a Nastran nas-file generated by ADRIAN

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GRID    2               3301.214-576.4052114.595                100
GRID    3               3297.169-576.7402114.145                100
GRID    4               3293.124-577.0802113.687                100
GRID    5               3289.081-577.4242113.223                100
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CQUAD4  2       1       27      28      23      24
CQUAD4  3       1       22      23      28      29
CQUAD4  4       1       29      30      21      22
CQUAD4  5       1       20      21      30      31
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+0007903
+0007903
$Default MAT1 Material
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+0007906
+0007906
GRID    4000            3185.794-611.2492040.905                100
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GRID    4002            3184.719-605.5692042.535                100
GRID    4003            3188.229-605.5062042.242                100
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CTRIA3  3904    2       4001    4002    4003
CTRIA3  3905    2       4009    4010    4004
CTRIA3  3906    2       4008    4009    4004
CTRIA3  3907    2       4005    4006    4008
.........
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+0007553
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+0007556
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GRID    7748            3309.517-604.9462059.157                100
GRID    7749            3308.935-602.3862062.636                100
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CTRIA3  7709    3       7917    7835    7836
CTRIA3  7710    3       7917    7836    7837
CQUAD4  7711    3       7918    7834    7835    7917
CQUAD4  7712    3       7837    7838    7920    7917
CQUAD4  7713    3       7919    7833    7834    7918
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$Default PSHELL Property
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+0007867
+0007867
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+0007870
+0007870
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8000003+
+        8000004 8000006
GRID     8000001         2990.33 -666.63 1959.08                100
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CHEXA    900000110000000 8000009 8000012 8000016 8000019 8000010
8000013+
+        8000015 8000017
CHEXA    900000210000000 8000010 8000013 8000015 8000017 8000008
8000011+
+        8000014 8000018
GRID     8000009         3009.81 -658.06 1971.69                100
GRID     8000010         3009.78 -659.22 1972.38                100
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GRID     8000016         3015.19 -659.01 1970.30                100
GRID     8000015         3015.17 -660.17 1971.00                100
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CHEXA    900000310000000 8000021 8000024 8000027 8000029 8000022
8000025+
+        8000028 8000031
CHEXA    900000410000000 8000022 8000025 8000028 8000031 8000020
8000023+
+        8000026 8000030
GRID     8000021         3037.25 -649.97 1985.89                100
GRID     8000022         3037.23 -651.11 1986.60                100
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CHEXA    900000510000000 8000034 8000037 8000040 8000043 8000033
8000036+
+        8000039 8000042
.........
RBE3     8000001         8000001     123.0031152     123
5436.0682029+
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+           123    5437.8881174     123    5440.0405646     123
5439
RBE3     8000000         8000000     123.0060098     123
341.0087406+
+           123     342.5838278     123     345.4014219     123
344
RBE3     8000002         8000002     123.0028388     123
5433.0536406+
+           123    5434.8960970     123    5437.0474236     123
5436
RBE3     8000003         8000003     123.0074442     123
338.0103219+
+           123     339.5706661     123     342.4115678     123
341
RBE3     8000005         8000005     123.9235667     123
5438.0249334+
+           123    5437.0013538     123    5434.0501461     123
5435
.........
CORD2R  1       0       3304.23 -592.60 2098.66 3303.24 -592.68
2098.55
        180.53  592.52  -2098.77
CONM2   5000001 6000001 1       0.005
        19.7            19.7                    39.0
CORD2R  2       0       3081.36 -454.81 2090.39 3081.59 -455.78
2090.33
        1360.55 453.84  -2090.46
CONM2   5000002 6000002 2       0.005
        19.7            19.7                    39.0
CORD2R  3       0       2958.77 -663.84 1985.36 2959.65 -663.62
1985.79
        801.51  664.05  -1984.93
CONM2   5000003 6000003 3       0.005
        19.7            19.7                    39.0
GRID    6000001         3304.23 -592.5982098.66
RBE2    7000001 6000001 123456  8768    8767    8766    8765    8764

+       8763    8712    8595    8594    8593    8541    8406    8405

+       8404    8403    8402    8401    8338    8337    8336    8212

+       8211    8210    8209    8208    8207    8158    8157    7749

+       7748    7747    7746    7745    1819    1818    1817    1816

+       1815    1814    1813    1812    1719    1718    1717    1716

+       1563    1363    1362    1361    1178    1173    1172    899

+       898     897     892     621     610     609     608     607

+       602     601     152     151     150     149     148     134

+       133     132     131     130     129     128     127     126

+       125     99      2       1
GRID    6000002         3081.36 -454.8092090.39
RBE2    7000002 6000002 123456  10009   10008   10007   10006   10005

+       10001   9997    9584    9583    9582    9581    9580    9579
```

```
+       9578    9577    9576    9575    9574    9573    9572    9571

+       9570    9569    9568    9567    9537    9499    9228    9227

+       9226    9225    9224    9223    9222    9221    9220    9116

+       9115    6007    6006    6005    6004    6003    6002    5949

+       5948    5871    5870    5869    5847    5824    5823    5822

+       5810    5809    5808    5807    5806    5805    5804    5803

+       5800    5799    5784    5783    5782    5781    5766    5765

+       5764    5672    5671    5571    5570    5569    5568    5549

+       5548    5547    5543    5542
GRID    6000003         2958.77 -663.8351985.36
RBE2    7000003 6000003 123456  11344   11343   11342   11341   11340

+       11339   11338   11195   11194   11193   10685   10684   10683

+       10682   10681   10680   5426    5425    5424    5423    5308

+       5307    5249    5244    5243    5242    5236    5235    5227

+       5226    5225    5093    5092    5091    5090    5089    5088

+       4993    4992    4991    4900    4899    4898    4897    4896

+       3155    3154    3153    3152    3151    3150    3149    3025

+       3024    3023    3022    2985    2984    2918    2885    2795

+       2530    2529    2528    2352    2351    1566    1565    1564

+       1269    1268    904     903     902     890     712     710

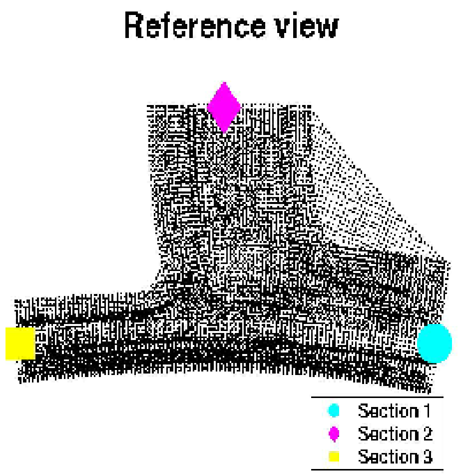
+       245     244     243     242     241
```

Appendix D - Results

HTML result documents and pictures of freqency animations of the first mode for five joints in Volvo S80-series:

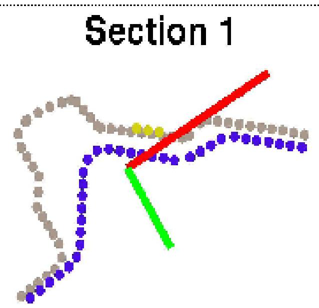
Result from ADRIAN job:

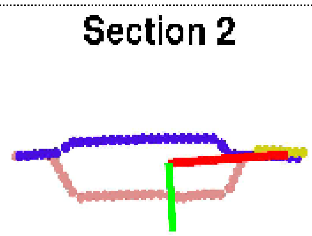
Fri Mar 15 16:16:37 JobID: 16141 Model: P23_A_UPPER

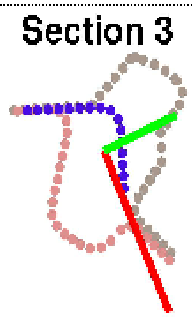


SHEET SETS	T [mm]
SET4	0.8
SET1	1.2
SET2	1.5
SET3	0.8

WELD SETS	D [mm]
SET3:SET4	4.5
SET1:SET2:SET4	4.5
SET2:SET3	4.5
SET1:SET2	4.5
SET1:SET3	4.5
SET1:SET2:SET3	4.5







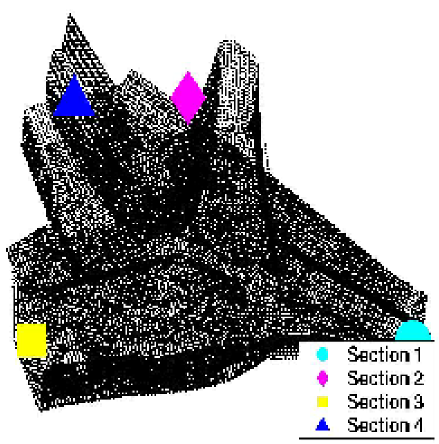
Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]	Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]	Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]

CONFIDENTIAL

Result from ADRIAN job:

Fri Mar 15 16:23:49 JobID: 16200 Model: P23_A_MIDDLE

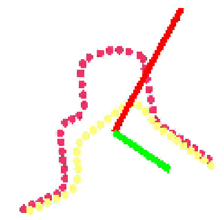
Reference view



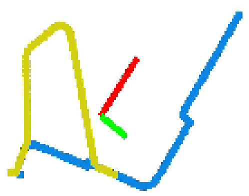
SHEET SETS	T [mm]
SET6	1.2
SET5	0.9
SET4	1.2
SET3	1.2
SET7	1.0
SET2	1.0
SET1	0.8

WELD SETS	D [mm]
SET1:SET2	4.5
SET1:SET3	4.5
SET3:SET4	4.5
SET1:SET6	4.5
SET3:SET6	4.5
SET1:SET5	4.5
SET3:SET7	4.5
SET4:SET7	4.5
SET3:SET2	4.5
SET1:SET4	4.5
SET1:SET4:SET5	4.5
SET4:SET5	4.5
SET6:SET7	4.5
SET1:SET2:SET3	4.5

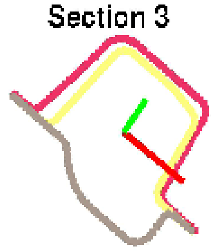
Section 1



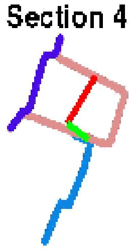
Section 2



Section 3



Section 4

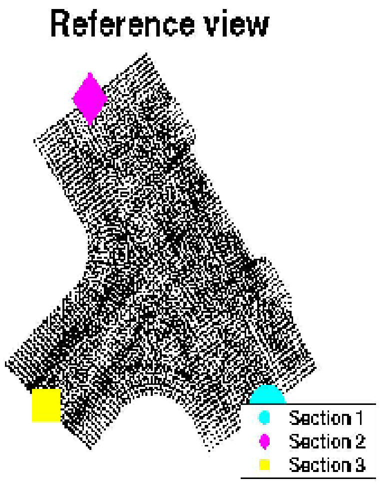


Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad	Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad	Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad	Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad

CONFIDENTIAL

Result from ADRIAN job:

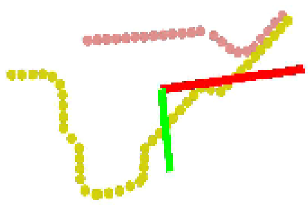
Fri Mar 15 16:31:21 JobID: 16293 Model: P23_B_UPPER



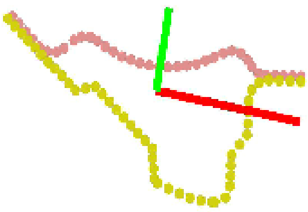
SHEET SETS	T [mm]
SET1	0.8
SET2	1.5
SET3	0.9

WELD SETS	D [mm]
SET1:SET2	4.5
SET1:SET3	4.5
SET1:SET2:SET3	4.5

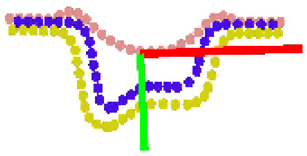
Section 1



Section 2



Section 3



Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]	Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]	Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]

CONFIDENTIAL

Result from ADRIAN job:

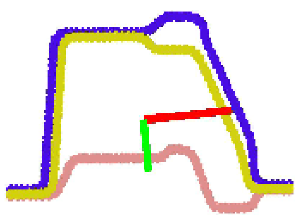
Fri Mar 15 16:38:10 JobID: 16340 Model: P23_B_LOWER

Reference view

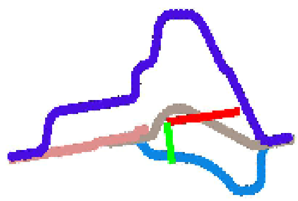
SHEET SETS	T [mm]
SET2	2.0
SET3	0.8
SET1	0.9
SET5	2.0
SET4	2.0

WELD SETS	D [mm]
SET2:SET3	4.5
SET1:SET3	4.5
SET1:SET2:SET3	4.5
SET1:SET4:SET5	4.5
SET1:SET4	4.5
SET1:SET3:SET4	4.5
SET1:SET2:SET3:SET4	4.5
SET2:SET3:SET4	4.5
SET2:SET3:SET4:SET5	4.5
SET3:SET4:SET5	4.5

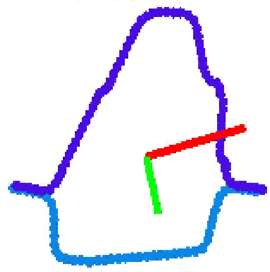
Section 1



Section 2



Section 3

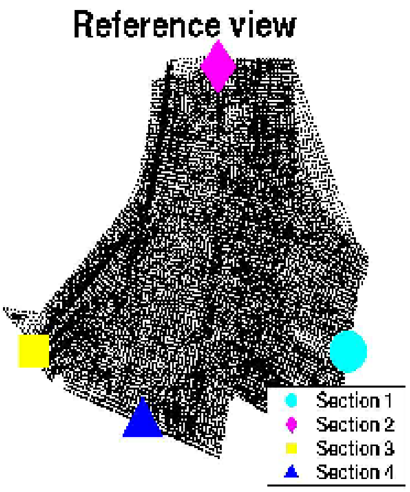


Section 1			Section 2			Section 3		
Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]	Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]	Max. stiffness [N/mm]	Min. stiffness [N/mm]	Rot. stiffness [Nmm/rad]

CONFIDENTIAL

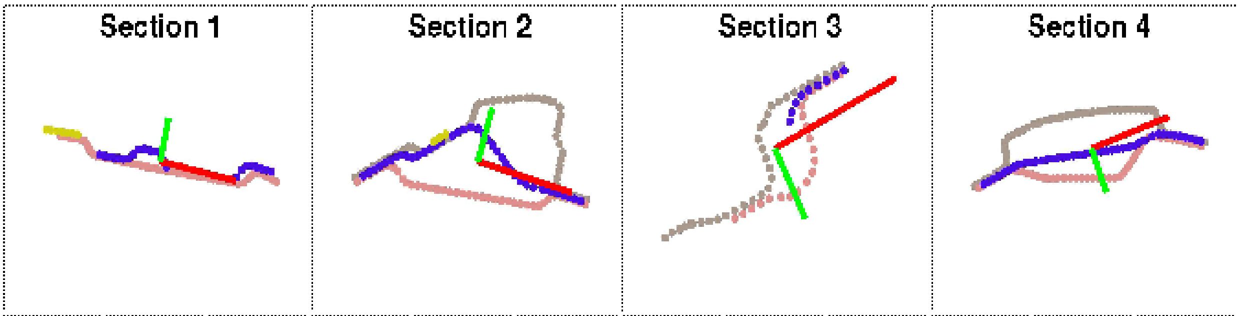
Result from ADRIAN job:

Fri Mar 15 16:46:28 JobID: 16434 Model: P23_C_UPPER



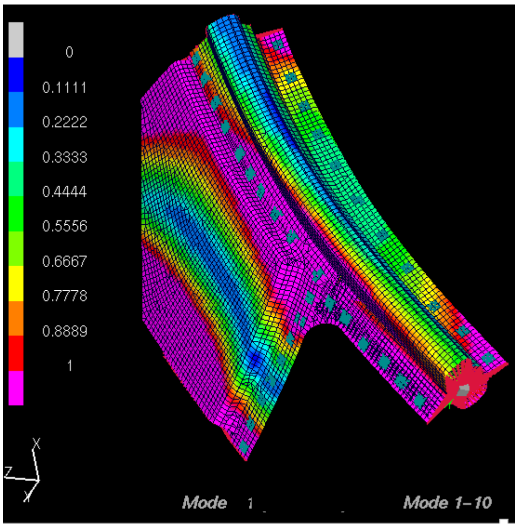
SHEET SETS	T [mm]
SET4	0.8
SET3	1.0
SET2	0.9
SET1	0.8

WELD SETS	D [mm]
SET1:SET4	4.5
SET1:SET2:SET4	4.5
SET2:SET3:SET4	4.5
SET2:SET4	4.5
SET1:SET2	4.5
SET2:SET3	4.5
SET1:SET2:SET3	4.5

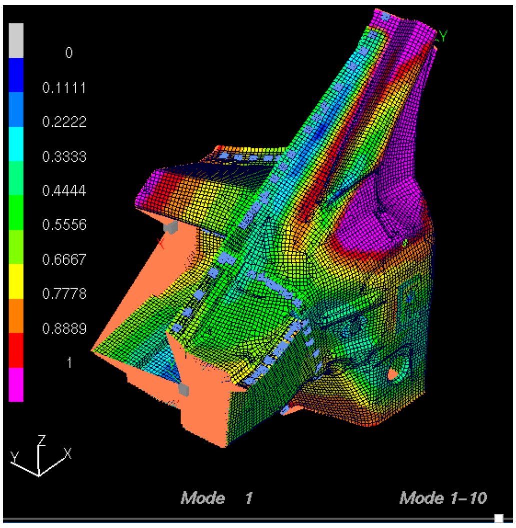


Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad	Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad	Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad	Max. stiffness N/mm	Min. stiffness N/mm	Rot. stiffness Nmm/rad

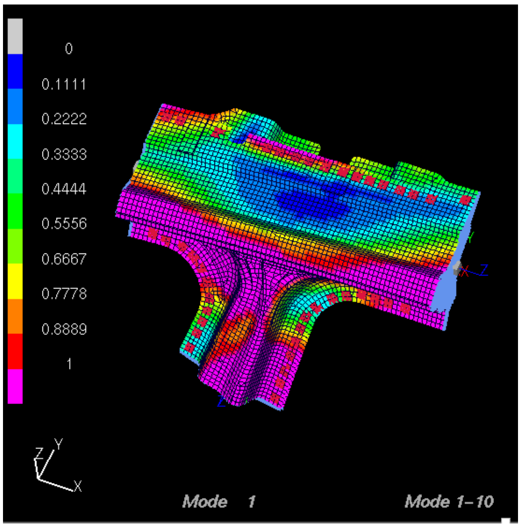
CONFIDENTIAL



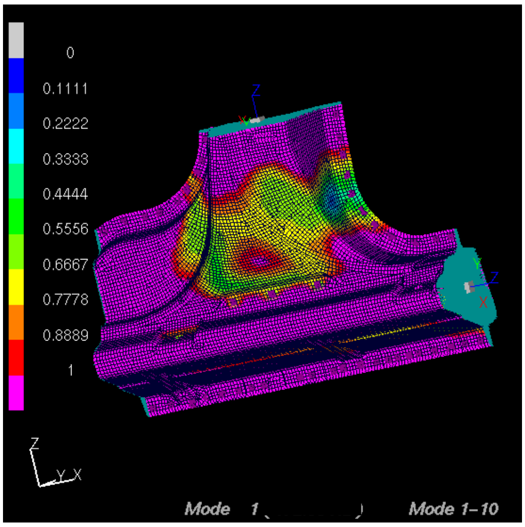
P23_A_UPPER



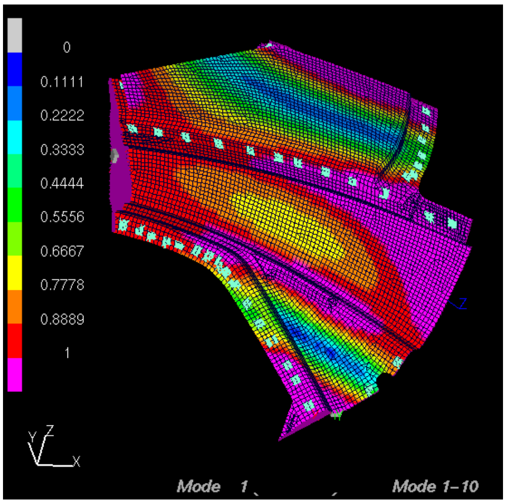
P23_A_MIDDLE



P23_B_UPPER



P23_B_LOWER



P23_C_UPPER

Appendix E - ADRIAN Help section

ADRIAN help 1.1

Catia

- Joint structure

IGES conversion

- IGES V1.1

ADRIAN

- File menu
- Complete menu
- Pre menu
- Nastran menu
- Post menu
  - Import pch (View stiffness) menu
  - Import op2 (freq. animation) menu
- Options menu
  - Settings menu
  - Advanced

This document was generated on 1 March 2002

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Joint structure

This section describes what to export from Catia. To use ADRIAN successfully it is important to use the syntax described below. It is also very important that the model exported is clean and therefore only consist of the components described below:

- Each **sheet** shall be placed in a separate Catia set
- A separate set consisting of **planes** describing the beam ends must be existent
- Sets for the **welds**

Sheets

Syntax

If the model for example consists of three sheets put each sheet in a separate set. Use the following syntax when creating a setname: **NAME**:T**SHEETTHICKNESS**, a setname may consist of maximum 30 characters. **NAME** is a unique name for each set, for example SET1, SET2 and SET3. The second part, **SHEETTHICKNESS**, is the sheet thickness given in millimetres in the range 0.5-2.5 mm. The sheet thickness is optional, if no value is given ADRIAN uses a default sheet thickness of 1.0 mm. The following setnames are examples of valid ADRIAN setnames: SET1:T2.1, SET2:T0.9 and SET3.

Restrictions on geometry

To obtain the best prestanda for Adrian the model should have faces on every surface. Make sure faces are applied on every surface in Catia and simply erase all surfaces. This will most often erase all surfaces which have not a corresponding face. Sometimes surfaces will still be existent in the model which are not necessary for describing the model. To avoid this it might be a good thing putting on a skin and copying the surfaces and faces of interest to an empty Catia model. If a model is imported into Adrian which consist of surfaces which has not a corresponding face, Adrian gives a user warning. If the model has faces on each surface, click Remove. This will remove all surfaces which do not belong to the model. If the model consist of both surfaces and faces, click Accept. Note that the Accept interaction can not garantee as good mesh quality as a model with face on each surface and that there may be remaining surfaces that do not belong to the model. When using a model with surfaces which have not a corresponding face, it is thus important that there are only surfaces necessary for descibing the model present.

Planes

A separate set consisting of planes describing the joint ends must be existent. ADRIAN looks for a set consisting of three or four planes, depending on joint type. The setname must be unique and consist of maximum 30 characters. There must be nothing else than these planes in the plane set.

Welds

In order to weld two sets together, simply create a new set named **NAME**:**NAME**:D**DIAMETER**, where **NAME** is the name part of the sheet set and **DIAMETER** is the weld diameter given in millimetres and in the range 4.0-9.9 mm, for example: SET1:SET2:D4.5. Note that it is also possible to weld three or four sets together, for example: SET1:SET2:SET3:D6.3 or SET1:SET2:SET3:SET4:D5.5. The weld diameter is optional; it is possible to create a weld set with the syntax **NAME**:**NAME**, for example SET1:SET2. If this is done, ADRIAN uses a default weld diameter of 4.5 mm. As the set is created, just put points marking the position of the welds. If, for some reason, Adrian fails to create a weld, the user get a warning message telling which point not resulting in a correct weld. Make sure weldpoint is in a logic position and that it belongs to a correct set, named after the sheets being welded together Note that there must be nothing else than points in a weld set. Note also that there is no limit in how many weld sets that can be existent in a model.

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IGES V1.1

In order to convert the Catia model to IGES, type
>iges
at the command prompt.

- Choose conversion <**1> Catia to IGES**
- Choose the path to the file that is to be converted
- Pick your Catia model file
- Choose what directory to place the resulting IGES-file in
- Enter name of the IGES file (Just pressing enter gives the Catia model name)
- Choose what to transfer **<1> SPACE (exter process GEOM)**
- Choose layer option **<1> All layers to one iges file**

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File menu

Left click on the File menu button. A scrolldown menu appears with an Exit-button. If Exit is chosen, a pop-up menu appears asking the user to confirm the choice. To exit ADRIAN press OK.

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Complete menu

Complete processing does all components of ADRIAN in one sequence; Pre-processing, Nastran calculation and Post-processing. The igs-file must have the structure described in the `Joint structure`-section. Left click on the `Complete` menu button. A scrolldown menu appears with an `Import igs`-button. If `Import igs` is chosen, a file manager appears. Here it is possible to navigate through the file system. Chose an appropriate IGES-file and press ok. This will start the processing. Note that Complete processing uses pre-processing settings and Nastran settings defined in the `Settings menu`. For Complete processing it is possible to set what kind of post-processing ADRIAN should do.

While running information on the job is displayed in the Output window. This information consists of a jobid, the contents of the igs-file, etc. As pre-processing is finished "Pre-processing done" is printed to the output window. The nastran-file can now be found in the $HOME/ADRIAN_ROOT/ **JOBNAME** directory, where **JOBNAME** is the name of the igs-file and a jobid consisting of 5 digits separeted by the character '_', for example myjoint_12352. Together with the Nastran-file is also a .post file used for displaying geometry in the `Stiffness postprocessor`. Now the nastran-file is submitted to a server. As Nastran has finished all its output files are copied to $HOME/ADRIAN_ROOT/**JOBNAME**. The three most important output files are f06-file, which contains error information about the calcutlation, the op2-file and pch-file, which are input files for the 2 different post-processing routines. As `Nastran` processing is finished the f06-file is scanned for errors. If a fatal error occurred during the calculation ADRIAN prints an error message to the output window and then returns to the main window. If a warning or a error occurred ADRIAN reports the number of warnings and errors to the output window and then prints "Nastran done" to the same window. If no fatal errors occurred the complete process continues with the post-processing. The available post processors are `Stiffness` and `Frequency` visualization

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Pre menu

From the Pre menu, pre-processing is carried out. Pre-processing in ADRIAN converts a joint in the igs-format to the Nastran format. The igs-file must have the structure described in the `Joint structure` -section. Left click on the `Pre` menu button. A scrolldown menu appears with an `Import igs`-button. If `Import igs` is chosen, a file manager appears. Here it is possible to navigate through the file system. Choose an appropriate IGES-file and press ok. This will start the processing. Note that Pre-processing uses the pre-processing settings defined in the `Settings menu` . Information about the job is displayed in the Output window. This information consists of a jobid, the contents of the igs-file, etc. As post-processing is finished "Post-processing done" is printed to the output window. The nastran-file can now be found in the $HOME/ADRIAN_ROOT/**JOBNAME** directory, where **JOBNAME** is the name of the igs-file and a jobid consisting of 5 digits separated by the character '_', for example myjoint_12352. The .post file, which is also found in this directory, is used in the stiffness postprocessing.

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Nastran menu

From the Nastran menu, Nastran jobs are submitted out. Left click on the `Nastran` menu button. A scrolldown menu appears with an `Import nas`-button. If `Import nas` is chosen, a file manager appears. Here it is possible to navigate through the file system. Choose an appropriate Nastran-file and press ok. This will start the processing. In order to use Nastran calculation in the Adrian program, the Nastran-file must be produced by the Adrian preprocessor. Note that Nastran uses the Nastran settings defined in the `Settings menu` .
Information on the job is displayed in the Output window. Note that the jobid displayed is a local jobid used by Nastran. The nastran-file is submitted to a server all Nastran output files are copied to the same directory as the original nastran-file. The three most important output files are the f06-file, which contains error information about the calcutlation, and the op2-file and pch-file, which are input files for the 2 different post-processing routines. As Nastran processing is finished the f06-file is scanned for errors. If a fatal error occurred during the calculation ADRIAN prints an error message to the output window and then returns to the main window. If a warning or a error occurred ADRIAN reports the number of warnings and errors to the output window and then prints "Nastran done" to the same window. If no fatal errors occurred it is possible to start the post-process.

Time-out

ADRIAN waits for Nastran to finish. If Nastran has not terminated after 2 hours, ADRIAN stops waiting. This may be due to a long queue on server. Note that if Nastran terminates after these two hours the user will still get Nastran output files copied to the directory of the submitted job. The user will then have to invoke ADRIAN postprocessing manually if running Complete processing.
Note that ADRIAN does not give the user information if Nastran for any reason fail to return the f06-file. If this is the case, ADRIAN will wait for 2 hours and exit.

Displaying the queue

In order to display the queue for the submitted Nastran job type
>. /vcc/apps/lsf/mnt/conf/profile.lsf
>xlsbatch
at your unix prompt. To locate your Nastran job sort the queue by jobid. The Nastran jobid for the submitted job is found in ADRIAN output window (Nastran Job <xxxxxx> is submitted to queue <csm_quick>.)

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Post menu

In the `Options menu` it is possible to enter the `import pch` -menu and the `import op2`-menu

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Post pch-menu

From the Post pch menu, stiffness visualisation is carried out. Left click on the `Post` menu button. A scrolldown menu appears with an `Import pch (view stiffness)`-button. If `Import pch` is chosen, a file manager appears. Here it is possible to navigate through the file system. Choose an appropriate pch-file and press ok. This will start the processing. The pch-postprocessing also uses the .post file which must be existent in the same directory as the .pch file.
Information on the processing is displayed in the Output window. As post-processing is finished "Post-processing pch done" is printed to the output window. Netscape is opened and the results are shown. The result consists of a picture of the reference view and pictures of each joint end. The sheet thicknesses and weld diameters used are given. In the joint end-pictures, the green axis represent the minimum stiffness direction and the red axis represent the maximum stiffness direction. Beneath each picture , three different stiffnesses are displayed. The maximum stiffness is below the red arrow, the minimum is below the green arrow. The third stiffness represent rotation in the "picture plane". Information on what model processed and when it was sent to Nastran calculation is also displayed.

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Post op2-menu

From the Post op2 menu, frequency animation is carried out. Left click on the `Post` menu button. A scrolldown menu appears with an `Import op2 (freq. animation)`-button. If `Import op2` is chosen, a file manager appears. Here it is possible to navigate through the file system. Choose an appropriate op2-file and press ok. This will start the processing. Information about the processing is displayed in the Output window. As op2 processing is finished "Post-processing op2 done" is printed to the output window. Animator is now started.

Animator

Changing the view

In order to reposition the view use: **Ctrl+leftmousebutton**-Rotate the picture with the mouse **Ctrl+middlemousebutton**-Translate the picture with the mouse **Ctrl+leftmousebutton+middlemousebutton**-Zoom in by moving mouse downwards, Zoom out by moving mouse upwards. **Ctrl+rightmousebutton**-Rotate the picture around an axis in he viewplane with the mouse **Ctrl+F1**-top view **Ctrl+Shift+F1**-bottom view **Ctrl+F2**-right view **Ctrl+Shift+F2**-left view **Ctrl+F3**-front view **Ctrl+Shift+F3**-rear view

Viewing node displacement

In order to view the node displacement in a color map choose **Utils->sty->int->dno->all**.

Changing freqeuency mode

It is possible to toggle through the first ten modes by using the **F1-F10** buttons. To obtain the next ten modes press F12 and to obtain the previous ten modes press **F11**. There are totally 13 modes available for viewing.

Changing animation speed

Change the animation speed by entering the **Utils->ani->spe** menu.

Changing animation displacement

Change the animation displacement by entering the **Utils->dis->sca** menu.

Disable animation

In order to disable animation press **Ctrl+Delete**.
For full documentation please refer to the Animator Help guide.

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Options menu

In the `Options menu` it is possible to enter the `Settings menu` and the `Advanced` settings menu.

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Settings menu

The `Settings menu` is divided into three parts Pre-processing settings, Nastran settings and Complete Process settings.

Pre-processing settings

Mesh size

Point on the scale and left-click in order to change the mesh size used by Ansa. Possible values for the mesh size are between 1 and 20 mm.

Use Catia sheet thickness

If the box is checked, ADRIAN looks for the sheet thickness defined in the setnames in Catia. The thickness should be given according to the syntax **NAME**:T**SHEETTHICKNESS**; a setname may consist of maximum 30 characters. **NAME** is a unique name for each set and **THICKNESS** is the sheet thickness of the sheet given in millimetres and in the range 0.5-2.5 mm, for example: SET1:T1.5.
If the box is unchecked, ADRIAN lets the user define the sheet thickness for each sheet set. In the first part of the pre-processing ADRIAN identifies the contents of the igs-file. A pop-up menu occurs with all the existing geometry sets. Enter the values desired and press the OK-button.

Use Catia weld diameter

If the box is checked, ADRIAN looks for weld diameters defined in the setnames in Catia. The diameter should be given according to the syntax **NAME**:**NAME**:D**DIAMETER**, where **NAME** is the name part of the sheet set and **DIAMETER** is the weld diameter given in millimetres and in the range 4.0-9.9 mm, for example: SET1:SET2:D4.5. Note that it is also possible to weld three or four sets together, for example: SET1:SET2:SET3:D6.3 or SET1:SET2:SET3:SET4:D5.5.
If the box is unchecked, ADRIAN lets the user define the weld diameter. In the first part of the pre-processing ADRIAN identifies the contents of the igs-file. A pop-up menu occurs with all the existing weld sets. Enter the values desired and press the OK-button.

Nastran settings

Max ratio

Nastran computes the ratios of the terms on the diagonal of the stiffness matrix to the corresponding terms on the diagonal of the triangular factor. If, for any row, this ratio is greater than maxratio, the matrix will be considered to be nearly singular. The default value for maxratio is 1E7.

Bailout

If the box is checked, the job is submitted to Nastran with the parameter BAILOUT set to -1. This makes Nastran continue processing if near singularities are found in the stiffness matrix. If a an Adrian job result in errors when calculating in Nastran, checking this box might be a good idea. This will make Adrian produce a result. Note that the solution may be of poor quality.

Queue

Determines what queue the nastran job is submitted to. For normal jobs the default queue csm_quick should be sufficient. This sets the maximum processing time to 10 min. For very large joint geometries, choose the csm_small option.

Complete process settings

Do stiffness post-processing

If the box is checked, ADRIAN automatically launches the stiffness matrix post-processing as a complete process job is submitted.

Do frequency post-processing

If the box is checked, ADRIAN automatically launches the frequency animation post-processing as a complete process job is submitted.

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Advanced

From the Advanced settings menu it is possible to set ADRIAN in Ansa user interactivity mode. Left click on the `Options` menu button. A scrolldown menu appears with an `Advanced`-button. If `Advanced` is chosen, a pop-up menu appears. If the `User interactivity mode` is set Ansa will process the different geometry sets one at a time. This gives the possibility to manipulate the geometry in Ansa, with functions like **Paste**, **Delete Double** etc. It is very important that the user exports a mesh to a nas-file. Note that the filename of the nas-file must be the same as the igs-file for example: **INPUT:**Set3.igs, **OUTPUT:**Set3.nas.
Use the flow of interactions described below: As the igs-model have been read into Ansa, use the **TOPO** menu deck to manipulate the surfaces. Use the **MESH** menu deck to create a mesh on the surfaces, and to manipulate the mesh created by Ansa. After having created a suitable mesh. choose **FILE->OUTPUT->NASTRAN** Type the name of the nastran-file in the Selection-box. The name **MUST** be the same as the file read in, with the suffix changed from .igs to .nas. The name of the file read in can be found in the Ansa Text Dialog. If for example SET1.igs is read in, type SET1.nas in the Selection box. Do **NOT** change the (temp) directory Ansa suggests!. Click the OK button. Press OK in the Output Parameter dialog Press Cancel in the Nastran Dech Parameters dialog Choose **FILE->QUIT** Repeate the action above for each set read in.

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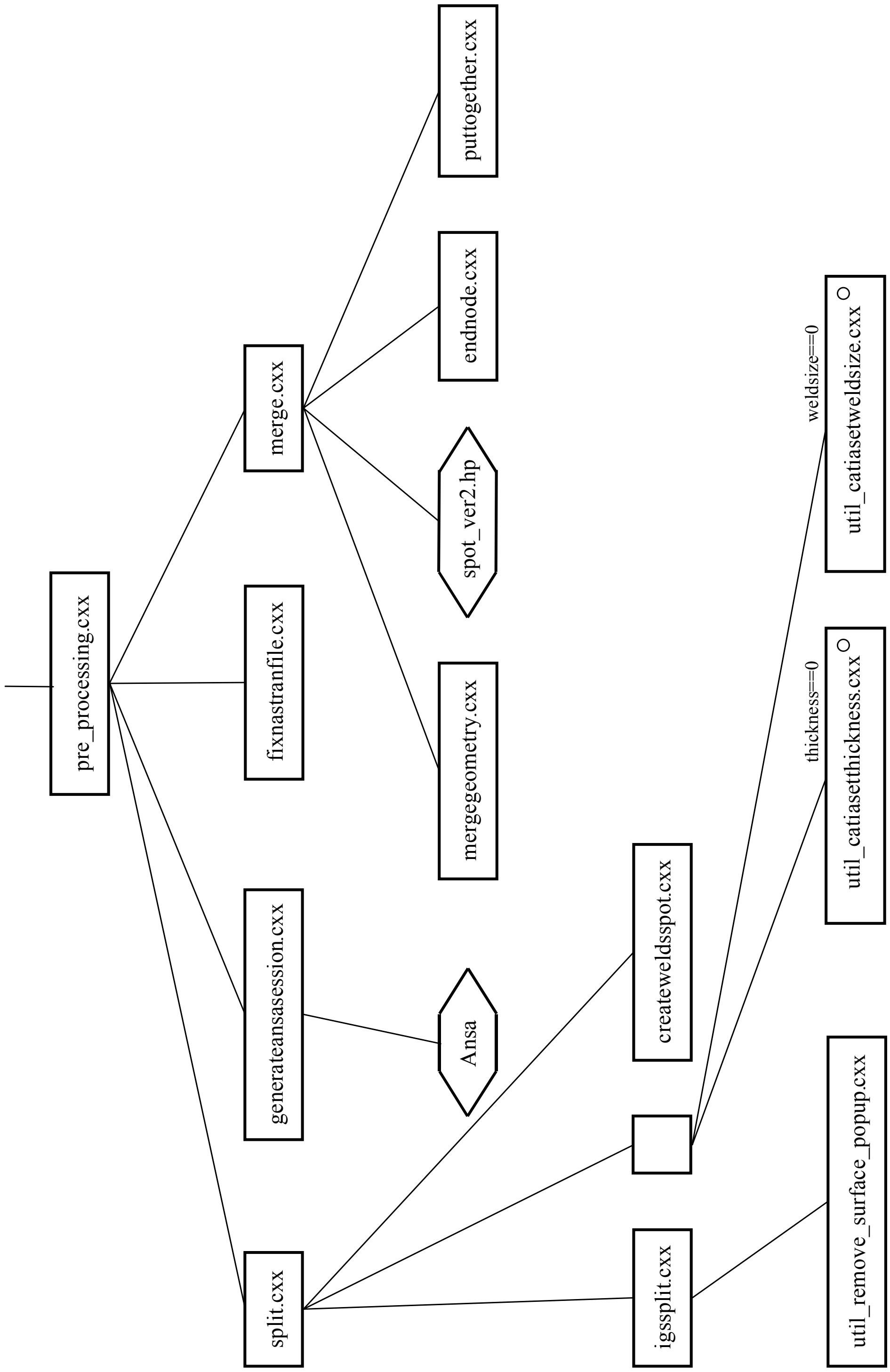
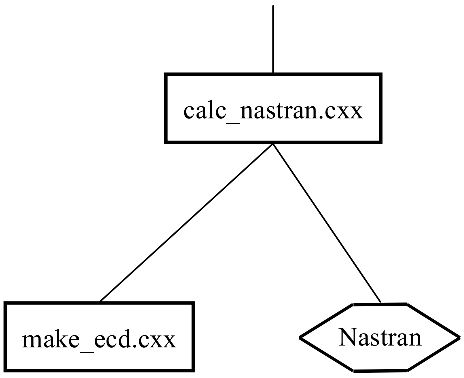
Appendix F – Structural diagrams

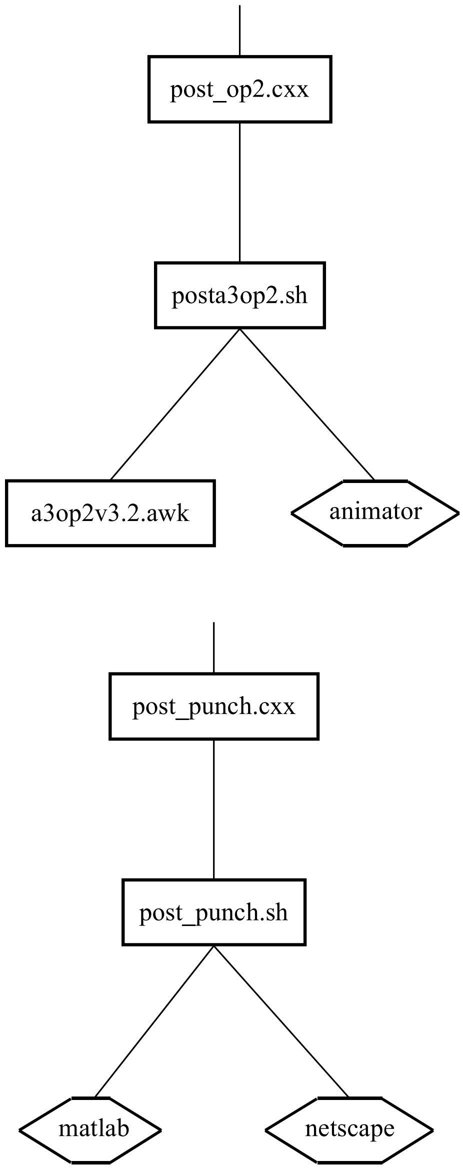
Pre-processing



Nastran calculation



Post-processing



Complete process