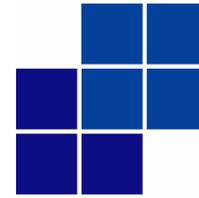


News.St7

Newsletter for Strand7 and Straus7 users

 Strand7 is marketed as  Straus7 in continental Europe



Issue 1, May 2003

Welcome to the first edition of our newsletter for 2003!

News.St7 aims to bring you the latest information about Strand7. It will highlight new Strand7 features, provide modelling tips, which will be useful to both the new user and the experienced user alike, summarise interesting work performed by Strand7 users, and in future editions will tell you more about planned Strand7 developments and upcoming releases. News.St7 will also keep you up to date with significant events on the Strand7 calendar, including exhibitions and courses.

We hope that you find this publication both interesting and useful. If you have any feedback or suggestions regarding the content, or you would like to have your latest project included in the 'Current Projects' section then please email News.St7@strand7.com. If you would like to receive your copy of News.St7 directly by email, simply send a blank email to Newsletter-Subscribe@strand7.com. 

Latest News

March 2003 saw the release of Strand7 2.2, packed with new features and options. One of two major new features is the Sparse solver. The Sparse solver can solve very large models in a much shorter time than before, and models which were too large to be solved using the Skyline solver, can now be solved. The Sparse solver uses the same basic procedure as the Skyline solver for solving equations. Therefore, it does not compromise solution accuracy to achieve its impressive speed increases. Faster solutions are achieved due to a much more efficient data storage and manipulation strategy, based on so-called "sparse matrix methods".

Changes have also been introduced to the constraint algorithms, which are used for implementing enforced nodal displacements and the Links. Previously, Strand7 used the Lagrange Multiplier approach for such constraints. The solvers in

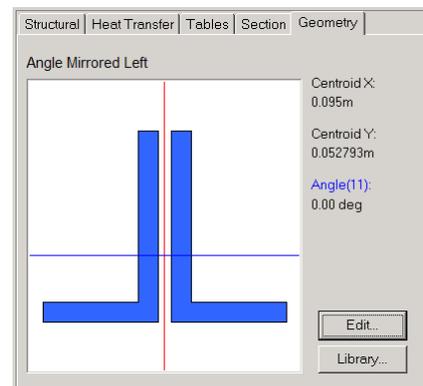
**100x speed
increases seen
with the new
Sparse solver**

Release 2.2 (both Sparse and the new Skyline) use a different approach, based on the removal from the global matrix, of dependent degrees of freedom. This leads to not only fewer equations when solving models containing links and enforced displacements but also removes the deterioration of the condition of the global stiffness matrix that occurs when these constraints are enforced with Lagrange Multipliers.

Release 2.2 also introduces new beam sections including trapezoid, triangle and cruciform. This avoids having to prepare a BXS for such sections.

Coupled with this is the new mirror option for beam sections, which allows simple creation of composite beam sections, by mirroring a basic shape about one or more mirror planes.

For those users who requested it we have now included Tonne Force and kips in our force units and plates have the option to contour Internal Angle Ratio to accommodate mixed Tri and Quad meshes.



Mirrored Angle Section

In this issue...

- Sparse solver
- Strand7 API
- Modelling bolted connections
- Current projects
- Heat transfer benchmark
- Training calendar
- Exhibitions calendar

In the post-processing options, beam fibre stresses can be enveloped and combination envelope cases are now an option.

Also available using the peek tool is reaction sum and node flux sum: these reduce the need for hand calculations and prove very useful when calculating total reactions (including moments) at structural boundaries. It also greatly simplifies global stability calculations.

The spectral response solver has been reconfigured to allow for multiple spectral solution cases, with different spectral tables.

You can now also choose the method of calculation for strain in geometry nonlinear problems. Options for nominal, engineering or Green's strain are provided.

This article presents just a sample of what is on offer in Strand7 2.2; more detailed information can be found at www.strand7.com. 

Strand7 API

Release 2.2 introduces a new and very powerful Strand7 tool – the *Strand7 Application Programming Interface (API)*. The Strand7 API allows you to interact with Strand7 via your own computer programs. This provides the capability to completely bypass the Strand7 Interactive Environment or to perform specialised functions that are currently not available within Strand7 itself.

In simple terms, the Strand7 API allows you to incorporate access to Strand7 within your own programs. More specifically it can be used to:

1. Directly create new Strand7 model files (binary ST7 files) from scratch.
2. Modify existing Strand7 model files.
3. Execute the Strand7 solvers.
4. Extract and process the results of a solution.

Did you know?

Dynamic scaling
With results open press F4 to enter the dynamic view environment.

View x

Left drag

Auto

rXY

rX

rY

rZ

Zoom

Pan

Scale

Origin

Centre

Reset

Model

Screen

Single

Both: Pan
Right: Zoom
Ctrl: Scale

OK

You can dynamically increase or decrease the Displacement Scale of deformed models by clicking **Scale** in the Dynamic Rotation toolbar (shown) and holding the left mouse button while moving the mouse: **up** to increase and **down** to decrease the displacement scale. When an appropriate scaling factor is obtained, click **OK**. This will automatically set the displacement scale to the desired value.

Shortcut
The **Scale** option can be quickly accessed (while performing any of the other dynamic functions - ie Auto, rXY, rX, rY, rZ, Zoom and Pan), simply by pressing and holding down both the **Ctrl key** and the left mouse button and following the procedures explained above.

Although these functions can be performed by using the Strand7 GUI directly, and data can be transferred between Strand7 and other applications via text-based import/export functions, copy-paste, etc, such an approach can require a significant amount of additional data processing or repetitive manual procedures when the same operation is to be performed many times.

The API approach provides a totally transparent way of interacting with Strand7 data so that repetitive tasks can be easily automated. Importantly, if the format of the Strand7 data files changes, such changes are fully absorbed by the API so that no changes to the external programs are required to use a more up-to-date version of Strand7 or the API.

API allows direct interface between Strand7 and your software

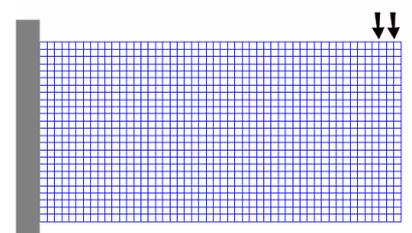
Example API application

An example use of the Strand7 API is a structural optimisation program. Structural optimisation methods that use FEA have seen increased popularity in recent years due to increases in computing power. An example of such an optimisation method is a Fully Stressed Design (FSD) method. This method sizes parts of a structure based on its relative stress state. If part of a structure is overstressed, it is added proportionally more material to compensate. Conversely, if part of a structure is under stressed, material is removed to increase the structure's efficiency.

In the case of a plate FE model, the adding and removal of material can be simulated by the varying of the thickness of each element. This implies that each 'region' considered for material redistribution is represented by each element. Hence, the plate thickness of each element becomes a design variable.

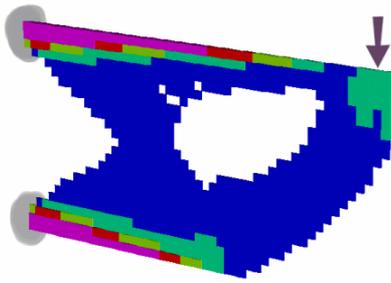
The 'Plate Optimisation' program, which is distributed with the Strand7 API toolkit as example code, is a simple program that uses such a method.

The following figures demonstrate how the optimisation program was used to optimise the design of a cantilever. The cantilever is modelled using plane stress elements and is subject to an in-plane vertical tip load. Note that the cantilever is 'discretised' into many elements – more than would be necessary for appropriate stress recovery. In the initial design, all plates have the same thickness.



Initial Cantilever Design

Over the course of several iterations, the design is modified by the API program until the optimised shape is obtained. This is shown in the figure below.



Optimised Design

The design is visualised in Strand7 by contouring the plate elements according to their thickness (note that elements with a very small thickness are not drawn – this is a new feature in the contouring options of Strand7 2.2 – it is possible to avoid drawing any element that falls outside specified limits).

It can be seen that the design is similar to an I Beam, where a thin shear web is sandwiched between two thick sections that take the moment. These sections gradually increase in thickness towards the root. Note that the web includes lightening holes where little shear is

experienced, to form what almost appears as a truss structure.

This example is based on a model that contains over a 1000 elements and the solver was run over a dozen times to achieve the final 'shape'. This involved countless modifications to individual plate thicknesses. Hence, an unthinkable slow manual procedure was automated through the use of the Strand7 API.

Find out more about the Strand7 API by visiting the Strand7 website. 

Current Projects

In this section we present current projects where Strand7 is being used to perform FE analyses. Projects from both Strand7 users and our own Strand7 Consulting will be presented.

If you would like to have your project included in the next edition of News.St7, please email News.St7@strand7.com 

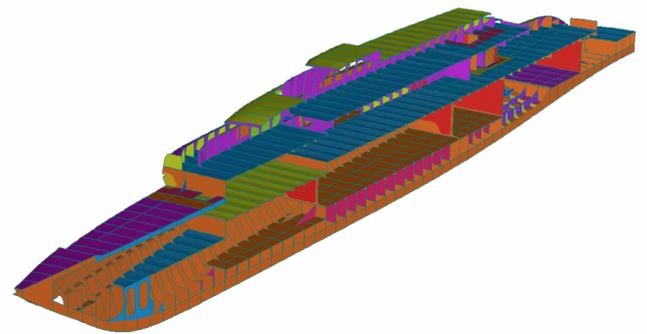
High speed Motor Yacht

Elan Design, based in Western Australia, is currently using Strand7 to design a high-speed motor yacht which must meet the requirements of Lloyd's Register rules. Measuring 240ft in length and rated at 31kts, it is to be one of the largest and fastest of its kind.

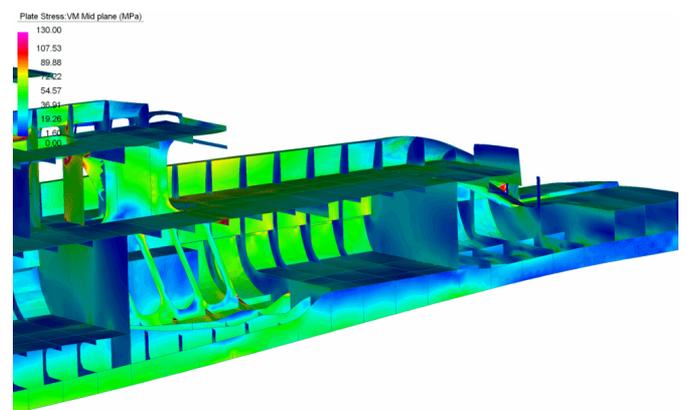
The model was created in Pro-Engineer, exported as an IGES file then imported, cleaned, automeshed and analysed in Strand7.

The resulting plate/shell model contained 72 000 elements and 360 000 degrees of freedom.

The final solution was arrived at after over 70 complete global solutions and more than 20 sub-models. During these iterations, it was discovered that applying the design rules straight out of the book would have produced a structure which would most likely fail when it first encountered a respectable storm. This pointedly proved the value of the FEA.



Use of Strand7 allowed the structure to be fully optimised with regard to stresses and deflections whilst meeting all requirements of the governing rules.



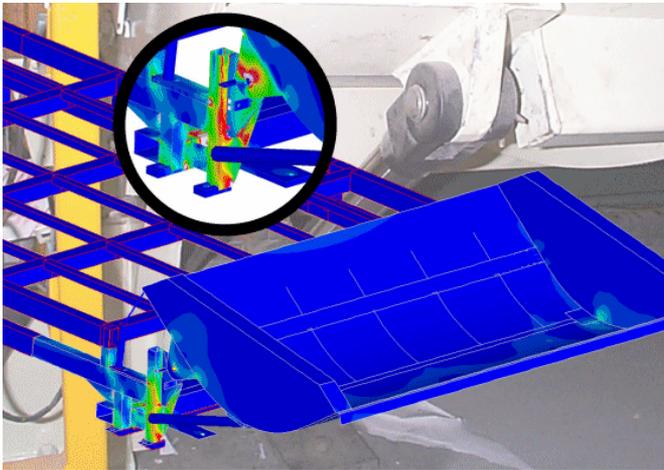
Nick Stark of Elan Design said:

"The whole process highlighted that while sound engineering practice is vital, it can at best provide guidelines by which to design. There is no substitute for the detailed knowledge of a specific design provided by FEA."

If you would like more information then please contact Elan Design: Tel +61 (0)8 9443 9170 Fax +61 (0)8 9443 9171 www.elandesign.com.au 

Paper Lift Bucket Mechanism

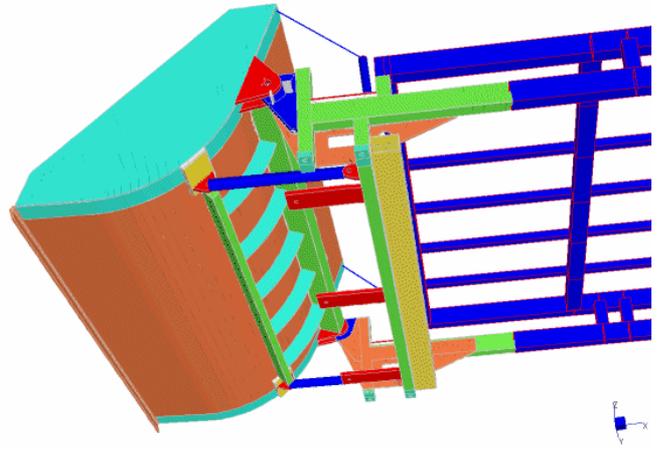
WBM Gippsland has been using Strand7 to investigate structural deformations that were occurring in their clients' paper roll lifting mechanism.



The bucket mechanism is used to lift 3 tonne rolls of paper onto a conveyor system for further handling and processing.

The client identified that permanent deformation of some of the main structural members had occurred over repeated operation of the lift. Some local pull-out of holding down bolts had also occurred.

WBM Engineering was contracted to investigate the potential cause of this deformation and devise remedial changes.



The paper bucket is hinged about 2 support points and lifted via 2 hydraulic rams.

WBM contracted the services of our own **Strand7 Consulting** team to create the initial model. This model was supplied to WBM to be used as the basis of their on-going investigation.

Strand7 was used to create a global model with sufficient detail to investigate some of the local stresses close to the bucket hinge and ram points.

The model was essentially divided into two zones. The first zone was the area away from the zone of influence. This incorporated the conveyor system behind the main lift bucket. This was modelled using Strand7 beam elements.

The second area, the zone of interest, was modelled in detail with shell elements and the 3 tonne paper roll represented as lumped mass.

A nonlinear static analysis was run. The load increments were chosen such that the bucket was lifted through its full operation cycle by applying appropriate strains to the lifting rams.

The Strand7 model was used by WBM to identify the most appropriate remedial measures to ensure ongoing structural integrity.

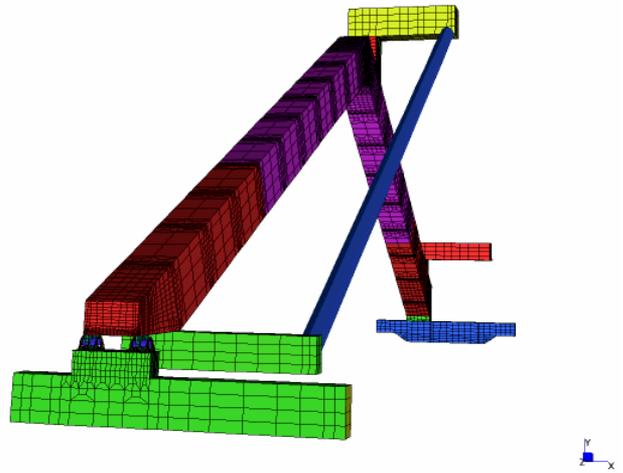
Further details can be obtained from Bill Young at WBM Pty Ltd, PO Box 888, Morwell, VIC 3840, Australia. www.wbmconsulting.com 

Coal Reclaimer

Wave Engineering in Western Australia used Strand7 to investigate the stress levels of a Coal Reclaimer.

The client had been experiencing abnormal operation of their portal type reclaimer and as a part of their condition monitoring program began an investigation into the structural integrity of the machine. The investigation was carried out in a stepped approach, namely:

1. Preliminary FEA model to generate 'first cut' stress levels and identify high stress points for location of strain gauges.
2. Strain gauge monitoring of the machine (at the high stress points) during machine operation to measure fluctuating stresses over time.
3. Refinement of the FEA model to calculate static stress levels in the structure, which were combined with strain gauge results to determine total stresses in the structure over time.



If you would like more information on this project then contact Ryan Hanrahan at Wave Engineering by telephone on +61 (0)8 9726 2422. Or alternatively you can email him at rhanrahan@waveeng.com.au. 



Stress results throughout the entire structure were required so a full plate model was generated. The final model consisted of 3,900 beam and 158,000 plate elements. The model was required to take into account the additional structural stiffness of the scraper boom and the effects of a rotational pivot on the non conveyor end bogie. The boundary conditions were set up in order to allow free movement of the bogies along the rails; this in turn allowed calculation of the natural structural deformation of the machine.

The final requirement was the reporting of total operating stresses (a combination of calculated and measured stresses) throughout the entire structure. Included in this was a detailed error analysis around high stress areas to fully justify the mesh quality and hence reported stresses.

The job highlighted a good case of using FEA and experimental procedures together. It would have been difficult to position strain gauges in meaningful locations without performing preliminary FEA first.

Did you know?

Ctrl-Click the Entity Show/Hide Toggle

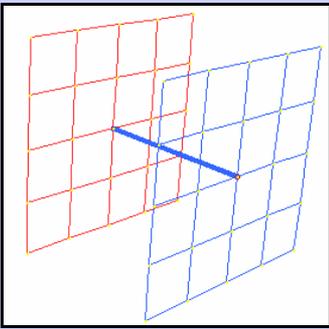
Normally, by clicking the show/hide toggles, the screen automatically updates and redraws to effect the changes. Often we need to turn on/off more than one entity and for large models this can take time when redrawing after each selection. Instead, hold the Ctrl key while clicking the entity toggles to prevent Strand7 from redrawing after each click. When finished select redraw to refresh the screen. (F3 or F5)



Modelling Tip

Frequently we are asked ‘what is the most appropriate way to model a bolted connection?’. Unfortunately there isn’t a straightforward answer to this question! There are several different modelling options which can be used but depend heavily upon the level of accuracy and local detail required. These options will be presented in order of increasing complexity including the pros and cons of each option.

1. Simple beam model.



This modelling option is used if only the global effects of the bolt are of interest and the local effects of the bolt on the plate mesh are not. The beam is modelled with the appropriate bolt properties.

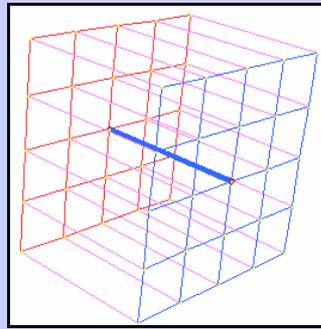
Pros

- Very simple to model;
- Good global representation.

Cons

- Local Singularities;
- Plates may pass through each other.

2. Simple beam model with contact elements between the plates.



Although similar to Option 1, this option would be more realistic as the plates are restricted from passing through each other by using contact elements.

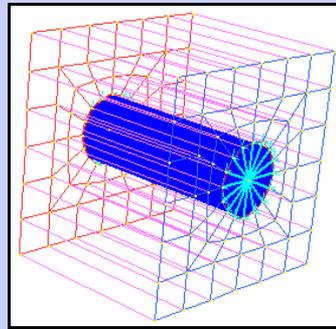
Pros

- A bolt pretension can be applied;
- More realistic than Option 1.

Cons

- Local Singularities;
- Requires nonlinear solver.

3. Beam model with rigid links at the ends and contact elements between the plates.



Use this option if you want to distribute the bolt forces to the surrounding plates. Ensure that the hole in the plate mesh is the same diameter as the bolt.

To improve this model, you could replace the rigid links on the bolt ends with stiff beams.

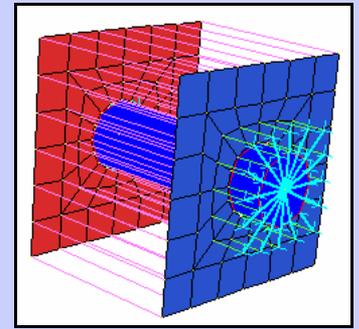
Pros

- Less Local Singularities;
- Bolt force is distributed to surrounding plates.

Cons

- Assumes full bolt contact;
- Requires nonlinear solver.

4. Beam model with bolt head modelled at the ends and contact elements between the plates.



This is the most realistic model you can obtain short of modelling a full brick model.

Pros

- Bolt head interaction with the plates can be seen;
- No singularities.

Cons

- Complex to model;
- Requires nonlinear solver.

As you can see there are considerable differences between the different modelling options. For models where you are only interested in the global effects, Option 1 will be sufficient. For models where you are interested in knowing the interactions of the bolt head with the plates then Option 4 would be adequate. As there is no clear-cut answer to which is the *best* option, we encourage you to experiment and discover which option would best suit your model.

If your analysis requires even further detail then you will need to model your bolt with brick elements. 

Benchmark

In each newsletter we will introduce a new benchmark that users can add to those already supplied with the Strand7 software in the form of the verification tests.

In this edition we will look at a heat transfer problem. The source of this benchmark is **EN ISO 10211-1:1995 Case 3**.

The heat transfer in a structure consisting of two walls meeting in a corner and a single floor is analysed. The boundary conditions applied are labelled with Greek letters α , β , γ and δ (see Benchmark Figure 2 and the Benchmark Table 1). Results of interest are the temperatures at the six points labelled U to Z in Benchmark Figure 1 and the heat loss/gain through α , β and γ surfaces shown in Benchmark Figure 2. Material and geometry data are shown in Benchmark Figure 2.

Label	Boundary Condition
α	$T = 20^{\circ}\text{C}$, $R = 0.2 \text{ m}^2\text{K/W}$
β	$T = 15^{\circ}\text{C}$, $R = 0.2 \text{ m}^2\text{K/W}$
γ	$T = 0^{\circ}\text{C}$, $R = 0.05 \text{ m}^2\text{K/W}$
δ	$Q = 0$ (Adiabatic)

Benchmark Table 1: Boundary Conditions

Target values:

Temperatures at the points shown in Benchmark Figure 1:

U = 12.9°C X = 12.6°C
 V = 11.3°C Y = 11.1°C
 W = 16.4°C Z = 15.3°C

Heat flow through surfaces shown in Benchmark Figure 2:

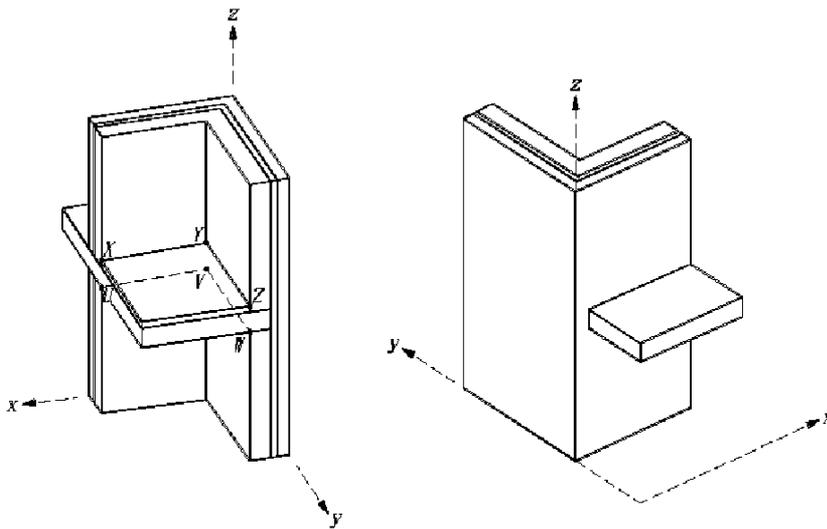
$\alpha = -46.3 \text{ J/s}$
 $\beta = -14.0 \text{ J/s}$
 $\gamma = 60.3 \text{ J/s}$

The building corner was modelled using linear and quadratic versions of the TETRA, WEDGE and HEXA brick elements. The number of elements employed in the models that are used for checking solution convergence is shown in Benchmark Table 2.

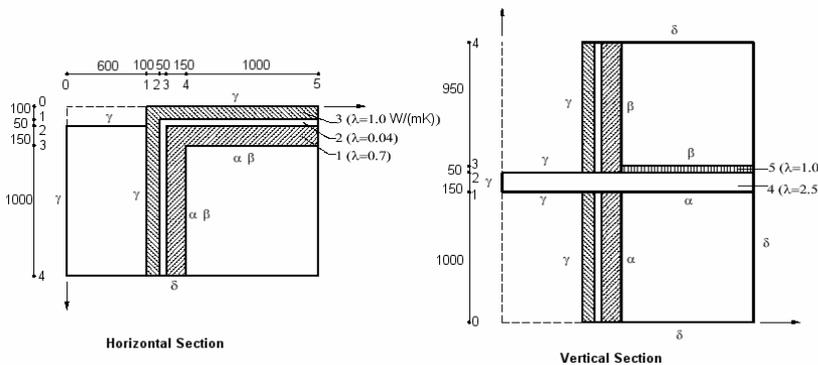
Element Type	Model
TETRA	6576
WEDGE	2192
HEXA	1096

Benchmark Table 2: Number of elements used

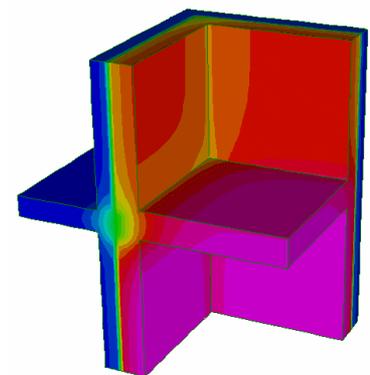
The heat flow results were obtained by summing the node fluxes on the relevant surfaces. The results are summarised in Benchmark Table 3.



Benchmark Figure 1: 3D Steady heat transfer problem



Benchmark Figure 2: Horizontal and Vertical Sections showing geometry, material properties and boundary conditions



Benchmark Figure 3: Temperature contour

Exclusively to readers of News.St7: you can download this benchmark model from the News.St7 readers page of our website:

www.strand7.com/News.St7.html

Strand7 Results summary:

Element	Temperature Results (degree difference)						Heat Flow Results (% difference)		
	U	V	W	X	Y	Z	α	B	γ
TETRA4	13.0 (0.1)	11.5 (0.2)	16.5 (0.1)	12.5 (0.1)	11.0 (0.1)	15.3 (0.0)	-47.7 (3.0)	-14.3 (2.1)	62.1 (3.0)
TETRA10	12.9 (0.0)	11.5 (0.2)	16.4 (0.0)	12.5 (0.1)	11.1 (0.0)	15.3 (0.0)	-46.3 (0.0)	-13.9 (0.7)	60.2 (0.2)
WEDGE6	12.8 (0.1)	11.7 (0.4)	16.5 (0.1)	12.3 (0.3)	11.1 (0.0)	15.3 (0.0)	-47.6 (2.8)	-14.3 (2.1)	61.9 (2.7)
WEDGE15	12.9 (0.0)	11.5 (0.2)	16.4 (0.0)	12.5 (0.1)	11.1 (0.0)	15.2 (0.1)	-46.3 (0.0)	-13.9 (0.7)	60.2 (0.2)
HEXA8	13.0 (0.1)	11.6 (0.3)	16.6 (0.2)	12.5 (0.1)	11.3 (0.2)	15.3 (0.0)	-47.2 (1.9)	-14.2 (1.4)	61.3 (1.7)
HEXA20	12.9 (0.0)	11.4 (0.1)	16.4 (0.0)	12.5 (0.1)	11.2 (0.1)	15.3 (0.0)	-46.3 (0.0)	-13.9 (0.7)	60.2 (0.2)

Benchmark Table 3: Summary of results obtained from the Strand7 models.

An important point about this benchmark is that it demonstrates that Strand7 can be used to determine heat flows (gains/losses) through structures. This can be very important for estimating energy requirements in buildings and other structures or processes.

The results in Benchmark Table 3 (with differences shown in brackets) indicate that total heat flows can be modelled quite well even with low order elements. This is a little different to what one would expect when using low order elements for stress analysis.

Finally, actually calculating the heat flows α , β , γ and δ is very simple in Release 2.2 when using the Flux summation option of the Peek tool, provided that the option Calculate Node Flux has been set at the commencement of the solution.

Thanks to Imagineering UK, the Strand7 agent in the UK, for sourcing this benchmark. Imagineering UK can be contacted on: Website: www.iuk.co.uk Email: info@iuk.co.uk

Training

This year we have already held courses covering 'Introducing Strand7', 'Nonlinear analysis' and 'Structural engineering'.

If you wish to attend one of the courses, then check the dates in the calendar and make your booking before it's too late. You can find full details of the content of the courses, prices and booking form at www.strand7.com; then select 'training' from the contents menu. 

Training Calendar

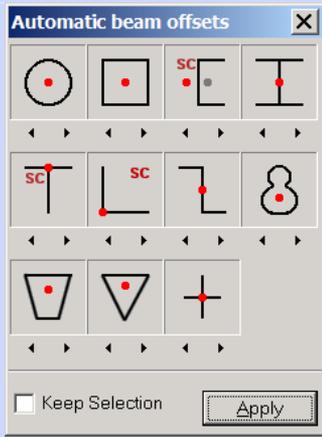
2003

7-10 July	Introducing Strand7
11 July	Heat transfer
14 July	Automeshing
15-16 July	Nonlinear analysis
17-18 July	Dynamic analysis
11-14 Nov	Introducing Strand7
18-19 Nov	Dynamic analysis
20-21 Nov	Structural engineering

Did you know?

Shear centres of beams

By default, Strand7 beam elements are positioned such that the element's nodes coincide with the section's centroid. In sections such as C-sections, where the shear centre is not located at the centroid, significant twisting displacements will be generated due to lateral (shear) loads. If your structure is constructed in such a way that this twist is restrained, due to the load passing through the shear centre, you can offset your section such that the nodes are located at the shear centre of the section. You can do this automatically with the *Auto Assign Beam Offsets* tool.



Exhibitions

This year we have so far planned to exhibit at the shows listed below. If you get the chance then we would be delighted to meet you at these exhibitions and discuss Strand7 with you. If not, we hope to publish a few snapshots of each exhibition in the next issue of News.St7. ■■

May 29-31, 2003

2003 Structures Congress & Exposition

Booth #304

Seattle, USA

www.asce.org/conferences/structures2003

June 2-4 2003

Atlantic Design & Manufacturing Show

Booth #1256

New York

www.atldesignshow.com

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