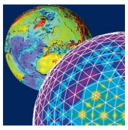
product option

LUSAS
Finite Element Analysis

Nonlinear Analysis



Nonlinear stress analysis is becoming increasingly important with designers employing a wider variety of materials in a multitude of different applications. The LUSAS Nonlinear option is rightly regarded as the leader in nonlinear analysis and provides the very latest powerful techniques for solving problems having either material, geometric or boundary nonlinearity.

For All Applications

Compared to other finite element systems, LUSAS contains some of the most advanced facilities for nonlinear analysis that are available today. The Nonlinear option is particularly effective in reducing the design and computer time required to solve all types of complex nonlinear problems. Because LUSAS was initially designed as a nonlinear analysis system, the features included in the Nonlinear option can be combined with the other LUSAS analysis options. As a result, the Nonlinear option can not only be used to solve a multitude of problems having large deformations, high levels of material nonlinearity and complex boundary conditions but it can also be combined with the LUSAS Dynamic and Thermal / Field options to solve problems in which the effects of time and temperature are important.

Ease of Use

The Nonlinear option includes features such as automatic load incrementation, automatic step reduction upon convergence failure and flexible restart facilities. These features enable newcomers to nonlinear finite element analysis to quickly become proficient in solving nonlinear problems.

Reliable Convergence

The robust automatic load incrementation, arc length and step reduction procedures mean that, in situations where other systems fail to converge, LUSAS reaches an accurate solution efficiently. For maximum flexibility any chosen incremental and iterative strategy may be specified using either load or displacement control, based on full or modified Newton Raphson iterations with optional line searches. Fine control is provided by monitoring the solution using a wide selection of convergence criteria.

Restart Facility

The restart facility enables nonlinear solutions which have been interrupted or terminated before completion to be restarted without the need to re-analyse the problem from the start. When using the restart facility analysis data can be optionally saved at regular intervals or, for large nonlinear problems where disk space may be a major consideration, the analysis data maybe saved for the last converged solution(s). Analyses may be restarted from any saved data as required.

Material Nonlinearity

LUSAS contains a wide selection of material models for the analysis of elasto-plastic, ductile fracture, cracking, damage and creep applications. There are nonlinear material models for metals, plastics, composites, rubber, foam, soils, rock and concrete. These material models may account for temperature dependent effects if required. Both isotropic and anisotropic nonlinear material models are available and material response may be dependent on the history and direction of straining. The direction of anisotropy is fully user definable. To ensure a fast and efficient solution the von Mises and Hill material models use a consistent formulation in the evaluation of the stiffness matrix which provides quadratic convergence characteristics. The speed of stress computation has been optimised by using the latest backward Euler technique. In addition, material, damage and creep model interfaces are provided so user defined material definitions may be added as required.

Creep

The creep facility allows time dependent material behaviour to be carried out efficiently. The creep algorithm is self-starting (it requires no preliminary linear solution) and automatically computes the most appropriate time step required in the transient analysis. A wide range of materials may be modelled by combining the creep algorithm with time independent plasticity both of which may be temperature dependent. In addition to the standard creep laws, non-standard laws may be incorporated via a user-defined creep interface.

Geometric Nonlinearity

Geometric nonlinearity needs to be accounted for when the structure deforms to such an extent that the original geometry and/or position and direction of the loads significantly affect the structural behaviour. Many LUSAS elements can accommodate large deformations and large rotations and the latest co-rotational formulation ensures that large strains can be accommodated when necessary.

Boundary Nonlinearity

For analyses with nonlinear boundary conditions LUSAS has a number of features for modelling contact and impact. Support lift-off may be modelled using a variety of nonlinear joint models while a powerful slideline facility helps to simplify the analysis of all types of general contact problems. The slideline and slidesurface facility may be used to model general contact between otherwise unconnected element groups in nonlinear and dynamic analysis. Typical uses include problems involving friction, impact / energy absorption and metal forming processes. A tied slideline option also exists which can be used in linear and nonlinear analysis to eliminate the need for a transition mesh region between areas of the model having coarse and fine mesh densities. For sensitive contact problems in which rapid convergence is difficult to achieve due to large changes in forces in the contact region a close contact detection facility is provided. This facility checks for any nodes that are about to come into contact and creates a transition zone, cushioning the nodes before full contact is reached. Both curved and rigid surface contact can be accomodated. For nonlinear static analyses where the surfaces of a slideline need to be brought into contact under the action of the applied loading and interface forces before the analysis proceeds a pre-contact facility is provided. This allows the surfaces of a slideline to be defined with a gap between them. The pre contact facility acts like a magnet in bringing the bodies into contact to avoid unrestrained rigid body motion. Boundary conditions can include springs and single or multi-point constraints.

Loading

Loading may be applied as prescribed displacements, point, distributed or body loading. This loading may be varied over the structure using a comprehensive variation facility and/or varied as the analysis progresses using an integral load curve facility. Both conservative loading (where the load direction does not change with deformation) and non-conservative loading (where the load direction changes with deformation) can be applied. Initial or residual stresses and strains and temperature loading can also be specified.

Stress Stiffening Effects

In rotating machinery the effects of rotation can have a significant effect on the natural frequencies of the structure. Within LUSAS the load correction terms required to accurately take account of the effects of rotation are introduced by carrying out an initial nonlinear analysis prior to carrying out a natural frequency analysis. For structures, such as cables in which applied loading, initial residual stress, or varying material properties can significantly affect the structural stiffness a frequency analysis can also be undertaken after a nonlinear analysis.

Element Birth and Death

In many application areas parts of the structure need to be added to or removed from the finite element model as the analysis progresses. Within LUSAS such an event can be accommodated using the birth and death facility. Any residual forces present after activation or deactivation of elements can be re-distributed to surrounding elements under user control. Additional options allow the definition of relaxation at any boundary together with the number of increments over which the activation/deactivation takes place. The birth and death facility enables problems such as general excavation, tunnelling and bridge construction to be accurately modelled.

Results Processing

In addition to all the usual powerful contouring, graphing and plotting features in LUSAS Graphics, a large number of specific nonlinear results processing features are available. These include:

- Automatic load-displacement graphs
- Viewing of material yield
- Viewing of concrete crack directions
- Graphing of analysis control criteria
- Animation of structure deformation
- Visualisation of contact zones and contact pressure

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- Incremental solutions with iterative correction
- User defined combination of full or modified Newton Raphson iterations with line searches
- Automatic arc length solution procedures with option for non-proportional loading
- Automatic step reduction on convergence failure
- Automatic load incrementation
- Wide selection of convergence criteria
- Robust, efficient isotropic and anisotropic nonlinear material models
- Temperature dependent material properties
- Load or displacement control
- Follower loads
- Residual stress input
- Large deformation, large rotation geometric nonlinearities
- Large strains
- Changing boundary conditions
- Nonlinear friction and gap models
- Nonlinear slidelines and slidesurfaces for contact and friction
- Automatic pre-contact algorithm
- Centripetal stress stiffening
- Element birth and death facility

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