CALHOUN

FACT SHEET

3D NON-LINEAR FINITE ELEMENT ANALYSIS

3D NON-LINEAR FINITE ELEMENT ANALYSIS FOR ENGINEERED FABRIC STRUCTURES

3D Non-linear Finite Element Analysis (FEA) software is a design tool that allows engineers to determine the stresses and displacements of structure in response to defined loads and constraints. FEA has become the preferred method for determining the required size and configuration of structural components based on site-specific conditions. 3D Non-Linear FEA is a more accurate and efficient method versus manual mathematical calculations and data sheets.

WHAT IS 3D NON-LINEAR FINITE ELEMENT ANALYSIS?

The aerospace industry is credited with advancing the application of 3D Non-Linear FEA to fulfill the crucial need for an accurate stress analysis of lightweight frames exposed to non-consistent aerodynamic loading forces.

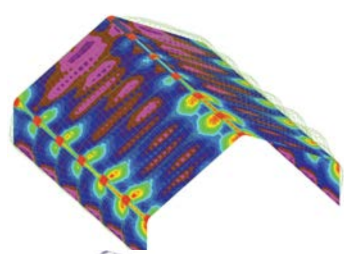
For a building system, lateral loads from winds, vertical loads from accumulated snow, other live and dead loads, and seismic loads must all be considered to determine the required structural capacity of each component.

Along with the parallel growth of 3D modeling in the architectural and engineering industry, high-speed processors have become available which enable FEA to be used for site-specific design of structures with fewer materials and greater reliability. This makes 3D Non-Linear FEA applications perfect for tensioned fabric structures.

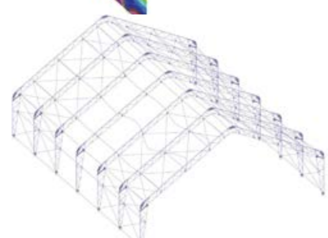
Some fabric structure manufacturers use computations based on the simplified and idealized properties of each fabricated steel component, and apply traditional industry practices with reference to standardized load tables. 3D Non-Linear FEA ensures fabric structures are engineered to the highest possible standard.

The inclusion of site-specific variables takes the design process further. Each structure is considered within its intended environment ensure the loads and constraints (also known as boundary conditions) used in FEA, accurately represent the site conditions.

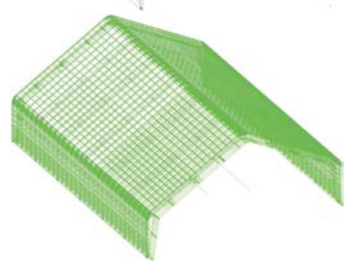
This design phase considers applicable codes and standards, the proposed structural framework, site topography, foundation conditions, and climate conditions. The overall process allows calculation of detailed reaction loads that will in turn allow for an optimized foundation design.



FABRIC STRESSES AND SCALED DISPLACEMENT



LOWEST MODE BUCKLED SHAPE FOR USE IN STABILITY CHECKS



ENVELOPE LOADING D+CL+WIND PARALLEL+IP CONDITION

UNDERSTANDING THE TERMS

A conceptual understanding of 3D Non-Linear Finite Element Analysis is found within the term itself:

NON-LINEAR

To accurately predict the behaviour of some structural systems, a nonlinear (or not constant) approach is required. This can occur, in the case of fabric buildings, when the deflection of the structure is large enough that the load paths through the structure under load differ substantially from the un-deformed shape.

FINITE ELEMENT

Components of the structural system are broken down into limited, or finite, elements. A system of equations for each finite element depends on the behaviour of each neighbouring element or boundary condition. In this fashion, a simulation model is built to calculate the behaviour of the entire structure, often involving millions of equations.

ANALYSIS

The system of equations for the simulation model is solved on very fast computer workstations. The solution time is typically several hours for a fabric structure.

POST-PROCESSING

Once the simulation model is solved, a review of the model ensures the model accurately simulated the behaviour of the structure, and that each component has sufficient capacity for the required demand. 3D Non-Linear FEA is a powerful tool for simulating complex structural systems in a fraction of the time with greater accuracy than can be achieved otherwise.

3D Non-Linear FEA is capable of simulating complex loading and the resulting relatively large displacements to validate the strength of a fabric structure. The end result is a process that can accurately determine the required structural capacity to meet site-specific demands and ensure a reliable structure

BUCKLING ANALYSIS

During the course of each and every site-specific analysis, a buckling analysis is completed at minimum for each of the controlling load combinations. This analysis ensures that the assumptions for the effective length estimates used to identify in the mass checks are suitable for the actual site-specific conditions, and whether second-order effects are a consideration in the design.

Buckling analysis is especially important for large displacement structures with tension-only elements since intermediate values of loads may generate instabilities that could otherwise go unnoticed in a static analysis. This could lead to failures well below the design load if not properly addressed. The systemic 3D buckling analysis goes to ensure that these intermediate instabilities are addressed in the design.

BENEFITS OF USING 3D NON-LINEAR FINITE ELEMENT ANALYSIS

> Provides significant insight and design guidance to create better products

> Safety and reliability qualification

> Reduced lead time in manufacturing

> Enhanced product development and performance

DETAILED WIND AND SEISMIC ANALYSIS

For each and every site-specific analysis, a comprehensive seismic analysis is completed which includes the modal response behavior of the building and the building's actual fundamental period. This analysis is also used in the wind design to ensure that the period of the structure will not substantially affect the behavior of the structure during a wind event.