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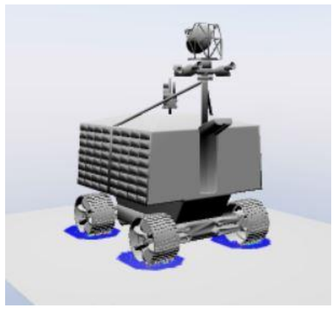
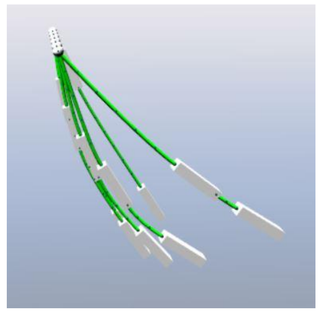
Investigation of the abilities of Project Chrono with focus on finite element simulations

Project Chrono

Finite Element Analysis has become a really powerful tool in structural engineering along the years. With that, many simulation software that allow for FEA have been developed. Project Chrono is one of them and has been gaining more and more attention each year. Project Chrono is however not a fully fledged out piece of software like ANSYS or SolidWorks, but an open-source multi-physics modelling and simulation engine. It is mostly coded in C++ language and structured in multiple libraries and modules. It mainly offers possibilities for FEA and contact simulations, but its use can be expanded using the optional modules. In this work, the objective was to analyze what Project Chrono offered for performing FEA simulations and how well it did it.



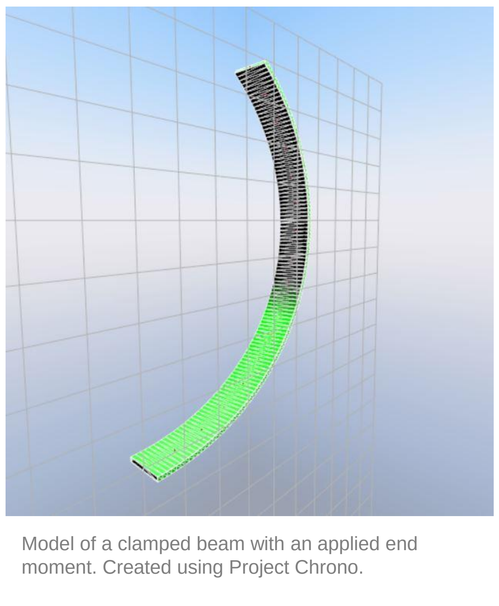
Project Chrono demo for a rover pressing on ground



Project Chrono tutorial for cables.

FEA Implementations

Project Chrono counts with a number of different node and element types. The node-types differentiate amongst themselves with respect to how many degrees of freedom they have and what those are. Regarding element types, one can find various options for beam, shell, and solid elements. These element types are available using the classical FEM formulation and using the Absolute Nodal Coordinate Formulation (ANCF), which is another FEM formulation where the direction of the elements is computed using nodal gradient position vectors instead of rotational matrices. Material models for elasticity, plasticity and viscosity are also available for most elements. Single or multiple loads can be applied to the nodes with simple methods or by creating the force implementation oneself. The same applies for boundary conditions, which in some cases can be created using Links. Finally, meshes can be either created in Project Chrono or imported, as well as exported for further use. Finally, one is not restricted to use only the implementations found already in the code since it is encouraged to create custom classes if something more specific is needed.

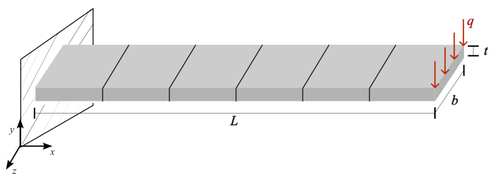


Model of a clamped beam with an applied end moment. Created using Project Chrono.

Benchmark Tests

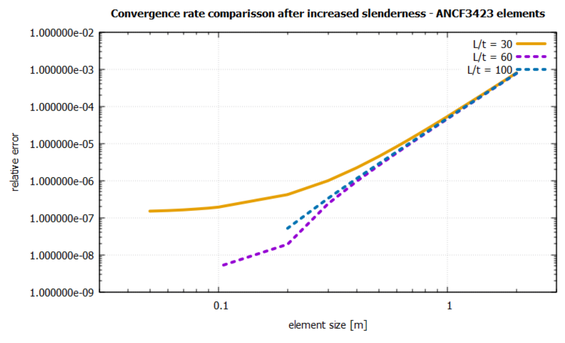
Benchmark tests were run with Euler-Bernoulli beam elements and Reissner-Mindlin and ANCF shell elements.

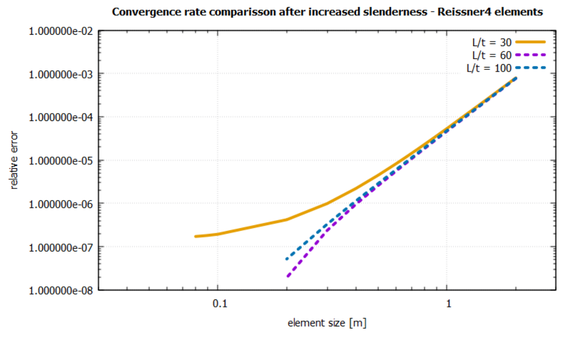
With the linear test, the displacement's convergence was tested and observed in regards to transverse shear locking, only with shell elements.

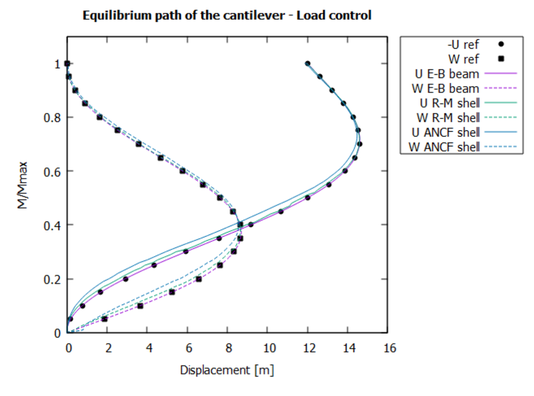


The shell elements showed good convergence and no shear locking behavior.

In the non-linear test, the ability to model nonlinear behavior for all elements mentioned was tested.







Literature

- Project Chrono – URL https://projectchrono.org/
- Recuero, A. ; Negrut, D.: The Absolute Nodal Coordinate Formulation - ANCF
- Berzeri, M. ; Shabana, A.A.: Development of simple models for the elastic forces in the absolute nodal co-ordinate formulation. In: Journal of Sound and Vibration 235 (2000), S. 539–565

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