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Structural Analysis of Steel Sectional Water Tanks

Abstract

The goal of the study is to determine the optimal structural distribution of internal connections in sectional water tanks of different sizes. To do so, an automatic generation and simulation of tanks of any dimension has been programmed, analyzed and structurally optimized. Numerical Simulation, Finite Element Analysis and Statistical Design of Experiments are the main techniques used to achieve this goal.

Different configurations have been selected as optimal depending on a wide range of sizes of the water tanks. This project helps product designers and companies to reduce the cost of the water tanks without compromising structural viability. The generated script is also intended to be useful as academic example of large-scale models in numerical simulation.

Process

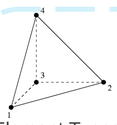
Step 1. Geometric & FEA Data Input

Geometric Input

Height - Width - Depth

Internal Connections

FEA Input



Element Types

Material

Mesh

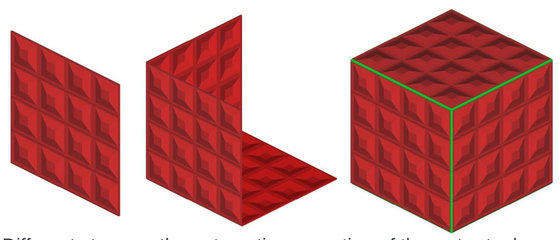
Boundary Conditions

Loads

[Images courtesy of The Noun Project]

Step 2. Automatic Tank Creation

Automatic generation of the tank using a parametric file. To do so, only geometric input is required.

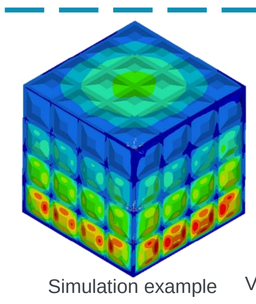


Different steps on the automatic generation of the water tank

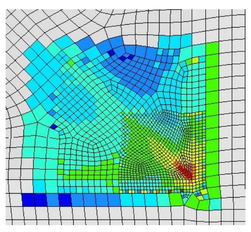
[Images courtesy of Altair Engineering, Inc. Release 13.0]

Step 3. Simulation & Verification

Numerical Simulation is applied to the resultant model to obtain results and verifications of its behaviour.



Simulation example

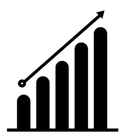


Verification example: refinement

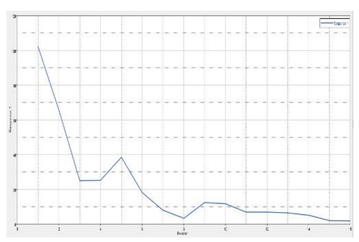
Verification

[Images courtesy of Altair Engineering, Inc. Release 13.0 and The Noun Project]

Step 4. Optimization



Optimization



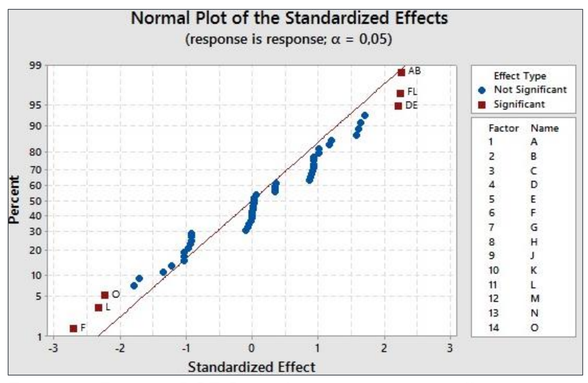
Design of Experiments using statistical software

Design of Experiments techniques are used to find the best possible solution amongst the feasible ones

[Images courtesy of Minitab-Academic. Release 17.0 and The Noun Project Users CC BY-SA 3.0]

Numeric Example

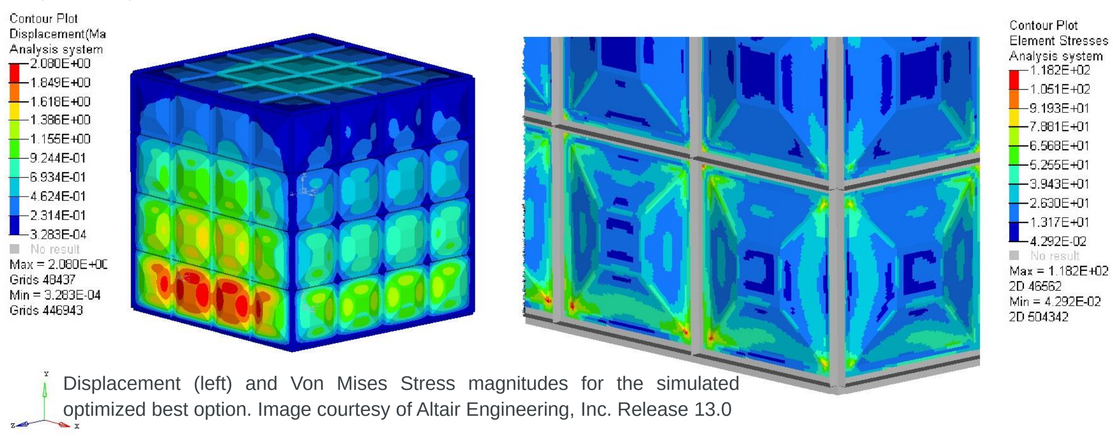
The following example shows the optimization procedure for tanks of reduced size (up to 10 panels in width or depth). Further optimization processes have been performed for tanks of bigger measures (refer to the report). The model goes through two statistical DOE techniques: Fractional and Full Factorials to obtain a concrete internal bar distribution



Fractional Factorial DOE Study. In red, the relevant effects.
Image courtesy of Minitab-Academic. Release 17.0

Successive simulations (64 and 32, in this optimization procedure), lead to the presented solution, with relative small displacements and assumable stresses.

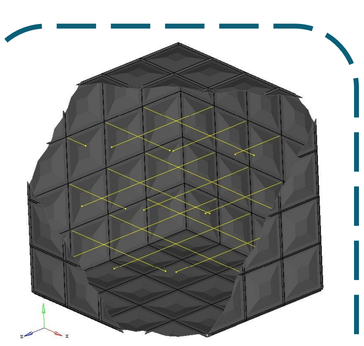
Max. Displacement	Max. Stress
2.08 mm	118 MPa



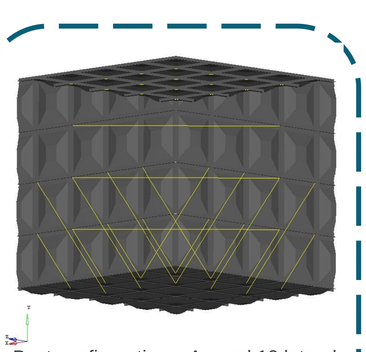
Displacement (left) and Von Mises Stress magnitudes for the simulated optimized best option. Image courtesy of Altair Engineering, Inc. Release 13.0

Conclusions

For the following sizes, different combinations of internal connections have been found optimal. The user of the script will found these solutions already integrated on it, allowing for a fast generation and computation of the tank of desired size.



Best configuration - Small Tanks. Up to 10 lateral panels



Best configuration – Around 10 lateral panels, circumstancial solution.

Best configuration – Big Tanks, no limit on lateral panels

[Images courtesy of Altair Engineering, Inc. Release 13.0]

Supervisor: Dr.-Ing Anton Tkachuk
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