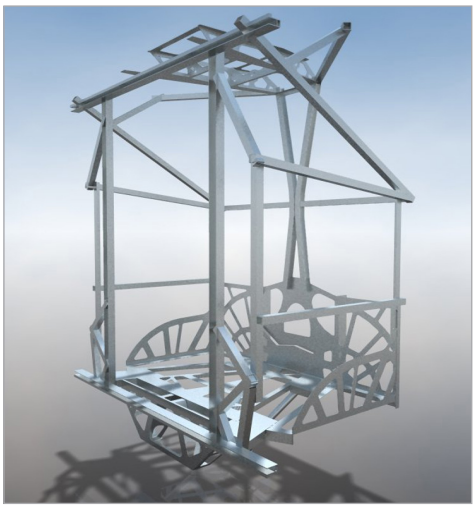
Developing a Revolutionary Elevator System for Tall Buildings



ThyssenKrupp

Key Highlights

Industry
Elevators

Challenge
Explore weight saving strategies for a new, cable-less elevator system

Altair Solution
Optimization technology applied to find the ideal material layout. New material configurations explored.

Benefits
- 56% under target weight
- Design met all performance targets

In the architecture industry, buildings are being built taller and ever more elaborately. The current world's tallest skyscraper, the Burj Khalifa in Dubai, UAE, stands at 828 meters (2,717 feet) tall. This impressive height brings with it a unique set of challenges, one of which is how to transport people from the ground floor to the top efficiently.

The majority of elevator systems in operation today pull the elevator up and lower it down via cable systems located in the top floor of the building. However, these systems generally offer a maximum ride height of up to 400 meters (1,312 feet), just half the distance of the world's tallest building. Relying on this traditional system, passengers would need to ride two or more elevators to reach the very top level.

ThyssenKrupp Elevator, part of the Germany based ThyssenKrupp Corporation, is one of the world's leading elevator companies. With sales of €6.4 billion and more than 50,000 employees at 900 locations, the company's products are installed in buildings throughout the world.

ThyssenKrupp Elevator's design and engineering teams developed an elevator which makes use of electro-magnetic drives attached to the frame of each cabin. The system does not require any roof mounted cables and can travel the full 800 meter distance with ease. In addition, it allows the elevators to move horizontally as well as vertically. The new concept brought its own challenges, chief among these being the fact that the system would not be able to carry as much weight as a traditional elevator.

Keywords: Concept optimization, carbon fiber

ThyssenKrupp Elevator Success Story

"The concept optimization process on the BackPack structure, in combination with the sizing optimization of the sandwich panel walls, managed to produce a cabin that was 42% less than the target weight. If the walls were constructed from carbon fiber, it would be possible to go even further, down to 56% below target."

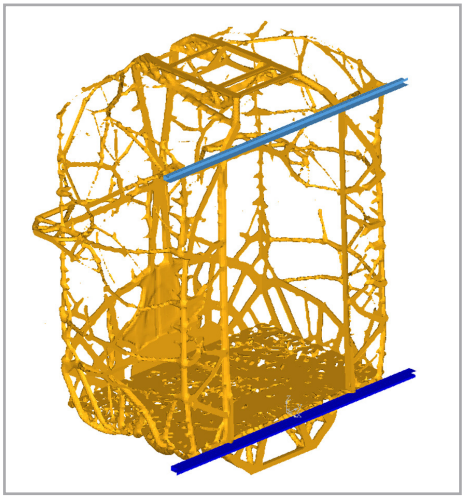
ThyssenKrupp Elevator wanted to explore ways to ensure that the new design was as lightweight as possible in order to maximize the loading capacity of the cabins. Altair ProductDesign was selected to explore methods and materials that could help to minimize the weight of the design due to the company's experience in removing mass from products in the automotive and aerospace sectors.

ThyssenKrupp Elevator had developed two concept designs related to how the electro-magnetic drives would lift the cabin. The first was the 'BackPack' concept which placed an electro-magnetic drive on the rear of the cabin, lifting it by a support structure from underneath.

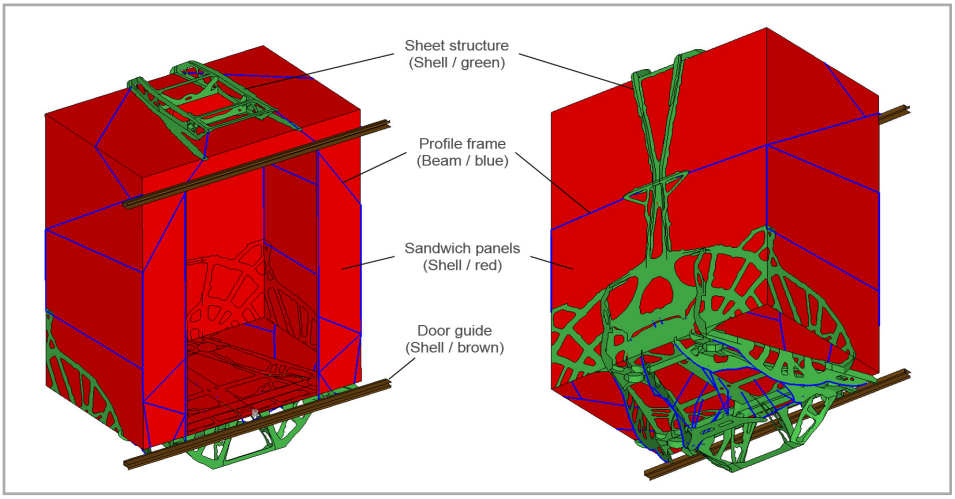
The second was the 'SideGuide' concept which used a frame built around the cabin with drives on the left and right to provide the lift. ThyssenKrupp Elevator's weight targets for both the BackPack and SideGuide designs were extremely low compared to traditional cabin designs.

Using Optimization Technology to Minimize Weight

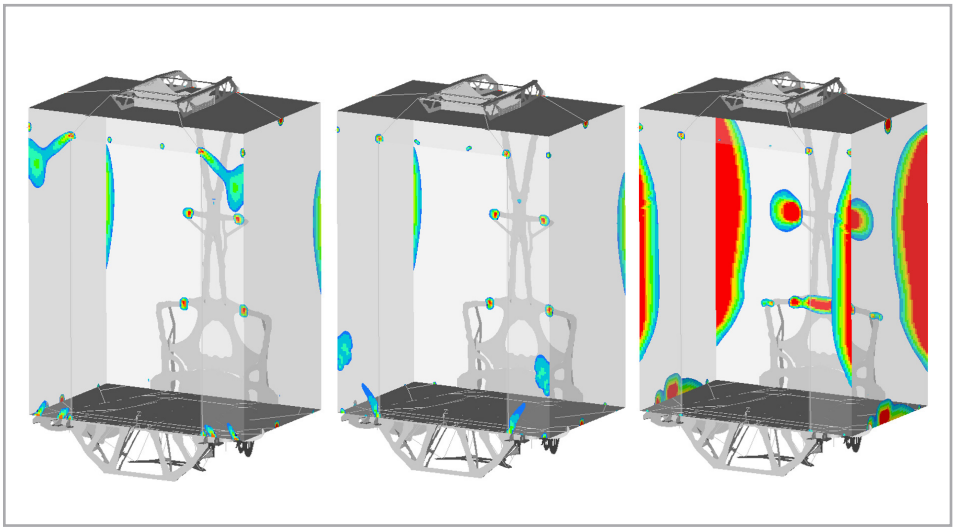
To achieve these targets, Altair ProductDesign developed a three stage approach. In the first stage, the team performed a topology optimization study on the BackPack concept using OptiStruct™, the design optimization solution within Altair's HyperWorks suite of simulation tools. With the freedom to create a totally new design, the team specified the cabin's 'design space'; the areas of the structure where the software was free to remove material and



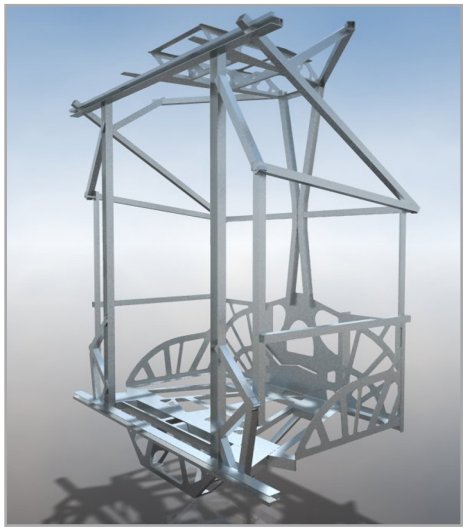
Concept topology optimization results



Design interpretation of the topology results



Exploring the ply shapes and orientation of the carbon fiber sandwich panels



A render of the final BackPack design

where it had to remain in place (such as the door guides). Loading information such as acceleration forces on the floor, occupants leaning on one of the walls, or a person standing on top of the cabin was gathered from ThyssenKrupp Elevator and entered into the software. OptiStruct was then able to suggest the most efficient layout of material for the cabin's structure while meeting design requirements. The results of the topology optimization study were then interpreted by Altair ProductDesign into a material layout that could be manufactured.

Exploring New Material Configurations

With the basic structure of the cabin defined, Altair ProductDesign was able to move to the second stage where the thicknesses of the materials could be investigated. Altair's team wanted to investigate the potential to minimize weight further through the use of different material configurations.

The walls of elevator cabins are usually made from metallic sheet panels, however Altair and ThyssenKrupp Elevator wanted to explore the lightweight potential of sandwich panel structures where aluminium or plastic facing sheets are used with a foam core. Using OptiStruct again, the team was able to perform a sizing optimization process where the technology would explore the thicknesses of the wall facing sheets and the foam core. Profile sections and sheet thicknesses were optimized at the same time in order to find the ideal layout for the different material combinations.

The third stage of the project involved exploring new materials. Altair ProductDesign has considerable experience in working with carbon fiber in the automotive and aerospace markets where the material is gaining traction as a lighter alternative to metals. The team wanted to explore its potential for the walls of the new cabin and set about developing an optimization study that would find not only the ideal thickness of material, but also the ideal fiber ply shapes and lay-up orientation of each layer. The same process was also applied to the SideGuide concept with the aim of providing detailed results to ThyssenKrupp Elevator to inform its decision on the best system to continue to develop.

Achieving Weight & Performance Targets

The weight reduction project produced some impressive results. The concept optimization process on the BackPack structure, in combination with the sizing optimization of the sandwich panel walls, managed to produce a cabin that was 42% less than the target weight. If the walls were constructed from carbon fiber, it would be possible to go even further, down to 56% below target.

The SideGuide concept also saw weight savings, 16% lighter than target using traditional materials with the potential to go to 33% under target using carbon fiber. The weight savings gave ThyssenKrupp Elevator additional confidence in the electro-magnetic concept as a practical alternative to the cable system. Motivated by the positive results from this project, ThyseenKrupp Elevators is continuing development of the BackPack concept. The design has now advanced for further testing and prototyping.

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Altair is focused on the development and broad application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held with more than 2,600 employees, Altair is headquartered in Troy, Michigan, USA and operates more than 45 offices throughout 24 countries. Today, Altair serves more than 5,000 corporate clients across broad industry segments.

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About Altair ProductDesign

Altair ProductDesign is a global, multi-disciplinary product development consultancy of more than 800 designers, engineers, scientists, and creative thinkers. As a wholly owned subsidiary of Altair Engineering Inc., this organization is best known for its market leadership in combining its engineering expertise with computer aided engineering (CAE) technology to deliver innovation and automate processes. Altair ProductDesign utilizes proprietary simulation and optimization technologies (such as Altair HyperWorks) to help clients bring innovative, profitable products to market on a tighter, more efficient time-scale.

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