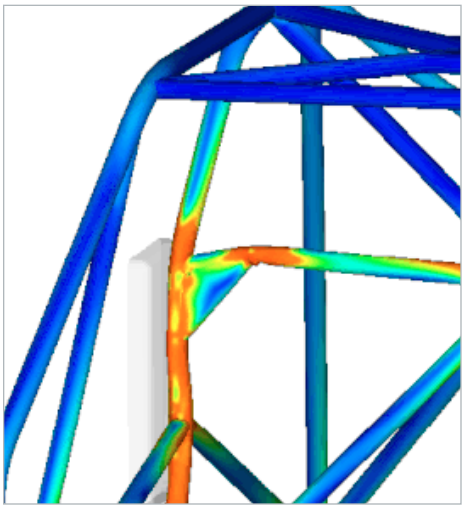
Bremar Automotion uses Altair RADIOSS to Design & Certify FIA Motorsport Roll Cages



Key Highlights

Industry
Motorsport

Challenge
To confirm the accuracy of computer modeling with physical testing of a full size roll cage as a pre-requisite to gain accreditation by CAMS and FIA.

Altair Solution
Nonlinear finite element analysis using RADIOSS

Benefits
- Greater safety of roll cage with reduced weight
- High degree of confidence in approval process

Background

The Federation Internationale de'l Automobile (FIA) is widely known as the world governing body for motorsport, and the Confederation of Australian Motor Sport (CAMS) is the representative body for the FIA in Australia. Together, CAMS and the FIA aim to ensure that motorsport events are conducted in accordance with the highest standards of safety, fairness and social responsibility.

Based in Melbourne, Australia, Bremar Automotion is an engineering design company specializing in simulation, testing, validation, and optimization of designs using Computer Aided Engineering (CAE) across a range of industries such as automotive, truck & trailer, mining, industrial equipment and motorsport. Bremar Automotion was recently granted approval from CAMS and the FIA to certify motorsport roll cages using Finite Element Analysis (FEA). This prestigious certification, granted only to approved bodies that are on the FIA's technical list No. 35, enables Bremar to independently homologate motorsport roll cages using FEA both in Australia and internationally.

Validation of A Roll Cage Virtual Model

The rollcage is the main safety item in any racecar, designed to protect the driver in the event of an accident, particularly one that involves rollover of the vehicle. In many vehicles the roll cage also forms the main structure of the chassis and they can often be a complex compromise between stiffness, safety, weight and cost.

As a requirement of their accreditation process, Bremar Automotion was required

Keywords: Roll cage, motorsport, CAMS, FIA, Bremar Automotion, RADIOSS, FEA, Rollover Protection Systems, ROPS

Bremer Automotion Success Story

“The Altair product is it for us in terms of simulation. That’s all we use. It’s great to be able to show such good correlation between the simulations and physical testing, and to have confidence in not only our approach, but also the Altair product as well. It’s a great product for us to be using, and the test results and these images just back that up for us.”

Brett Longhurst
Managing Director
Bremar Automotion

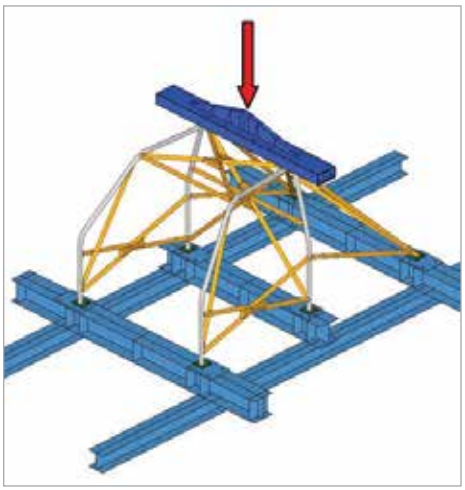
to construct and test a full size roll cage by applying the FIA’s specified roll cage loads to the structure. Destructive testing was required to confirm the accuracy of their computer modeling and to demonstrate competency to the FIA.

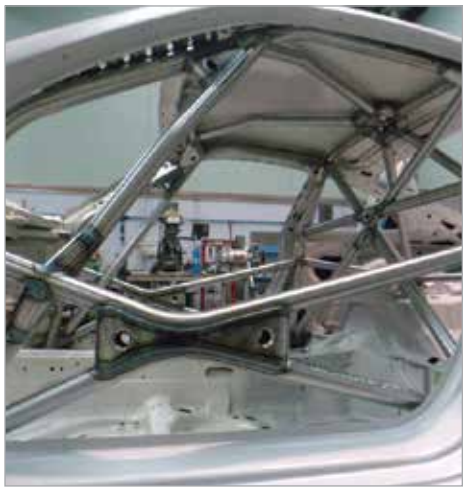
The roll cage used for the physical tests was designed by Bremar to result in a notable amount of plastic deformation of the structure under the applied loads. This required a nonlinear, high-displacement and plastic deformation FEA analysis. Since Bremar engineers were already experienced users of Altair’s HyperWorks products, RADIOSS was the obvious choice for the nonlinear analysis requirements of this project.

FIA Load Testing – Main Roll Hoop Test

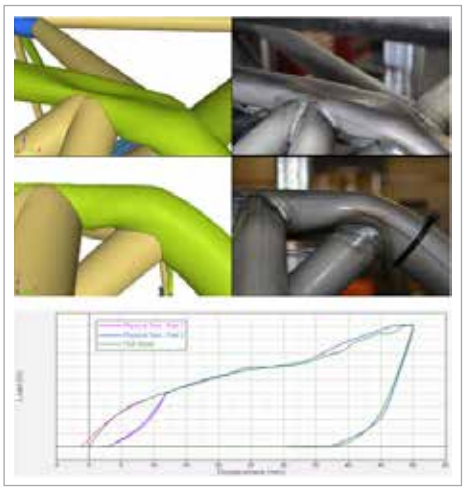
They began by designing a mild steel roll cage to suit the test rig, which was loosely based around a medium sized vehicle weighing approximately 1200kg. The FIA load required on the main roll hoop was in the order of 10T. Once the FIA load criteria had been met, they also ran another test on the main hoop where they applied the maximum allowable displacement of 50mm, which required a load well in excess of 20T. The roll cage was instrumented with multiple sensors and strain gauges in order to measure deflection and strain at various locations on the structure and allow correlation with the FEA model. The displacement and load applied by the hydraulic cylinder was also recorded.

The results from the physical test compared with the FEA results using RADIOSS demonstrated the close correlation between

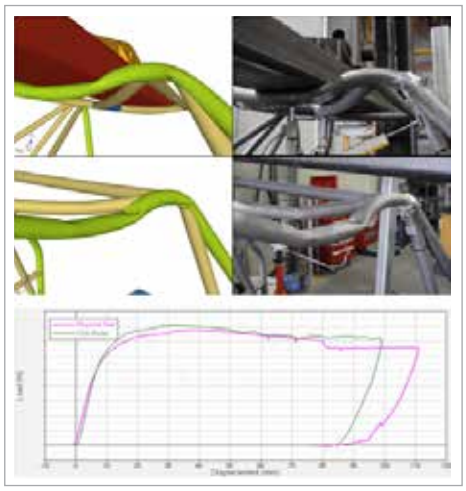




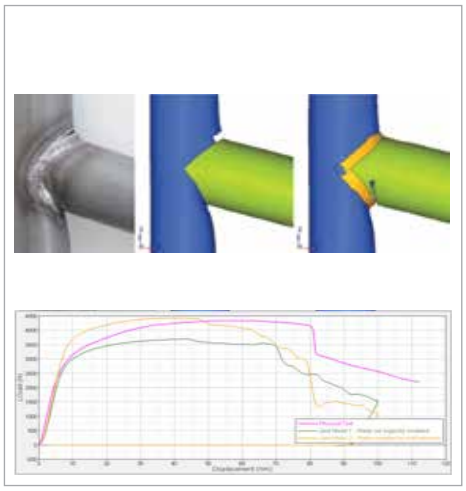
Instrumentation of roll cage with sensors and strain gauges for measurement of deflection and strain



Correlation of results – Vertical Main Hoop Physical testing with FEA using RADIOSS



Correlation of results – High Displacement Roof Test



Correlation of results – Detail T Piece Testing

the physical test and the computer model. "The graphs show the load applied to the main hoop by the hydraulic cylinder versus its displacement. There's a curve presented for the physical test, which is very close to the FEA results. The images clearly show how well the RADIOSS model correlated with the physical testing. It was very reassuring to see it lining up that well," said Brett Longhurst, Managing Director at Bremar Automotion.

Additional Testing - High Displacement Roof Test

An additional test was performed on the full cage to observe what happens at very high levels of displacement. The stamp applying the load was moved forward onto the unsupported roof section and loaded to the travel limit of the test machine at around 120mm. Simulating this level of loading and deflection was quite complex due to the highly nonlinear behavior.

Joint Tests - Detail T Piece Testing

Finally, a set of tests was performed to understand behavior around welded joints, since the roll cage structure is effectively made up of welded tube joints. Six separate tests were conducted on different sized tubes and material properties, with the intent of comparing the strength and performance of the different tube sizes and materials. These tests were also used to validate and develop methods of modeling the welded joints in the FEA analysis.
For these tests, a set of fixtures were designed to test a welded T piece. The fixtures were designed so that they can also be used for testing bolted roll cage joints to the FIA standards. Various sizes of mild steel and chromium-molybdenum steel (commonly known as chromoly) welded T pieces were tested and the FEA models of the welded regions were fine-tuned for good correlation. This was an invaluable part of the test schedule because it provided critical insights into how to model failure of these welded joints both accurately and conservatively.

Accurate Prediction of Highly Nonlinear Deformations

To achieve a higher degree of confidence in their process, some of the tests performed on the motorsport roll cage were above and beyond those required for the FIA accreditation. Bremar's test schedule also included a similar range of physical tests conducted on large Rollover Protection Systems (ROPS), as used on trucks, tractors and earthmoving machinery.

Good correlation was achieved for these tests as well, again confirming the accuracy of Bremar's simulation methods and the RADIOSS software.

"We did a range of extra tests that were not required for the FIA approval process. These additional tests were done to get as much deformation out of the structures as we could. We were interested in correlating our models in the high deformation, high nonlinear regions, so we basically pushed it as far as the test equipment would allow. In most cases, the correlation continued to stay very close over the whole range of displacement," said Mr. Longhurst, "The Altair product is it for us in terms of simulation. That's all we use. It's great to be able to show such good correlation between the simulations and physical testing, and to have confidence in not only our approach, but also the Altair product as well. It's a great product for us to be using, and the test results and these images just back that up for us." he concluded.

For more information visit:
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