2017-12-10

Scott Kebschull Bio:

Scott Kebschull is Vice President and Technical Director of Dynamic Research, Inc. of Torrance California. Scott has been with DRI for over 30 years, and during that time has been primarily involved in crashworthiness and occupant protection for passenger cars, motorcycles, and off-road vehicles. Scott was one of the main authors of the ISO 13232 Standard for evaluating protective devices on motorcycles and serves on various committees that develop standards for off-road vehicles. He is an expert in multi-body and finite element computer simulation and was responsible for the finite element simulation work that resulted in the team's winning of the Head Health Challenge III Grand Prize. Scott has a Bachelor of Science Degree in Mechanical Engineering from Valparaiso University and a Master of Science Degree in Mechanical Engineering from the University of Southern California.

Written Testimony of Scott A. Kebschull to the Committee on Science, Space, and Technology, Subcommittee on Research and Technology of the U.S. House of Representatives, "Preventing Head Trauma: The NIST-NFL Head Health Challenge 2017-12-13

BACKGROUND

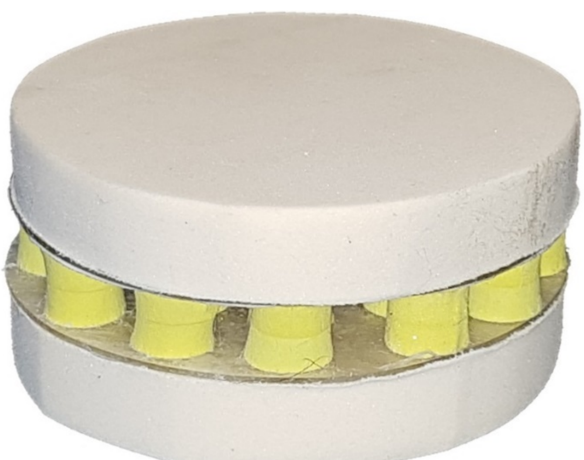
My company, DRI, partnered with 6D Helmets for the Head Health Challenge III prize competition to develop a material, suitable for use in football helmets or other protective equipment, that can better protect against traumatic brain injury. DRI is primarily involved in automotive research and testing as well as helmet research and testing. 6D Helmets designs and manufactures helmets for bicycle and motorcycle riders that uses their patented Omni-Directional Suspension technology. 6D's role in this project was to provide the IP and to fabricate the material samples for testing, and DRI's role was to manage the project, develop the Finite Element (FE) simulation models, and optimize the geometry and material characteristics.

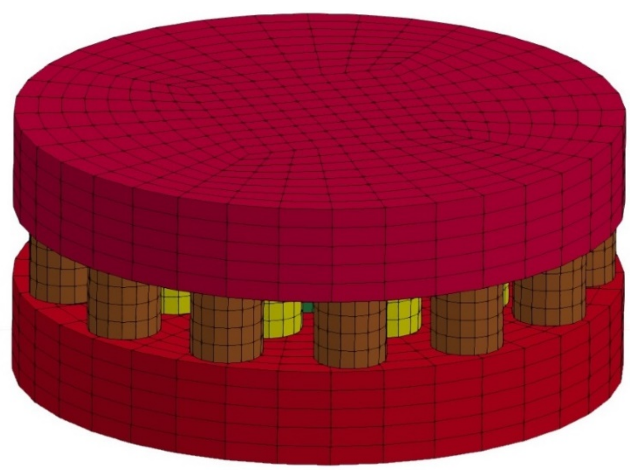
Football helmets with foam liners have been around since the 1950s. With the latest helmets available on the market, fatal head injuries are rare, but concussions still occur frequently.

Traditional helmet liners are made out of monolithic blocks of foam. When these blocks of foam are optimized for linear performance, in other words, their performance in a perpendicular impact, they are much too stiff in shear, as occurs in glancing or angled impacts. It has been known for many years that absorbing the energy in linear impacts is important for head protection, and more recently it has become clear that cushioning impacts that cause rotation of the head is also important to protecting against both severe brain injuries as well as concussions. Therefore, our goal was to develop a ***multi-impact*** material that performs well in both linear and shear impacts and in both severe and relatively minor impacts.

APPROACH

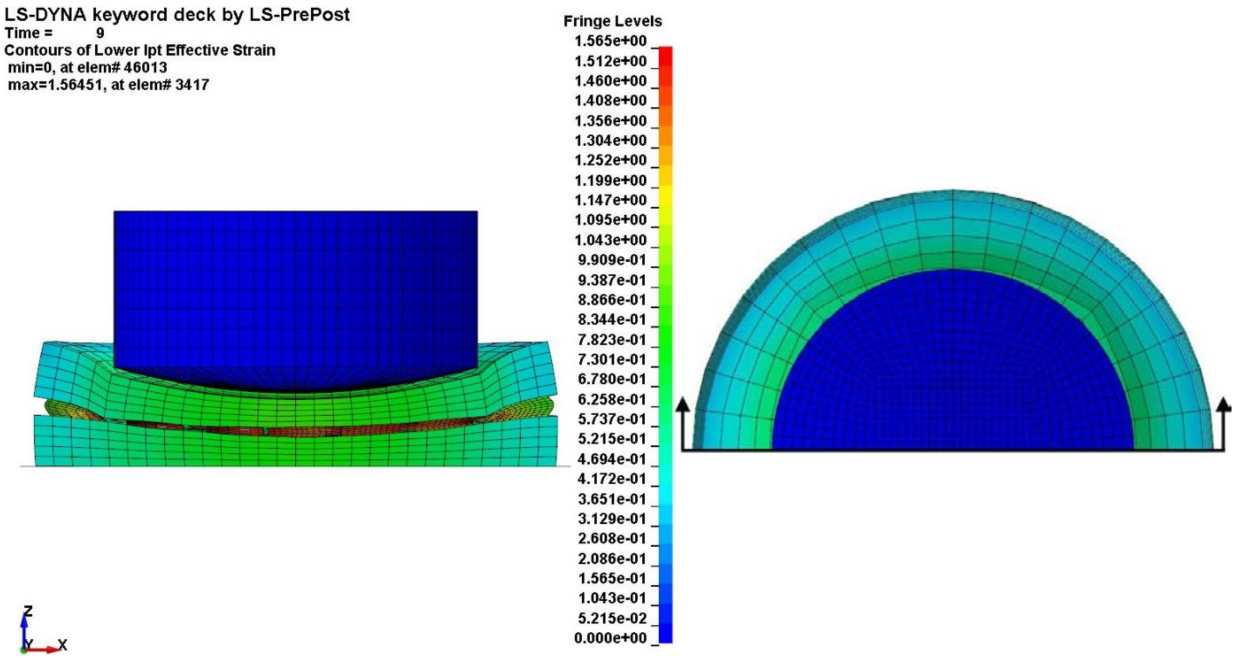
Finite Element models of the prototype material were developed as shown below. Hundreds of computer simulations were run in order to optimize parameters such as the height of the columns; the width of the columns; the spacing of the columns; and the material properties of the top foam, bottom foam, and columns.





Prototype Material (Left) and Finite Element Model (Right)

The simulations allow the evaluation of the stresses and strains at each point in time as shown in the example linear impact simulation below. The colors toward the red end of the spectrum indicate relatively higher levels of strain (deformation), and the colors toward the blue end of the spectrum indicate relatively lower levels of strain.



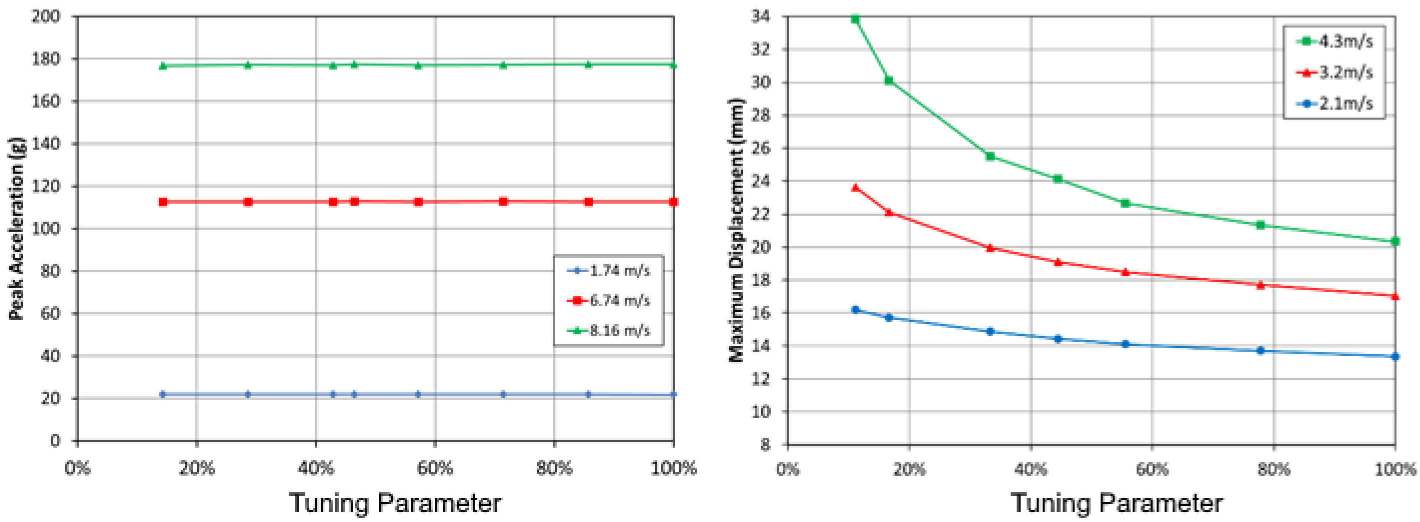
Cutaway View of FE Linear Impact Simulation Model Showing Strain Levels

Simulations were also run in order to evaluate other shapes for the columns such as cones, but ultimately the cylindrical shape was selected as the best design.

RESULTS

The material design that was ultimately selected is based on 6D Helmets' Omni-Directional Suspension (ODS) technology, modified for multi-impact usage. It comprises top and bottom layers of foam separated by a layer of foam columns glued to the top and bottom layers. As you might expect, since the layer of columns has quite a bit of empty space between the columns, this layer is softer in compression than the top and bottom layers. This provides good protection in lower speed, or minor, linear impacts. The layer of columns also allows the top layer to slide laterally and rotate relative to the bottom layer in order to mitigate shear impacts.

The key breakthrough in our research was identifying a method for making the material softer in shear without changing the linear performance, which allows optimization of the material for ***both*** linear and shear performance. The figures below show the effect of a key tuning parameter on the linear and shear performance. In these figures, as the value of the tuning parameter is reduced, the material's linear performance does not change, but in shear, the material becomes softer (allows greater shear displacement).



a. Linear Impact *b. Shear Impact*

Effect of Column Attachment in Linear and Shear Impact Simulations

NEXT STEPS

Now that we have won the Head Health Challenge III Grand Prize, our next step is to incorporate this material into a football helmet and optimize it for both linear and shear impacts in severe and also relatively minor impacts. This will involve using an FE model of an existing commercially available football helmet, including the shell, liner, and facemask. This baseline helmet would be tested in laboratory drop tests in order to validate the results of the simulation model. Then, a liner for the helmet based on the column ODS design would be modeled to replace the baseline liner, and that model would be optimized for linear impacts and shear impacts (oblique impacts) at a range of impact speeds representing sub-concussive level impacts up to very severe impacts.

LESSONS LEARNED

This research which has brought us to the point where we are now would not have been possible without the Head Health Challenge competition. The announcement of the competition solicited 125 ideas for improved materials. From that 125, the judging panel selected the most promising five finalists to receive first round funding to develop their ideas, and of those five, one was selected the Grand Prize winner.

This approach proved to be a cost-effective way of soliciting a wide variety of ideas from bright people around the country to find potential solutions to a very difficult problem. Without the science prize competition format, the judging panel would not have seen these 125 ideas and would not have benefitted from seeing how the five selected ideas could be developed.

In addition, there would not have been the added benefit of competition. It's difficult to quantify, but to me, the competition aspect was a great motivator. We spent hours pouring over our simulation models, brainstorming ideas about how to achieve the best results, and wondering what our competitors were up to.

In my view, some problems, such as the one we're talking about today, have proved to be difficult for the private sector to solve alone. Funding is very difficult to come by for ideas that have not yet reached a particular level of development, but ideas cannot reach that level of development without funding. For these problems, one of the ways that the federal government can spur innovation is through the use of science prize competitions. In partnership with key stakeholders from the private sector who can provide much needed financial and technical resources, I believe these competitions can result in revolutionary breakthroughs.

The concussion problem is most visible at the NFL and college football levels, but the benefits of improved helmets can go well beyond that. Over one million kids play high school tackle football in the U.S. as well as over one million younger children. Protecting them needs to be a high priority.

The material we are developing also holds promise for other types of helmets. In fact, 6D has already incorporated what we learned in our Head Health Challenge research into their new cycling helmet that has recently arrived for sale in the marketplace.

Potentially this material could also be used in other multi-impact helmets such as hockey or lacrosse helmets, in other protective equipment such as shoulder pads, in flooring or turf subsurfaces, or in protective crash barriers on roadways and racetracks.

In view of my experience with the Head Health Challenge, and the important strides that have been made toward improved head impact protection, I would urge Congress to continue to support science prize competitions.