DuPage County ACT-SO

Motorcycle Helmet Design for Improved Comfort and Safety

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FERMILAB-POSTER-22-080

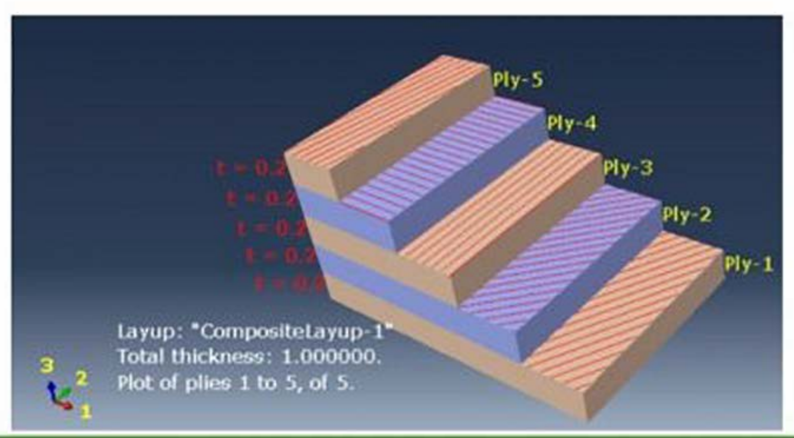
ABSTRACT

Traumatic brain injuries are the most common outcome from Motorcycle accidents.

- 30% of motorcycle choose not to wear a helmet because of reasons such as: **heavy weight**, poor ventilation, and the feeling of suffocation.

Goal: Increase helmet usage by modifying the design of the helmet by addressing the cost and helmet weight and finding the best material.

After comparing the five different materials (kevlar composite, ABS, Carbon-fiber reinforced polymer, Carbon- fiber reinforced polymer (Epoxy), and Fiberglass epoxy) using Abaqus CAE. The best material was the Carbon-fiber reinforced polymer (Epoxy) and the second best material, but the cheaper option, was Fiberglass Epoxy.



PURPOSE & Background

- Traumatic brain injuries are ten times more likely to occur by unhelmeted motorcyclists
- About 41% of motorcycle drivers who die in accidents are not wearing a helmet.
- Among Survivors severe head injuries can lead to lifelong complications
- TBI can leave a person handicapped and will affect their ability to work and make a living wage.

<u>"Evaluation of the Use and Reasons for Not Using a Helmet by Motorcyclists Admitted to the Emergency Ward of Shahid Bahonar Hospital in Kerman"</u>

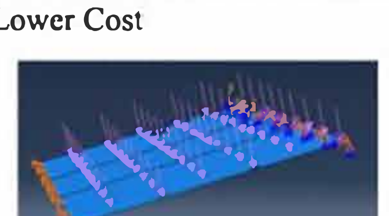
- 377 motorcyclists were evaluated and only 21.5% were wearing helmets.

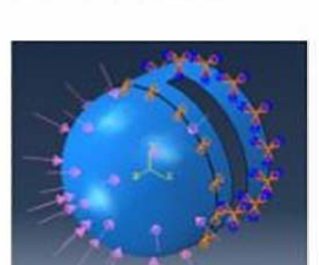
HYPOTHESIS

The weight of a conventional helmet can be reduced if mechanically robust materials such as a kevlar composite, ABS, Carbon-fiber reinforced polymer, Carbon-fiber reinforced polymer (Epoxy), and Fiberglass epoxy are incorporated into the external shell. Such a modification will lead to a helmet where the structural integrity and safety factor are maintained while improving the ergonomic aspects of the helmet.

Methods

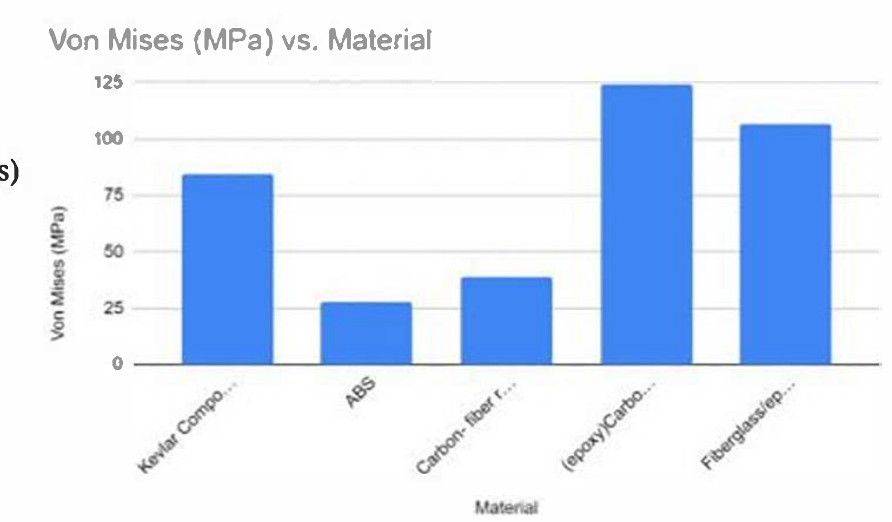
- **Finding the Best Material**
- High tensile, compressive, and high Von Mises stress ranges using Abaqus
  - -Applying stress to a slab first to find the best of the five materials
  - - Further comparison using the Helmet
- Lower Cost





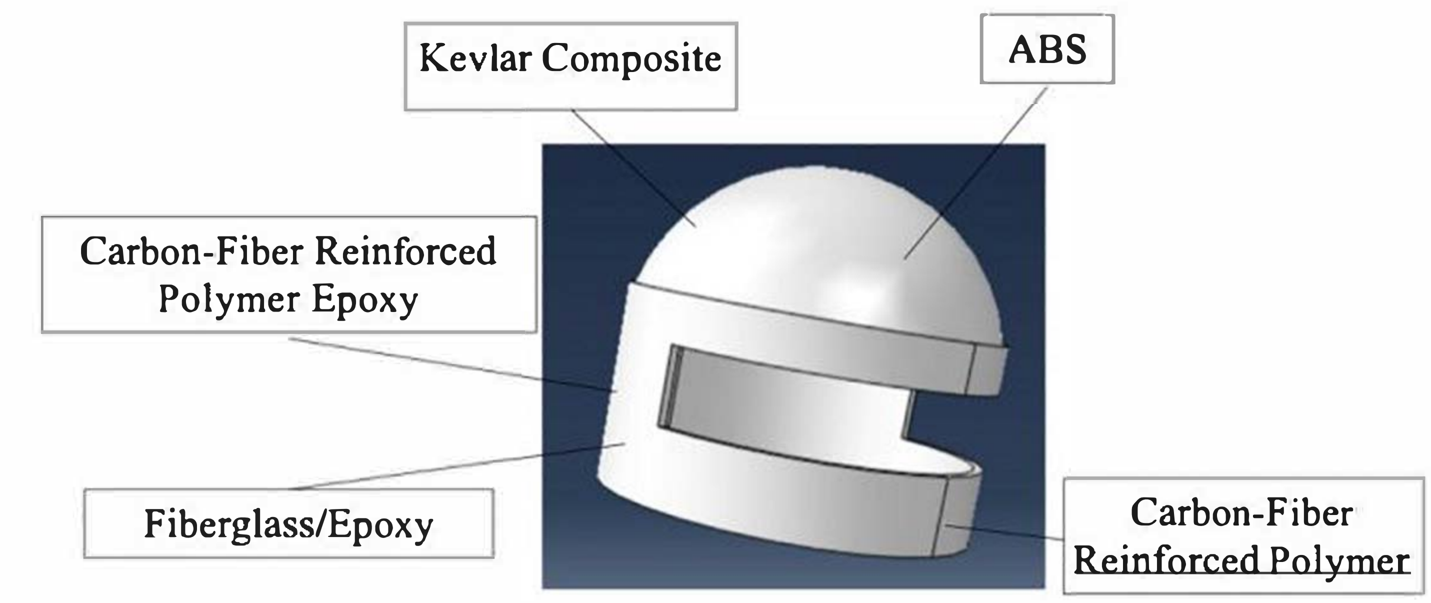
PROCEDURE

1. **Create two parts using Abaqus CAE**
   - <u>**First part:**</u> the flat sheet (0.5 x 0.5 m^2) to test each potential material for the helmet shell by analyzing the failure parameters of von Mises, S11, and S22.
   - <u>**Second part:**</u> the helmet shell, to test the best two materials and compare. This part had a radius of 0.1m, whereas a medium-sized helmet radius can range from 9 - 10 cm.
2. **Enter each of the five materials into Abaqus**
   - **Classification:** lamina (for a unidirectional reinforced material)
   - **Damage Classification:** Hashin damage (define the stress of the lamina in different directions)
3. In the slab five layers were added to the base with a thickness of 0.2 mm.
4. **Deformation procedure: Static general step with linear perturbation.**
5. **Add boundary conditions and a load to the sheet with a quadrilateral structural mesh.**
6. **Apply pressure to the face of the shell.**
7. **Element type: standard, shell, and linear then, mesh the part.**
8. **Create the job with element deletion and submit then the results are seen in the field outputs.**



MATERIALS

Table 1: Description of test materials



RESULTS

Table 2: Summary of von Mises stress for tested sheets

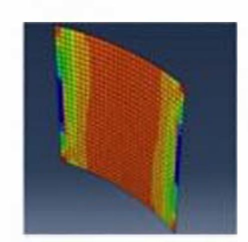
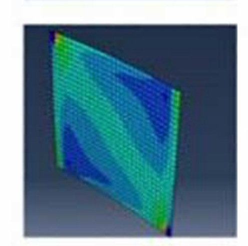
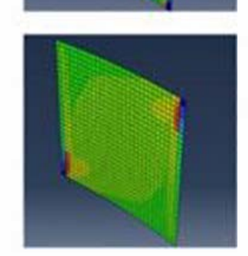
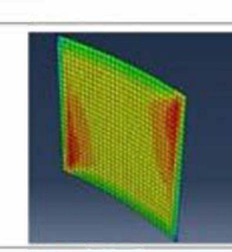
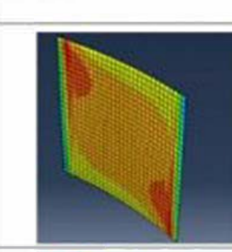
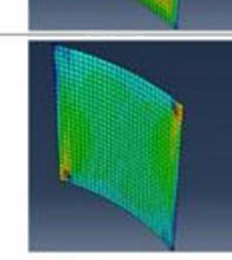
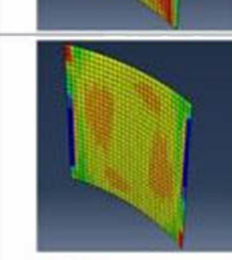
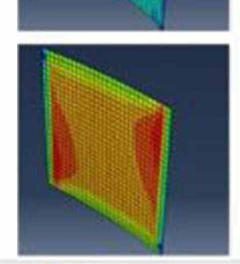
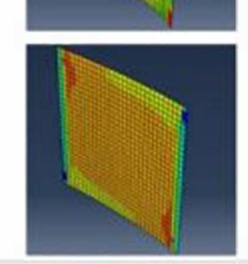
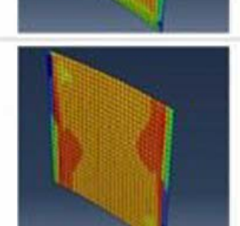
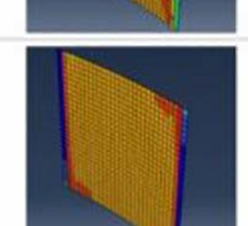
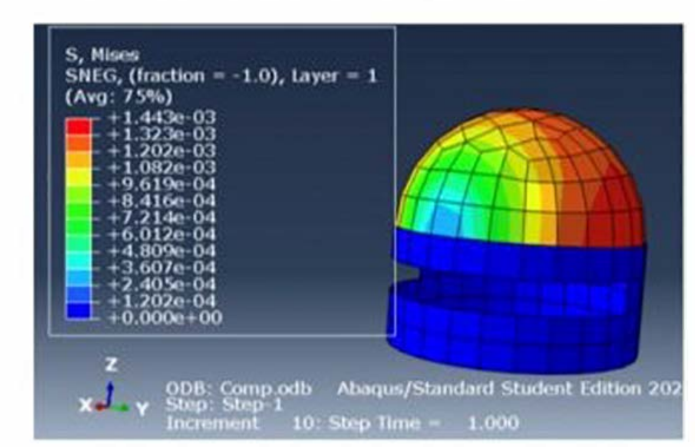
ABS		Range: 23.7-27.5 MPa Maximum: 27.5 MPa
Carbon-Fiber reinforced polymer (Epoxy)		Range: 44-75.6 MPa Maximum: 124.4 MPa
Fiberglass/Epoxy		Range: 51.1-100 MPa Maximum: 107.2 MPa

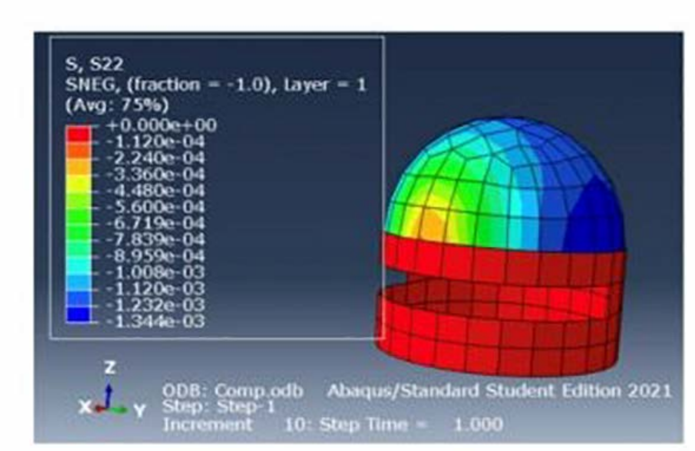
Table 3: Summary of the Principal stresses for tested sheets

Material	S11		S22	
Kevlar Composite		Range: (7.5-12.1 MPa) Max: 25.6 MPa		Range: (36.7- 46.1 MPa) Max: 65.1
ABS		Range: (4.7-14.5 MPa) Max: 22.3 MPa		Range: (17.1-20.6) Max: 24.1 MPa
Carbon-fiber reinforced polymer epoxy		Range: (14.0-21.8 MPa) Max: 37.4 MPa		Range: (60.4-79.3 MPa) Max: 116.9 MPa
Fiberglass/Epoxy		Range: (23.1-29.3) Max: 41.7 MPa		Range: (33.0-39.5) Max: 52.6

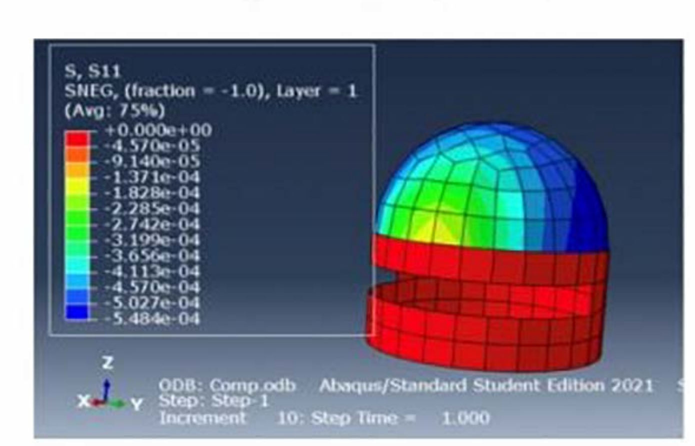
Carbon-fiber reinforced Epoxy and Fiberglass Epoxy Composite



Carbon-fiber reinforced Epoxy and Fiberglass Epoxy Composite



Carbon-fiber reinforced Epoxy and Fiberglass Epoxy Composite



CONCLUSION

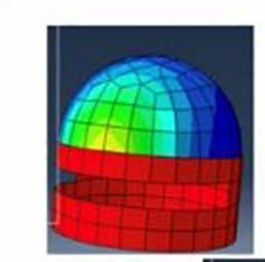
- Carbon-Fiber reinforced polymer epoxy exhibited the best failure resistance and Fiberglass Epoxy had the second best failure resistance.

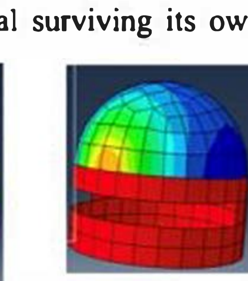
Characteristics:

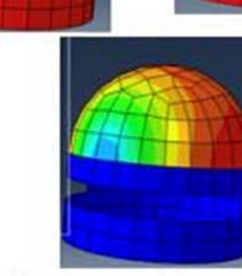
- The materials have a **high Von Mises yield criterion**
- The material have a **high maximum tensile stress**
- **High compressive principal stress** is beneficial for the material surviving its own compression through higher impacts.

Price:

- <u>Carbon-Fiber Reinforced Polymer Epoxy:</u>
  Density: 1500 kg/m^3
  Mass: 0.375kg or 0.83lbs (Full Helmet: 4.15lbs)
  Cost: $4.15
- <u>Fiberglass Epoxy:</u>
  Density: 2440 kg/m^3
  Mass: 0.61kg or 1.345lbs (Full Helmet: 6.73lbs)
  Cost: $2.018







Future Work: creating a composite consisting mostly of Fiberglass and some Carbon-Fiber reinforced polymer epoxy to lower the cost while sustaining the strength of the material.

- Stronger version of the composite with ventilation and weight in mind

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