



A numerical study on Quasi-isotropic (QI) Panels Made from Dyneema® Woven Fabrics at Ballistic Impact

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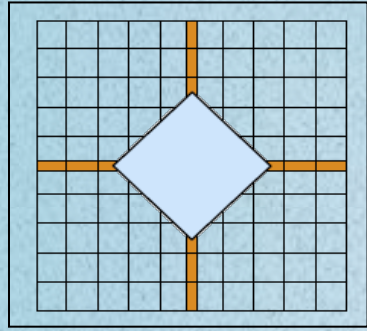


Background and Introduction

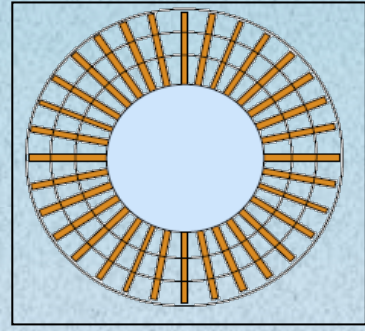
? What is a QI panel made from woven fabrics?

A multilayer QI fabric panel made up of N layers requires the layer to be oriented at $90^\circ/N$ between each other owing to the biaxial structure of woven fabrics, where N is larger than 1.

?? Why are the QI fabric panels used for ballistic protection?



Aligned panel



QI panel

More secondary yarns are involved in transverse deformation to absorb more energy in comparison with the aligned panel.

Aim and Objectives

Aim Identify the mechanisms of aligned and QI panels made from Dyneema® woven fabrics at ballistic impact

Objectives:

- (1) Numerically analyse the influence of QI structure on the transverse deformation;
- (2) Numerically analyse the influence of QI structure on the stress distribution;

Methodology

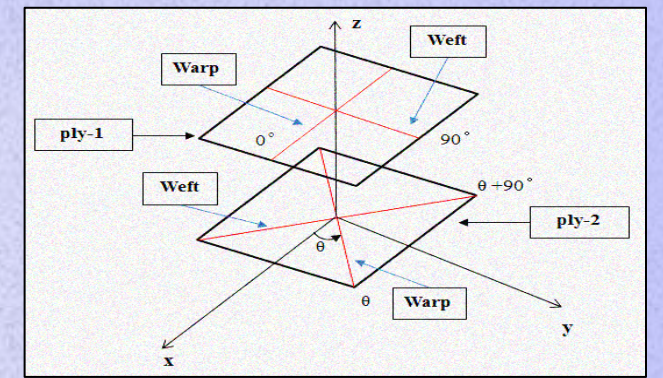
Panels in use:

2-ply aligned and QI panels:
[0/0], [0/45];

3-ply aligned and QI panels:
[0/0/0], [0/30/60];

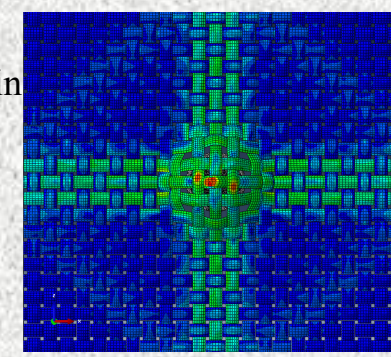
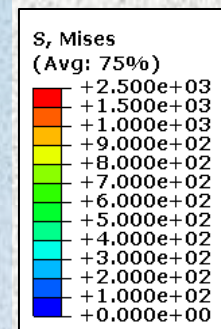
4-ply aligned and QI panels:
[0/0/0/0], [0/22.5/45/67.5];

Constructions of multi-ply fabric panel

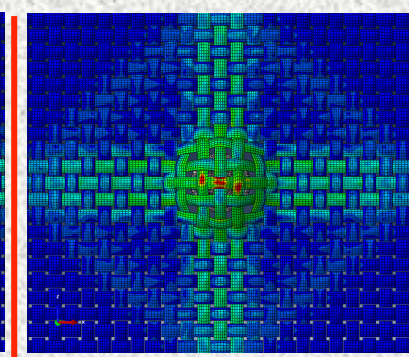


3. Stress distribution

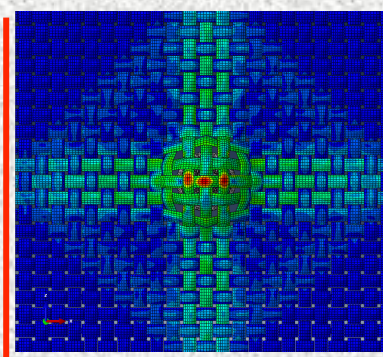
The back ply in aligned panels



2-ply panels

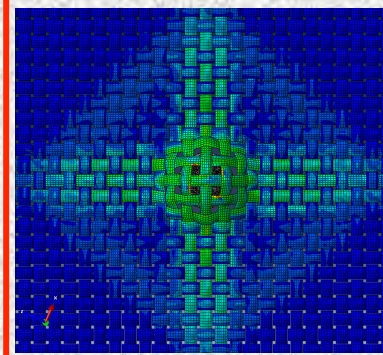
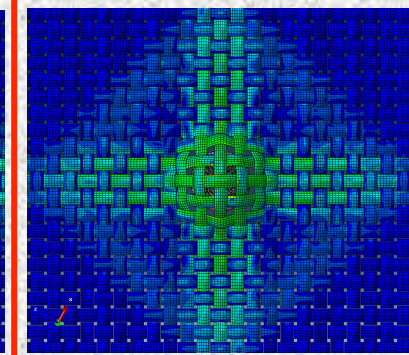
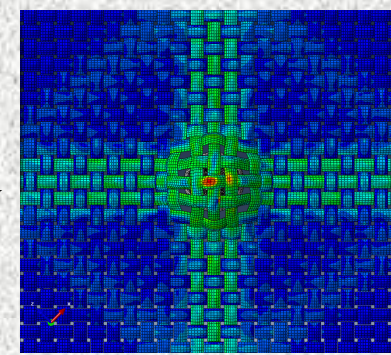


3-ply panels



4-ply panels

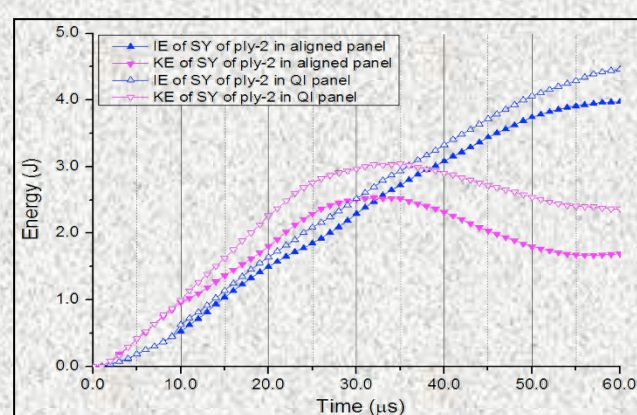
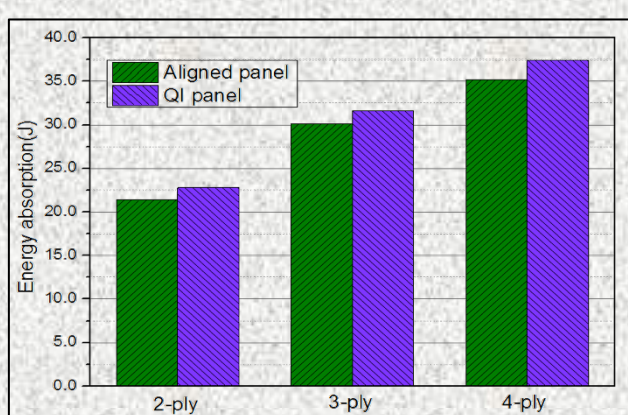
The back ply in QI panels



The stress in QI panels tends to distribute to secondary yarns while the stress in aligned panels tends to propagate along the thickness direction thereby giving rise to stress concentration in the back.

Results and Analysis

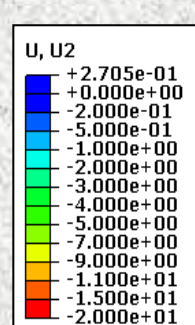
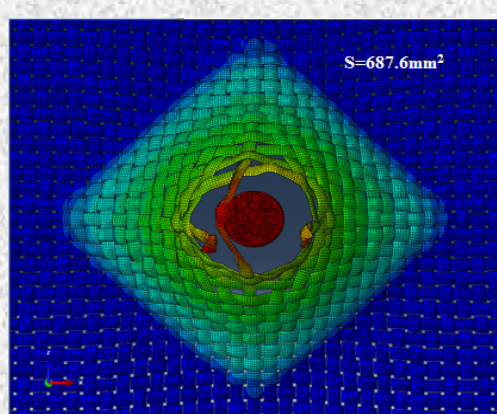
1. Energy absorption



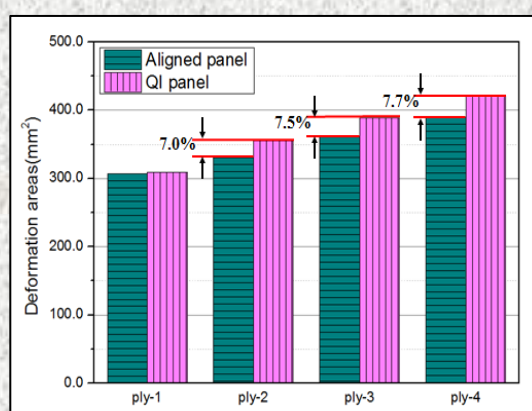
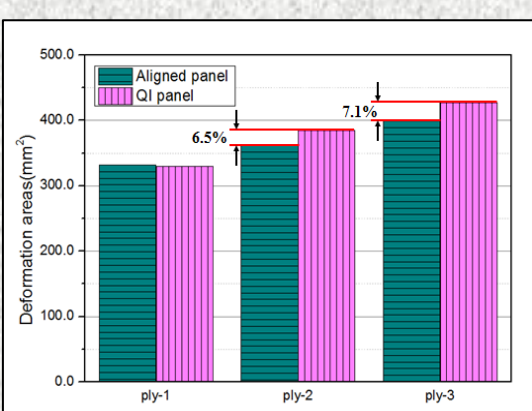
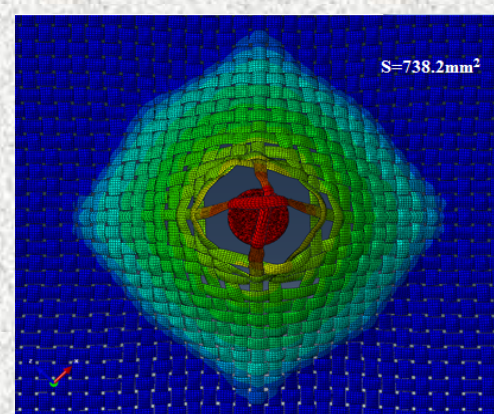
The increase of the energy absorption of the QI panels is principally owing to the increase of KE and IE of secondary yarns in the middle and back plies.

2. Deformation areas

Ply-2 of 2-ply aligned panel



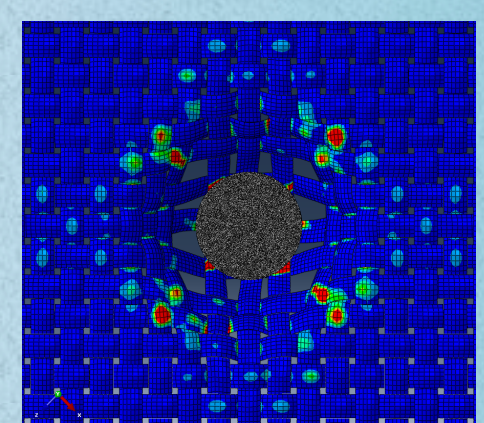
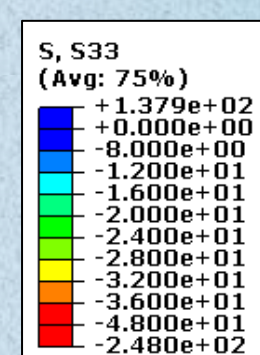
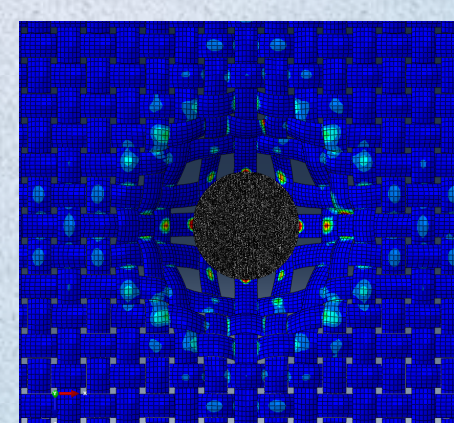
Ply-2 of 2-ply QI panel



The deformation areas of the plies in the middle and the back in the QI panels are larger than the counterparts in the aligned panels.

Discussion and Conclusion

Discussion



The compression of the primary yarns in the ply-1 causes the stresses propagating to the secondary yarns in the ply-2.

Conclusion

Compared with aligned panels, QI panels take more advantages of the secondary yarns in terms of deformation and stress distribution by means of actions of primary yarns in the ply on the secondary yarns in the followed plies.

References

- Kaw A K. Mechanics of composite materials [M]. CRC press, 2010.
- Wang Y, Chen X, Young R, Kinloch I and Garry W. A numerical study of ply orientation on ballistic impact resistance of multi-ply fabric panels. Composites Part B: Engineering, 2015. **68**: p. 259-265.