

Failure analysis on laminate structures of windsurfing boards using thin film modelling techniques



Fig. 1



Fig. 2

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WHAT?

Investigation of load problems during windsurfing leading to board damage due to quasistatic contact, impact and bending loads. Comparison with mechanical failure mechanisms observable in thin film technology. The boards are of laminate structure modelled with up to 20 layers.

HOW?

Using the method of image loads together with either the model of the layered infinite halfspace (impact loads) or the model of the layered thick plate (bending loads).

→ Fast & completely analytical solutions (no FEM)!

RESULT?

Excellent agreement with practical observations of load tests performed by professional windsurfers on a variety of board type structures under demanding conditions (c.f. fig. 1, 2).

Types of loads leading to failure:

IMPACT LOADS

(due to flat landing after high jumps, skag hits reef or body hits board's nose)

EXAMPLES:

BENDING LOADS

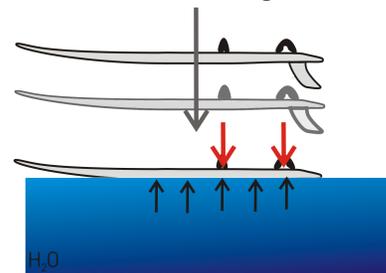
(due to overturning of loops, landing between 2 waves or nose/tail dives after jumps)

EXAMPLES:

Case 1: Windsurfer's body hits board's nose



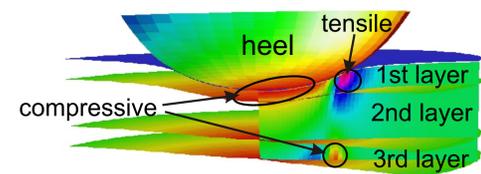
Case 2: Flat landing after high jump



Case 3: "Bad" landing between two waves



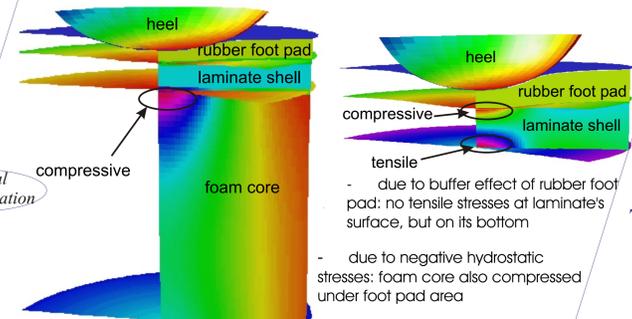
Case 4: "Tail dive" after high jump



failure behaviour is well known from layered structures of hard thin films deposited on relatively soft substrates! (Hertzian-like fracture of the coating)



Failure



In thin film technology: similar failure behaviour known as "star crack formation"



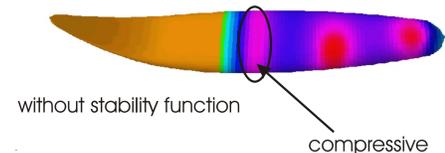
Conclusion:

The investigations of loads occurring on windsurfing boards showed that:

- qualitative failure analysis can be done by using thin film modelling techniques
- methods are fast and accurate & can predict stress maxima and weak points in the construction
- Thus: models are appropriate tools for the optimisation of laminate structures

Outlook:

- those techniques might even be used in boat industry, for automobile bodies or fuselage constructions



without stability function

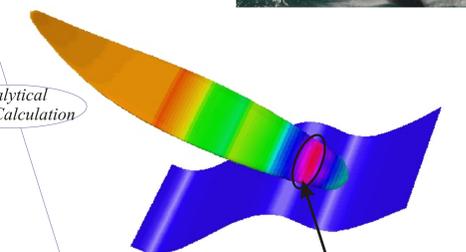


with stability function - thickness variations & reinforcements taken into account



failures are similar to those known from a 4-point-bending-test of plate-like laminate structures!

Analytical Stress Calculation



tensile stress



Failure