Buckling Strength of Thick Composite Panels in Wind Turbine Blades

Part II: Effect of Delaminations

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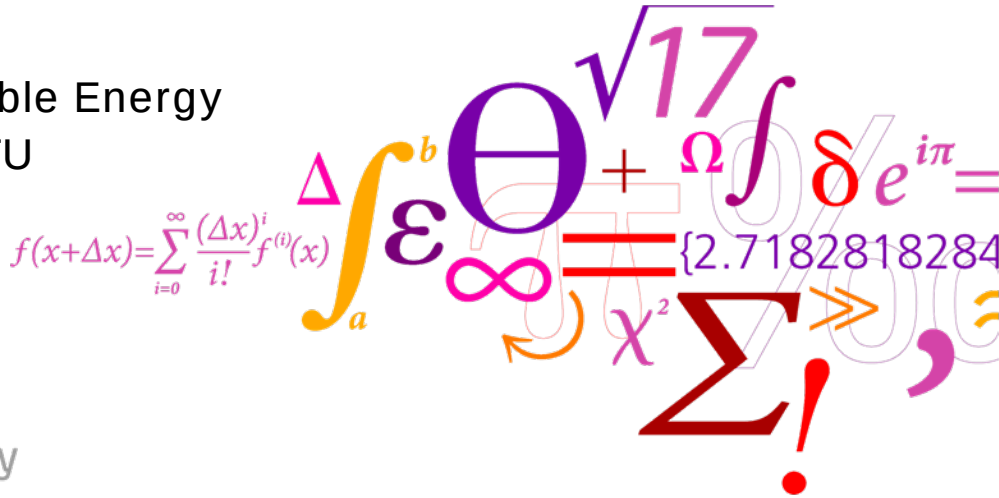

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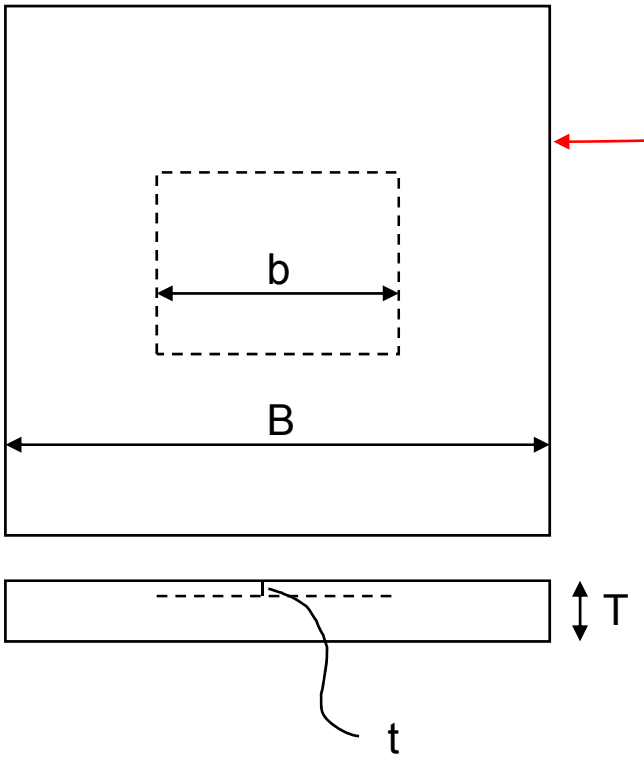
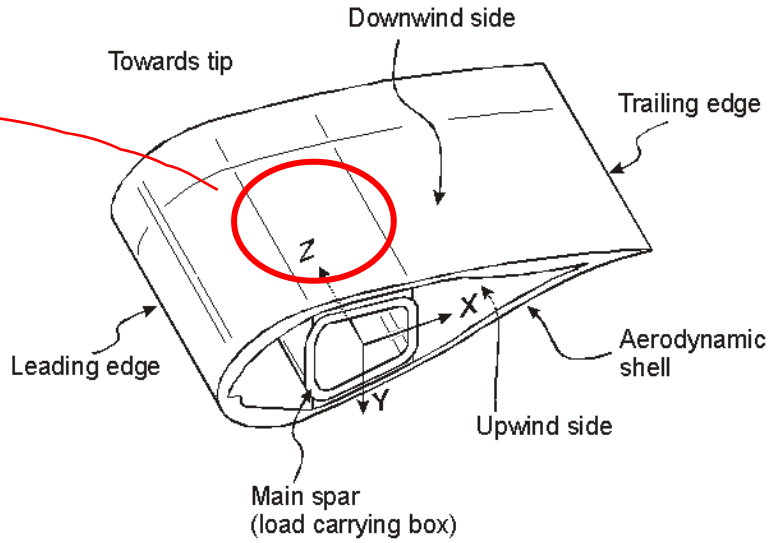
Outline

- Motivation and test panel description
- Experimental setup
- Experimental results
- Stable growth delamination video
- Buckling map for delaminations
- Conclusions

Panel description

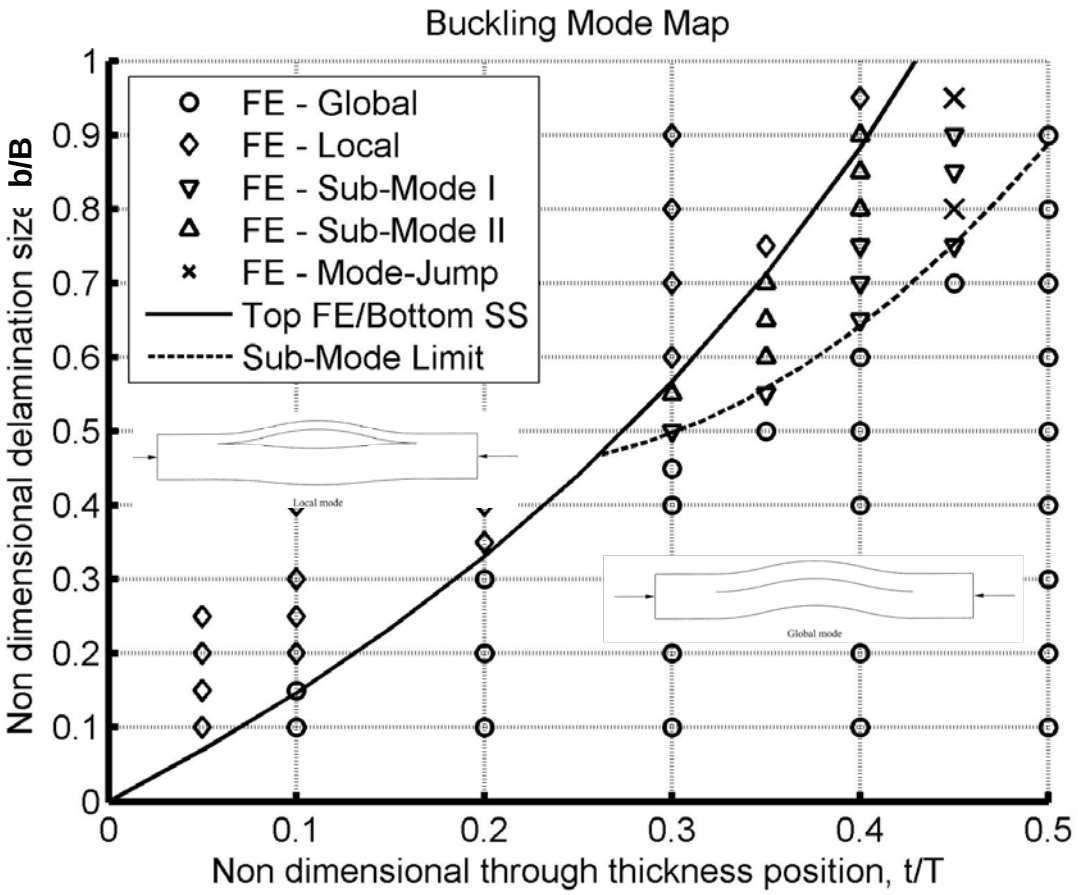
- Panels with approx. 90% UD
- Similar to load carrying panels in wind turbine blades
- Teflon sheet imbedded to simulate debonded area

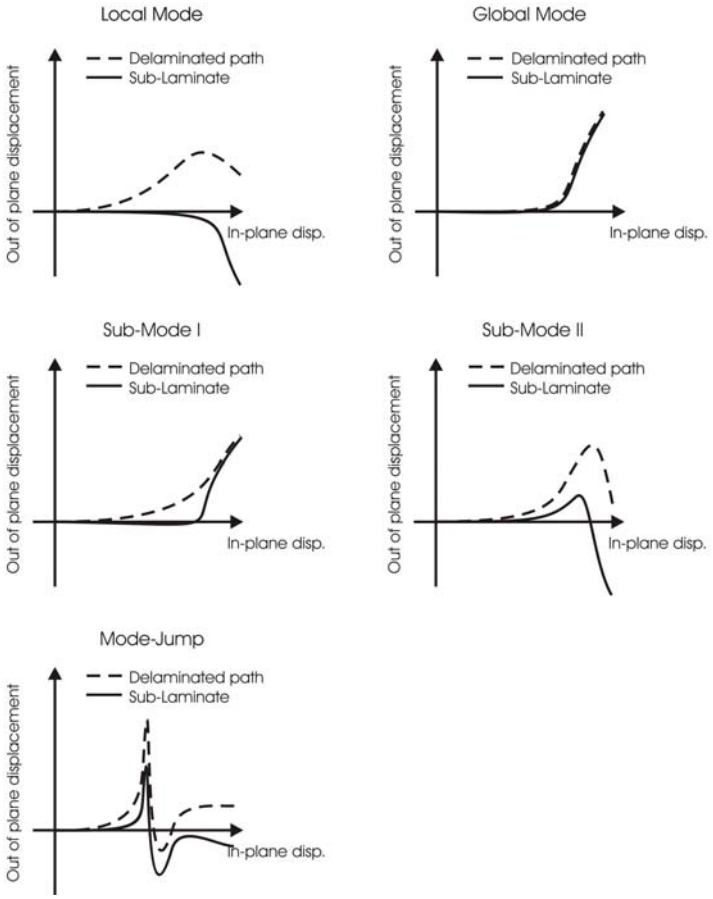




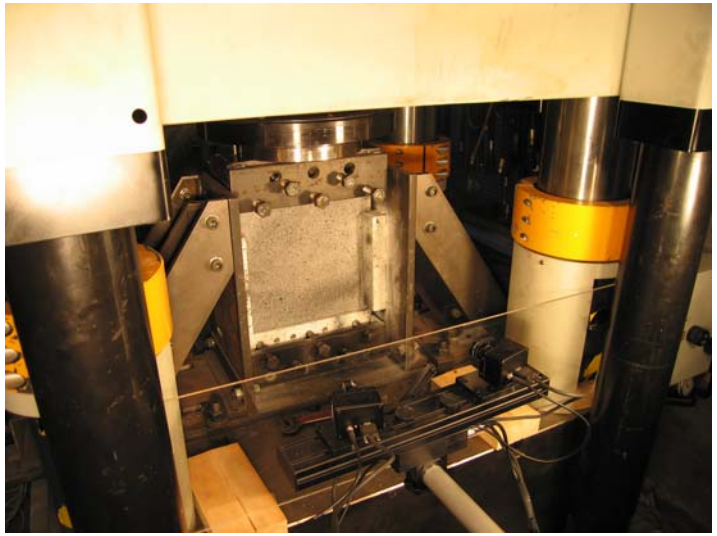
Buckling driven delamination

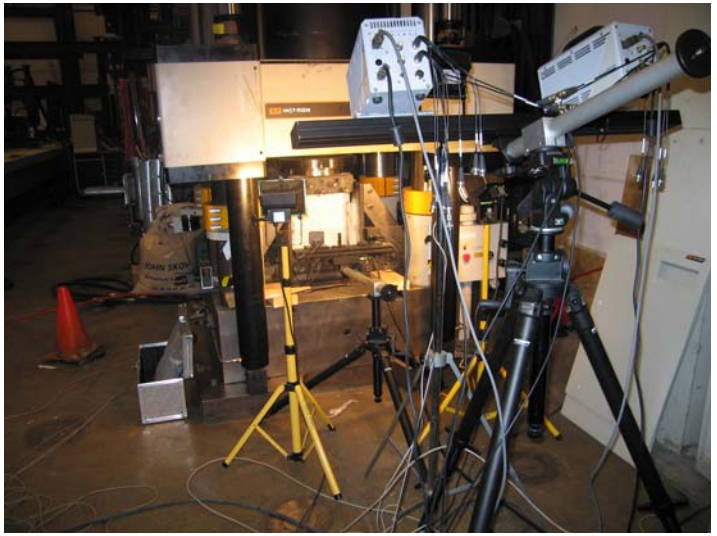
- For isotropic material
- Different size and position of delamination

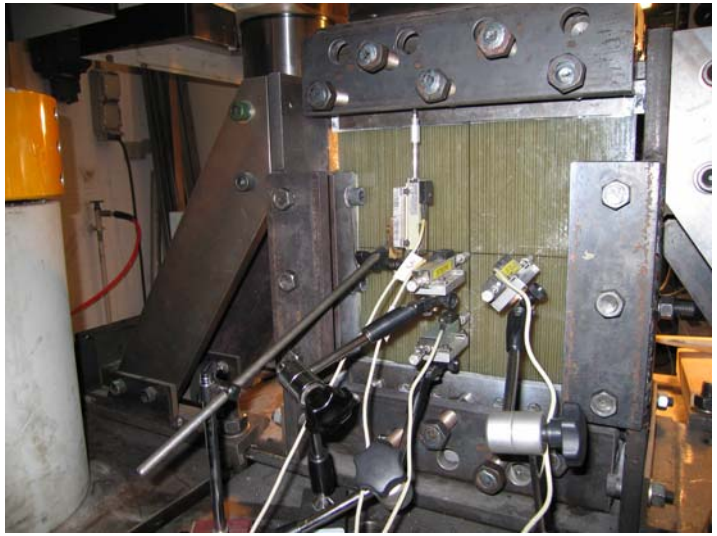




Experimental Setup







Experimental results

The following buckling responses were observed during the experiments:

a. Global buckling

b. Local buckling without growth

The delaminated zone pops out and very little growth of the delaminated zone is observed before ultimate failure

c. Local buckling with growth

The delaminated zone pops out and substantial growth of the delaminated zone is observed before ultimate failure

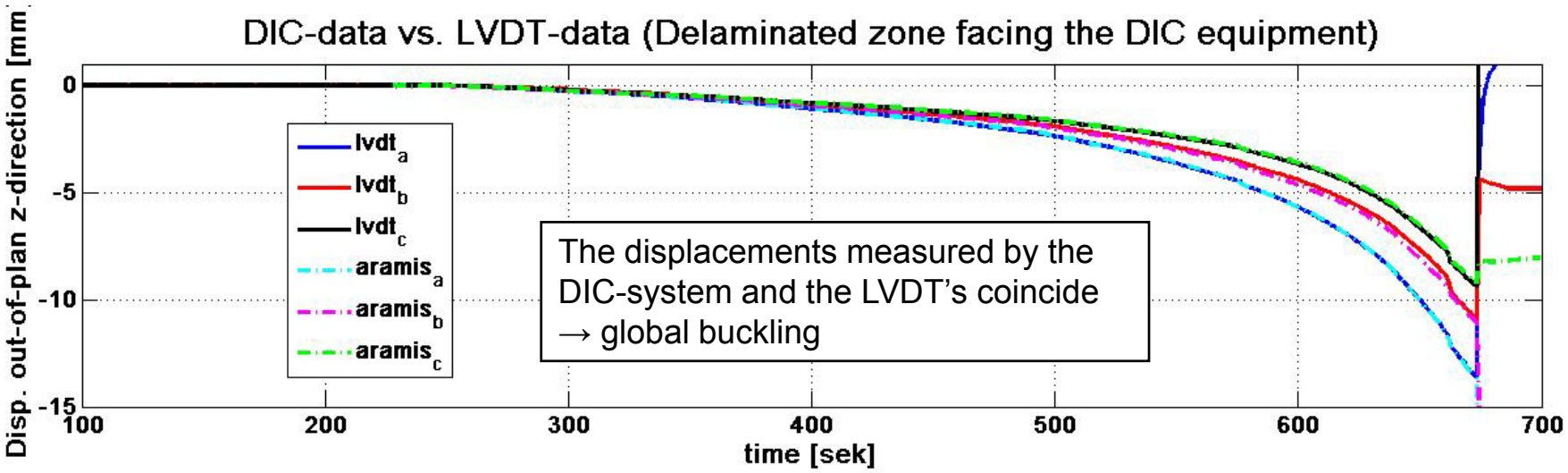
d. Global buckling with mode jump

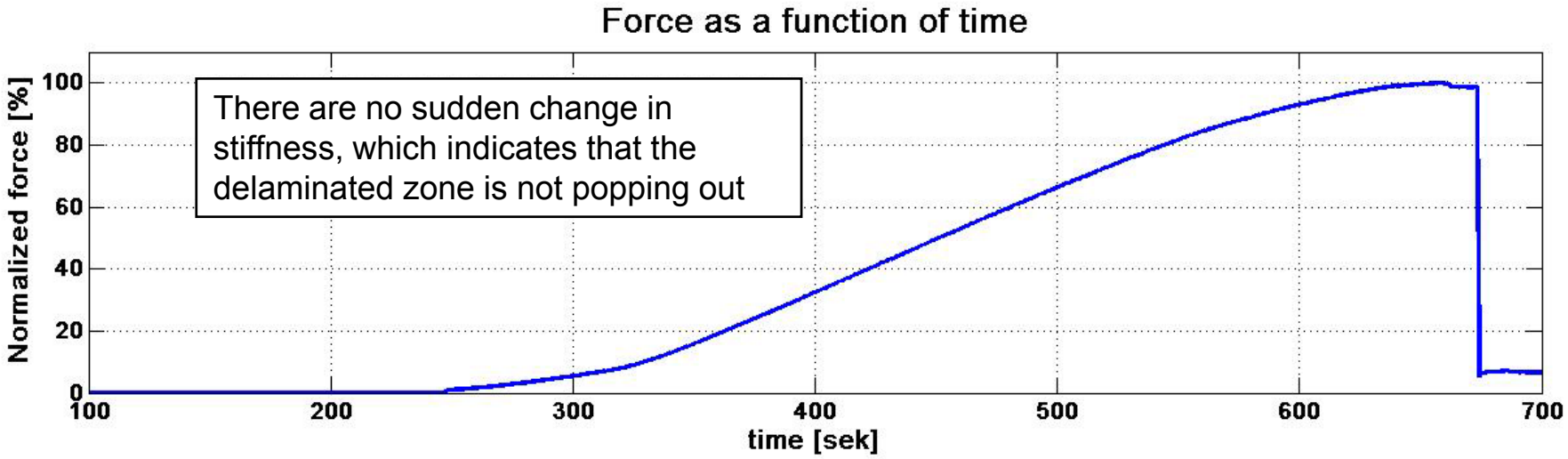
The buckling begin in the 1. global mode-shape. At failure a mode-jump is observed and the panel fails in a s-shape

e. Local buckling cause instant failure

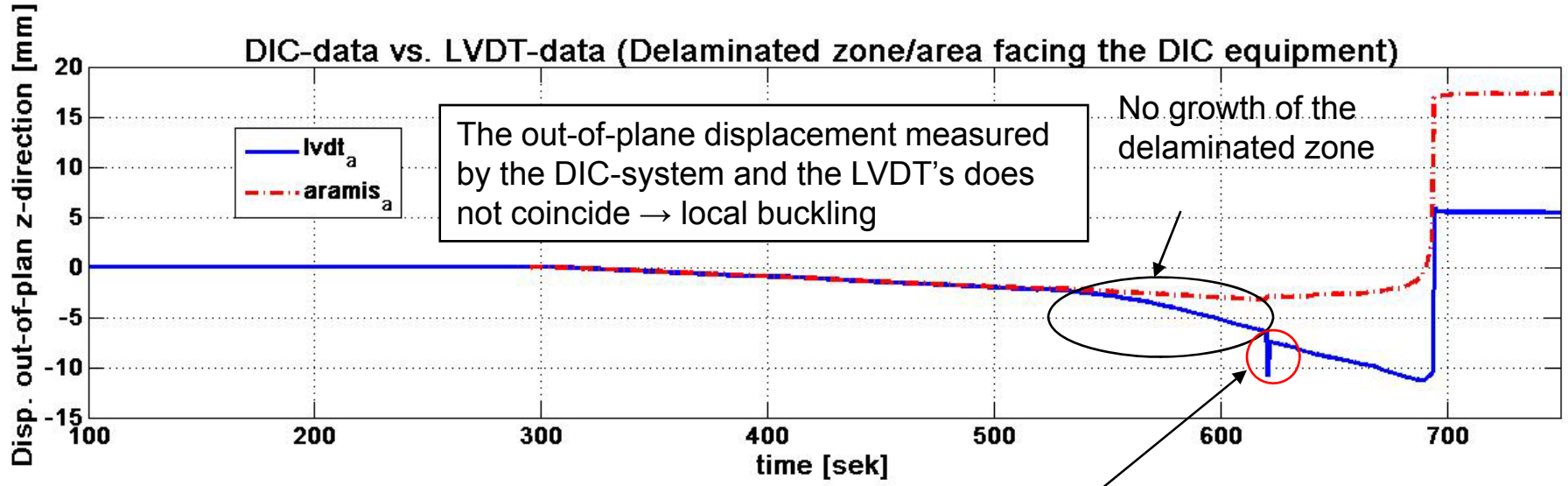
The panel fails right after the delaminated zone pops out. This typically occurs at high loading

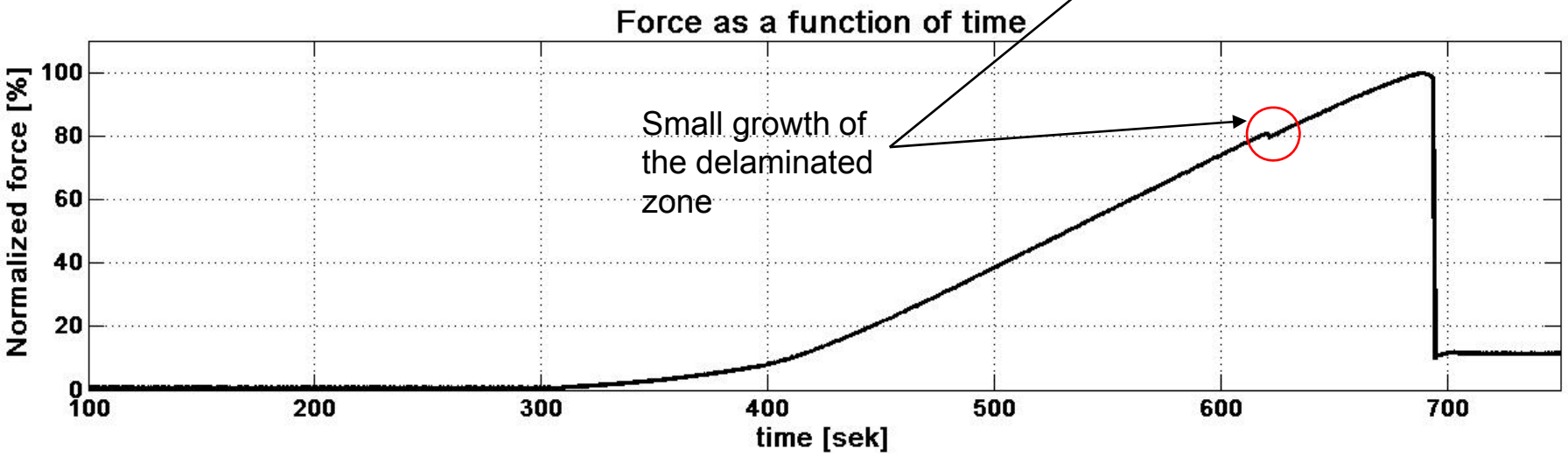
Experimental results (a. Global buckling)



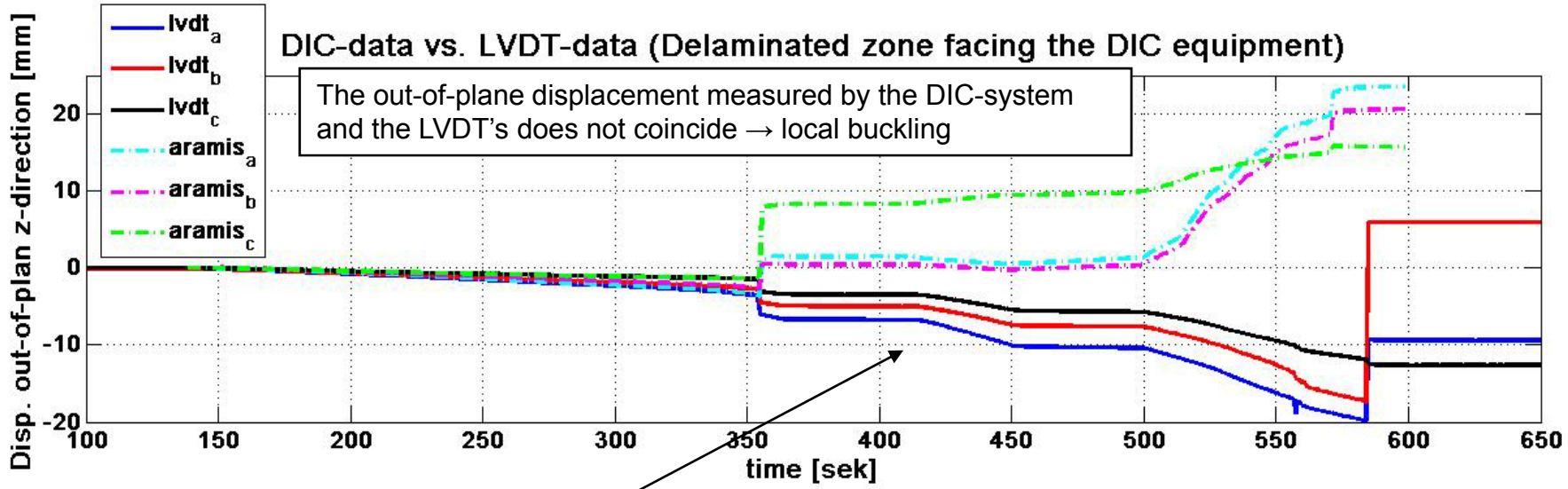


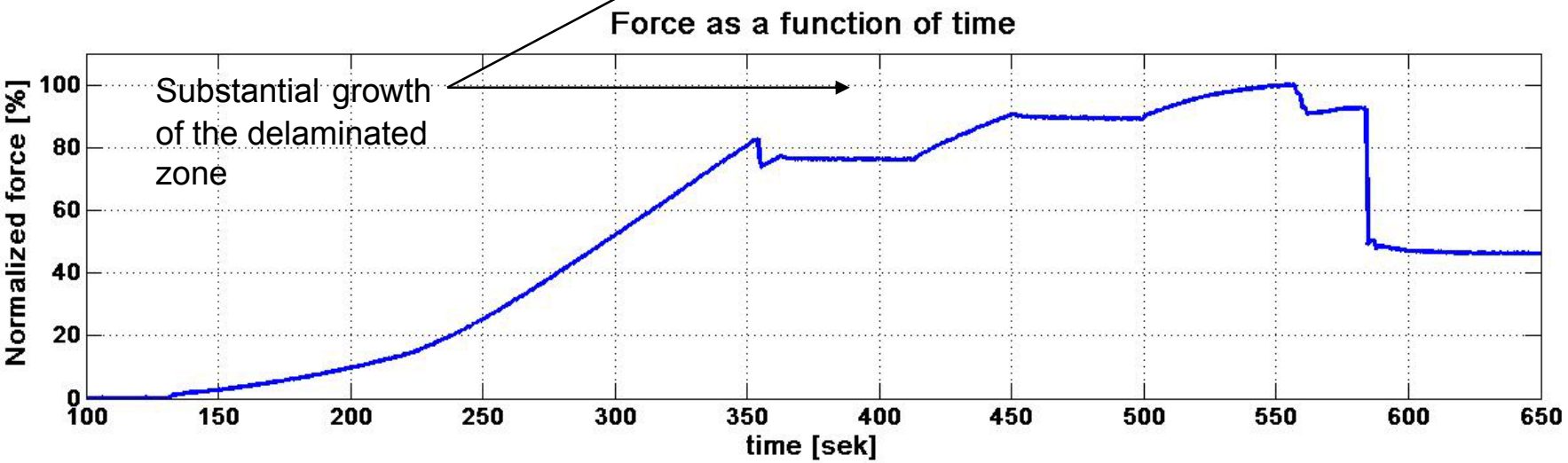
Experimental results
(b. Local buckling without growth)



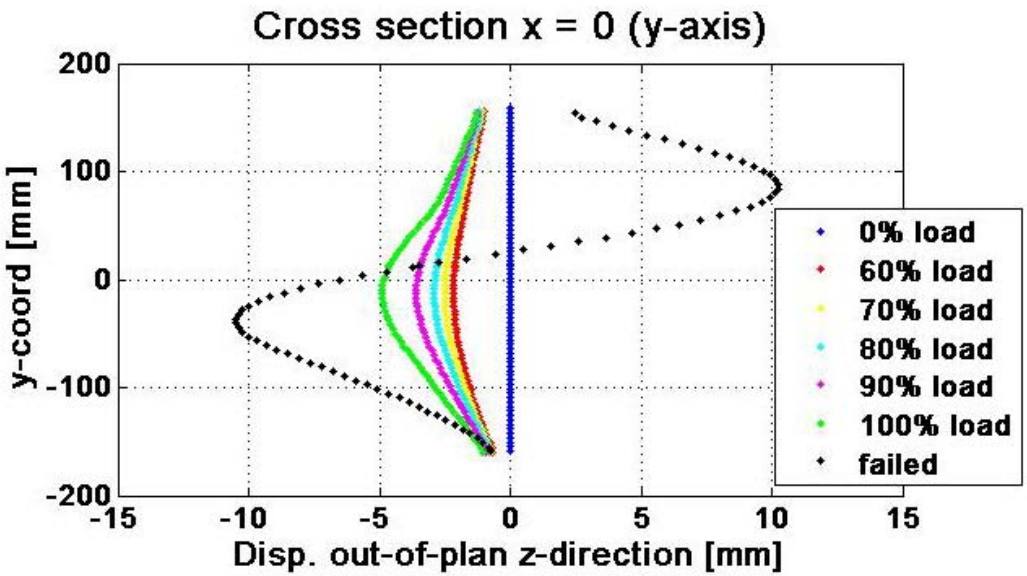


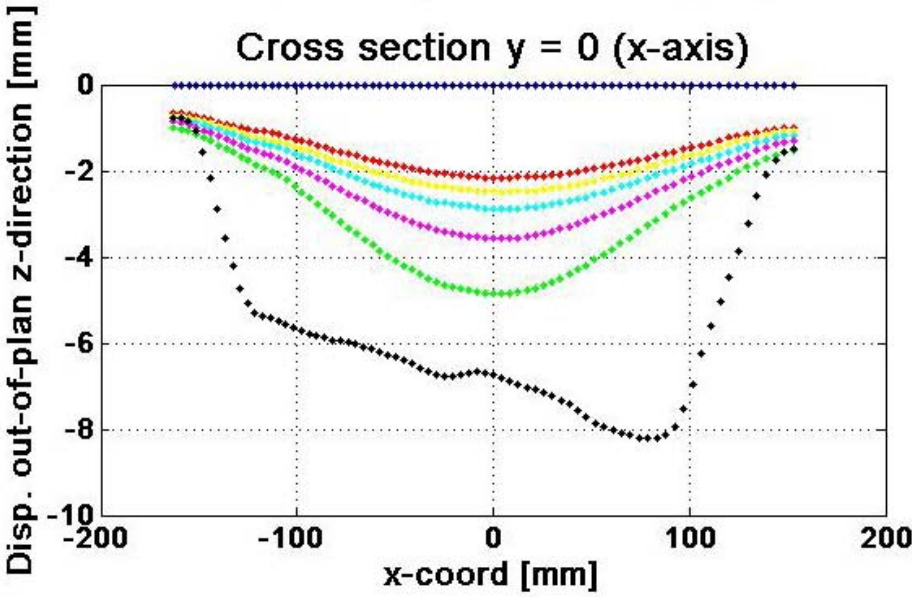
Experimental results
(c. Local buckling with growth)

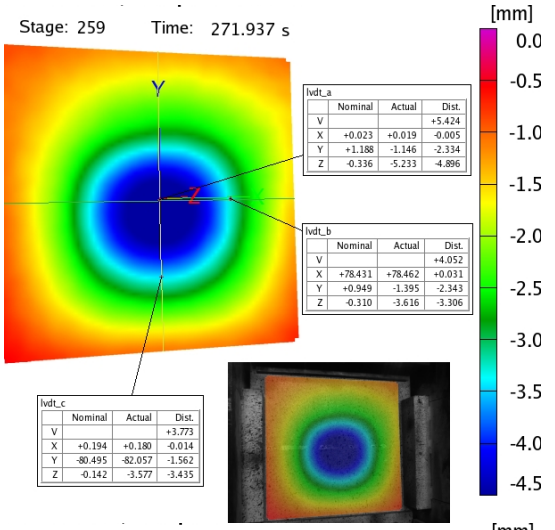


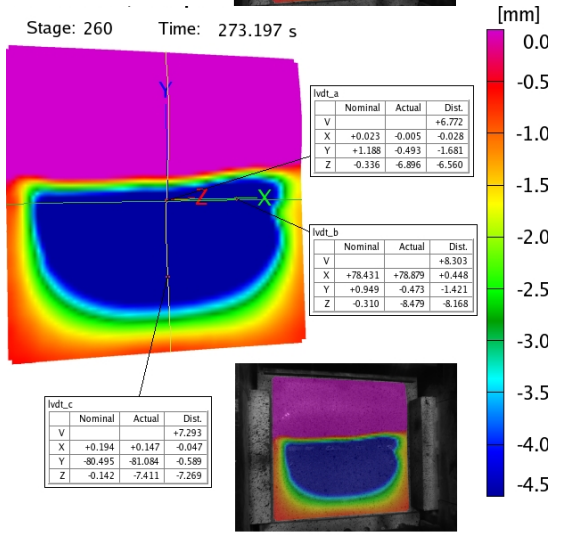


Experimental results (d. Mode-jump to s-form)



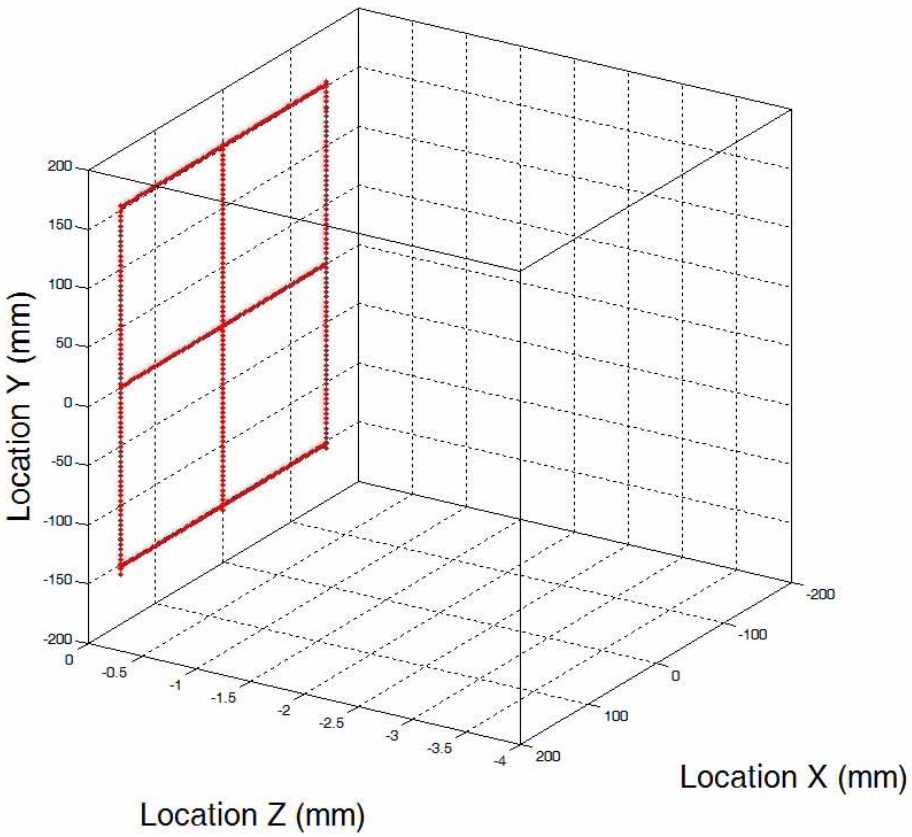


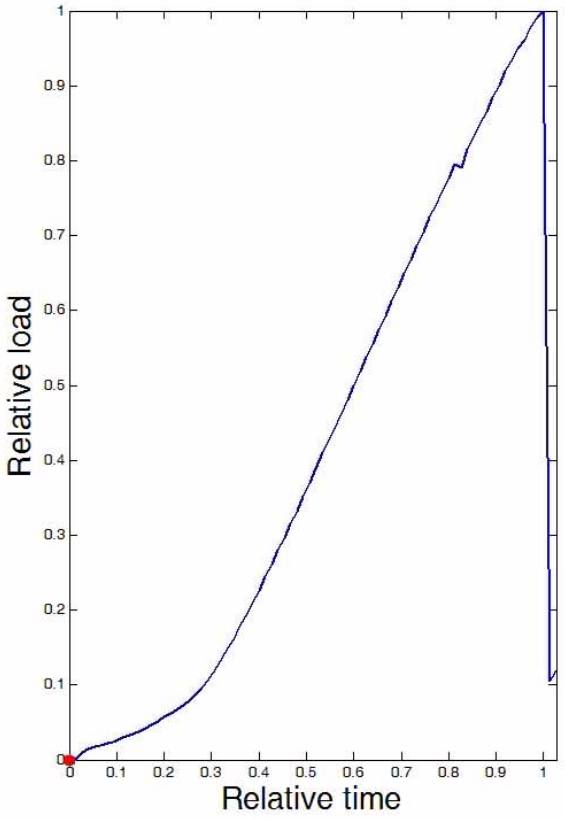




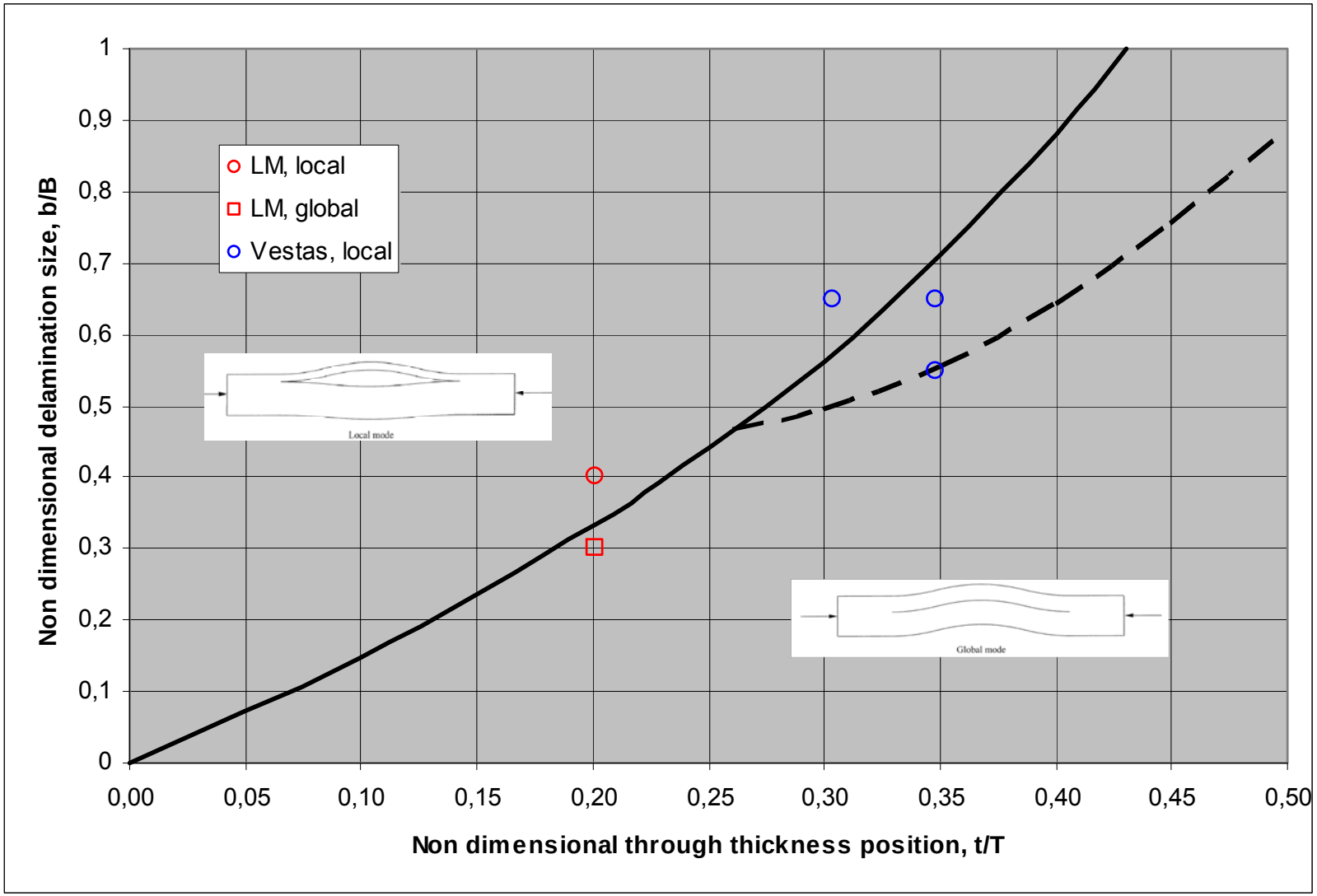
The buckling begin in the 1. global mode-shape. At failure a mode-jump is observed and the panel fails in a s-shape.

Boundary conditions





Buckling map for delaminations, test results



Conclusions

- Good comparison between numerical predictions and panel tests.
- Generally it is found that large and deep delaminations caused local buckling and instant failure.
- Smaller delaminations closer to the surface are in some cases found to develop stable growth of the delaminated zone.
- This work is a step towards a design criterion for how large and deep delaminations can be accepted without increasing the risk of blade collapse.

Acknowledgements

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