Temadag om hærdeplast og hærdeplastiske kompositmaterialer

Torsdag, den 29. oktober 2009

Aalborg Universitet Esbjerg, Auditorium C113, Niels Bohrs Vej 8, DK-6700 Esbjerg

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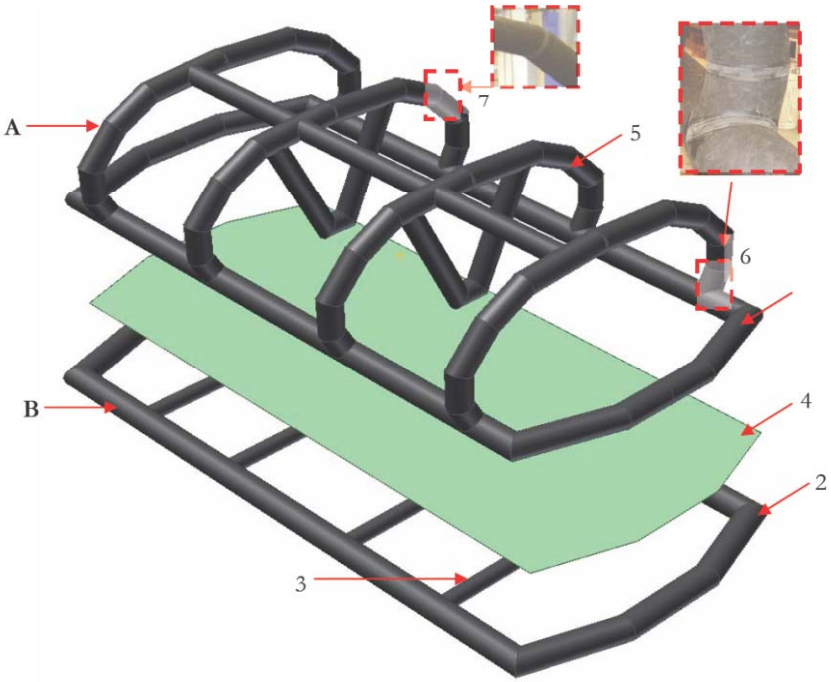

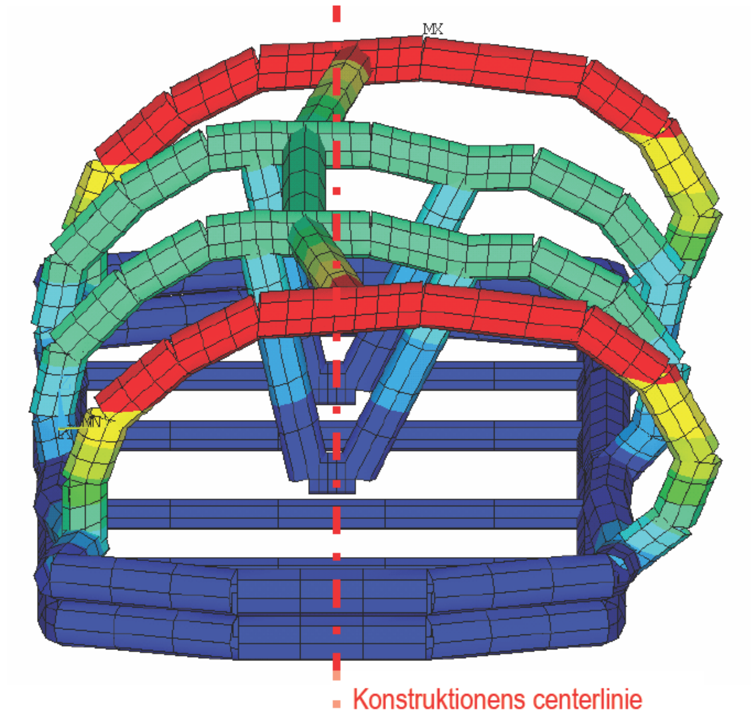

SIMULERING AF KOMPOSITTE MATERIALER OG STRUKTURER

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Præsentation

Program

- Computer Aided Engineering (CAE)
  - Integreret design
- Muligheder
- Eksempler på projektsamarbejder i Esbjerg
  - Grundlæggende undersøgelser af komposit bjælke
  - Analyse og simulering af oppustelig redningsflåde udført i et gummikomposit materiale
  - Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge

Computer Aided Engineering

- Inventor 3D CAD/Workbench
- ANSYS Classic
- ANSYS Workbench

Figure 2: Load unit of a Volvo Wheel Loader with 16 journal bearings.

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Integreret design

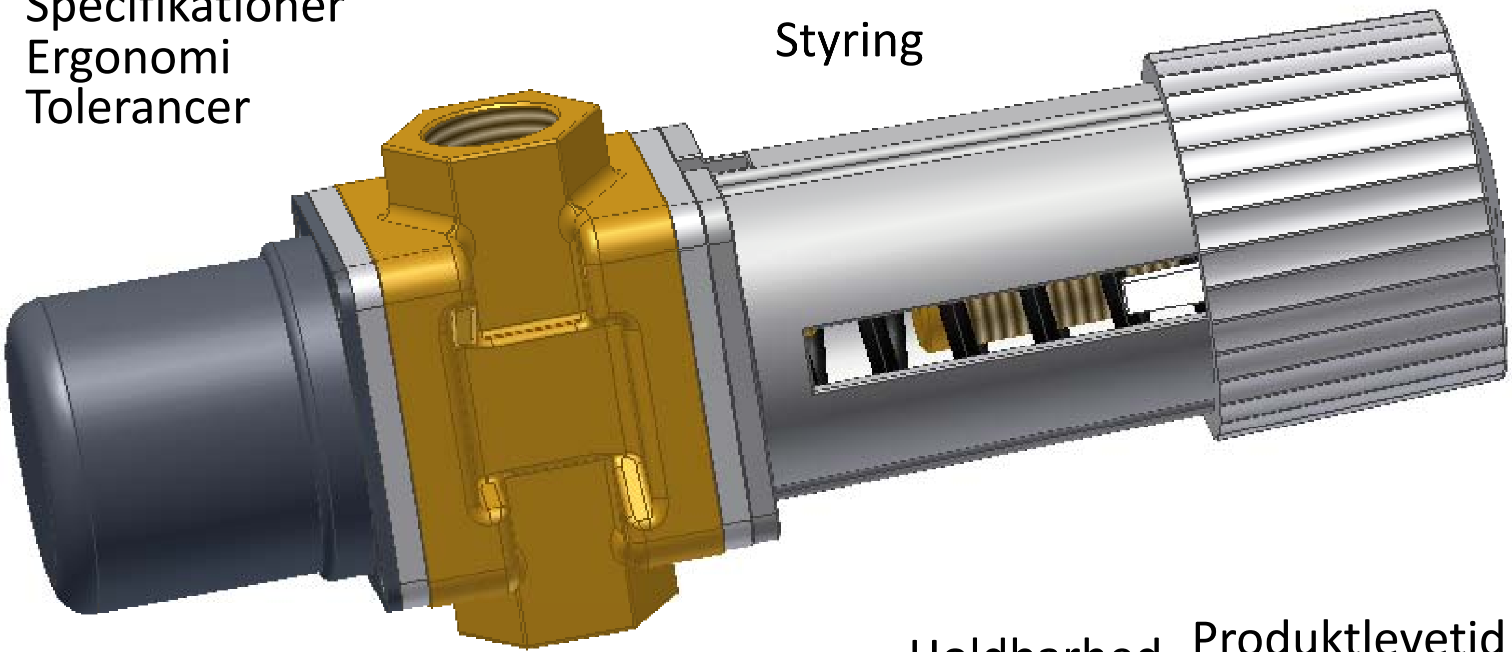
Produktion
Poka-yoke
Pris
Procesudstyr

Kvalitet
Tolerancer
Poka-yoke

Service

Funktion
Specifikationer
Ergonomi
Tolerancer

Styring



Materiale
Pris
Genbrug

Holdbarhed
Produktlevetid
Driftsforhold

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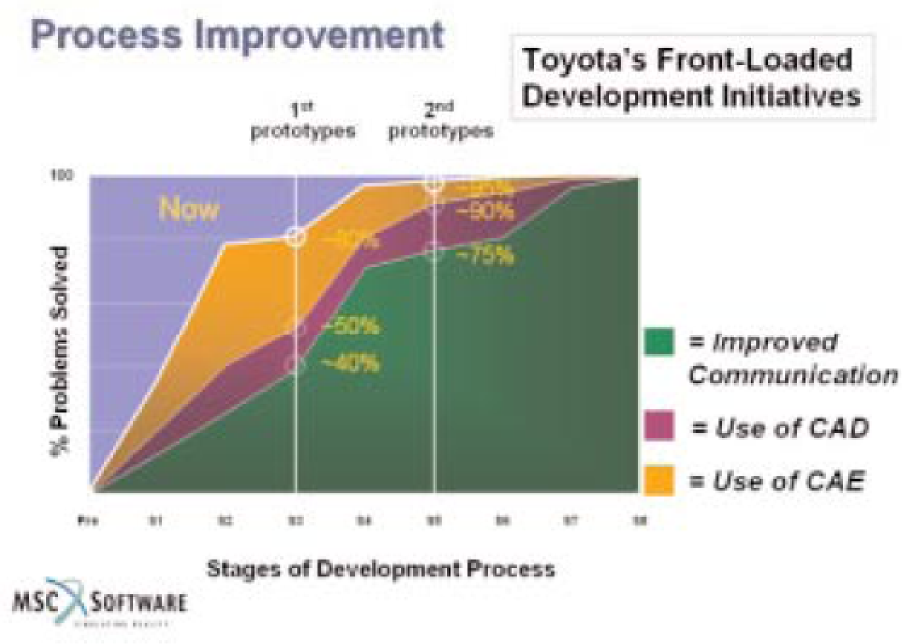
By tracking problems over multiple development projects, they identified and corrected about 40% of their problems by Stage 3 (1st physical prototypes) and 75% by Stage 5 (2nd prototypes). However, finding problems late in the design and manufacturing process is clearly more expensive than finding and fixing them in Stage 1 or 2. As a result, Toyota invested heavily in PLM technologies like CAD, CAM and CAE to help identify and solve more problems related to the design of their vehicles. This investment helped Toyota progress to find and fix about 50% of their problems by Stage 3 and nearly 90% of their problems by Stage 5. In the late 1990s through today, they have built upon their investments in PLM technologies, and focused specifically on VPD to help them identify and solve more problems related to the functional performance of their vehicles during the design phase.

Toyota expects to eliminate approximately 80% of their problems by Stage 2 (before the first prototypes are made!) and over 90% by Stage 4. The conclusion of their study clearly illustrated that combining 3D CAD with VPD is far more effective in identifying and correcting design performance issues earlier in the development process other than relying solely on CAD data. Between the 1st and 3rd front-loading initiatives, Toyota slashed their development time and costs by 30-40% (including the amount of physical prototyping needed). In addition, Toyota is now transferring 'problem and solution' information from previous projects to the front end of new development projects, further accelerating the development cycle.



NOKIA Case

- 7 års udviklingsperiode
- I starten 3-4 personer i forskellige afdelinger
- Motivation – hvad kan de andre indenfor CAE?

- Motivation - forretningsmæssigt
  – Jo senere en fejl opdages jo dyrere er den

- Nokia har i dag ca. 50.000 ansatte
  – 1000-1500 i R&D alene

Muligheder

- Projektsamarbejde gennem studieprojekter
  - Projekter i grundforløbet (4 mdr delt med undervisning)
  - Afgangsprojekt – diplom (2 mdr – kan kobles med praktik ophold)
  - Afgangsprojekt – civil (langt afgangsprojekt)
  - Ph.D./Erhvervs Ph.D. (3 år)
  - Post Doc.
  - Forskningsprojekt – formaliseret samarbejde

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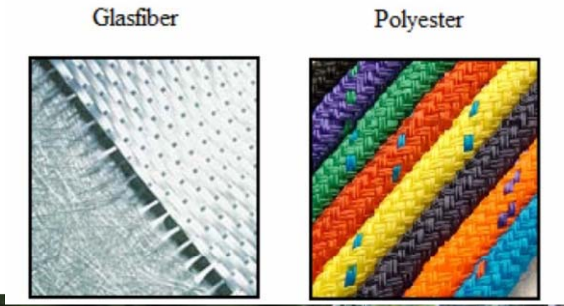
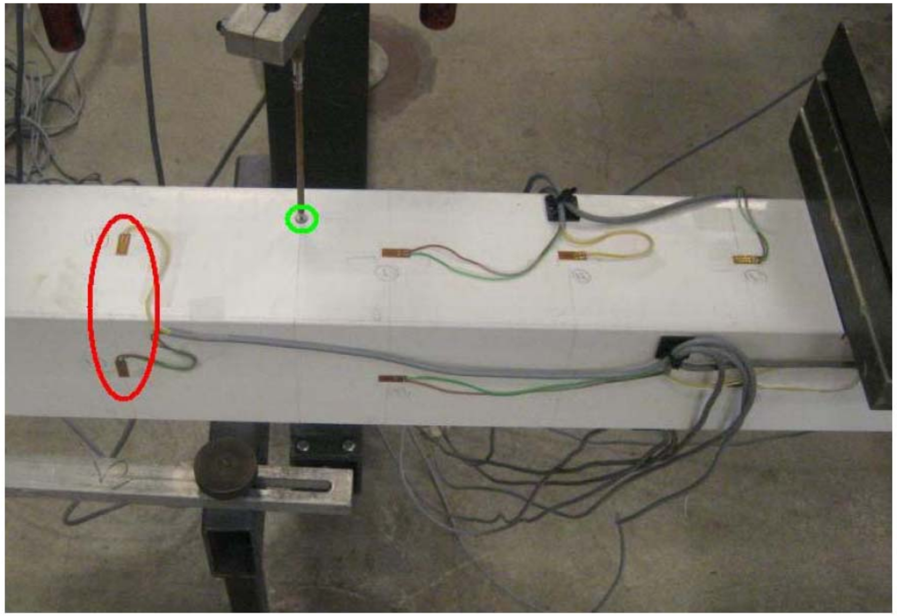
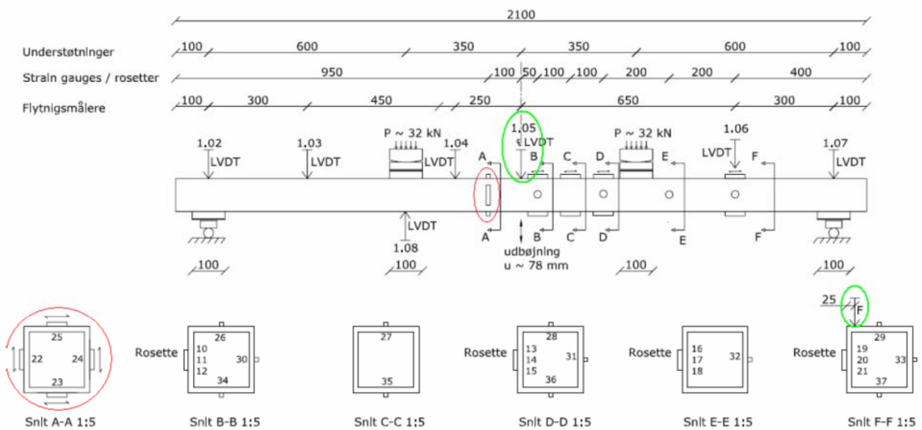
Grundlæggende undersøgelser af komposit bjælke







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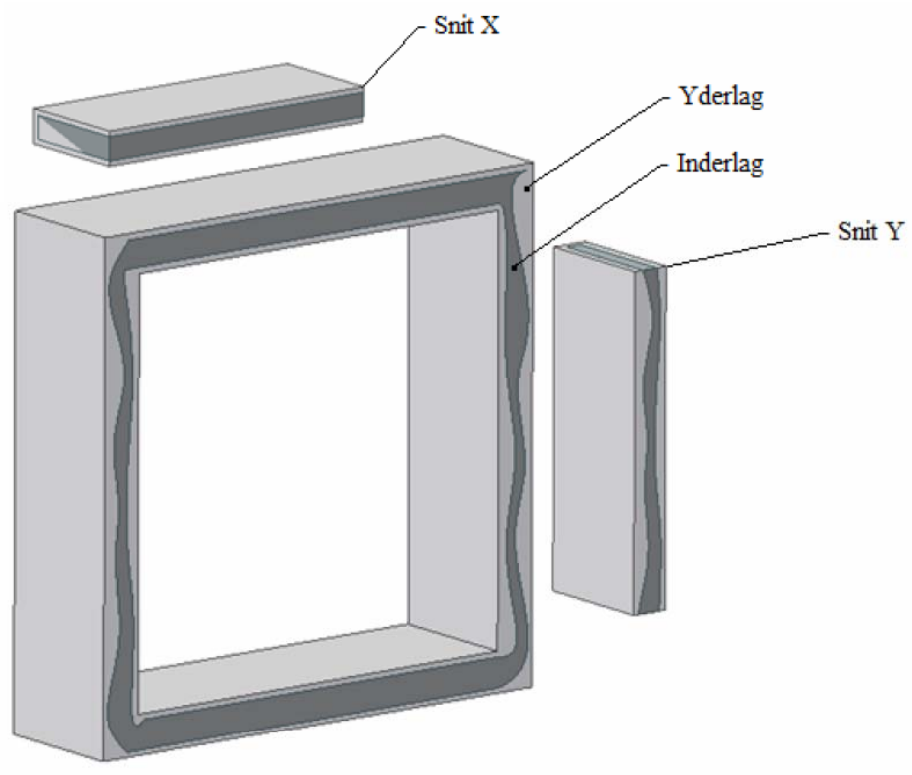

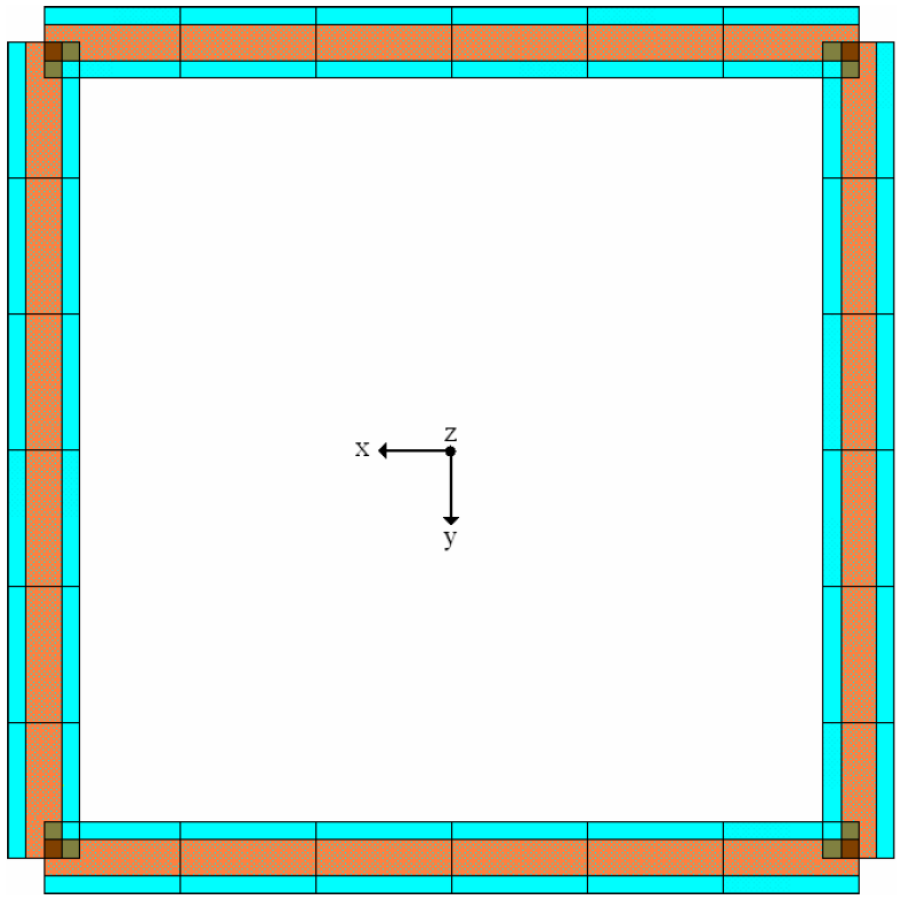

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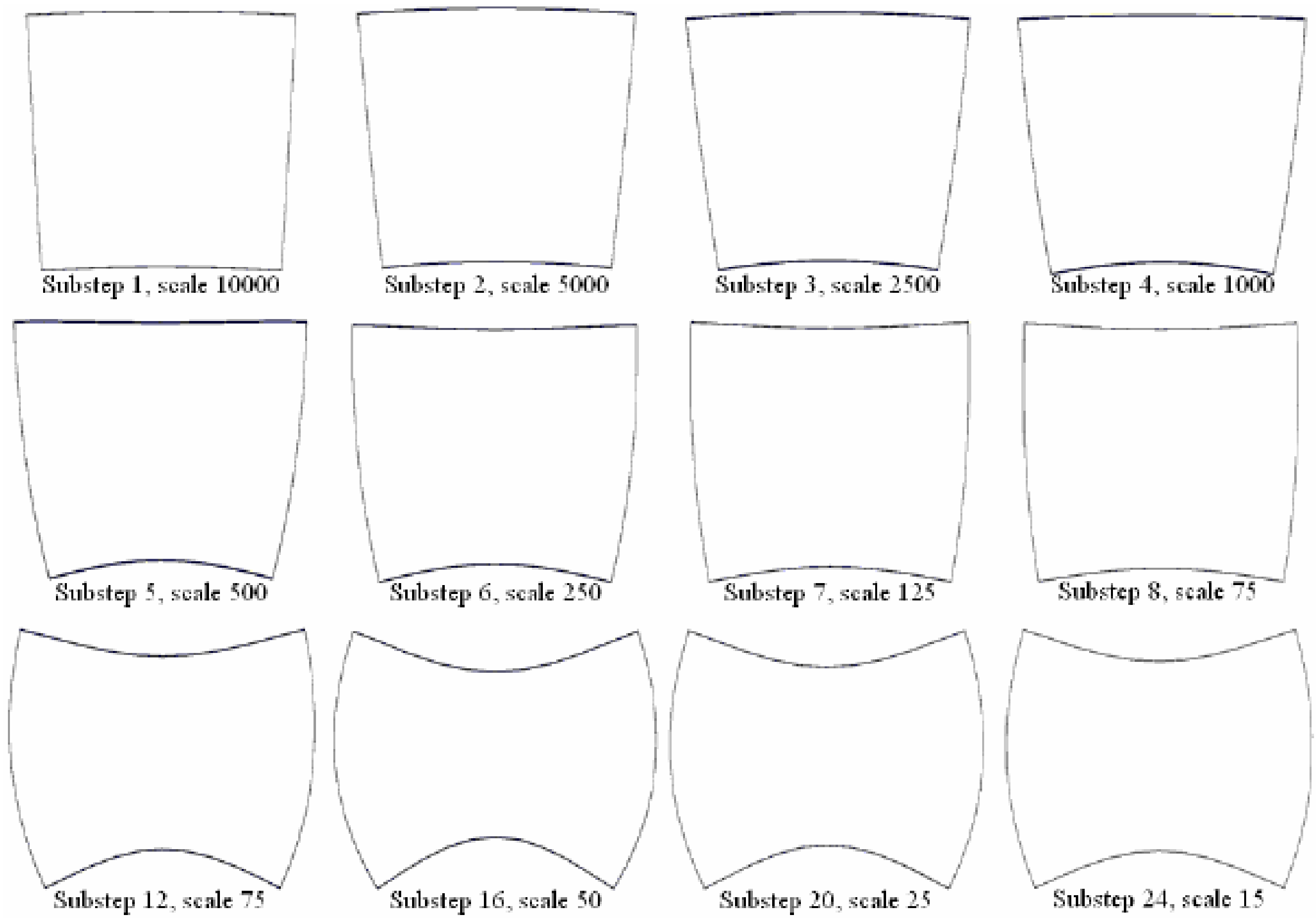

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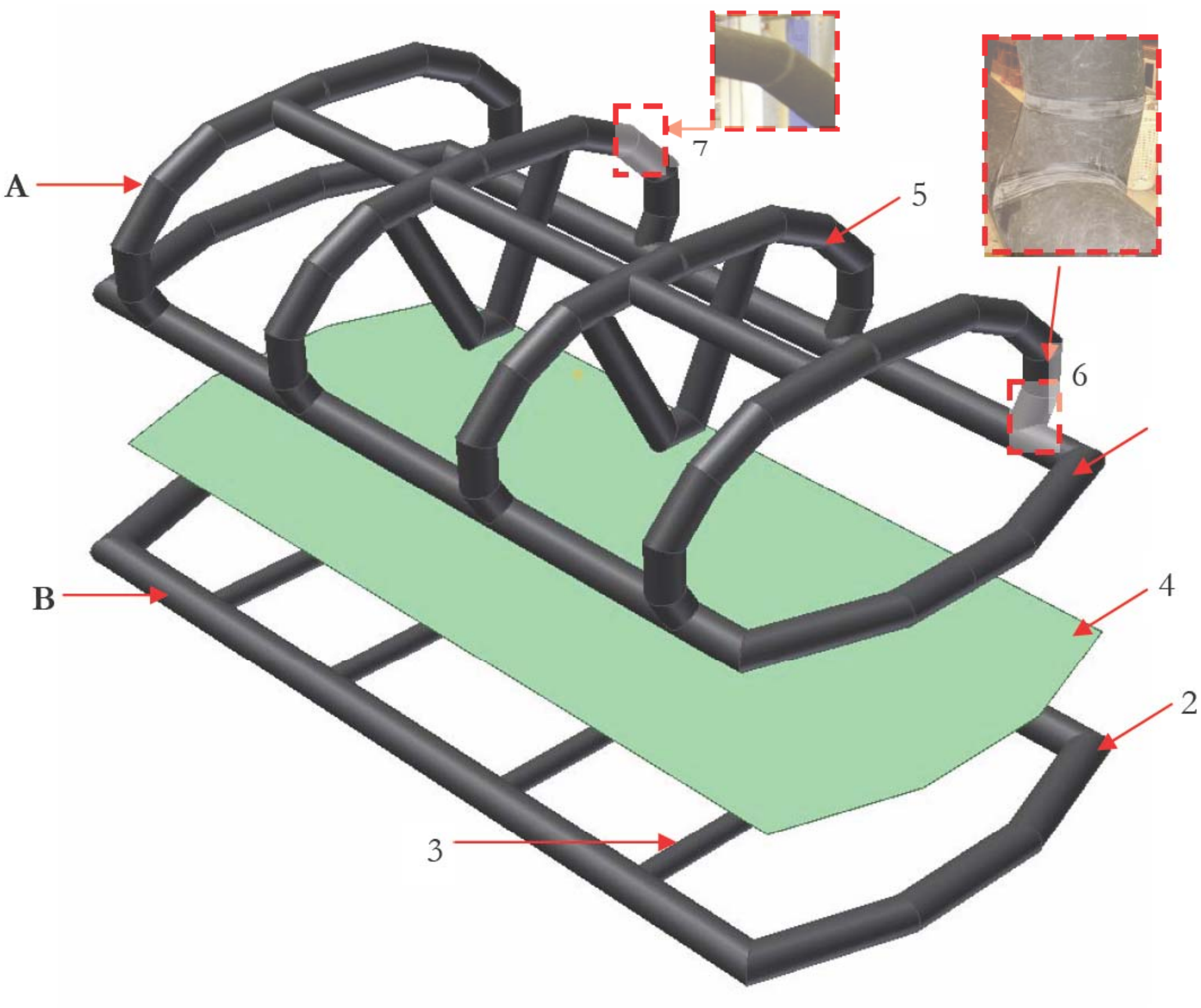
Analyse og simulering af oppustelig redningsflåde udført i et gummikomposit materiale



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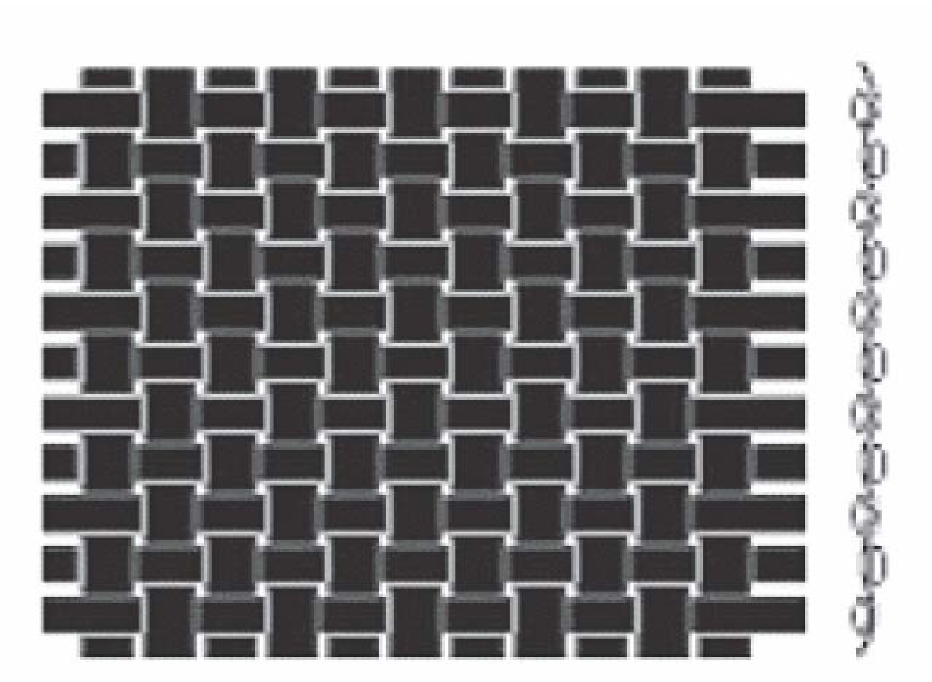
Temadag om hærdeplast og hærdeplastiske kompositmaterialer,
29 October, 2009, AAU, Esbjerg, Denmark

Analyse og simulering af oppustelig redningsflåde udført i et gummikomposit materiale

Væv af Polyamid fibre (PA66)



Naturgummi matrice (NK 205/2)

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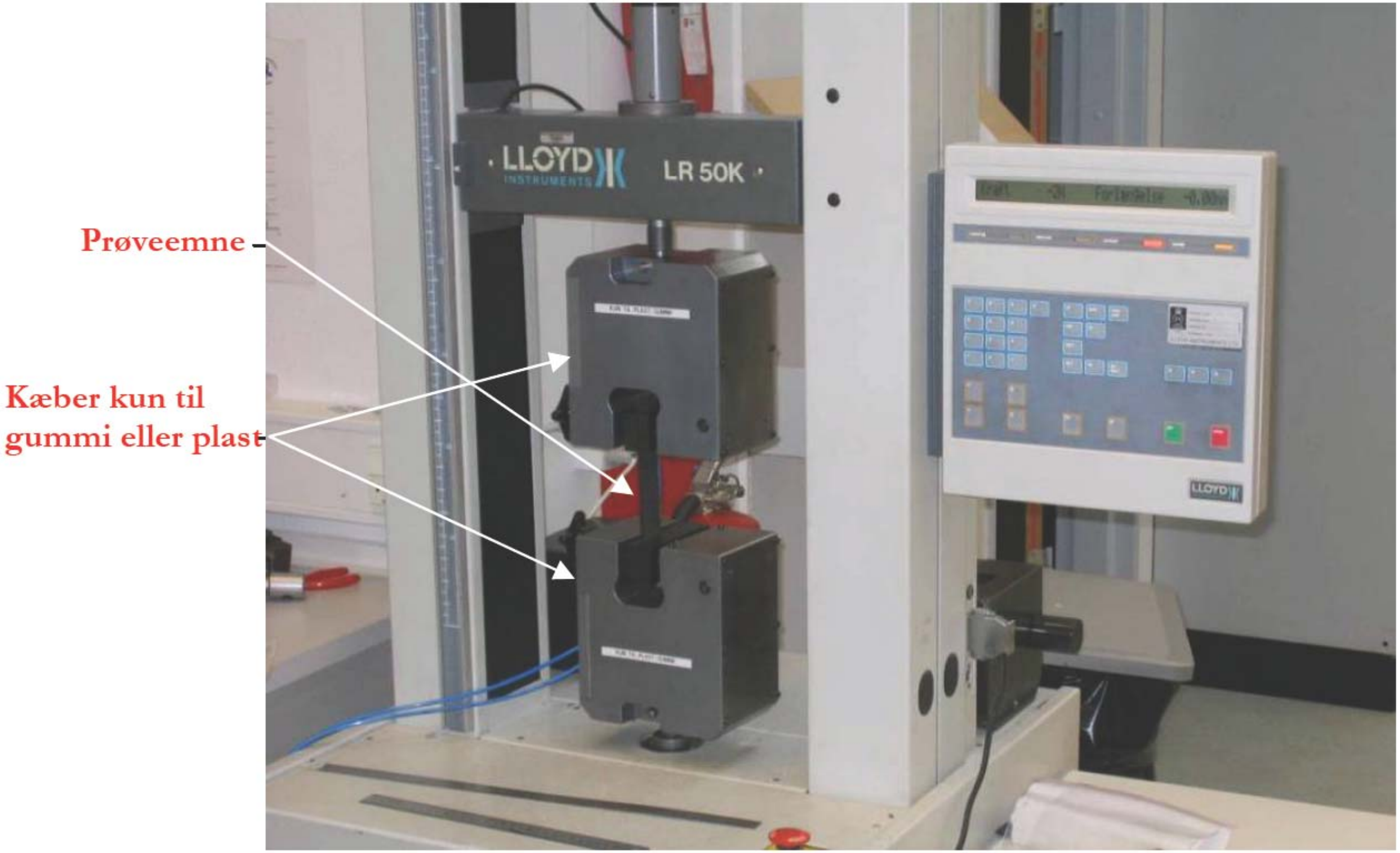

Mekaniske test i henhold til ISO 1421

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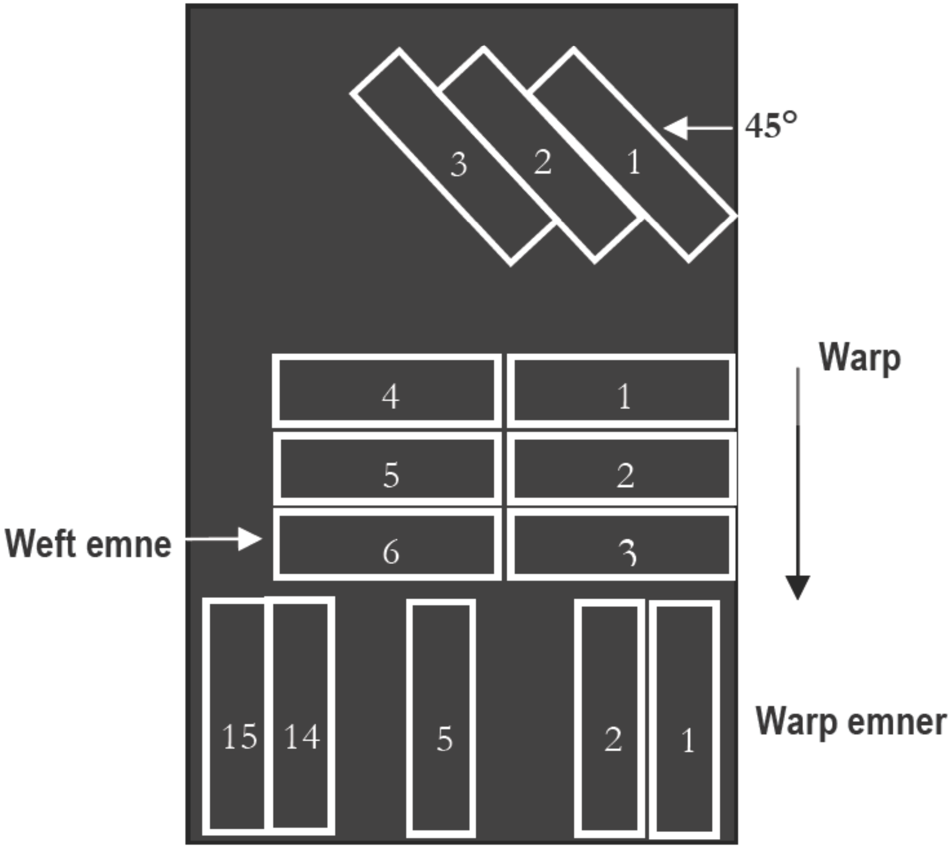

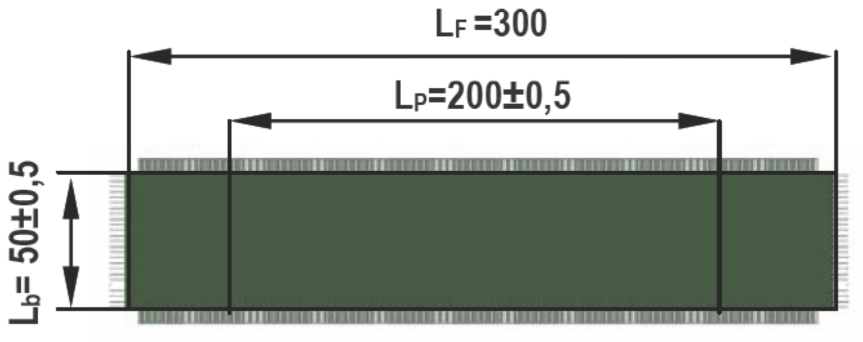

- Prøvelængde (mellem kæber): Lp = 200 ± 0,5 mm
- Emnets fulde længde skal være L_F = 300 mm, inklusiv den del, der klemmes i kæberne
- Prøveemnets bredde: Lb = 50 ± 0,5 mm

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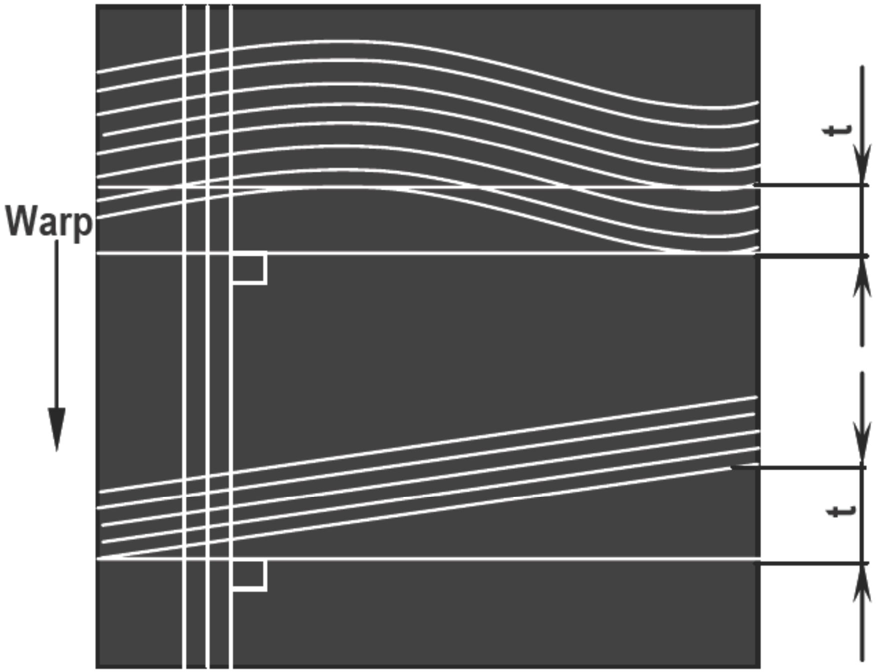
Analyse og simulering af oppustelig redningsflåde udført i et gummikomposit materiale



Warp emner	Max	Min	Mean	Median	Coefficient of Variance	Standard Deviation
Maksimum Load [N]	3390	3330	3360	3350	0.72%	24.2
Deflection at Max Load [mm]	37.7	36.9	37.5	37.7	1.06%	0.39
Stress at Max Load [MPa]	112.91	110.96	111.85	111.67	0.72%	0.81
Weft emner						
Maksimum Load [N]	3290	3250	3270	3270	0.69%	22.7
Deflection at Max Load [mm]	46.7	42.8	45.3	46.3	0.92%	0.42
Stress at Maxi Load [MPa]	109.83	108.31	109.07	109.07	0.69%	0.76
45° emner						
Maksimum Load [N]	2166	1428	1833	1866	12.77%	14.10
Deflection at Max Load [mm]	103,8	76,2	90	90	9.93%	5.37
Stress at Max Load [MPa]	72.49	47.58	61.36	62.19	12.77%	7.84

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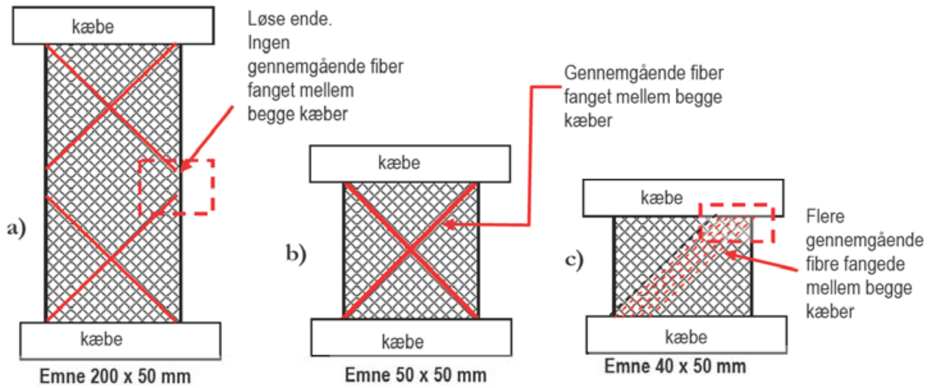

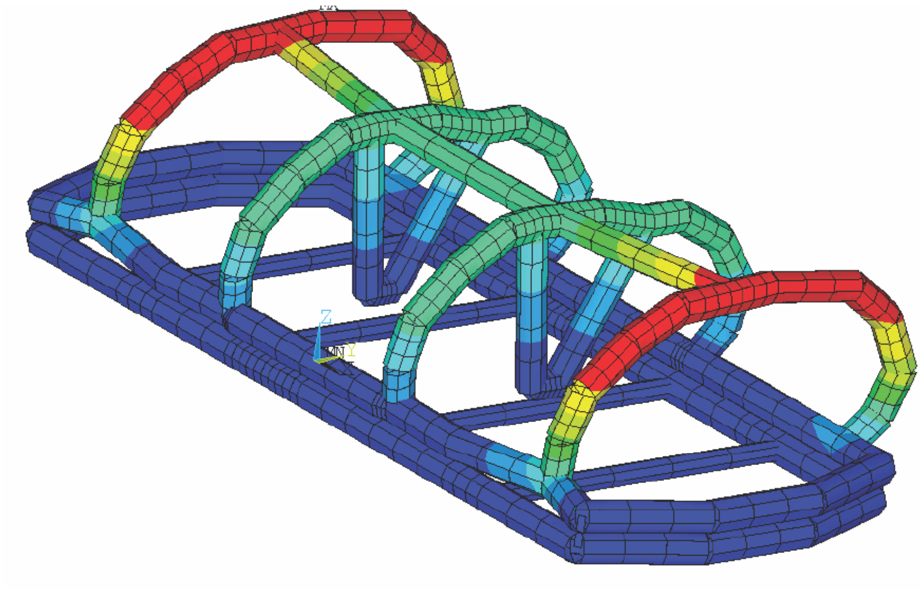

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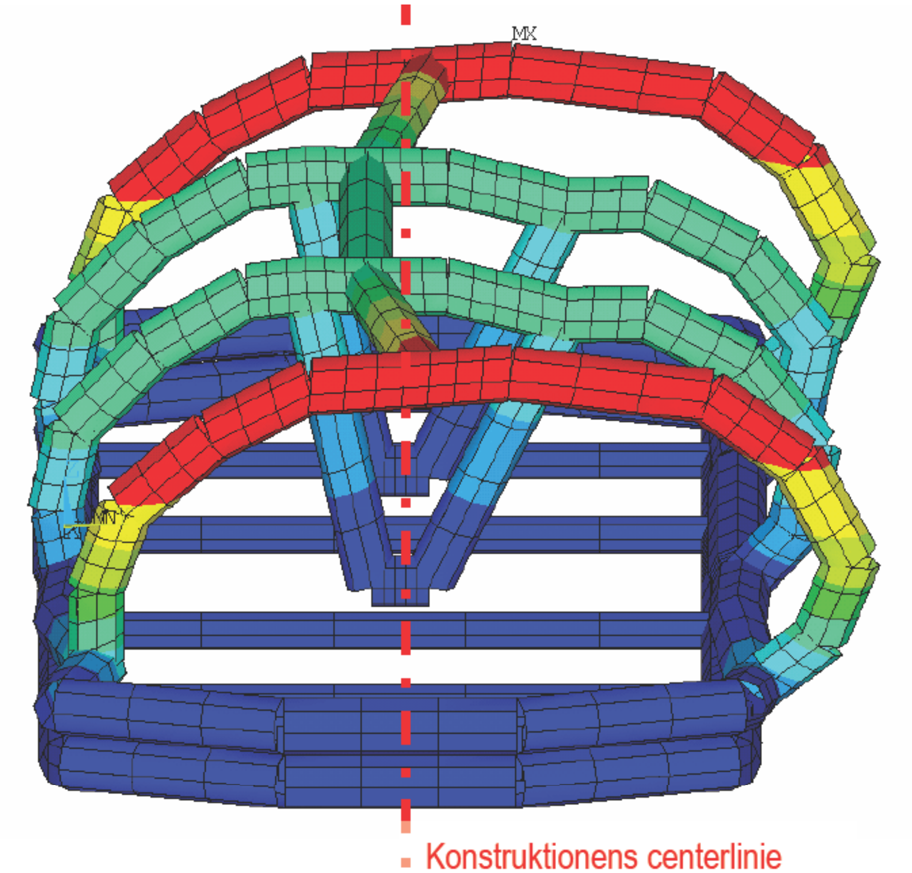

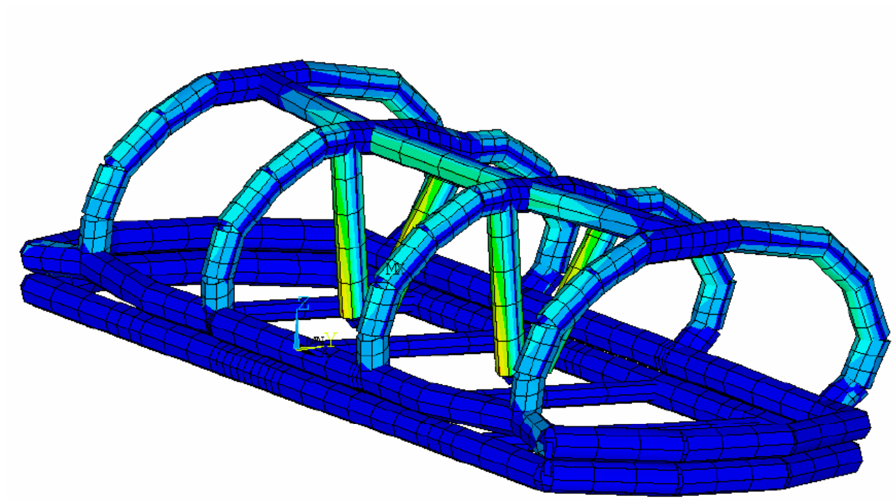

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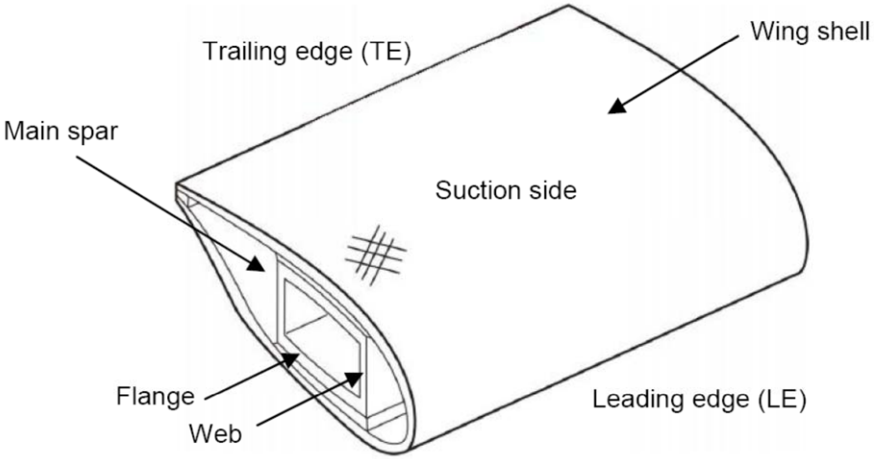
Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge



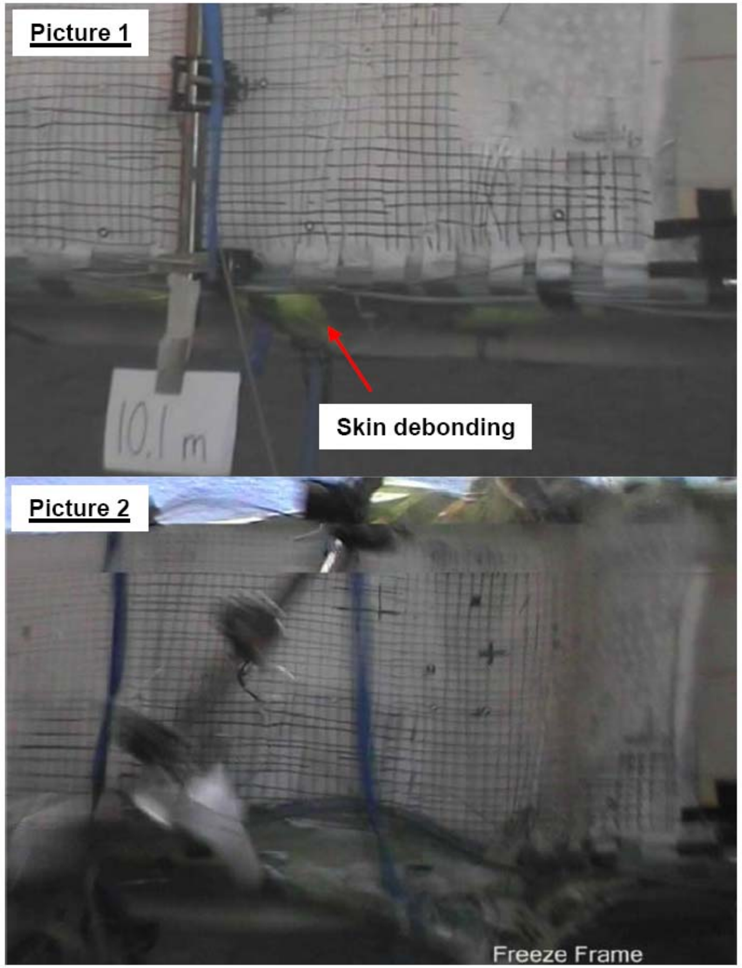


Figure 1-4: *Still pictures that illustrate the fracture in the web and final failure. [Pictures: Find Mølholt Jensen, Risø].*

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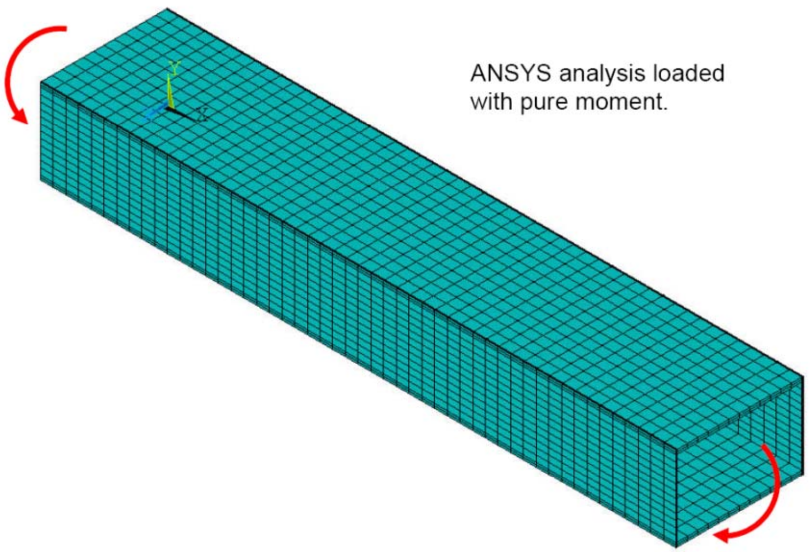
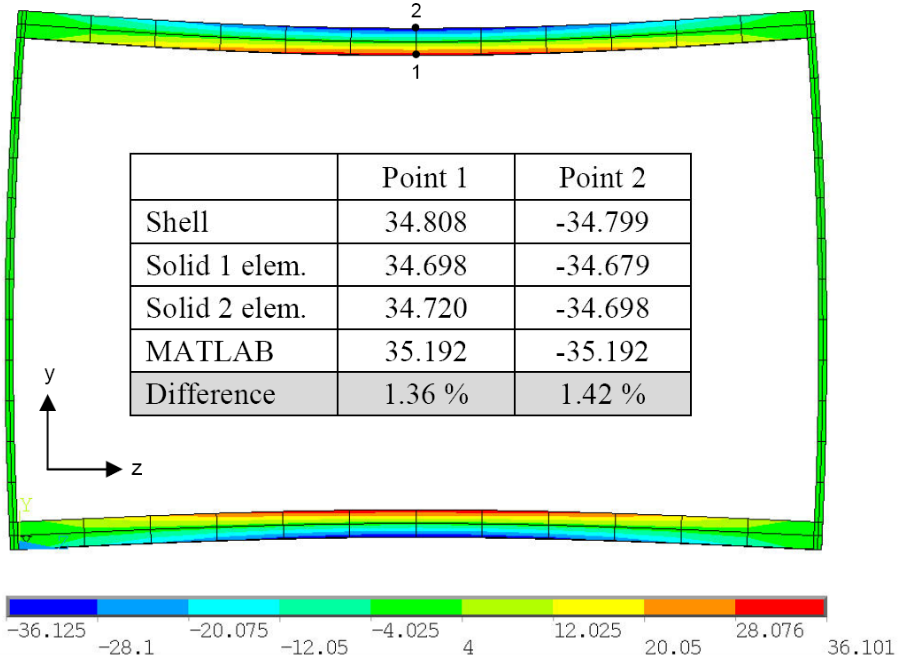


Figure 4-25: *The ANSYS analysis used for comparisons. A rectangular hollow beam loaded with pure moment.*



	Point 1	Point 2
Shell	34.808	-34.799
Solid 1 elem.	34.698	-34.679
Solid 2 elem.	34.720	-34.698
MATLAB	35.192	-35.192
Difference	1.36 %	1.42 %

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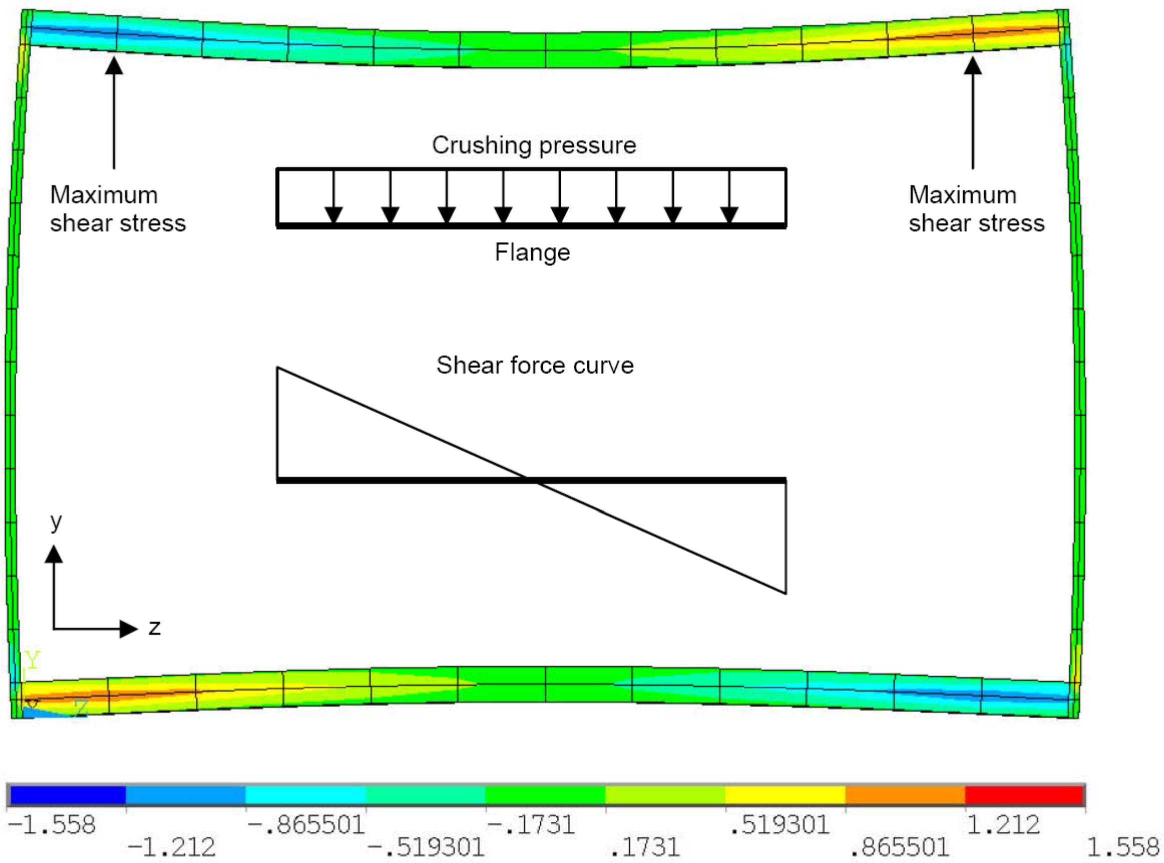
Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge

The Brazier effect cause compression stresses in the web as previous described. In the flanges it will cause shear stresses in the y-z plane, which is illustrated in Figure 4-29. The shear forces are largest near the flange ends and zero in the middle.



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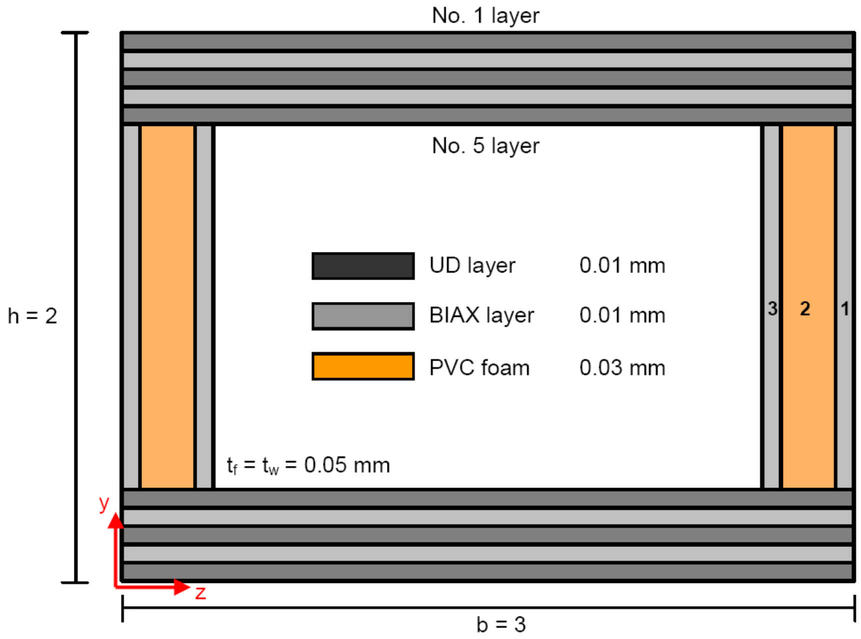
Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge



	E_x [MPa]	$E_y = E_z$ [MPa]	ν [-]	G [MPa]
UD layer	40000	10000	0.3	4000
BIAX layer	15000	15000	0.3	10000
Sandwich foam	40	Isotropic	0.3	Isotropic

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Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge

The finite element model is build with one solid layered element through the thickness. The joints between the flanges and webs are made as shown in Figure 5-5.

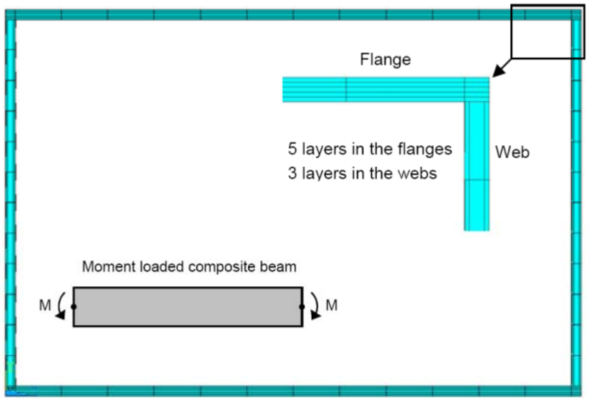

Figure 5-5: *Cross section of the FE model with layered elements. ANSYS plot.*

The SOLID46 element is used in the FE model. It is a 3D 8-node solid layered element, as shown in Figure 5-6. The stresses are calculated in the top and bottom of each layer, and vary linear through the thickness of the layers.

The linear stresses are calculated analytical from eq. (5.5) and compared with the numerical results from ANSYS. The only stresses that occur are normal stresses in the longitudinal x-direction. The stresses are largest in the outer fibres and zero in centroid plane, as shown in Figure 5-7. To the right on the figure it is seen how the stresses vary between each layers.

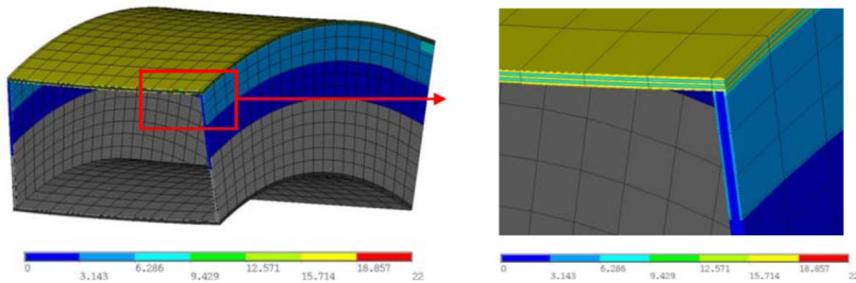

Figure 5-7: *Contour plot from ANSYS of the longitudinal stresses σ_x in the composite beam. The grey area on the beam indicates the boundary between the tensile and compression stresses.*

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Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge

In Figure 5-9 the result of the non-linear FE analysis is seen. The normal stresses in the z direction are plotted. It is seen that the outer sides of the flanges are in compression while the inner sides are in tension.

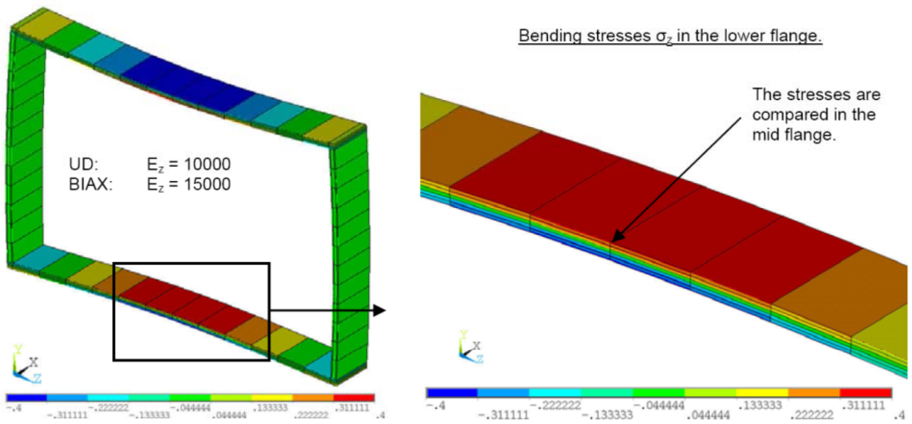

Figure 5-9: *Contour plot from ANSYS of the normal stresses σ_z in the lower flange. The layer on the outer side has number 1 and the layer on the inner side has number five.*

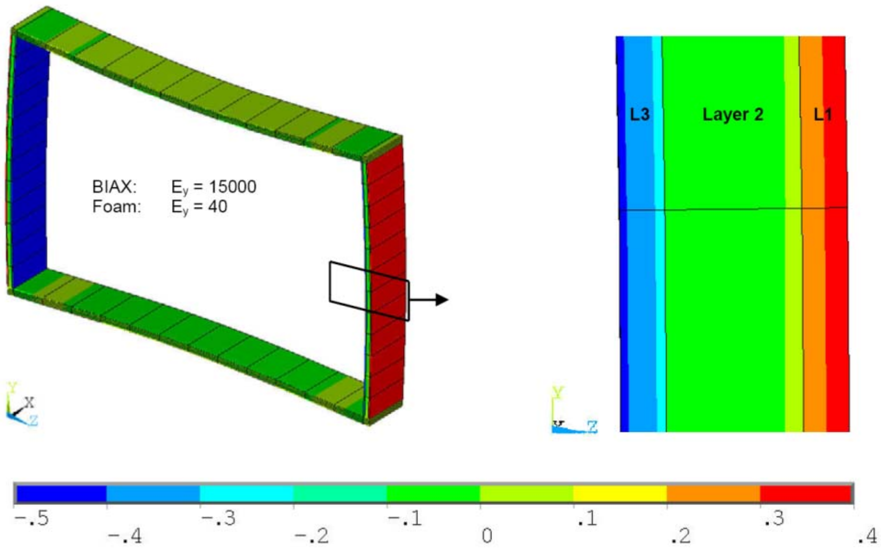

Figure 5-10: *Contour plot from ANSYS of the normal stresses σ_y in the mid web.*

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Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge

The possible failure modes are:

- UD failure in compression flange
- Web failure (as in the full-scale test)
- Buckling of compression flange
- Longitudinal failure

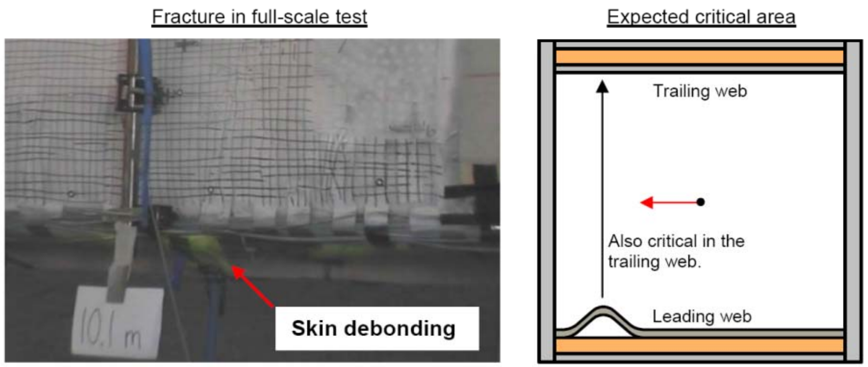

Figure 9-1: *Fracture in the leading web towards the compression flange. Skin debonding failure.*

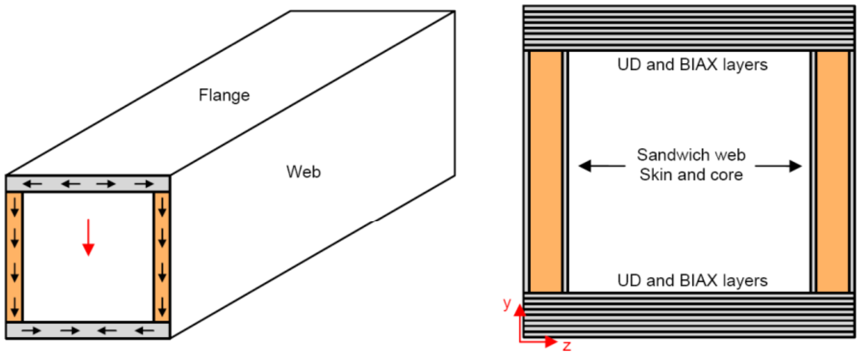

Figure 6-3: *The directions of the shear stresses in the composite cross section plane.*

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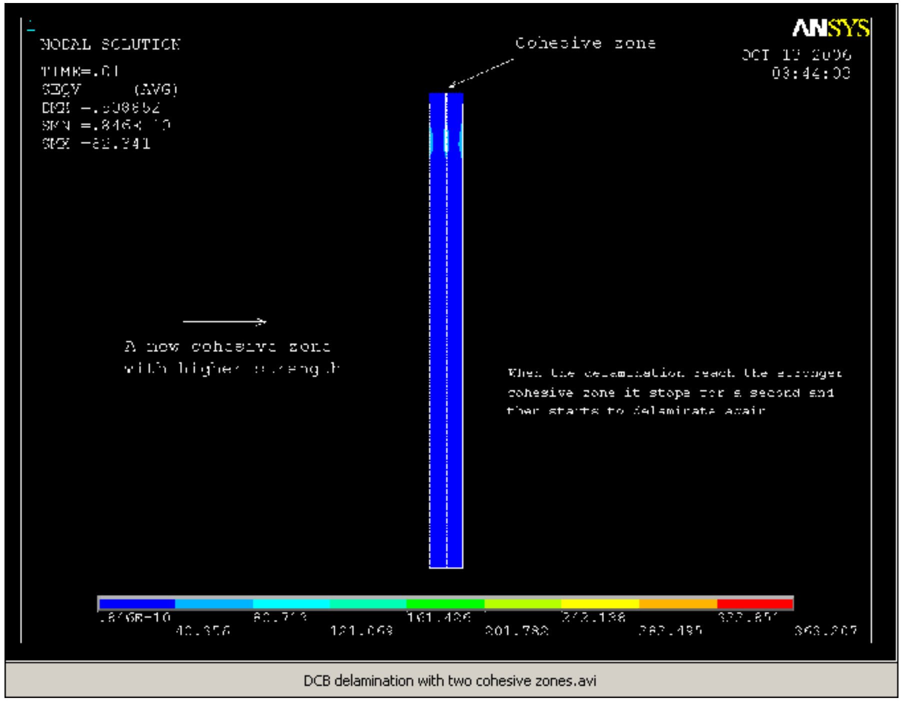
Simulering af ikke-lineære strukturelle effekter i en vindmøllevinge

- Skin debonding by cohesive elements in ANSYS Classic using a Xu and Needleman approach



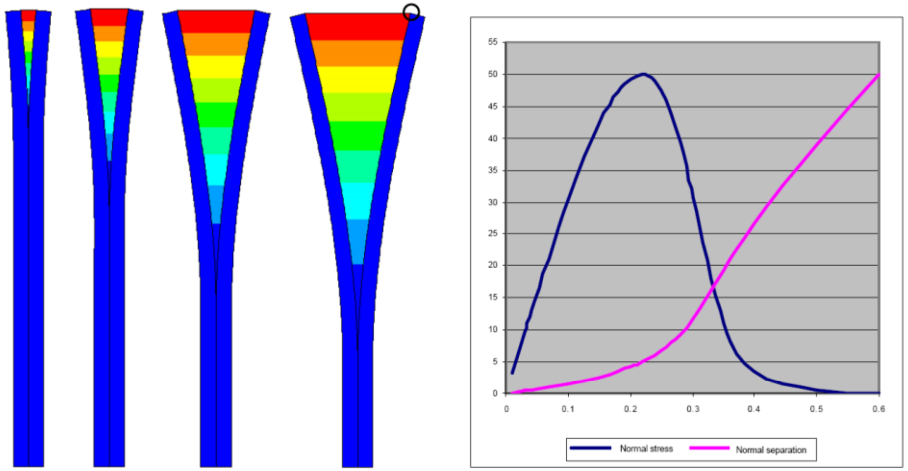


Figure 7-5: *Left: Deformed figures from ANSYS with growth of delamination in mode I loading. The separation is scaled with a factor 10. Right: The normal stress and separation as function of the sub step. The normal separation is scaled with a factor 100.*

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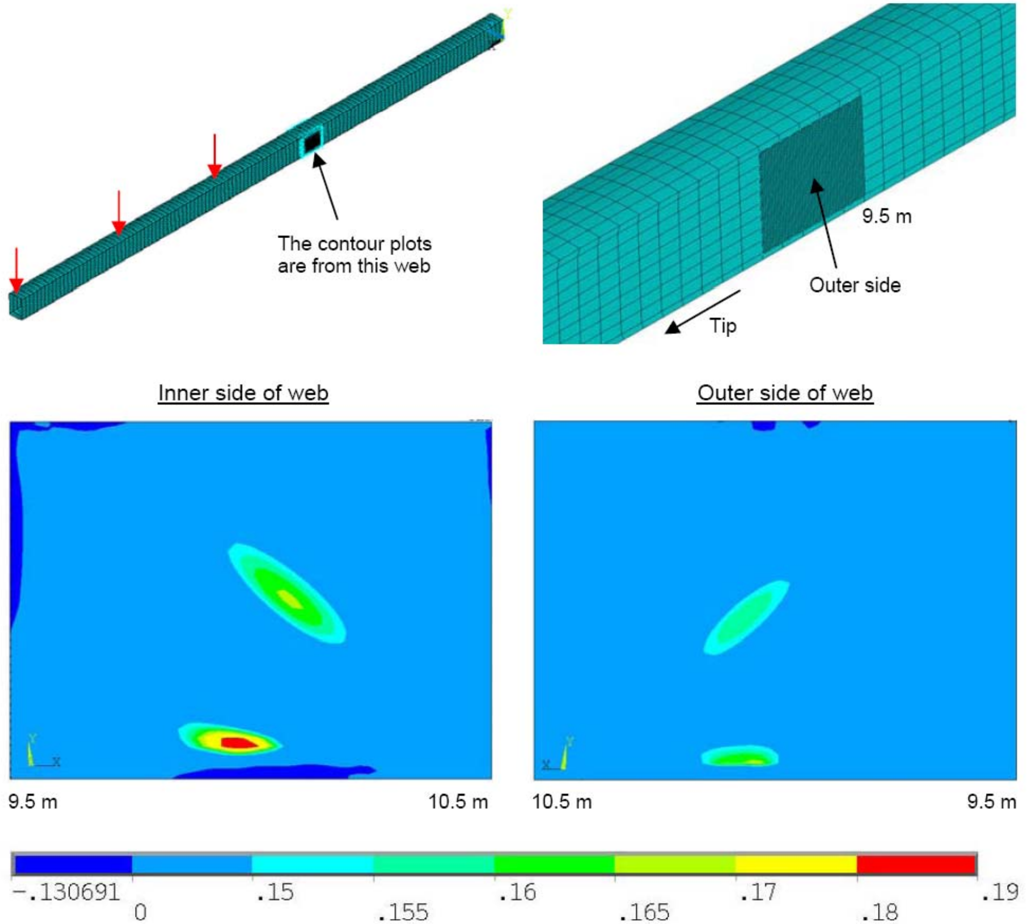

Figure 9-8: *Contour plots from ANSYS of the separation of the cohesive elements. Skin-debonding is seen in the middle of the web and in the web towards the compression flange.*

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Afrunding

- Samarbejder kører for tiden med udgangspunkt i studenterprojekter
- Forenklede FEA modeller kan give større indsigt i kritiske forhold for et system bare i de indledende og afklarende faser da der stilles mange spørgsmål til konstruktionens egentlige funktion og fysiske opførsel
- Med udgangspunkt i CAE søges at understøtte det arbejde, der udføres i virksomheden, sådan at eksempelvis udviklede CAD modeller kan anvendes i produktionen
- Det er muligt at samkøre et projektforløb vha. praktik som giver en arbejdsperiode fra april til og med december
- Der arbejdes problemorienteret imod en vidensopbygning, hvilket giver basis for et detaljeret dokumentationsarbejde som eventuelt kan anvendes overfor certificerende myndighed
- Det er muligt at køre mere målrettede forskningsorienterede projekter med udgangspunkt i Esbjerg (Ph.D. eller Erhvervs Ph.D.)