Bonded Point-Supports: Understanding Today - Optimizing for the Future

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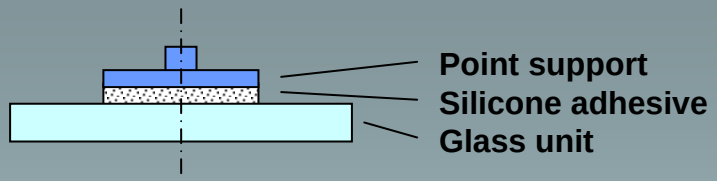
Why Bonded Point Supports?



In contrast to mechanical point supports they offer :

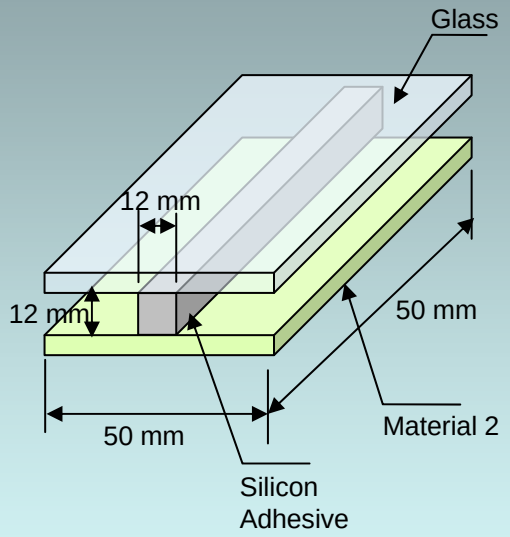
- **No or less visibility from outside**
- **‘Soft’ load introduction, beneficial for the glass unit**
- **No drilling of holes into glass in case of planar point supports**

Contents

- **Characteristics of Silicone Bondings**
- **Planar Bonded Point Supports**
- **Countersunk Bonded Point Supports**
- **Conclusions and Outlook**

Bonded Point Supports and ETAG 002

- **Line-type bonding designs for structural glazing systems are covered by European guideline ETAG 002.**
- **ETAG 002 is limited to simple geometries - rectangular cross section and a two-sided joint design.**
- **For approval of bonding designs a special H-type specimen is defined in ETAG 002 for determination of mechanical limits.**
- **The operating conditions of ETAG 002 does not require much knowledge about the adhesive material properties.**
- **Application of bonded point supports is obviously beyond the scope of ETAG 002.**



Stiffness in Relation to Dog-Bone Tests

Two issues have to be considered:

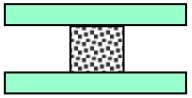
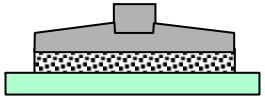
- the interface to stiffer adherents

- the almost perfect incompressibility of silicone

This leads to:

- a much higher effective stiffness

- a more complex material loading.

Specimen Type	Dog-Bone 	ETAG H-type Specimen 	Planar Round Point Support 	U-type Point Support 
Stress and strain fields	Uni-axial (1D)	Complex (3D)	Complex (3D)	Complex (3D)
Strain $\varepsilon_N=\Delta l/l_0$ *	1,19	0,82	0,08	0,06
Stiffness σ_N/ε_N	0,84	1,21	12,9	16,9
Stiffness related to dog-bone	1	1,44	15,4	20,1

* Nominal stress 1 N/mm^2

The boundary conditions are critical for adhesives with a Poisson's ratio in the vicinity of 0,5!

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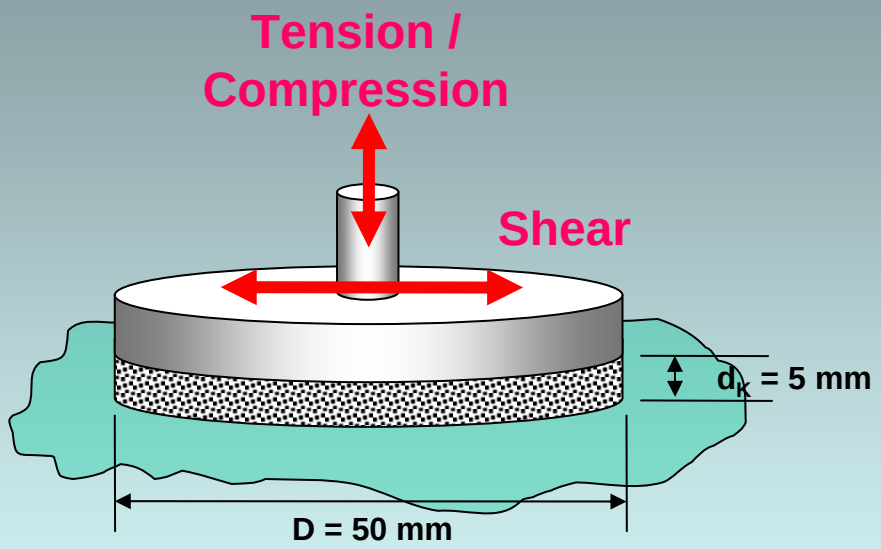
Planar Point Supports



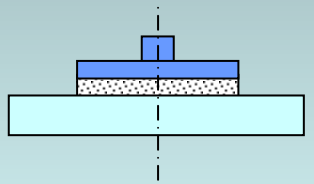
Typical loads are:

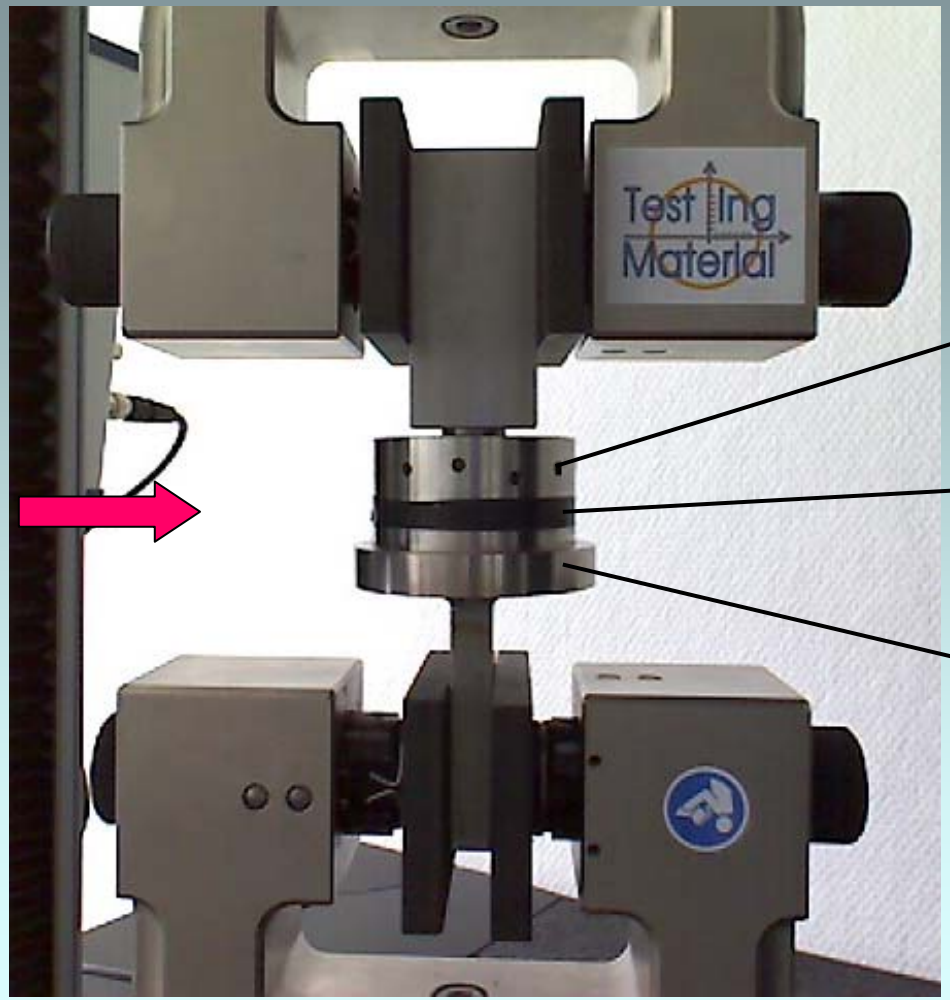
Shear	**soft characteristics, typically beneficial for thermal loads**
Tension	**higher effective stiffness due to suppression of lateral contraction**

Tensile loads are more critical for sizing and more difficult to understand.

Therefore, research focus is given to tensile load cases.

Test Configuration for Tension





upper fitting simulating support

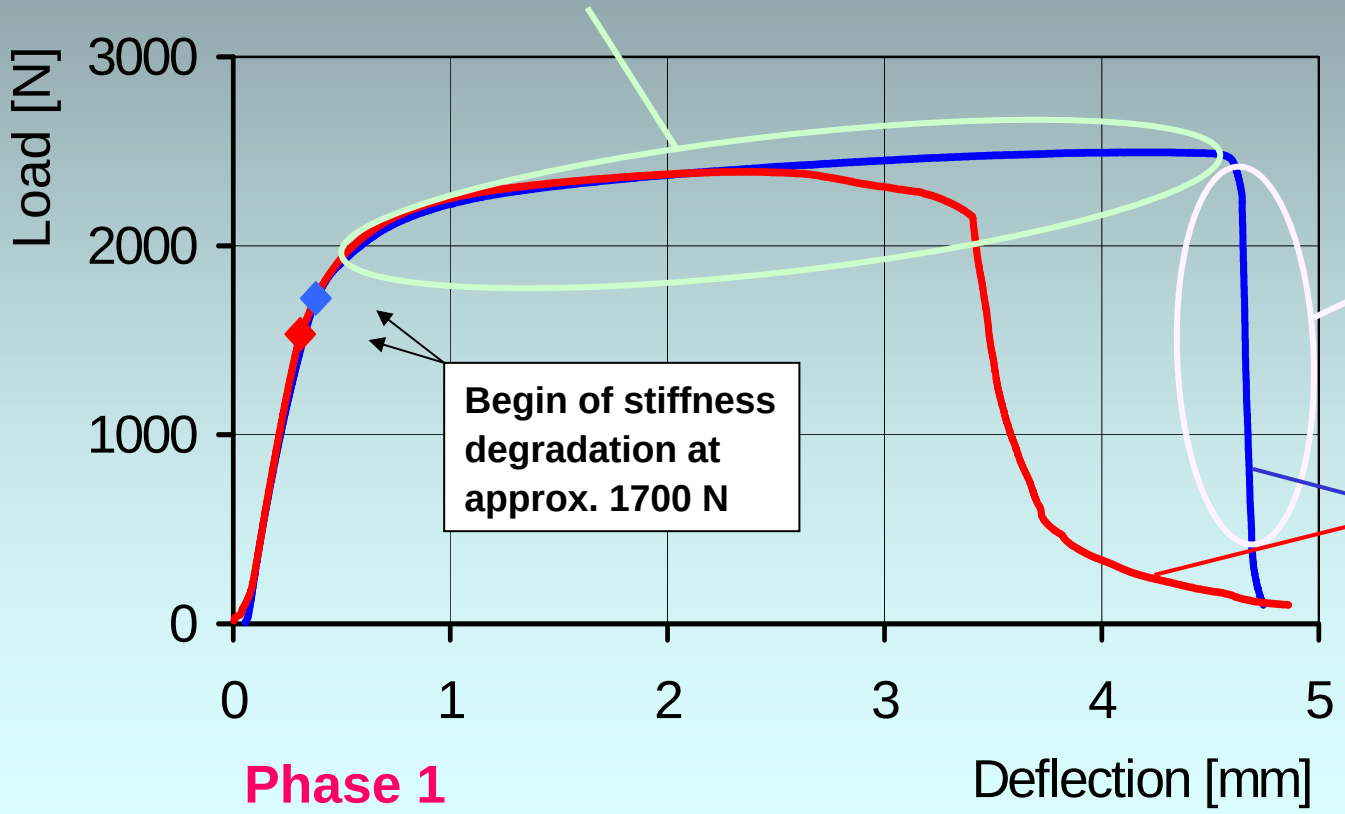
Silicone adhesive Ø 50mm (two component DC993)

lower fitting simulating glass

Test Results for Point Supports d = 50 mm

Phase 2

showing micro damages in the bulk of adhesive

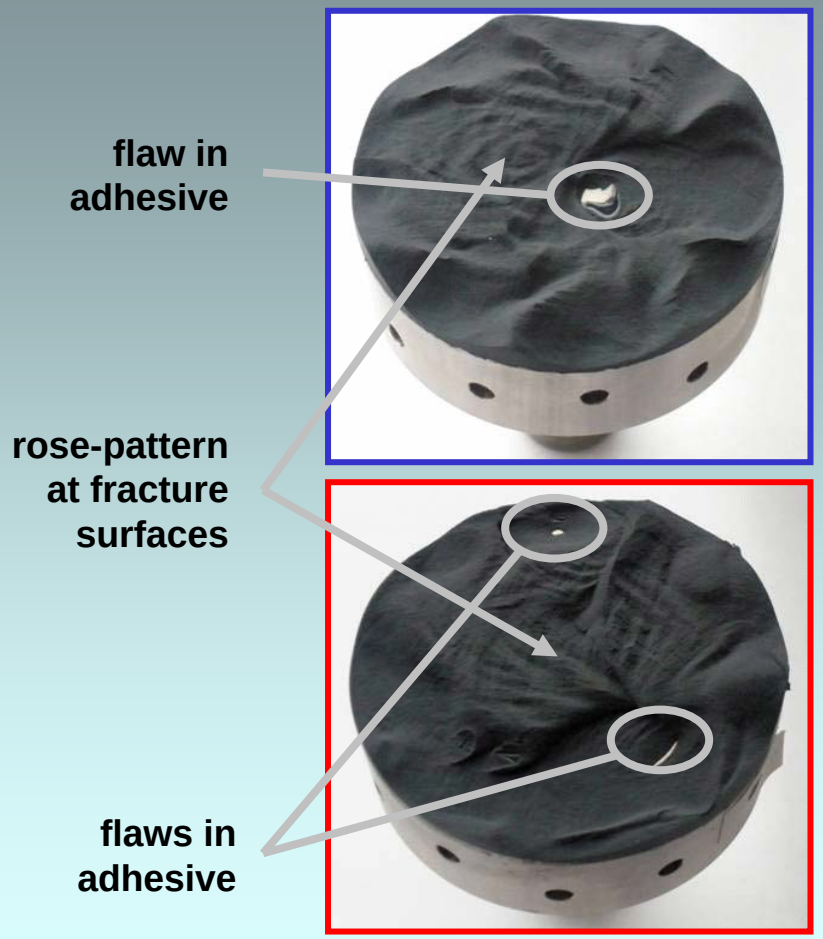


Phase 3

macro cracks lead to total failure

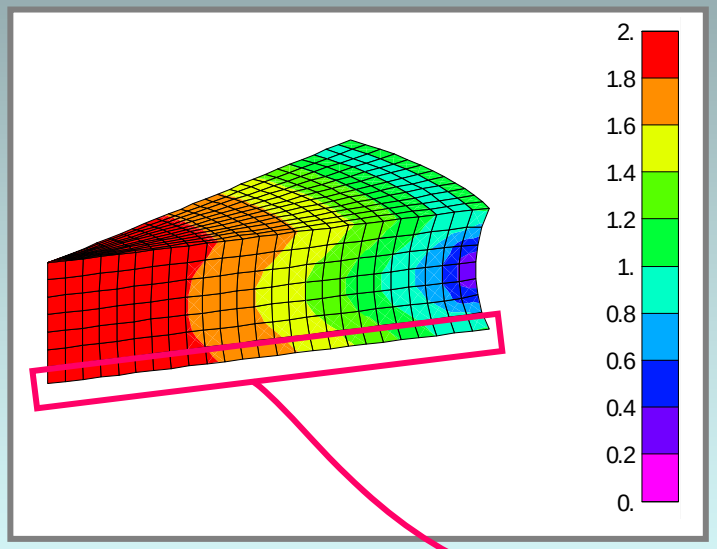
Different final failure behaviour due to flaws in adhesive

Comparison of Fracture Surfaces

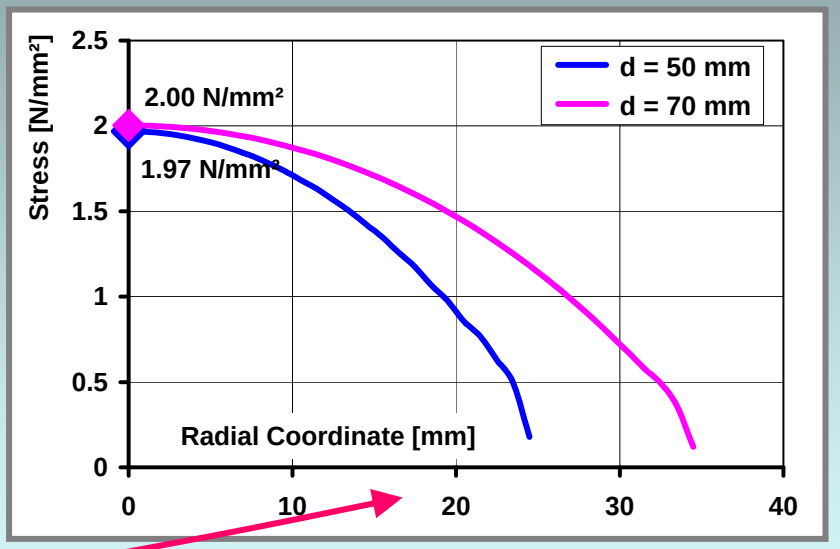


Stresses under Tensile Loading

Distribution of maximum principal stress for 1700 N (begin of stiffness degradation)



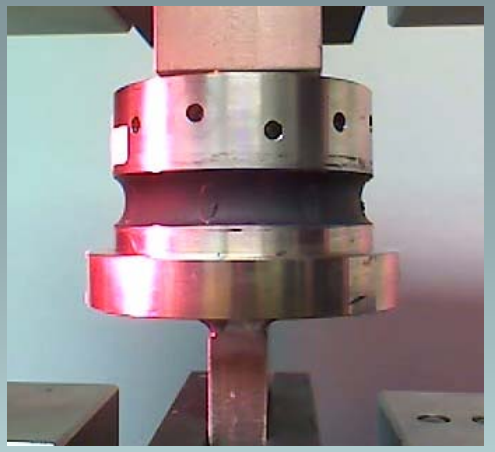
Comparison of stresses for diameters 50 mm and 70 mm showing similar stress levels at the center.



Please note:
- **The failure is assumed to start when the loss of stiffness occurs.**
- **The stress level of approximately 2 N/mm² is of more general validity (also experienced for U-type bonding, two component structural adhesive DC993).**

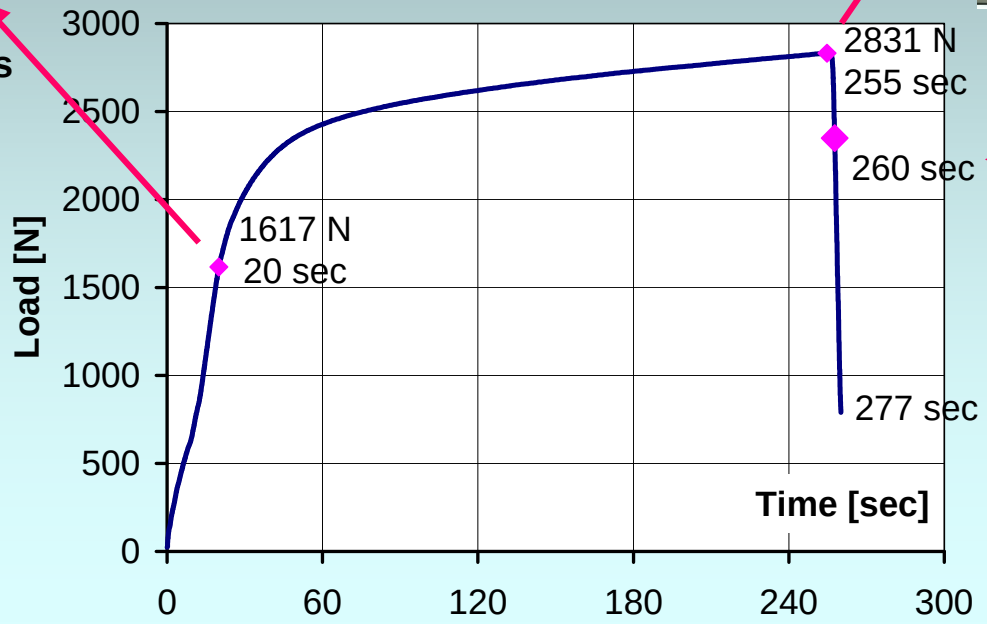
Test Run for Test 8

Three test curve points are of special interest



beginning of cracks inside after 255 s.

decrease of stiffness starts after 20 s.



cracks observed outside

stop of test and cut up

Movie of Test Run

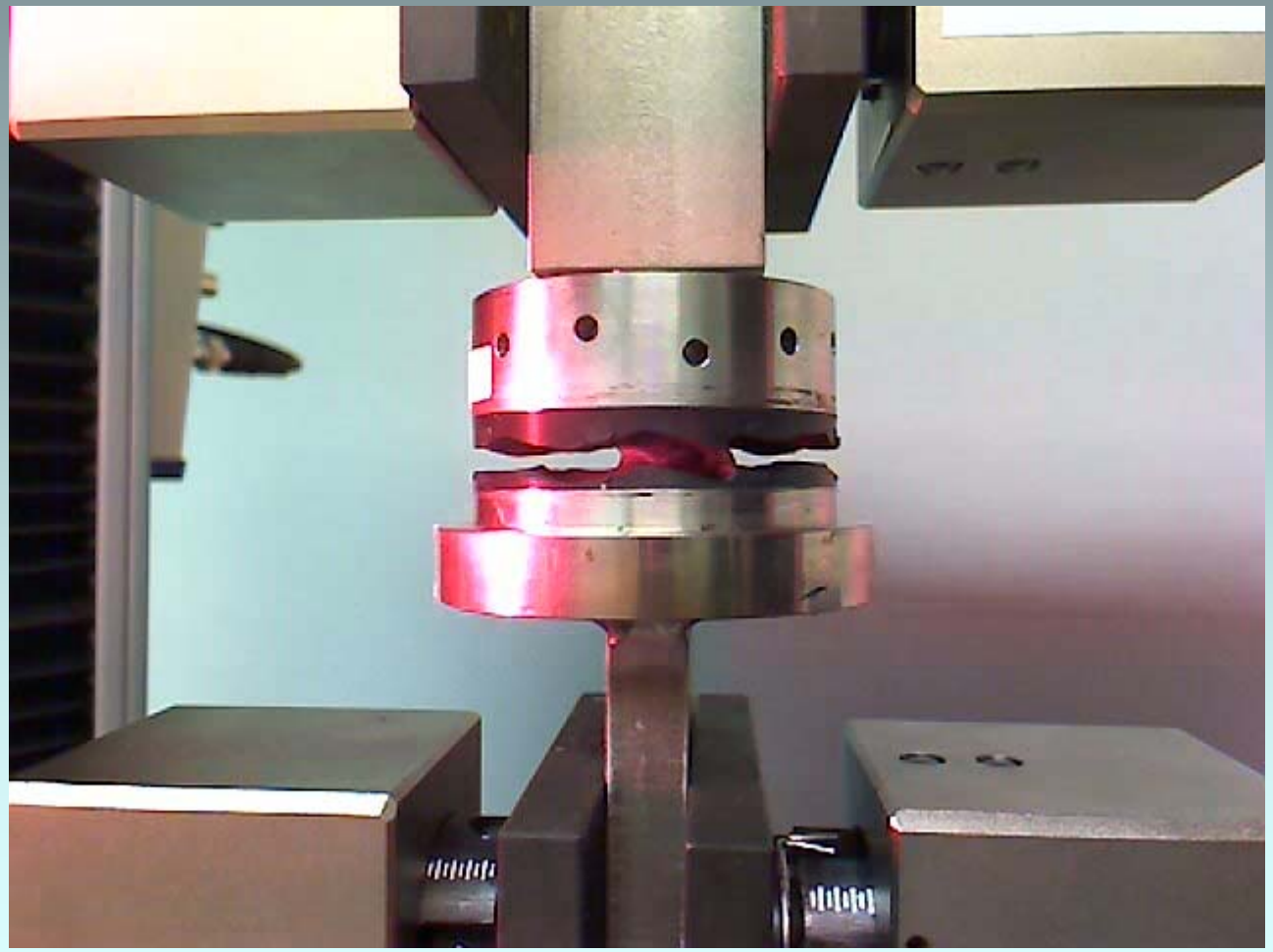
start

one step

255 s

real time

total failure



This is what happens... (Hypothesis)

1

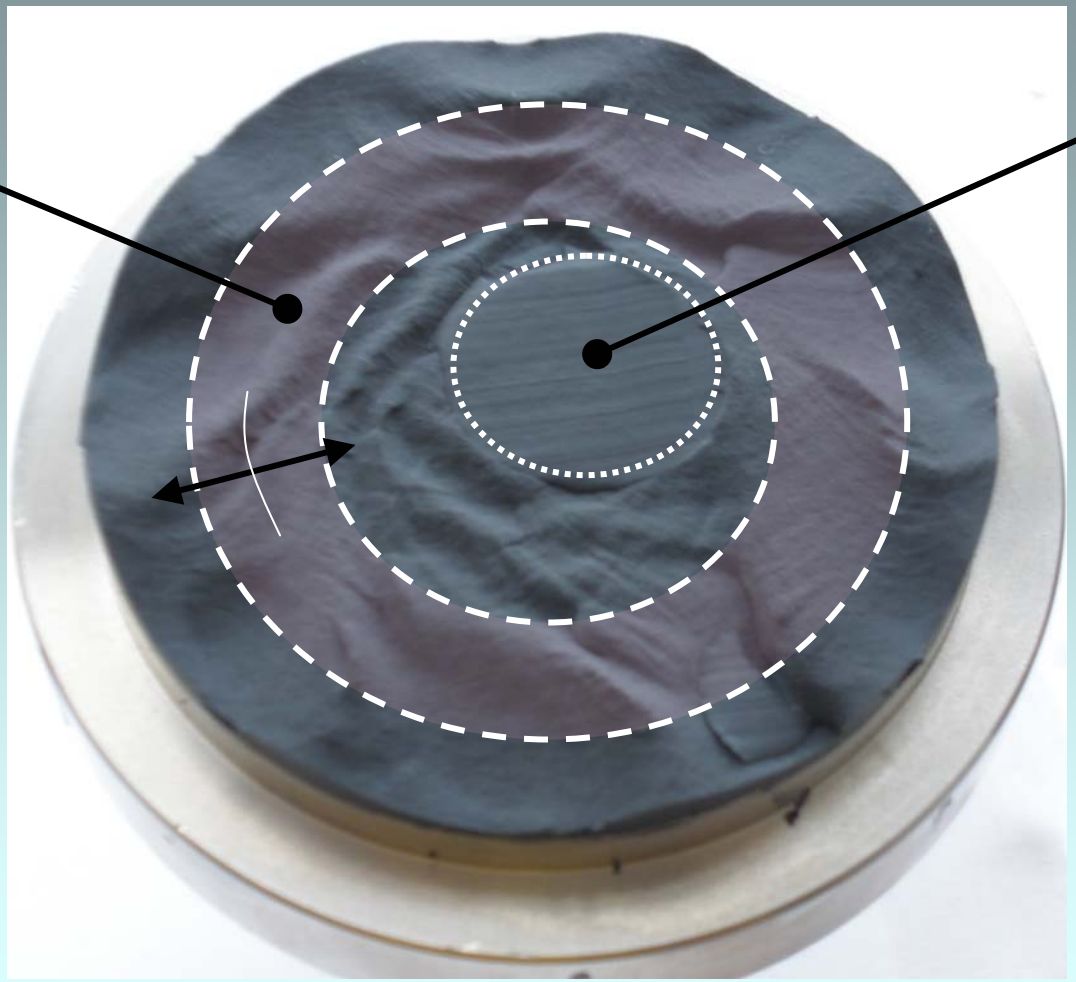
Beginning of macro cracks at an inner circle

after 255 sec

2

Crack-progress to inside and outside

255 - 277 sec



3

Finally the core fails

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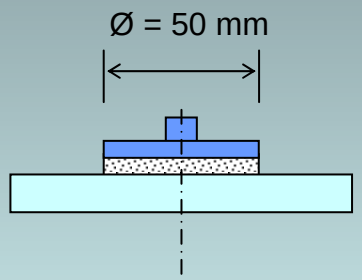
Numerically Investigated Point Supports

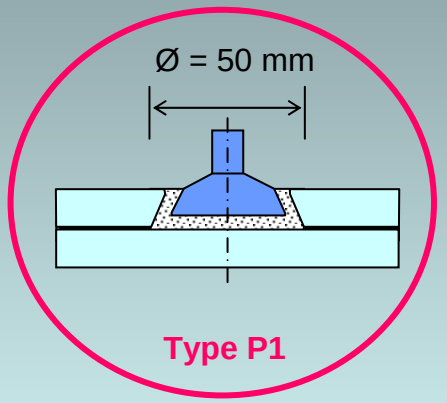
Why using countersunk point supports?

The target is the direct support of both panes of laminated glass units.



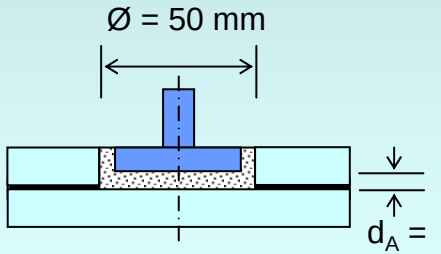
Type PB

baseline for comparison



Type P1

conical countersunk point support

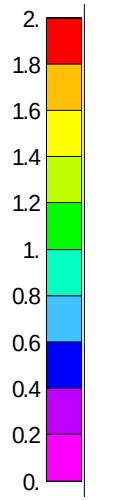


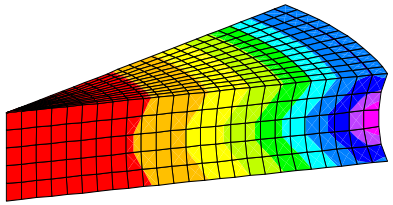
Type P0

countersunk point support baseline

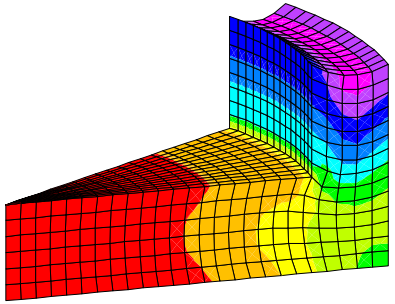
Type P1 was chosen for experimental testing due to increased load share of the inner pane

Stress Distribution of Adhesive - Tension

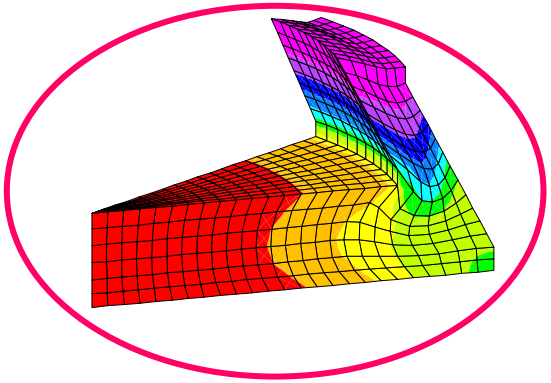




Type PB



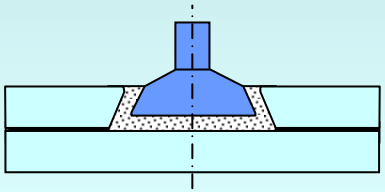
Type P0

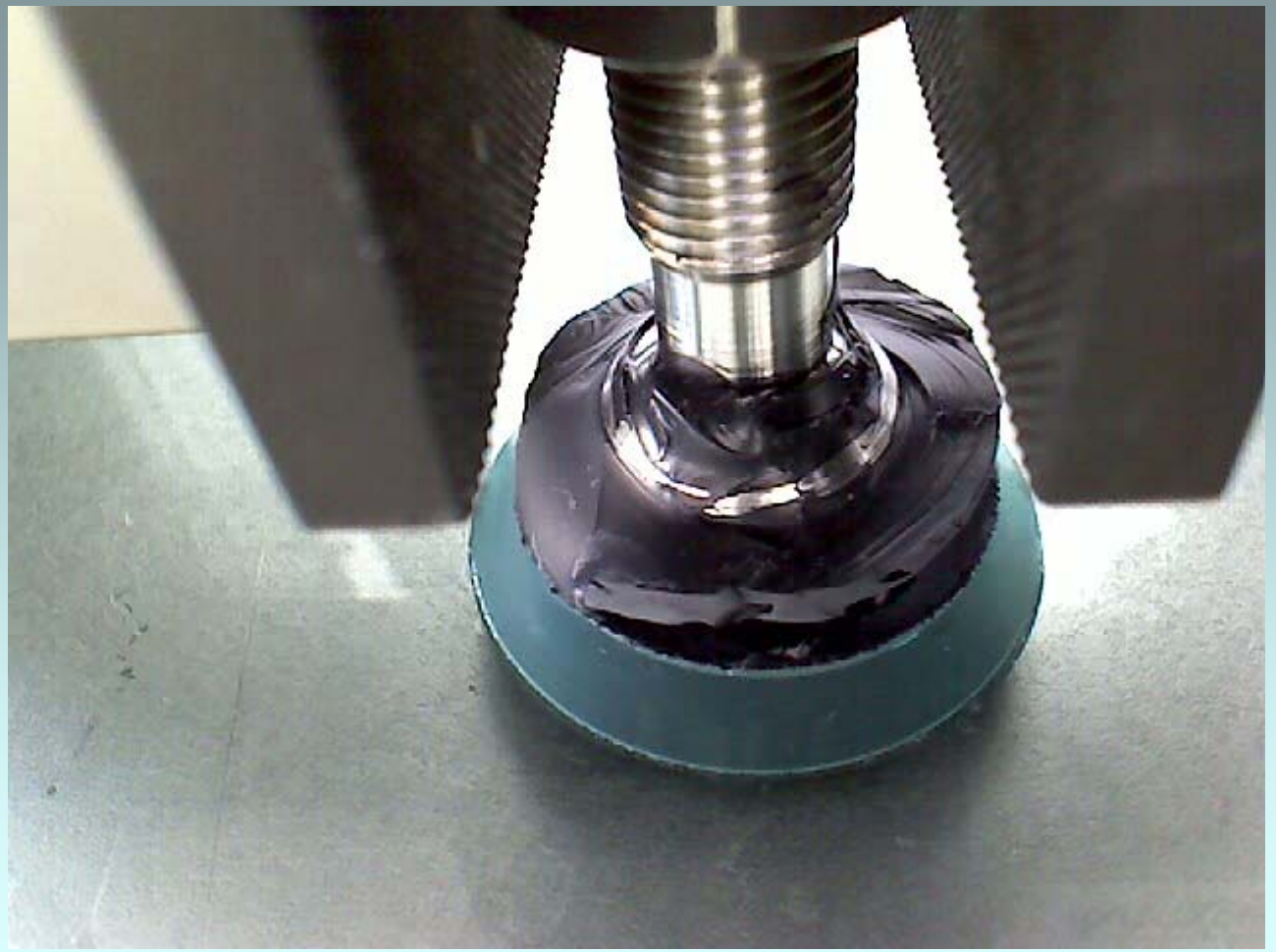


Type P1

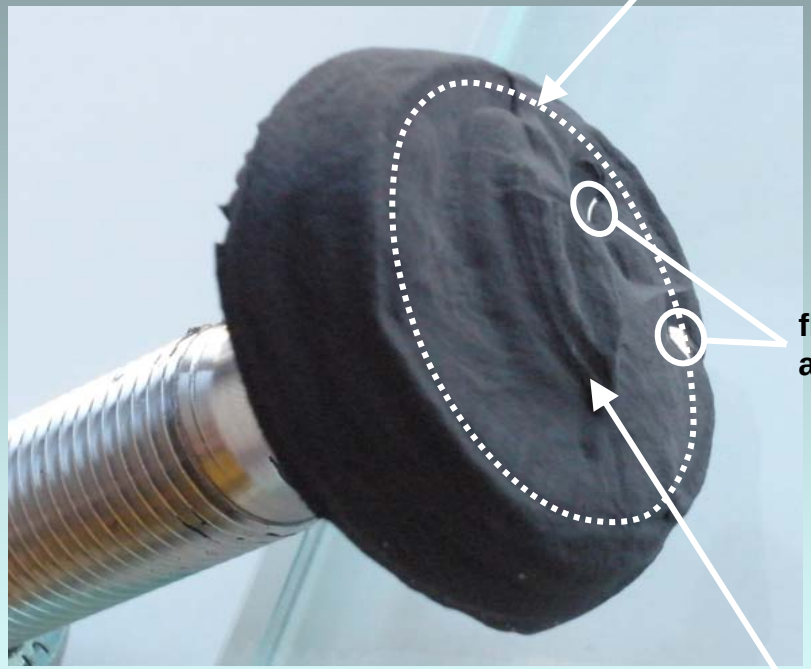
comparison of maximum principal stresses for different point support designs

Movie of Test Run of Point Support Type P1



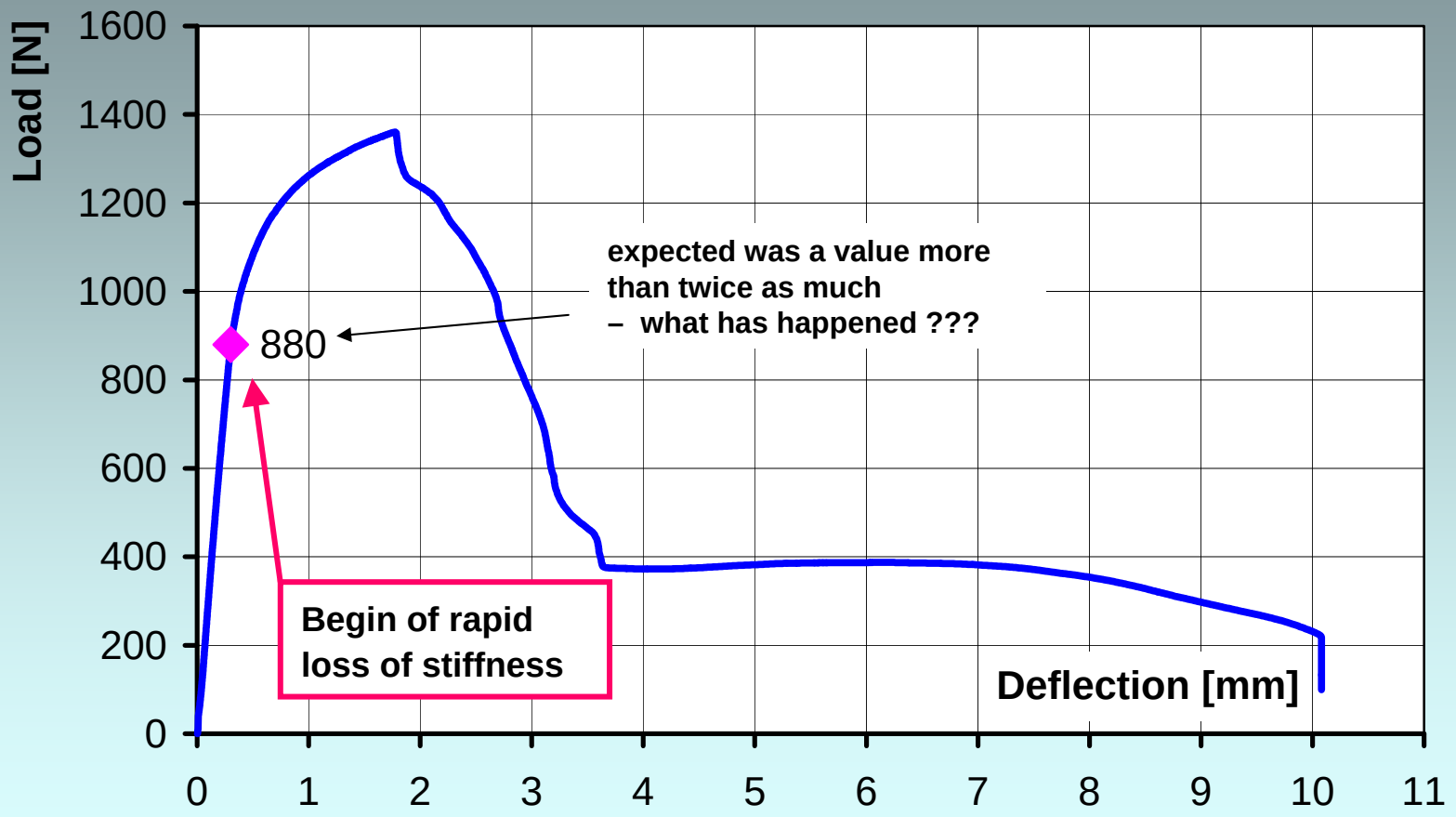


Fracture Surface of Point Support Type P1

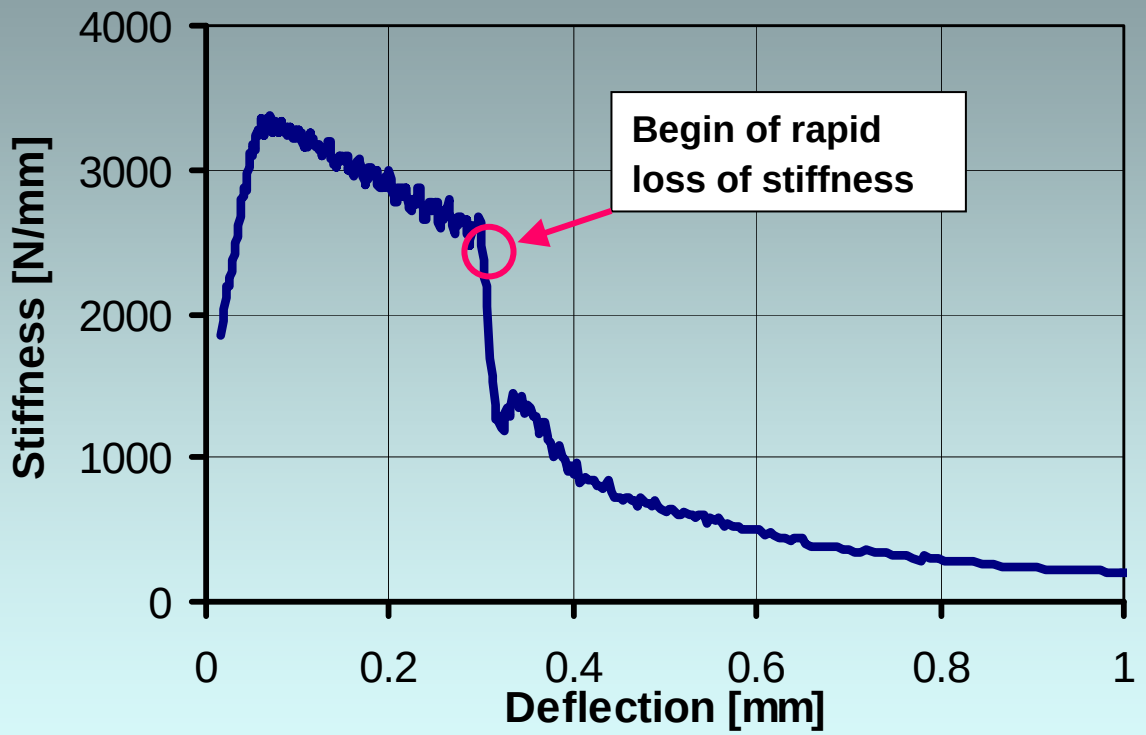


failure surface
at glass-side

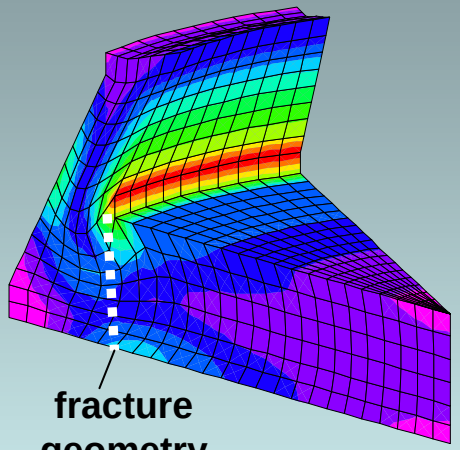
Test Results of Point Support Type P1

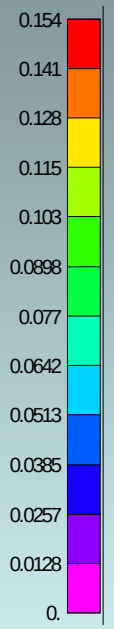


Identification of Stiffness Loss Begin

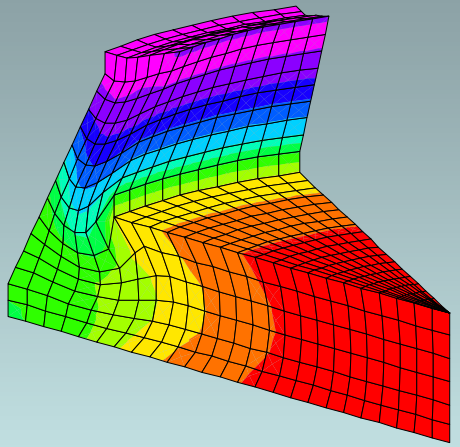


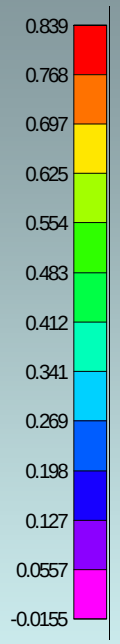
Stresses at Begin of Loss of Stiffness





shear stresses





max. principal stresses

- **The assumption of maximum principal stresses of 2 N/mm² is not fully valid for those kind of point supports.**
- **The initial failure is evoked by this special kind of ‘sharp’ design.**

Contents

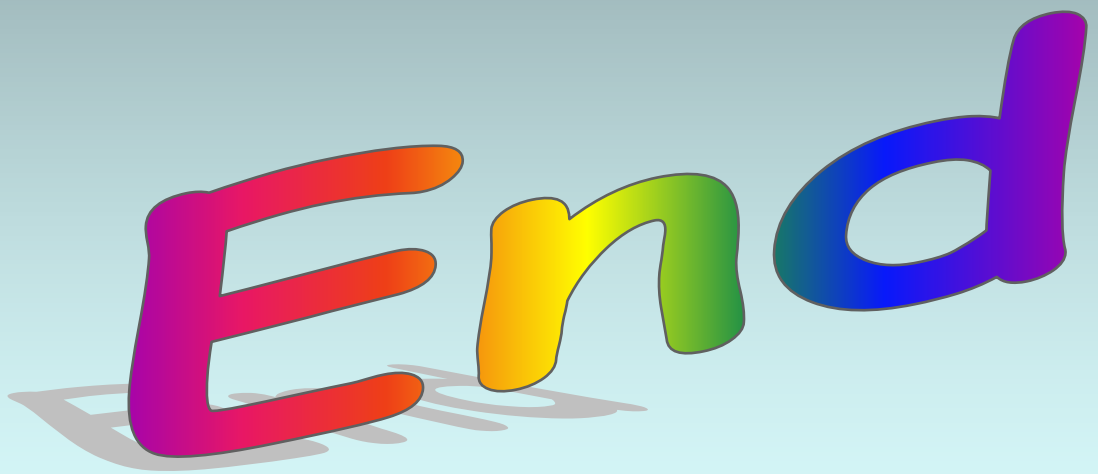
Conclusions and Outlook

- **Comparison of different geometries of Silicone bondings shows that suppression of lateral contraction influences significantly the mechanical characteristics of a bonding.**
- **This effect is due to the low stiffness of the adhesive (compared to the adherent materials like glass, steel, aluminum) and due to the almost perfect incompressibility of silicone.**
- **For point supports, this effect is obviously dominated by the small bonding thickness compared to the diameter.**
- **For different point supports, a maximum principal stress in the vicinity of 2 N/mm^2 is related to the significant loss of stiffness.**
- **For complex point supports which introduce local peaks in the adhesive loading (e.g. edges), a failure can occur before reaching this stress level.**

Thank you!

Glas Troesch — **for preparing and providing glass panes for the conical countersunk point supports**

Dow Corning — **for performing the bonding of all needed specimens and the extensive support**



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