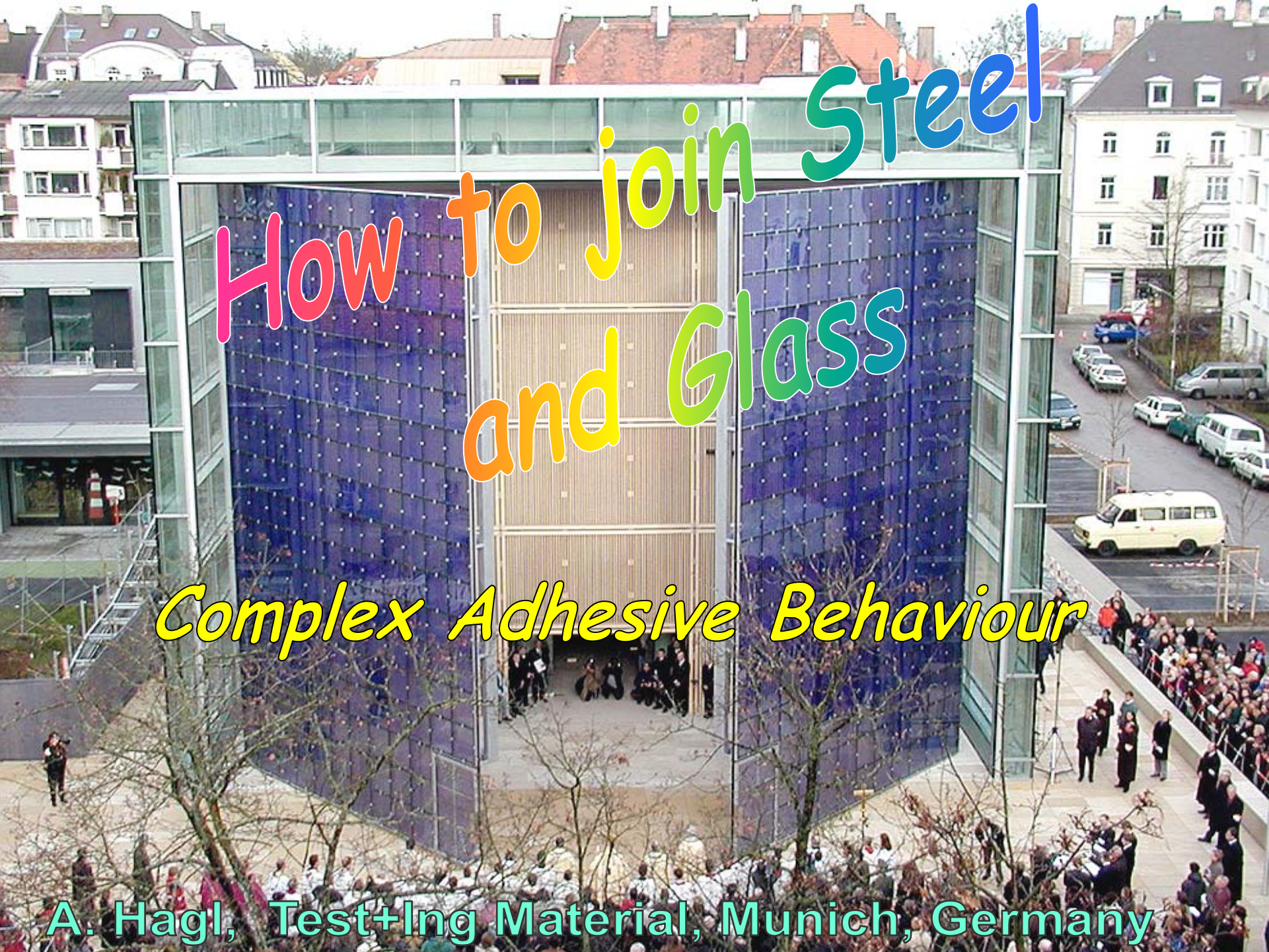
How to join Steel and Glass
Complex Adhesive Behaviour
A. Hagl, Test+Ing Material, Munich, Germany

Contents

- **Glass Façade Herz Jesu Church, Munich**
- Newly Investigated Bonding Geometries and Attachment Designs
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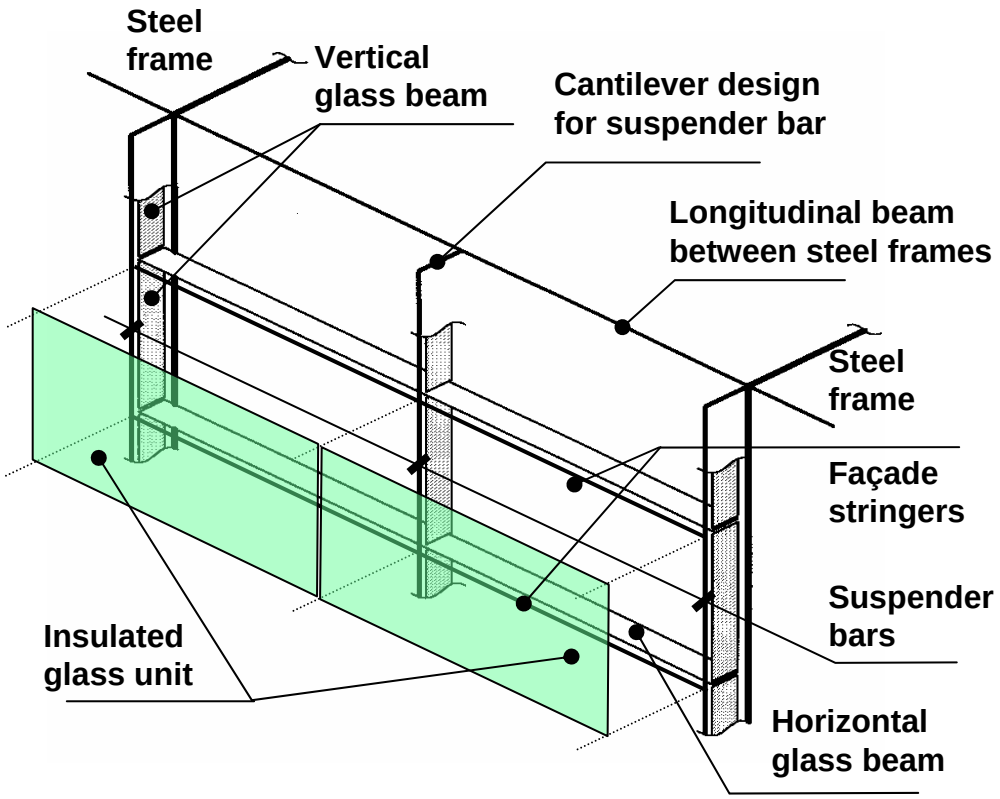
Example of U-type-Bonding: Herz Jesus Church, Munich

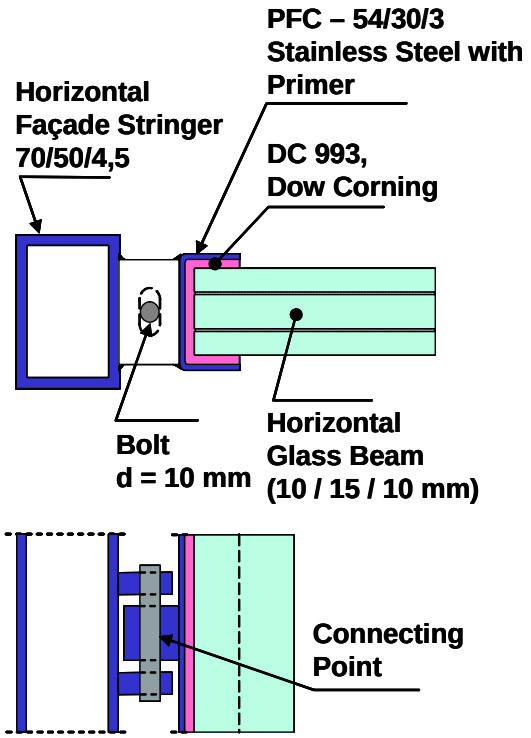
Architectural objective: Minimizing of visible load carrying structures

- **Horizontal and vertical glass beams for supporting the glass façade**
- **Load carrying bonding by Silicone adhesives applied to glass beams**

Details of the Glass Façade

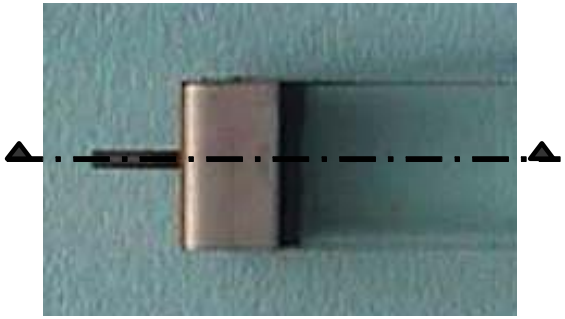


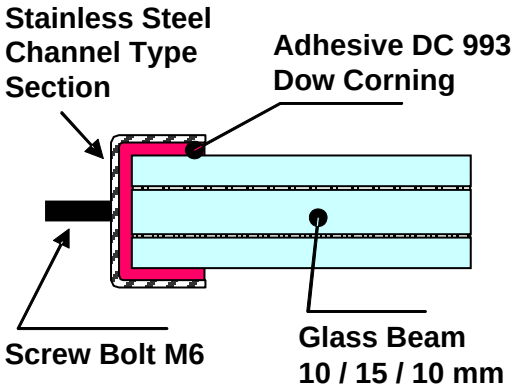
Overview of Glass Façade

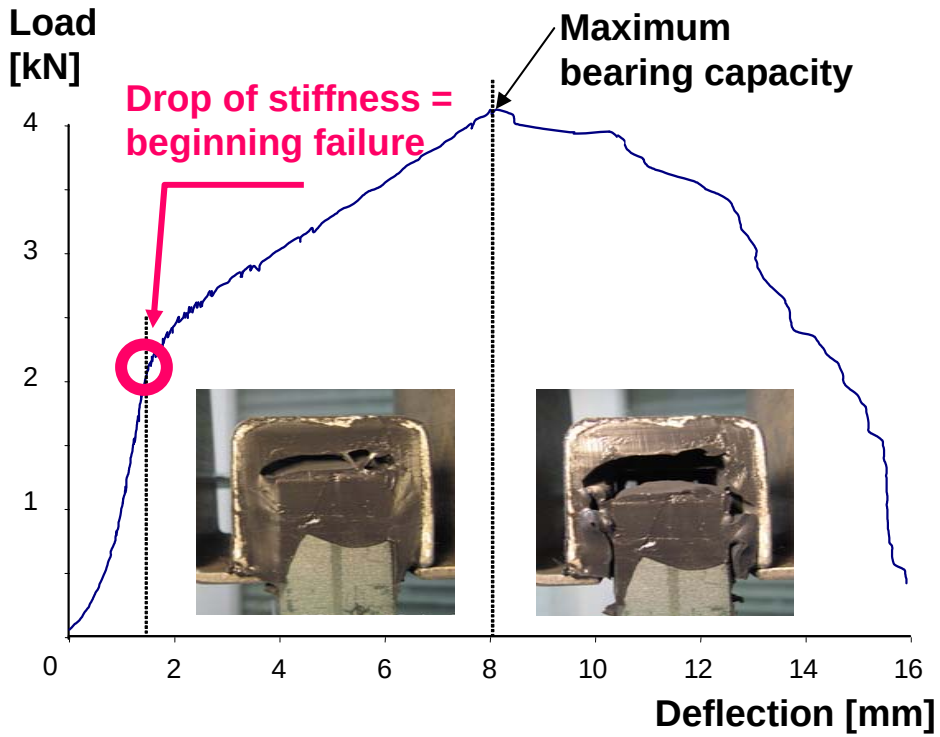


Glass Beam Attachment

Tension Testing of Bonded Glass Beam Specimens







- Three different phases of load-deflection behaviour can be observed:
  - Below 1.5mm high stiffness of joint, fully operational bonding
  - Between 1.5mm and 8mm significant drop of joint stiffness, partial failure of front region
  - Above 8mm total failure of the joint specimen

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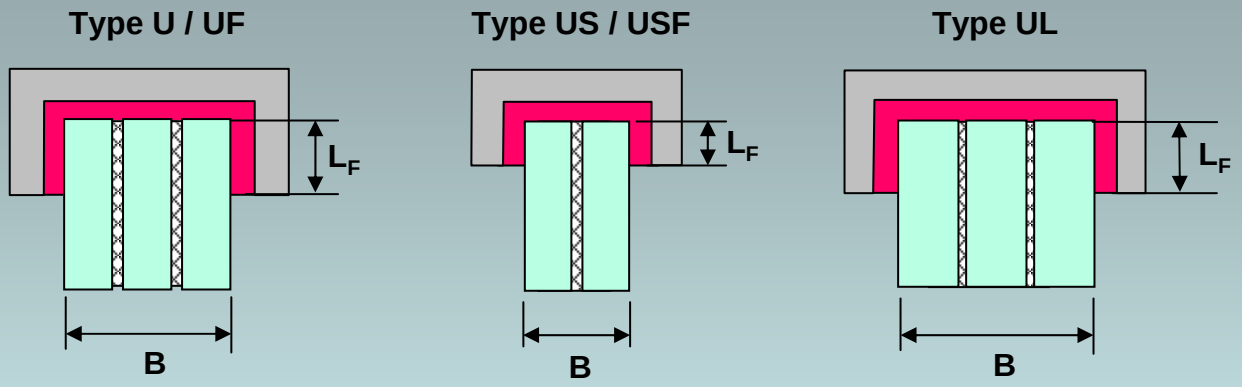
Variation of Investigated U-type Bonding Geometries

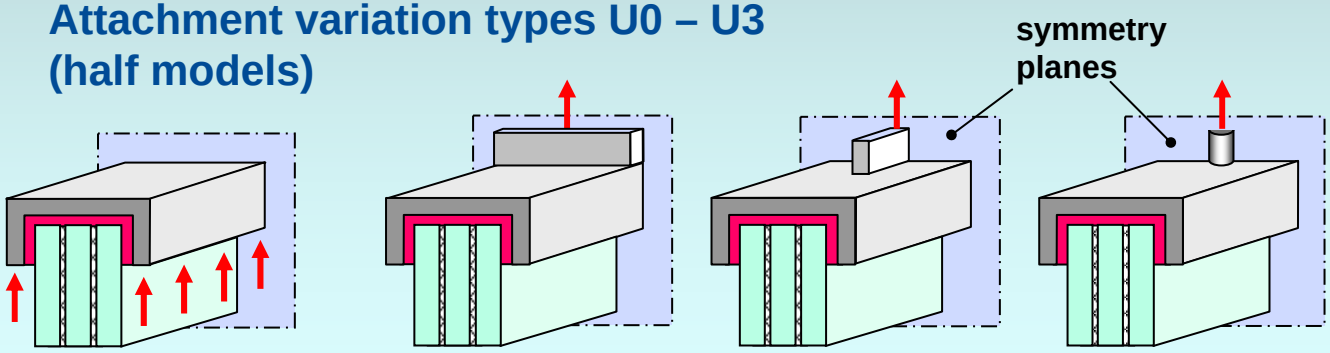
Different cross sections



Variation of investigated bonding cross-sections

Type	Glass	B [mm]	L_F [mm]
U	3 x 12	39	22
UF			15
US	2 x 12	25,5	22
USF			15
UL	3 x 15	48	22

Attachment variation types U0 – U3 (half models)



Type U0 - line type load introduction

Type U1

Type U2

Type U3

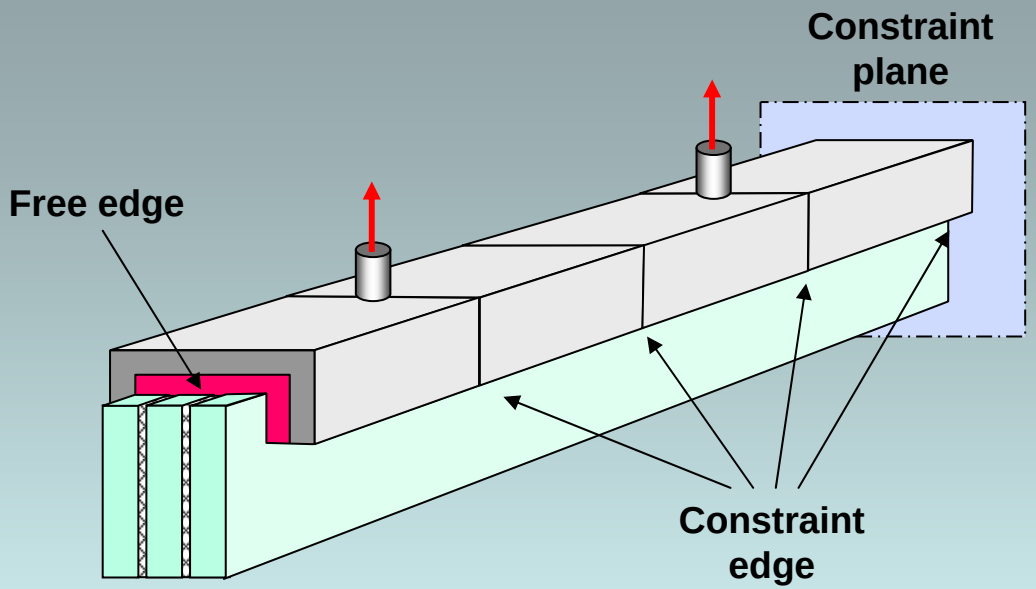
local (point like) load introduction

Adhesive d_A = 5 mm

PFC, steel d = 3 mm

Applied Load

Comparison „Free Edge“ and „Constraint Edge“



Two edge conditions are possible:

Free edge: at the beginning of a line-type adhesive connection

Constraint edge: in symmetry planes of a line-type adhesive connection

Note:

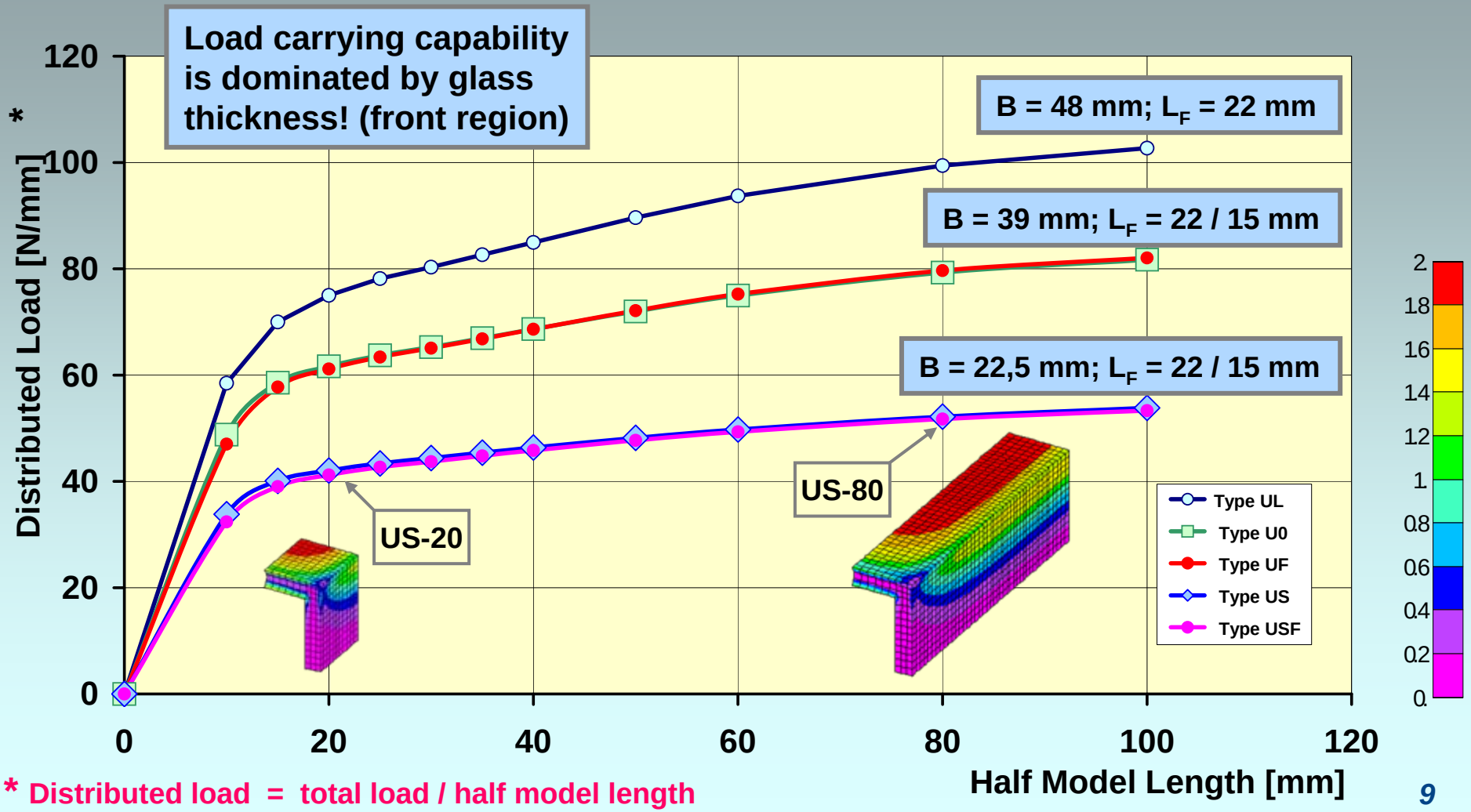
Free edge: lateral contraction of adhesive is possible

Constraint edge: lateral contraction is suppressed

Consequence: very high local stiffness and load bearing capability for incompressible materials in case of constraint edges

Comparison of Load Carrying Capabilities

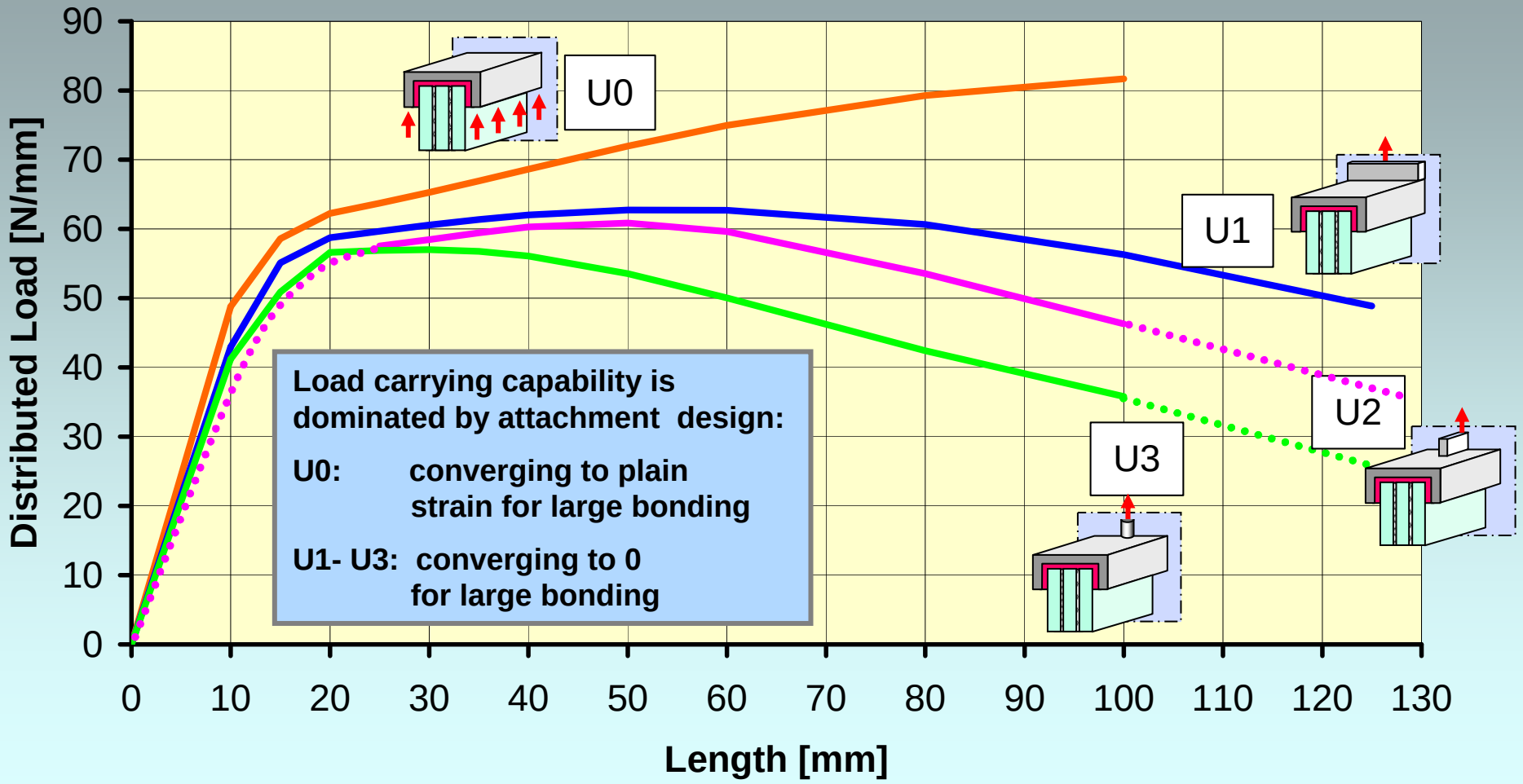
Data points defined by approximately 2 N/mm² max. principal stress (beginning failure)



* Distributed load = total load / half model length

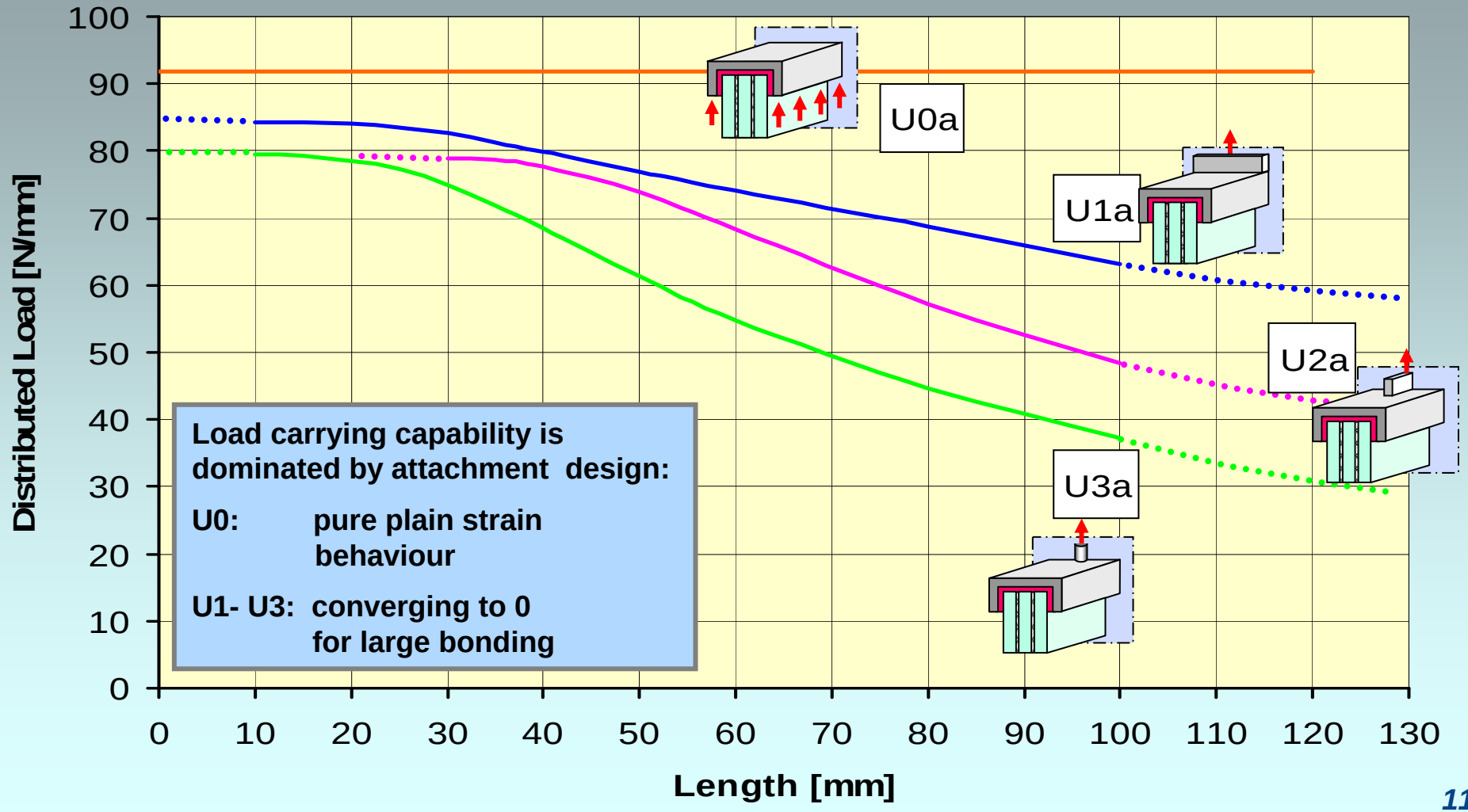
Efficiency of Different Attachments

Free edges – allowing lateral contraction of the adhesive



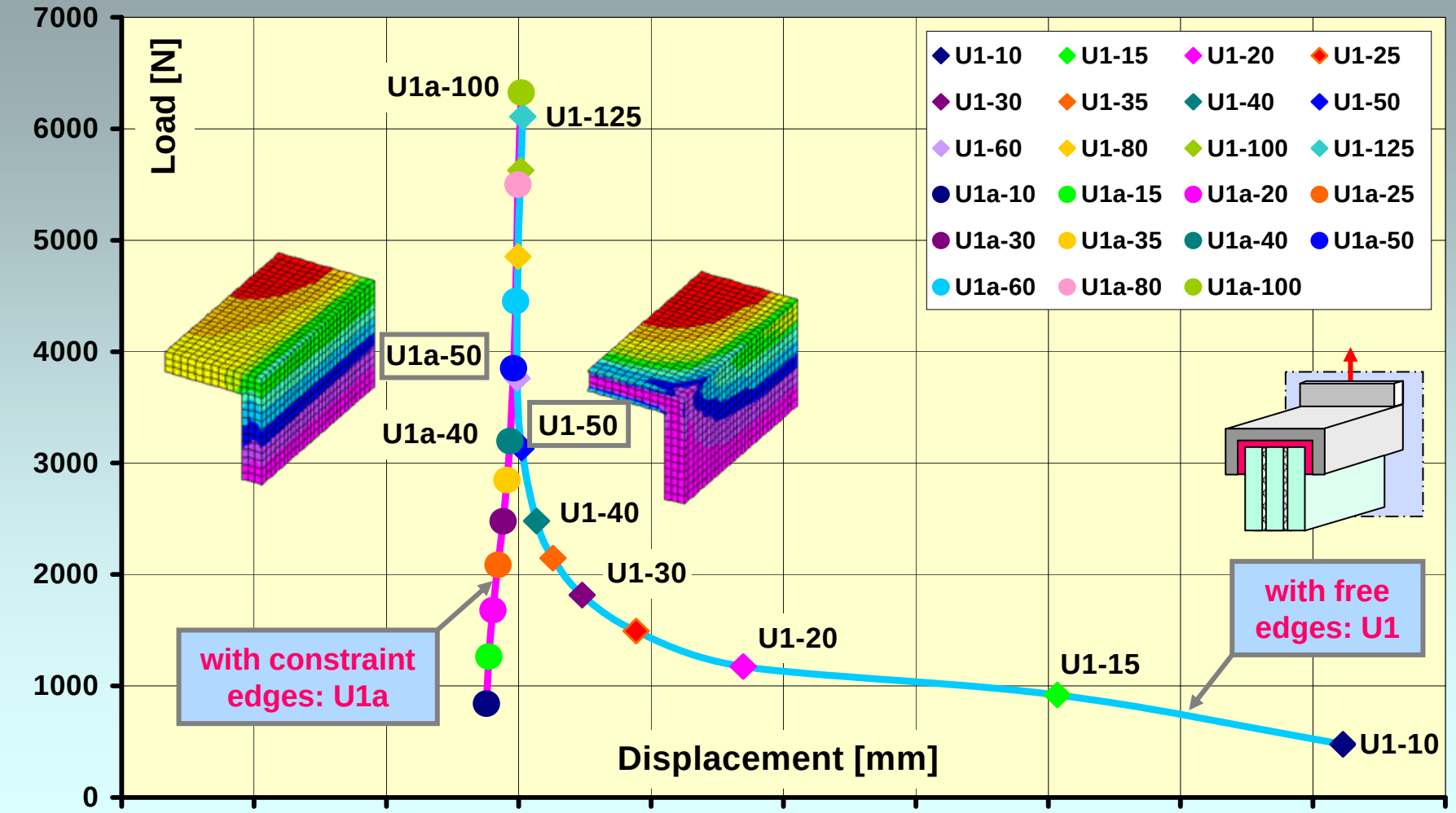
Efficiency of Different Attachments

Constraint edges (several attachment points inside of a long bonding): Index a



Comparison of Bonding Stiffness

showing 3D edge effects within the first 50 mm of bonding length



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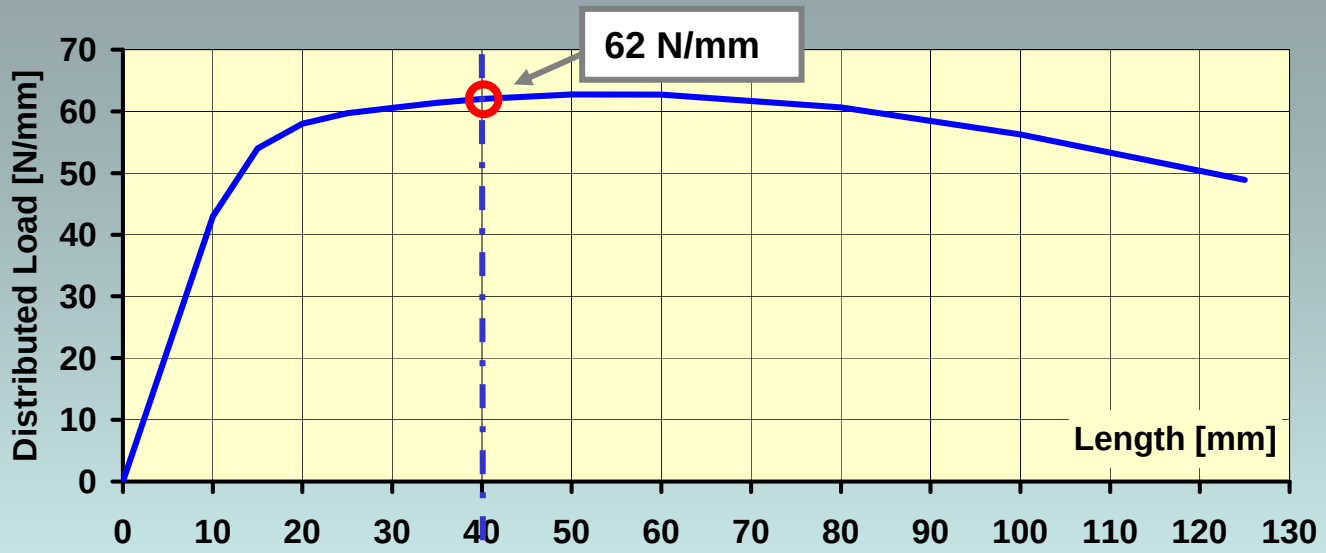
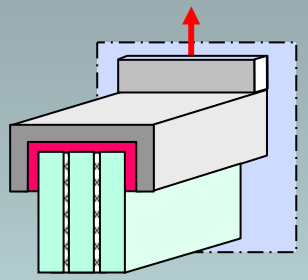
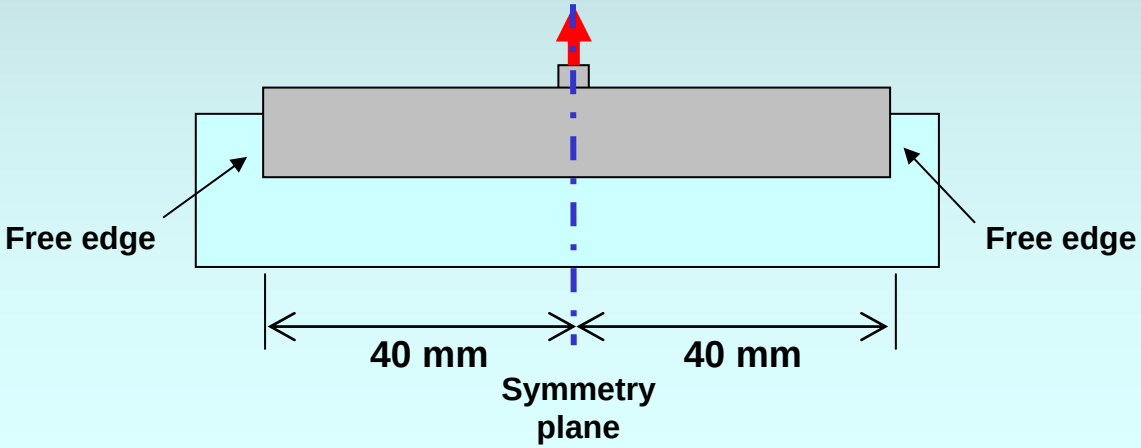
Sizing of a U-type Bonding Geometry U1

case study "free edges" : discrete load introduction





Type U1

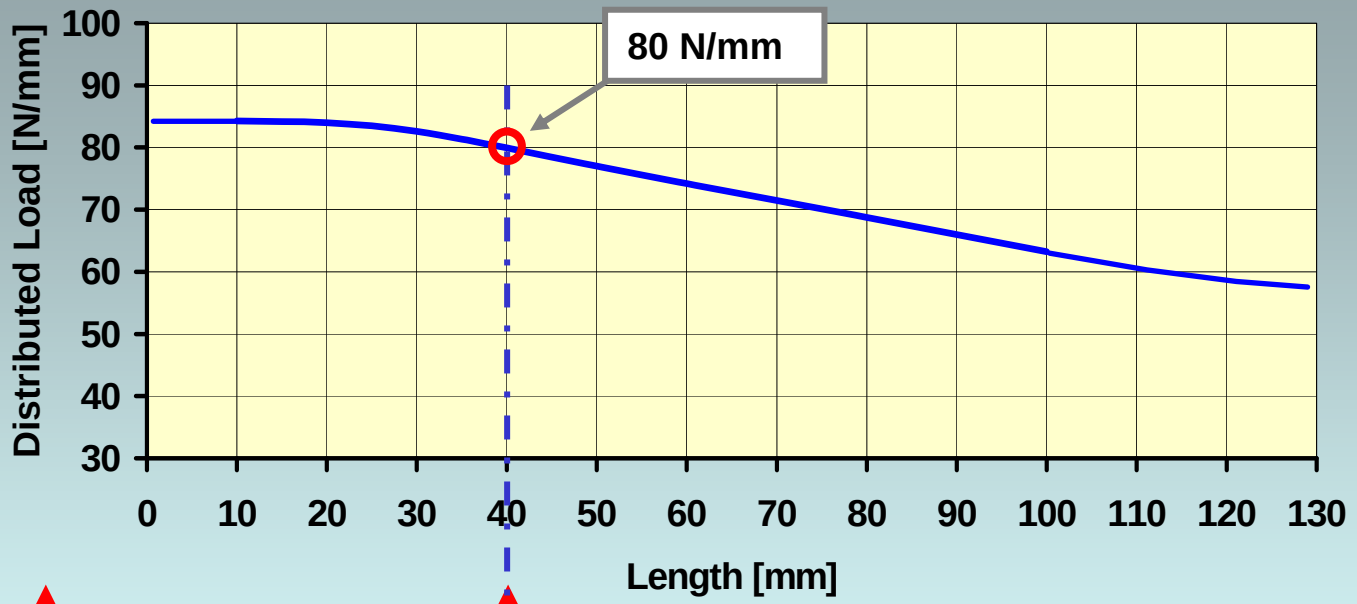


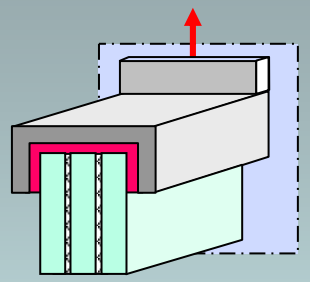
Estimated load at beginning of break:

$F_b = 2 \times 40 \times 62 = 4960$ N

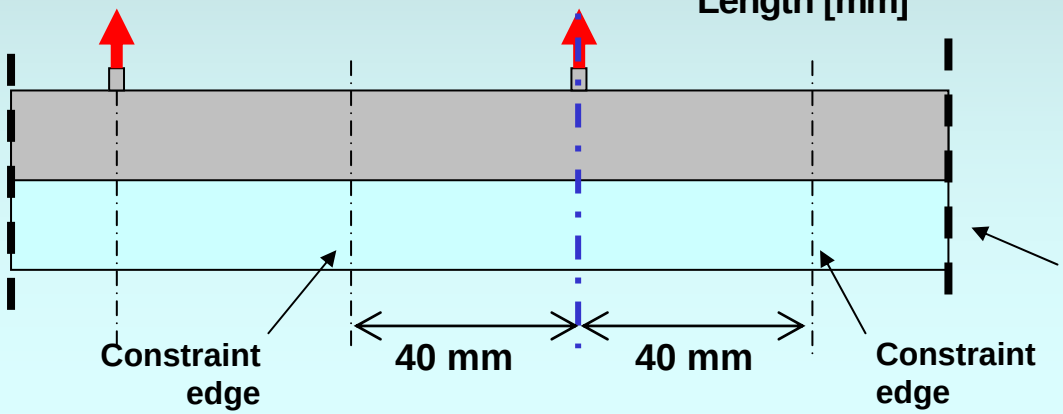
Sizing of a U-type Bonding Geometry U1a

case study "constraint edges" : several load attachments





Type U1a



Estimated load at beginning of break:

$F_b = 2 \times 40 \times 80 = 6400$ N

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Summary and Outlook

- **U-type Bonding geometries are of high interest for civil engineering**
- **Parameter studies performed for different cross sections and different ways of load introduction**
  - **Load carrying capabilities of different cross sections dominated by front region size (glass thickness)**
  - **The efficiency of local load introduction is lower compared to line type loading (important point for testing procedure)**
- **Sizing procedure presented for two different cases**
  - **Free edge**
  - **Constraint edge**
- **Outlook: Generalisation of results for pre-design activities**
  - **Other cross section dimensions (Lf, …)**
  - **Other cross section families (L, T, …)**
  - **Other PFC materials (Aluminium, ….)**

Thank you for Attention