# Risici ved Glasfacader

- hvordan løser vi det?

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Introduction to the case

05 Solution



Post breakage behaviour test

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### Ramboll Facade Engineering



### Introduction to the LOCAL TEAM



Søren Peter Kristensen Chief Specialist & Team Manager



Anne Bagger Senior Specialist



Jakob Dydensborg Chief Specialist & Head of Design



Ivar Lauritzen Project Manager



Frederik Blum Winther Chief Specialist, energy performance



Gergana Spaseva Engineer



Tommaso Vidali Facade Engineer



Antonia Szabo Facade Engineer



Martin Jensen Meyland Industrial PhD Student, Glass







Introduction to the case





Post breakage behaviour test

- Project name: NN Facade renovering
- Contract: EPC Art Andersen part of Ramboll was hired as main contractor





Composition of the facade



The considered case study is a refurbishment project of a stick system facade composed of triple IGU (Insulated Glass Unit) and double (IGU) spandrel panel. The facade has a negative **5deg inclination**, therefore the facade is leaning out. The lowest panel is installed at the ground level and the highest panel is installed at about **16 m** from the ground level.

• Composition of the facade

#### Vision panels



Spandrel	panels



Layer 1	Toughened glass	8 mm
Layer 2	Float glass	6 mm
Layer 3	Toughened glass	6 mm

Layer 1	Enameled toughened glass	8 mm
Layer 2	Toughened glass	6 mm

• Composition of the facade



a) Nord - Øst Facade

	Rectangular			Trapezoidal		
	Amount	Area	Perimeter	Amount	Area	Perimeter
	n	m²	m	Stk.	m²	m
Tot	502	1676	3720	50	221	404







Introduction to the case





Post breakage behaviour test

#### Post breakage behaviour test – Panel 3



#### Post breakage behaviour test – Panel 2

















Introduction to the case





Post breakage behaviour test

#### Risk assessment

Boundary conditions:

The facade is part of an office complex surrounded by a parking facility. The entrances to the building are reached by people with a path along the facade. Therefore, in case of a panel breaks, it is highly probable the presence of people surrounding the building along the facade. Moreover, the inclination of the facade implies a permanent portion of the dead-load applied perpendicularly to the facade plane.

**Risk evaluation:** 

From the investigation, it is concluded that layer 1 of the double IGU does break into few pieces. The pieces break only when the collision with the floor happens. It is roughly estimated that the biggest single piece of layer 1 of the IGU is approximately 1 m by 0,6 m. Considering, as described by EN 16612, the density of the glass equal to = 2500 kg/m3, the biggest piece of the toughened glass pane falling o the ground is approximately 12-16 kg.

It is clear that the fall of a glass chuck of 12-16 kg from up to 16 m height, could lead to fatal injuries for people standing or passing along the facade.

#### Risk assessment – EN 12150

Paragraph 8. Fragment Test in EN 12150 describes how to execute and evaluate the results of the fragment test. The fragment test aims to investigate if the considered glass pane can be classified as thermally toughened soda lime silicate safety glass.

The tests aim to count the number of particles in the region of course fracture. The particle count is performed on a square region on the pane of approximately (50 1)mm x (50 1)mm. The number of particles is counted and then compared to the minimum particle count values collected in Table 10 of EN 12150.

Nominal	Minimum	Shower
Thickness, d	particle count	enclosure
mm	number	(see EN 14428)
2	15	not applicable
3	15	40
4  to  12	40	40
15  to  25	30	40

Table 3Minimum particle count. Table 10 in [2]

Besides the minimum particle count test, EN 12150 gives an additional requirement on the maximum length of the longest particle. In order to classify as thermally toughened soda lime silica safety glass, the length of the longest particle shall not exceed 100 mm.

### Risk assessment – EN 12150

Side 1



Minimum particles count: 40

Total number of particles: 110

EN 12150 requirements fulfilled

Side 2



Minimum particles count: 40

Total number of particles: 1

!!!EN 12150
requirements NOT
fulfilled!!!

Side 2



Maximum length of a single particle: 40

Length of the particle: 160

!!!EN 12150
requirements NOT
fulfilled!!!







Introduction to the case





Post breakage behaviour test







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---Loads (LC) ٠ GRASSHOPPER -RHINO Sections Def. Geometry • Supports • SALAMANDER PLUG-IN DEVELOPED IN RAMBOLL Joint releases • ROBOT AUTODESK Linear rel. ٠ Section app. ٠ Analysis • 0,07 0,0 -1,50 -3,00 -4,50 -0,00 -7,50 -10,50 -12,00 -13,50 -15,20 -15,20 -15,20 -15,20 -15,20 -15,00 -15,00 -15,00 -15,00 -15,00 -15,00 -12,50 -15,00 -15,00 -15,00 -12,00 -15,00

#### Nonlinear analysis to define real deformation



#### Mock-up test at Danish Technological Institute



Maximum deformation equal to 24 mm.

Maximum deformation equal to 23 mm.

Additional stiffeners are use to reduce deformation while considering the panel in wind zone A and maximum direction and seasonal coefficient according to DS EN 1991-1-4.





# Thank you

Please visit Art Andersen & Copenhagen www.art-andersen.dk for more references

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