



# Full-scale test of glazing for stairs in theatre

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GPD Finland 2013  
14.06.2013



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# Mariinsky II project (2009)





# Mariinsky II project (2013)







# The stair mock-up (day)





# The stair mock-up (night)







# The stair mock-up (details)





# Test program

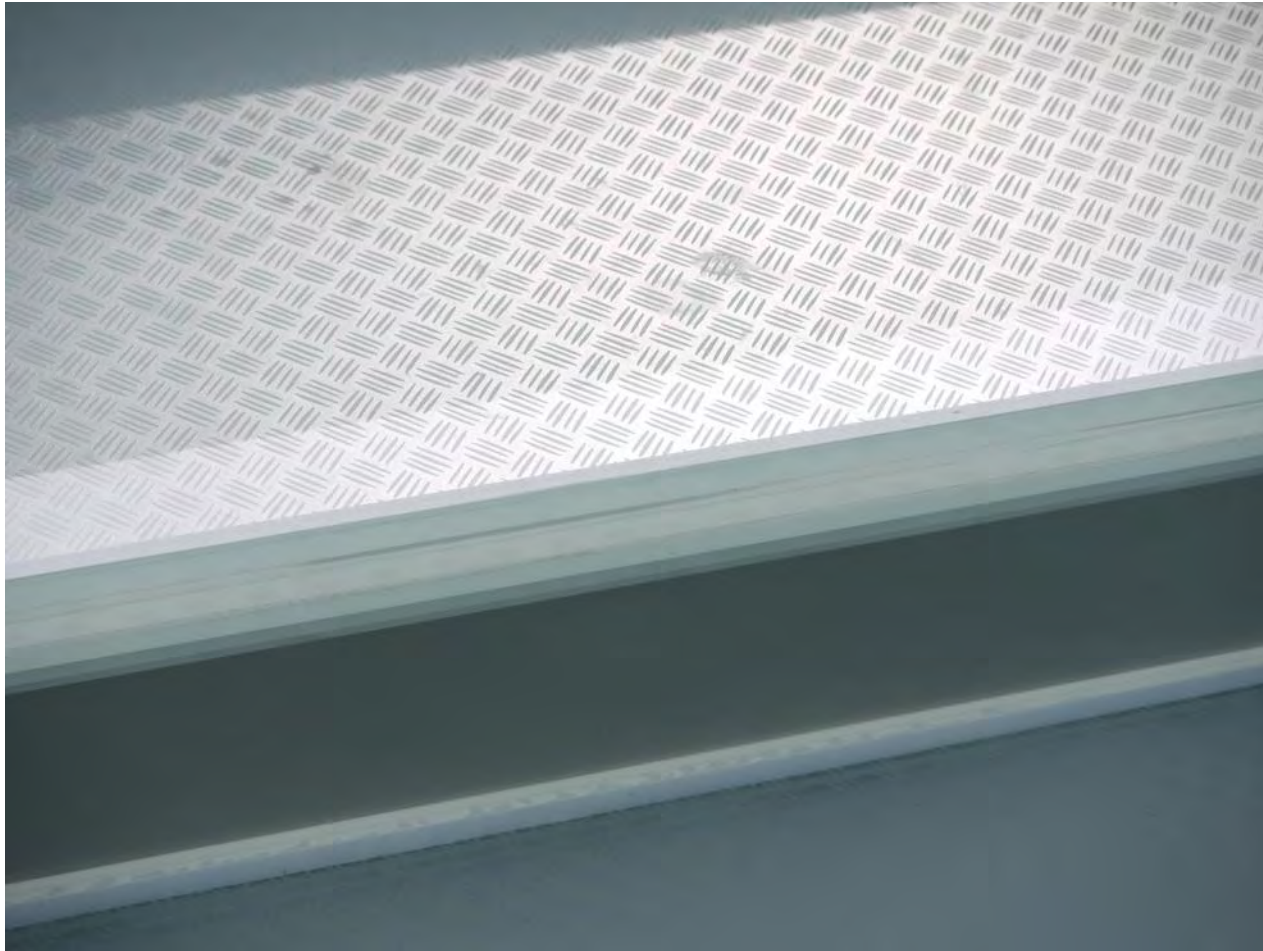


- ▶ **Uniformly distributed load test**
  - Uniformly distributed load of 6 kPa was applied to the specimen during 30 minutes.
- ▶ **Concentrated load test**
  - 6 kN was applied in the center of the specimen through the square nylon gasket and 100 mm side steel cube.
- ▶ **Shock load by steel ball (EN356):**
  - Steel ball test with standard ball of 4.11 kg mass. Drop height: 3 meters (120 Joules).
    - a) Test started with first drop from 3 m height.
    - b) Upper layer of glass must be broken after that by hand if it was not broken by ball. After that, second and third drops were carried out.
    - c) After that the specimens were loaded by uniformly distributed load of 4 kPa during 30 minutes with deformation control.
    - d) And finally, the same specimens were loaded by the concentrated load of 4 kN in the middle of the specimen during 30 minutes with deformation control.
- ▶ **Shock load by soft body impact:**
  - This is standard soft body impact test with rubber tires on metal core impactor. Soft body had mass of 50 kg and drop height was 1200 mm, so impact energy was 600 Joules. Detailed sequence was the following:
    - e) The specimen of the balustrade was tested by one soft body impact with 600 Joules of energy.
    - f) If the glass layers were unbroken after previous step, one glass layer was broken by hand and linear load of 1.5 kN/m applied the specimen without deflection control.





# The specimens: “Step 8hs.12hs.12hs.8hs”





# The specimens: “Step 8.15.15.8” (2000×400 mm)







# The specimens: “Barrier 12t.12t”







# The tests and results





# Concentrated load test (1700 mm gap)







# Static load test results (Step 8hs.12hs.12hs.8hs #1)





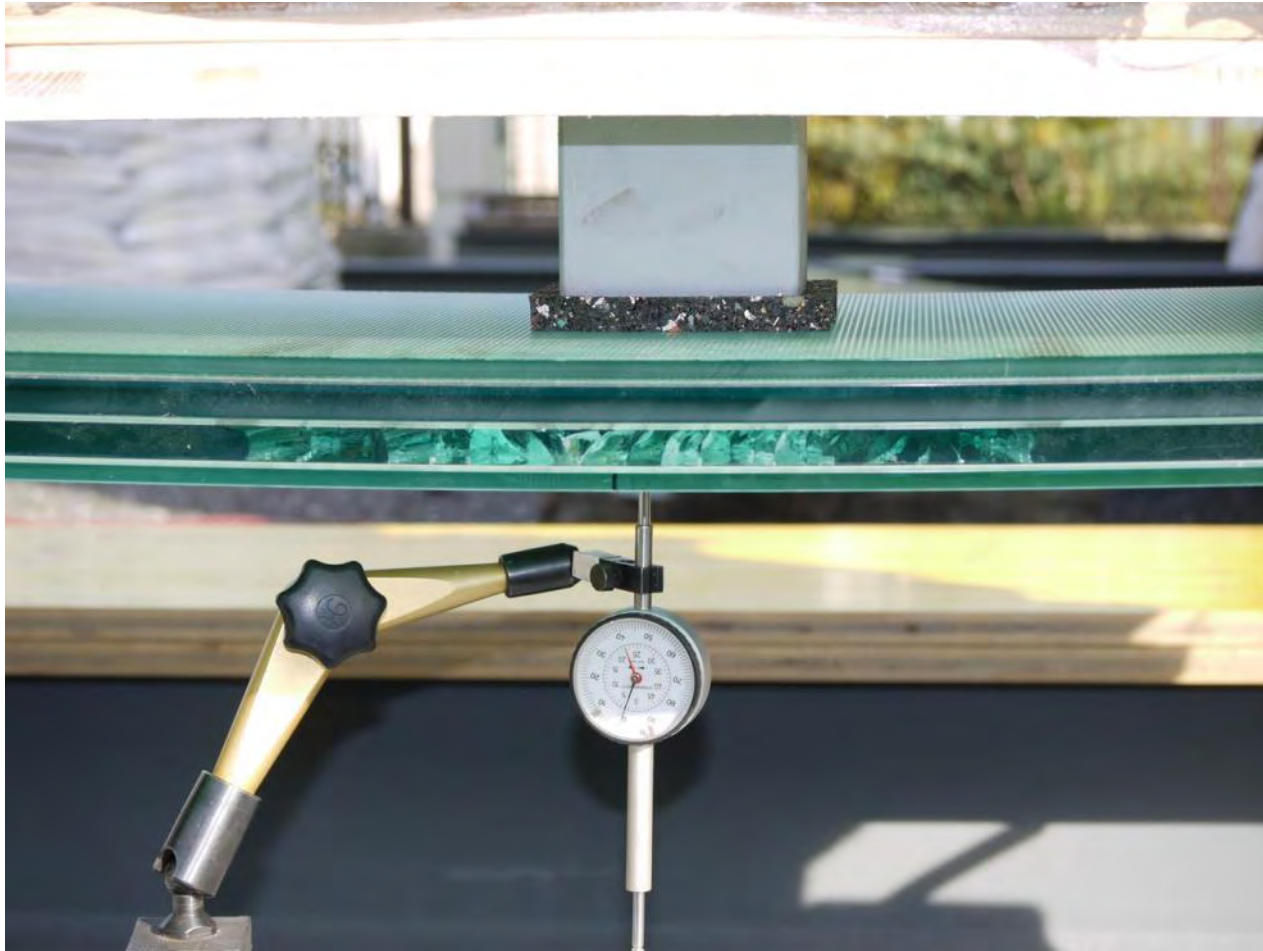


# Static load test results (Step 8hs.12hs.12hs.8hs #3)



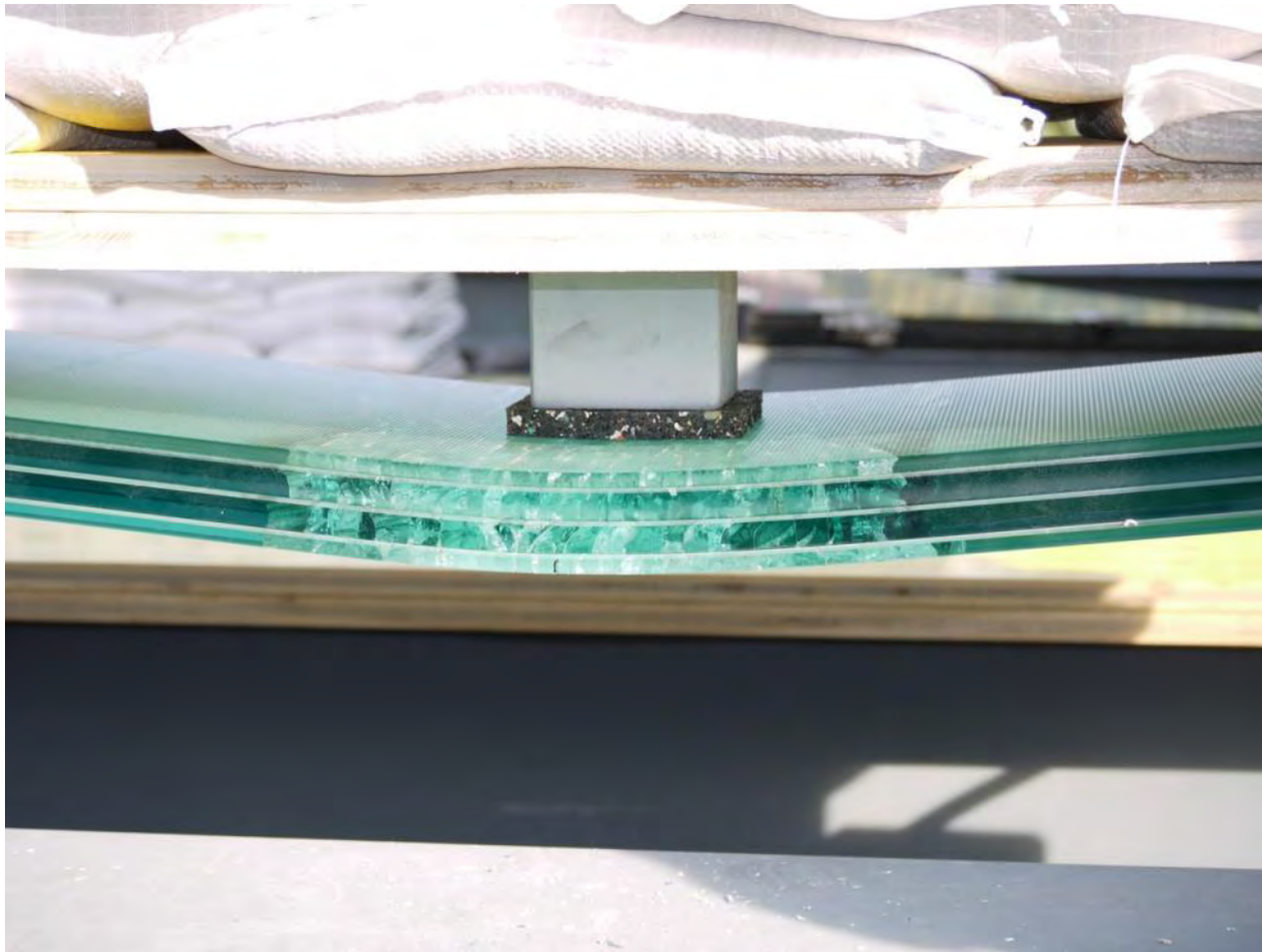


# Concentrated load test results (Step 8.15.15.8 #1) (1 / 3)





# Concentrated load test results (Step 8.15.15.8 #1) (2 / 3)





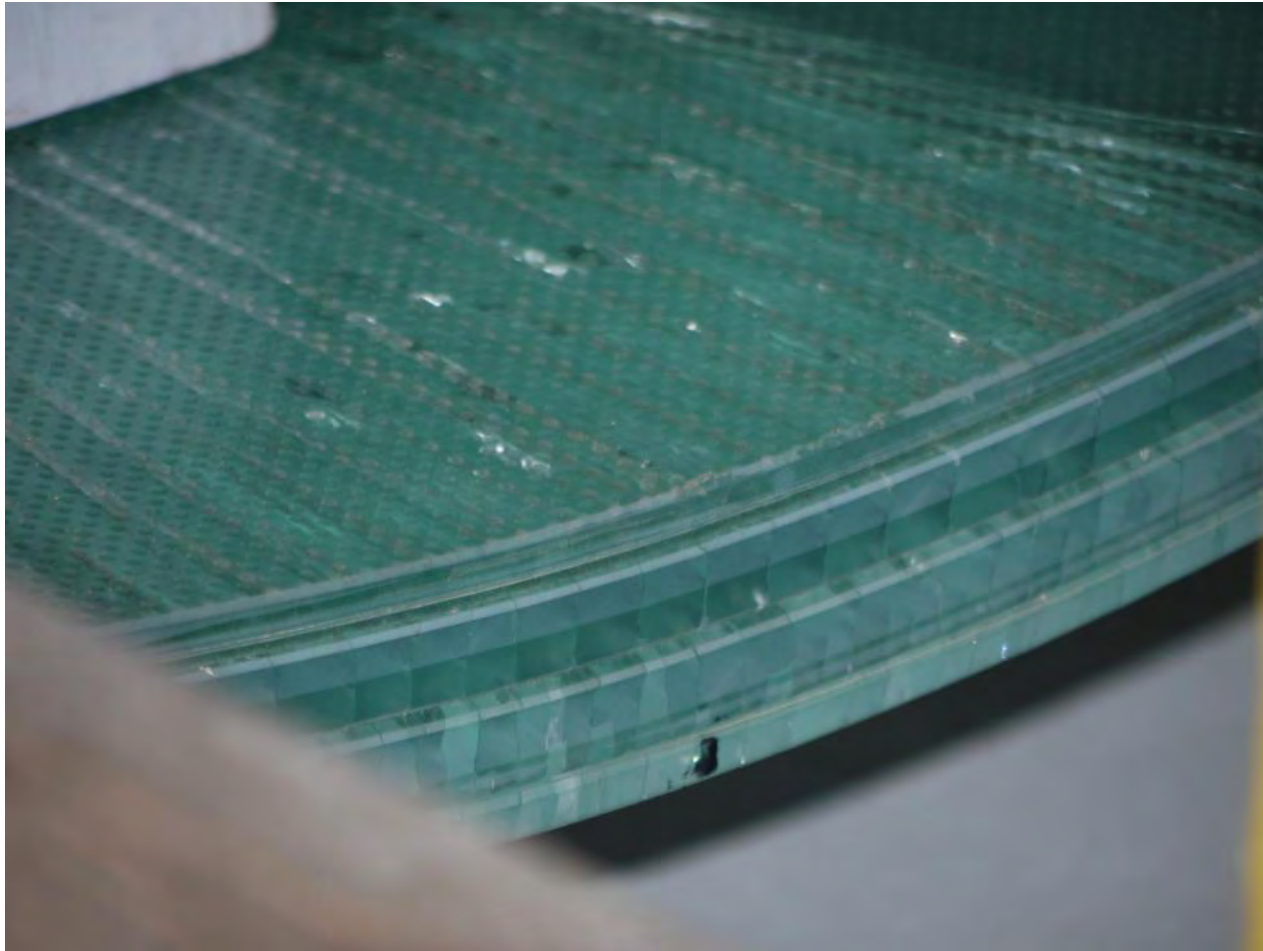


# Concentrated load test results (Step 8.15.15.8 #1) (3 / 3)





# Concentrated load test results (Step 8.15.15.8 #3)





# Concentrated load test results (Step 8.15.15.8 #2)





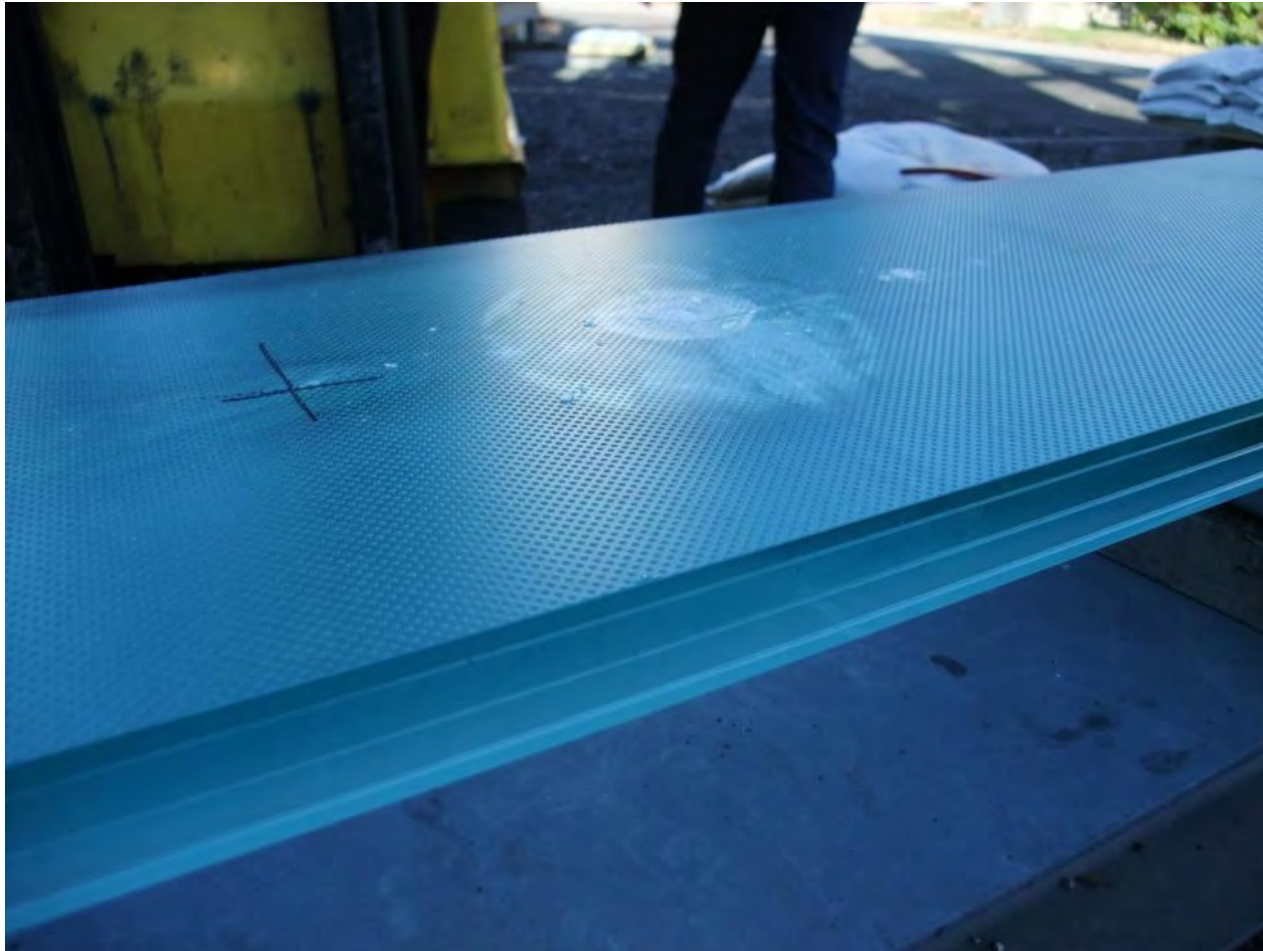


# Uniform load test results (Step 8.15.15.8 #5)





# Hard body impact test results (Step 8.15.15.8 #2) (1 / 2)





# Hard body impact test results (Step 8.15.15.8 #2) (2/2)







# Hard body impact test results (Step 8.15.15.8 #5)



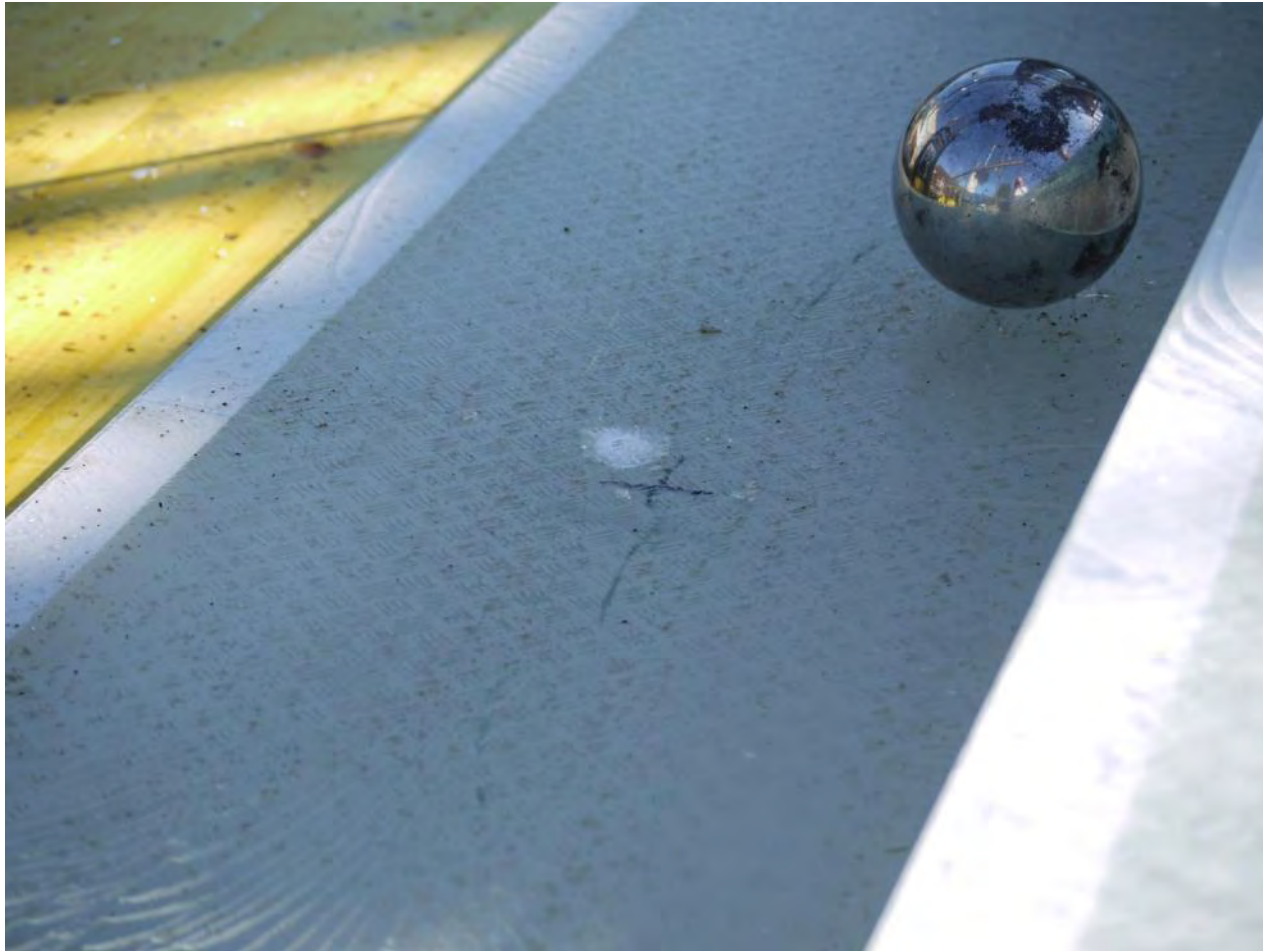


# Hard body impact test results (Step 8hs.12hs.12hs.8hs #1)





# Ball test results (Step 8hs.12hs.12hs.8hs #2) (1 / 2)







# Ball test results (Step 8hs.12hs.12hs.8hs #2) (2 / 2)





# Hard body impact test results (Step 8hs.12hs.12hs.8hs #3)





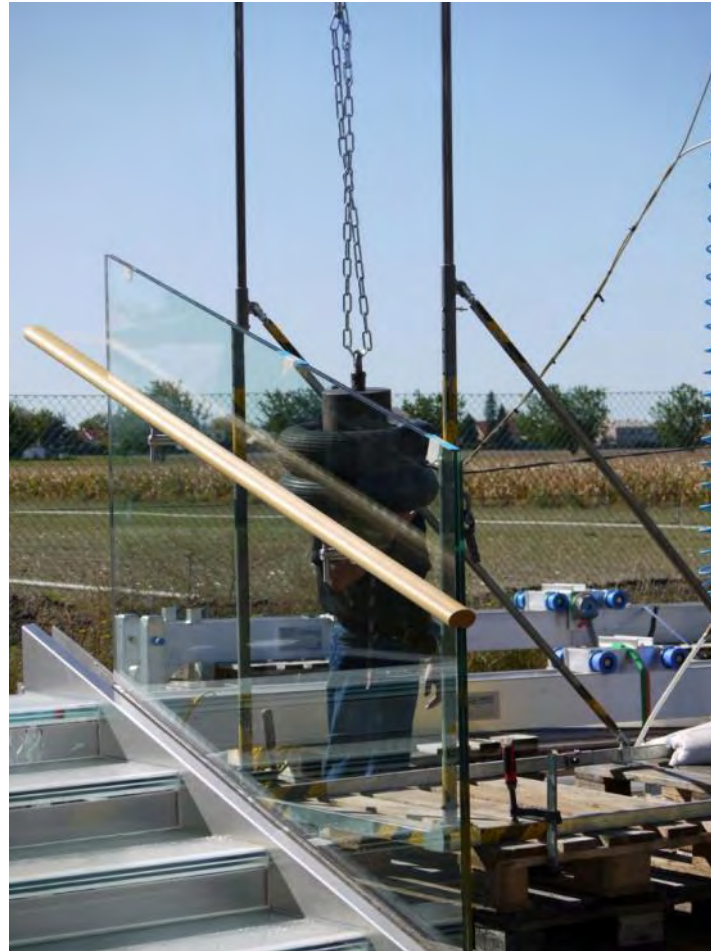
# Soft body impact test results (1 / 4)





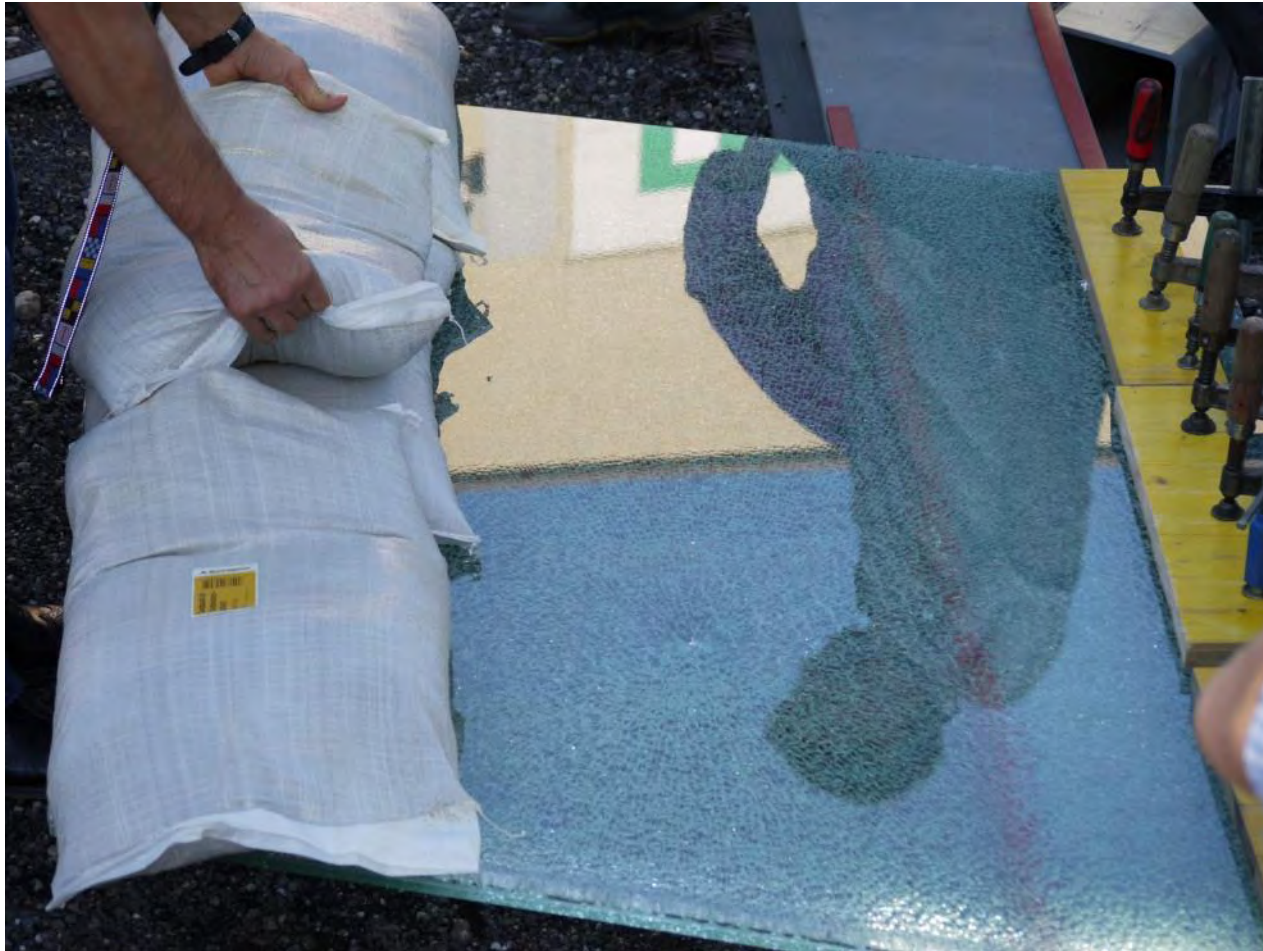


# Soft body impact test results (2/4)





# Soft body impact test results (3 / 4)







# Soft body impact test results (4 / 4)







# Summary of the test results

- ▶ All specimens of “Step 8hs.12hs.12hs.8hs” showed good performance and passed all tests without serious comments.
  - Average deflection under concentrated load of 600 kg was 8.21 mm which very close to the recommended deflection of 8.00 mm (for uniform load).
- ▶ Ionoplast interlayers showed very good stability and stiffness comparing to PVB films.
- ▶ Specimens of “Step 8.15.15.8” did not pass the tests.
  - Average deflection under uniformly distributed load was lower than recommended deflection: 6.40 mm comparing to 6.80 mm.
- ▶ All specimens of “Barrier 12t.12t” passed their tests very successfully.



# Conclusions



- ▶ Two designer's options for the steps were not equal in performance and had different characteristics. Tests allowed to find compromise between mechanical strength, price, visual appearance etc.
- ▶ Obtained results were different from the modelling ones.
- ▶ Obtained results are very different from the typical results in standard test conditions.
- ▶ Mock-up tests produce very convincing example of the real life performance.



# Acknowledgements



- ▶ Authors thank all our colleagues in Malishev Wilson Engineers, Waagner-Biro Stahlbau AG, OOO ALAND, Hochschule für angewandte Wissenschaften - FH München for their great work on this project. Special thanks to Gennady Vasilchenko-Malishev (Malishev Wilson Engineers), Stephan Prandstetter (Waagner-Biro Stahlbau AG), Thomas Fink (Waagner-Biro Stahlbau AG) and Alexander Lorenz (FH München).

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Thank you for  
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