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The so called „Telecom-Center“ in Munich was designed by the architects Kiessler and partner. The twin towers, together with the rotunda are in danger of blast loading due to the BFB building which stores pure alcohol and which is close to the telecom center. If we are talking about typical explosive loads as for example showed in figure 2, the question is always how to numerically describe materials and structures. Required are not only strain rate dependent material laws but also possibilities to describe broken glass. Therefore failure criteria especially for glass together with the interlayer as well as for the bonding are required.

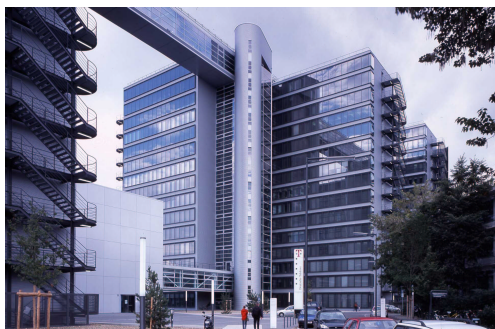


figure 1



figure 2

Due to the complexity of the problem we decided to use the numerical simulation in order to deal with the different types of facades. This type of numerical simulation allows to solve the wave propagation problem, which results in different pressures for different surfaces. Due to the effect that glass and framing is in interaction during the impulsive pressure load, we used also complex finite element models in order to describe these parts of the structure. Using this type of procedures it was possible to realize the

architectural idea and to keep the glass thickness as originally designed and therefore to realize an economical solution.

As a conclusion of theoretically dealing with impulsive loads, it can be recommended in general to use flexible structures in order to reduce the pressure load on the structure. With our actual investigations, we try to activate the breakage of the glass in order to dissipate energy and to take advantage of post-critical membranes states. The latter are able to carry high membrane forces, if these can be carried by the supporting structure. In our opinion the development of these type of solutions should be based on the numerical simulation. This is due to the scattering of even shock tube tests and due to economical purposes. As an important precondition, the numerical models used throughout the simulation have to be qualified. This is quite easy, if we are dealing with unbroken glass. The comparison of the measured and the calculated solution can be seen from figure 4, which shows, that both solutions are nearly the same.

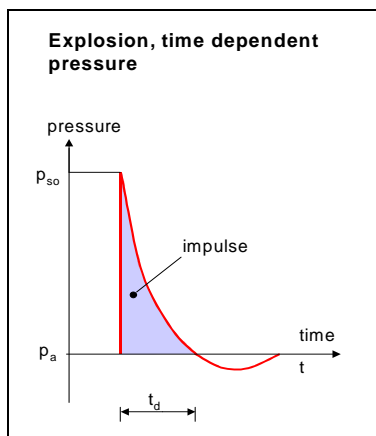


figure 3

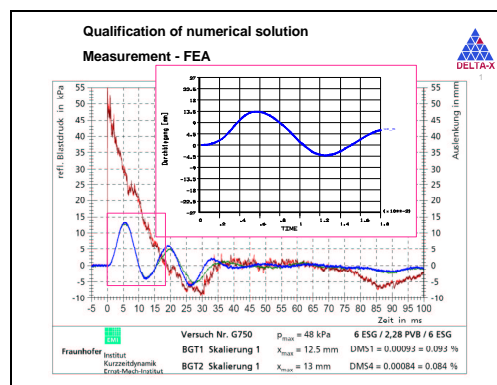


figure 4

Figure 5 shows the result of a shock tube test, where the glass was broken.

The observed behavior is completely non-linear together with large deformations in the middle of the glass. In order to numerically represent the broken glass we used two identical shell-elements. Shell 1 is representing the unbroken glass, shell 2 represents the broken glass together with the appropriate stiffness and the non-linear material law. Figure 5 shows, that the calculated green curve is very close to measured values.

Furthermore it can be seen, how the crack pattern develops over time. At the end, the cracked pattern observed from the test is very well represented by the numerical solution.

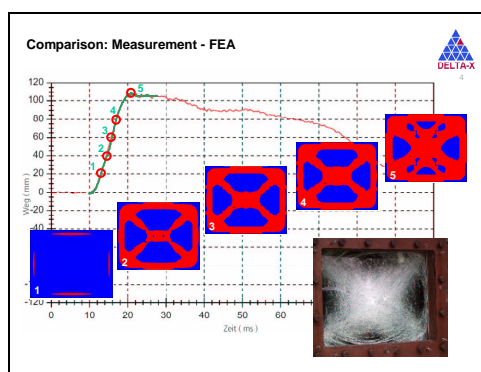


figure 5

Summarizing it can be stated, that there are numerical solutions which are able to described broken glass. For the real construction we recommend to dynamically optimize the load bearing behavior of the façade. These concepts are not necessarily easy to apply, but economically increase the capacity of current façade solutions. This is desired in order to strengthen the actual facade solutions and to enable architects and engineers to design façades, that are bomb blast resistant as well as transparent.

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