A HOLISTIC PROTECTION PORTFOLIO FOR URBAN INFRASTRUCTURE

Christoph Roller[1] and Alexander Stolz[2]

[1] christoph.roller@emi.fraunhofer.de, [2] alexander.stolz@emi.fraunhofer.de
Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut,
Dept Safety Technology and Protective Structures, Am Klingelberg 1,
79588 Efringen-Kirchen, (Germany)

Abstract

Over the past decades, more and more people have decided to become city dwellers. As a result, the settlement structure had to grow in size and complexity. In fact, it did grow. It still does and so does the interrelation between buildings and infrastructure supply systems. The simultaneous increase of natural and man-made hazards for urban areas leads to a significant need for protection of this habitat and its infrastructure. The present paper gives an insight into the developing process of a benchmark protection portfolio starting from gathering a database of innovative protection products through generation of input using advanced test facilities and numerical methods up to implementation of the derived information into a user-friendly guidance tool. Thus, the presented approach covers all fields of a resilience cycle in a unique way and hence brings forward future urban security.

Keywords: Critical infrastructure, protective structures, urban security.

1 INTRODUCTION – NECESSITY OF A PROTECTION PORTFOLIO

During the last century, urbanization has become a major part of our social evolution: 100 years ago, Great Britain was the only society that could be regarded urbanized [1]. Nowadays, more than half of the world's population lives in urban areas. In Europe, the rate of urban population even rises above 70 percent [2]. Such a demographic trend requires local expansion of infrastructure supply systems in all essential parts (i.e., mobility, energy, communication, etc.). Building planners have managed to establish the required increase in size and complexity of infrastructure over the last decades. But this progress is accompanied with an increase of interdependencies within the urban environment. Breakdown of one component might result in failure of other dependent parts of the system [3]. This vulnerability gives rise to concern, especially since urban areas became objects of man-made hazards and attacks lately [4]. Deliberate attacks on supply systems might cause cascade effects that go beyond previously coincidental events.

Thus, the global challenge to protect people, the societal community and critical infrastructures against consequences of accidental and intentional events has become a major issue in the work of building planners. Design of new and existing urban infrastructure requires approaches beyond common architecture and structural engineering. Standards [5], [6], [7], guidelines [8], [9] and expertise [10], [11] for design of protective structures have been issued and well-established by now. But although building designers can work with this resource, their customers (stakeholders, building owners and end-users) are rather interested in solutions than in design concepts. They are attracted to ready-to-use products instead of prototypes, fast assessment tools instead of time-consuming calculations and, most important, a cost factor so that they can price their protection effort. This is where the developed portfolio [12] fills the gap between experts and users:

Single solutions are available to realize sufficient resilience of urban infrastructure. However, in most cases, these solutions are found in course of research for project-specific problems and require expertise. Since protective design will stay an essential part in future, solutions need to be commonly available and to be established in normal planning and building procedures just like the application of reinforced concrete during the last decades. A catalogue with a pool of state-of-the-art and innovative protection measures for both structural components and indoor air quality is an important step towards this goal. To translate this innovative idea of a protection portfolio into action, Fraunhofer EMI made significant contributions within the SPIRIT [12] project, funded by the EC under the 7th Framework Programme.

2 METHODOLOGY – STRUCTURE AND INPUT OF THE PORTFOLIO

2.1 Overall structure

A consistent representation of the different protection products within the portfolio is essential to create a neutral document. This prerequisite is accomplished by choosing a set-up similar to a catalogue with different chapters for each protection category. The main body of the portfolio consists of the detailed description of available products. It is based on collected, compiled and analyzed data of various solution types. This includes data of fiber concrete, strong and intermediate masonry retrofit and glazing systems regarding explosive (E)-threats and monitoring plus filter systems regarding chemical, biological and radiological (CBR)-threats. The data is broadened with input acquired from surveys regarding further protection products available on the market. The description of every product is such that building designers can comprehend its technical principles and use it to estimate costs. For that purpose, we continuously cooperated closely with different partners from the industry as representative end-users and product contributors during the edition process.

Besides the general description, assessment diagrams for the single protective measures give a significant input for the portfolio. The diagrams are directly linked to the protection materials or solution type. Furthermore the diagrams are integrated into a user-friendly guidance tool [12] for risk assessment with regard to efficient protective measures. The integration of the portfolio into the tool helps to improve the most vulnerable components of critical infrastructure. If the tool's prediction leads to the statement that strengthening respectively retrofitting of the analyzed structure is required, the user is directed to the protection products of the portfolio. Thus, the user of the tool is able to integrate the chosen countermeasure to the building and receive information on its effectiveness regarding resistance of the building component. In addition, it shows the effectiveness of the countermeasures compared to unprotected building designs also on the economic level via related costs. Linking the tool's data with the protection portfolio completes the comprehensive security advisory approach. Since the portfolio only contains systems that are ready-to-use and actually available on the market, its practical relevance is of high magnitude. Fig. 1 displays the overall structure of the portfolio catalogue and how it is linked to the guidance tool.

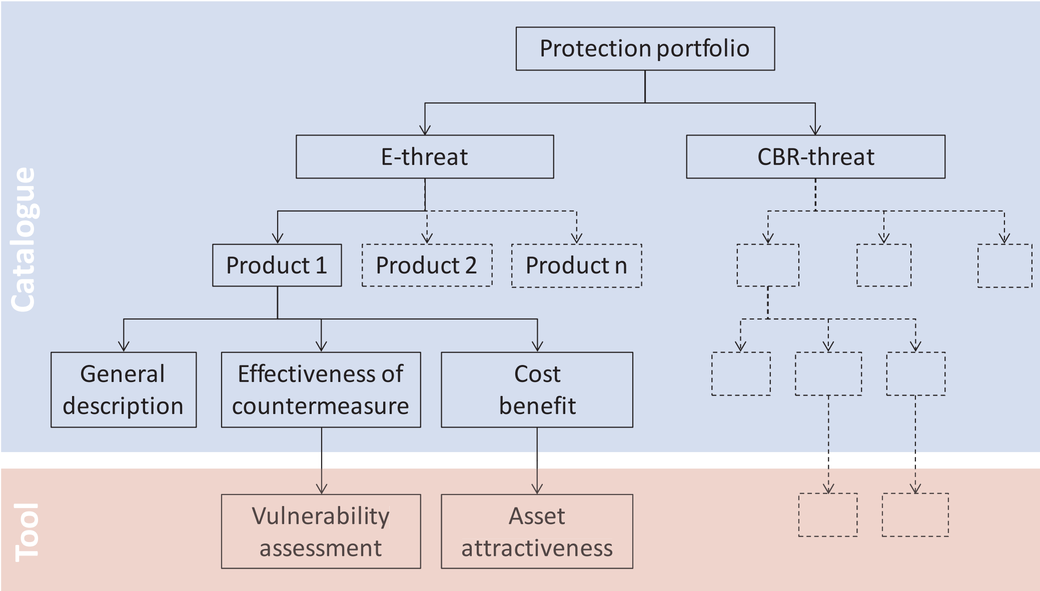

Figure 1: Overall structure of protection portfolio and linkage to guidance tool.

2.2 Gathering input

Based on existing security systems, extensive test series have been developed and conducted for detection and filtering systems, blast-resistant window/façade systems, explosion-resistant columns and retrofit systems for walls. It was possible to analyze the single systems beyond their proven efficiency against various CBRE-threats and broaden their application range beyond the state of the art for the whole range of possible incidents. To make the new findings available for potential customers, existing evaluation diagrams have been updated and successively implemented in the portfolio and the fast-running assessment tool.

In order to extend the database of investigated protection systems with a range of standardized systems, web and literature research was conducted with regard to technologies and manufacturers on the market. Relevant companies have been invited to provide information on their products via specially developed templates. Additional sources such as security conferences and exhibitions have been used to make direct contact with potential contributors. To complete the database, further input was continuously gathered via the project website. During the entire process of collecting input, it was addressed that being part of this portfolio offers companies the opportunity to be introduced to a wide array of professionally interested and diverse user groups. Furthermore, special attention was paid that only actually available protection products were considered for description in the portfolio. All this extra information decisively filled the content of the protection portfolio and the guidance tool.

3 RESULTS – EXEMPLARY FOREGROUND

The additional value gained by the development of the portfolio goes beyond a simple collection of state-of-the-art protection products. A variety of these products has been analyzed and developed further to broaden their application range. To mention all of the improvements would exceed the scope of this paper. This section uses protective design for façade and wall elements as an example to represent the generated foreground.

We have extensively characterized and also developed and improved a large variety of safety measures for a wide range of façades or single wall elements in detail. The introduced protection portfolio can be used to design structural components for future security buildings and infrastructures. Fig. 2 shows the range of characteristic curves for designing safety-relevant elements that have been derived: fiber concrete, masonry and glazing. Single areas of application are described in detail in the following.

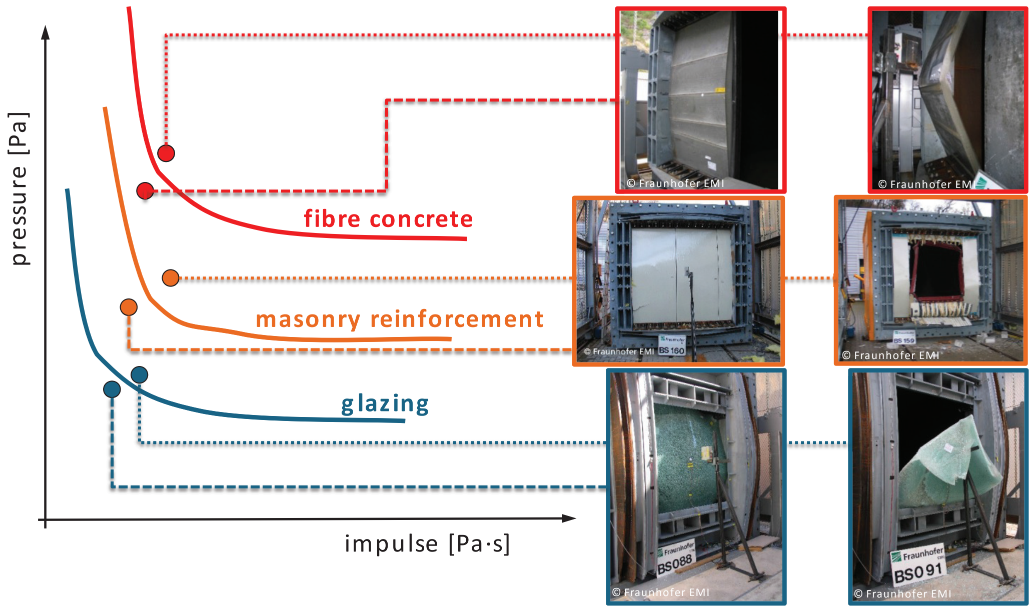

Figure 2: Schematic overview of the range of characteristic curves for designing safety-relevant elements: fibre concrete, masonry and glazing.

So far, innovative safety products for masonry walls had only been validated with regard to single configurations and only for detonative loads in the far field [15]. Now, load cases in near-field, in contact- und in confined areas are validated with comprehensive systematic experimental analyses by means of different test facilities at Fraunhofer EMI. For designing masonry wall elements, the application and load spectrum of existing retrofit concepts was extended significantly. For example, the resistance of lightweight walls (and panels) can be increased considerably.

Additionally, further potential was revealed combining and varying different construction and protection elements. A new and cost-effective reinforcement system for masonry walls for moderate load cases was developed and is now available on the market. Derived iso-damage curves enable users (manufacturers, designers) to quickly and easily evaluate resistance characteristics of different reinforcement concepts.

Accordingly, the resistance of DUCON® [16] ductile high-performance concrete was characterized systematically. Comprehensive experiments at Fraunhofer EMI's own shock-tube facility "BlastSTAR" [17] were performed resulting in reliable design curves to quickly determine the variable critical load.

As an example for glazing components, point-fixed glass façade elements were closely examined with regard to their suitability to function as protective for modern urban architecture. The results are very promising. Besides clamped windows, now another type of façades has become potentially relevant to protective design which essentially widens the range of applications of blast-resistant elements. A large number of "BlastSTAR" tests with toughened glass and different laminated safety glass with pvb and pc components allowed important insights and generated valuable results regarding fracture and failure behavior of single materials for glazing elements. Again, evaluating all test results offered a valuable range of specific characteristic and design criteria which lead to another extension of the targeted protection portfolio.

The complete range of data – regarding resistance characteristics as well as cost-effectiveness – for the analyzed materials as described above is included in the portfolio. Users (architects, planners, building owners) now have a comprehensive and flexible basis for designing safe but also architecturally attractive buildings. Fig. 3 exemplarily shows the reduction of damage of a glass façade when suitable configurations of glazing panes are chosen.

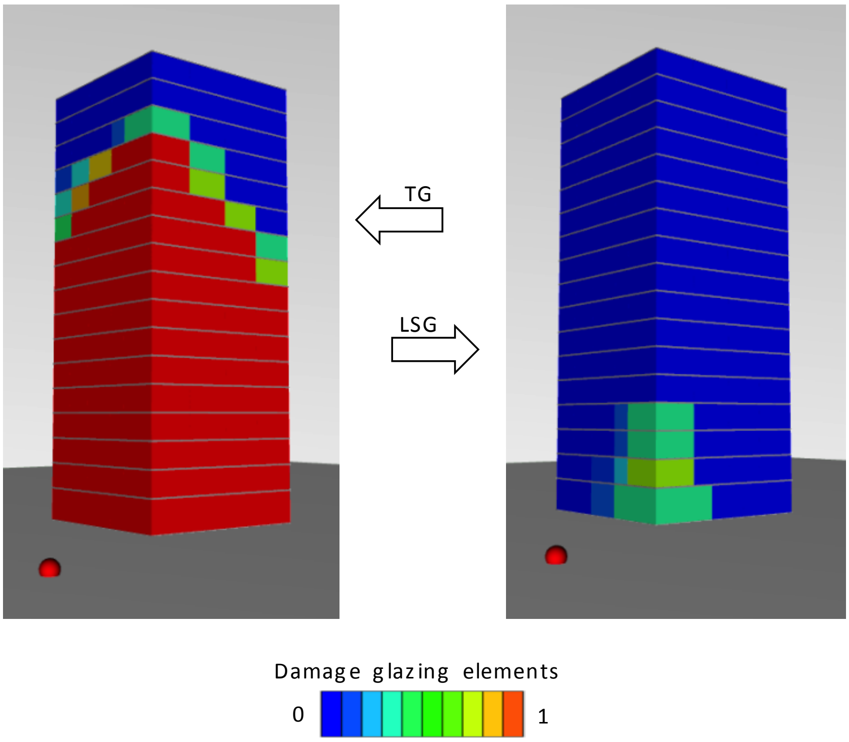

Figure 3: Comparison of damage areas between façades made of common toughened glass (left) and laminated safety glass (right).

4 SUMMARY

A protection portfolio has been developed for the essential parts of built urban infrastructure. Options to reduce effects of defined scenarios such as integrating filter or monitoring systems as well as reinforcement measures for façades or single wall elements such as blast wall systems are now available for a comprehensive range. The relevance of the results to applied security research in the building sector is obvious: Buildings can be designed with a high level of security while allowing flexible decision-making and architectural attractiveness.

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